MONTANA FISH, WILDLIFE & PARKS

Targeted Elk Brucellosis Surveillance Project
2018 Annual Report

EXECUTIVE SUMMARY

Montana Fish, Wildlife & Parks (MFWP) is conducting a multi-year targeted elk brucellosis surveillance project to evaluate 1) prevalence and spatial extent of brucellosis exposure in elk populations, 2) elk spatial overlap with livestock and interchange between elk populations, 3) risk of seropositive elk shedding and potentially transmitting *Brucella abortus*, and 4) effects of brucellosis management hazing and lethal removal on elk distributions and spatial overlap with livestock. This report is an annual summary of the 2018 targeted elk brucellosis surveillance project. In February 2018, we sampled a total of 141 elk from populations in the Madison Valley and Tendoy Mountains areas and screened blood serum for exposure to *B. abortus*. We found elk exposure to *B. abortus* in both Hunt District (HD) 360 South (14%, n = 29) and HD 362 (17%, n = 12) in the Madison Valley, and HD 300 in the Tendoy Mountains (2%, n = 60), but not in HD 302 in the Tendoy Mountains (0%, n = 40). We collared 30 elk in the Tendoy Mountains and 40 elk in the Madison Valley and are currently collecting elk movement information. To evaluate the risk of seropositive elk shedding *B. abortus* during abortion or birth events, we recaptured and assessed the pregnancy status of 11 seropositive elk originally captured and collared in southwest Montana elk populations during 2014 and 2015. We found that 8 of the 11 seropositive elk were pregnant. We outfitted these pregnant elk with vaginal implant transmitters (VITs) to monitor birth events and sampled birth sites for *B. abortus*. We identified and sampled 1 abortion and 3 live birth events, and *B. abortus* was not detected at any site. The VITs in 3 elk malfunctioned and failed, and 1 elk retained her VIT and no birth event was documented. We opportunistically necropsied and sampled 2 seropositive elk to estimate the prevalence of active *B. abortus* infections in seropositive elk. We submitted a comprehensive assortment of tissue samples from these 2 elk for culture testing and *B. abortus* was not detected in either seropositive elk. We worked with collaborators at the U.S. Geological Survey to develop a model of elk-to-livestock transmission risk that predicts cumulative elk abortions across the Montana designated surveillance area (DSA) and identifies the highest transmission risk areas. That report is available on the MFWP brucellosis webpage in the reports section at http://fwp.mt.gov/fishAndWildlife/diseasesAndResearch/healthPrograms/brucellosis/default.html and can be downloaded directly here http://fwp.mt.gov/fwpDoc.html?id=87528.

INTRODUCTION

Montana Fish, Wildlife & Parks (MFWP) has conducted surveillance for brucellosis in elk populations since the early 1980s. Surveillance consists of screening blood serum for antibodies signifying exposure to *Brucella abortus*, the bacteria that causes the disease brucellosis. Brucellosis typically causes abortion in pregnant elk from February through May (Cross et al. 2015) and is primarily transmitted through contact with infected fetuses, birthing fluids and material. Elk that test positive for exposure to *B. abortus* (seropositive) may or may not be actively infected with the bacteria. Although not a true indicator of infection or the ability of an animal to shed *B. abortus* on the landscape, detection of seropositive elk indicates brucellosis is present in the area and indicates the potential for elk to transmit the disease to livestock or other elk.

In an effort to increase understanding of brucellosis in elk populations, MFWP initiated a targeted elk brucellosis surveillance project in 2011. The goals of the project are to 1) evaluate the prevalence and spatial extent of brucellosis exposure in elk populations, 2) document elk movements to evaluate the extent of spatial overlap with livestock and interchange between elk herds, 3) evaluate the risk of seropositive elk shedding and potentially transmitting *B. abortus*, and 4) evaluate the effects of brucellosis management actions, such as hazing and lethal removal, on elk distributions and spatial overlap with livestock. In order to achieve these goals, MFWP has conducted intensive sampling efforts focused on 1 – 2 elk populations per year each year since 2011. Study areas are selected based on their proximity to the known distribution of brucellosis and/or significant livestock concerns. Surveillance areas are identified through collaborative discussions between MFWP, the Montana Department of Livestock (DOL), and landowners. Surveillance areas are both inside and outside of the State of Montana brucellosis designated surveillance area (DSA, Figure 1).

STUDY AREAS

Since 2011, we have sampled elk populations from 13 study areas (Figure 1). In February 2018, we sampled elk from 2 populations in the Tendoy Mountains (HD300, HD302) and the east side of Madison Valley (HD362 S, HD360). The purpose of sampling in the Tendoy Mountains was to evaluate if brucellosis was present in the elk population, and gain additional information regarding elk distributions and spatial overlap with livestock. The purpose of the sampling in the east Madison Valley was to collect fine-scale elk movement information and evaluate the effects brucellosis management hazing on elk distributions and spatial overlap with livestock.

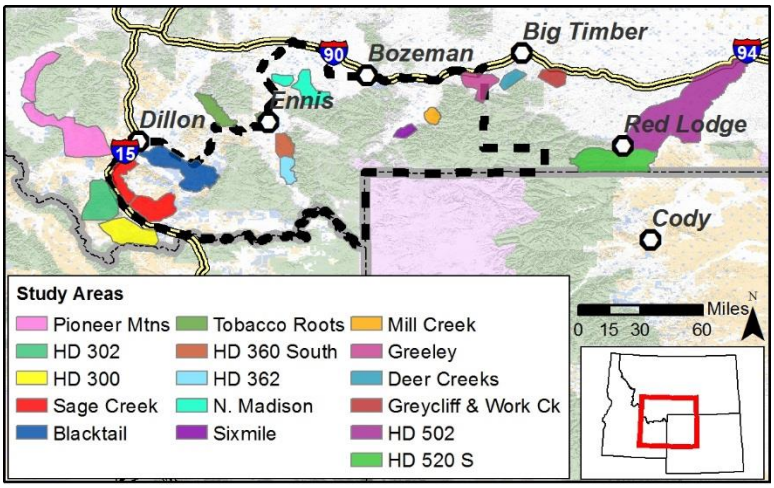

Figure 1. Study areas sampled during the 2011 – 2018 targeted elk brucellosis surveillance project.

METHODS

To evaluate *B. abortus* presence and prevalence in the Tendoy Mountains and Madison Valley study areas, we captured elk using helicopter net-gunning and collected a blood sample to screen animals for exposure. We also opportunistically collected blood samples from hunter harvested animals. Exposure was determined by the presence of antibodies to *B. abortus* in an animal's blood serum. Blood serum samples were tested at the Montana Department of Livestock Diagnostic Lab (Diagnostic Lab). Samples were screened utilizing the Rapid Automated Presumptive (RAP) and Fluorescence Polarization Assay (FPA) plate tests. Suspect or reactors to these screening tests were

further tested with the FPA tube test. Final classification of serostatus (i.e., seropositive or seronegative) was based on test results received from the Diagnostic Lab.

We collared a sample of elk in the Tendoy Mountain study area to track movements and evaluate risk of brucellosis transmission to livestock and other elk populations. We deployed collars that have a timed-release mechanism that releases the collar after 52 – 72 weeks so that collars may be retrieved and location data downloaded. We deployed collars in the Madison Valley study area to evaluate the effects of brucellosis management actions on elk to livestock brucellosis transmission risk. These collars collect a GPS location every hour from 0600 to 1800 and every 2 hours at night during December through April when management actions are most likely to occur, and every 5 hours during May through November, and transmit location data through a satellite service. Collars are expected to function for 3 years. All collars have a mortality sensor that detects if the collar is stationary for > 6 hours.

We recaptured seropositive elk initially detected and collared during the 2011 – 2015 portion of this project. The purpose of maintaining a collared sample of seropositive animals is to monitor serostatus and birth events for 5 years to understand the epidemiology of the disease post-infection, and determine the level of risk associated with exposed elk through time. We retest seropositive elk annually for exposure to determine if elk experience antibody titer loss following exposure. While testing blood serum annually determines if an elk has antibodies for *B. abortus*, lethal removal is the most reliable way to determine if an elk is infected (i.e., capable of transmitting the disease brucellosis) because reproductive organs and lymph nodes need to be collected to culture *B. abortus*. We euthanize seropositive elk following 5 years of monitoring and sample to detect *B. abortus* bacteria using culture testing of tissues. No seropositive elk were scheduled to be removed in 2018, but we opportunistically sampled 2 seropositive elk that died. One seropositive elk from the Greeley population likely died

from a hunting related injury in December 2017 and had been monitored for 2.5 years. The second seropositive elk was from the Sixmile population and died of natural causes in January 2018. The Diagnostic Laboratory performed a necropsy and collected extensive tissue samples (e.g., lymph nodes, organs). Samples were submitted to the National Veterinary Services Lab (NVSL) for culture testing to detect *B. abortus* bacteria.

At each of the seropositive elk recapture events, we assessed pregnancy status and outfitted pregnant elk with a VIT to track seropositive elk birth events. VITs are programmed to emit a slow pulse when the temperature is 32^0 C or higher (i.e., inside the body), and emit a fast pulse once the temperature cools below 28^0 C (i.e., expelled outside the body during an abortion or live birth). VITs have a precise event transmitter (PET) code which indicates the time since the VIT was expelled and cooled to a temperature below 28^0 C. We monitored the pulse rate and PET code to determine if an implant had been expelled and the timing of expulsion. To identify birth events, we tracked elk outfitted with VITs every 1 – 2 days from time of capture until the VITs were expelled.

We investigated each birth site to determine if an abortion or live birth occurred and sampled the birth site to determine if *B. abortus* bacteria were shed. We collected birth site samples from the VIT, soil, vegetation, and any available tissue or fluid. We also collected swabs of the VIT and any moist surface or material. All samples were submitted to the Diagnostic Lab to culture (i.e., grow) and identify any bacteria present in the sample. If bacteria cultured from the samples are suspected to be *B. abortus* they are forwarded to the National Veterinary Services Laboratory (NVSL) for final identification. In addition, we submitted a swab of the VIT to the Wyoming State Veterinary Lab for a polymerase chain reaction

(PCR) test that detects *B. abortus* DNA and can detect bacteria that is no longer viable (i.e., died from exposure before sampling). The PCR method allows for detection of dead bacteria that would not be detected in culture testing of tissues. The PCR test is a new method of detecting *B. abortus* that was unavailable before 2015. Detection of *B. abortus* from any sample, via culture or PCR, led to the classification of detected for that event. We categorized each birth site as *B. abortus* "detected" or "not detected" based on culture and PCR results. We considered elk that gave birth on or after May 15 to have carried their calf to full term, unless evidence of an abortion event was detected at the birth site (Barbknecht et al. 2009, Cross et al. 2015). We monitored the adult elk post-calving to confirm the presence of a live calf whenever possible. We categorized birth events as a confirmed abortion, suspected abortion, confirmed live birth, suspected live birth, or unknown. We defined a confirmed abortion as a birth event when the fetus was located and a suspected abortion as a birth event occurring outside of the normal calving period (May 15 – June 30) when no fetus was located at the birth site. We defined a confirmed live birth as a birth event where a live calf was located at the birth site or observed with the adult female, and a suspected live birth as a birth event occurring during the normal calving period (May 15 – June 30) where no fetal material or live calf was observed. Unknown events were restricted to cases where the VIT was lost due to a malfunction (i.e., stopped transmitting), the VIT was expelled but not at a birth site (i.e., mechanical failure of the VIT), or when no birth event was detected and the elk retained the VIT.

To evaluate the effects of brucellosis management hazing and lethal removal on elk distributions and spatial overlap with livestock, we monitored both elk movements and brucellosis management actions in the Sixmile Creek and Madison Valley areas. During 2018, brucellosis management included hazing elk from high-risk areas. Hazers conducting brucellosis management carried GPS units and recorded track logs during each elk hazing event. We will evaluate the effects

of brucellosis management actions on elk movements to determine the distance and amount of time elk stayed away from high-risk areas.

RESULTS

Brucellosis surveillance

In February 2018, we sampled 100 elk from the Tendoy Mountains. This area includes 2 elk populations, with semi-distinct core winter ranges (Figure 2). In the HD300 population, 1 of 60 elk tested positive for exposure to *B. abortus*, and we deployed collars on 16 elk (Table 1). In the HD302 population, 0 of 40 elk tested positive for exposure to *B. abortus*, and we deployed collars on 14 elk. Estimated seroprevalence and 95% confidence intervals were 2% (95% CI = 0.3-9%) in the HD300 population and 0% (95% CI = 0-9%) in the HD302 population (Table 1). Location data for Tendoy Mountains elk are limited to flights every 3 – 4 months until the collars drop off in Spring 2019 and data are retrieved from the collars.

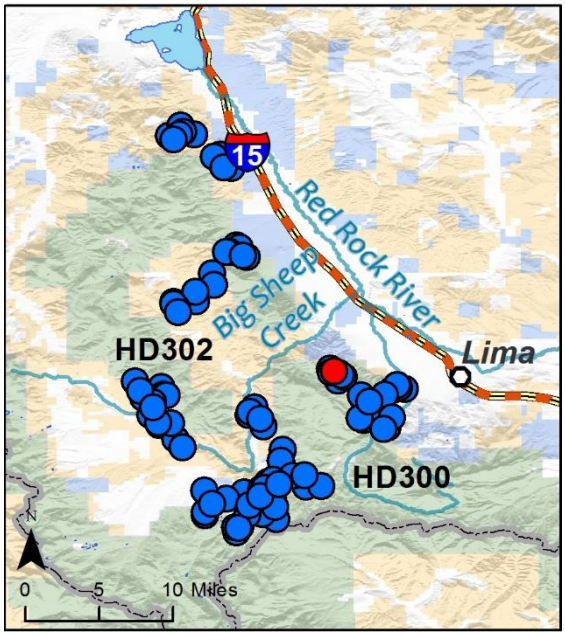

Figure 2. Capture locations of seropositive (red) and seronegative (blue) elk from the Tendoy Mountains study area during February 2018.

In late February 2018, we sampled 41 elk from the east side of the Madison Valley. This area includes 2 elk populations, with semi-distinct core winter ranges (Figure 3). In the HD362 population 2 elk tested positive for exposure to *B. abortus*, and we deployed collars on 12 elk (Table 1). In the HD360 S population 4 elk tested positive for exposure to *B. abortus*, and we deployed collars on 28

elk. Estimated seroprevalence and 95% confidence intervals were 17% (95% CI = 5-45%) in the HD362 population and 14% (95% CI = 5-31%) in the HD360 S population (Table 1).

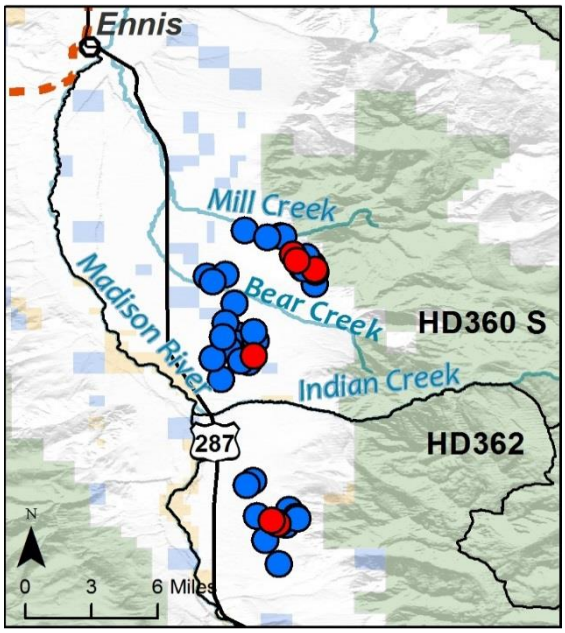

Figure 3. Capture locations of seropositive (red) and seronegative (blue) elk from the Madison Valley study area during February 2018.

Table 1. The study areas, elk populations, number of elk screened for exposure, number of elk testing seropositive for exposure, and the estimated seroprevalence with 95% confidence intervals (in parentheses) during February 2018 brucellosis sampling.

Study Area	Population	Sample Size	Number Seropositive	Estimated Seroprevalence (95% Binomial Confidence Interval)
Tendoy Mtns	HD 300	60	1	0.02 (0.003, 0.09)
Tendoy Mtns	HD 302	40	0	0 (0, 0.09)
Madison Valley	HD 362	12	2	0.17 (0.05, 0.45)
Madison Valley	HD360 S	29	4	0.14 (0.05, 0.31)

Combining data from the last 11 years of hunter harvest samples and sampling from brucellosis surveillance captures of elk, we estimate brucellosis seroprevalence in elk varies spatially across southwest Montana and ranges from 0 – 37% (Figure 4).

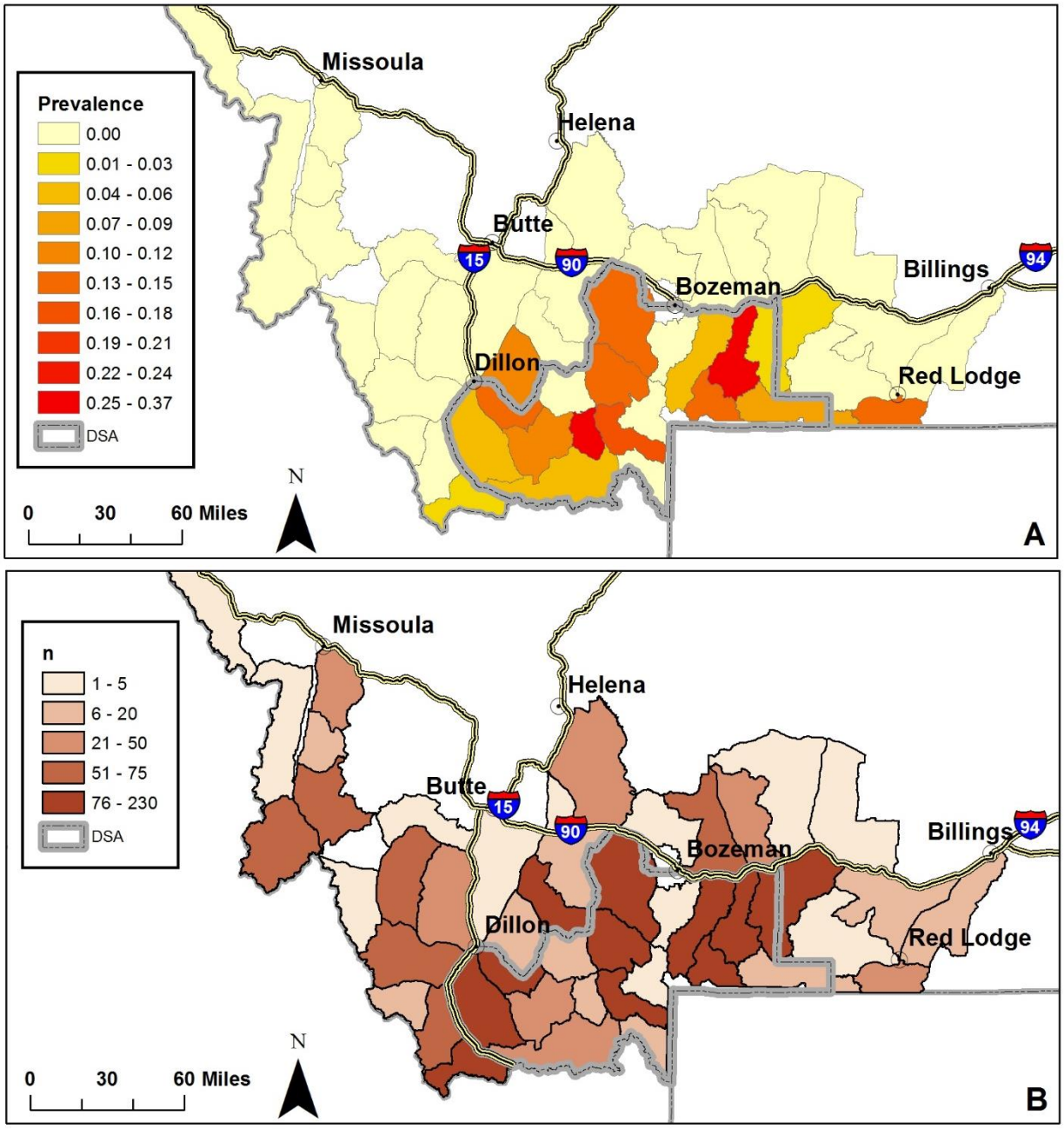

Figure 4. The estimated brucellosis seroprevalence (Panel A) and number of samples screened (n, Panel B) for adult female elk by hunting district* during 2007 – 2018. Samples include those collected during winter research captures and fall hunter harvest. Note some seroprevalence estimates are derived from a low number of samples. The gray line denotes the boundary of the Montana designated brucellosis surveillance area (DSA). *Hunt district 520, west of Red Lodge, is divided in two along a legally defined sub-district boundary to reflect the limited sampling in the northwestern portion of the district.

Elk movements

We first deployed collars in the Red Lodge area in 2016 and returned in 2017 to increase our sample size. In February 2017, we deployed 4 collars in the northern portion and 6 collars in the central portion of the Red Lodge study area (Figure 5). We assigned animals to herd based on a combination of the capture location (i.e., which core winter range the animal was captured within) and movement patterns (i.e., location data collected from collars). We recovered data from 6 of 10 collars deployed in 2017 and an additional 2 collars deployed in 2016. Two collared elk were harvested in October 2017 from the Red Lodge area, 1 from Silver Run and 1 from Dry Creek, both originally captured in 2016. Six collars are still deployed on Red Lodge elk due to failure of the timed-release drop-off mechanisms.

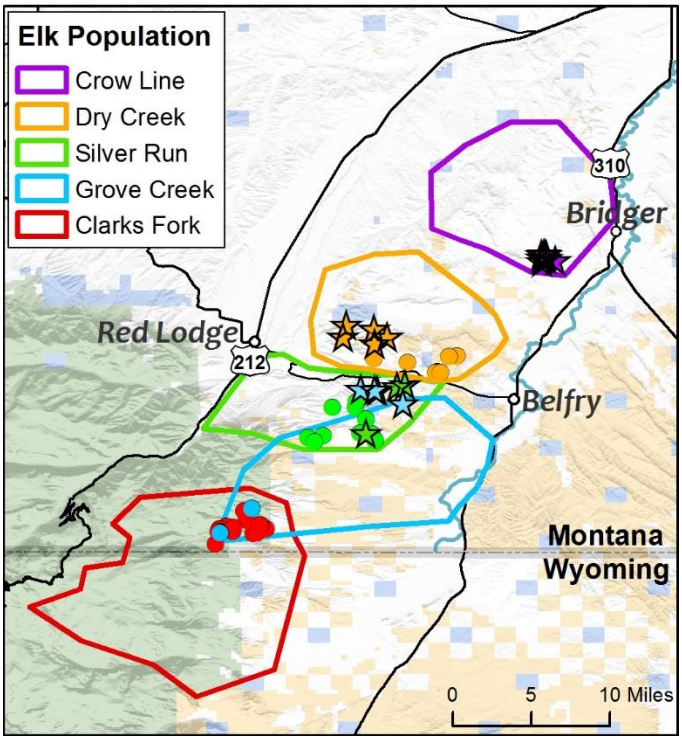

Figure 5. Red Lodge area collar deployment locations in February 2017 (stars), January 2016 (circles), and approximate boundaries of elk population winter ranges (polygons).

In 2018, we recovered collar location data from 2 Grove Creek, 1 Silver Run, 1 Dry Creek, and 4 Crow Line elk. In 2017, we recovered collar location data from 8 Clarks Fork, 2 Grove Creek, 5 Silver Run, and 2 Dry Creek elk. Figures 6 & 7 represent the combined collar location data from 25 elk recovered from February 2016 through April 2018. In general, Clarks Fork elk winter in the foothills of the Beartooth Mountains on both sides of the MT-WY border near Line Creek (Figure 6). All 8 collared Clarks Fork elk migrated south into Wyoming for the summer. Five of those elk spent portions of the summer in Montana within 3 miles of the MT-WY border near Line Creek. Movement

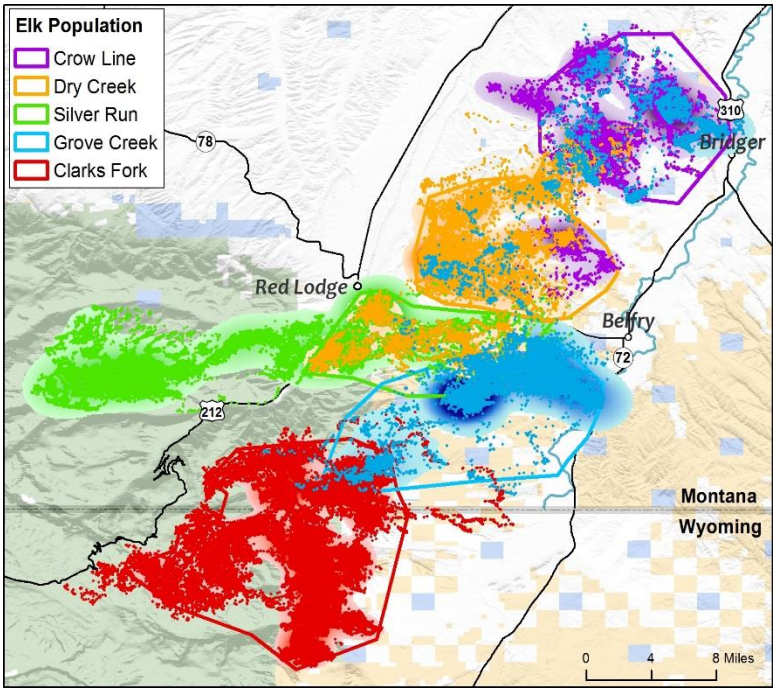

Figure 6. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Clarks Fork (red), Grove Creek (blue), Silver Run (green), Dry Creek (orange), and Crow Line (purple) populations in the Red Lodge study area, 2016-2018.

data from 2 collared elk captured within the Clarks Fork herd winter range indicate that they are from the Grove Creek herd. These 2 Grove Creek elk moved northeast after capture and summered along Grove Creek in Montana (Figure 6). Grove Creek elk are nonmigratory and associated with agricultural lands southwest of Belfry throughout the year, whereas Clarks Fork elk are migratory. One Grove Creek elk moved farther north into the Dry Creek and then Crow Line population areas in fall 2016, where she remained until her collar dropped off in March 2017.

Silver Run elk typically wintered east of Red Lodge and south of MT-308. In the spring, all 6 collared Silver Run elk migrated southwest into the Beartooth Mountains between West Fork Rock Creek and Lake Fork Creek (Figure 6). Most remained west of highway US-212 into the fall. Dry Creek elk are non-migratory and remained east of US-212 year-round (Figure 6). These elk stayed primarily north of MT-308 near the headwaters of both the North and South Fork of Dry Creek, venturing north to Sand Creek in early Spring and late Fall. All 3 Dry Creek elk spent some time south of MT-308 in winter, primarily January through March. Crow Line elk are also non-migratory and primarily stayed in between MT-212 and MT-310 (i.e., Selmes and Bridger, MT) near the Selms road,

along Elbow and Cedar Creeks. Four Crow Line elk spent some time south along the North and South Forks of Dry Creek July through September.

During the February through June risk period, Clarks Fork elk were in Wyoming and up to 4 miles north into Montana (Figure 7). Grove Creek elk spent most of the risk period along Grove Creek and Wolf Creek near Belfry, MT (Figure 7). One of the collared elk moved southwest towards Line Creek but returned to the Grove Creek area. One collared elk from the Grove Creek herd moved northwest of Belfry, MT in the fall of 2016 and remained there into the 2017 risk season. Silver Run elk resided on their winter and early summer range during the risk season, spreading from Wolf Creek to the West Fork of Rock Creek (Figure 7). Dry Creek elk spent most of the risk season north of MT-308 and south of Gramps Bluff, but did spend part of February, March and April south of MT-308 (Figure 7). Crow Line elk spent the risk season north of Gramps Bluff near the Selms Road along Elbow and Cedar Creeks (Figure 7).

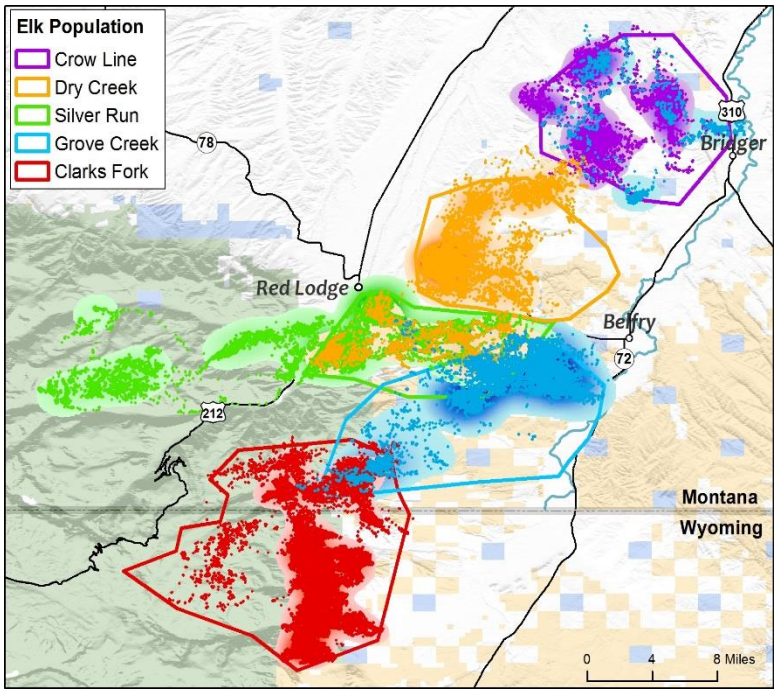

Figure 7. Risk period (Feb-June) locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Clarks Fork (red), Grove Creek (blue), Silver Run (green), Dry Creek (orange), and Crow Line (purple) populations in the Red Lodge study area, 2016-2018.

In 2017, we outfitted 40 Sixmile Creek elk with satellite uplink GPS collars that provide real time location data. There were 2 mortalities in 2017 and 2 in 2018. In addition, 15 collars have failed and are no longer uploading location data. We are currently collecting location data from 21 elk. In general, Sixmile elk winter near the Dailey Lake Wildlife Management Area (WMA), north and south of Sixmile Creek (Figures 8 & 9). Migration generally begins in May and continues through June with most elk moving southeast into Yellowstone National Park, stretching from the Mammoth Hot Springs area east to the Mirror Plateau and south to Yellowstone Lake. One elk did migrate southwest to Hebgen Lake in Montana. Four collared elk resided in Paradise Valley year-round, moving west across highway US-89 in late April and returning to the east side in late August. Fall migration generally begins in October with all elk back near Dailey Lake by December.

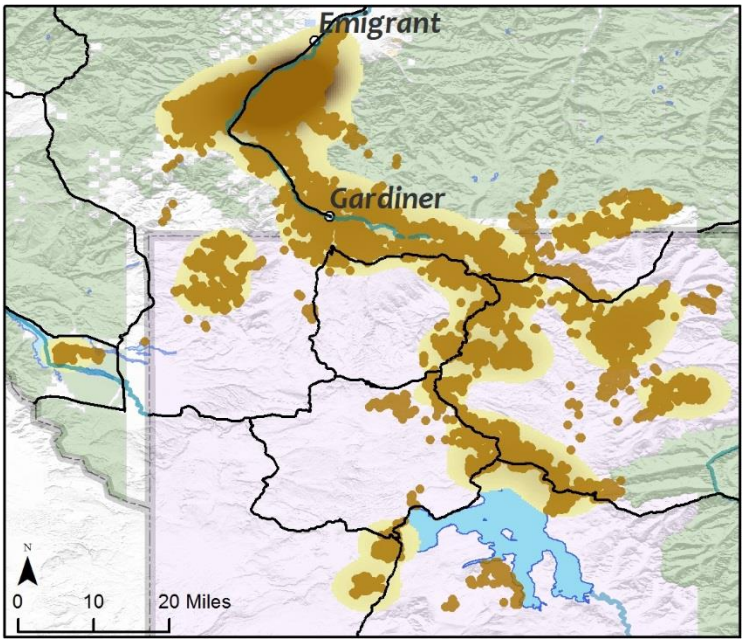

Figure 8. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Sixmile Creek population.

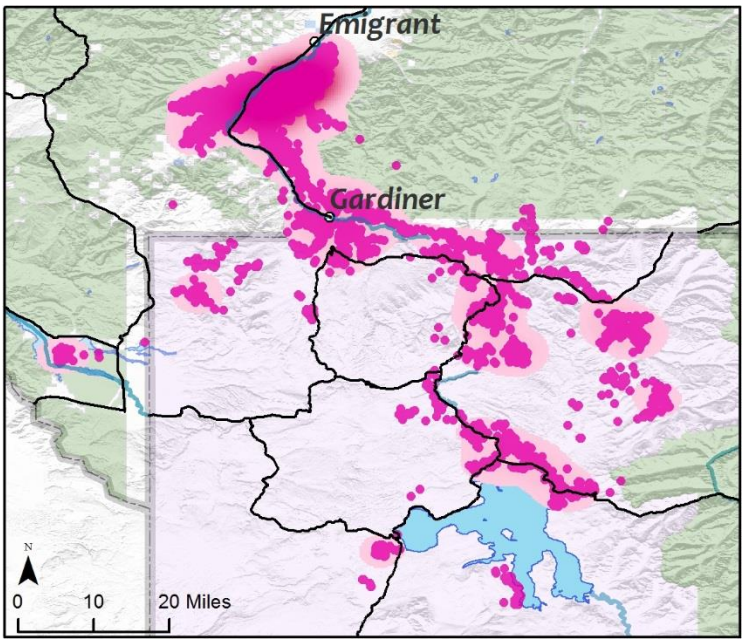

Figure 9. Risk period (Feb-June) locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Sixmile Creek population.

In 2018, we outfitted 40 elk in the Madison Valley (HD360 S & HD362) with satellite upload collars as a second study area for the management evaluation portion of the project. There have been 2 mortalities since February. We are currently collecting location data from 38 elk (Figure 10). In general, elk movement is very similar between HD360 S and HD362, with both populations wintering in the lower foothills and flats between Mill Creek and Sun Creek. HD360 S elk predominantly winter at the northern end while HD362 elk winter at the southern end, but mixing occurs frequently. Six elk from HD362 and 3 elk from HD360 S moved west of the Madison River in March and April, spending time on the Wall Creek WMA. Migration began for both populations in May and continued through June with similar movements to the south and east out of the valley. Seven elk from HD 360 S were still in the foothills on the east side of the Madison Valley at the end of June.

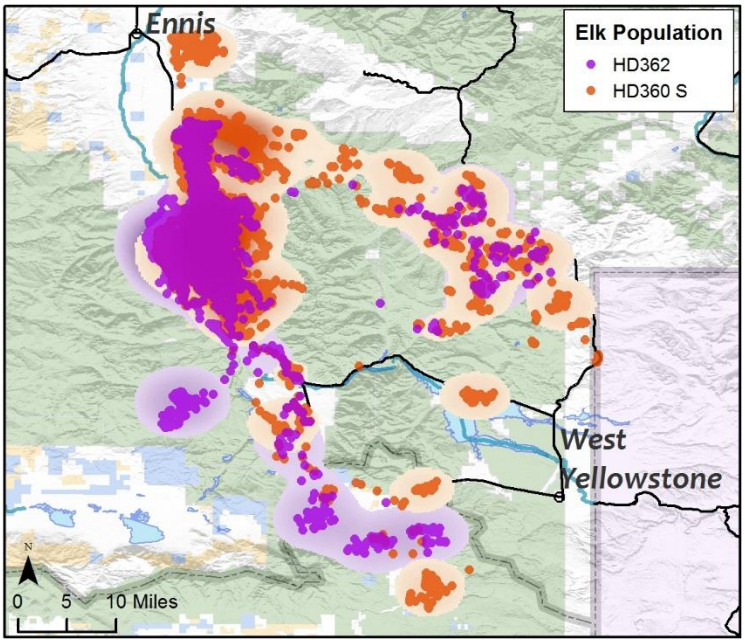

Figure 10. Risk period (Feb-June) locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the HD360 S (orange) and HD362 (purple) populations.

Management hazing in the Sixmile Creek and Madison Valley areas occurred throughout the winter to move elk off private property with cattle (Table 2). No brucellosis hunts were implemented in either area during winter-spring 2017 – 2018. We will continue to monitor brucellosis management actions and elk responses to management actions through 2019 in Sixmile Creek and 2020 in the Madison Valley. Analysis of elk response to management actions is ongoing.

Table 2. Number of brucellosis management hazing events in the Sixmile Creek and Madison Valley areas by month for winter 2017 – 2018.

	Dec	Jan	Feb	Mar	Apr	May	Jun
Sixmile Creek	3	3	2	19	20	23	0
Madison Valley	0	0	8	18	18	6	0

Seropositive elk recapture and sampling

During February and March 2018, we recaptured 11 seropositive elk from the Northern Madison (n = 2) and Mill Creek (n = 9) populations. Eight of these recaptured, seropositive elk were pregnant and were outfitted with VITs, while the remaining 3 recaptured, seropositive elk were open and not outfitted with VITs. We monitored the 8 seropositive elk pregnancies through the entire parturition season and documented 3 confirmed live births, 1 confirmed abortion, and 4 unknowns; 3 VITs malfunctioned and ceased transmitting, 1 elk retained the VIT and no birth event was detected (Table 3). PCR testing of VITs at the 3 birth and 1 abortion sites did not detect *B. abortus*. Culture testing of vegetation, soil and fluids at the 3 birth sites did not detect *B. abortus*. The fetus at the abortion event was largely consumed, but tissue fragments (e.g., skull, leg), as well as environmental samples were submitted for culture testing and *B. abortus* was not detected.

Table 3. The total number of 2018 seropositive elk pregnancies monitored by population, and *Brucella* testing status summarized by birth event type. Unknown events are when a VIT malfunctioned or was not expelled.

Population	Total	Abortion		Live Birth		Unknown
	Monitored	Confirmed	Suspected	Confirmed	Suspected	
N. Madison	1	0	0	1	0	0
Mill Creek	7	1	0	2	0	4
TOTAL	**8**	**1**	**0**	**3**	**0**	**4**

B. abortus was not detected in the tissue sampling of the seropositive elk from the Greeley and Sixmile Creek populations that died from a hunting related injury and natural causes, respectively. Culture testing was conducted on 17 samples from the Greeley elk and 21 samples from the Sixmile Creek elk. Neither elk was pregnant. Tissue samples submitted from both elk for culture testing included: lymph nodes (supramammary, popliteal, prefemoral, prescapular, iliac, hepatic, mesenteric, parotid, mandibular, retropharyngeal), organs (kidney, liver, spleen, ileum), reproductive tract (mammary gland, uterus), and feces. Additional samples submitted from the Sixmile Creek elk included swabs (vaginal, rectal, uterine) and the bronchial lymph node. The annual serology results for these elk show that both remained seropositive throughout their monitoring period (Table 4). It should be noted that the Sixmile Creek elk was not scheduled to be recaptured and monitored on a yearly basis, and that her necropsy was opportunistic. We do not plan on removing and necropsying additional seropositive elk from the Sixmile Creek population. The Greeley elk was originally captured in 2015 and remained seropositive through 2017. From 2015 – 2017, we documented 1 year of not being pregnant and 1 live birth for the Greeley elk (Table 5). No abortions were documented and *B. abortus* was not detected at the birth site. The Sixmile Creek elk was pregnant during capture in February 2017.

Table 4. Annual serology results for two necropsied seropositive elk by individual and year, 2015 – 2017.

ElkID	Study Area	2015	2016	2017
GR51	Greeley	Pos	Pos	Pos
SM40	Sixmile	---	---	Pos

Table 5. Annual pregnancy and/or birth event results for 2 necropsied seropositive elk by individual and year, 2015 – 2017.

ElkID	Study Area	2015	2016	2017
GR51	Greeley	Unknown	Open	Live Birth
SM40	Sixmile	---	---	Pregnant

DISCUSSION

Brucellosis surveillance efforts documented exposure to *B. abortus* in elk from the HD300 population in the Tendoy Mountains for the first time. Hunter harvest samples (n = 46) of adult and yearling female elk from HD300 in 2008 – 2011 previously tested negative. Surveillance efforts did not detect exposure to *B. abortus* in elk from the HD302 population North of Big Sheep Creek in the Tendoy Mountains. Previous hunter harvest samples (n = 19) in 2008 – 2010 from HD302 all tested negative. Brucellosis surveillance efforts confirmed the presence of *B. abortus* in elk from the HD360 S and HD362 populations in the Madison Valley. *B. abortus* was first documented in elk from HD360 in 1987 (n = 8, 12%) and in elk from HD362 in 1991 (n = 159, 3%). Between 2000 – 2010, brucellosis seroprevalence in HD360 was estimated at 10% (95% CI: 7-14%, n=250), and seroprevalence in HD362 was estimated at 17% (95% CI: 13 – 21%, n=413). Our prevalence estimate of 14% (95% CI = 5 – 31%, n = 29) for HD360 S and 17% (95% CI = 5 – 45%, n = 12) for HD362 both fall within the previously observed variation for those HD's.

Our targeted brucellosis surveillance efforts in the Red Lodge area during 2016 and 2017 confirmed the presence of brucellosis in the portion of the Clarks Fork elk population that winters along the border of Montana and Wyoming (Scurlock and Edwards 2010). However, to date, brucellosis has not been detected in the adjacent elk populations in the Red Lodge area of Montana. Elk movement data shows that there is interchange among elk herds in the Red Lodge area. These movements identify the potential for northward brucellosis expansion in Red Lodge area elk herd units, and continued surveillance efforts in this area are warranted. MFWP will continue to collect blood samples and will encourage hunters to participate in collection of samples from harvested antlerless elk in this area.

Our epidemiological results from 2018 are similar to results from 2011 – 2017 and suggest that only a small proportion of seropositive elk are shedding *B. abortus* bacteria and pose a risk for transmitting the disease to livestock or other elk. We have observed 4 abortion events out of a total of 65 (6.1%) known-fate birth events from 30 individual elk, and *B. abortus* was present at 3 of these 4 abortion sites. The abortion events occurred on 30 March 2014, 13 April 2018, 20 April 2012 and 14 May 2012. These dates fall within the riskiest time of year, March through mid-May (Cross et al. 2015). Additionally, since 2011, *B. abortus* was detected at 2 of 61 live birth events (3.3%), suggesting that live births pose some limited risk for transmission, although these cases are rare. The Wyoming Game and Fish Department (WGFD) have similarly detected *B. abortus* at 5 out of 118 (4%) live birth events (B. Scurlock, personal communication, August 2016). Although time to detection and sampling efforts did not differ between abortions and live birth events, typical female elk behavior during live birth events (i.e., consumption of birth material and vegetation) may remove some of the *B. abortus* shed at a live birth event. Difficulty locating the abortion site in 2018 coupled with access restrictions prevented us from sampling the site until 5 days after the event, at which time most of the fetus had been consumed. This delayed and limited sampling may have prevented detection of *B. abortus* that was present. Previous abortion events were sampled within 1, 3 and 5 days, however, the entire fetus was still present at the abortion events sampled later, thus providing adequate samples for detection.

The sampling and culture testing of the 2 necropsied, seropositive elk in 2018 did not detect *B. abortus* in any tissues. Full necropsy and testing has been performed on a total of 11 seropositive elk since 2016 and we have examined a total of 252 tissue samples. In 2016, we detected *B. abortus* in 1 of 22 tissue samples from 1 seropositive elk from the N. Madison study area, and we have been unable to culture *B. abortus* from all other tissue samples. Our limited detection from tissues of seropositive elk

suggests that (1) *B. abortus* is difficult to culture, and (2) seropositive individuals do not harbor widespread infections of *B. abortus*. Even if *B. abortus* is difficult to culture, given the considerable number of samples collected and tested from these seropositive elk, it is likely that at least some of them were not actively infected at the time of their death. It should be noted that this does not mean these elk posed no transmission risk over the previous 5 years, or prior to inclusion in this study. They could have been actively infected in previous years.

Data from GPS collars has improved our understanding of elk movement and potential routes for the spatial spread of brucellosis or other diseases among elk populations (Figure 13). Elk movements have been and will continue to be used to determine the timing and degree of spatial overlap between elk and livestock in focused analyses.

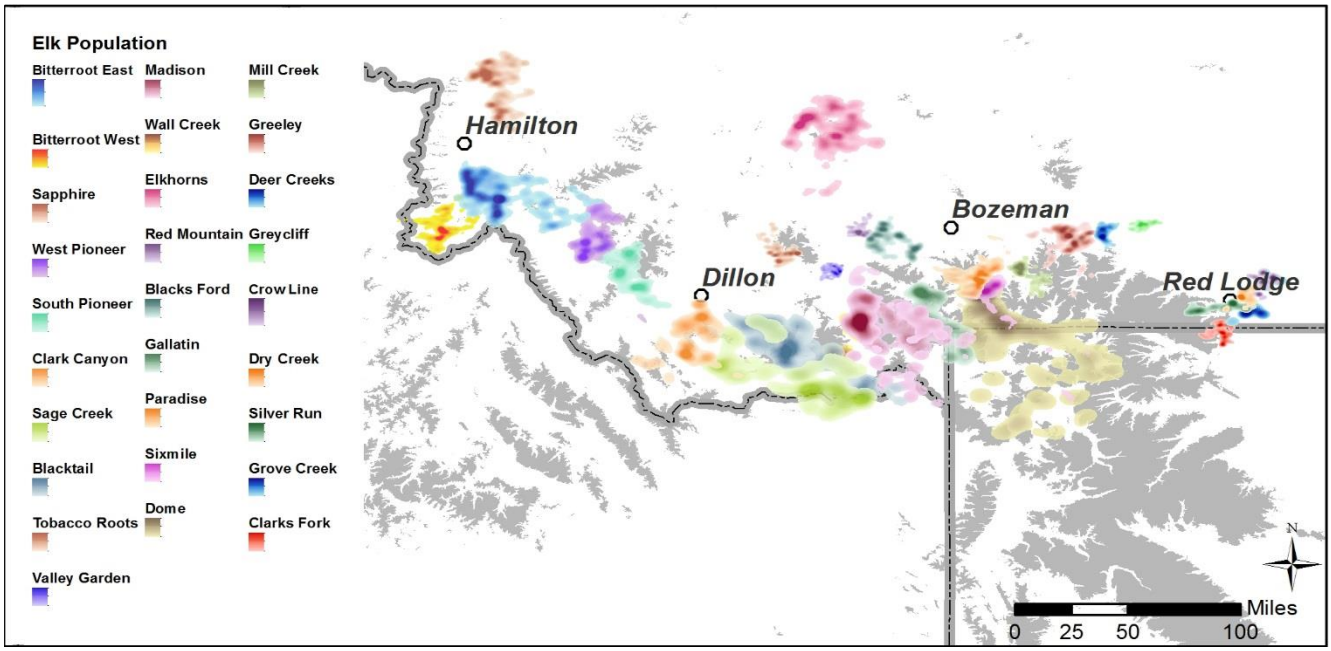

Figure 13. Annual kernel density distributions of elk herds in SW Montana with GPS collar data showing the potential overlap and interchange between herds. Gray polygons represent mountain ranges.

We worked with collaborators at the U.S. Geological Survey to develop a model to assess elk-to-livestock transmission risk within the Montana DSA. The relative probability of daily female elk occurrence during the risk period (February – June) was predicted from resource selection functions using elk telemetry data. We combined these spatiotemporal predictions with elk seroprevalence, demography and density, and transmission timing data to quantify the number, timing and location of abortions. Additionally, we integrated these predictions with spatiotemporal data on livestock distribution to estimate daily risk of livestock encountering an elk abortion. Using the brucellosis transmission risk model, we estimated that 525 brucellosis-induced abortions occur each year within the Montana DSA (Rayl et al., In Review). We predicted that approximately half of those abortion events occur on property with livestock, and that 98% of those properties were private ranchlands, as opposed to state or federal grazing allotments. Risk was greatest from March through May and Madison and Paradise Valleys were the highest risk areas within the Montana DSA (Figure 12). The potential for disease

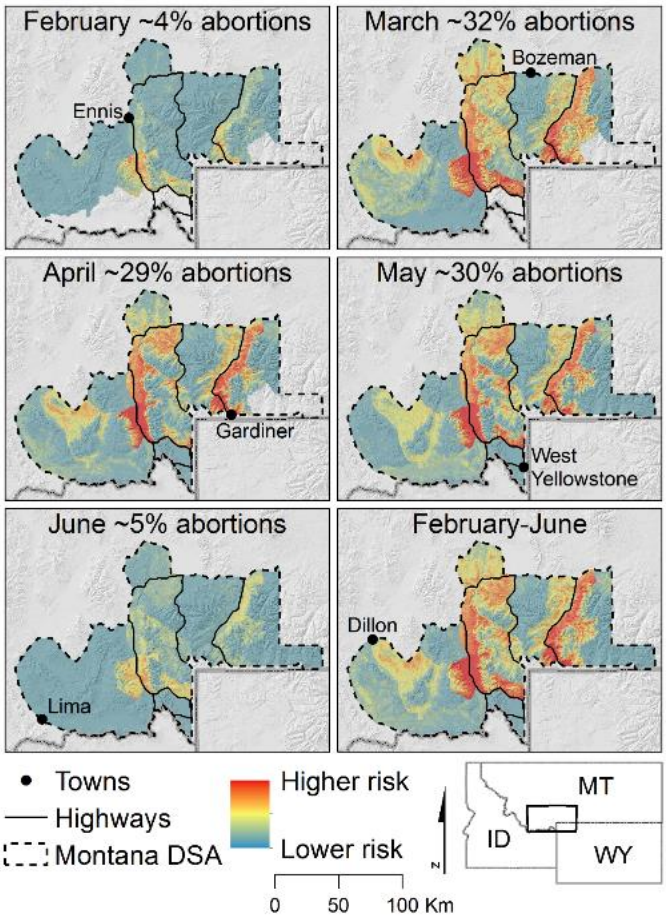

Figure 12. Predicted risk of transmission events by adult female elk within the boundary of the Montana designated brucellosis surveillance area (DSA) during each month of the brucellosis transmission risk period (15 February-30 June). Monthly estimates were produced by summing daily estimates of the risk of abortion events during all days of the month. Shading depicts hillshade of elevation.

transmission risk was strongly influenced by disease prevalence, transmission timing, elk abundance, and elk distribution. The full report is available on the MFWP brucellosis webpage at: http://fwp.mt.gov/fishAndWildlife/diseasesAndResearch/healthPrograms/brucellosis/default.html.

The primary goal of this project is to provide wildlife and livestock managers with information useful for designing strategies to reduce the risk of brucellosis transmission from elk to livestock. The brucellosis transmission risk model helps to meet this need by combining all of our data on elk movement, distribution, and density, brucellosis prevalence, and timing of disease transmission to predict abortion events and the potential for elk-to-livestock transmission. The model serves as a useful tool for wildlife managers to identify areas of high transmission risk and proactively target these risky areas for more effective resource allocation, to help ensure that FWP-funded risk management efforts are targeted in risky areas.

Next Steps

In 2019, we plan to continue brucellosis surveillance efforts in the Tendoy Mountains southwest of Dillon, Montana in the northern portion of HD302 and HD328 (Figure 13), as well as a second surveillance site that is yet to be identified. The elk population in the Tendoy Mountains is large enough to necessitate a second capture effort to yield a large enough sample size for an accurate seroprevalence estimate, particularly after the detection of 1 seropositive elk in HD300. The focus of next years' effort will be to 1) continue to

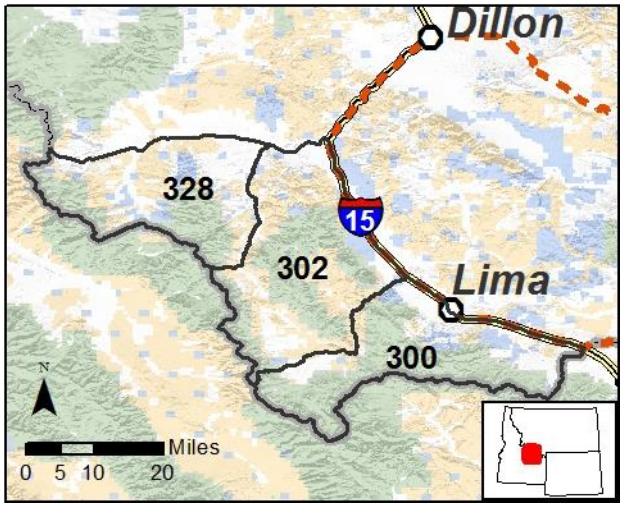

Figure 13. Planned sampling area for 2019 in the Tendoy Mountains west of Lima, MT near the Montana – Idaho border.

document the spatial extent of the disease, 2) to finalize the exposure, movement and epidemiology data to predict the risk of transmission from elk to livestock, and 3) to evaluate the effectiveness of elk management actions designed to affect elk distribution and elk-cattle spatial overlap at reducing transmission risk within the DSA. For seropositive elk captured prior to 2016, we will continue to monitor their serology, movement and birth events. Seropositive elk in N. Madison will be euthanized in 2019 and Mill Creek in 2020 in an attempt to culture *B. abortus* from their body tissues.

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