Montana Fish, Wildlife & Parks' 2023 Chronic Wasting Disease Surveillance and Monitoring Report

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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 2023, FWP prioritized sampling in northcentral, southwestern, southcentral, and eastern Montana. FWP continued CWD management in the Libby CWD Management Zone with the 5th annual Special Libby CWD Hunt and through agency trapping and removal of white-tailed deer within the town of Libby. Additionally, CWD management was conducted in southwest Montana through the 4th consecutive special CWD hunt known as the Southwestern Montana CWD Management Hunt. FWP offered free state-wide testing. Hunters could submit samples via mail, at CWD sampling stations, and at all FWP regional offices in 2023.

During the 2023-2024 season, FWP tested 7188 samples from mule deer (n=2926), white-tailed deer (n=3258), elk (n=968), and moose (n=36). Of these, 238 animals tested positive for CWD, including 86 mule deer, 151 white-tailed deer, and 1 elk. In 2023, CWD was detected in 3 new hunting districts: 213, 471, 703. Among CWD-positive hunting districts across the state, prevalence estimated from hunter-harvested and agency trapped animals sampled from 2021-2023 ranged from <1% - 19% in mule deer and <1% - 30% in white-tailed deer, including data from CWD Management Zones. Within white-tailed deer, CWD prevalence was highest in hunting districts 322 (30%, 95%CI: 28-33%, N = 1323) and 340 (13%, 95%CI: 10-18%, N = 305). Based on a small sample size, hunting district 555 (14%, 95%CI: 4%-40%, N = 14) also had a very high CWD prevalence in white-tailed deer but also had a wide confidence interval. Within mule deer, in districts that are well-sampled, CWD prevalence was highest in hunting districts 600 (19%, 95%CI: 15-23%, N = 295), 640 (14%, 95%CI: 11-18%, N = 348), and 670 (10%, 95%CI: 8-13%, N = 566). Notably, hunting district 213 (13%, 95%CI: 2-47%, N=8) had among the highest CWD prevalences in mule deer, but the small number of tested samples led to a broad confidence interval. In the town of Libby, 10% (95%CI: 7-13%, N = 337) of hunter-harvested or trapped white-tailed deer were positive for CWD in 2021 -2023, whereas only 5% (95%CI: 4-7%. N = 830) were positive outside the town within the Libby CWD Management Zone. In the Southwestern Montana CWD Management Hunt Area, the three-year CWD prevalence among hunter-harvested white-tailed deer was 51% (95%CI: 48-55%, N = 707) for 2021-2023.

An analysis of all data collected from 2017-2023 from hunter-harvested deer (n = 25643) in CWD-positive hunting districts suggested several state-wide patterns of infection across species, sex, age class, management zones, and time. Outside of the Libby and SW Montana Management Zones, we found no significant statewide difference in prevalence among adult male white-tailed deer and adult male mule deer. By contrast, the relative risk of CWD in adult female mule deer was significantly lower than in adult female white-tailed deer (female mule deer had 0.3 times the relative risk of adult female white-tailed deer, 95%CI: 0.1-0.6; average prevalence across positive hunting districts was 1% (95%CI: 0.3-1%) in female mule deer and 2% (95%CI: 1-4%) in female white-tailed deer in 2023). We found that males of both species were generally at higher risk of infection than females, with the average model-estimated prevalence across hunting districts at 3% (95%CI: 2-6%) among males and 2% (95%CI: 1-4%) among females outside of CWD management zones. Within age classes for both species, 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 2024, FWP will continue to enforce proper carcass disposal requirements and provide educational materials and programs. FWP will continue to advertise CWD sampling station locations and hours of operation as well as distribute information for hunters who wish to collect and submit their own samples throughout the hunting season. Harvest

management aimed at minimizing the spread and population effects of CWD is ongoing in various regions around the state. CWD management hunts are expected to continue in the Libby CWD Management Zone and Southwest Montana CWD Management Hunt Area. Trap and removal efforts in the town of Libby will also continue to be used to manage CWD prevalence and spread within the area. In 2024, FWP will increase sampling effort in hunting districts with historically small sample sizes that intersect a 40-mile buffer of known positives, where CWD has not yet been found. FWP will target districts in southwestern, central-central, and central-eastern Montana for surveillance and monitoring to improve understanding of CWD presence and prevalence in these hunting districts.

Background

Chronic Wasting Disease 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 course of infection. The CWD-associated prion is transmitted via direct animal-to-animal contact and indirectly 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 35 US states, four Canadian Provinces, Norway, Sweden, Finland, and South Korea (USGS, 2024). CWD is generally considered a 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 early detection of CWD 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 (CDC, 2021).

Introduction

Surveillance programs for CWD are essential for 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 or adjacent to Montana where CWD has not yet been detected. In addition, once an area is determined to be positive for CWD, FWP focuses on monitoring prevalences and 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 2023, FWP conducted CWD surveillance and monitoring in northcentral, southwestern, southcentral, and eastern Montana (Figure 1). FWP organized the 4th annual special CWD management hunt in southwestern Montana in 2023 in response to the high prevalence of CWD detected there. In addition, FWP conducted the 5th annual Special CWD Management Hunt in the Libby CWD Management Zone and continued to trap and euthanize white-tailed deer within the town of Libby as part of an 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 2023. Below, we report on the results and lessons learned from the 2023 CWD surveillance and monitoring efforts.

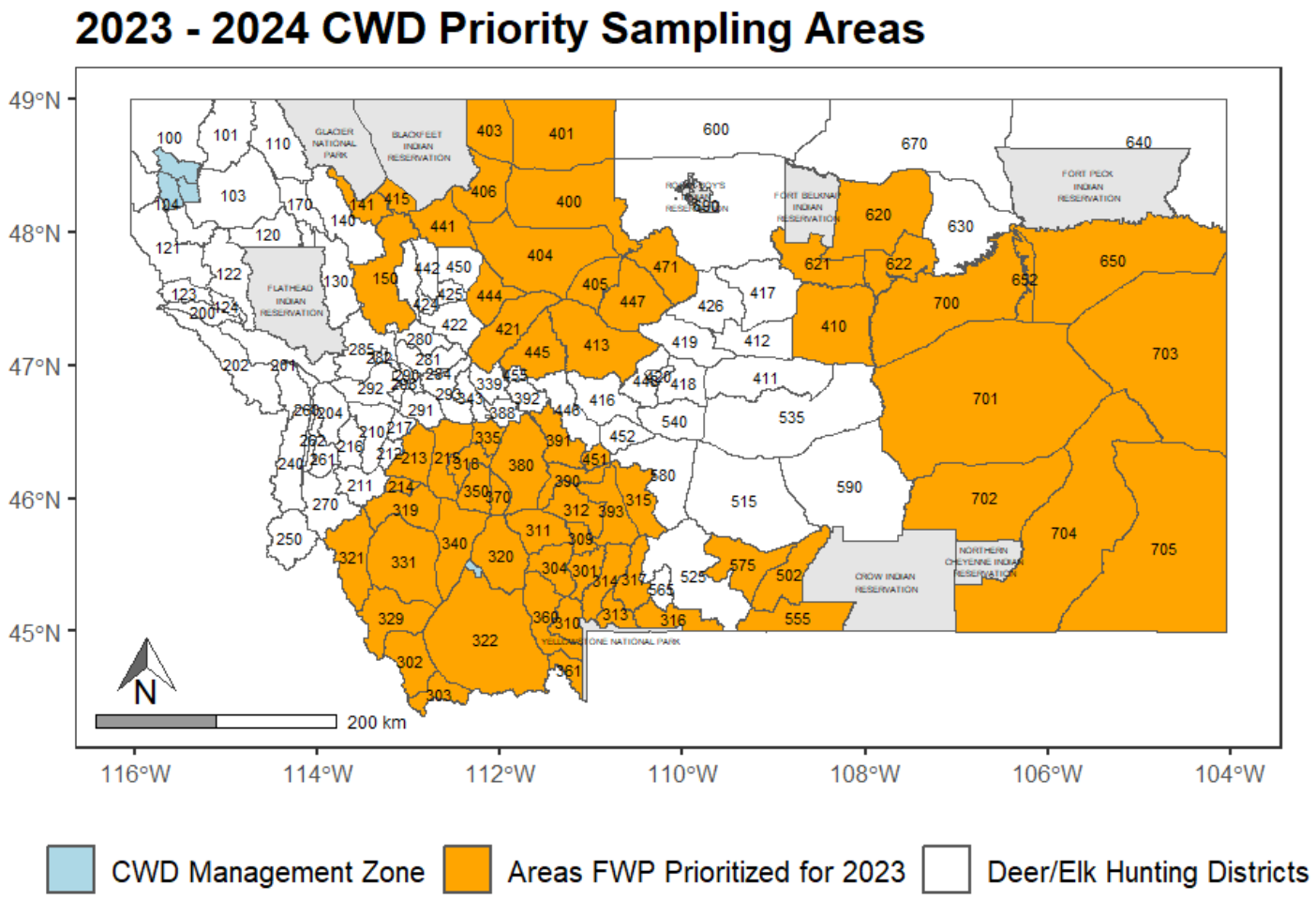

Figure 1. CWD priority sampling areas in Montana, 2023. CWD surveillance and monitoring areas included northcentral, southwestern, southcentral, and eastern Montana, shown in orange. Boundaries of the CWD Libby Management Area and the Southwestern Montana CWD Management Hunt Area (located in hunt district 322) are displayed in light blue. Note that hereafter the Libby Management Area includes animals harvested and trapped within the town of Libby (Libby Surveillance Areas) unless otherwise stated.

Methods

Surveillance

In 2023, FWP focused its surveillance efforts on districts where CWD had not yet been detected in northcentral, southwestern, southcentral, and eastern Montana. Priority sampling areas are broken into priority surveillance areas (PSAs), priority areas where CWD has not yet been detected, and priority monitoring areas (PMAs), priority areas where positive CWD samples have been collected and where FWP collects data to establish prevalence. Priority sampling areas have been previously comprised of minimum surveillance units (MSUs) that sometimes included one or more hunting districts. In 2023, MSUs were the

same as hunting districts within priority sampling areas and will be referred to as hunting districts here forward. Within each hunting district, 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 each hunting district, were necessary to meet our detection goals in each hunting district. Sample size goals were specific to a single species within a hunting district, and our efforts prioritized the sampling of deer since they 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	0.001	NA

FWP staff collected samples between July 1, 2023 – March 15, 2024, 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 sampling stations, processors and taxidermists, outfitters, landowners, Montana Department of Transportation, 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 were submitted to Montana Veterinary Diagnostic Laboratory for ELISA testing. Samples requiring an IHC test (e.g., moose samples and confirmations of ELISA positives) were sent to Utah Veterinary Diagnostic Laboratory or Colorado State University Veterinary Diagnostic Laboratory on a weekly basis. In previous years, samples have also been sent to the National Veterinary Services Laboratory. Testing costs were $15/sample for the ELISA, and $37.00 - 38.50/sample for IHC, depending on the lab. Results from hunter-harvested animals were posted on FWP's website as soon as results were received from the lab and the submitting hunter was notified of their available online results via

email. Differing from previous years, FWP only contacted hunters via phone upon a harvested animal testing positive for CWD on the ELISA (labeled a "suspect") if 1) the hunter did not list an email address, 2) the positive sample was harvested in a hunting district that had no previous positive samples, or 3) the hunter indicated the positive animal would be processed at a commercial meat processor or donated to a foodbank. IHC confirmations were typically available 1-3 weeks later, so we did not require hunters to wait for that result before legally disposing of the carcass.

In addition to the focused sampling efforts in the 2023 priority sampling areas, FWP collected or received samples from symptomatic or hunter-harvested animals statewide. Hunters that harvested an animal outside of the priority sampling areas and wanted to have their animal tested either brought their animal to a CWD sampling station, a regional headquarters/area office, or were instructed how to collect and mail in their samples. Testing costs were paid by FWP. The video instructing hunters how to collect their own CWD sample can be found at fwp.mt.gov/conservation/chronic-wasting-disease under "Hunter Info."

Monitoring of prevalence and distribution within CWD Positive Areas

In 2023, FWP continued to prioritize sample collection for monitoring of known positive areas in northcentral, southwestern, southcentral, and eastern Montana, and continued to test any hunter-submitted samples from other hunting districts around the state. In 2023, FWP held the 4th annual Special CWD Management Hunt in southwestern Montana. In addition, FWP held the 5th annual Special CWD Management Hunt within the Libby CWD Management Zone and continued to trap and euthanize white-tailed deer in the town of Libby to further reduce deer densities. Although CWD testing was not required, it was encouraged to improve our estimates of CWD prevalence and distribution in Priority Sampling Areas (Figure 1). To reflect a more recent and current estimate, prevalence estimates in this report were calculated using only data from hunter-harvested or agency trapped and euthanized animals (i.e., town of Libby), from 2021-2023. Beginning with this 2023 CWD Annual Report, some annual model-estimated prevalences were also provided. The increased robustness of the data set allowed the incorporation of a year effect and yielded better fitting models for our analysis of trends. (See Results and Discussion.)

Data summaries and analyses

For surveillance, 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) using data collected from 2021-2023. For each species, we tallied the number of samples collected within each of the age/sex/cause of death categories outlined in Table 1, multiplied this by their assigned point value, and summed all points within a hunting district. 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:

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

All analyses were carried out in Program R (R Core Team 2024). For CWD monitoring following detection and in consistence with previous CWD Annual Reports, we reported three-year observed prevalences using CWD

samples from hunter-harvested and agency trapped animals from 2021-2023. Three-year prevalence estimates were calculated using the proportion of positive tests and the Wilson method to calculate confidence intervals. We also explored patterns of infection among hunter-harvested and management-removal deer in CWD-positive hunting districts and management zones using logistic, generalized linear mixed models (Package glmmTMB, Brooks et al. 2017). We evaluated the probability of CWD infection as a function of fixed-effects including species, sex, age class, whether the animal was harvested in the Libby CWD Management Zone (including the town of Libby), Southwestern Montana CWD Management Hunt Area (i.e. SW Montana Management Zone), or outside of these areas, and time (Year). We used hunting district or management zone as a random intercept effect and explored random slopes of either Year or Species by hunting district/management zone. Models with various permutations of these covariates were evaluated using Akaike's Information Criterion (AIC; Burnham and Anderson 2004), and 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); it can also be calculated as the ratio of the estimated prevalences of the two groups being compared). We report prevalence at the scale of hunting districts, and the Libby CWD Management Zone or Southwestern Montana CWD Management Hunt Area (also referred to as SW Montana Management Zone). We calculated 95% binomial confidence intervals using the Wilson method.

Results

Between July 1, 2023 – March 15, 2024, FWP submitted 7188 samples that were suitable for testing, which was a 2% increase from the number of samples collected in 2022 (n=7027) and a 17% decrease compared to the number of samples collected in 2021 (n=8690) (Table 2). Most of these samples were analyzed at Montana Veterinary Diagnostic Laboratory, with a much smaller number of IHC tests conducted at Colorado State University Veterinary Diagnostic Laboratory and Utah Veterinary Diagnostic Laboratory. Of these samples, 2926 were collected from mule deer, 3258 from white-tailed deer, 968 from elk, and 36 from moose. Forty-four percent (n = 3137) of testable samples were collected from outside our priority sampling areas. Hunters collected and submitted 945 of their own samples in 2023 and, of the hunter-submitted samples, 926 (98%) were suitable for testing. Hunter submitted testable samples made up 14% of all submitted testable samples in 2023. Table 3 includes summaries of hunter submitted samples for other years. Since FWP's renewed surveillance efforts in 2017, we have tested 41627 samples statewide (Figure 2). FWP detected 238 CWD positive cervids during the 2023 sampling season, which included 86 mule deer, 151 white-tailed deer, and 1 elk. In the 2023 sampling season, we detected CWD in 3 new hunting districts, including: 213, 471, and 703 (Figure 2).

Table 2: Testable CWD Samples submitted by year.

Year	Total Testable Samples
2017	1963
2018	6840
2019	7938
2020	7938
2021	8690
2022	7027
2023	7188

Table 3: Hunter-submitted CWD samples by year.

Year	Hunter-Submitted Samples	Testable Hunter-Submitted Samples	Proportion Testable	Proportion of All Hunter-Harvested Samples
2017	5	5	1.00	0.003
2018	10	10	1.00	0.005
2019	1126	1052	0.934	0.162
2020	1156	1152	0.997	0.153
2021	1035	1018	0.984	0.123
2022	620	610	0.984	0.093
2023	945	926	0.980	0.139

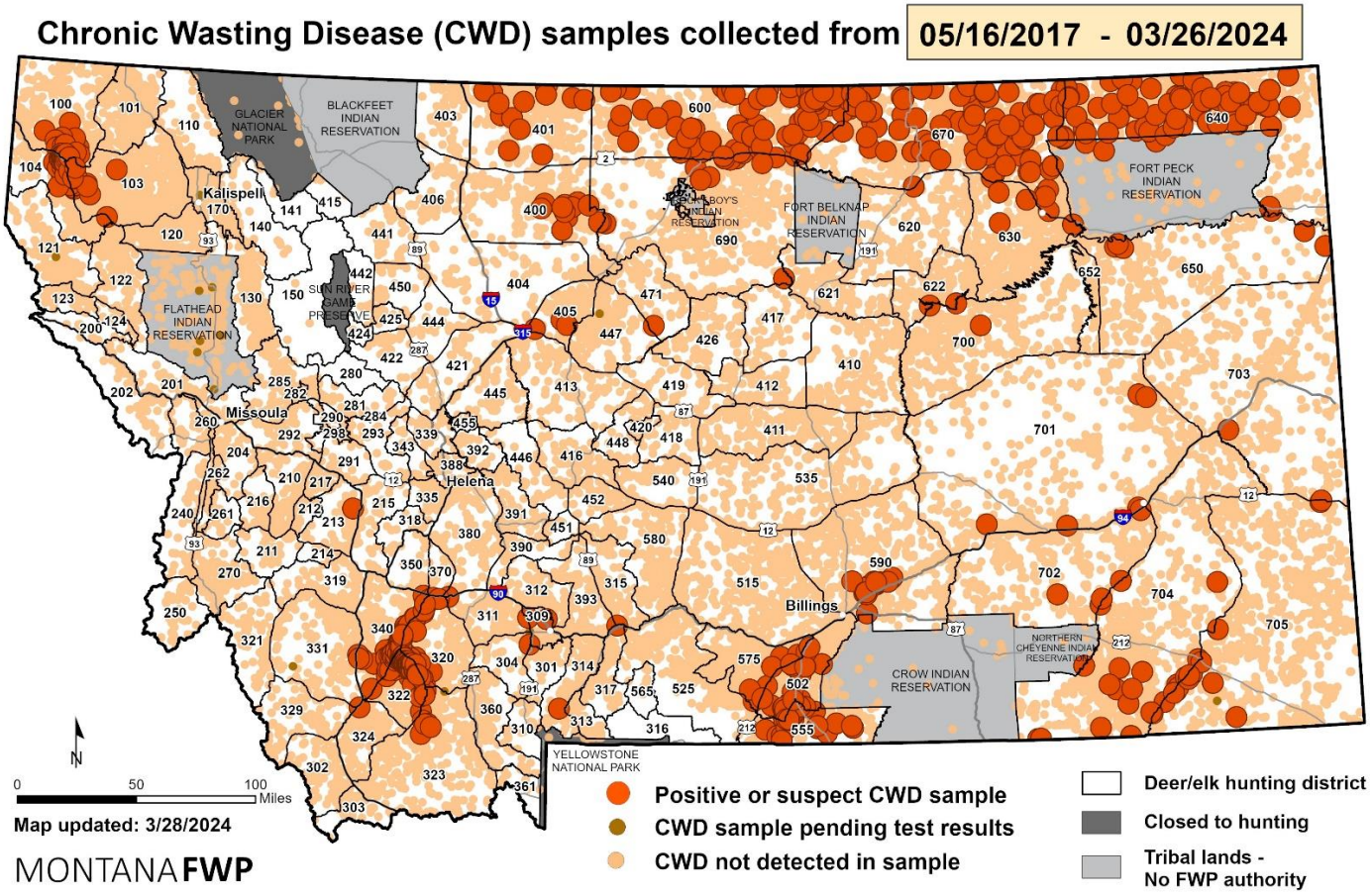

Figure 2. Map of sampling locations and CWD positives among deer, elk, and moose from 2017-2024.

Priority sampling areas are broken into priority surveillance areas (PSAs), priority areas where CWD has not yet been detected, and priority monitoring areas (PMAs), priority areas where positive CWD samples have been collected and where FWP collects data to monitor prevalence. In PSAs, FWP's goal as outlined in the 2020 CWD Management Plan is to achieve 300 weighted sampling points over no more than a 3-year period to

determine if CWD is present at >1% prevalence with 95% confidence. Within PSAs, we only met our goal of 300 weighted surveillance points in HD 312 with samples from white-tailed deer. In all other 2023 PSAs in northcentral Montana (i.e., hunting districts 141, 150, 403, 404, 406, 413, 415, 421, 441, 444, 445, 447, 471), southwest Montana (i.e., hunting districts 213, 214, 215, 301, 302, 303, 310, 312, 313, 315, 316, 318, 319, 321, 329, 331, 335, 350, 360, 361, 370, 380, 390, 391, 393, 451), and eastern Montana (i.e. 410, 620, 621, 652, 703), we failed to meet our surveillance points within each hunting district (Appendix I, Figure A1). All priority sampling area hunting districts in southcentral Montana (i.e. 502, 555, 575) were PMAs. Falling short of the 300-point goal suggests that we cannot rule out the presence of CWD at <1% prevalence with 95% confidence in these hunting districts. Additional sampling is warranted among these hunting districts to achieve the necessary surveillance goals. As of the 2023 sampling season, CWD was found to be present in priority surveillance hunting districts 213, 471, and 703 (Figure 2). Though we did not meet the 300 points for surveillance among any species in hunting districts 213, 471, and 703, future sampling effort in these hunting districts will be geared toward monitoring due to these new positive samples.

Among all CWD-positive hunting districts, three-year prevalence estimated from hunter-harvested animals sampled from 2021-2023 ranged from <1% - 19% in mule deer and <1% - 30% in white-tailed deer (Figure 3 and 4; see Appendix II for prevalence estimates by hunting district), with 95% confidence intervals of varying widths. Appendix II, Figure A2 shows 2021-2023 sampling numbers for PMAs. Estimates of prevalence in most PMAs in northcentral Montana (i.e. 401, 400, 405), southwestern Montana (i.e. 309, 311, 314, 317, 320, 322, 340) southcentral Montana (i.e. 502, 555, 575), and eastern Montana (i.e. 622, 650, 700, 701, 702, 704, 705) were improved by another year of sampling (Figures 3 and 4 and Appendix II, Figure A2). Specifically, in northcentral Montana, we reached the targeted range of precision (+/- 3% margin of error; i.e. a 95% confidence interval no wider than 0.06) in mule deer prevalence estimates in HD 400 and HD 405. In southwestern Montana, we reached our target precision in HDs 309, 311, 317, 320, and 322 in white-tailed deer and in HD 322 in mule deer. In southcentral Montana, we reached target precision in HD 575 in mule deer prevalence estimates. In eastern Montana, we reached target precision in HDs 650, 700, 701, 702, 704, 705 in mule deer and in HD 701 for white-tailed deer.

Using the proportion of positive tests and the Wilson method to calculate confidence intervals, we calculated three-year observed prevalences for management areas and hunt districts (see Appendix II for a table of three-year observed prevalences for all hunting districts). Between 2021-2023 in the town of Libby, known as the Libby Surveillance Area, 10% (95%CI: 7-13%) of hunter-harvested or trapped white-tailed deer were positive for CWD, whereas only 5% (95%CI: 4-7%) were positive outside the town but otherwise within the Libby Management Zone. Between 2021-2023 statewide, including CWD Management Areas, CWD prevalence among hunter-harvested and FWP trapped white-tailed deer was highest in hunting districts 322 (30%, 95%CI: 28-33%, N = 1323) and 340 (13%, 95%CI: 10-18%, N = 305). Based on a small sample size, hunting district 555 (14%, 95%CI: 4%-40%, N = 14) also had a very high CWD prevalence in white-tailed deer but also had a wide confidence interval. Among hunter-harvested mule deer, in districts that were well-sampled, CWD prevalence was highest in hunting districts 600 (19%, 95%CI: 15-23%, N = 295), 640 (14%, 95%CI: 11-18%, N = 348), and 670 (10%, 95%CI: 8-13%, N = 566). Notably, hunting district 213 (13%, 95%CI: 2-47%, N=8) had among the highest CWD prevalences in mule deer, but the small number of tested samples led to a broad confidence interval.

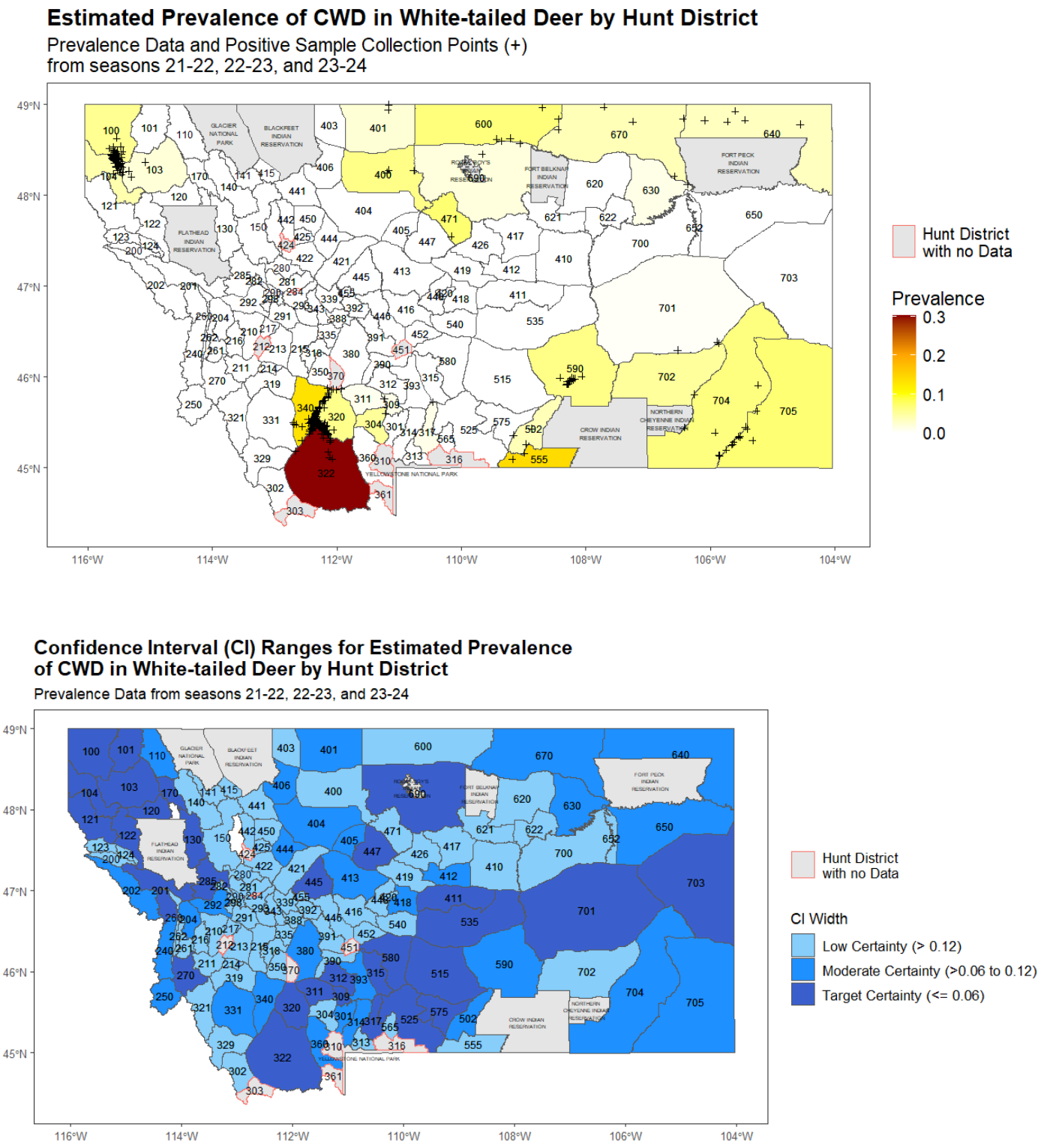

Figure 3. Estimated CWD prevalence in white-tailed deer (top map), estimated by hunting district across Montana, 2021-2023. Prevalence is calculated by dividing the number of test-positives by the total number of animals sampled. Only data from hunter-harvested or agency removal/trapping were used to calculate prevalence. The corresponding confidence interval ranges are displayed in the bottom map. The numbers represented in the legend (CI Width) show the range the prevalence estimate has within a 95% confidence interval. 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.

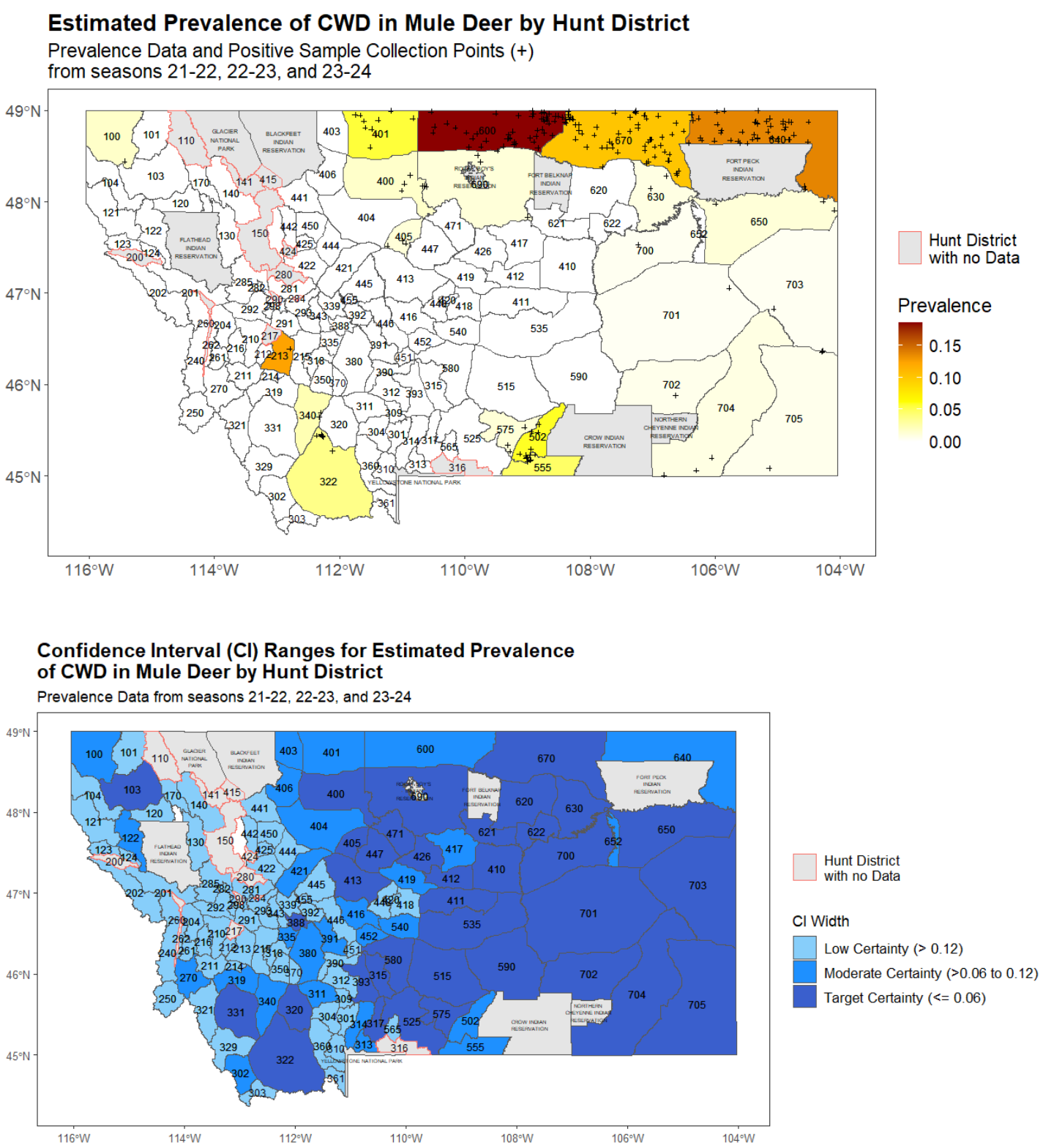

Figure 4. Estimated CWD prevalence in mule deer (top map), estimated by hunting district across Montana, 2021-2023. Prevalence is calculated by dividing the number of test-positives by the total number of animals sampled. Only data from hunter-harvested or agency removal/trapping were used to calculate prevalence. The corresponding confidence interval ranges are displayed in the bottom map. The numbers represented in the legend (CI Width) show the range the prevalence estimate has within a 95% confidence interval. 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.

An analysis of all data collected between 2017-2023 from deer harvested by hunters or removed during management efforts in CWD-positive hunting districts (n= 25,371) suggested several state-wide patterns of infection across species, sex, age class, location, and time. Our best-supported model indicated that the probability of an animal testing positive for CWD was influenced by deer species, sex, a species by sex interaction, age class, whether the deer was harvested or removed inside the Libby Management Zone, the SW Montana Management Zone, or outside of the two management areas (a categorical variable referred to as "MGZN2"), time, and a time by MGZN2 interaction (see Appendix III for the list of evaluated models). Our best supported model also indicated that starting prevalences of CWD and the estimated effect of species varied by hunting district or Management Zone (i.e. random intercept and slope model; Figures 5 & 6).

Our best-supported model identified white-tailed deer CWD hotspots in the Libby and SW Montana Management Zones, although white-tailed deer prevalence was only significantly higher within the SW Montana Management Zone as compared to estimates from elsewhere around the state. CWD Management in the Libby area includes trap and removal efforts in the town of Libby (Libby Surveillance Area) as well as harvest management in the designated area surrounding the town of Libby (the Libby Management Zone). For this analysis, we refer to the Libby Management Zone (Figure 1) as including all data within the Libby Surveillance Area and Libby Management Zone, unless otherwise stated. In 2023, adult male and female white-tailed deer in the Libby Management Zone had 2.3 (95%CI: 0.3 –11.9) and 2.3 (95%CI: 0.3 – 14.1) times the risk of infection, respectively, compared to adult male and female white-tailed deer from elsewhere in the state. In 2023 in the SW Montana Management Zone, adult male and female white-tailed deer had 22.0 (95%CI: 8.4 – 27.7) and 31.1 (95%CI: 9.4 – 43.8) times the risk of infection, respectively, compared to adult male and female white-tailed deer from elsewhere in the state. In 2023, the model-estimated adult white-tailed deer prevalence inside the Libby Management Zone was 11% (95%CI: 8-15%) among males and 7% (95%CI: 5-10%) among females (Figure 6); in the SW Montana Management Zone, it was 76% (95%CI: 70-81%) among males and 66% (95%CI: 59-73%) among females (Figure 6); and outside of these areas, the average model-estimated prevalence across hunting districts was 3% (95%CI: 2-6%) among males and 2% (95%CI: 1-4%) among females, respectively (Figure 5). Inside the Libby Management Zone, male white-tailed deer had 1.6 times the relative risk of CWD of females (95%CI: 1.4-1.9); inside the SW Montana Management Zone, male white-tailed deer had 1.1 times the relative risk of CWD of females (95%CI: 1.1-1.2).

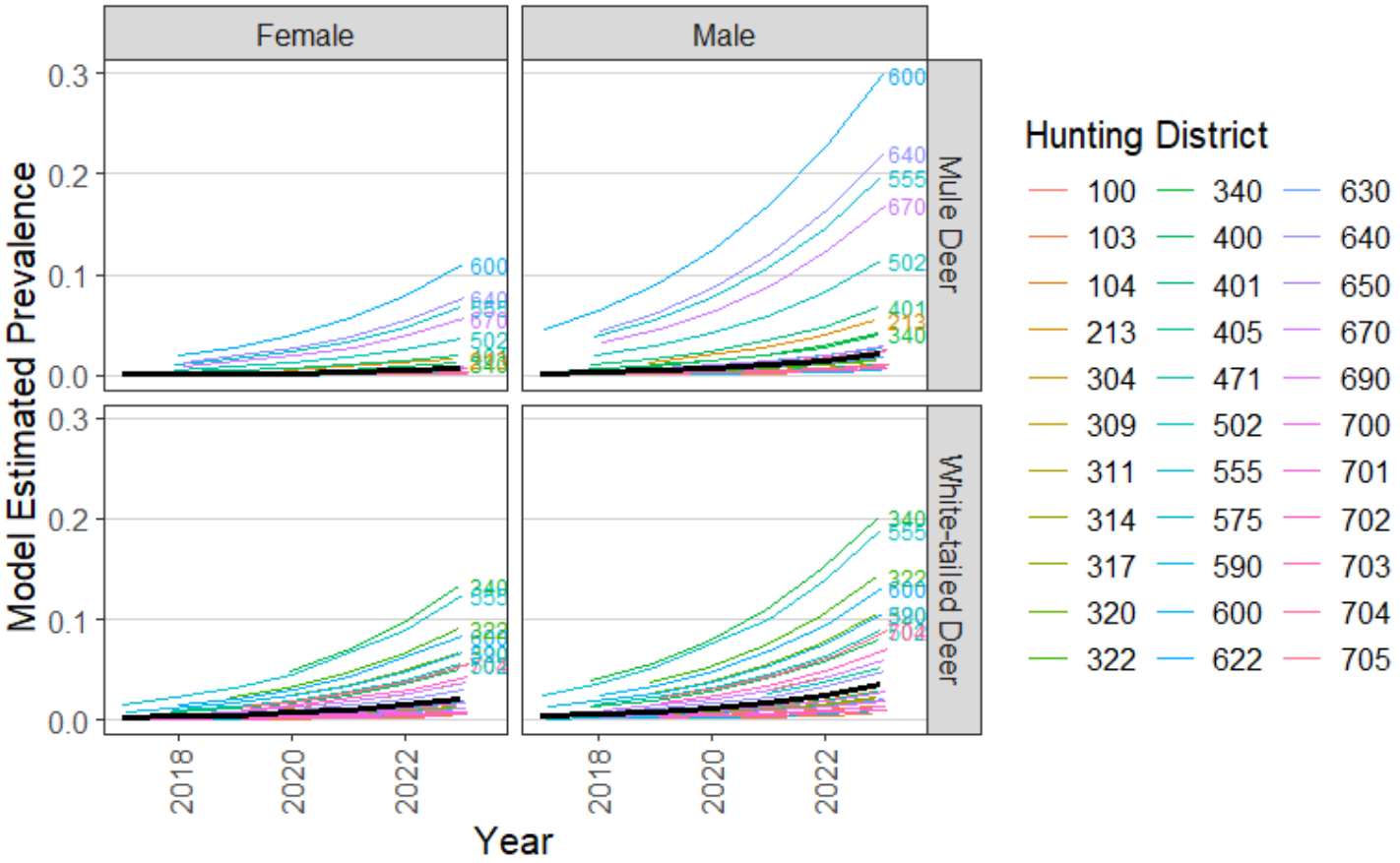

Figure 5. Model-estimated prevalence from 2017-2023, based on our best-supported model, for CWD-positive hunting districts. The bold black lines indicate the average prevalence over time across CWD-positive hunting districts. The top 8 highest prevalence districts in 2023 are labeled for reference (in mule deer: 600, 640, 555, 670, 502, 401, 213, 340; in white-tailed deer: 340, 555, 322, 600, 590, 320, 704, 502). Prevalence estimates for hunting districts 100, 103, 104, and 322 exclude data from the Libby and SW Montana Management Zones.

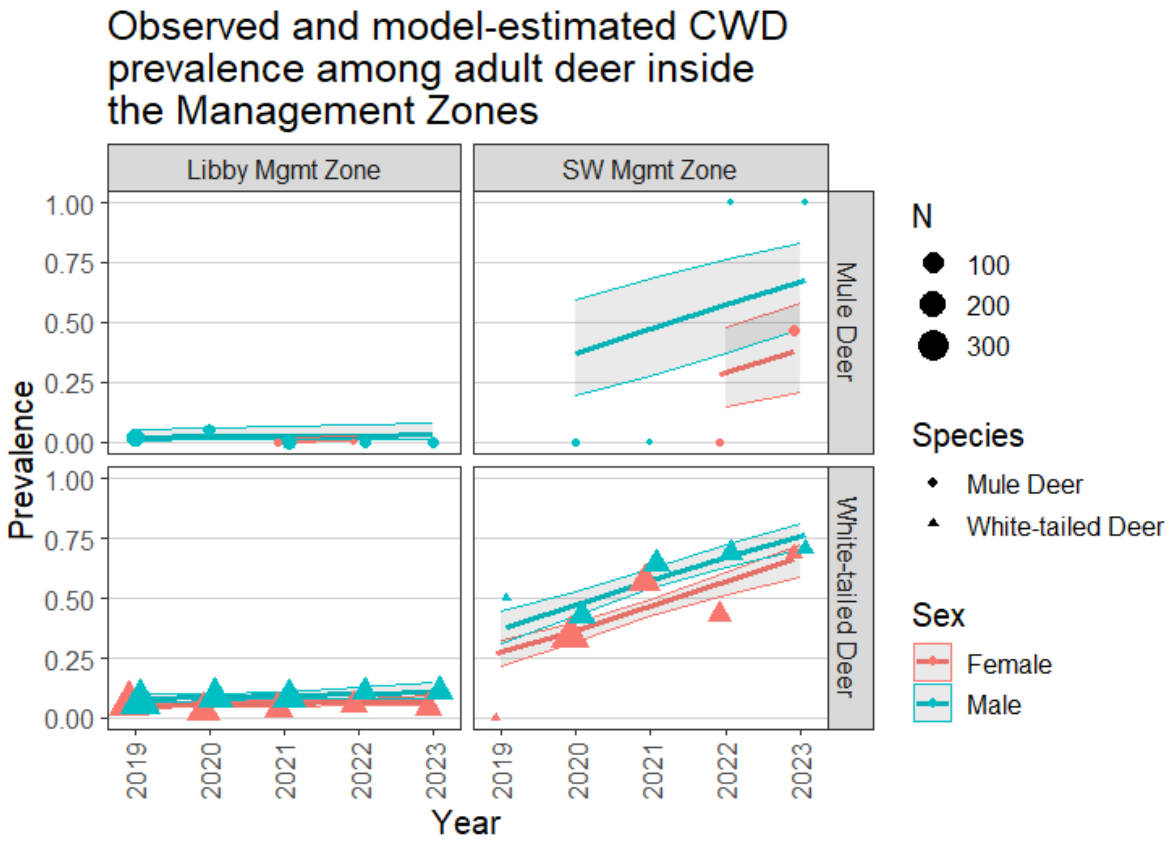

Figure 6. Observed (points) and model-estimated (bold lines) CWD prevalence among adult mule deer and white-tailed deer from 2019-2023 within the Libby and SW Montana Management Zones. Female and male data are denoted in red and blue, respectively. Sample sizes (N) are denoted by point size. The grey ribbon represents the 95% confidence interval around the model-estimated prevalence.

Outside of the Libby and SW Montana Management Zones, we found no significant statewide difference in prevalence among adult male white-tailed deer and adult male mule deer (adult male mule deer have 0.6 times the relative risk of adult male white-tailed deer, 95%CI: 0.3 – 1.1; average prevalence across positive hunting districts is 3% in male white-tailed deer versus 1% in male mule deer). By contrast, the relative risk of CWD in adult female mule deer was significantly lower than in adult female white-tailed deer (female mule deer had 0.3 times the relative risk as adult female white-tailed deer, 95%CI: 0.1-0.6; average prevalence across positive hunting districts was 1% (95%CI: 0.3-1%) in female mule deer and 2% (95%CI: 1-4%) in female white-tailed deer). In both cases, there was substantial variation among hunting districts and management zones as to whether white-tailed deer or mule deer were more likely to be positive (Figure 7).

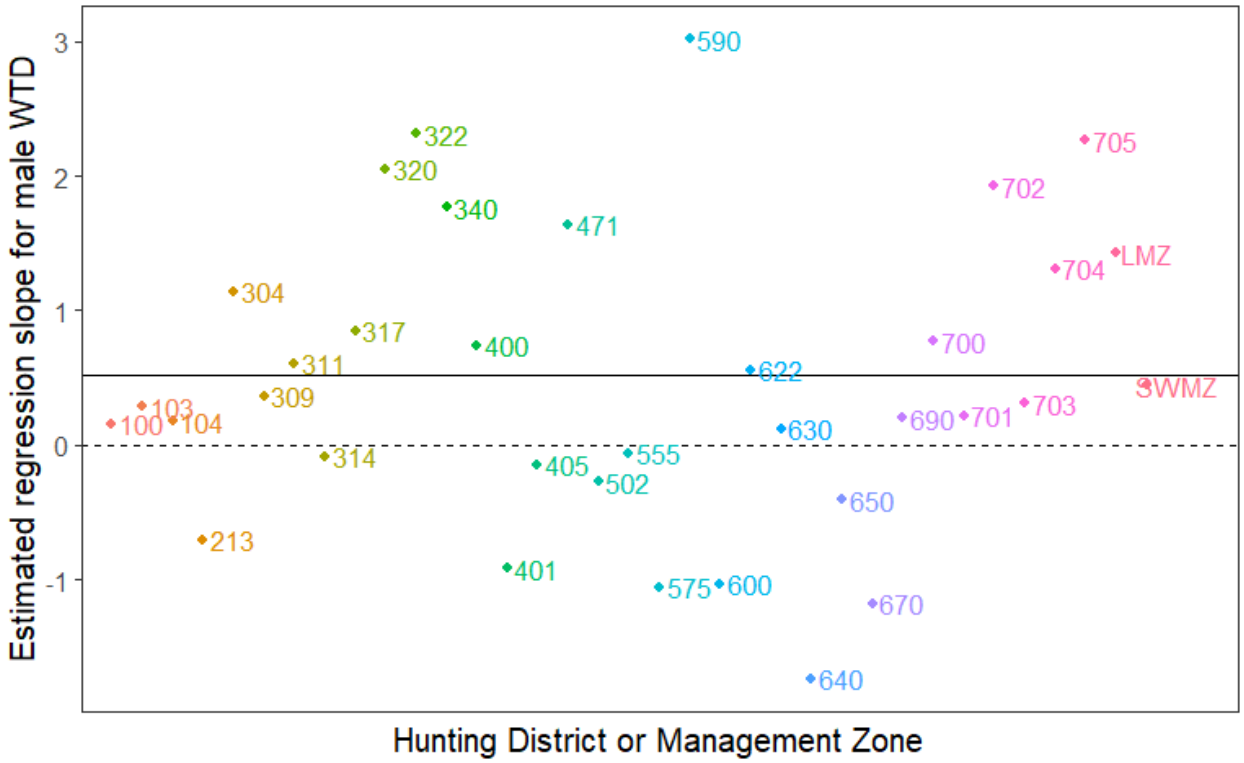

Figure 7. Hunting district or Management Zone-specific slope estimates for male white-tailed deer (WTD) as compared to male mule deer. The horizontal black line indicates the average slope estimate, across hunting districts and Management Zones, indicating a slight bias, on average, towards higher prevalences among male white-tailed deer versus male mule deer. A slope of 0, denoted by the dashed line, indicates no difference between species in the probability of testing positive for CWD. Points that fall above the solid horizontal line indicate districts or management zones where male white-tailed deer are more likely than average to test positive for CWD than male mule deer; points that fall below the dashed line where the estimated species slope is 0, indicate districts or management zones where male mule deer are more likely to test positive than male white-tailed deer.

In 2023 outside of the CWD Management Zones, adult male mule deer had 3.4 times the risk of infection of adult females (95%CI: 2.5 – 4.6), and model-estimated average adult male mule deer prevalence across positive hunting districts was 2% (95%CI: 1-4%) versus 1% (95%CI: 0.3-1%) among adult females (Figure 5). Outside of the CWD Management Zones, adult male white-tailed deer had 1.6 times the relative risk as females (95%CI: 1.4 – 1.9; adult white-tailed deer female prevalence = 2% (95%CI: 1-4%), adult white-tailed deer male prevalence = 3% (95%CI: 2-6%)). Across deer species in CWD-positive hunting districts, young of the year and yearlings had 0.1 times (95%CI: 0.1 – 0.2) and 0.5 times (95%CI: 0.4 – 0.6) the risk of infection as adults, respectively.

Outside of the two CWD Management Zones, CWD has had a maximum annual growth rate of 36% across mule deer and white-tailed deer between 2017-2023 (the estimated coefficient on Year is: $\beta = 0.36$ (se = 0.03)). When estimated from species-specific versions of our best-supported model, where we use all the same covariates except species, white-tailed deer have an estimated maximum annual CWD growth rate of 38% (se = 0.05) versus 35% in mule deer (se = 0.03). We found that the Libby Management Zone had a significantly slower annual growth rate in prevalence between 2017-2023, estimated at 10% (se = 0.06), when compared to CWD-positive hunting districts and the SW Montana Management Zone (Figures 5, 6, 8 & 9). The annual growth in CWD prevalence in the SW Montana Management Zone was not statistically different from

that of other CWD-positive hunting districts, although, as prevalence has reached 66% and 76% in adult female and male white-tailed deer, the realized annual change is starting to slow (e.g. the annual relative risk from 2022-20203 in male white-tailed deer was 1.09 (95%CI: 1.06-1.11)) suggesting that the epidemic in this area is no longer in the exponential growth phase. In 2023, we also observed a slight decline in CWD prevalence across many hunting districts, which anecdotally followed the severe winter of 2022-2023. General trends in annual CWD prevalence in adult male mule deer and white-tailed deer can be seen in Figures 8 and 9, respectively.

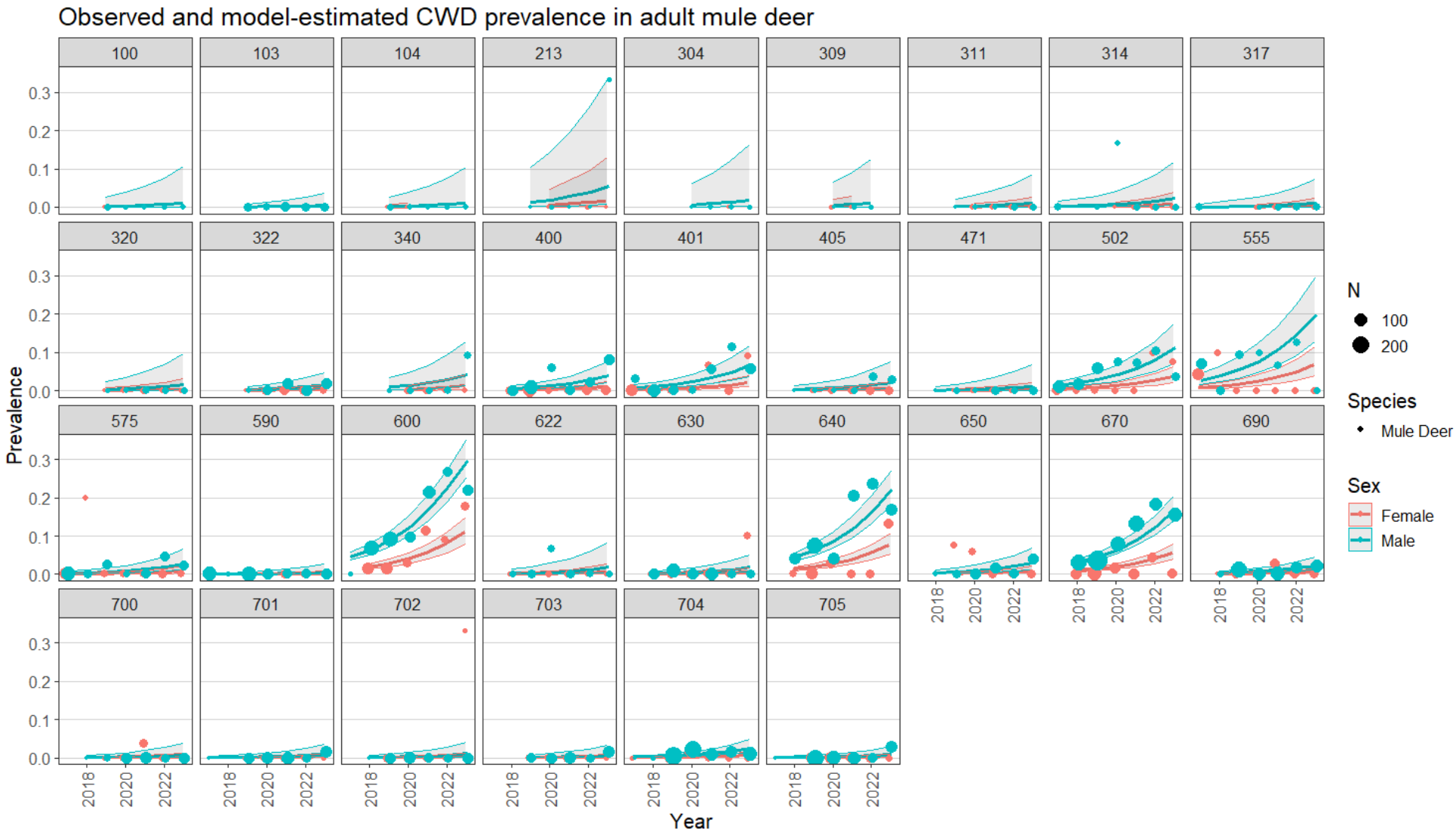

Figure 8. Observed (points) and model-estimated (bold lines) CWD prevalence among adult mule deer from 2017-2023 within CWD-positive hunting districts. Female and male data are denoted in red and blue, respectively. Sample sizes (N) are denoted by point size. The grey ribbon represents the 95% confidence interval around the model-estimated prevalence. Prevalence estimates for hunting districts 100, 103, 104, and 322 exclude data from the Libby Management Zone and SW Montana Management Zone.

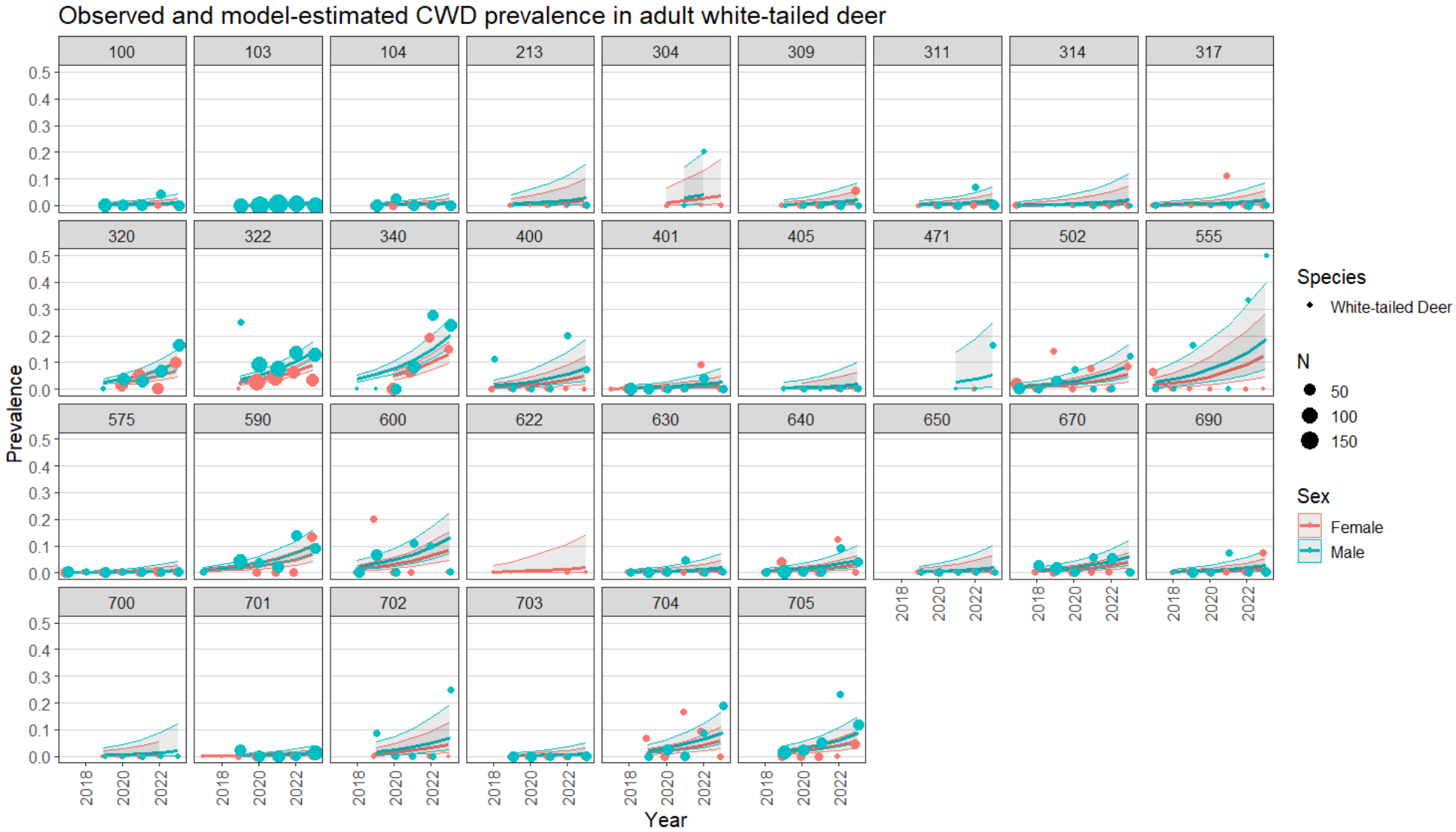

Figure 9. Observed (points) and model-estimated (bold lines) CWD prevalence among adult white-tailed deer from 2017-2023 within CWD-positive hunting districts. Female and male data are denoted in red and blue, respectively. Sample sizes (N) are denoted by point size. The grey ribbon represents the 95% confidence interval around the model-estimated prevalence. Prevalence estimates for hunting districts 100, 103, 104, and 322 exclude data from the Libby Management Zone and SW Montana Management Zone.

CWD Management Hunts:

Southwestern Montana CWD Management Hunt

FWP ran the Southwestern Montana CWD Management Hunt from December 10, 2023–February 15, 2024, in a portion of hunting district 322 (referred to as "SW Montana Management Zone" above; Figure 2). That was the fourth consecutive year a CWD management hunt for white-tailed deer was implemented in southwest Montana. During the initial two years, the hunt area was broad and the primary objective was to improve our understanding of the prevalence and distribution of CWD among white-tailed deer. In 2022, the CWD management hunt area was reduced in size to focus hunter harvest within an area of known high CWD prevalence among white-tailed deer. The primary objective of the hunt became reducing that localized population of white-tailed deer to the lowest extent possible through hunter harvest of all sex and age classes. In 2023, the management hunt was implemented across the same focused area as in 2022. Mule deer were included in the 2023 hunt in response to testing results that showed high CWD prevalence among a population of mule deer within the hunt area.

During the 2023 hunt, hunters were allowed to use any unused 2023 general deer licenses, 003-00 white-tailed deer B-licenses, and 399-00 white-tailed deer B-licenses. Either-sex of white-tailed deer could be harvested using any of the licenses. Antlerless mule deer could be harvested using the general deer license. The white-tailed deer B-licenses 003-00 and 399-00 were also available for purchase throughout the hunt. There were no testing or reporting requirements associated with the hunt. However, 28 white-tailed deer and 6 mule deer were harvested in the SW Montana CWD Management Area and submitted for CWD testing December 10, 2023 to February 28, 2024. Of those, 21 of the white-tailed deer and 3 of the mule deer were CWD-positive. Collectively, during the entire 2023 sampling season and across all age and sex classes, the observed prevalence of white-tailed deer was 62% (95%CI: 52-72%) within the SW Montana Management Zone, increasing from 48% (95% CI: 41-54) in 2022. At the hunting district level for the 2023 sampling season, observed prevalence of white-tailed deer in hunting districts 322, 340, and 320 was 30% (95%CI: 28-33%), 13% (95%CI: 10-18%), and 6% (95%CI: 3-9%), respectively. (Appendix I, Figure A5 & Appendix II).

Libby

In late 2021, Libby's City Council passed Resolution 1979, which acts as the city's temporary deer management plan. The goals of Resolution 1979 include: 1) eliminating sickly and aggressive deer, 2) reducing deer damage to private property, 3) preventing illegal feeding of deer, 4) educating the public about safe disposal of deer carcasses, and 5) cooperating with FWP on their CWD management goals. Resolution 1979 allows FWP to continue to cooperatively manage deer inside city limits with the goal of reducing CWD prevalence to <5%. FWP offered 2,000 either-sex white-tailed deer licenses (199-20 B-licenses) during the 2023 season as part of the ongoing effort to increase harvest within the Libby CWD Management Area. From January 2, 2024 through March 7, 2024, FWP trapped, euthanized, and tested an additional 60 white-tailed deer within the Libby Surveillance Area (i.e., town of Libby), of which 7 were positive or suspect. Using data from hunter-harvested or trapped and euthanized white-tailed deer during the 2023 sampling season, observed prevalence was 8% (95%CI: 5-11%) in the Libby CWD Management Zone, a figure very similar to estimates from previous years' data, 7% (95%CI: 5-10%). The Libby Surveillance Area had an observed prevalence of 13% (95%CI: 8-22%, N = 90) in white-tailed deer, whereas the remaining outer ring of the Libby Management Zone had a prevalence of 6% (95%CI: 3-19%) in white-tailed deer. While the prevalence for the outer ring of the Libby Management Zone for 2023 was very similar to 2022, there was a substantial increase in the prevalence among white-tailed deer in the Libby Surveillance area from 2022, 9% (95%CI: 5-16%, N = 99), to 2023 (Appendix I, Figure A5). Within the Libby CWD Management Zone for the 2023 sampling season, only 15 mule deer, 3 elk, and 0 moose

were harvested and CWD sampled, and CWD was not detected in any of these samples.

Testing and reporting turn-around time

On average, it took 7 calendar days (sd = 4 days) from the day a sample was collected to the day the ELISA test result was posted online during the 2023 season. This was similar to the turnaround time from 2022, when our average was 8 days and an improvement in turnaround time from 2021, when our average was 10 days. Of this time, it took on average 3 days (sd = 10 days) from the time the sample was collected until shipment to Montana Veterinary Diagnostic Laboratory, and an average of 4 days (sd = 11 days) from the day of shipment until results were received by FWP, which includes 1-2 days of transit time. Using Colorado State University Veterinary Diagnostic Laboratory, the IHC testing of moose samples took an average of 16 days (sd = 4) from the time they were mailed to lab to when FWP received test results.

When a suspect CWD test result was received, FWP staff called hunters if 1) the hunter did not list an email address, 2) the positive sample was harvested in a hunt district that had no previous positive samples, or 3) the hunter indicated the positive animal would be processed at a commercial meat processor or donated to a foodbank. 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. Most hunters with positive animals had either waited for their test result prior to processing or processed their animal at home.

Discussion

Through dedicated CWD surveillance and monitoring efforts, we now know that the disease is found in 33 of Montana's 139 2024-2025 hunting districts and is geographically distributed across much of Montana. Statewide testing that is offered free-of-charge to hunters, while requiring a significant amount of time and resources, continues to be successful at detecting positives in new areas. We plan to continue offering free statewide testing to allow hunters to make informed decisions about meat consumption, improve our understanding of CWD distribution in the state through surveillance, inform prevalence estimates in positive districts through monitoring, and determine and inform future CWD management in Montana.

During the 2023 sampling season, we did not meet our 300-sample surveillance goal in many priority surveillance areas, but we met target precision of three-year prevalence in a much higher proportion of priority monitoring areas. With a decline in annual CWD sample numbers compared to 2020 and 2021 (Table 2), meeting our target sample size in priority sampling areas could become an ongoing challenge. During the 2023 season, the first positive CWD sample was collected in Region 2 (HD 213), which has broadened the known geographic distribution of the disease, increasing the number of hunting districts that should be targeted for surveillance to include 78% of Montana's hunting districts in 2024. This large proportion of hunting districts has led us the further prioritize the 2024 CWD sampling goals beyond those within a 40-mile buffer of known positives. Some districts still in need of additional samples were incorporated into priority sampling areas for the 2024 sampling season. Other districts were excluded to allow us to monitor districts in the 2024 season that have historically been under-sampled, hopefully allowing us to achieve our target detection threshold of ≥1% prevalence with 95% confidence.

The geographic distribution of CWD continues to expand and prevalences continue to increase statewide. In 2023, CWD was detected in three new hunting districts. Between 2017-2023, we estimated that CWD has had a maximum annual epidemic growth rate of 38% among white-tailed deer and 35% among mule deer in

Montana. For the average prevalence observed across hunting districts (1% in MD, 3% in WTD), that annual growth rate translates to an expected increase of just 0.5 - 1 percentage point in prevalence next year. Many districts have lower prevalences, translating to even smaller observed differences in prevalence between years. However, for those districts and management zones that currently have high prevalences, including HDs 600, 640, 555, and 670 for mule deer and HDs 340, 555, and 322 for white-tailed deer, that annual epidemic growth rate could translate to more significant jumps in prevalence in the coming year.

Our best-supported model identified the Libby and SW Montana Management Zones as white-tailed deer hotspots; the SW Management Zone may be becoming a hotspot for mule deer as well, although more data is needed to evaluate this. While we don't have experimental controls that allow us to conclusively measure the impacts of CWD management efforts within these two zones, we used the Year*MGZN2 interaction to explore the hypothesis that our management zones might have different annual growth rates compared to less-intensively managed positive hunting districts. The Libby Management Zone has experienced a significantly lower rate of annual growth than we would expect based on trends elsewhere around the state (Figure 6), particularly in the core Libby Surveillance Area where white-tailed deer are trapped and euthanized (Figure A5). The annual rates of change in the SW Montana Management Zone appear to be statistically similar to those outside the zone, suggesting that it's likely more difficult to impact the trajectory of an epidemic through trapping and removal when prevalences are very high at the time of discovery.

Hunting districts vary in terms of their prevalence at the time of CWD detection as well as which species exhibit higher prevalences. Some districts and management zones, including 322, 320, 340, 471, 702, 704, 705, and the Libby Management Zone, have higher prevalences among white-tailed deer than mule deer. Other districts have higher prevalences in mule deer, including 640, 670, 600, 575, and 401. These differences may be due to variation in the dominant species present within a district or the relative timing that a species first became infected within the district. This difference in the species-effect by hunting district was better at explaining variation than a year-effect specific to hunting districts. We currently don't have enough data to estimate a separate year and species effect for each hunting district.

Statistical modelling showed patterns of CWD prevalence related to sex. 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), and 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). In Montana, males still have higher prevalences than females for both mule deer and white-tailed deer. The magnitude of difference between the sexes in white-tailed deer are the same for Libby and the other positive hunting districts (males have 1.6 times the relative risk of females), whereas within the SW Management Zone, male and female white-tailed deer prevalences are closer (male:female relative risk is just 1.1). This may indicate a shift in the relative bias of sex at the advanced stages of an epidemic, and may be the result of either an increasing shift towards environmental transmission or a reflection of higher contact rates within and between the sexes in high-density areas like the SW Management Area.

FWP continues to target the Libby Management Zone and SW Montana Management Zone for focused CWD management efforts. Within the Libby Management Zone prevalence has stayed lower than expected, suggesting FWP and City of Libby management actions may be effective in slowing CWD spread. In the SW Montana Management Zone, we are so far unable to detect an obvious management effect when comparing CWD prevalence to other positive hunting districts with varying levels of CWD management. This may not be surprising given how advanced the epidemic is in this area. Some models show that environmental

transmission plays a larger role in CWD spread as the epidemic progresses, likely causing management through hunting and culling to become less effective (Almberg et al, 2011). Despite significant reductions in deer density in the SW Montana Management Zone, transmission from the environment and vertical transmission are likely contributing to CWD spread. While continued management may not reduce prevalence in the SW Montana Management Zone, it may help reduce outward spread and slow increases in prevalence in surrounding areas.

With the CWD sampling dataset for Montana becoming larger and more robust for each species and demographic group, the development of Montana-specific estimates of weighted surveillance point values (Table 1) has begun. Next year, we anticipate incorporating Montana-specific weighted surveillance points into surveillance efforts and results reporting.

In 2024, we will conduct surveillance in hunting districts that intersect the 40-mile buffer around known positive where CWD has not yet been found and that have had historically low sample numbers (Figure 5). In addition, FWP will conduct targeted monitoring in some hunting districts with known positives that have lower samples sizes, causing broad confidence intervals for three-year prevalence. These priority sampling areas are primarily located in southwestern, central, and central-eastern Montana (Figure 5). Having greater sample numbers in these priority sampling areas will allow FWP to better understand if CWD exists at or above a 1% prevalence in previous undetected hunting districts, provide more accurate prevalences in positive hunting districts, evaluate existing management strategies, and provide better informed management recommendations.

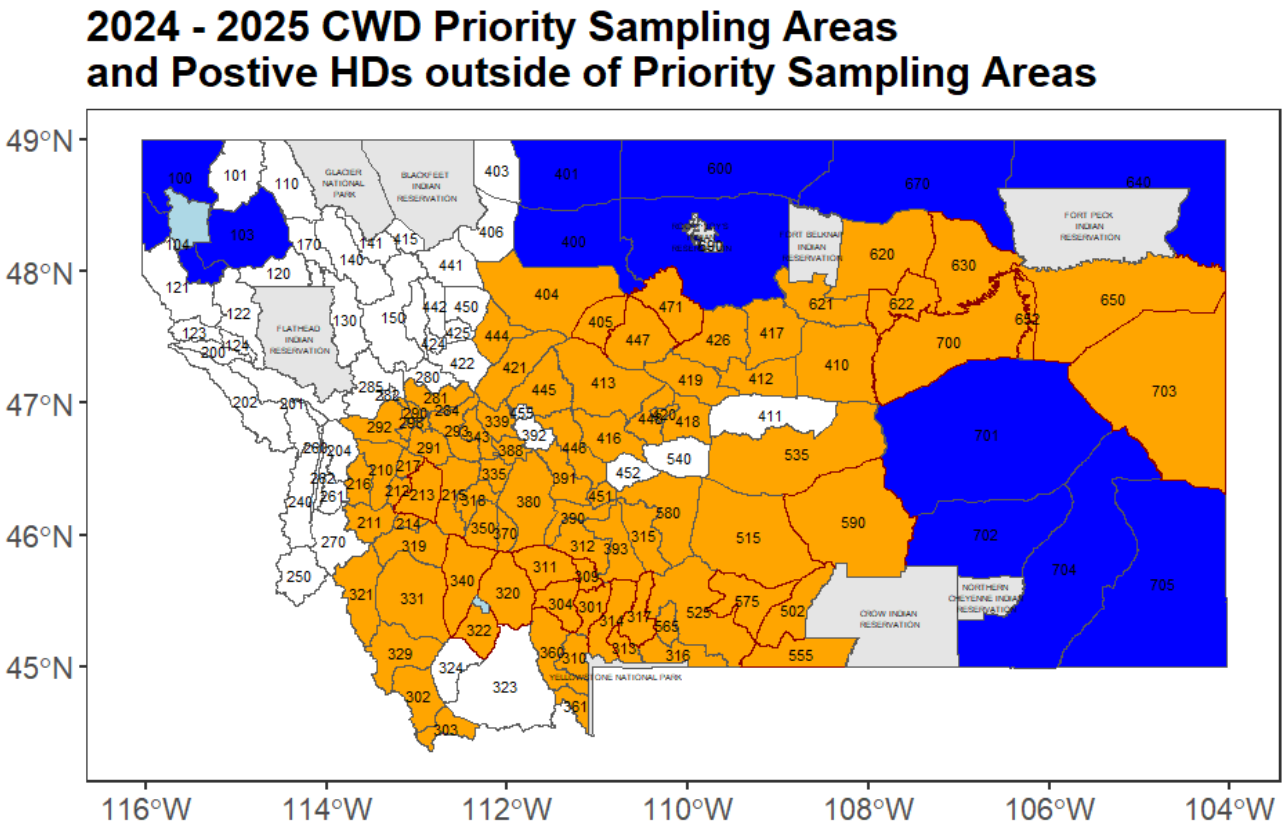

Figure 5. Map of 2024 CWD priority sampling areas (orange) and CWD-positive hunting districts (blue) not selected in the

2024 priority sampling areas. Priority sampling areas outlined in dark red are also positive hunt districts. The light blue shapes represent areas with annual CWD management hunt or controlled removal for CWD management.

Management updates

FWP committed to managing CWD to minimize its spread and to keep prevalences below 5% in the 2020 Montana Chronic Wasting Disease Management Plan. Management has 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 worked with the Libby City Council to write an Urban Deer Management Plan, which was completed in 2021 and calls for the annual trapping and euthanasia of white-tailed deer in the effort to manage CWD prevalence at ≤5%. Also in response, the Fish & Wildlife Commission approved an either-sex B-license with a quota of 2,000 valid within the Libby CWD Management Zone. In December 2023, the Fish and Wildlife Commission approved a change to the 2,000 either-sex B-license (199-20) making CWD testing mandatory. This mandatory testing also applies to the limited mule deer buck permits in HD 103 (HD103-50 permits).
- Region 2: FWP offered 8 strategically placed carcass disposal dumpster stations during the hunting season to facilitate FWP's carcass disposal policy aimed at reducing the human-assisted spread of CWD to new areas of the state. Of the 8 dumpster stations, 7 were in R2 for the 2022-2023 season. The first CWD sample to test positive for CWD was collected in Region 2 during the 2023-2024 season. In response, FWP offered a special impromptu check station to collect CWD samples near Deer Lodge on the last weekend of general rifle season in 2023-2024.
- Region 3: FWP ran the Southwestern Montana CWD Management Hunt from December 10, 2023 – February 15, 2024 in a portion of hunting district 322 (Figure 2) with a high prevalence of CWD. Hunters were allowed to use any unused 2023 general deer licenses, 003-00 white-tailed deer B-licenses and 399-00 white-tailed deer B-licenses, valid for harvest of antlered or antlerless white-tailed deer. The general deer license was also valid for antlerless mule deer harvest. White-tailed deer B-licenses 003-00 and 399-00 were available for purchase throughout the hunt. The goals of the hunt were to: continue ongoing priority CWD surveillance; reduce the number of CWD-positive animals; slow the spread of CWD among white-tailed deer populations and to neighboring populations of mule deer, elk, and moose, measurably reduce white-tailed deer populations where high CWD prevalence had been measured to a level that could be more effectively managed through general hunting season harvest; and to evaluate CWD prevalence among a localized population of mule deer that partially overlaps the area of high CWD prevalence among white-tailed deer.
- 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 and is still in effect. More recently, CWD was found in HD 405 in January 2023. HD

405 has maintained an either-sex mule deer season type, along with liberal numbers of mule deer B-licenses to maintain and/or reduce the deer population. This season type continues to date.

- Region 5: In 2019, Region 5 implemented CWD-related season changes in south-central Montana (previously hunting districts 510, 502, 520, and 575) designed to liberalize both mule deer and white-tailed deer harvest, particularly of bucks. Restructuring of hunting district boundaries in 2022 changed these to hunting districts 555, 502, 525, and 575. From the 2021 hunting season to the 2022 hunting season, hunting in HD 502 and HD 555 shifted from buck-heavy harvest to either-sex. HD 525 had an antlered buck mule deer season, with additional antlerless mule deer B-licenses available. HD 575 maintained the antlered buck mule deer season type but doubled the number of antlerless B-licenses issued compared to 2018. In the 2023 season, changes in Region 5 hunt district mule deer regulations included either-sex mule deer opportunity being removed from the general license, when applicable, and only allowing antlered mule deer buck harvest on the general license. These changes were put in place to both shift harvest to mule deer bucks in CWD management hunt districts and to decrease harvest pressure on antlerless portion of the mule deer population in hunt districts with decreasing mule deer numbers. Region 5 hunting districts that had not been restricted to antlered buck mule deer on the general license were changed during the December 2023 commission meeting. HDs 515, 535, 565 and 590 had antlered mule deer buck harvest with general license. HDs 502, 525, 540, 555, 575, 580 had either-sex mule deer youth opportunity with general license, in addition to antlered mule deer buck with general license. All Region 5 hunt districts had either-sex white-tail deer opportunity with a general license.

- Region 6: Managers have issued higher numbers of mule deer B-licenses than would have been prescribed in the absence of CWD, but B-license levels have still decreased as populations have trended downward. In 2023, 6,200 mule deer antlerless B-licenses were issued region-wide, with 4,000 (65%) of those issued in hunting districts with CWD prevalence above 5%. These hunting districts include 600, 640, and 670 where CWD prevalence ranged from 8-14% in mule deer based on the 2020-2023 estimates. The general mule deer season structure remained either-sex for the majority of Region 6, and hunter participation was high throughout the Region in 2023. Early indications suggest a relatively liberal antlered buck harvest occurred relative to the lower mule deer population. Antlerless white-tailed deer B-licenses remained unlimited with a maximum of 4 licenses per hunter, despite below average white-tailed deer populations in most areas of the region following epizootic hemorrhagic disease events in recent years. The number of buck permits issued in the Region's sole limited buck-permit hunting district, HD 652, was reduced from 200 to 125 in reaction to lower deer numbers. CWD has not been detected in HD 652. Additionally, one carcass disposal dumpster was placed in R6 for the 2023 sampling season to facilitate FWP's carcass disposal policy aimed at reducing the human-assisted spread of CWD to new areas of the state.

  Region 6, with the assistance from the Wildlife Health Program, drafted a hunting season proposal to increase harvest of mule deer (both antlered and antlerless) within portions of HDs 600, 640, and 670 that were identified as "hotspots". The proposal was both scoped and put out for public comment during the season setting process for 2024-2025 hunting seasons and received much opposing public comment. As a result, the department asked the Chair of the Fish and Wildlife Commission to carry an amendment to remove the proposal.

- Region 7: Management in 2023 was a little more restrictive than previous years. Unlike previous years where the general deer license was valid across the region for either-sex, either-species opportunity, the license structure was adjusted to be valid for antlered buck mule deer or either-sex white-tailed

deer. Additionally, population declines related to prolonged drought conditions and to a lesser extent disease (i.e., bluetongue, epizootic hemorrhage disease viruses) resulted in fewer B-licenses available regionally. The region-wide mule deer B-license quota was set at 1,000, which was down from 5,500 in 2022, and which was also reduced from 2021 when 11,000 were offered. The region-wide white-tailed deer B-license quota was set at 8,500 in 2023, which was the same quota offered in 2022. Management of cervid species in Region 7 were generally motivated by population declines but are relevant to CWD management and progression of the epidemic.

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 coordinators and technicians that worked sampling 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, Colorado State University's Veterinary Diagnostic Laboratory, National Veterinary Services Laboratory, and Utah 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 has come from deer and elk auction license sales, a Pittman-Robertson Management Grant 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

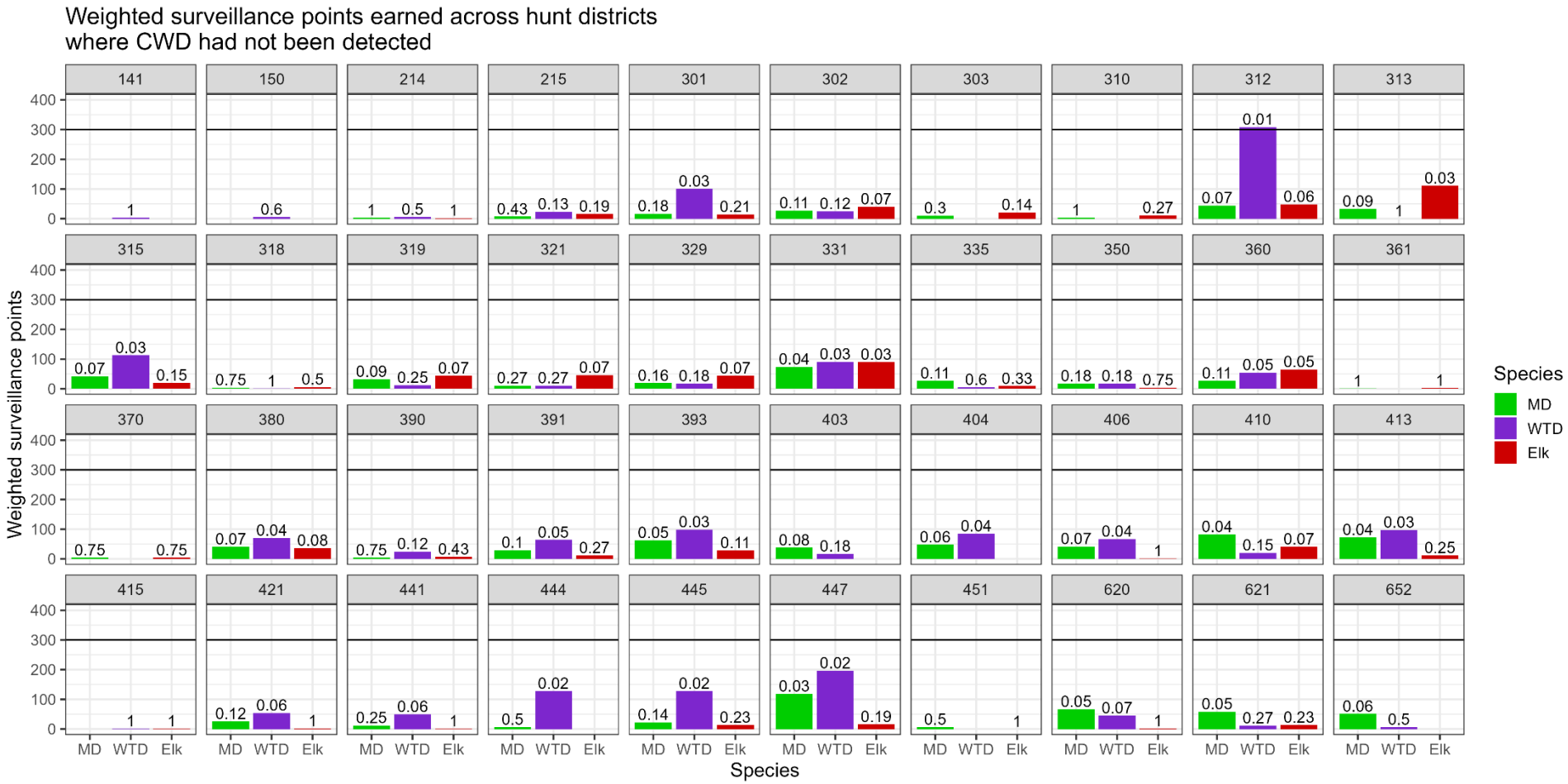

Figure A1. Weighted surveillance points earned for mule deer (MD), white-tailed deer (WTD), and elk within the 2023 hunt districts in Montana, using data collected from the 2021-2023 hunting seasons. Under the weighted surveillance framework, different demographic groups (age, sex, or cause of death 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. There have been no CWD samples from any year from HD 316, a 2023 Priority Sampling Area not depicted above.

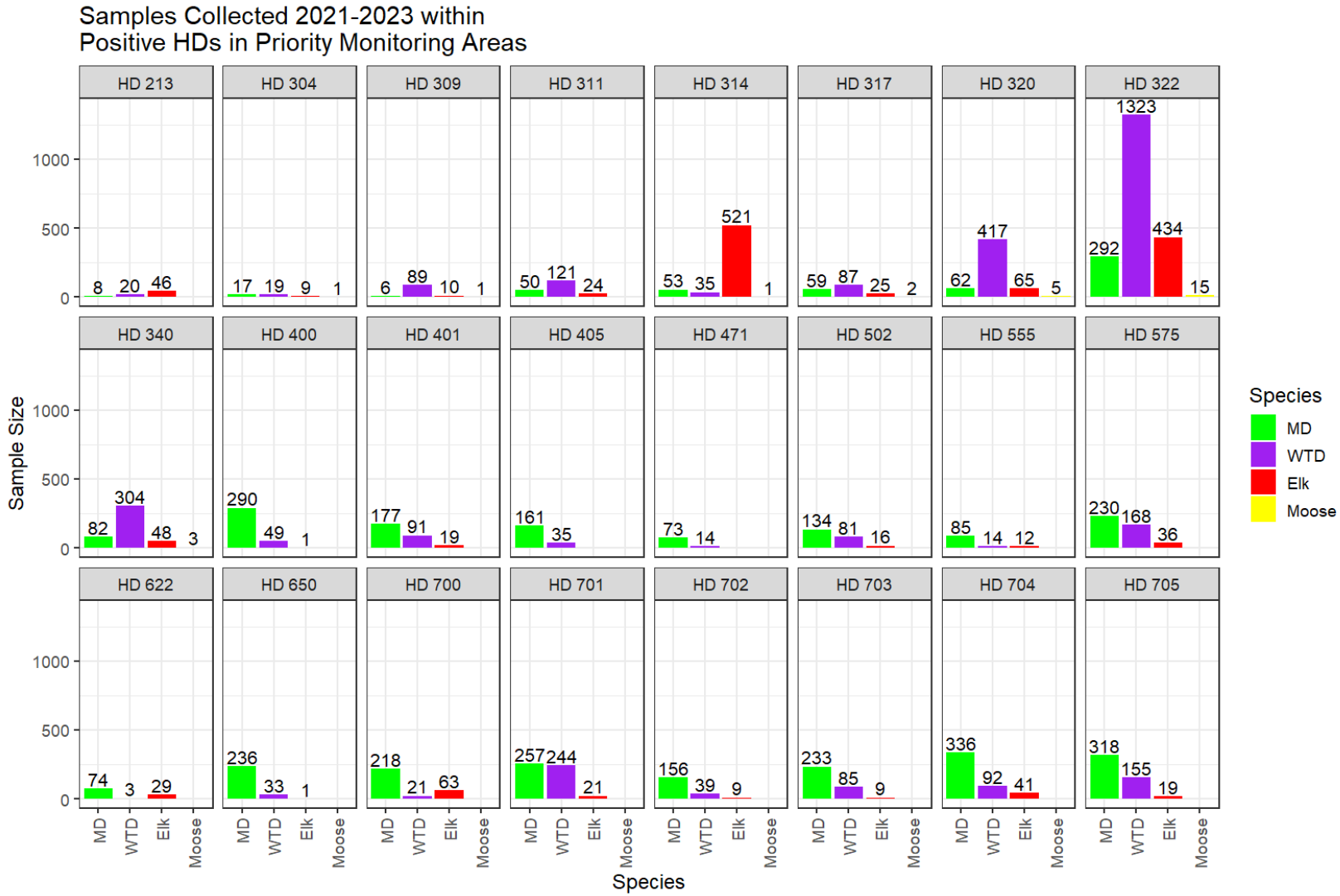

Figure A2. Samples collected from mule deer (MD), white-tailed deer (WTD), elk, and moose within the 2023 priority monitoring areas in Montana, using data collected from the 2021-2023 hunting seasons. We are typically aiming for at least 200 samples distributed across the population, to achieve a prevalence estimate with a margin of error ≤3%. Above each bar, we have displayed the total number of individuals sampled.

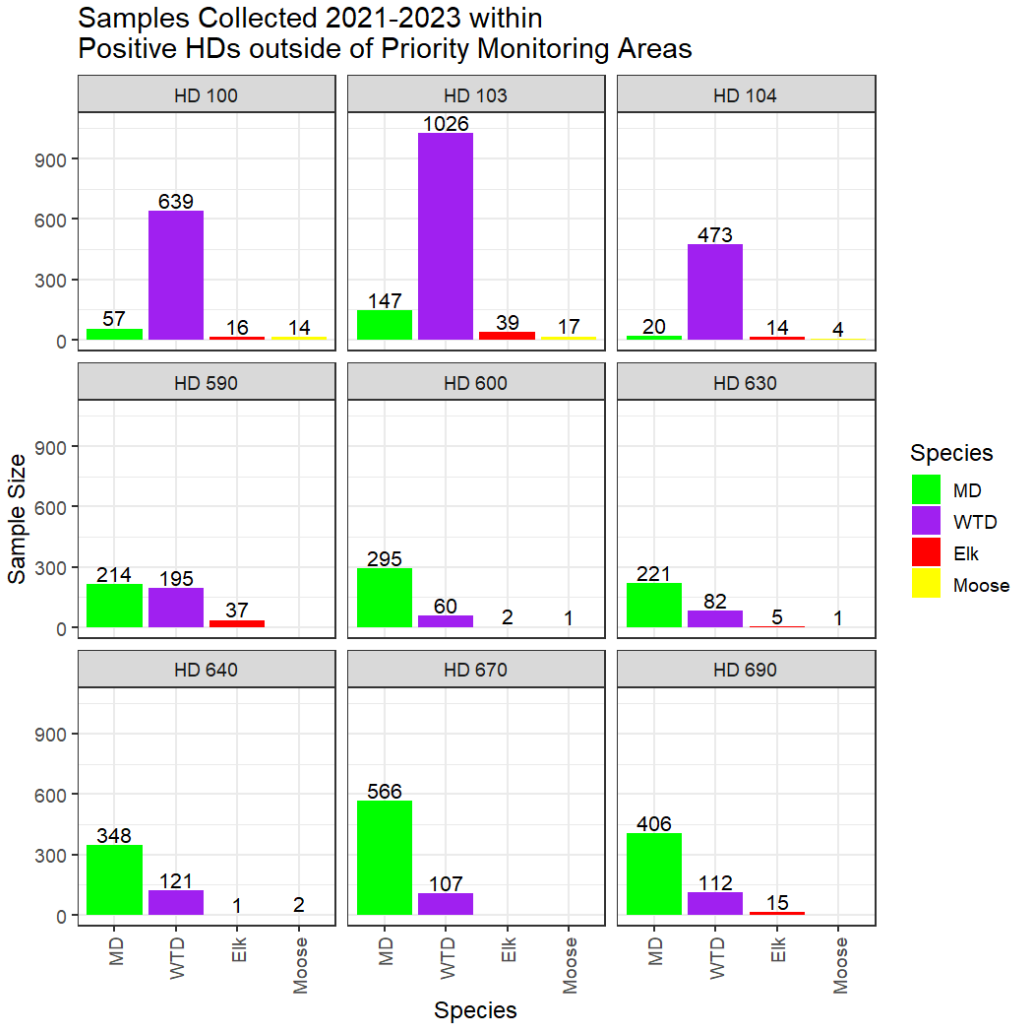

Figure A3. Samples collected from mule deer (MD), white-tailed deer (WTD), elk, and moose in positive hunt districts outside of the 2023 priority monitoring areas in Montana, using data collected from the 2021-2023 hunting seasons. Though these were not 2023 priority monitoring areas, we are looking at how close they fall within the goal 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.

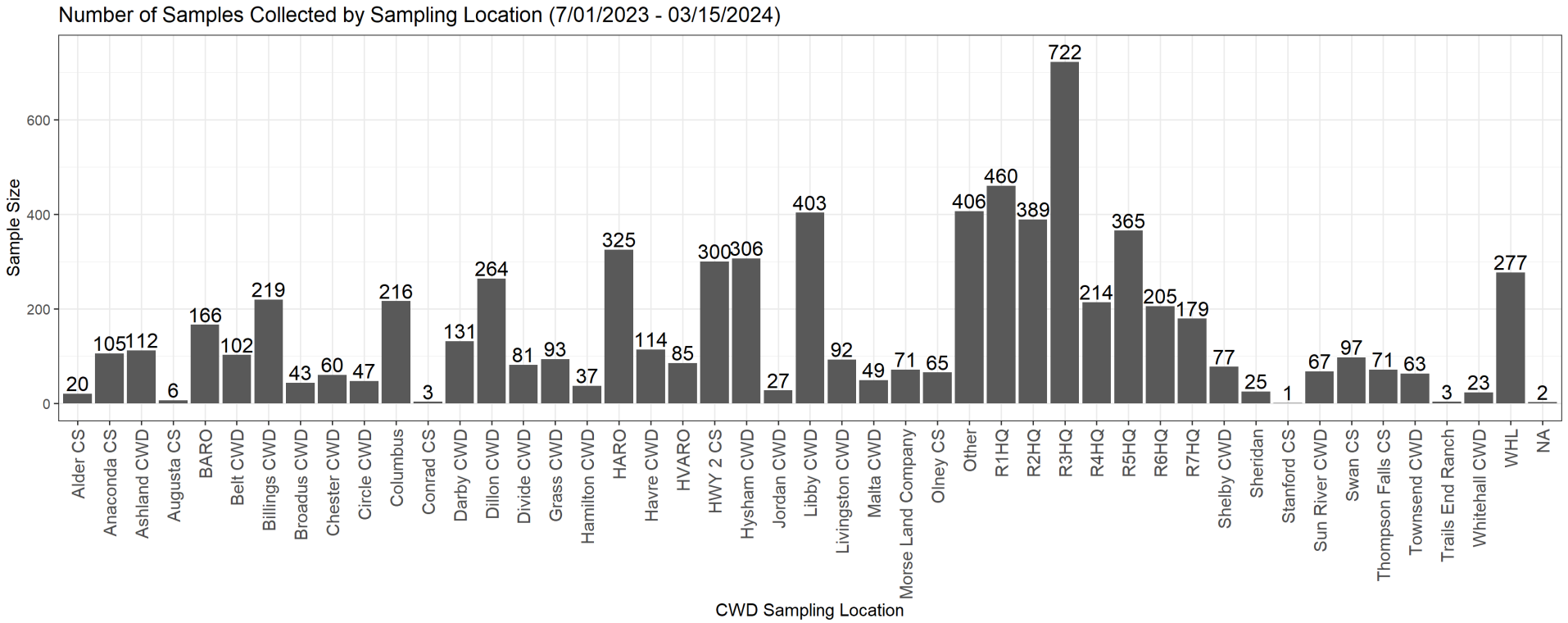

Figure A4. Number of samples collected at various CWD sampling locations around the state during the 2023 hunting season. "HQ" stands for headquarters and "WHL" stands for the Wildlife Health Lab. "HVARO", "HARO", and "BARO" stand for Havre Area Resource Office, Helena Area Resource Office, and Butte Area Resource Office, respectively. "Other" includes all the additional locations that samples were collected (e.g. private property, trailheads, BMA, etc.,).

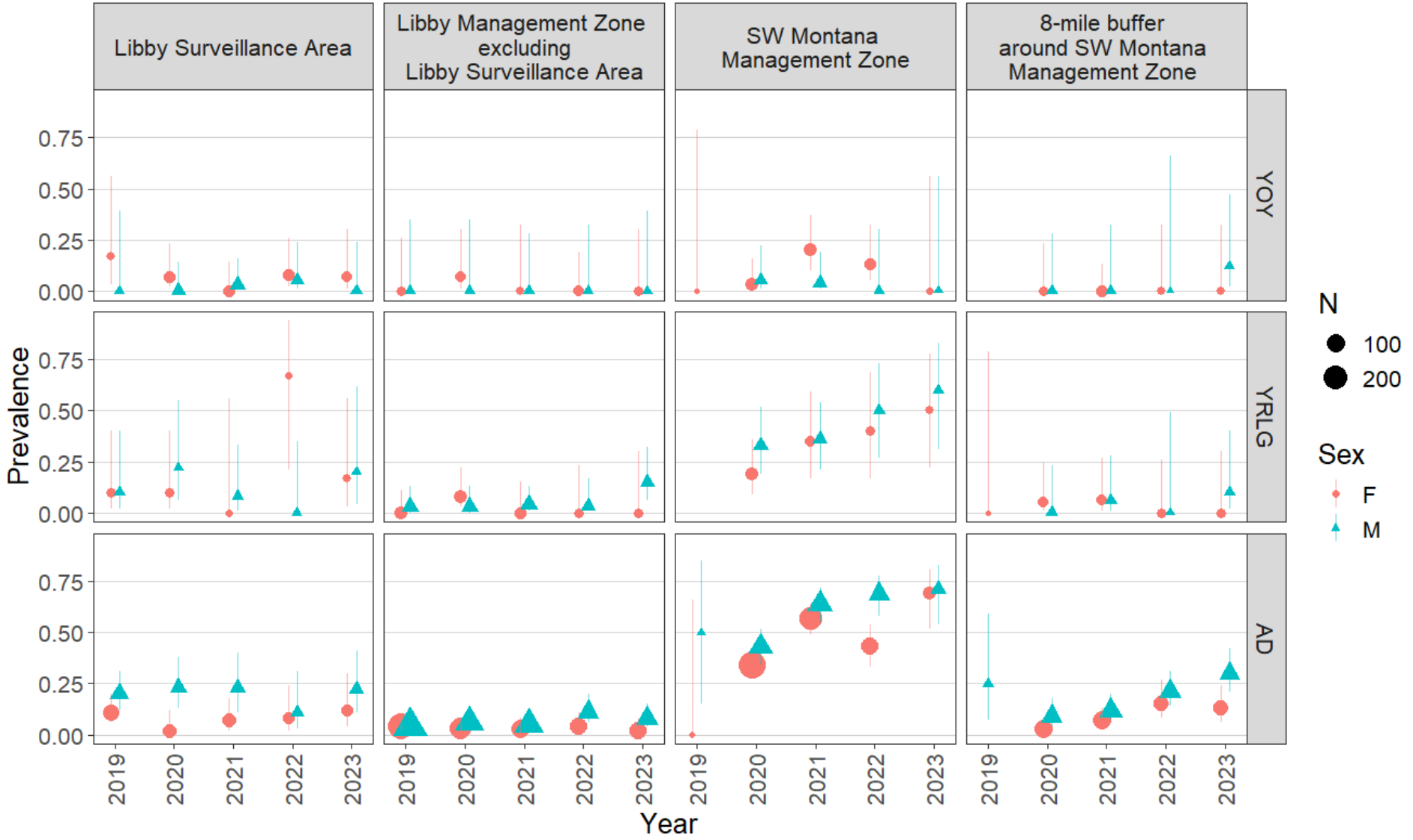

Figure A5. CWD prevalence estimates among white-tailed deer from 2019 -2023 for the Libby Surveillance Area, Libby Management Zone excluding the Libby Surveillance Area, SW Montana Management Zone and an 8-mile buffer around the SW Montana Management Zone. Estimates are shown for young of year (YOY), yearlings (YRLG), and adults (AD). Error bars seen for each point (F = female, M = male) represent the 95% binomial confidence intervals.

Appendix II. Three-year CWD Prevalence Estimates

Table A1. Estimated CWD prevalence by hunting district (HD) and species, using data from 2021-2023 Sampling from hunter-harvested or agency removed (i.e. in Libby) animals. The lower (LBCI) and upper (UBCI) 95% confidence intervals are provided along with sample size (N) and total number of positives (Positive Samples) by species in each HD.

Hunt District	Species	Positive Samples	Number of Samples (N)	Prevalence	LBCI (95%)	UBCI (95%)
100	MD	1	57	0.02	0	0.09
100	WTD	36	639	0.06	0.04	0.08
101	MD	0	21	0	0	0.15
101	WTD	0	230	0	0	0.02
103	MD	0	147	0	0	0.03
103	WTD	21	1026	0.02	0.01	0.03
104	MD	0	20	0	0	0.16
104	WTD	20	473	0.04	0.03	0.06
110	WTD	0	53	0	0	0.07
120	MD	0	14	0	0	0.22
120	WTD	0	333	0	0	0.01
121	MD	0	19	0	0	0.17
121	WTD	0	132	0	0	0.03
122	MD	0	34	0	0	0.1
122	WTD	0	177	0	0	0.02
123	MD	0	18	0	0	0.18
123	WTD	0	25	0	0	0.13
124	MD	0	3	0	0	0.56
124	WTD	0	9	0	0	0.3
130	MD	0	3	0	0	0.56
130	WTD	0	256	0	0	0.01
140	MD	0	2	0	0	0.66
140	WTD	0	23	0	0	0.14
141	WTD	0	1	0	0	0.79
150	WTD	0	2	0	0	0.66
170	MD	0	2	0	0	0.66
170	WTD	0	176	0	0	0.02
200	WTD	0	6	0	0	0.39
201	MD	0	24	0	0	0.14
201	WTD	0	67	0	0	0.05
202	MD	0	6	0	0	0.39
202	WTD	0	35	0	0	0.1
204	MD	0	4	0	0	0.49
204	WTD	0	46	0	0	0.08
210	MD	0	2	0	0	0.66
210	WTD	0	15	0	0	0.2
211	MD	0	2	0	0	0.66
211	WTD	0	5	0	0	0.43

212	MD	0	5	0	0	0.43
213	MD	1	8	0.12	0.02	0.47
213	WTD	0	20	0	0	0.16
214	MD	0	3	0	0	0.56
214	WTD	0	3	0	0	0.56
215	MD	0	9	0	0	0.3
215	WTD	0	9	0	0	0.3
216	MD	0	12	0	0	0.24
216	WTD	0	11	0	0	0.26
217	WTD	0	2	0	0	0.66
240	MD	0	11	0	0	0.26
240	WTD	0	55	0	0	0.07
250	MD	0	10	0	0	0.28
250	WTD	0	28	0	0	0.12
260	WTD	0	10	0	0	0.28
261	MD	0	2	0	0	0.66
261	WTD	0	7	0	0	0.35
262	MD	0	3	0	0	0.56
262	WTD	0	24	0	0	0.14
270	MD	0	43	0	0	0.08
270	WTD	0	58	0	0	0.06
280	WTD	0	1	0	0	0.79
281	MD	0	1	0	0	0.79
281	WTD	0	20	0	0	0.16
282	MD	0	2	0	0	0.66
282	WTD	0	5	0	0	0.43
285	MD	0	13	0	0	0.23
285	WTD	0	86	0	0	0.04
290	WTD	0	2	0	0	0.66
291	MD	0	7	0	0	0.35
291	WTD	0	4	0	0	0.49
292	MD	0	6	0	0	0.39
292	WTD	0	32	0	0	0.11
293	MD	0	2	0	0	0.66
293	WTD	0	9	0	0	0.3
298	MD	0	1	0	0	0.79
298	WTD	0	2	0	0	0.66
301	MD	0	18	0	0	0.18
301	WTD	0	37	0	0	0.09
302	MD	0	35	0	0	0.1
302	WTD	0	10	0	0	0.28
303	MD	0	12	0	0	0.24
304	MD	0	17	0	0	0.18
304	WTD	1	19	0.05	0.01	0.25
309	MD	0	6	0	0	0.39
309	WTD	1	89	0.01	0	0.06

310	MD	0	5	0	0	0.43
311	MD	0	50	0	0	0.07
311	WTD	1	121	0.01	0	0.05
312	MD	0	21	0	0	0.15
312	WTD	0	120	0	0	0.03
313	MD	0	39	0	0	0.09
313	WTD	0	1	0	0	0.79
314	MD	0	53	0	0	0.07
314	WTD	0	35	0	0	0.1
315	MD	0	61	0	0	0.06
315	WTD	0	68	0	0	0.05
317	MD	0	59	0	0	0.06
317	WTD	1	87	0.01	0	0.06
318	MD	0	4	0	0	0.49
318	WTD	0	1	0	0	0.79
319	MD	0	43	0	0	0.08
319	WTD	0	5	0	0	0.43
320	MD	0	62	0	0	0.06
320	WTD	25	417	0.06	0.04	0.09
321	MD	0	13	0	0	0.23
321	WTD	0	8	0	0	0.32
322	MD	11	292	0.04	0.02	0.07
322	WTD	402	1323	0.3	0.28	0.33
329	MD	0	26	0	0	0.13
329	WTD	0	10	0	0	0.28
331	MD	0	104	0	0	0.04
331	WTD	0	45	0	0	0.08
335	MD	0	31	0	0	0.11
335	WTD	0	3	0	0	0.56
339	MD	0	16	0	0	0.19
339	WTD	0	9	0	0	0.3
340	MD	2	82	0.02	0.01	0.08
340	WTD	41	304	0.13	0.1	0.18
343	MD	0	12	0	0	0.24
343	WTD	0	8	0	0	0.32
350	MD	0	18	0	0	0.18
350	WTD	0	11	0	0	0.26
360	MD	0	26	0	0	0.13
360	WTD	0	28	0	0	0.12
361	MD	0	1	0	0	0.79
370	MD	0	6	0	0	0.39
380	MD	0	47	0	0	0.08
380	WTD	0	34	0	0	0.1
388	MD	0	151	0	0	0.02
388	WTD	0	15	0	0	0.2
390	MD	0	5	0	0	0.43

390	WTD	0	14	0	0	0.22
391	MD	0	35	0	0	0.1
391	WTD	0	25	0	0	0.13
392	MD	0	14	0	0	0.22
392	WTD	0	2	0	0	0.66
393	MD	0	66	0	0	0.06
393	WTD	0	45	0	0	0.08
400	MD	5	290	0.02	0.01	0.04
400	WTD	3	49	0.06	0.02	0.17
401	MD	10	177	0.06	0.03	0.1
401	WTD	2	91	0.02	0.01	0.08
403	MD	0	47	0	0	0.08
403	WTD	0	7	0	0	0.35
404	MD	0	43	0	0	0.08
404	WTD	0	35	0	0	0.1
405	MD	2	161	0.01	0	0.04
405	WTD	0	35	0	0	0.1
406	MD	0	34	0	0	0.1
406	WTD	0	27	0	0	0.12
410	MD	0	101	0	0	0.04
410	WTD	0	8	0	0	0.32
411	MD	0	105	0	0	0.04
411	WTD	0	107	0	0	0.03
412	MD	0	69	0	0	0.05
412	WTD	0	49	0	0	0.07
413	MD	0	59	0	0	0.06
413	WTD	0	46	0	0	0.08
415	WTD	0	1	0	0	0.79
416	MD	0	30	0	0	0.11
416	WTD	0	18	0	0	0.18
417	MD	0	50	0	0	0.07
417	WTD	0	5	0	0	0.43
418	MD	0	12	0	0	0.24
418	WTD	0	30	0	0	0.11
419	MD	0	30	0	0	0.11
419	WTD	0	20	0	0	0.16
420	MD	0	4	0	0	0.49
420	WTD	0	2	0	0	0.66
421	MD	0	30	0	0	0.11
421	WTD	0	18	0	0	0.18
422	MD	0	7	0	0	0.35
422	WTD	0	10	0	0	0.28
425	MD	0	10	0	0	0.28
425	WTD	0	10	0	0	0.28
426	MD	0	104	0	0	0.04
426	WTD	0	15	0	0	0.2

441	MD	0	13	0	0	0.23
441	WTD	0	24	0	0	0.14
442	MD	0	1	0	0	0.79
442	WTD	0	4	0	0	0.49
444	MD	0	9	0	0	0.3
444	WTD	0	55	0	0	0.07
445	MD	0	25	0	0	0.13
445	WTD	0	60	0	0	0.06
446	MD	0	8	0	0	0.32
446	WTD	0	24	0	0	0.14
447	MD	0	134	0	0	0.03
447	WTD	0	86	0	0	0.04
448	MD	0	16	0	0	0.19
448	WTD	0	6	0	0	0.39
450	MD	0	9	0	0	0.3
450	WTD	0	13	0	0	0.23
451	MD	0	6	0	0	0.39
452	MD	0	31	0	0	0.11
452	WTD	0	25	0	0	0.13
455	MD	0	2	0	0	0.66
455	WTD	0	2	0	0	0.66
471	MD	0	73	0	0	0.05
471	WTD	1	14	0.07	0.01	0.31
502	MD	8	134	0.06	0.03	0.11
502	WTD	3	81	0.04	0.01	0.1
515	MD	0	198	0	0	0.02
515	WTD	0	118	0	0	0.03
525	MD	0	108	0	0	0.03
525	WTD	0	192	0	0	0.02
535	MD	0	164	0	0	0.02
535	WTD	0	62	0	0	0.06
540	MD	0	29	0	0	0.12
540	WTD	0	22	0	0	0.15
555	MD	4	85	0.05	0.02	0.11
555	WTD	2	14	0.14	0.04	0.4
565	MD	0	1	0	0	0.79
565	WTD	0	6	0	0	0.39
575	MD	3	230	0.01	0	0.04
575	WTD	0	168	0	0	0.02
580	MD	0	58	0	0	0.06
580	WTD	0	140	0	0	0.03
590	MD	0	214	0	0	0.02
590	WTD	12	195	0.06	0.04	0.1
600	MD	55	295	0.19	0.15	0.23
600	WTD	4	60	0.07	0.03	0.16
620	MD	0	76	0	0	0.05

620	WTD	0	17	0	0	0.18
621	MD	0	70	0	0	0.05
621	WTD	0	4	0	0	0.49
622	MD	0	74	0	0	0.05
622	WTD	0	3	0	0	0.56
630	MD	2	221	0.01	0	0.03
630	WTD	1	82	0.01	0	0.07
640	MD	48	348	0.14	0.11	0.18
640	WTD	4	121	0.03	0.01	0.08
650	MD	3	236	0.01	0	0.04
650	WTD	0	33	0	0	0.1
652	MD	0	54	0	0	0.07
652	WTD	0	2	0	0	0.66
670	MD	58	566	0.1	0.08	0.13
670	WTD	4	107	0.04	0.01	0.09
690	MD	5	406	0.01	0.01	0.03
690	WTD	2	112	0.02	0	0.06
700	MD	1	218	0	0	0.03
700	WTD	0	21	0	0	0.15
701	MD	1	257	0	0	0.02
701	WTD	1	244	0	0	0.02
702	MD	1	156	0.01	0	0.04
702	WTD	2	39	0.05	0.01	0.17
703	MD	1	233	0	0	0.02
703	WTD	0	85	0	0	0.04
704	MD	3	336	0.01	0	0.03
704	WTD	6	92	0.07	0.03	0.14
705	MD	2	318	0.01	0	0.02
705	WTD	11	155	0.07	0.04	0.12

Appendix III. Models of infection patterns

Table A1. Logistic generalized linear mixed models used to evaluate the probability of infection as a function of species (mule deer vs. white-tailed deer), sex, age class (young of the year, yearlings, adults), whether the animal was from the Libby Management Zone, SW Montana Management Zone, or from outside these areas (MGZN2), and time (Year). A random Intercept for hunting district or management zone (HDmz) was included in all models, and in some cases, a random slope adjustment for species or year was included (e.g. (1 + Species|HDmz)). Models are ranked from best supported to least supported. All complete deer records from hunter-harvested or management-removal deer were included in this analysis (n=25,371).

Model	K	AICc	Delta AICc	Relative Model Likelihood	AICc Weight
fit17: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Year + (1 + Species|HDmz)	14	7037.55	0.00	1.00	0.74
fit23: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + MGZN2*Year + (1 + Species|HDmz)	16	7040.95	3.40	0.18	0.13
fit29: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Sex + MGZN2*Year + (1 + Species|HDmz)	17	7042.12	4.57	0.10	0.07
fit26: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Species + MGZN2*Year + (1 + Species|HDmz)	17	7042.73	5.19	0.07	0.05
fit16: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + (1 + Species|HDmz)	12	7053.18	15.63	0.00	0.00
fit22: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + (1 + Species|HDmz)	14	7056.60	19.05	0.00	0.00
fit25: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Species + (1 + Species|HDmz)	15	7057.33	19.78	0.00	0.00

fit28: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Sex + (1 + Species|HDmz)	15	7057.43	19.88	0.00	0.00
fit30: logit (Pr(Infected)) ~ 1+ Year + AgeClass + MGZN2*Species*Sex + (1 + Species|HDmz)	18	7062.46	24.91	0.00	0.00
fit10: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + (1 + Species|HDmz)	10	7063.87	26.32	0.00	0.00
fit7: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + AgeClass + (1 + Species|HDmz)	9	7077.59	40.05	0.00	0.00
fit20: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + MGZN2*Year + (1|HDmz)	14	7147.69	110.14	0.00	0.00
fit24: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Species + (1 + Year|HDmz)	15	7149.78	112.23	0.00	0.00
fit21: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + (1 + Year|HDmz)	14	7150.89	113.34	0.00	0.00
fit27: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + Year*Sex + (1 + Year|HDmz)	15	7152.69	115.14	0.00	0.00
fit14: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Year + (1|HDmz)	12	7153.15	115.61	0.00	0.00
fit15: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + (1 + Year|HDmz)	12	7156.28	118.73	0.00	0.00
fit19: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + (1|HDmz)	12	7163.63	126.08	0.00	0.00
fit9: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + (1 + Year|HDmz)	10	7164.99	127.44	0.00	0.00

fit13: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + MGZN2 + (1|HDmz)	10	7168.19	130.65	0.00	0.00
fit8: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + Species*Sex + AgeClass + (1|HDmz)	8	7176.58	139.04	0.00	0.00
fit6: logit (Pr(Infected)) ~ 1+ Year + Species + Sex + AgeClass + (1|HDmz)	7	7190.68	153.14	0.00	0.00
fit12: logit (Pr(Infected)) ~ 1+ Species + Sex + Species*Sex + AgeClass + MGZN2 + (1 + Species|HDmz)	11	7247.85	210.30	0.00	0.00
fit18: logit (Pr(Infected)) ~ 1+ Species + Sex + Species*Sex + AgeClass + MGZN2 + MGZN2*Species + (1|HDmz)	11	7363.49	325.95	0.00	0.00
fit11: logit (Pr(Infected)) ~ 1+ Species + Sex + Species*Sex + AgeClass + MGZN2 + (1|HDmz)	9	7369.42	331.88	0.00	0.00
fit5: logit (Pr(Infected)) ~ 1+ Species + Sex + Species*Sex + AgeClass + (1|HDmz)	7	7379.20	341.65	0.00	0.00
fit3: logit (Pr(Infected)) ~ 1+ Species + Sex + AgeClass + (1|HDmz)	6	7388.36	350.81	0.00	0.00
fit4: logit (Pr(Infected)) ~ 1+ Species + Sex + Species*Sex + (1|HDmz)	5	7545.70	508.15	0.00	0.00
fit2: logit (Pr(Infected)) ~ 1+ Species + Sex + (1|HDmz)	4	7556.67	519.13	0.00	0.00
fit1: logit (Pr(Infected)) ~ 1+ Species + (1|HDmz)	3	7641.70	604.15	0.00	0.00

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