Montana Fish, Wildlife & Parks' 2020 Chronic Wasting Disease Surveillance and Monitoring Report

Federal Aid in Wildlife Restoration Grant W-171-M

Annual report, May 14, 2021


Dr. Emily Almberg
Disease Ecologist, MTFWP
1400 S. 19th Avenue, Bozeman, MT 59718
406-577-7881, ealmberg@mt.gov

Matthew Becker
Wildlife Veterinary Technician, MTFWP
1400 S. 19th Avenue, Bozeman, MT 59718
406-577-7882, matthew.becker@mt.gov

John Thornburg
CWD Program Lead Technician, MTFWP
1400 S. 19th Avenue, Bozeman, MT 59718
406-577-7883, john.thornburg@mt.gov

Justin Gude
Wildlife Research & Technical Services
Bureau Chief, MTFWP
1420 E. 6th Avenue, Helena, MT 59620
406-444-3767, jgude@mt.gov

Dr. Jennifer Ramsey
Wildlife Veterinarian, MTFWP
1400 S. 19th Avenue, Bozeman, MT 59718
406-577-7880, jramsey@mt.gov

STATE:	***Montana***
AGENCY:	***Fish, Wildlife & Parks***
GRANT:	***Montana Wildlife Disease Surveillance & Response Program***
MT TRACKING:	***W-171-M***

Executive Summary

Montana Fish, Wildlife, and Parks (FWP) has been conducting surveillance for chronic wasting disease (CWD) since 1998, and first detected CWD in wild deer in 2017. In 2020, FWP prioritized sampling in northwestern, southwestern, and eastern/southeastern Montana. In addition, FWP continued to target sampling in the Libby CWD Management Zone and organized a special CWD hunt known as the Southwestern Montana CWD Management Hunt. FWP offered free state-wide testing available via mail-in, CWD-check stations, and all regional FWP headquarter offices in 2020.

During the 2020 season, FWP tested 7974 samples from mule deer (n=3108), white-tailed deer (n=4088), elk (n=729), and moose (n=49). Of these, 271 animals tested positive for CWD, including 38 mule deer and 233 white-tailed deer. In 2020, we detected CWD in 6 new hunting districts, including: 309, 314, 320, 324, 326, and 622.

Among CWD-positive hunt districts across the state, prevalence estimated from hunter-harvested animals sampled from 2017-2020 ranged from <1% -7% in mule deer and <1% - 25% in white-tailed deer. In the town of Libby, 12% (95%CI: 9-16%) of hunter-harvested or trapped white-tailed deer were positive for CWD, whereas only 4% (95%CI: 3-5%) were positive outside the town within the Libby CWD Management Zone. In southwestern Montana, CWD prevalence among hunter-harvested white-tailed deer was highest in hunting districts 322 (25%, 95%CI: 22-28%), 324 (11%, 95%CI: 2-43%), and 326 (5%, 95%CI: 1-17%).

An analysis of all data collected from 2017-2021 from hunter-harvested deer in CWD-positive hunting districts suggests several state-wide patterns of infection across species, sex, age class, and geographic area. The Libby CWD Management Area and the Southwestern Montana CWD Management Hunt Area contain significant hotspots of CWD among white-tailed deer. Outside of these two areas, CWD prevalence did not significantly differ by deer species (relative risk of white-tailed deer: mule deer = 0.8 (95%CI: 0.5 – 1.2); white-tailed deer prevalence = 1%, mule deer prevalence = 2%). Among mule deer, adult males had 3.8 times the risk of infection as adult females across Montana's hunting districts, whereas among white-tailed deer, sex was not significantly associated with infection status. The risk of infection was greatest in adults, followed by yearlings and young of the year.

FWP continues to plan for long-term CWD management in positive areas. In 2021, FWP will continue to educate the public on, and enforce, proper carcass disposal requirements. Administrative rules governing the use of scents are expected to be finalized by the Fish & Wildlife Commission in 2021. Harvest management aimed at managing CWD is ongoing in various regions around the state. In 2021, FWP will attempt surveillance in all hunting districts that intersect a 40-mile buffer on known positives, where CWD has not yet been found. In addition, FWP will target districts in southcentral, southwestern, northcentral, and northwestern Montana for monitoring to improve our understanding of whether the prevalence and distribution of the disease is changing.

Background

Chronic Wasting Disease (CWD) is a fatal neurologic disease of cervids (deer, elk, moose and caribou) for which there is no known cure. CWD is caused by an infectious, mis-folded prion protein which is shed by infected individuals for much of their approximately 2-year infection. The CWD associated prion is transmitted via direct animal-to-animal contact and through the ingestion of prion-contaminated materials in the environment. Since CWD was discovered in Colorado in 1967, it has been documented in captive or free-ranging cervid populations in 26 US states, three Canadian Provinces, Norway, Sweden, Finland, and South Korea. CWD is a relatively slow-moving disease, and if left unmanaged, may take decades to reach prevalences of 20-30%. Significant herd-level declines are predicted at such high prevalences (Gross and Miller 2001, Wasserberg et al. 2009, Almberg et al. 2011), and have been documented among mule deer and white-tailed deer in Wyoming (DeVivo 2015, Edmunds et al. 2016) and Colorado (Miller et al. 2008). Surveillance programs aimed at detecting CWD early are essential to providing the best options for managing the spread and prevalence of the disease. While CWD is not known to infect humans, public health authorities advise against consuming meat from a CWD-positive animal and recommend hunters have their deer, elk, or moose tested if it was harvested within a CWD-endemic area.

Introduction

Surveillance programs for CWD are essential to the early detection of the disease in wild cervid populations. Detection of CWD while prevalence is still low is thought to be critical to the success of managing the disease. Nationally, surveillance efforts for CWD have varied over time and have fluctuated in response to funding and public interest. This has been true for Montana as well. More recently, renewed concerns over the potential risk to human health (Czub et al. 2017), the discovery of CWD in wild cervids in several new states, and renewed national legislative discussion on CWD have fueled interests to increase surveillance once again. With additional surveillance and concerted efforts at managing the disease, such as those outlined in the Western Association of Fish and Wildlife Agencies' 2017 Recommendations for Adaptive Management of CWD in the West, our goal is to effectively manage the disease in wild populations and stave off the worst of the predicted population declines.

Montana Fish, Wildlife, and Parks (FWP) has been conducting surveillance for CWD since 1998, with varying levels of intensity. In 2017, FWP renewed its CWD surveillance and management plans with the help of an internal CWD Action Team and a CWD Citizen's Advisory Panel. FWP's plan outlines a strategy to maximize our ability to detect CWD in high-priority areas where it is not known to exist. This entails (1) continuing to test any symptomatic deer, elk, or moose statewide, (2) focusing surveillance on mule deer and white-tailed deer, and (3) employing a weighted surveillance strategy aimed at detecting 1% CWD prevalence with 95% confidence (Walsh 2012) that rotates among high-priority CWD surveillance areas. High priority surveillance areas are defined as those hunting districts that intersect a 40-mile buffer on known CWD positive cases inside, and outside of Montana's borders in neighboring states and provinces. In addition, once an area is determined to be positive for CWD, FWP may set up special CWD hunts, or use hunter-harvest samples from the general season to monitor the distribution and prevalence of the disease.

In the fall of 2020, FWP conducted CWD surveillance and monitoring in northwestern, southwestern, and eastern/southeastern Montana (Figure 1). FWP organized a special CWD management hunt in southwestern Montana in 2020 in response to the high prevalence of CWD detected there. In addition, FWP continued to trap and euthanize white-tailed deer within the town of Libby as part of the effort to reduce deer densities and help control CWD within the surrounding Libby CWD Management Zone. Lastly, FWP continued to provide free, state-wide CWD testing of hunter-harvested animals in 2020. Below, we report on the results and lessons learned from the 2020 CWD surveillance and monitoring efforts.

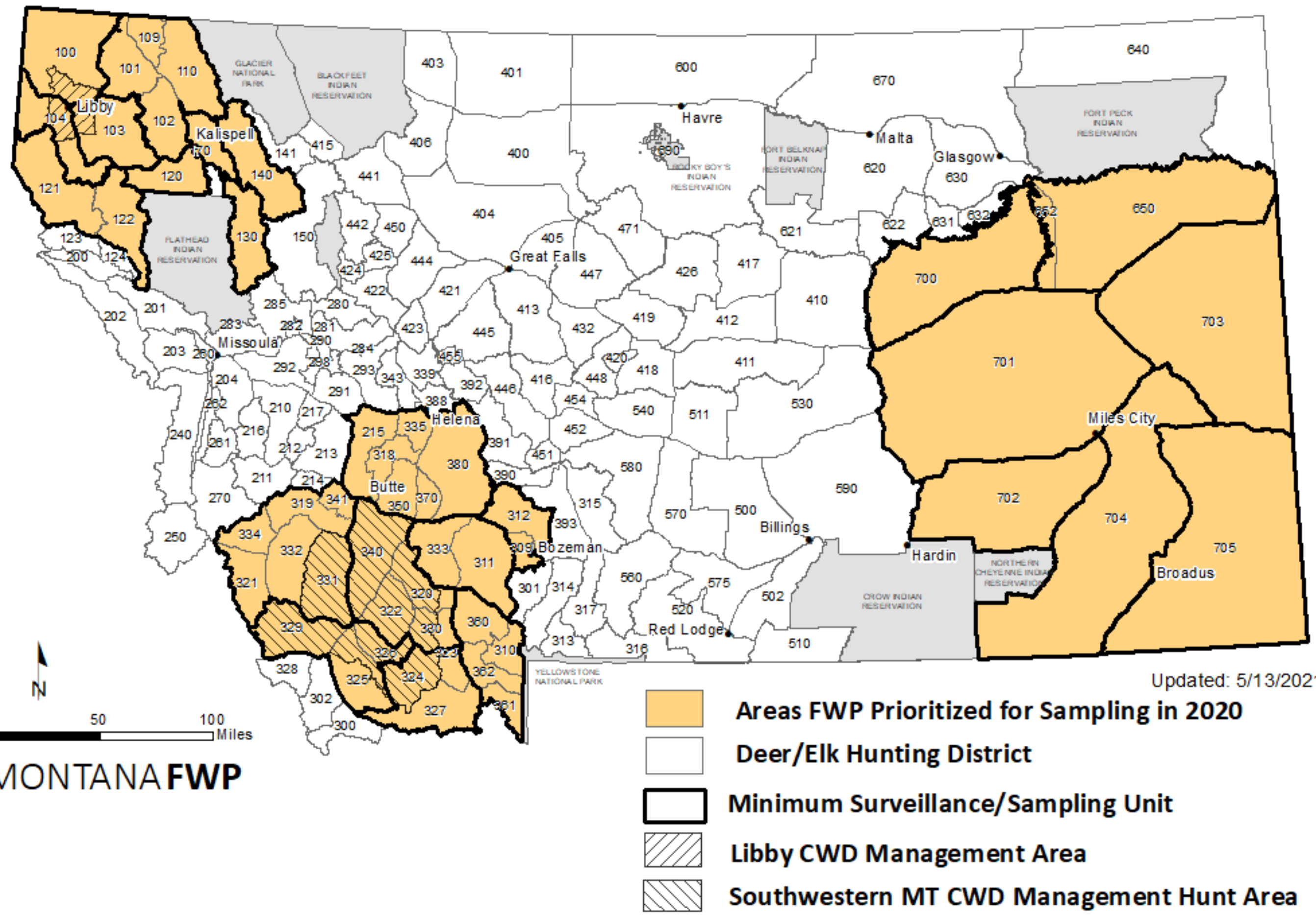


Figure 1. CWD priority sampling areas in Montana, 2020. CWD surveillance and monitoring areas included northwestern, southwestern and eastern/southeastern Montana. Boundaries of the Libby CWD Management Area and the Southwestern Montana CWD Management Hunt Area are displayed in cross-hatch.

Methods

Surveillance

In 2020, FWP focused its surveillance efforts on districts where CWD had not yet been detected in northwestern, southwestern, and eastern/southeastern Montana. Priority surveillance areas were divided into minimum surveillance units (Figure 1). Each minimum surveillance unit was defined as a portion of, or an aggregation of hunting districts meant to capture discrete and well-mixed population units of deer with ≤15,000 mule deer. Within each minimum surveillance unit, we employed a weighted surveillance strategy aimed at detecting 1% CWD prevalence with 95% confidence (Walsh 2012). Under the weighted surveillance framework, different demographic groups (age, sex, or cause of death categories) of a species are assigned different point-values based on their relative risk of being infected (Table 1). A total of 300 points, spatially distributed across the unit, were necessary to establish our detection goals within each minimum surveillance unit. Sample size goals were specific to a single species within a minimum surveillance unit, and our efforts prioritized the sampling of deer since they appear to have the highest prevalences among the different cervid species where they overlap (Miller et al. 2000). Elk and moose were sampled opportunistically.

Table 1. Relative weights or "points" associated with each demographic group of deer and elk that count towards meeting a sample size goal using a weighted surveillance strategy based on data from mule deer and elk in CWD-positive areas in Colorado (Walsh and Otis 2012) and white-tailed deer in Wisconsin's CWD management zone (Jennelle et al. 2018).

	Weight/Points		
Demographic Group	**Mule Deer**	**White-tailed Deer**	**Elk**
Symptomatic female	13.6	9.09	18.75
Symptomatic male	11.5	9.09	8.57
Road-killed males/females	1.9	0.22	0.41
Other mortalities (predation, other unexplained in adults and yearlings)	1.9	7.32	0.41
Harvest-adult males	1	3.23	1.16
Harvest-adult females	0.56	1.30	1.00
Harvest-yearling females	0.33	0.85	0.23
Harvest-yearling males	0.19	1	NA
Harvest-fawns/calves	0.001	0.04	NA

FWP staff collected samples between April 1, 2020 – March 15, 2021 from mule deer, white-tailed deer, elk, and moose that were either hunter-harvested, road-killed, symptomatic and euthanized, or found dead. An animal was considered symptomatic if it appeared extremely sick and/or displayed symptoms consistent with CWD (emaciation, lack of coordination, drooping head/ears, excessive salivation, etc.). FWP used a variety of tools to obtain samples, including working with hunters at check stations, processors and taxidermists, outfitters, landowners, Montana Department of Transportation, Highway Patrol, and by sending letters to license holders notifying them of the surveillance effort. Field and laboratory staff collected retropharyngeal lymph nodes (Hibler et al. 2003) or an obex sample if lymph nodes were not available (both lymph nodes and obex were collected from moose), an incisor tooth for aging, and a small genetic sample (muscle tissue) from each cervid sampled as part of the CWD surveillance program. Field staff worked with hunters to gather precise location information on where the animal was harvested/found, as well as species, age, and sex information for each sampled animal. Lymph nodes and obex from deer and elk were frozen for subsequent enzyme-linked immunosorbent assay (ELISA) testing, whereas lymph nodes and obex from moose were fixed in 10% buffered formalin for immunohistochemistry (IHC) testing. Samples tested using the ELISA were submitted to Montana Veterinary Diagnostic Laboratory, whereas anything needing an IHC test (e.g. moose samples and confirmations of ELISA positives) were sent to Colorado State University Veterinary Diagnostic Laboratory on a weekly basis. Testing costs were $13/sample for the ELISA, and $35/sample for IHC. Results from hunter-harvested animals were posted on FWP's website as soon as results were received from the lab. When a harvested animal tested positive for CWD on the ELISA (labeled a "suspect"), FWP directly contacted the associated hunter to inform them of the test results, to let them know the meat could be legally disposed of, and to discuss proper disposition of the carcass parts. IHC confirmations were typically available 1-3 weeks later, so we did not require hunters to wait that full time before legally disposing of the carcass.

In addition to the focused sampling efforts in the 2020 priority surveillance areas, FWP collected or received samples from symptomatic or hunter-harvested animals state-wide. Hunters that harvested an animal outside of the priority surveillance areas that wanted to have their animal tested either brought their animal to a CWD check station or a regional headquarters office or were instructed on how to collect and mail in their samples for testing that was paid for by FWP. The video instructing hunters how to collect their own CWD sample can be found at fwp.mt.gov/CWD under "Submitting Samples."

Monitoring of prevalence and distribution within CWD Positive Areas

In 2020, FWP continued to prioritize sample collection from known positive areas in northwestern, southwestern, and eastern/southeastern Montana, and continued to test any hunter-submitted samples from other positive areas around the state. In 2020, FWP also initiated a CWD management hunt in southwestern Montana. Although sampling was not required, it was encouraged to improve our estimates of CWD prevalence and distribution in these areas (Figure 1). In addition, FWP continued to trap and euthanize white-tailed deer in the town of Libby to further reduce deer densities. Estimates of prevalence were calculated using only data from hunter-harvested, or agency trapped and euthanized animals (in Libby), from 2017-2021.

Data summaries and analyses
Weighted surveillance points were calculated separately for mule deer, white-tailed deer and elk (relative risk of infection data currently does not exist for moose). For each species, we tallied the number of samples collected within each of the age/sex/cause of death categories outlined in Table 2, multiplied this by their assigned point value, and summed all points within a minimum surveillance unit. We then modified the equation for the sample size (n) needed to establish freedom from disease at a specified prevalence level (P; proportion of the population that is positive), with a desired level of statistical confidence (α),

$$n = \frac{-\ln\,(1-a)}{P}$$

to calculate the threshold prevalence above which we would expect to detect at least one positive given our weighted surveillance points (n) and assuming 95% statistical confidence:

$$P = \frac{-\ln\,(1-a)}{n}$$

Following detection, we explored patterns of infection among hunter-harvested deer in CWD-positive hunting districts using logistic, generalized linear mixed models. We evaluated the odds of infection as a function of species, sex, age class, whether the animal was harvested in either the Libby or Southwestern MT CWD Management Hunt Area or outside of these areas, and relative timing of harvest within the general season (early-rut: Oct 15-Nov 14; late-rut: Nov 15-Dec 5), while using hunting district as a random effect. Models with various permutations of these covariates were evaluated using Akaike's Information Criterion (AIC; Burnham and Anderson 2002), and unless otherwise noted, we report the estimated covariate effects from the best supported models (< 2 AIC units from the top model). Odds ratios (exponentiated logistic coefficients) were converted to estimates of relative risk to facilitate interpretation (relative risk = odds ratio/(1-p_0 + (p_0*odds ratio)), where p_0 is the prevalence within the baseline group; Grant 2014). All analyses were carried out in Program R (R Core Team 2017).

We report prevalence at the scale of hunting districts and within the Libby CWD Management Area. We calculated 95% binomial confidence intervals using the Wilson method.

Results

Between April 1, 2020 – March 15, 2021, FWP submitted 7974 samples for testing, which was a 13% increase over the number of samples collected in 2019 (n=7025). The majority of these samples were analyzed at Montana Veterinary Diagnostic Laboratory, with a much smaller number of IHC tests conducted at Colorado State University's Veterinary Diagnostic Laboratory. Of these samples, 3108 were collected from mule deer, 4088 from white-tailed deer, 729 from elk, and 49 from moose. Thirty five percent (n=2833) of samples were collected from outside our priority sampling areas. Hunters collected and submitted 1126 of their own samples in 2020, of which 1105 (98%) were suitable for testing. Since FWP's renewed surveillance efforts in

2017, we have tested 18870 samples statewide (Figure 2).

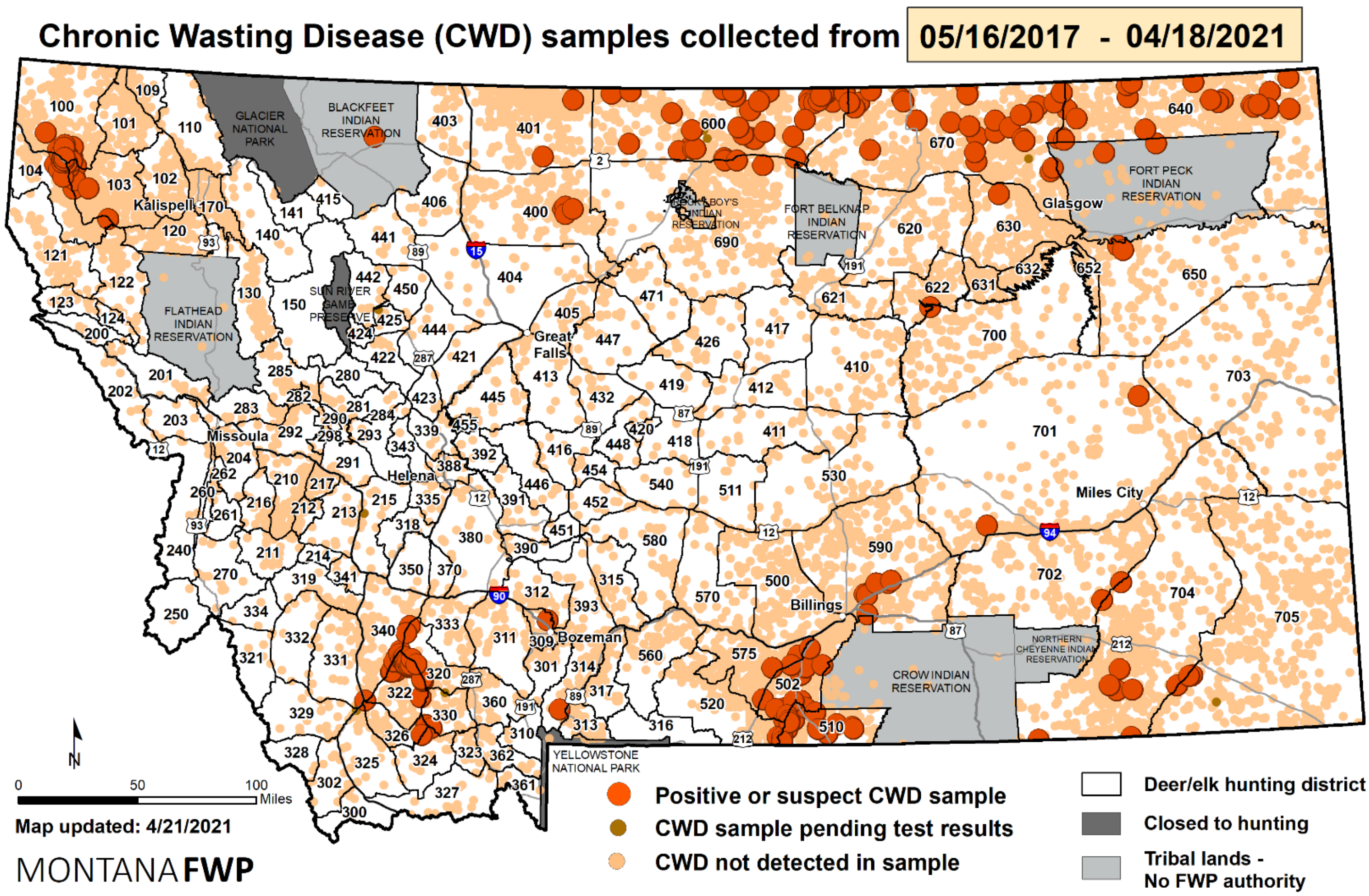


Figure 2. Map of sampling locations and CWD positives among deer, elk, and moose from 2017-2021.

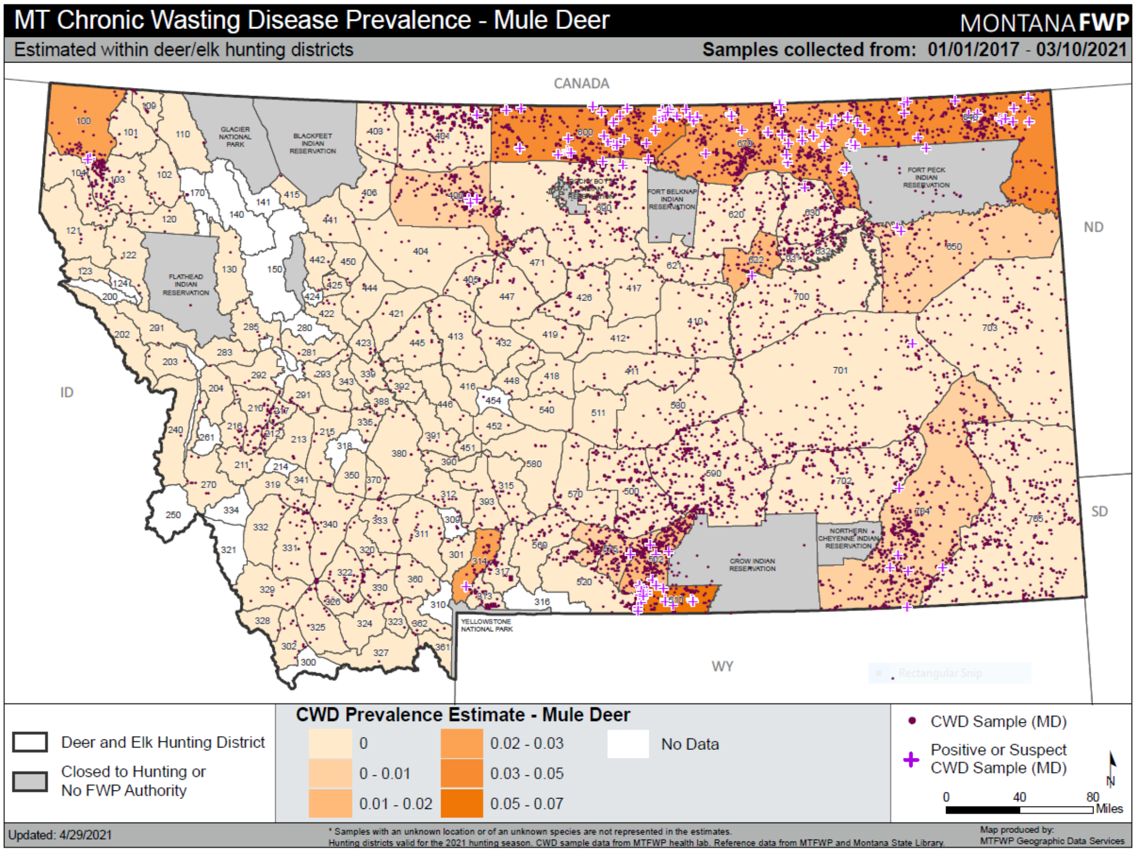
FWP detected 271 CWD positive cervids during the 2020 season, including 38 mule deer, 233 white-tailed deer, 0 elk, and 0 moose. In 2020, we detected CWD in 6 new hunting districts, including: 309, 314, 320, 324, 326, and 622 (Figure 2). In addition, the Blackfeet Indian Reservation detected their first case of CWD on the Reservation in a white-tailed deer.

We met or exceeded our numerical surveillance goals among most of the minimum surveillance units in northwestern Montana for white-tailed deer, except for in HDs 130, 140, and 170 (Appendix I, Figure A1, A4). This suggests that if CWD is present among these units, it is likely to be affecting <1% of the white-tailed populations. This confirms that the foci of infection around the Libby area still appears to be contained within hunting districts 100, 103, and 104. However, inspection of the sampling distribution suggests that continued sampling could improve district coverage and increase our confidence that these districts have extremely low prevalence. Priority surveillance hunting districts 320, 324, and 326 were all found to have CWD present (Figure 2). We did not detect CWD within the other southwestern minimum surveillance units (Appendix I, Figure A1, A5), however we fell short of the necessary surveillance points to rule out infection in these areas. Similarly, in hunting districts 652, 700 and 703, we did not find any CWD positives, but fell short of our sampling goals. Of these three eastern districts, hunting district 703 has been sampled most intensively, and with the sampling effort to date we should have detected at least 1 positive with 95% confidence if prevalence were ≥2% in mule deer and ≥1% in white-tailed deer (Appendix I, Figure A1, A9).

Among CWD-positive hunt districts, prevalence estimated from hunter-harvested animals sampled from 2017-2020 ranged from <1% - 7% in mule deer and <1% - 25% in white-tailed deer (see Appendix II for prevalence estimates by hunting district), with varying levels of precision. Estimates of prevalence in eastern Montana were improved by another year of sampling and in most cases allowed us to exceed our targeted range of precision of ± 3% margin of error (Figures 3 and 4). In the town of Libby, 12% (95%CI: 9-16%) of hunter-harvested or trapped white-tailed deer were positive for CWD, whereas only 4% (95%CI: 3-5%) were positive outside the town within the Libby CWD Management Zone (additional details below). In southwestern Montana, CWD prevalence among hunter-harvested white-tailed deer was highest in hunting districts 322 (25%, 95%CI: 22-28%), 324 (11%, 95%CI: 2-43%), and 326 (5%, 95%CI: 1-17%).

An analysis of all data collected from 2017-2021 from hunter-harvested deer in CWD-positive hunting districts suggested several state-wide patterns of infection across species, sex, and age class. Our best supported model included deer species, sex, a species by sex interaction, age class, an indicator for the Libby and Southwestern (SW) Management Area, and an interaction between the Management Area indicator and species (see Appendix III for the list of evaluated models). We included an indicator for the white-tailed deer CWD hotspots in Libby and in Southwestern Montana to account for the intensity of infection in those locations without skewing the estimated patterns for the rest of the state. Indeed, within these two areas, white-tailed deer prevalence was significantly higher than estimates from elsewhere around the state (on average, white-tailed deer from the Management Areas have 12.8 times the risk of infection as white-tailed deer elsewhere in the state ((95%CI: 6.4 – 24.1); average white-tailed deer prevalence inside the Libby and Southwestern Management Areas = 13% versus outside = 1%). Outside of the Libby and Southwestern CWD Management Areas, we found that CWD prevalence did not significantly differ by deer species (Relative risk of white-tailed deer: mule deer = 0.8 (95%CI: 0.5 – 1.2); white-tailed deer prevalence = 1%, mule deer prevalence = 2%). Among mule deer, adult males had 3.8 times the risk of infection as adult females (adult male mule deer prevalence = 2%, adult female prevalence = 0.6%; Relative risk of males:females = 3.8, 95%CI: 2.1 – 6.6). By contrast, among white-tailed deer there was no significant difference in the relative risk of infection between the sexes (outside of the Libby and SW Management Areas: adult white-tailed deer female prevalence = 1%, adult white-tailed deer male prevalence = 1%; Relative risk of females:males = 0.7, 95%CI: 0.6 – 1.0). Across deer species in CWD-positive hunting districts, young of the year and yearlings had 0.2 times (95%CI: 0.1 – 0.4) and 0.5 times (95%CI: 0.4 – 0.8), respectively, the risk of infection as adults (outside of the management areas: young of the year prevalence = 0.2%, yearling prevalence = 0.2%, and adult prevalence = 1.7%).

During the general rifle season (October 15 – December 5), deer harvested during the late rut (after November 15^{th}) were 1.3 times more likely to be infected than those deer harvested during the early rut (prevalence during early rut: 2%, prevalence during late rut: 3%; Relative risk late:early = 1.3, 95%CI: 1.0 – 1.7; Appendix III, Table A2). However, when we repeated the analysis within each species' datasets, we found no significant association between infection and timing of harvest.



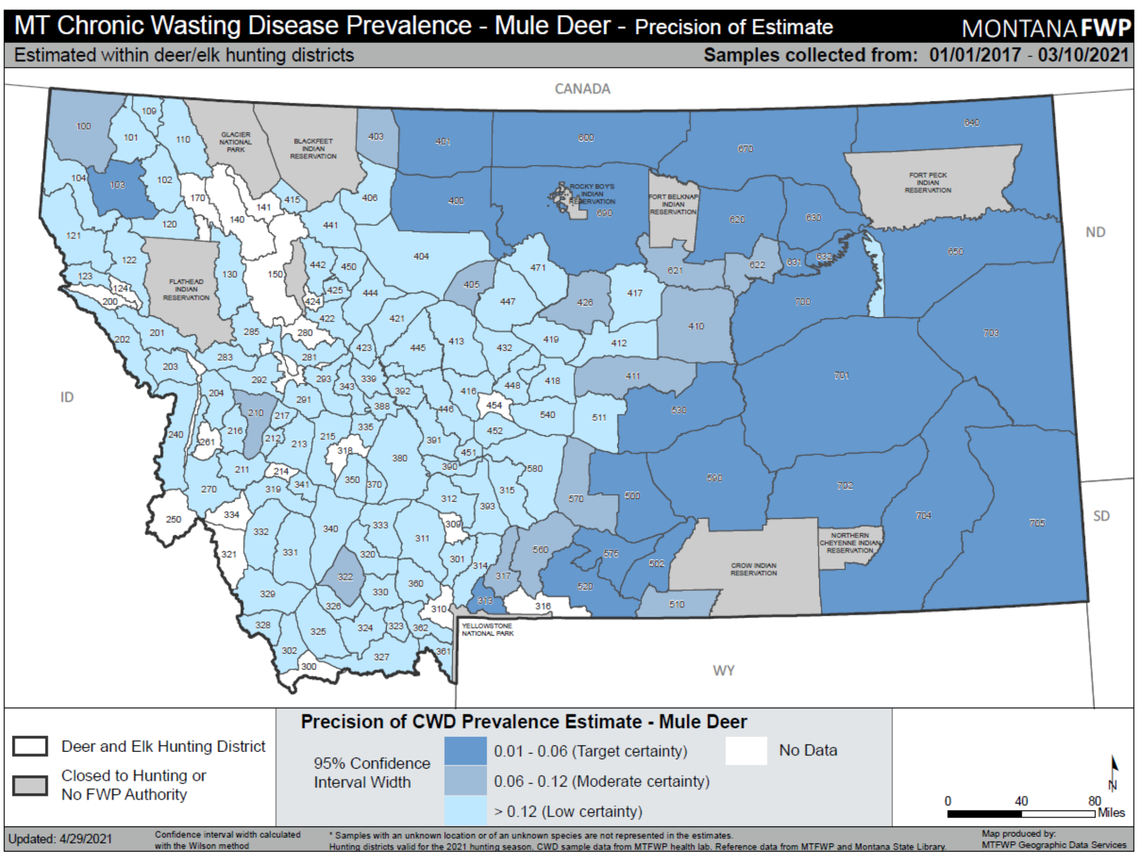


Figure 3. CWD prevalence in mule deer (top figure), estimated by hunting district across Montana, 2017-2020. Prevalence is calculated by dividing the number of test-positives by the total number of animals sampled. Only data from hunter-harvested or agency removal/trapping were used to calculate prevalence. The corresponding precision of these estimates is displayed in the bottom figure. Small 95% confidence interval widths (dark blue) indicate higher certainty in prevalence estimates; large 95% confidence interval widths (light blue) indicate low certainty in the estimates. Where CWD has not been detected (i.e. prevalence = 0 in top figure), additional sampling may still be necessary to declare the area free from disease, or below 0.01 prevalence, with 95% confidence.

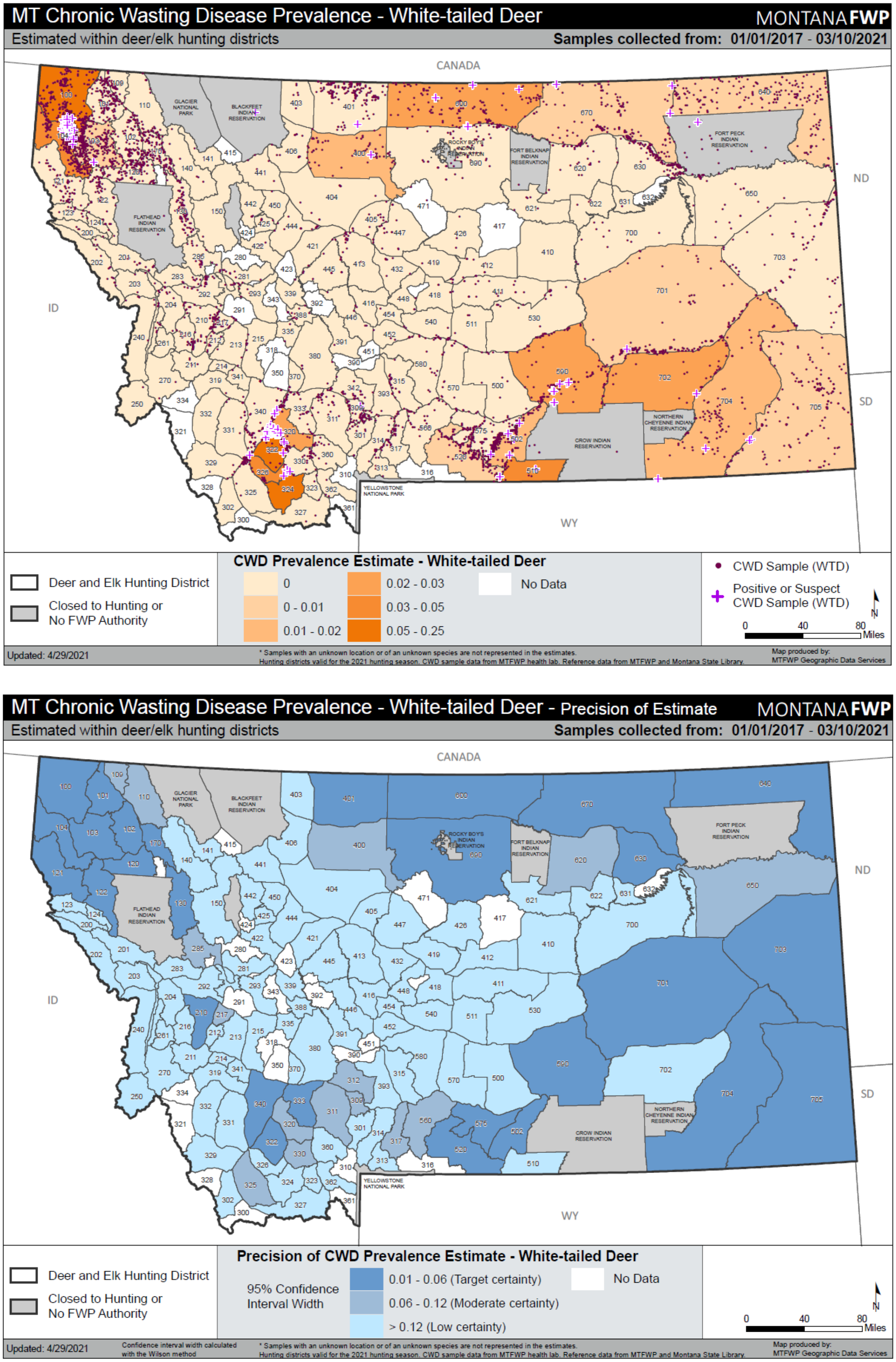


Figure 4. CWD prevalence in white-tailed deer (top figure), estimated by hunting district across Montana, from hunter-harvested or agency removed/trapped deer from 2017-2020. Prevalence is calculated by dividing the number of test-positives by the total number of animals sampled. The corresponding precision of these estimates is displayed in the figure below. Small 95% confidence interval widths (dark blue) indicate higher certainty in prevalence estimates; large 95% confidence interval widths (light blue) indicate low certainty in the estimates. Where CWD has not been detected (i.e. prevalence = 0 in top figure), additional sampling may still be necessary to declare the area free from disease, or below 0.01 prevalence, with 95% confidence.

CWD Management Hunts:

Southwestern Montana CWD Management Hunt

FWP ran the Southwestern Montana CWD Management Hunt from December 15, 2020 – February 15, 2021 that included hunting districts (or portions of) 320, 322, 324, 325, 326, 329, 330, 331, and 340. Hunters were allowed to apply any unused 2020 general deer licenses for either-sex white-tailed deer harvest and/or existing unused 2020 003-00, 331-01, and 399-00 B-licenses for antlerless white-tailed deer. There were no testing or reporting requirements associated with the hunt, however, 329 white-tailed deer harvested during the hunt were submitted for testing. Of these, we found 55 additional CWD positives. These samples, combined with general season samples, improved the precision of our prevalence estimates in some of the districts, although some districts remain below our targets for sampling intensity (Appendix I, Figure A2).

Libby

FWP continued to offer antlerless white-tailed deer licenses during the 2020 season as part of the ongoing effort to increase harvest within the Libby CWD Management Area. During the general hunting season, hunters submitted 491 white-tailed deer from this area for testing, of which 23 were positive for CWD. From January 4, 2021 through February 28, 2021, FWP trapped, euthanized, and tested an additional 107 white-tailed deer within the Libby CWD Management Area, of which 13 were positive. Using only data from hunter-harvested or trapped and euthanized deer during the 2020-2021 season, the estimated prevalence was 6% (95%CI: 4-8%) in the entire Libby CWD Management Zone, a figure comparable to estimates from previous years' data. Within this zone, the core "Libby Surveillance Area" (the town of Libby) had a prevalence of 9% (95%CI: 6-15%), whereas the remaining outer ring of the Management Zone had a prevalence of 5% (95%CI: 3-7%). Only 33 mule deer were harvested, of which 1 was positive (prevalence = 3%, 95%CI: 1-15%). Of 5 elk tested, none were found positive. There were no moose tested from within the Libby CWD Management Zone during the 2020-2021 season.

Testing and reporting turn-around time

On average, it took 8 calendar days (sd = 5 days) from the day a sample was collected to the day the test results were posted online, a significant improvement in turnaround time from 2019, when our average was 19 days. Of this time, it took on average 3 days (sd = 4 days) from the time the sample was collected until shipment to Montana Veterinary Diagnostic Laboratory, and an average of 5 days (sd = 3 days) from the day of shipment until results were received, which includes 1-2 days of transit time. The confirmations of ELISA positives and the testing of moose samples (mean = 17 days) continued to take significantly longer due to the more time-consuming nature of the IHC test.

When a suspect CWD test result was received, FWP staff called hunters to notify them and to inquire about the disposal of the meat/carcass. If meat had gone to a processor, the Department of Public Health and Human Services contacted the processor and followed up with any hunters who may have received meat that was batch-processed with the positive animal. The majority of hunters with positive animals had either waited for their test result prior to processing or processed their animal at home.

Discussion

To date, targeted CWD surveillance has confirmed our predictions of CWD presence within the north-central, north-eastern, south-central, and south-eastern borders of our state. However, we have also detected CWD in places where we did not expect to find it, including Libby, Sheridan, and Bozeman. These detections indicate the disease is more widely distributed than we initially expected, consistent with Montana's mostly intact landscape and widely connected state-wide deer populations. State-wide testing that is offered free-of-charge to hunters, while demanding a significant investment in resources, staff and technician time, continues to be successful at detecting positives in new areas outside of those targeted for annual surveillance (e.g. HD 314, 622, and the Blackfeet Reservation). We plan to continue offering free state-wide testing to meet hunter interest and to improve our sampling coverage across the state.

In 2020-2021, we largely met our surveillance and monitoring goals for northwestern and southeastern Montana but fell short of the target sample sizes and distribution of sampling in most of the southwestern districts that we had prioritized this year. Districts where we still need additional samples will continue to be prioritized in coming years.

Our state-wide analysis suggests that outside of the CWD hotspots among white-tailed deer in the Libby and SW Management Areas, there is little difference in risk of infection (i.e. prevalence) between white-tailed deer and mule deer elsewhere in the state. The Sheridan and Libby areas, dominated by white-tailed deer, have the highest measured local CWD prevalences in the state (25% in HD 322 and 12% within the town of Libby). In other areas where both mule deer and white-tail deer are abundant, prevalences tend to be relatively similar between the species (Figures 3 & 4). Other western states and provinces have reported that mule deer have higher prevalences than white-tailed deer where they overlap (Miller et al. 2000, DeVivo 2017, Nobert et al. 2016), and indeed Montana's previous CWD surveillance plan prioritized mule deer for CWD detection. However, it is clear that white-tailed deer populations should remain a priority for surveillance and monitoring in Montana, particularly when they are abundant or the dominant species in an area. The fact that the patterns in Montana diverge from those reported elsewhere may relate to differences in the way the two species are managed among states and provinces, the relative timing of disease introduction across the two species, or local differences in the ecology, movement and population dynamics of the two species in Montana, all of which may result in differences in transmission dynamics among or between the species.

We also found that while adult male mule deer are much more likely to be infected than adult females, there are no significant differences in infection risk among the sexes in white-tailed deer. Male mule deer have been found to have higher prevalences than females in other western states and provinces (Miller et al. 2000, DeVivo 2017, Nobert et al. 2016). However, reported patterns among the sexes in white-tailed deer have been more variable, including evidence for a female bias (Edmunds et al. 2016), a male bias (Grear et al. 2006, Nobert et al. 2016), and no detectable differences in prevalence between the sexes (Miller et al. 2000). Our data suggests that we should continue to emphasize the sampling of adult male mule deer over females for surveillance, but that adult male and female white-tailed deer may be equally valuable for surveillance in Montana. With Montana's dataset, we plan to estimate our own weighted surveillance point values (Table 1) that are based on patterns observed within our state.

Conner et al. (2000) found that the risk of harvesting CWD positive mule deer, particularly mule deer bucks, increased over the harvest season. One hypothesis is that older-aged animals, which are more likely to be positive, are more susceptible to harvest during the rut, which could bias the estimate of prevalence upwards in late vs. early season. Another hypothesis is that CWD-infected deer may be less aware or responsive to hunters, particularly when they are already distracted by the rut. We looked for a similar pattern in Montana's data. We found marginal support for a general pattern where hunters were more likely to harvest a CWD-positive mule deer and white-tailed deer later in the rut (after November 15th) than earlier. However, when we repeated the analysis within each species' datasets, there was no clear pattern. Differences observed between the Montana dataset and the Conner et al. (2000) study may be related to differences in deer management among states. The Conner et al. (2000) pattern is based on Colorado data, where they have statewide limited-entry hunting, producing higher buck ratios and older age structures. By contrast, Montana has much more liberal buck harvest, producing younger buck age structures. This may result in a higher likelihood that hunters harvest an older (and more likely positive) buck as the rut progresses in Colorado than in Montana.

In 2021, we will attempt surveillance in all hunting districts that intersect a 40-mile buffer on known positives, where CWD has not yet been found (Figure 5). In addition, FWP will target districts in southcentral, southwestern, northcentral, and northwestern Montana for monitoring to improve our understanding of whether the prevalence and distribution of the disease is changing.

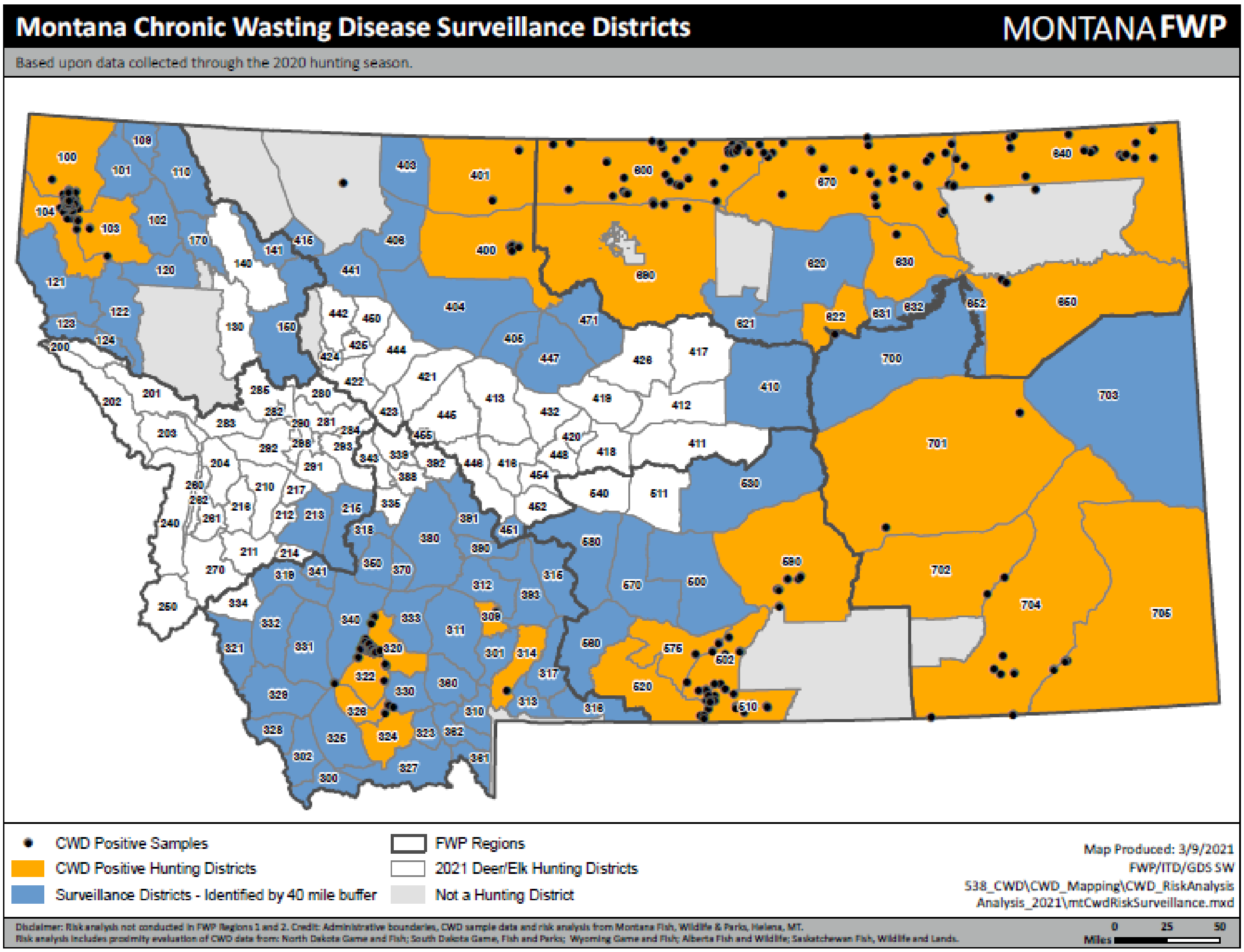


Figure 5. Map of future priority CWD surveillance districts (blue) that are within 40 miles of known CWD positives. CWD-positive hunting districts are in orange.

Management updates

FWP is committed to managing CWD to minimize its spread and to keep prevalences below 5%. Management has been changed in response to CWD in the following areas:

- Region 1: Following the detection of CWD in Libby, the region focused on increasing the accuracy and precision of prevalence estimates. Efforts were made to increase signage and/or public messaging throughout the Libby CWD Management Zone about 1) not feeding/aggregating deer, 2) discouraging carcass dumping, and 3) informing hunters of proper carcass disposal. FWP is currently working with the Libby City Council to assist the City with drafting an Urban Deer Management Plan. Lastly, the Commission approved an either sex B-license valid within the Libby CWD Management Zone. There are no limits on the number of B-licenses that can be sold, but there is a limit of one license per person. These licenses will continue to be available in 2021.
- Region 2: Using a US Department of Agriculture Animal and Plant Health Inspection Service grant, we offered 5 strategically placed carcass disposal dumpsters during the hunting season to facilitate FWP's new carcass disposal policy aimed at reducing the human-assisted spread of CWD to new areas of the state. All 5 dumpsters were located in R2; we have plans to expand the offering of these dumpsters to other parts of the state in the fall of 2021.
- Region 3: FWP ran the Southwestern Montana CWD Management Hunt from December 15, 2020 – February 15, 2021 that included hunting districts (or portions of) 320, 322, 324, 325, 326, 329, 330, 331, and 340. Hunters were allowed to apply any unused 2020 general deer licenses for either-sex white-tailed deer harvest and/or existing unused 2020 003-00, 331-01, and 399-00 B-licenses for antlerless white-tailed deer. The goals of the hunt were to continue ongoing priority CWD surveillance; to reduce the number of CWD positive animals, prevalence, and slow the spread of CWD among white-tailed deer populations; to measurably reduce white-tailed deer populations where CWD currently occurs and where CWD is likely to occur in the future; reduce white-tailed deer populations and CWD prevalence to levels that can be more effectively managed through general hunting season harvest; and to reduce probability of CWD spreading to overlapping mule deer, elk, and moose.
- Region 4: Based on CWD surveillance findings in 2019, FWP Region 4 managers proposed a change from a 3-week general deer season to a 5-week general deer season in HD's 400, 401, 403, and 406. Due to significant public resistance and direction from the Fish & Wildlife Commission, the Department proposed an alternative of limited species-specific antlered buck permits valid for 2 weeks after the 3-week general season in these 4 hunting districts. This change was approved by the Commission on February 13, 2020.
- Region 5: 2019 was the first year of CWD-related season changes in south-central Montana (hunting districts 510, 502, 520, and 575) designed to liberalize both mule deer and white-tailed deer harvest, particularly of bucks. HD 502 went from a buck-only mule deer to an either-sex harvest, and additional antlerless mule deer B licenses were made available. HD 510 went from an unlimited mule deer buck permit to an either-sex general season hunt. HD 520 went to an either-sex mule deer season in that portion of HD 520 lying east of Highway 212. HD 575 maintained the antlered buck mule deer season type but doubled the number of antlerless B-licenses issued compared to 2018.

  Harvest estimates for 2019 suggest:
    - In HD 502, white-tailed and mule deer buck and doe harvest were slightly above the previous 5-year averages.
    - In HD 510, mule deer buck harvest was the lowest since 1998, and doe harvest was very low but slightly above average for the previous 5 years. Harvest of both sexes of white-tailed deer remained stable with the previous 5-year averages.

    - In HD 520, mule deer buck harvest was the lowest recorded since 1986, and doe harvest was double the 5 year average, but still very low. Among white-tailed deer, buck harvest was at its lowest since 1998, and doe harvest was 20% lower than the 5 year average.
    - In HD 575, mule deer buck harvest was at its lowest since 1996, and doe harvest was four times higher than the 5 year average. Among white-tailed deer, buck harvest was at its lowest since 1992, and doe harvest was 16% below 5 year average and third lowest since 1991.
    - These harvest numbers reflect that deer numbers of both species are at or near lowest levels in 40 years.

- Region 6: Managers have actively increased antlerless B-licenses in recent years for both mule deer and white-tailed deer in response to the presence of CWD and increasing deer populations. In 2020, 6,800 mule deer B-licenses were issued region-wide, which was a 106% increase since 2017 (3,300). In 2020, 3,000 limited draw, region-wide white-tailed deer B-licenses were available, which was a 200% increase over 2018 (1000). The sale of licenses for antlerless white-tailed deer (over-the-counter licenses + 699-licenses) has remained relatively stable from 2018-2020, but there was a total increase of sales by 22% in 2020 from 2018.

- Region 7: Management continues to be fairly liberal as it has been for the last few decades. The general deer license is valid for either-sex, either-species across the entire region. Region-wide mule deer B licenses have been set at the maximum quota (11,000) within the quota range from 2017-2020. Region-wide white-tailed deer B licenses are available over-the-counter, 1 per hunter. An additional 2,000 licenses are available for residents to purchase as a 2nd white-tailed deer B license, valid region-wide.

In addition, in 2021, FWP's Fish & Wildlife Commission adopted regulation regarding carcass disposal in Montana, and they are developing administrative rules (ARMs) to address the use of cervid-derived scents. The Commission rule (CR) adopted regarding carcass disposal reads "To prevent the spread of Chronic Wasting Disease, all parts of the head or skull containing brain material and/or the spinal columns of deer, elk, and moose harvested in Montana must be left in the field at the kill site or, if transported for further processing including taxidermy or meat processing, must be disposed of in a class II landfill once that processing is complete." This policy was designed to replace former within-state carcass transport restrictions.

Three separate ARMs have been drafted to regulate the use of scents. Statute (MCA 87-6-221) restricts the use of cervid urine to sources from states that do not have CWD unless the Commission designates a urine production facility within a CWD positive state to comply with the standards set for in MCA 87-6-221. Consequently, the first proposed ARM designates the states and provinces where CWD is currently found; this ARM may need to be updated annually or as frequently as additional states detect CWD within their administrative boundaries. The second ARM identifies that products that display approval by the Archery Trade Association (ATA) or the Responsible Hunting Scent Association (RHSA) are in compliance with the standards set forth in MCA 87-6-221. The final ARM under consideration by the Commission establishes that glandular scents that comply with the ATA or RHSA approval or artificial scents not using natural glandular scent sources may be used as attractants for deer, elk, or moose in Montana. The Commission provided initial approval of these rules on April 1, 2021, and a public hearing on the proposed ARM is scheduled for May 13, 2021, at 9 am using a virtual meeting. Pending final Commission approval at their June 24, 2021 meeting, the ARM should become effective before August 2021.

Acknowledgements

CWD surveillance required significant involvement from FWP regional enforcement staff, biologists, communication and education staff, administrative staff, the Wildlife Health Lab, and hired technicians. A special thank you to all the technicians that worked check stations and regional offices during the general season. We greatly appreciate their help for making this effort a success. We would like to extend a special thank you to the staff at the Montana Veterinary Diagnostic Laboratory and at Colorado State University's Veterinary Diagnostic Laboratory for analyzing all our samples as quickly as possible. We would also like to thank hunters, landowners, supportive residents and communities, vigilant wildlife watchers, and State, Federal and Tribal agency partners. Funding for this project came from deer and elk auction license sales, Federal Aid in Wildlife Restoration Grant W-171-M to Montana Fish, Wildlife and Parks, a USDA APHIS CWD Grant, and generous donations from the Rocky Mountain Elk Foundation and the Mule Deer Foundation.

Appendix I. Additional Figures

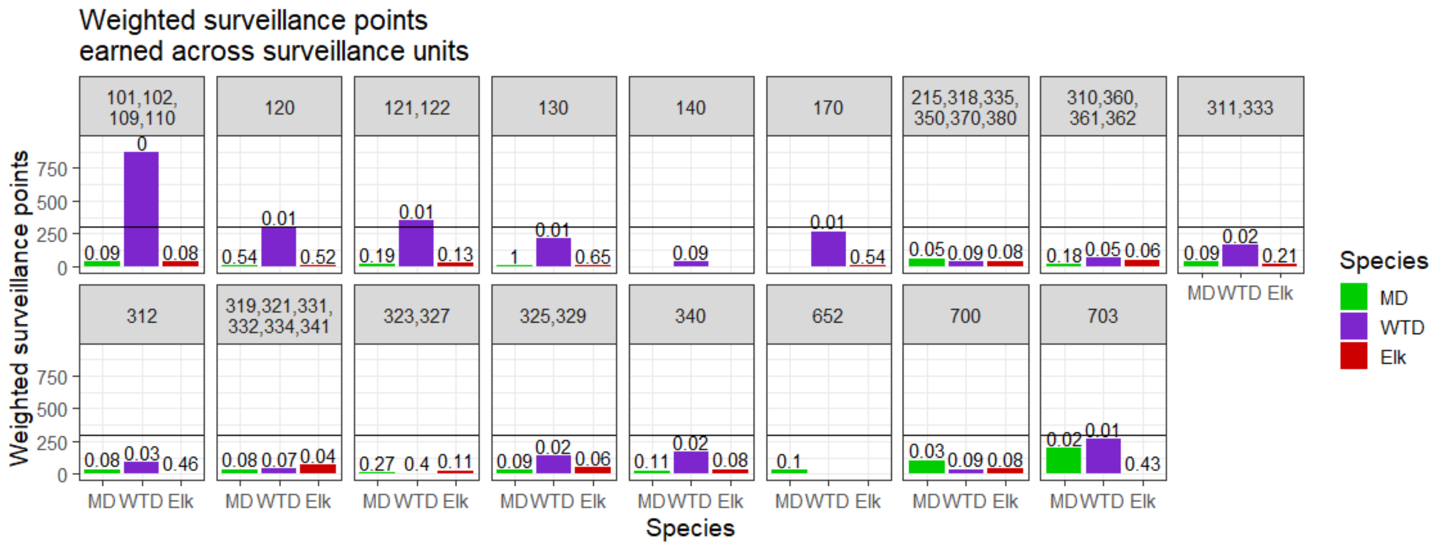


Figure A1. Weighted surveillance points earned for mule deer (MD), white-tailed deer (WTD), and elk within the 2020 minimum surveillance units in Montana, using data collected from 2017-2020. Under the weighted surveillance framework, different demographic groups (age, sex, or cause of death categories) of a species are assigned different point-values based on their relative risk of being infected and summed to a total point value. Our goal was to reach 300 weighted surveillance points in mule deer and/or white-tailed deer to detect ≥ 1% prevalence with 95% confidence. Above each bar, we have displayed the threshold prevalence, above which we would expect to detect at least 1 positive if the disease were present, given the number of surveillance points earned.

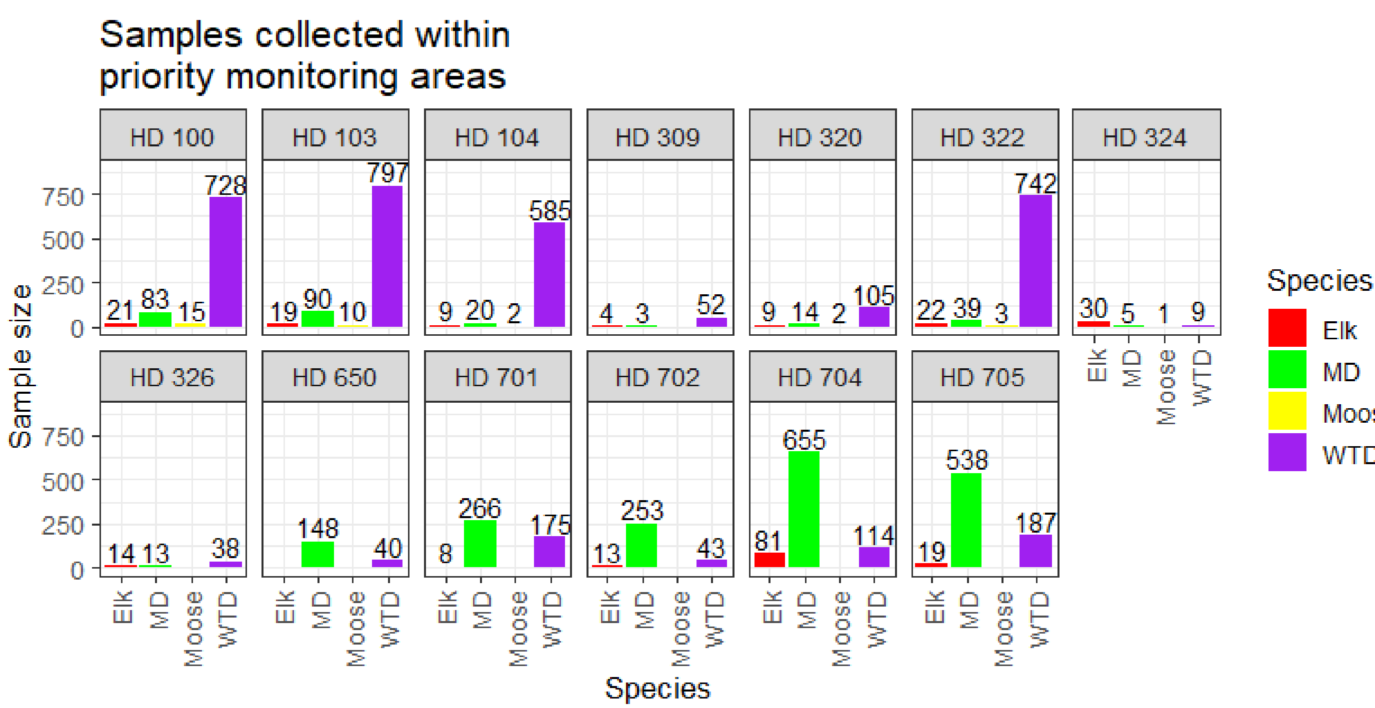


Figure A2. Samples collected from mule deer (MD), white-tailed deer (WTD), elk, and moose within the 2020 priority monitoring areas in Montana, using data collected from 2017-2020. We are typically aiming for at least 200 samples distributed across the population, to achieve a prevalence estimate with a margin of error ≤3%. Above each bar, we have displayed the total number of individuals sampled.

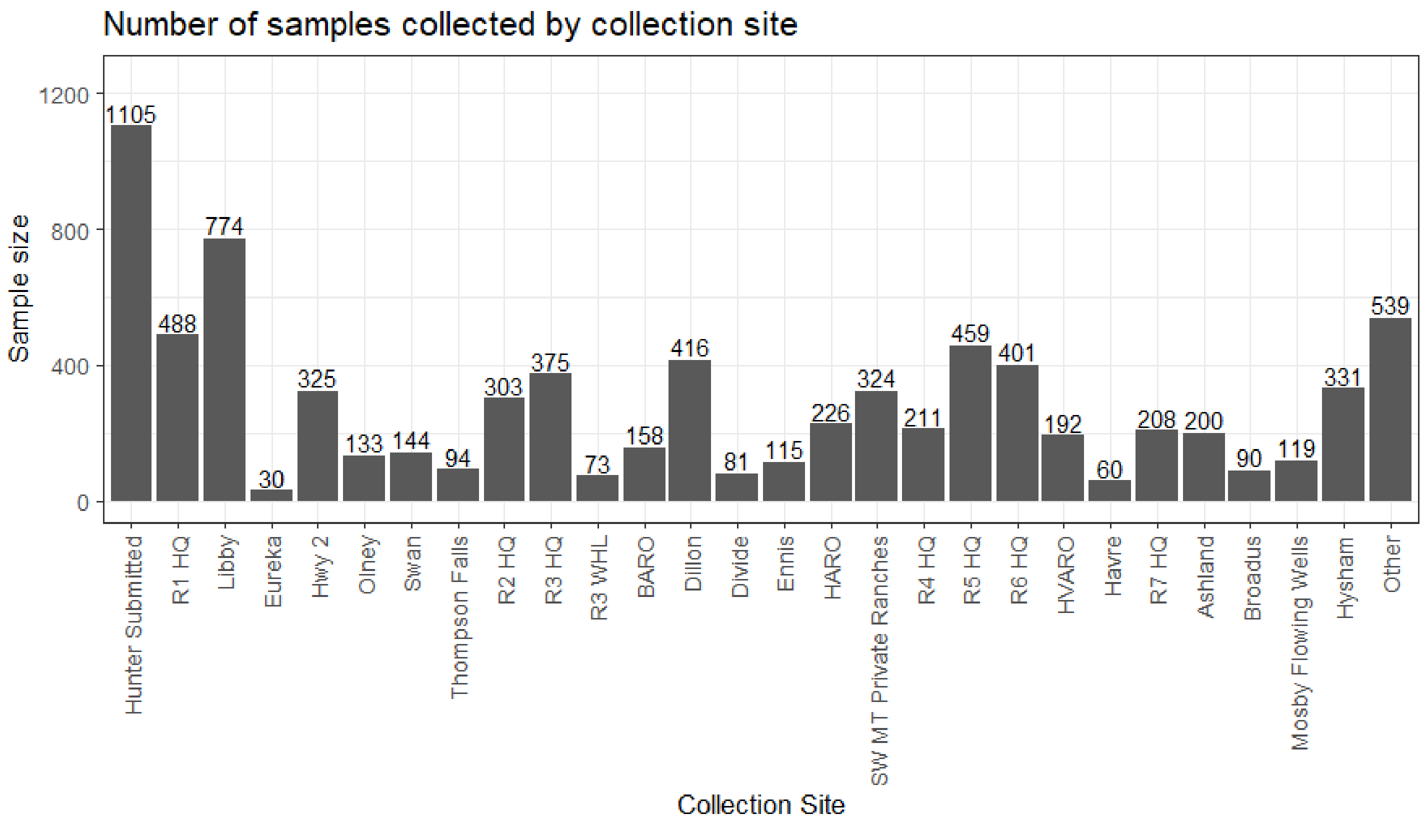


Figure A3. Number of samples collected at various CWD sampling locations around the state during the 2020 hunting season. "Hunter submitted" is the number of samples collected and submitted by hunters. "HQ" and "CS" stand for headquarters and check station, respectively. "R3 WHL" stands for the Region 3 Wildlife Health Lab. "HVARO" stands for Havre Area Resource Office.

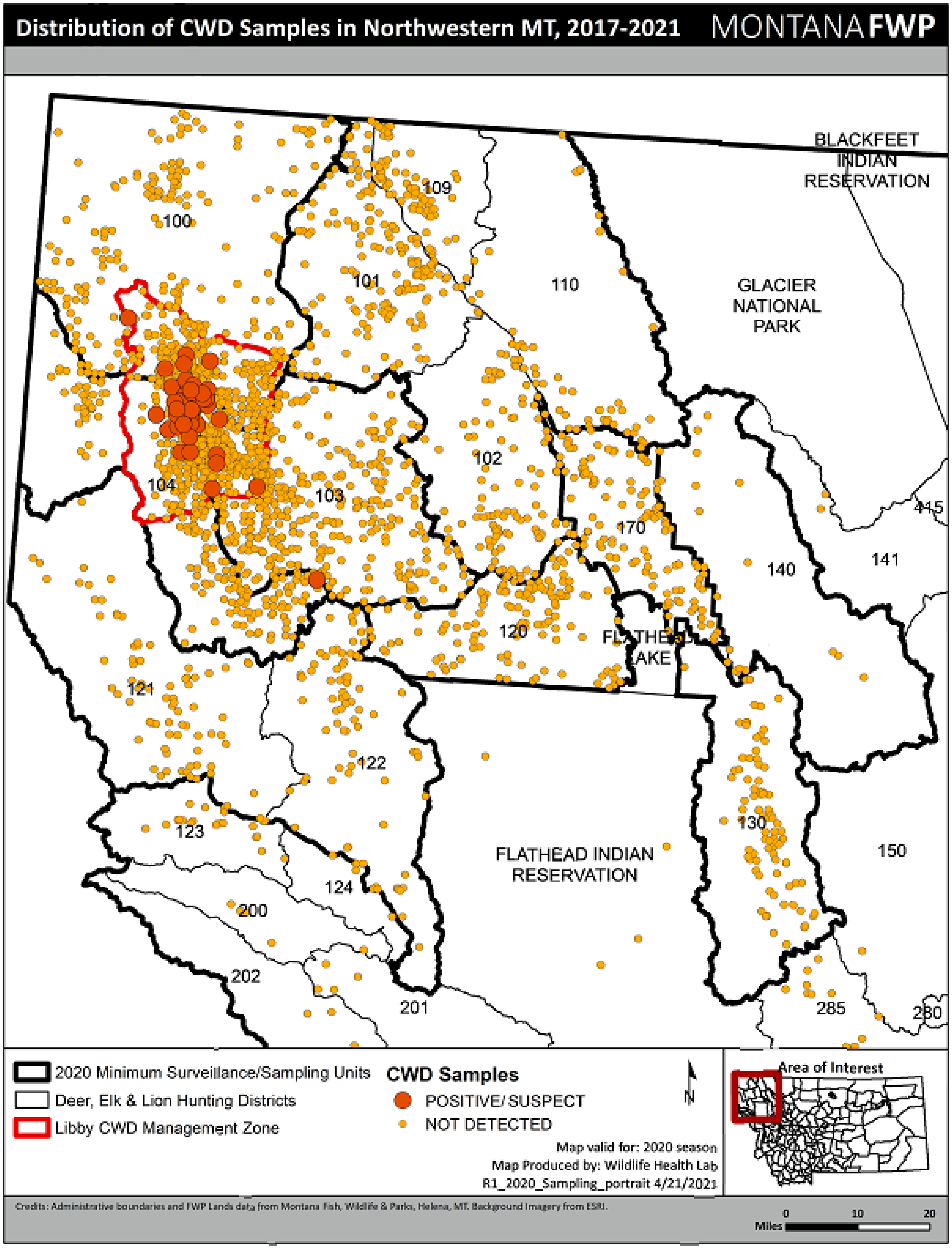


Figure A4. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in Northwestern Montana from 2017-2021.

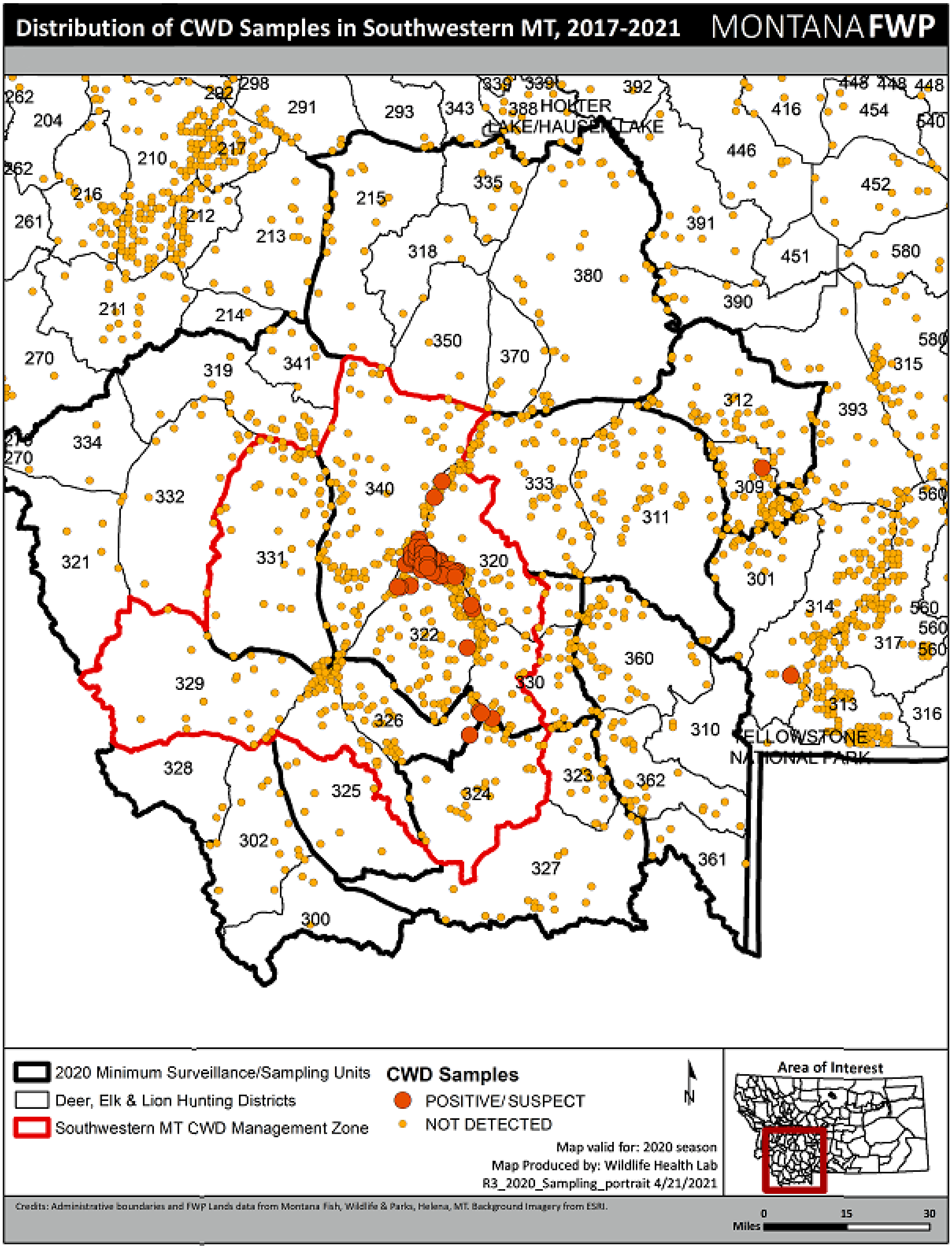


Figure A5. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in Southwestern Montana from 2017-2021.

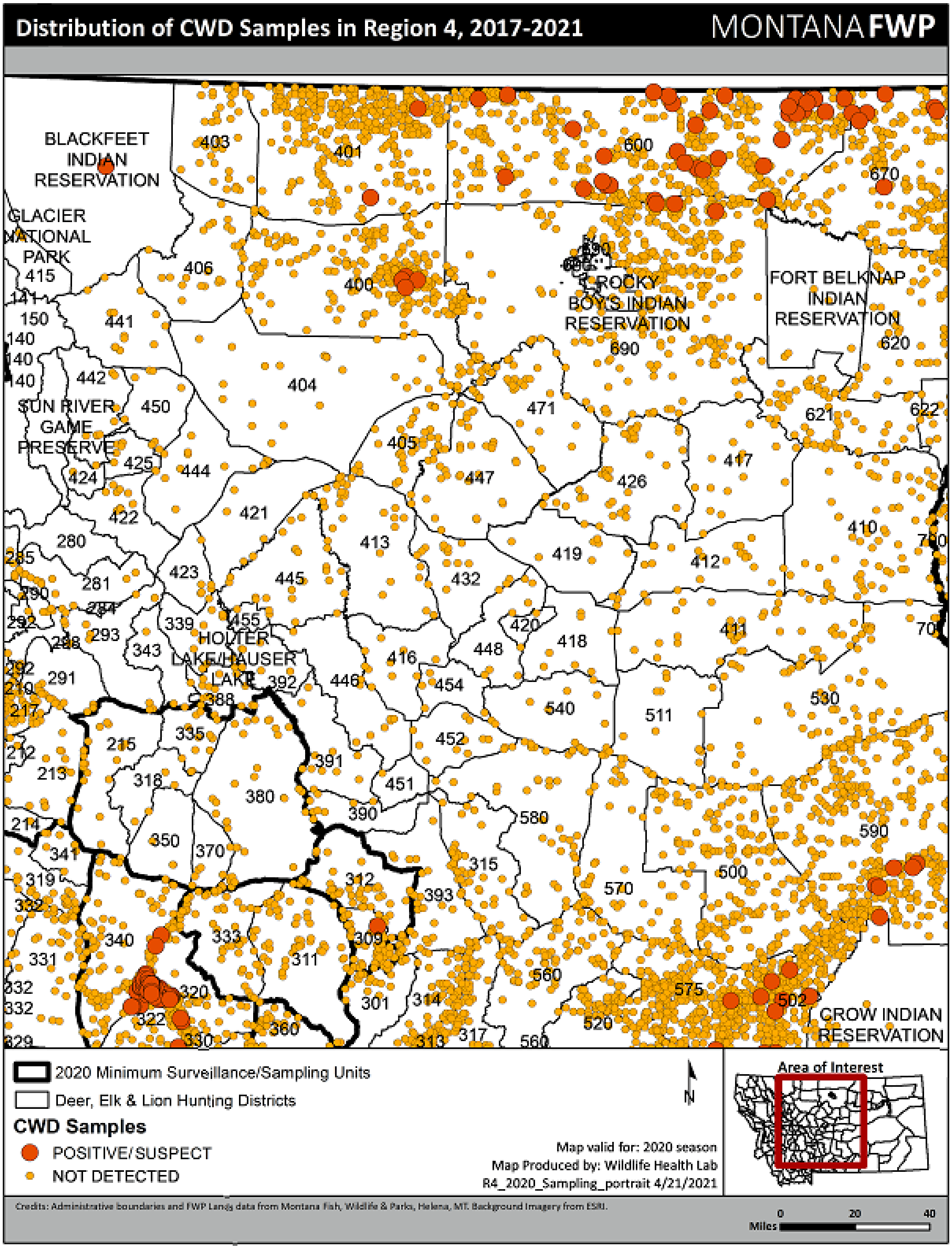


Figure A6. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in FWP Administrative Region 4 from 2017-2021.

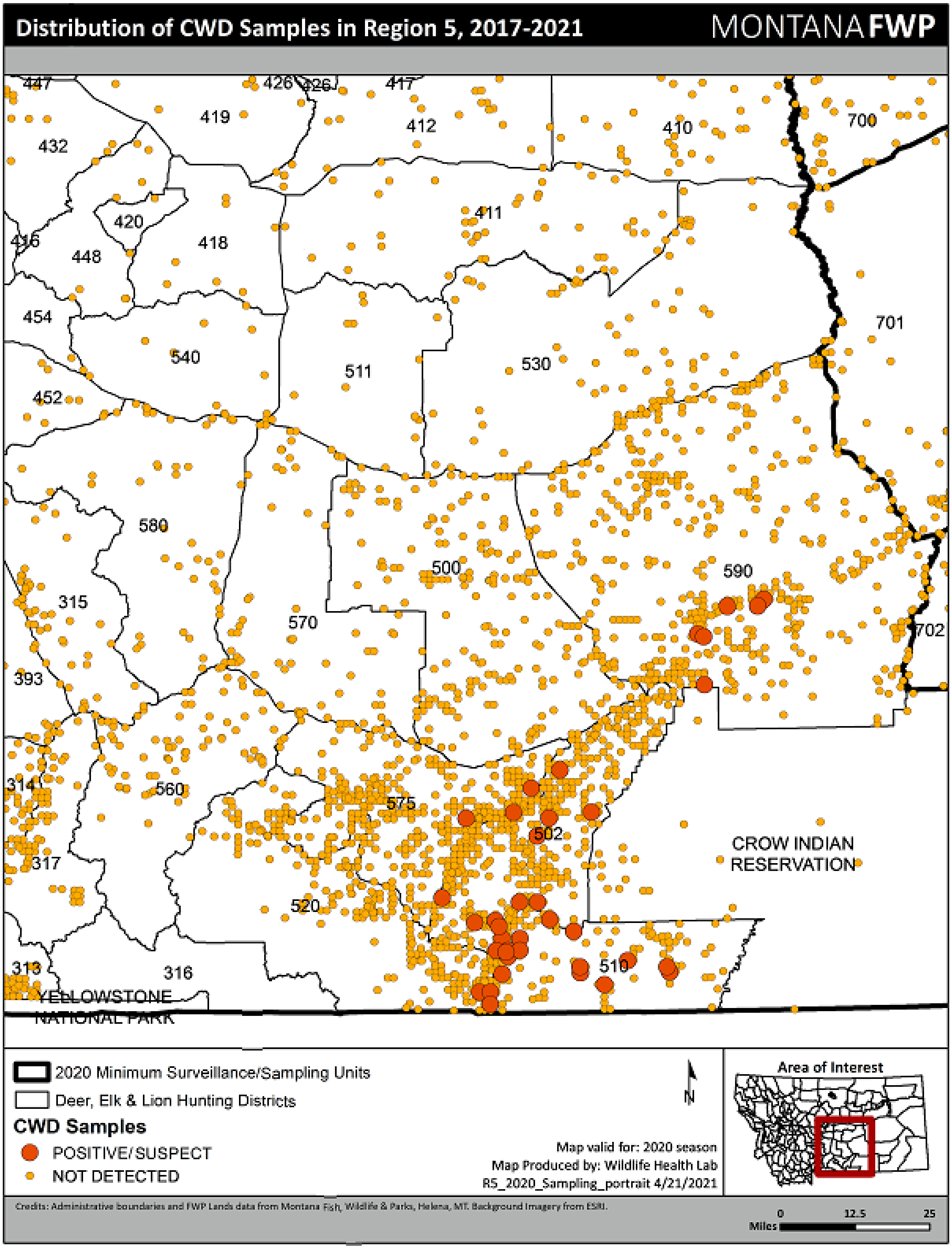


Figure A7. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in FWP Administrative Region 5 from 2017-2021.

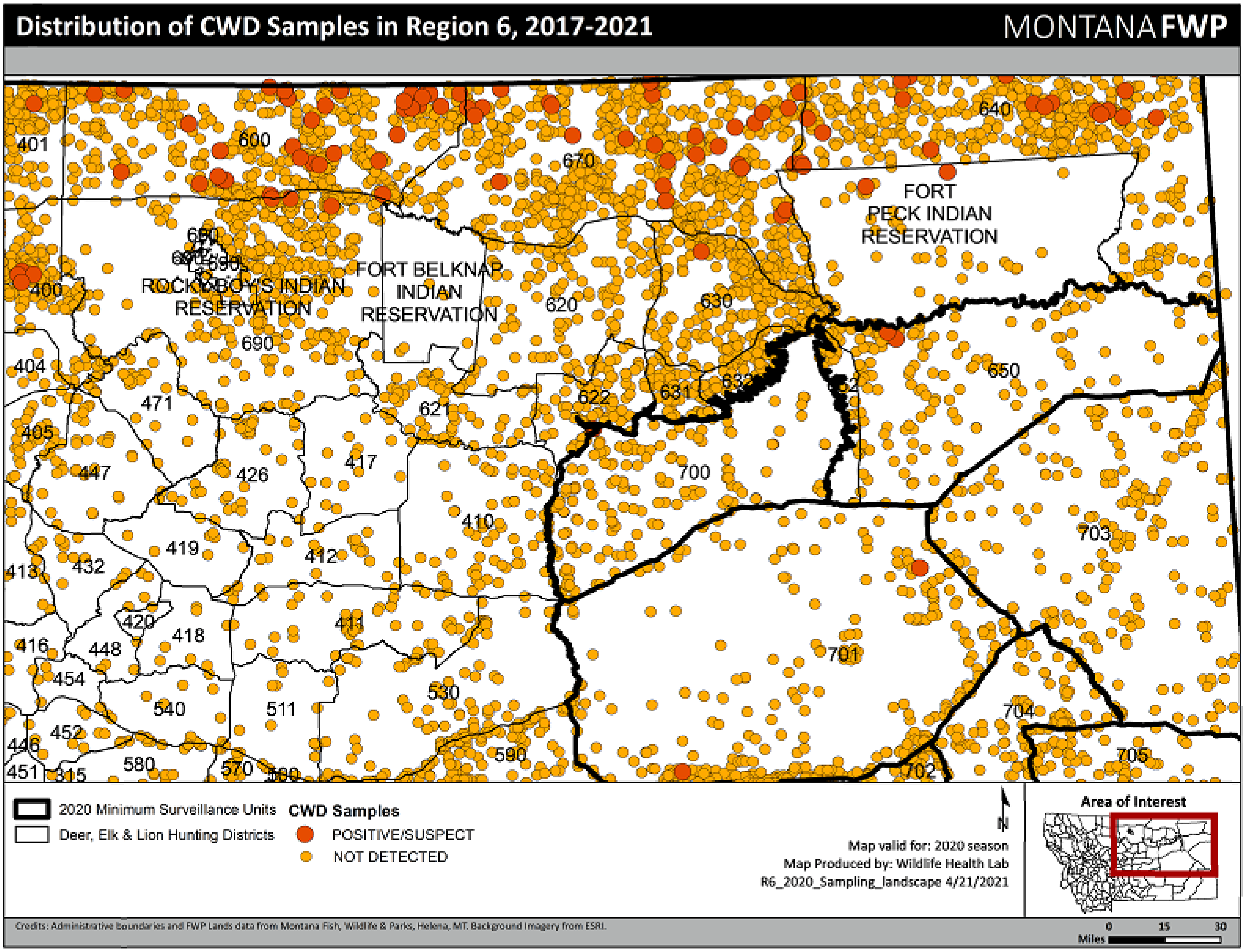


Figure A8. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in FWP Administrative Region 6 from 2017-2021.

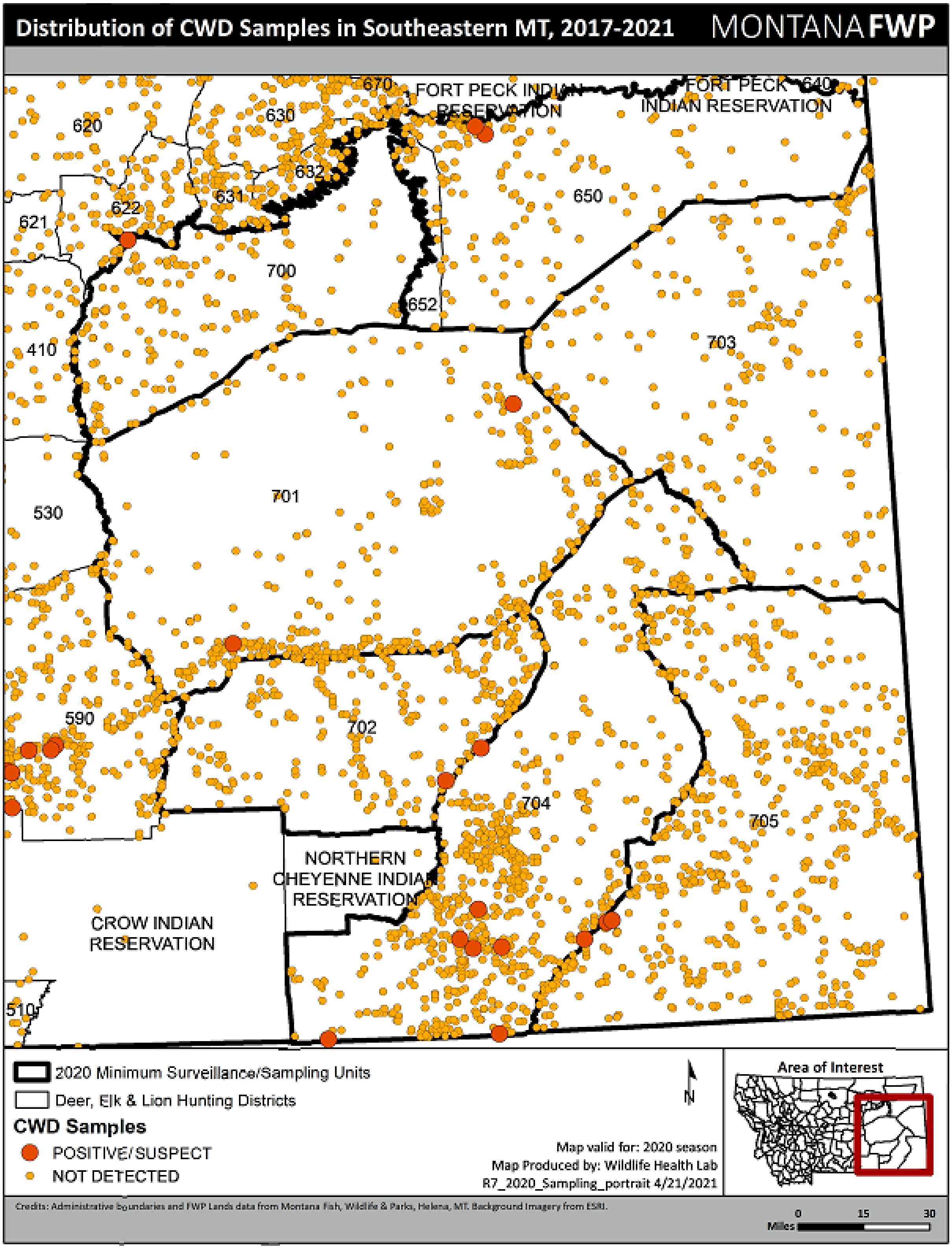


Figure A9. Map of sampling locations and positive/suspect white-tailed deer, mule deer, elk, and moose in Southeastern Montana from 2017-2021.

Appendix II. Table of estimated CWD prevalence by hunting district (HD) and species, using data from 2017-2021 from hunter-harvested or agency removed (i.e. in Libby) animals. The lower (LB) and upper (UB) 95% confidence intervals are provided along with sample size (N) and total number of positives by species in each HD.

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
100	MD	80	2	0.03	0.01	0.09
100	WTD	695	45	0.06	0.05	0.09
100	Elk	20	0	0.00	0	0.16
100	Moose	12	1	0.08	0.01	0.35
101	MD	11	0	0.00	0	0.26
101	WTD	146	0	0.00	0	0.03
101	Elk	6	0	0.00	0	0.39
101	Moose	1	0	0.00	0	0.79
102	MD	7	0	0.00	0	0.35
102	WTD	97	0	0.00	0	0.04
102	Elk	3	0	0.00	0	0.56
102	Moose	2	0	0.00	0	0.66
103	MD	86	0	0.00	0	0.04
103	WTD	755	8	0.01	0.01	0.02
103	Elk	19	0	0.00	0	0.17
103	Moose	8	1	0.13	0.02	0.47
104	MD	20	0	0.00	0	0.16
104	WTD	532	29	0.05	0.04	0.08
104	Elk	8	0	0.00	0	0.32
104	Moose	1	0	0.00	0	0.79
109	MD	14	0	0.00	0	0.22
109	WTD	55	0	0.00	0	0.07
109	Elk	4	0	0.00	0	0.49
110	MD	2	0	0.00	0	0.66
110	WTD	32	0	0.00	0	0.11
110	Elk	3	0	0.00	0	0.56
110	Moose	2	0	0.00	0	0.66
120	MD	6	0	0.00	0	0.39
120	WTD	125	0	0.00	0	0.03
120	Elk	5	0	0.00	0	0.43
120	Moose	1	0	0.00	0	0.79
121	MD	7	0	0.00	0	0.35
121	WTD	62	0	0.00	0	0.06
121	Elk	19	0	0.00	0	0.17
122	MD	7	0	0.00	0	0.35
122	WTD	68	0	0.00	0	0.05
122	Elk	5	0	0.00	0	0.43
122	Moose	2	0	0.00	0	0.66

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
123	MD	1	0	0.00	0	0.79
123	WTD	11	0	0.00	0	0.26
123	Elk	7	0	0.00	0	0.35
124	WTD	1	0	0.00	0	0.79
124	Elk	4	0	0.00	0	0.49
130	MD	4	0	0.00	0	0.49
130	WTD	94	0	0.00	0	0.04
130	Elk	4	0	0.00	0	0.49
140	WTD	16	0	0.00	0	0.19
140	Elk	3	0	0.00	0	0.56
140	Moose	1	0	0.00	0	0.79
141	WTD	1	0	0.00	0	0.79
150	WTD	1	0	0.00	0	0.79
170	WTD	89	0	0.00	0	0.04
170	Elk	5	0	0.00	0	0.43
200	WTD	5	0	0.00	0	0.43
201	MD	2	0	0.00	0	0.66
201	WTD	17	0	0.00	0	0.18
201	Elk	4	0	0.00	0	0.49
202	MD	2	0	0.00	0	0.66
202	WTD	9	0	0.00	0	0.3
203	MD	3	0	0.00	0	0.56
203	WTD	3	0	0.00	0	0.56
203	Elk	2	0	0.00	0	0.66
204	MD	1	0	0.00	0	0.79
204	WTD	10	0	0.00	0	0.28
204	Elk	8	0	0.00	0	0.32
210	MD	27	0	0.00	0	0.12
210	WTD	72	0	0.00	0	0.05
210	Elk	37	0	0.00	0	0.09
211	MD	5	0	0.00	0	0.43
211	WTD	6	0	0.00	0	0.39
211	Elk	8	0	0.00	0	0.32
212	MD	18	0	0.00	0	0.18
212	WTD	11	0	0.00	0	0.26
212	Elk	9	0	0.00	0	0.3
213	MD	5	0	0.00	0	0.43
213	WTD	6	0	0.00	0	0.39
213	Elk	12	0	0.00	0	0.24
214	WTD	1	0	0.00	0	0.79
215	MD	5	0	0.00	0	0.43
215	WTD	2	0	0.00	0	0.66
215	Elk	10	0	0.00	0	0.28

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
216	MD	11	0	0.00	0	0.26
216	WTD	14	0	0.00	0	0.22
216	Elk	3	0	0.00	0	0.56
216	Moose	1	0	0.00	0	0.79
217	MD	18	0	0.00	0	0.18
217	WTD	30	0	0.00	0	0.11
217	Elk	14	0	0.00	0	0.22
240	MD	1	0	0.00	0	0.79
240	WTD	5	0	0.00	0	0.43
240	Elk	3	0	0.00	0	0.56
250	WTD	1	0	0.00	0	0.79
260	WTD	3	0	0.00	0	0.56
261	WTD	1	0	0.00	0	0.79
261	Elk	1	0	0.00	0	0.79
262	MD	3	0	0.00	0	0.56
262	WTD	4	0	0.00	0	0.49
262	Elk	1	0	0.00	0	0.79
270	MD	7	0	0.00	0	0.35
270	WTD	3	0	0.00	0	0.56
270	Elk	4	0	0.00	0	0.49
281	MD	3	0	0.00	0	0.56
281	WTD	8	0	0.00	0	0.32
281	Elk	2	0	0.00	0	0.66
283	MD	2	0	0.00	0	0.66
283	WTD	11	0	0.00	0	0.26
283	Elk	1	0	0.00	0	0.79
285	MD	6	0	0.00	0	0.39
285	WTD	27	0	0.00	0	0.12
285	Elk	4	0	0.00	0	0.49
290	WTD	4	0	0.00	0	0.49
290	Elk	1	0	0.00	0	0.79
291	MD	8	0	0.00	0	0.32
291	Elk	1	0	0.00	0	0.79
292	MD	5	0	0.00	0	0.43
292	WTD	26	0	0.00	0	0.13
292	Elk	2	0	0.00	0	0.66
293	MD	7	0	0.00	0	0.35
293	WTD	3	0	0.00	0	0.56
293	Elk	2	0	0.00	0	0.66
298	WTD	5	0	0.00	0	0.43
298	Elk	2	0	0.00	0	0.66
300	Elk	3	0	0.00	0	0.56
301	MD	5	0	0.00	0	0.43

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
301	WTD	17	0	0.00	0	0.18
301	Elk	3	0	0.00	0	0.56
301	Moose	1	0	0.00	0	0.79
302	MD	11	0	0.00	0	0.26
302	WTD	1	0	0.00	0	0.79
302	Elk	4	0	0.00	0	0.49
302	Moose	1	0	0.00	0	0.79
309	WTD	37	0	0.00	0	0.09
309	Elk	4	0	0.00	0	0.49
310	Elk	2	0	0.00	0	0.66
311	MD	15	0	0.00	0	0.2
311	WTD	30	0	0.00	0	0.11
311	Elk	15	0	0.00	0	0.2
312	MD	11	0	0.00	0	0.26
312	WTD	36	0	0.00	0	0.1
312	Elk	6	0	0.00	0	0.39
312	Moose	1	0	0.00	0	0.79
313	MD	61	0	0.00	0	0.06
313	WTD	3	0	0.00	0	0.56
313	Elk	37	0	0.00	0	0.09
314	MD	29	1	0.03	0.01	0.17
314	WTD	26	0	0.00	0	0.13
314	Elk	30	0	0.00	0	0.11
315	MD	21	0	0.00	0	0.15
315	WTD	26	0	0.00	0	0.13
315	Elk	6	0	0.00	0	0.39
317	MD	31	0	0.00	0	0.11
317	WTD	27	0	0.00	0	0.12
317	Elk	12	0	0.00	0	0.24
318	Elk	4	0	0.00	0	0.49
319	MD	11	0	0.00	0	0.26
319	WTD	2	0	0.00	0	0.66
319	Elk	19	0	0.00	0	0.17
319	Moose	1	0	0.00	0	0.79
320	MD	13	0	0.00	0	0.23
320	WTD	102	3	0.03	0.01	0.08
320	Elk	7	0	0.00	0	0.35
321	Elk	2	0	0.00	0	0.66
321	Moose	2	0	0.00	0	0.66
322	MD	38	0	0.00	0	0.09
322	WTD	729	181	0.25	0.22	0.28
322	Elk	22	0	0.00	0	0.15
322	Moose	1	0	0.00	0	0.79

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
323	MD	6	0	0.00	0	0.39
323	WTD	2	0	0.00	0	0.66
323	Elk	16	0	0.00	0	0.19
324	MD	4	0	0.00	0	0.49
324	WTD	9	1	0.11	0.02	0.43
324	Elk	30	0	0.00	0	0.11
325	MD	15	0	0.00	0	0.2
325	WTD	41	0	0.00	0	0.09
325	Elk	10	0	0.00	0	0.28
326	MD	11	0	0.00	0	0.26
326	WTD	38	2	0.05	0.01	0.17
326	Elk	14	0	0.00	0	0.22
327	MD	5	0	0.00	0	0.43
327	WTD	2	0	0.00	0	0.66
327	Elk	12	0	0.00	0	0.24
327	Moose	2	0	0.00	0	0.66
328	MD	1	0	0.00	0	0.79
328	Elk	1	0	0.00	0	0.79
329	MD	9	0	0.00	0	0.3
329	WTD	6	0	0.00	0	0.39
329	Elk	5	0	0.00	0	0.43
330	MD	15	0	0.00	0	0.2
330	WTD	27	0	0.00	0	0.12
330	Elk	9	0	0.00	0	0.3
330	Moose	1	0	0.00	0	0.79
331	MD	21	0	0.00	0	0.15
331	WTD	22	0	0.00	0	0.15
331	Elk	14	0	0.00	0	0.22
332	MD	5	0	0.00	0	0.43
332	WTD	1	0	0.00	0	0.79
332	Elk	13	0	0.00	0	0.23
332	Moose	1	0	0.00	0	0.79
333	MD	14	0	0.00	0	0.22
333	WTD	56	0	0.00	0	0.06
333	Elk	4	0	0.00	0	0.49
334	Elk	3	0	0.00	0	0.56
334	Moose	1	0	0.00	0	0.79
335	MD	11	0	0.00	0	0.26
335	WTD	2	0	0.00	0	0.66
335	Elk	3	0	0.00	0	0.56
339	MD	11	0	0.00	0	0.26
339	WTD	3	0	0.00	0	0.56
339	Elk	2	0	0.00	0	0.66

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
340	MD	23	0	0.00	0	0.14
340	WTD	92	0	0.00	0	0.04
340	Elk	17	0	0.00	0	0.18
340	Moose	1	0	0.00	0	0.79
341	MD	1	0	0.00	0	0.79
341	WTD	3	0	0.00	0	0.56
341	Elk	3	0	0.00	0	0.56
341	Moose	1	0	0.00	0	0.79
343	MD	3	0	0.00	0	0.56
343	Elk	1	0	0.00	0	0.79
350	MD	2	0	0.00	0	0.66
350	Elk	1	0	0.00	0	0.79
360	MD	14	0	0.00	0	0.22
360	WTD	21	0	0.00	0	0.15
360	Elk	21	0	0.00	0	0.15
361	MD	1	0	0.00	0	0.79
361	Elk	2	0	0.00	0	0.66
361	Moose	1	0	0.00	0	0.79
362	MD	6	0	0.00	0	0.39
362	WTD	4	0	0.00	0	0.49
362	Elk	25	0	0.00	0	0.13
370	MD	4	0	0.00	0	0.49
370	WTD	2	0	0.00	0	0.66
380	MD	23	0	0.00	0	0.14
380	WTD	12	0	0.00	0	0.24
380	Elk	21	0	0.00	0	0.15
388	MD	4	0	0.00	0	0.49
388	WTD	6	0	0.00	0	0.39
388	Elk	2	0	0.00	0	0.66
390	MD	3	0	0.00	0	0.56
390	Elk	3	0	0.00	0	0.56
391	MD	5	0	0.00	0	0.43
391	WTD	6	0	0.00	0	0.39
391	Elk	3	0	0.00	0	0.56
392	MD	6	0	0.00	0	0.39
392	Elk	1	0	0.00	0	0.79
393	MD	19	0	0.00	0	0.17
393	WTD	12	0	0.00	0	0.24
393	Elk	8	0	0.00	0	0.32
400	MD	379	3	0.01	0	0.02
400	WTD	61	1	0.02	0	0.09
400	Elk	1	0	0.00	0	0.79
401	MD	389	1	0.003	0	0.01

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
401	WTD	199	0	0.00	0	0.02
401	Elk	54	0	0.00	0	0.07
401	Moose	1	0	0.00	0	0.79
403	MD	33	0	0.00	0	0.1
403	WTD	8	0	0.00	0	0.32
404	MD	16	0	0.00	0	0.19
404	WTD	12	0	0.00	0	0.24
405	MD	35	0	0.00	0	0.1
405	WTD	12	0	0.00	0	0.24
406	MD	19	0	0.00	0	0.17
406	WTD	15	0	0.00	0	0.2
406	Elk	2	0	0.00	0	0.66
410	MD	52	0	0.00	0	0.07
410	WTD	3	0	0.00	0	0.56
410	Elk	17	0	0.00	0	0.18
411	MD	30	0	0.00	0	0.11
411	WTD	23	0	0.00	0	0.14
411	Elk	7	0	0.00	0	0.35
412	MD	10	0	0.00	0	0.28
412	WTD	8	0	0.00	0	0.32
412	Elk	11	0	0.00	0	0.26
413	MD	16	0	0.00	0	0.19
413	WTD	17	0	0.00	0	0.18
413	Elk	2	0	0.00	0	0.66
415	MD	1	0	0.00	0	0.79
415	Elk	1	0	0.00	0	0.79
416	MD	4	0	0.00	0	0.49
416	WTD	2	0	0.00	0	0.66
416	Elk	4	0	0.00	0	0.49
417	MD	8	0	0.00	0	0.32
417	Elk	11	0	0.00	0	0.26
418	MD	6	0	0.00	0	0.39
418	WTD	4	0	0.00	0	0.49
419	MD	7	0	0.00	0	0.35
419	WTD	3	0	0.00	0	0.56
420	MD	1	0	0.00	0	0.79
421	MD	3	0	0.00	0	0.56
421	WTD	1	0	0.00	0	0.79
422	MD	1	0	0.00	0	0.79
422	WTD	5	0	0.00	0	0.43
422	Elk	2	0	0.00	0	0.66
423	MD	7	0	0.00	0	0.35
425	MD	2	0	0.00	0	0.66

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
425	WTD	4	0	0.00	0	0.49
426	MD	42	0	0.00	0	0.08
426	WTD	2	0	0.00	0	0.66
426	Elk	1	0	0.00	0	0.79
432	MD	8	0	0.00	0	0.32
432	WTD	7	0	0.00	0	0.35
432	Elk	1	0	0.00	0	0.79
441	MD	5	0	0.00	0	0.43
441	WTD	5	0	0.00	0	0.43
441	Elk	3	0	0.00	0	0.56
442	MD	3	0	0.00	0	0.56
442	WTD	4	0	0.00	0	0.49
442	Elk	2	0	0.00	0	0.66
444	MD	2	0	0.00	0	0.66
444	WTD	13	0	0.00	0	0.23
445	MD	15	0	0.00	0	0.2
445	WTD	15	0	0.00	0	0.2
445	Elk	6	0	0.00	0	0.39
446	MD	2	0	0.00	0	0.66
446	WTD	5	0	0.00	0	0.43
446	Elk	1	0	0.00	0	0.79
446	Moose	1	0	0.00	0	0.79
447	MD	23	0	0.00	0	0.14
447	WTD	14	0	0.00	0	0.22
447	Elk	2	0	0.00	0	0.66
448	MD	4	0	0.00	0	0.49
448	WTD	3	0	0.00	0	0.56
448	Elk	2	0	0.00	0	0.66
450	MD	3	0	0.00	0	0.56
450	WTD	2	0	0.00	0	0.66
450	Elk	3	0	0.00	0	0.56
451	MD	1	0	0.00	0	0.79
452	MD	5	0	0.00	0	0.43
452	WTD	9	0	0.00	0	0.3
452	Elk	2	0	0.00	0	0.66
454	WTD	1	0	0.00	0	0.79
454	Elk	3	0	0.00	0	0.56
455	MD	1	0	0.00	0	0.79
471	MD	25	0	0.00	0	0.13
471	Elk	1	0	0.00	0	0.79
500	MD	202	0	0.00	0	0.02
500	WTD	19	0	0.00	0	0.17
500	Elk	7	0	0.00	0	0.35

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
502	MD	417	8	0.02	0.01	0.04
502	WTD	260	5	0.02	0.01	0.04
502	Elk	16	1	0.06	0.01	0.28
510	MD	190	13	0.07	0.04	0.11
510	WTD	27	1	0.04	0.01	0.18
511	MD	8	0	0.00	0	0.32
511	WTD	4	0	0.00	0	0.49
511	Elk	1	0	0.00	0	0.79
520	MD	158	0	0.00	0	0.02
520	WTD	167	1	0.01	0	0.03
520	Elk	42	0	0.00	0	0.08
520	Moose	3	0	0.00	0	0.56
530	MD	65	0	0.00	0	0.06
530	WTD	22	0	0.00	0	0.15
530	Elk	3	0	0.00	0	0.56
540	MD	3	0	0.00	0	0.56
540	WTD	10	0	0.00	0	0.28
540	Elk	3	0	0.00	0	0.56
560	MD	46	0	0.00	0	0.08
560	WTD	31	0	0.00	0	0.11
560	Elk	12	0	0.00	0	0.24
570	MD	44	0	0.00	0	0.08
570	WTD	23	0	0.00	0	0.14
570	Elk	3	0	0.00	0	0.56
575	MD	400	2	0.01	0	0.02
575	WTD	211	0	0.00	0	0.02
575	Elk	13	0	0.00	0	0.23
580	MD	10	0	0.00	0	0.28
580	WTD	22	0	0.00	0	0.15
580	Elk	14	0	0.00	0	0.22
590	MD	416	0	0.00	0	0.01
590	WTD	177	6	0.03	0.02	0.07
590	Elk	31	0	0.00	0	0.11
600	MD	616	32	0.05	0.04	0.07
600	WTD	143	5	0.03	0.02	0.08
600	Elk	5	0	0.00	0	0.43
620	MD	138	0	0.00	0	0.03
620	WTD	30	0	0.00	0	0.11
620	Elk	3	0	0.00	0	0.56
621	MD	51	0	0.00	0	0.07
621	WTD	5	0	0.00	0	0.43
621	Elk	12	0	0.00	0	0.24
622	MD	60	1	0.02	0	0.09

HD	Species	N	Positives/ Suspects	Prevalence	LB 95%CI	UB 95%CI
622	WTD	2	0	0.00	0	0.66
622	Elk	20	0	0.00	0	0.16
630	MD	250	1	0.004	0	0.02
630	WTD	132	0	0.00	0	0.03
630	Moose	1	0	0.00	0	0.79
631	MD	56	0	0.00	0	0.06
631	WTD	1	0	0.00	0	0.79
631	Elk	8	0	0.00	0	0.32
632	MD	62	0	0.00	0	0.06
632	Elk	3	0	0.00	0	0.56
640	MD	525	20	0.04	0.02	0.06
640	WTD	196	1	0.01	0	0.03
640	Elk	1	0	0.00	0	0.79
650	MD	145	2	0.01	0	0.05
650	WTD	39	0	0.00	0	0.09
652	MD	23	0	0.00	0	0.14
652	WTD	2	0	0.00	0	0.66
670	MD	938	26	0.03	0.02	0.04
670	WTD	185	2	0.01	0	0.04
670	Elk	2	0	0.00	0	0.66
690	MD	425	2	0.00	0	0.02
690	WTD	92	0	0.00	0	0.04
690	Elk	11	0	0.00	0	0.26
700	MD	114	0	0.00	0	0.03
700	WTD	15	0	0.00	0	0.2
700	Elk	37	0	0.00	0	0.09
701	MD	236	1	0.004	0	0.02
701	WTD	156	1	0.01	0	0.04
701	Elk	8	0	0.00	0	0.32
702	MD	210	0	0.00	0	0.02
702	WTD	35	1	0.03	0.01	0.15
702	Elk	12	0	0.00	0	0.24
703	MD	159	0	0.00	0	0.02
703	WTD	95	0	0.00	0	0.04
703	Elk	6	0	0.00	0	0.39
704	MD	640	6	0.01	0	0.02
704	WTD	111	2	0.02	0	0.06
704	Elk	76	0	0.00	0	0.05
705	MD	527	0	0.00	0	0.01
705	WTD	186	2	0.01	0	0.04
705	Elk	19	0	0.00	0	0.17

Appendix III.

Table A1. Logistic generalized linear mixed models used to evaluate the odds of infection as a function of species (mule deer vs. white-tailed deer), sex, age class (young of the year, yearlings, adults), and whether the animal was from the Libby or Southwestern MT CWD Management Area (ManagementArea=1) or from outside these areas (ManagementArea =0). Models are ranked from best supported to least supported. All complete deer records were included in this analysis (n=12134).

Model	AIC	Delta AIC	Relative model likelihood	AIC weight
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + ManagementArea + ManagementArea*Species + (1|HD)	2797.19	0.00	1	1
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + ManagementArea + (1|HD)	2822.62	25.43	0	0
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + (1|HD)	2878.92	81.73	0	0
Infected~ 1+ Species + Sex + AgeClass + (1|HD)	2893.31	96.12	0	0
Infected~ 1+ Species + Sex + Species*Sex + (1|HD)	2913.22	116.03	0	0
Infected~ 1+ Species + Sex + (1|HD)	2929.60	132.41	0	0
Infected~ 1+ Species + (1|HD)	2937.90	140.70	0	0

Table A2. Logistic Generalized Linear Mixed Models used to evaluate the odds of infection for deer as a function of species, sex, age class, and timing of harvest (pre-rut vs. rut/post-rut), whether the animal was from the Libby or Southwestern MT CWD Management Area (ManagementArea=1) or from outside these areas (ManagementArea =0). Models are ranked from best supported to least supported. All complete deer records from the general rifle season were included in this analysis (October 15-December 5; n=10791).

Model	AIC	Delta AIC	Relative model likelihood	AIC weight
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + ManagementArea + ManagementArea*Species + HarvestTiming + (1|HD)	2175.37	0	1	0.8
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + ManagementArea + ManagementArea*Species + (1|HD)	2178.09	2.72	0.26	0.2
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + HarvestTiming + (1|HD)	2233.12	57.75	0	0
Infected~ 1+ Species + Sex + Species*Sex + AgeClass + (1|HD)	2234.78	59.41	0	0
Infected~ 1+ Species + Sex + Species*Sex + HarvestTiming + (1|HD)	2262.09	86.72	0	0
Infected~ 1+ Species + Sex + Species*Sex + HarvestTiming + Sex* HarvestTiming + (1|HD)	2263.81	88.44	0	0
Infected~ 1+ Species + Sex + Species*Sex + (1|HD)	2264	88.63	0	0
Infected~ 1+ Species + Sex + Species*Sex + HarvestTiming + Species* HarvestTiming + (1|HD)	2264.09	88.72	0	0
Infected~ 1+ Species + Sex + (1|HD)	2276.13	100.77	0	0
Infected~ 1+ Species + (1|HD)	2287.85	112.48	0	0

Literature Cited

Almberg, E.S., Cross, P.C., Johnson, C.J., Heisey, D.M. and Richards, B.J., 2011. Modeling routes of chronic wasting disease transmission: environmental prion persistence promotes deer population decline and extinction. *PloS one*, *6*(5), p.e19896.

Czub, S., Schulz-Schaeffer, W., Stahl-Hennig, C., Beekes, M., Schaetzl, H., and Motzkus, D. 2017. First evidence of intracranial and peroral transmission of Chronic Wasting Disease (CWD) into Cynomolgus macaques: a work in progress. Presentation at the PRION 2017 Conference, Edenborough, Scotland. https://www.youtube.com/embed/Vtt1kAVDhDQ.

DeVivo, M.T., 2015. *Chronic wasting disease ecology and epidemiology of mule deer in Wyoming*. Ph.D., Department of Veterinary Sciences, University of Wyoming.

Edmunds, D., Kauffman, M., Schumaker, B., Lindzey, F., Cook, W., Kreeger, T., Grogan, R., and Cornish, T., 2016. Chronic Wasting Disease Drives Population Decline of White-Tailed Deer. *PLOS ONE*. 11 (8): e0161127 DOI: 10.1371/journal.pone.0161127

Grant, R.L., 2014. Converting an odds ratio to a range of plausible relative risks for better communication of research findings. *BMJ*, *348*, p.f7450.

Grear, D.A., Samuel, M.D., Langenberg, J.A. and Keane, D., 2006. Demographic patterns and harvest vulnerability of chronic wasting disease infected white-tailed deer in Wisconsin. *The Journal of Wildlife Management*, *70*(2), pp.546-553.

Gross, J.E. and Miller, M.W., 2001. Chronic wasting disease in mule deer: disease dynamics and control. *The Journal of Wildlife Management*, pp.205-215.

Hibler, C.P., Wilson, K.L., Spraker, T.R., Miller, M.W., Zink, R.R., DeBuse, L.L., Andersen, E., Schweitzer, D., Kennedy, J.A., Baeten, L.A. and Smeltzer, J.F. 2003. Field validation and assessment of an enzyme-linked immunosorbent assay for detecting chronic wasting disease in mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and Rocky Mountain elk (*Cervus elaphus nelsoni*). *Journal of Veterinary Diagnostic Investigation*, *15*(4), pp.311-319.

Jennelle, C.S., Walsh, D.P., Samuel, M.D., Osnas, E.E., Rolley, R., Langenberg, J., Powers, J.G., Monello, R.J., Demarest, E.D., Gubler, R. and Heisey, D.M., 2018. Applying a Bayesian weighted surveillance approach to detect chronic wasting disease in white-tailed deer. *Journal of Applied Ecology*, *55*(6), pp.2944-2953.

Miller, M.W., Williams, E.S., McCarty, C.W., Spraker, T.R., Kreeger, T.J., Larsen, C.T. and Thorne, E.T., 2000. Epizootiology of chronic wasting disease in free-ranging cervids in Colorado and Wyoming. *Journal of Wildlife Diseases*, *36*(4), pp.676-690.

Miller, M.W., Swanson, H.M., Wolfe, L.L., Quartarone, F.G., Huwer, S.L., Southwick, C.H. and Lukacs, P.M., 2008. Lions and prions and deer demise. *PLoS one*, *3*(12), p.e4019.

Nobert, B.R., Merrill, E.H., Pybus, M.J., Bollinger, T.K. and Hwang, Y.T., 2016. Landscape connectivity predicts chronic wasting disease risk in Canada. *Journal of applied ecology*, *53*(5), pp.1450-1459.

R Core Development Team 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Russell, R.E., J.A. Gude, N.J. Anderson and Ramsey, J.M., 2015. Identifying priority chronic wasting disease surveillance areas for mule deer in Montana. *Journal of Wildlife Management* 79(6): 989-997.

Walsh, D.P., ed., 2012. Enhanced surveillance strategies for detecting and monitoring chronic wasting disease in free-ranging cervids: U.S. Geological Survey Open-File Report 2012– 1036, pp. 42.

Walsh, D.P. and Otis, D.L., 2012. Disease surveillance: Incorporating available information to enhance disease-detection efforts, In: Enhanced surveillance strategies for detecting and monitoring chronic wasting disease in free-ranging cervids: U.S. Geological Survey Open- File Report 2012–1036, pp. 11-23.

Wasserberg, G., Osnas, E.E., Rolley, R.E. and Samuel, M.D., 2009. Host culling as an adaptive management tool for chronic wasting disease in white-tailed deer: a modelling study. *Journal of Applied Ecology*, *46*(2), pp.457-466.

Western Association of Fish and Wildlife Agencies. 2017. Recommendations for Adaptive Management of Chronic Wasting Disease in the West. WAFWA Wildlife Health Committee and Mule Deer Working Group. Edmonton, Canada and Fort Collins, USA.