Montana Fish, Wildlife & Parks' 2018 Chronic Wasting Disease Surveillance Report

Federal Aid in Wildlife Restoration Grant W-171-M

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AGENCY:	***Fish, Wildlife & Parks***
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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 the fall of 2018, FWP focused its CWD sampling efforts along the central Hi-Line (Hunting Districts (HDs) 400, 401, 403, 600, 611), eastern Hi-Line (HDs 620, 630, 640, and 670), around Philipsburg (HDs 210, 212, 217), and south of Billings in the Carbon County CWD Positive Area (HDs 502, 510, 520, 575). During the 2018 season, FWP collected a total of 1922 samples from mule deer (n=1367), white-tailed deer (n=458), elk (n=105), and moose (n=9). Through these efforts, FWP detected 26 new cases of CWD among wild deer, including 21 cases along the northern border in every county from Liberty County east to the North Dakota border, and 5 cases within the CWD-positive area south of Billings.

Prevalence of CWD in the northern CWD-positive hunting districts (HDs 400, 401, 600, 611, 670, and 640) averaged 2% (95% CI: 1-3%) in mule deer, and 1% (95% CI: 0-3%) in white-tailed deer. Among hunting districts, prevalence varied from 2-4% among mule deer and 0-4% among white-tailed deer. South of Billings, CWD prevalence was estimated to be 2% (95% CI: 1-3%) in mule deer and 1% (95% CI: 0-3%) in white-tailed deer. There too, prevalence varied across hunting districts ranging from <1% - 6% in mule deer and 0-1% among white-tailed deer.

To date, CWD has been detected in Carbon, Liberty, Hill, Blaine, Phillips, Valley, Daniels, and Sheridan Counties. The current distribution of CWD within Montana is consistent with the natural spread of the disease from Alberta and Saskatchewan to the north, and from Wyoming to the south. Currently, Montana hunting districts that share a border with Alberta, Saskatchewan, and Wyoming where CWD has been present for some time, have higher prevalence rates of CWD compared to neighboring interior hunting districts.

In 2018, we met our surveillance goals in all areas except around Philipsburg. While we did not detect CWD around Philipsburg, we fell short of our sampling goal needed to ensure confidence that we would have detected CWD if it were present at ≥1%. We will plan to revisit the Philipsburg area for surveillance in 2019.

FWP continues to plan for long-term CWD management in positive areas. In 2019, MFWP will consolidate “CWD positive areas” and “Transport Restriction Zones” into the single moniker “CWD Management Zones,” and the southern portion of MFWP Region 7 will be included in the southern CWD Management Zone in anticipation of finding CWD positive deer in that area. CWD surveillance/monitoring during fall 2019 will be focused in southeastern MT, around Philipsburg, and along the Hi-Line.

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, 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, 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 new plan outlines a strategy to efficiently use finite resources of staff and funding to maximize our ability to detect CWD in high-risk areas where it is not known to exist. This entails (1) continuing to test any symptomatic deer, elk, or moose statewide, (2) focusing systematic surveillance primarily on mule deer, which typically exhibit the highest prevalences of CWD among deer and elk, 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 (Figure 1) are defined as those areas within Montana that have both high mule deer densities and that are closest to the nearest known cases of CWD (Russell et. al 2015). In the fall of 2018, FWP conducted CWD surveillance along the central and eastern Hi-Line (northern border) and around Philipsburg (Figure 1). In addition, FWP continued monitoring CWD prevalence in the Carbon and Liberty County CWD positive areas identified in 2017.

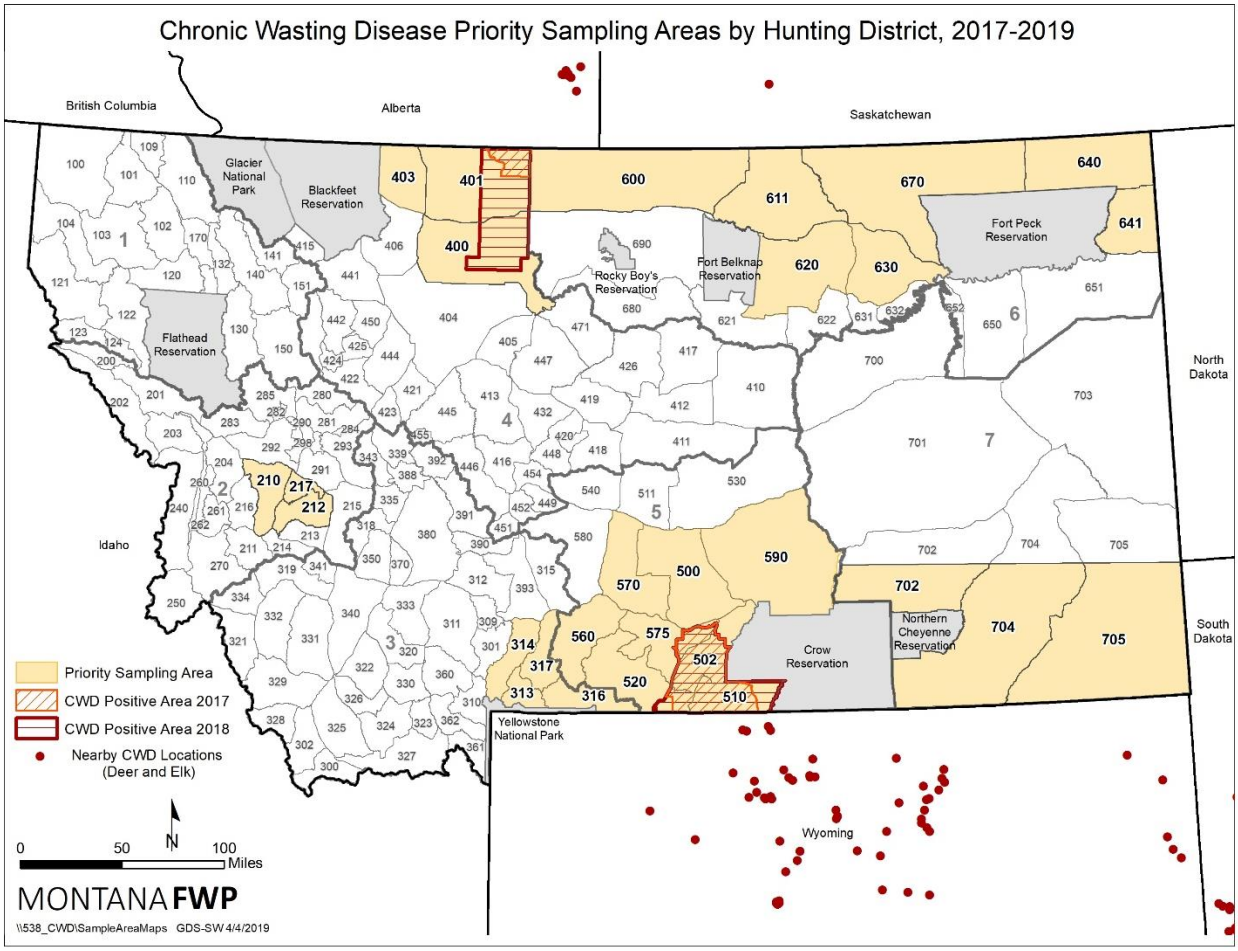

Figure 1. High priority CWD surveillance areas in Montana. Areas were based on proximity to known CWD cases (red dots) in neighboring states/provinces and mule deer densities in Montana from Russell et al. (2015). Hunting Districts 210, 212, and 217 (in west-central Montana) surround the captive elk facility that tested positive for CWD in 1999. High-priority areas will change depending on new detections of CWD in surrounding states and provinces or in Montana. Deer/elk hunting districts are displayed.

Below, we report on the results and lessons learned from the 2018 CWD surveillance effort as well as the 2017-2018 sampling efforts in the Carbon and Liberty County CWD positive areas.

Methods

Surveillance

Montana Fish, Wildlife, and Parks identified priority surveillance areas around the state that have both high mule deer densities (within the upper quartile, based on resource selection functions integrated with count data) and are within the lowest 25% of distances to the nearest known cases of CWD (Russell et. al 2015; Figure 1). In 2018, FWP focused its surveillance efforts on the Hi-Line and around Philipsburg. The priority surveillance area along the Hi-Line was divided into two minimum surveillance units, and the area around Philipsburg constituted a single minimum surveillance unit (Figure 1). Each minimum surveillance unit was defined as an aggregation of hunting districts meant to capture discrete and well-mixed population units of deer with ≤15,000 mule deer (Table 1). 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 2). A total of 300 points 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 mule deer since they appear to have the highest prevalences among the different cervid species where they overlap (Miller et al., 2000). Elk, white-tailed deer, and moose were sampled opportunistically.

Table 1. Minimum CWD surveillance units within the 2018 priority surveillance areas and estimated mule deer population sizes (2015 estimates). Continued CWD monitoring was conducted in the Carbon County CWD Positive Area.

Minimum CWD surveillance units for mule deer populations (Aggregations of hunting districts)	Estimated mule deer population size
Philipsburg: HDs 210, 212, 217	2000
Central Hi-Line: HDs 400, 401, 403, 600, 611	10500
Eastern Hi-Line: HDs 620, 630, 640, 670	12500
Carbon County CWD Positive Area: parts of HDs 510, 502, 520, 575	8500

Table 2. 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 & 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	0.001	NA

FWP staff collected samples between July 1, 2018 – December 15, 2018 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 they 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 Montana Department of Transportation, Highway Patrol, hunters at check stations, processors and taxidermists, outfitters, landowners, 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) for each cervid sampled as part of the CWD surveillance program. Field staff worked with hunters or others to gather precise location information on where the animal was harvested/found, 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 were submitted to Colorado State Veterinary Diagnostic Laboratory on a weekly basis. Testing costs ranged from $18/sample for the ELISA, and $35/sample for IHC (also used to confirm positive test results). 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, 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.

In addition to the focused sampling efforts in the 2018 priority surveillance areas, FWP collected or received a relatively small number of 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 were provided information on how to collect samples, submit them, and pay for their own testing. As part of that process, hunters had the option to sign a release allowing Colorado State University's Veterinary Diagnostic Lab to share the results with FWP.

Monitoring of prevalence and distribution within CWD Positive Areas

CWD was detected among wild deer for the first time in south-central and north-central Montana in the fall of 2017. Following these detections, FWP initiated special hunts during the winter of 2017-2018 and established transport restriction zones (TRZ) around CWD positive areas to reduce the risk of CWD positive carcasses being taken to other areas of the state. The Liberty County CWD Positive Area was further sampled as part of surveillance efforts along the Hi-Line during the fall of 2018. To improve estimates of CWD prevalence and distribution within the Carbon County CWD Positive Area, FWP continued to collect hunter-harvest samples from deer, elk and moose harvested within the positive area boundaries. Estimates of prevalence and distribution presented within this report include data from 2017-2018 for both the Liberty and Carbon County Positive Areas.

Data summaries

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),

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

to calculate our level of statistical confidence that we could detect at least one positive given our weighted surveillance points (*n*) and assuming prevalence was ≥1%:

$$\alpha = -e^{-Pn} + 1.$$

Following detection, prevalence among hunter-harvested animals was summarized by species, age, and sex classes by hunting district and by CWD Positive Area. We calculated 95% binomial confidence intervals using the Wilson method.

Results

Between July 1, 2018 and February 6, 2019, FWP collected a total of 1922 samples from mule deer (n=1367), white-tailed deer (n=458), elk (n=105), and moose (n=9) across the state of Montana (Figure 2). Of these samples, 1526 were collected as part of our surveillance efforts within our three priority surveillance areas, and 257 samples were collected within the Carbon County CWD Positive Area (Table 3). Outside of our priority surveillance areas, we collected and tested an additional 161 cervid samples statewide, 19 of which were from symptomatic animals. We received 90 results (13 complete with location information) from samples collected, submitted, and paid for by hunters.

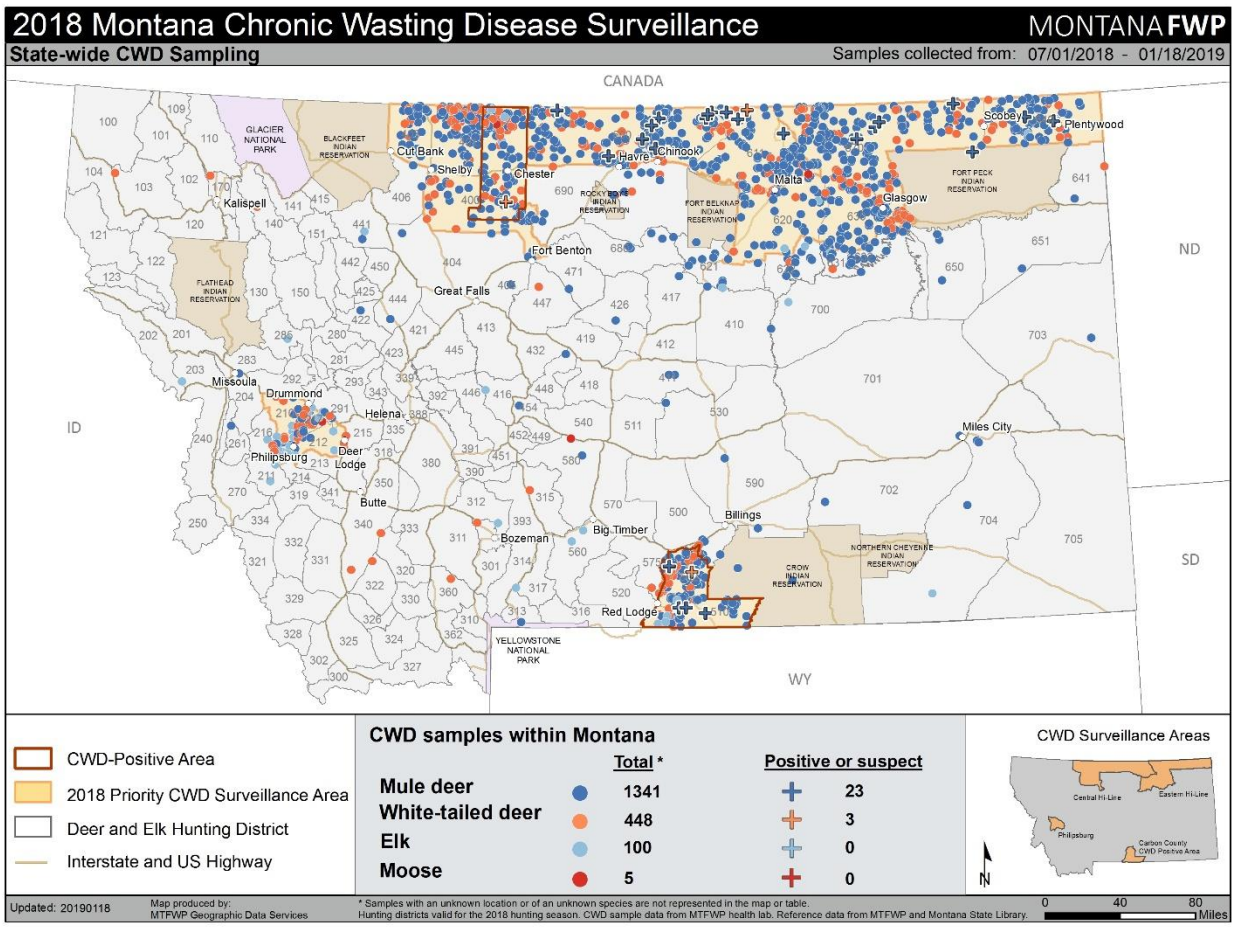

Figure 2. Map of locations where samples were collected during the general CWD surveillance and monitoring efforts in Montana, 2018, color-coded by species. Priority surveillance and monitoring units are highlighted in tan with orange boundary lines. Positives are denoted by the color-coded "plus" signs. See Figures A1.1-A1.4 in Appendix I for greater detail.

FWP's 2018 surveillance and monitoring efforts led to the detection of 26 new cases of CWD, including 21 positives (19 mule deer and 2 white-tailed deer) distributed along the Hi-Line in every northern county from Liberty County east to the North Dakota border, and 5 positives (4

mule deer and 1 white-tailed deer) from within the Carbon County CWD-Positive Area (Figure 2). We detected CWD within HDs 400, 401, 502, 510, 575, 600, 611, 640, 670, and on the Fort Peck Indian Reservation. The unexpected CWD detection in a white-tailed deer in HD 400 on October 31, 2018 led FWP to expand its surveillance efforts to HD 400 for the remainder of the general hunting season.

We detected no CWD positives within the Philipsburg surveillance unit, however, we only achieved 10% of our 300-point goal in mule deer (Table 3, Figure 3), leaving us 25% confident that we would have detected at least 1 positive if prevalence were ≥1%. Within the eastern Hi-Line surveillance unit, we detected CWD in HDs 640 and 670, but not in the more southernly HDs 620 and 630. Retrospectively, we wanted to know the likelihood that we would have detected a positive in these two hunting districts given our sampling effort there. We collected 130 mule deer weighted surveillance points within HDs 620 and 630, leaving us 73% confident that we would have detected a positive if prevalence in these districts was ≥1%.

Table 3. Number of samples collected for each species, total weighted surveillance points earned, and the percentage of points that we earned towards our 300-point goal for our 2018 CWD surveillance season.

Surveillance/Monitoring Unit	Species	Samples Collected	Weighted Surveillance Points	% points earned towards 300 point goal
Central Hi-Line: HDs 400, 401, 403, 600, 611	MD	625	460	153
	WTD	211	455	152
	Elk	42	37	12
	Moose	2	NA	NA
Eastern Hi-Line: HDs 620, 630, 640, 670	MD	409	392	131
	WTD	107	269	90
	Elk	3	2	1
Philipsburg: HDs 210, 217, 212	MD	29	29	10
	WTD	53	101	34
	Elk	39	36	12
	Moose	1	NA	NA
Carbon County Positive Area: HDs 502, 510, 520, 575	MD	190	NA	NA
	WTD	61	NA	NA
	Elk	6	NA	NA

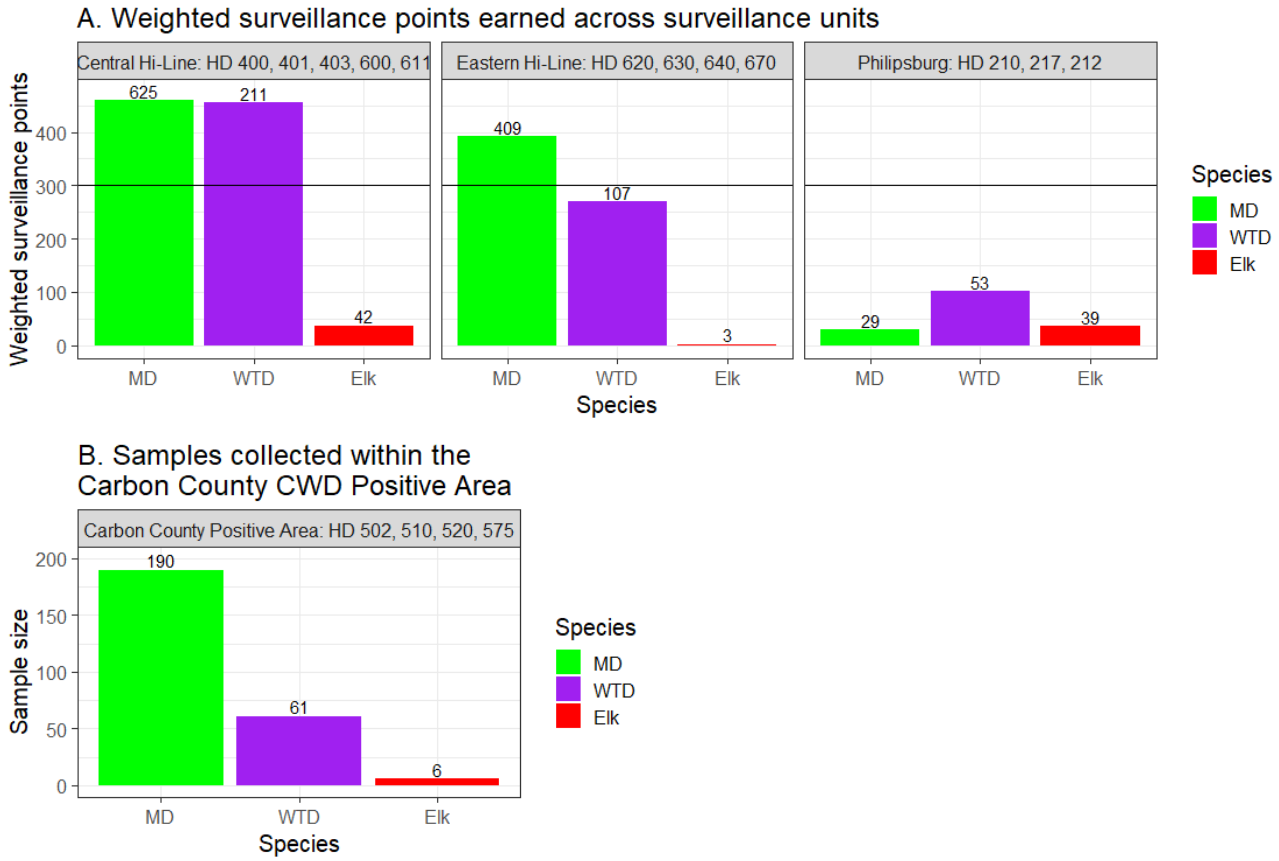

Figure 3. A. Weighted surveillance points earned for mule deer (MD), white-tailed deer (WTD), and elk within each of the three priority surveillance units in Montana, 2018. Under the weighted surveillance framework, different demographic groups (age, sex, or cause of death categories) of a species are 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 (depicted by the horizontal black line) in mule deer to detect ≥ 1% prevalence with 95% confidence. The sample size of individual animals that we tested for each species is displayed above each bar. These data include samples collected during the general surveillance effort (July 1, 2018 – February 6, 2019). B. Samples collected during CWD monitoring efforts within the Carbon County Positive Area, 2018. Samples collected in this area were used to estimate prevalence, and thus a weighted surveillance scheme with points was not applicable.

Most samples collected during the 2018 surveillance season were from hunter-harvested animals, followed by road-kill, symptomatic animals, and other causes of mortality (e.g. unexplained, predation, etc.; Figure 4). Most hunter-harvested animals were sampled at check stations or regional offices (See Appendix II for a breakdown of samples collected by location). We observed a substantial increase in the number of hunters actively seeking to have their animals sampled and tested following the announcement of the first two CWD detections of the season in Liberty and Carbon counties on October 31, 2018 (Figure 5).

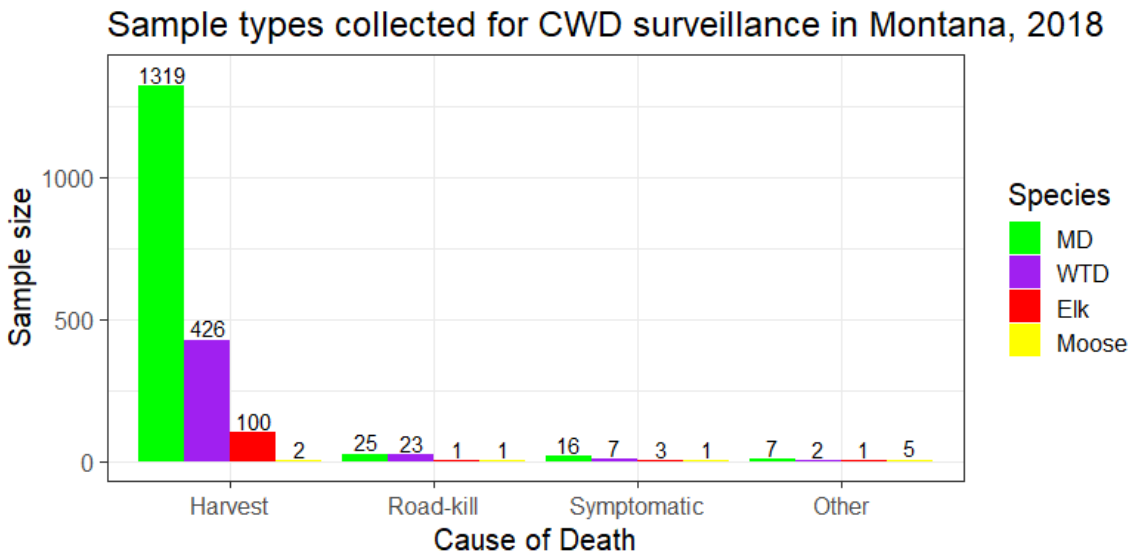

Figure 4. Samples collected by species and cause of death during the 2018 CWD surveillance and monitoring efforts in Montana.

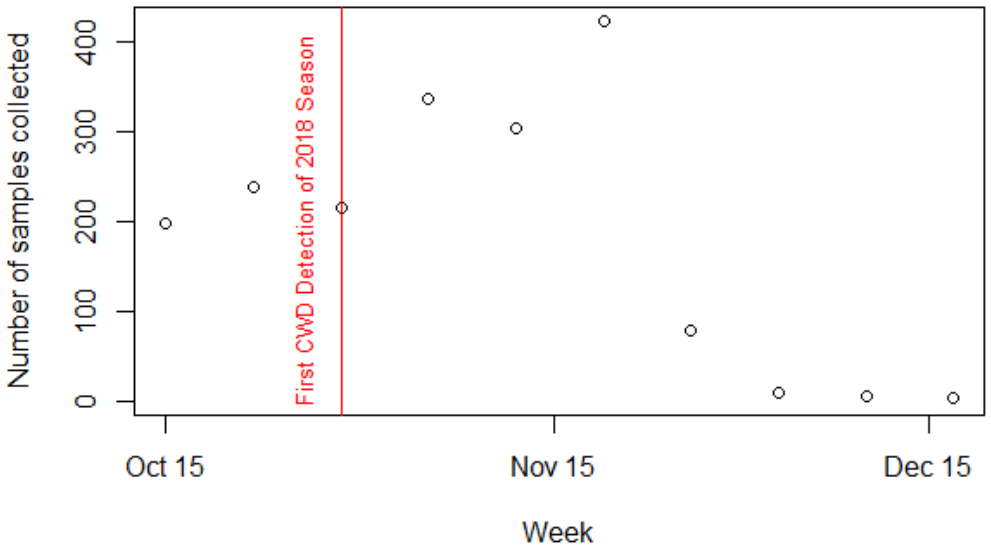

Figure 5. Number of hunter-harvested samples collected by week in Montana (Oct 15-Dec 23, 2018) in the R2, R4, and R6 priority surveillance areas and in the R5 CWD management zone. Check stations experienced an increase in hunter participation in sampling after the first CWD detection was announced during the 2018 surveillance season.

On average, it took 14 days (sd = 4 days; median = 13 days) from the time staff collected a sample to have it analyzed and the test results posted online. Samples were shipped to Colorado State University's Diagnostic Lab 1-2 times per week, depending on volume.

CWD Prevalence Estimates

Region 4: Liberty County CWD Positive Area and Hunting Districts 400 and 401

Following the detection of the CWD positive white-tailed deer in HD 400, FWP expanded the boundaries of the Liberty County CWD Positive Area to include all of Liberty County (Figure 6). FWP sampled 310 deer harvested during 2017-2018 within the boundaries of the expanded Liberty County Positive Area and detected CWD in 1 mule deer buck and 1 white-tailed deer buck. The estimated prevalence of CWD was 0.005 (95% CI: 0 – 0.03, n=220) in mule deer and 0.02 (95% CI: 0 – 0.09, n=59) in white-tailed deer within the boundaries of the Liberty County CWD Positive Area (Figure 7, Table 4).

At the hunting district level, we estimated prevalence in HD 400 to be 0 (95% CI: 0 – 0.04, n=86) in mule deer and 0.06 (95% CI: 0.01 – 0.26, n=18) in white-tailed deer (Figure 7, Table 4). In HD 401, we estimated prevalence to be 0.003 (95% CI: 0 – 0.02, n=293) in mule deer and 0 (95% CI: 0 – 0.03, n=107) in white-tailed deer (Figure 7, Table 4). We had too few positives to detect meaningful differences in prevalence among the sexes.

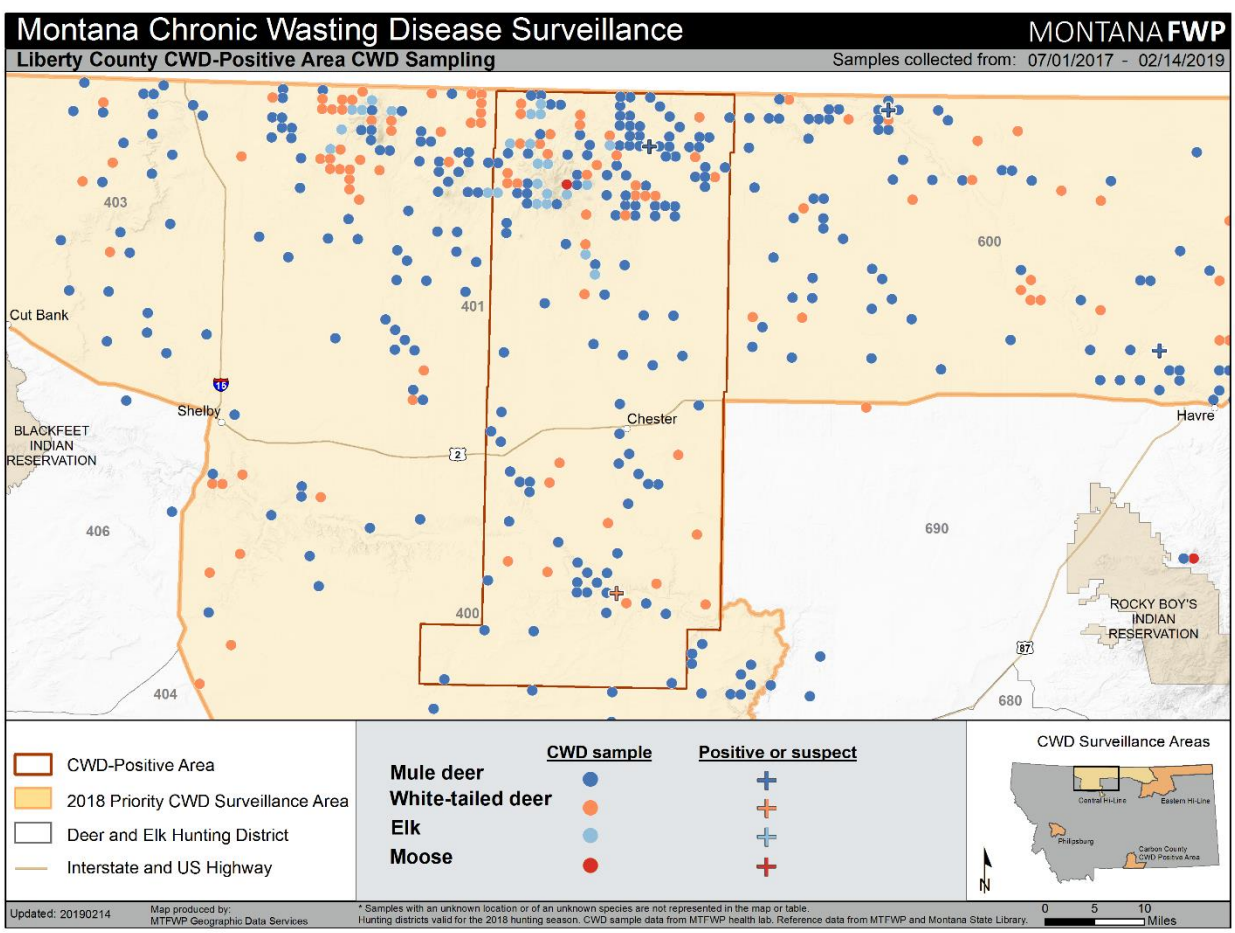

Figure 6. Map of hunter-harvest locations for CWD samples collected from 7/1/2017 - 2/14/2019 in and around the Liberty County CWD Positive Area (2018 expanded boundaries) during the Sage Creek Special Hunt (1/6/2018– 2/15/2018) and 2018 general CWD surveillance

season. Sample locations are color-coded by species. Positives are denoted by the color-coded "plus" signs.

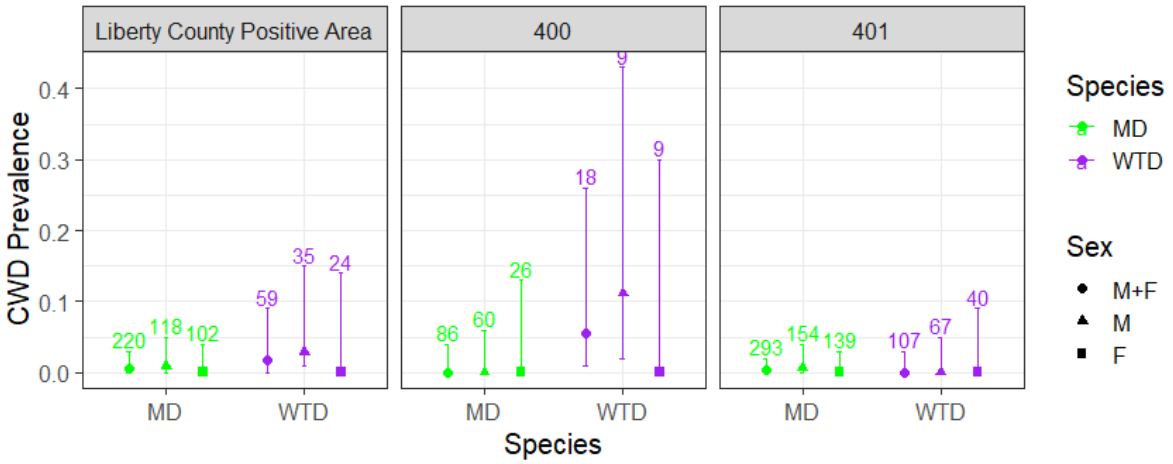

Figure 7. Estimated CWD prevalence in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within the Liberty County Positive Area, and associated hunting districts, July 1, 2017-February 6, 2019. Hunting district data is for the entire hunting district, including portions that fall outside the Liberty County CWD Positive Area. Mule deer data are plotted in green; white-tailed data are plotted in purple. Sample sizes are displayed above 95% confidence intervals.

Table 4. Estimated CWD prevalence and associated 95% confidence intervals in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within the Liberty County Positive Area, and associated hunting districts 400 and 401. Hunting district data is for the entire hunting district, including portions that fall outside the Liberty County CWD Positive Area.

Spatial Unit	Species	Sex	Prevalence (95% CI)	Sample Size (Positives)
Liberty County CWD Positive Area	MD	M+F	0.00 (0 - 0.03)	220 (1)
		M	0.01 (0 - 0.05)	118 (1)
		F	0.00 (0 - 0.04)	102 (0)
	WTD	M+F	0.02 (0 - 0.09)	59 (1)
		M	0.03 (0.01 - 0.15)	35 (1)
		F	0.00 (0 - 0.14)	24 (0)
Hunting District 400	MD	M+F	0.00 (0 - 0.04)	86 (0)
		M	0.00 (0 - 0.06)	60 (0)
		F	0.00 (0 - 0.13)	26 (0)
	WTD	M+F	0.06 (0.01 - 0.26)	18 (1)
		M	0.11 (0.02 - 0.43)	9 (1)
		F	0.00 (0 - 0.3)	9 (0)
Hunting District 401	MD	M+F	0.00 (0 - 0.02)	293 (1)
		M	0.01 (0 - 0.04)	154 (1)
		F	0.00 (0 - 0.03)	139 (0)
	WTD	M+F	0.00 (0 - 0.03)	108 (0)
		M	0.00 (0 - 0.05)	67 (0)
		F	0.00 (0 - 0.09)	41 (0)

Region 5: Carbon County CWD Positive Area and Hunting Districts 502, 510, 520, and 575

FWP sampled 599 mule deer and 274 white-tailed deer harvested between 2017-2018 within the boundaries of the Carbon County CWD Positive Area (Figure 8), and detected CWD in 12 mule deer and 3 white-tailed deer. The estimated prevalence was 0.02 (95% CI: 0.01 – 0.03, n=599) among mule deer and 0.01 (95% CI: 0 – 0.03, n=274) among white-tailed deer within the Carbon County Positive Area (Figure 9, Table 5). At this spatial scale, we detected no statistical differences in estimated prevalence between mule deer and white-tailed deer (x^2 = 0.5, df = 1, p = 0.5), or between the sexes in either mule deer (x^2 = 0, df = 1, p = 1) or white-tailed deer (x^2 = 0, df = 1, p = 0.96; Table 5).

Prevalence in mule deer significantly varied (x^2 = 28.1, df = 3, p < 0.001) across the four hunting districts (HD 502, 510, 520, 575) within and surrounding the Carbon County Positive Area (Figure 9, Table 5). For example, prevalence in mule deer was estimated at 0.06 (95%CI: 0.03 – 0.12, n=143) in HD 510 on the Wyoming border, compared to ≤0.01 in all the surrounding districts (Figure 9, Table 5). By contrast, we detected no significant variation in prevalence across hunting districts for white-tailed deer (x^2 = 1.3, df = 3, p = 0.72); however, smaller sample sizes and fewer detections likely reduced our power to discern any differences at this scale (Figure 9). Estimated prevalence in white-tailed deer was ≤0.01 across all four hunting districts (Figure 9, Table 5).

Despite finding four times as many CWD-positive mule deer than white-tailed deer, we found no significant differences in the prevalence between the two species within HDs 502 (x^2 = 0, df = 1, p = 1), 510 (x^2 = 0.2, df = 1, p = 0.6), 520 (x^2 = 0, df = 1, p = 1), or 575 (x^2 = 0, df = 1, p = 1). At the hunting district level and within species, we measured slight differences in the prevalence of CWD across the sexes, but none of these were statistically significant (Figure 9, Table 5).

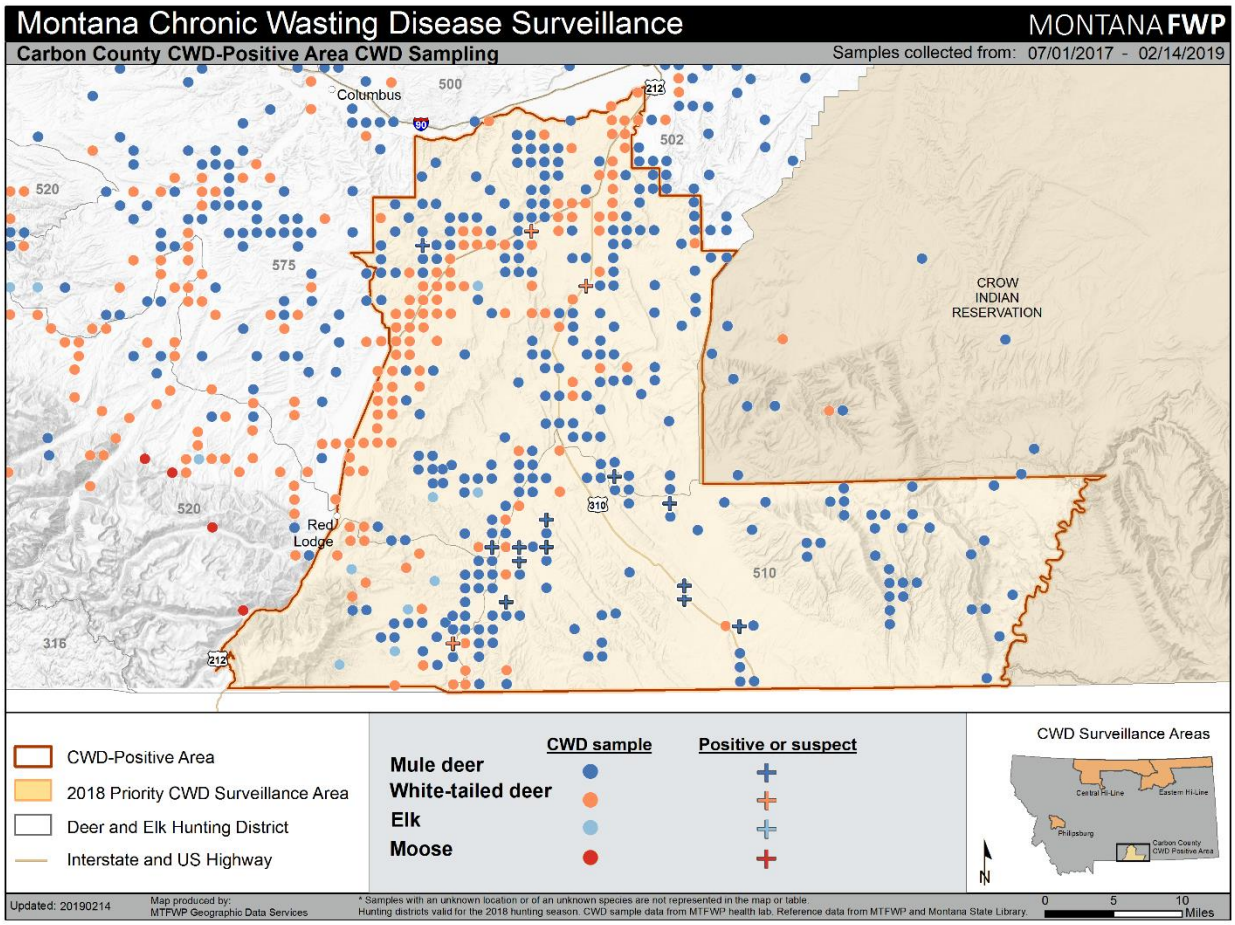

Figure 8. Map of hunter-harvest locations for CWD samples collected from 7/1/2017 - 2/14/2019 in and around the Carbon County CWD Positive Area during the 2017 and 2018 general CWD surveillance seasons and the Bridger Creek Special Hunt (12/15/2017- 2/15/2018). Sampling locations are color-coded by species. Positives are denoted by the color-coded "plus" signs.

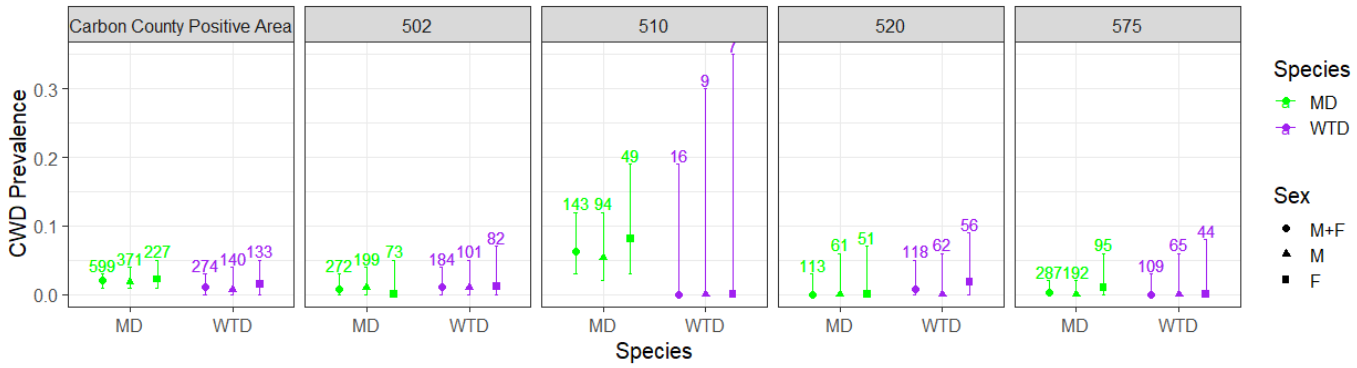

Figure 9. Estimated CWD prevalence in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within the Carbon County Positive Area, and associated hunting districts. Hunting district data are for the entire hunting district, including portions that fall outside the Carbon County CWD Positive Area. Mule deer data are

plotted in green; white-tailed data are plotted in purple. Sample sizes are displayed above 95% confidence intervals.

Table 5. Estimated CWD prevalence and associated 95% confidence intervals in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within the Carbon County Positive Area, and associated hunting districts 502, 510, 520, and 575. Hunting district data are for the entire hunting district, including portions that fall outside the Carbon County CWD Positive Area.

Spatial Unit	Species	Sex	Prevalence (95% CI)	Sample Size (Positives)
Carbon County Positive Area	MD	M+F	0.02 (0.01 - 0.03)	599 (12)
		M	0.02 (0.01 - 0.04)	371 (7)
		F	0.02 (0.01 - 0.05)	227 (5)
	WTD	M+F	0.01 (0 - 0.03)	274 (3)
		M	0.01 (0 - 0.04)	140 (1)
		F	0.02 (0 - 0.05)	133 (2)
Hunting District 502	MD	M+F	0.01 (0 - 0.03)	272 (2)
		M	0.01 (0 - 0.04)	199 (2)
		F	0 (0 - 0.05)	73 (0)
	WTD	M+F	0.01 (0 - 0.04)	184 (2)
		M	0.01 (0 - 0.05)	101 (1)
		F	0.01 (0 - 0.07)	82 (1)
Hunting District 510	MD	M+F	0.06 (0.03 - 0.12)	143 (9)
		M	0.05 (0.02 - 0.12)	94 (5)
		F	0.08 (0.03 - 0.19)	49 (4)
	WTD	M+F	0 (0 - 0.19)	16 (0)
		M	0 (0 - 0.3)	9 (0)
		F	0 (0 - 0.35)	7 (0)
Hunting District 520	MD	M+F	0 (0 - 0.03)	113 (0)
		M	0 (0 - 0.06)	61 (0)
		F	0 (0 - 0.07)	51 (0)
	WTD	M+F	0.01 (0 - 0.05)	118 (1)
		M	0 (0 - 0.06)	62 (0)
		F	0.02 (0 - 0.09)	56 (1)
Hunting District 575	MD	M+F	0 (0 - 0.02)	287 (1)
		M	0 (0 - 0.02)	192 (0)
		F	0.01 (0 - 0.06)	95 (1)
	WTD	M+F	0 (0 - 0.03)	109 (0)
		M	0 (0 - 0.06)	65 (0)
		F	0 (0 - 0.08)	44 (0)

Region 6: Hunting Districts 600, 611, 640, and 670

FWP sampled 609 mule deer and 150 white-tailed deer harvested between 2017-2018 within hunting districts 600, 611, 640, and 670, and detected CWD in 18 mule deer and 1 white-tailed deer (Figure 10). Prevalence among mule deer was estimated to be 0.04 (95% CI: 0.02 – 0.08, n=236) in HD 600, 0.02 (95% CI: 0.01 – 0.07, n=103) in HD 611, 0.03 (95% CI: 0.01 – 0.12, n=59) in HD 640, and 0.02 (95% CI: 0.01 – 0.05, n=211) in HD 670. Differences in mule deer prevalence estimates across hunting districts were not statistically significant (x^2 = 2.6, df = 3, p = 0.46). Prevalence among white-tailed deer was estimated to be 0 (95% CI: 0 – 0.07, n=55) in HD 600, 0.04 (95% CI: 0.01 – 0.2, n=24) in HD 611, 0 (95% CI: 0 – 0.17, n=19) in HD 640, and 0 (95% CI: 0

– 0.07, n=52) in HD 670 (Figure 11). White-tailed deer prevalence estimates across hunting districts were not significantly different from one another (x^2 = 5.3, df = 3, p = 0.15). Although we detected CWD much more commonly among mule deer than white-tailed deer across the four hunting districts, we did not detect a significant difference in prevalence estimates between the two species (x^2 = 1.7, df = 1, p = 0.19) due to low samples sizes for white-tailed deer. Across all four hunting districts, male mule deer exhibited higher prevalences than female mule deer (Table 6). This pattern was nearly significant at the regional scale (aggregating HDs 600, 611, 640, and 670; x^2 = 3. 2, df = 1, p = 0.07), but not statistically significant within hunting districts (in all cases, p ≥ 0.2). There were no significant differences in prevalence detected among male and female white-tailed deer (x^2 = 0, df = 1, p = 1; Table 6).

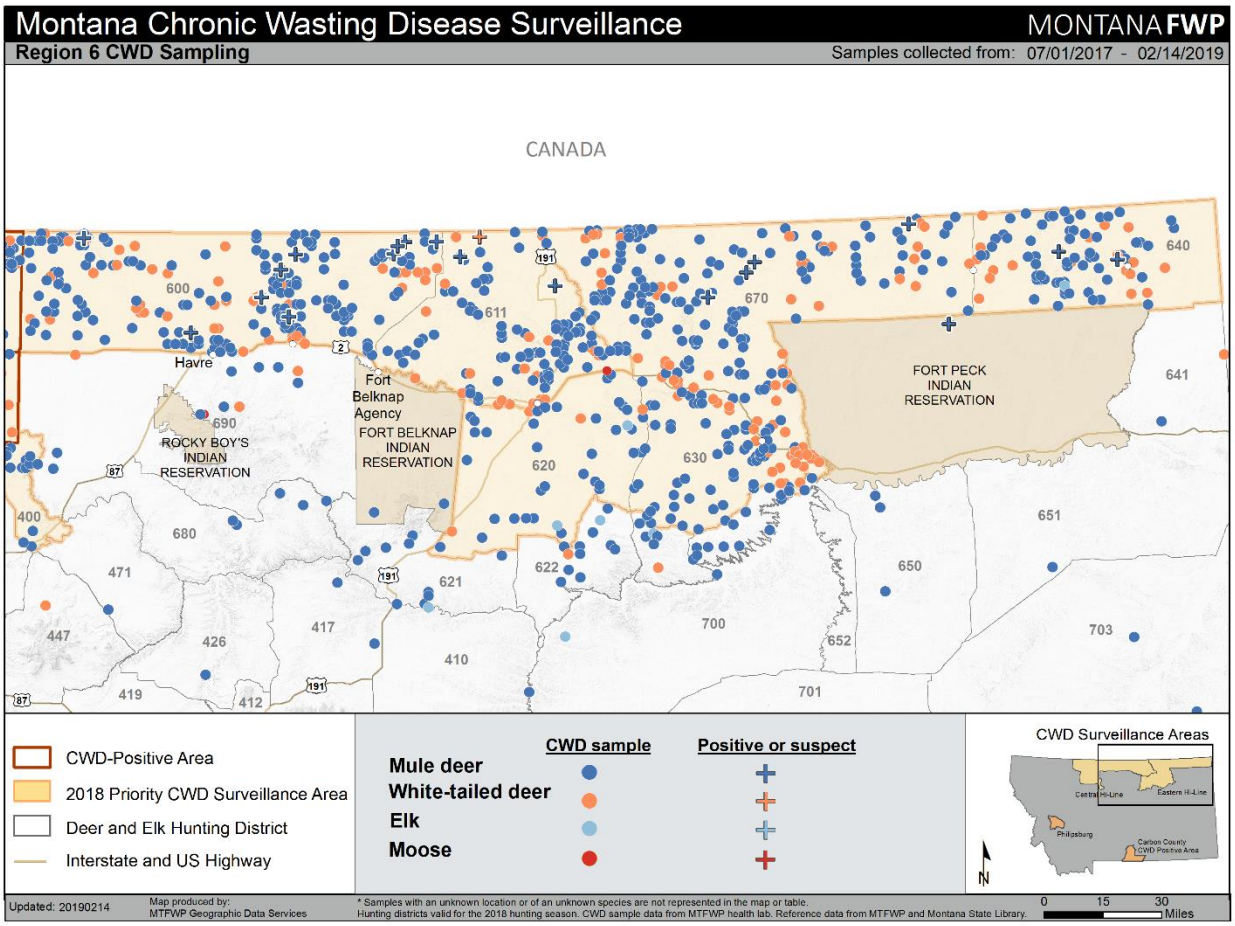

Figure 10. Map of hunter-harvest locations for CWD samples collected within the CWD-positive Region 6 hunting districts (600, 611, 640, and 670) during the 2018 general CWD surveillance season. Sample locations are color-coded by species. Positives are denoted by the color-coded "plus" signs.

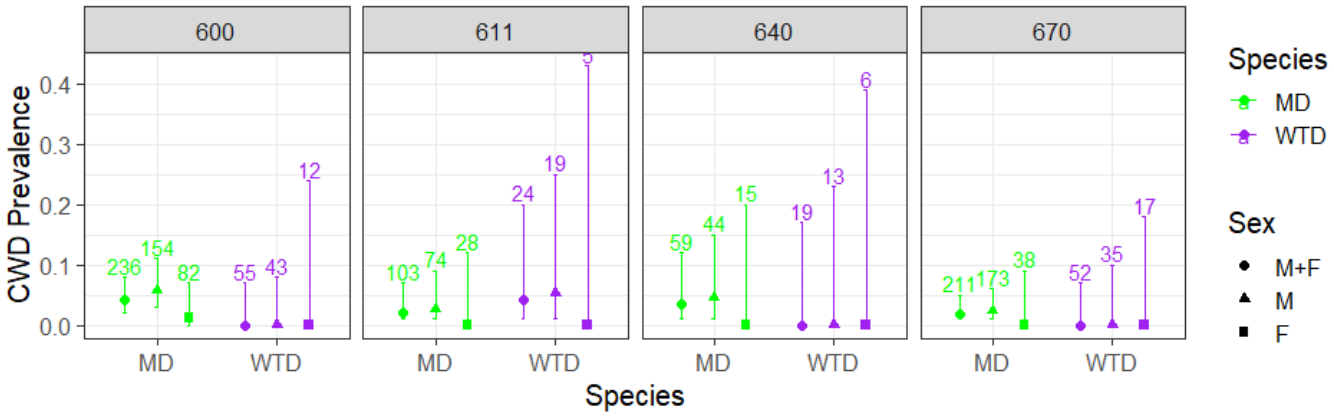

Figure 11. Estimated CWD prevalence in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within CWD-positive hunting districts on the Hi-Line in Administrative Region 6. Mule deer data are plotted in green; white-tailed data are plotted in purple. Sample sizes are displayed above 95% confidence intervals.

Table 6. Estimated CWD prevalence and associated 95% confidence intervals in mule deer (MD) and white-tailed deer (WTD) across the sexes (M+F) and among the sexes (M = male, F= female) within the Region 6 Hi-Line hunting districts 600, 611, 640, and 670. Hunting district data are for the entire hunting district.

Spatial Unit	Species	Sex	Prevalence (95% CI)	Sample Size (Positives)
Hunting District 600	MD	M+F	0.04 (0.02 - 0.08)	236 (10)
		M	0.06 (0.03 - 0.11)	154 (9)
		F	0.01 (0 - 0.07)	82 (1)
	WTD	M+F	0 (0 - 0.07)	55 (0)
		M	0 (0 - 0.08)	43 (0)
		F	0 (0 - 0.24)	12 (0)
Hunting District 611	MD	M+F	0.02 (0.01 - 0.07)	104 (2)
		M	0.03 (0.01 - 0.09)	74 (2)
		F	0 (0 - 0.12)	29 (0)
	WTD	M+F	0.04 (0.01 - 0.2)	24 (1)
		M	0.05 (0.01 - 0.25)	19 (1)
		F	0 (0 - 0.43)	5 (0)
Hunting District 640	MD	M+F	0.03 (0.01 - 0.12)	59 (2)
		M	0.05 (0.01 - 0.15)	44 (2)
		F	0 (0 - 0.2)	15 (0)
	WTD	M+F	0 (0 - 0.17)	19 (0)
		M	0 (0 - 0.23)	13 (0)
		F	0 (0 - 0.39)	6 (0)
Hunting District 670	MD	M+F	0.02 (0.01 - 0.05)	211 (4)
		M	0.02 (0.01 - 0.06)	173 (4)
		F	0 (0 - 0.09)	38 (0)
	WTD	M+F	0 (0 - 0.07)	52 (0)
		M	0 (0 - 0.1)	35 (0)
		F	0 (0 - 0.18)	17 (0)

FWP contacted all hunters whose animals tested positive for CWD to ask them to dispose of the carcass or meat in a Class II Landfill. FWP worked closely with the Montana Department of

Environmental Quality to identify Class II Landfills for the public. FWP also worked closely with the Department of Public Health and Human Services and the Department of Livestock to contact processors that had received and handled infected carcasses. At least 5 known CWD-positive animals went to processors in 2018. All CWD-positive, hunter-harvested animals appeared outwardly healthy.

FWP began notifying the public before the hunting season of carcass transport restrictions in effect for Carbon and Yellowstone Counties, as well as Liberty, Toole, Hill, Blaine, and Phillips Counties through press releases, fliers distributed at check stations and regional offices, letters to permit holders, and through lighted sign boards along the highway. As new detections were made on the Hi-Line, additional counties were added to the Transport Restriction Zone (TRZ) mid-season with limited success. Despite a similar public outreach effort to make hunters aware of these new TRZs, enforcement documented numerous violations of these transport restrictions and it was clear the public remained unaware or confused by TRZ boundaries.

Discussion

Montana Fish, Wildlife, and Parks' 2018 CWD surveillance efforts were largely successful and significantly expanded the known distribution of CWD in Montana. FWP identified new CWD-positive areas along Montana's northern border with Alberta and Saskatchewan and detected CWD among wild mule deer and/or white-tailed deer in every county along the Hi-Line from Liberty County east to the North Dakota border. Prevalence in mule deer ranged from <1% in Liberty County to 2-4% in the hunting districts to the east in the Central and Eastern Hi-Line minimum surveillance units. In addition, FWP improved the precision of estimates of CWD prevalence within the Carbon County CWD Positive Area (2% in mule deer and 1% in white-tailed deer) after a second season of intensive sampling. We estimated prevalence as high as 6% in mule deer where positive CWD cases were clustered within the southern-most hunting district in the Carbon County Positive Area.

The current distribution of CWD within Montana is consistent with the natural spread of the disease from Alberta and Saskatchewan to the north, and from Wyoming to the south (Figure 12). To date, Montana hunting districts that border neighboring jurisdictions where cervids have higher prevalence rates, have higher prevalence rates of CWD than adjacent interior districts. Prevalence estimates within hunting districts 510 and 600 along our borders are high enough to suggest that CWD has been present in these areas for some time. The growth rates of CWD prevalence are typically quite low, and it often takes decades to reach prevalences >20% (Gross and Miller 2001, Wasserberg et al. 2009, Almberg et al. 2011). We expect continued transmission and spatial spread of the disease as has been observed in Wyoming, Alberta and Saskatchewan, but hope that targeted CWD management will at least slow the rates of transmission and spatial spread.

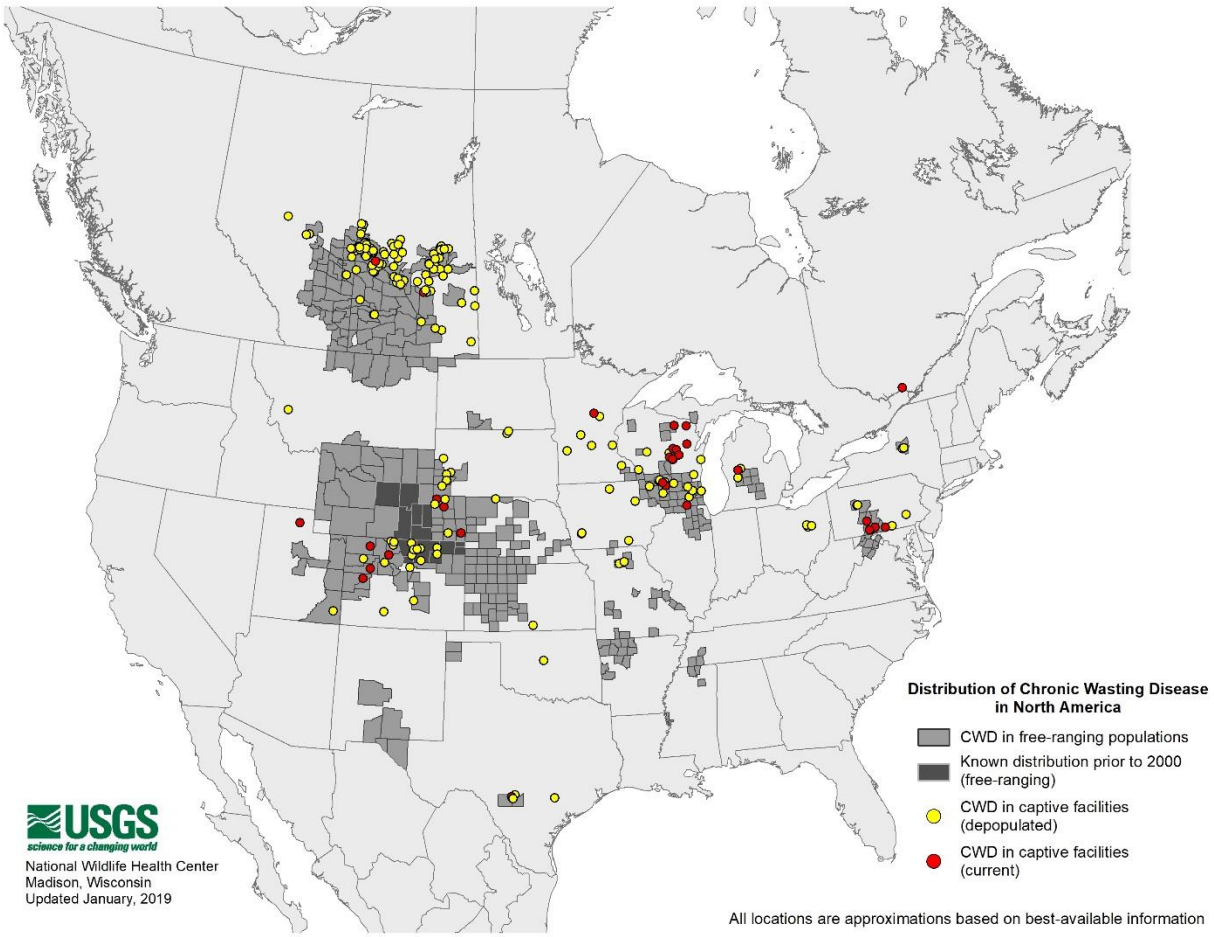

Figure 12. Map of the 2018 distribution of CWD in North America, produced by the US Geological Society (www.cwd-info.org).

Although we have detected many more cases of CWD in mule deer (N = 32) than in white-tailed deer (N = 5) to date, we have not found statistically significant differences in the patterns of infection between the two species. Much of our initial sampling has focused on mule deer, since they often exhibit higher prevalences of CWD than white-tailed deer in the same area (Miller et al. 2000) and thus are considered most valuable for the purposes of CWD detection. However, this mule deer bias in our surveillance efforts has meant that we have less power to precisely describe patterns in white-tailed deer or discern differences between the species. To improve our future estimates, we plan to sample white-tailed deer more aggressively, even during general surveillance.

During surveillance, we have also emphasized the sampling of males over females, since CWD prevalence is typically higher in males (Walsh & Otis, 2012). On the Hi-Line, we observed a trend towards higher prevalences in males than females, though these trends weren't statistically significant. In the Carbon County CWD Positive Area, prevalence estimates were remarkably similar between the sexes.

After a second season of sampling, we were surprised to only find one new case of CWD in and around the Liberty County CWD Positive Area in 2018. The low estimated prevalence in hunting districts 401 and 400 suggest that this area is on the southwestern periphery of the larger Alberta-Saskatchewan-Montana endemic area (Figure 12). This will be an important area to manage and monitor in the future to control and track the spread of CWD in the region.

FWP learned numerous lessons over the course of the 2018 general surveillance season. This year, we observed a dramatic increase in testing demand at regional offices across the state, not just those offices in the priority surveillance areas. To better prepare for this in the future, we plan to provide additional regional staff training to prepare for this increased demand in 2019, and in some cases, additional technicians. In addition, to prepare for possible detections in southeastern Montana during our fall 2019 surveillance, we are budgeting for, and will be encouraging the intensive sampling of all cervids and both sexes in the priority surveillance areas to get a start on the broader effort to describe prevalence needed for CWD management.

FWP's CWD surveillance is guided by a risk model that defines high priority surveillance areas as those that have both high mule deer densities and are within the lowest 25% of distances to the nearest known cases of CWD (Russell et. al 2015). This strategy for prioritizing our efforts appears to be successful. We found CWD where model predictions indicated we were most likely to. Unfortunately, this risk model suggests we are likely to find CWD in southeastern Montana when we conduct surveillance there in 2019. High or increasing prevalence estimates and spatial spread of CWD detected in northern Wyoming and in North and South Dakota suggest it is only a matter of time before we detect more widespread infections within Montana's borders. At the end of the 2019 surveillance season, we plan to re-run the risk model using updated information on CWD detections within and outside of the state to help re-prioritize surveillance areas for the following 3 years.

In the fall of 2019, FWP plans to conduct surveillance in the southeast corner of the state (HDs 702, 704, 705; Figure 1) and around Philipsburg, MT (HDs 210, 212, and 217; Figure 1), where CWD was detected on a depopulated captive elk farm in 1999. In addition, FWP will return to conduct additional sampling along the Hi-Line to improve our estimates of prevalence and distribution among the different age and sex classes of mule deer and white-tailed deer.

Future management

FWP anticipates making several long-term changes to management within CWD-positive areas. In February 2019, Montana FWP's Commission approved proposed harvest management changes for hunting districts 510, 502, 520, and 575 in south-central Montana to liberalize both mule deer and white-tailed deer harvest, particularly of bucks. Beginning in the 2019 hunting season, in HD 502, the general mule deer season will be changed from buck-only to either-sex; in HD 510, FWP will eliminate the unlimited 510-50 buck mule deer permit and establish an either-sex mule deer season; in HD 520, FWP will change the general mule deer season from buck-only to either-sex in that portion of HD 520 lying east of Highway 212; and in HD 575, FWP will increase the number of 575-00 antlerless mule deer B licenses from 250 to 500 and has proposed an increase in the biennial range from 200 to 750 (this proposal is outside the current

biennial range and requires commission action). Decisions regarding CWD management in Region 4 are ongoing. Region 6 is considering increases to antlerless mule deer and white-tailed deer B licenses.

In addition, Montana FWP and Wyoming Game and Fish have begun to plan a collaborative CWD management project that will compare the impacts of harvest management and population structure on CWD prevalence and vital rates for infected deer populations on adjacent sides of the Montana-Wyoming border. This comparative study is being developed in accordance with the Western Association of Fish and Wildlife Agencies' Recommendations for Adaptive Management of CWD in the West (Western Association of Fish and Wildlife Agencies. 2017).

In 2019, MFWP will consolidate "CWD Positive Areas" and "Transport Restriction Zones" into the single moniker "CWD Management Zones." Hunters that harvest cervids within a CWD Management Zone cannot transport whole carcasses, spinal columns, or whole heads outside of the management zone. The Northern Montana CWD Management Zone will include hunting districts 400, 401, 600, 611, 640, 641, and 670 (Figure 13). In addition, the Fort Peck Reservation will follow the Northern CWD Management Zone regulations. The Southern Montana CWD Management Zone will include portions of hunting districts 575, 520, 590, all of 502 and 510, and the southern portion of MFWP Region 7, which is being included in anticipation of CWD positive cervids being found in that area in 2019 (Figure 13).

Carcass parts that may be removed from CWD Management Zones include meat that is cut and wrapped or meat that has been separated from the bone, quarters or other portions of meat with no part of the spinal column or head attached, hides with no heads attached, skull plates or antlers with no meat or tissue attached, and skulls that have been boiled and cleaned to remove flesh and tissue, and full or partial-body taxidermied mounts. FWP would like to remind hunters to dispose of all carcass waste in class II landfills. It is in the interest of our wild cervid species, and the public that enjoys them, that proper carcass disposal and carcass transport restrictions are adhered to; we hope these policies minimize the inadvertent spread of CWD by hunters who might otherwise move infectious carcasses around the state.

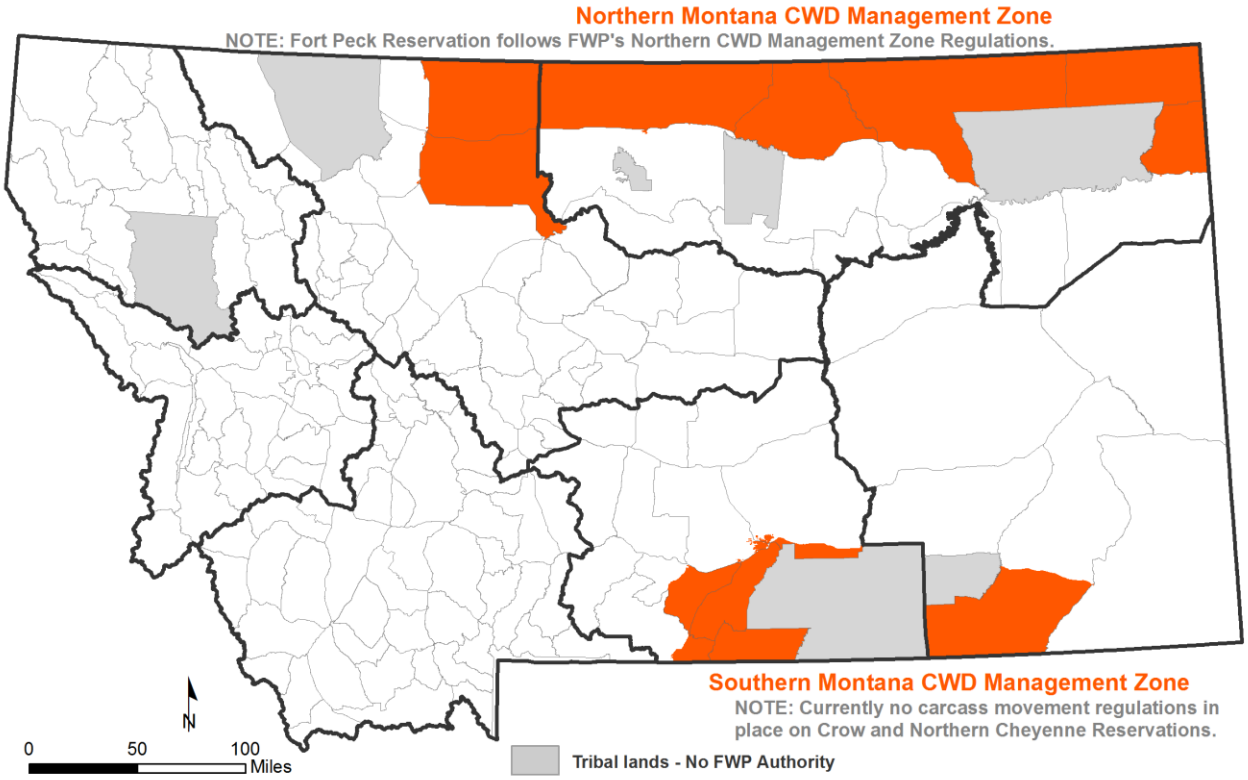

Figure 13. Map of 2019 CWD Management Zones, which encompass CWD positive areas and former Transport Restriction Zones.

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 the 7 technicians that worked check stations and regional offices during the general season: Heidi Anderson, Matt Becker, Nick Bromen, Matt Gaffney, Julie Herrick, Courtney Long, and Heather Whitley. We greatly appreciate their help for making this effort a success. We would also like to thank hunters, landowners, supportive residents and communities, vigilant wildlife watchers, and State, Federal and Tribal agency partners. A special thank you to the "rock stars" of lymph node collection: Courtney Long (204), Matt Becker (156), Nick Bromen (117), Matt Gaffney (116), Scott Hemmer (91), Heidi Anderson (74), Skyler Mitchell (68), Ryan Williamson (69), Matt Ladd (66), and John Thornburg (63) who collectively took 50% of our ~2000 cervid samples. 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, and generous donations from the Rocky Mountain Elk Foundation and the Mule Deer Foundation.

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Appendix I: Maps of sampling locations for each of the 2018 CWD priority surveillance/monitoring areas.

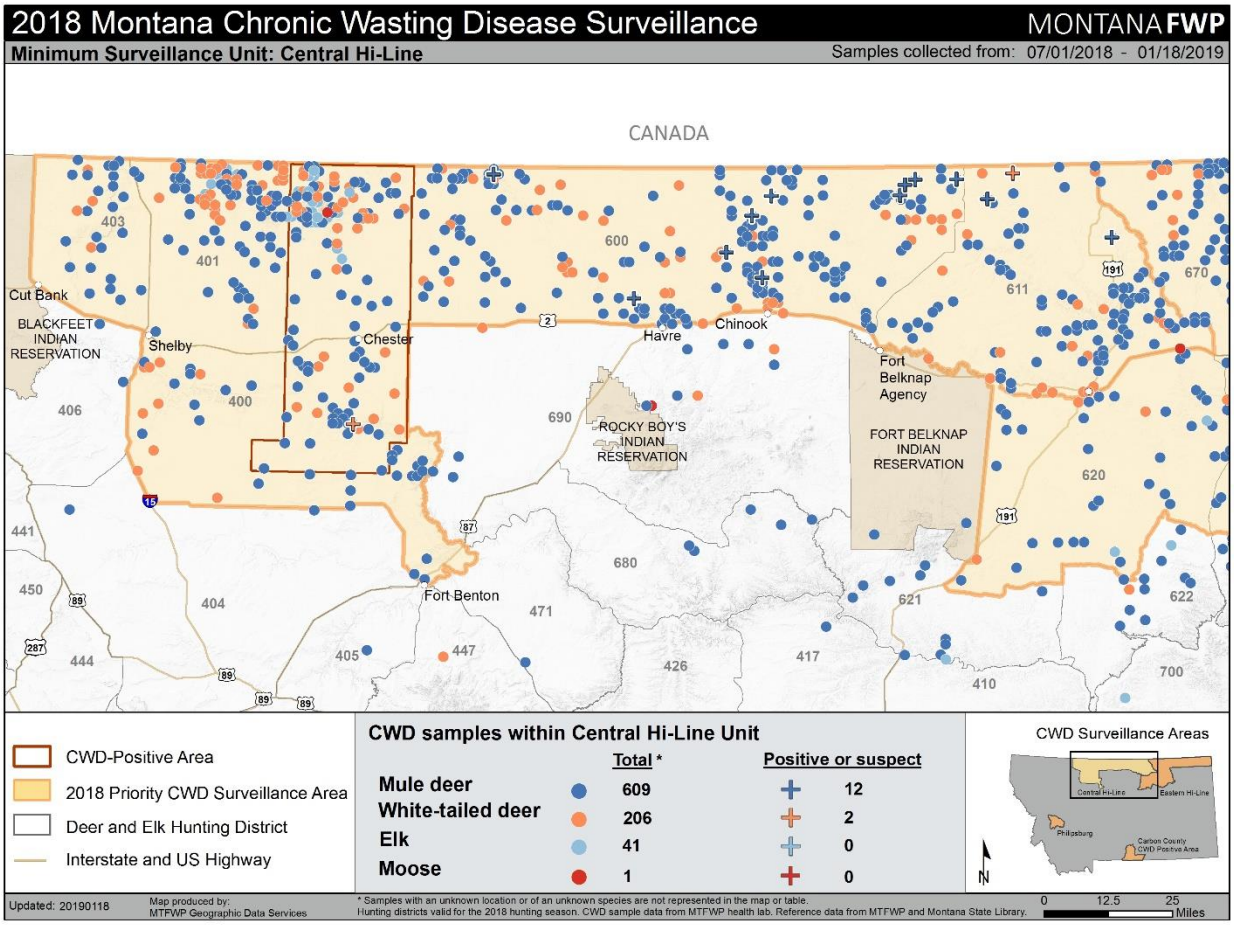

Figure A1.1. Map of locations where samples were collected during the general CWD surveillance and monitoring efforts in the Central Hi-Line Priority Surveillance Unit, Montana, 2018, color-coded by species. Priority surveillance and monitoring units are highlighted in tan with orange boundary lines. Positives are denoted by the color-coded “plus” signs.

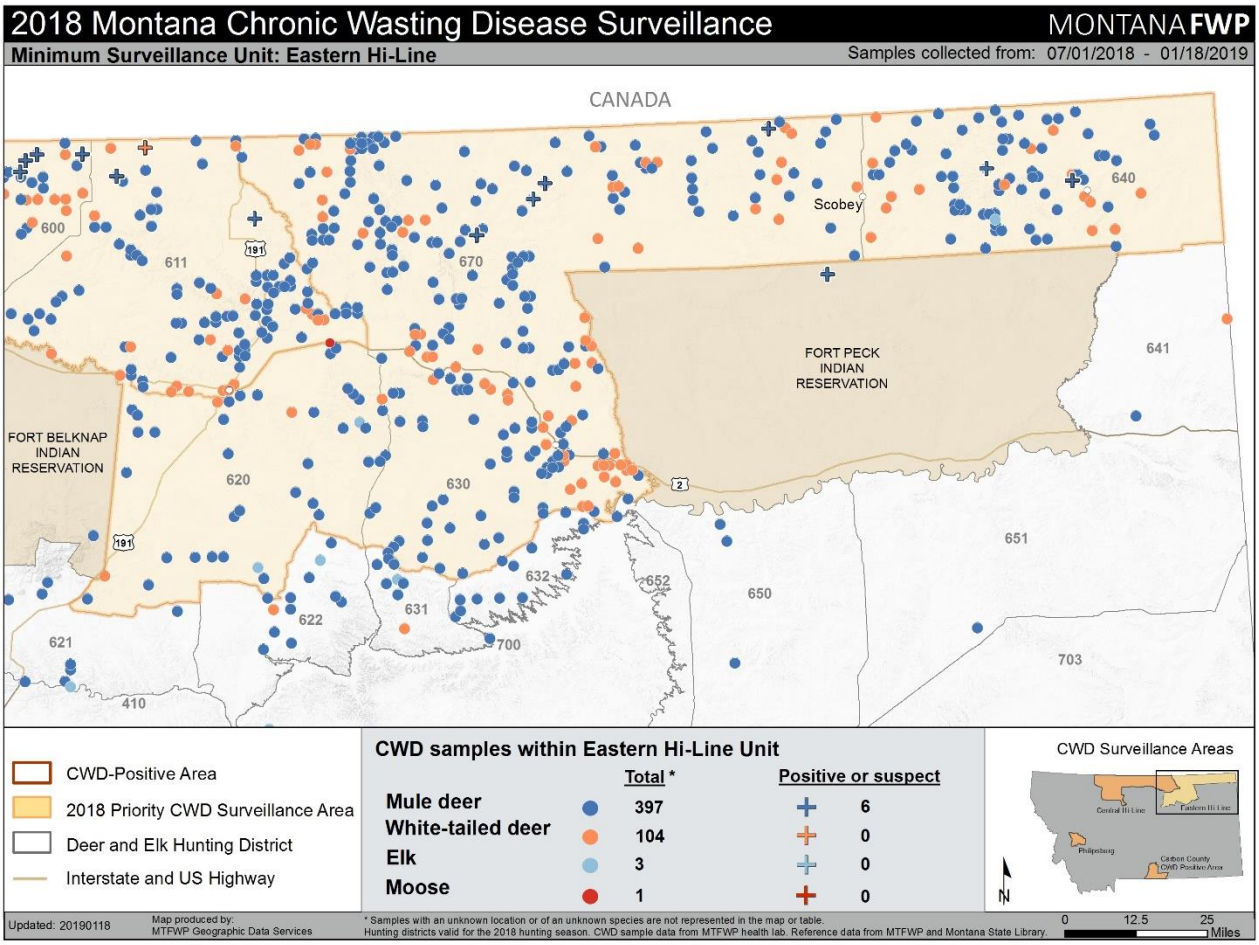

Figure A1.2. Map of locations where samples were collected during the general CWD surveillance efforts in the Eastern Hi-Line Priority Surveillance Unit, Montana, 2018, color-coded by species. Priority surveillance and monitoring units are highlighted in tan with orange boundary lines. Positives are denoted by the color-coded “plus” signs.

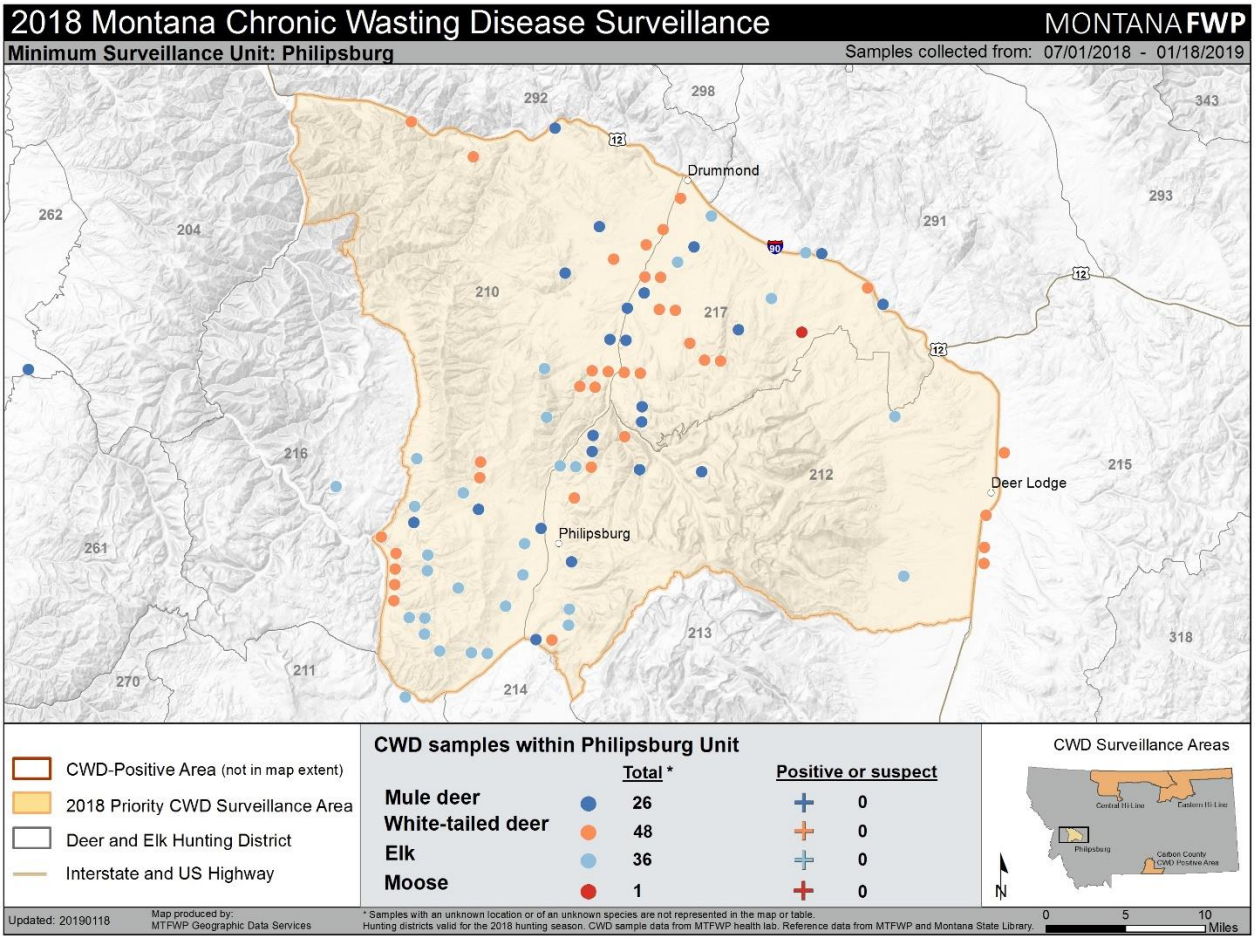

Figure A1.3. Map of locations where samples were collected during the general CWD surveillance efforts in the Philipsburg Priority Surveillance Unit, Montana, 2018, color-coded by species. Priority surveillance and monitoring units are highlighted in tan with orange boundary lines. Positives are denoted by the color-coded “plus” signs.

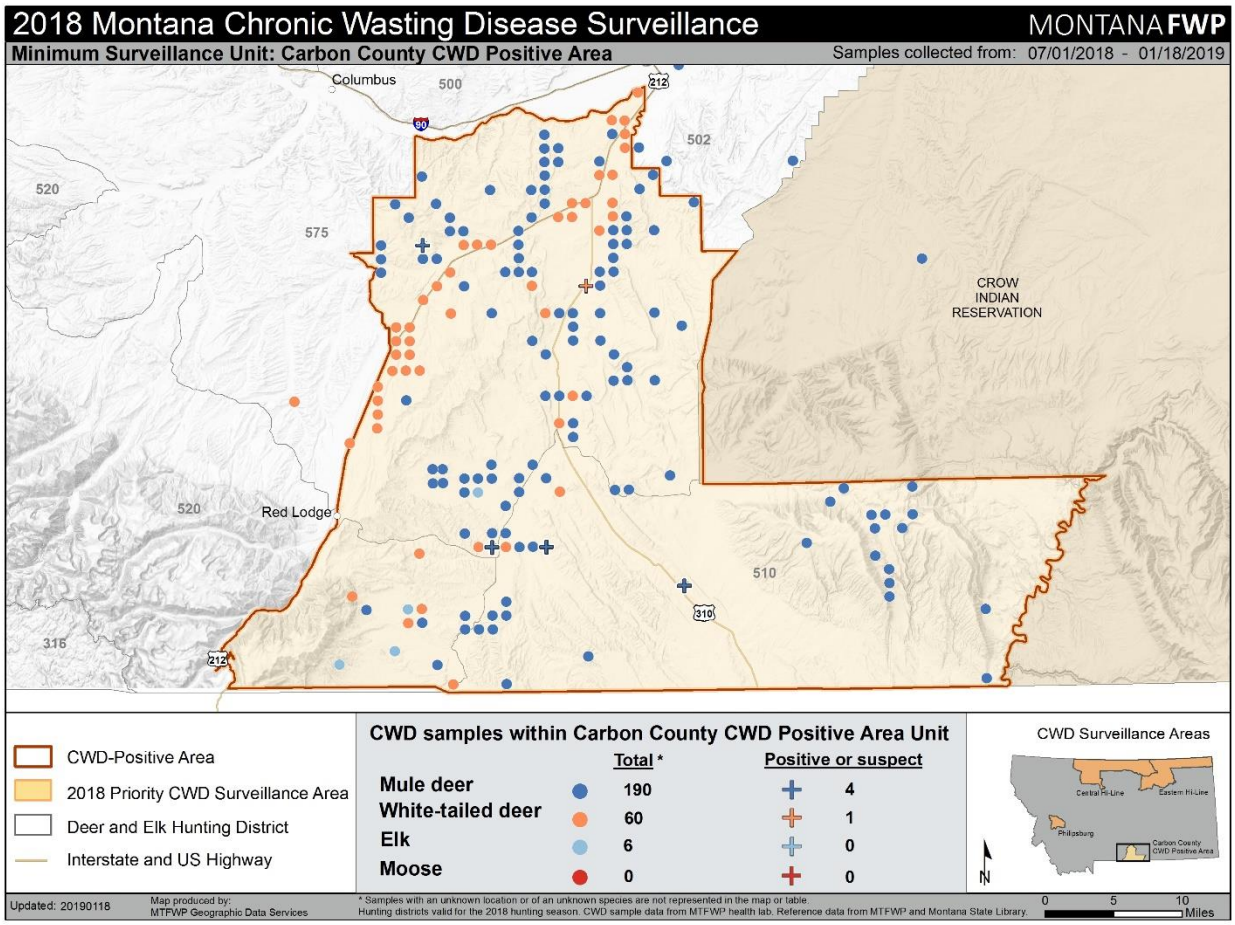

Figure A1.4. Map of locations where samples were collected during the general CWD monitoring efforts in the Carbon County CWD Positive Area, Montana, 2018, color-coded by species. Priority surveillance and monitoring units are highlighted in tan with orange boundary lines. Positives are denoted by the color-coded “plus” signs.

Appendix II: Number of samples collected at check stations or regional offices from July 1, 2018 – February 6, 2019.

Check Stations	N
Angels Nest Landing	7
Augusta Check Station	3
Big Sandy Check Station	4
Billings Check Station	8
Chester Check Station	253
Columbus Check Station	1
Glasgow Check Station	94
Hall Check Station	62
Havre Check Station	238
Laurel Check Station	206
Malta Check Station	197
Outlook, MT	31
Plentywood, MT	11
R1 HWY 2 Check Station	3
Scobey Check Station	41
Shelby Check Station	208
Skalkaho Check Station	35
Whitlash Region 4	25
Regional/Area Offices	**N**
R1 Kalispell HQ	32
R2 Missoula HQ	23
R3 Bozeman HQ	25
R4 Great Falls HQ	48
R5 Billings HQ	68
R6 Havre Area Resource Office	105
R6 Glasgow HQ	100