Targeted Elk Brucellosis Surveillance Project
2019 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 2019 targeted elk brucellosis surveillance project. In January 2019, we sampled a total of 99 elk from populations in the northern Tendoy Mountains and screened blood serum for exposure to *B. abortus*. We sampled 100 elk in the southern Tendoy Mountains in 2018 and report estimates of brucellosis seroprevalence within the 3 Tendoy Mountains hunt districts (HD) based on the combined 2018 and 2019 sampling results. Within the Tendoy Mountains area, we detected exposure to *B. abortus* in HD 300 (prevalence = 2%, 95% CI = 0.3-9%, n = 60), but did not detect exposure in HD 302 (0%, 95% CI = 0-4%, n = 83) or HD 328 (0%, 95% CI = 0-6%, n = 56). We also sampled a total of 56 elk in the southern Bangtail Mountains. All Bangtail Mountains elk tested negative for exposure to *B. abortus* (prevalence = 0%, 95% CI: 0-6%, n = 56). Potential overlap with livestock and interchange between elk populations is being monitored with GPS radio collars. We collared 30 elk in the Tendoy Mountains and 15 elk in the Bangtail Mountains and are currently collecting elk movement information. To assess the risk of seropositive elk shedding *B. abortus*, we euthanized, necropsied and sampled 7 seropositive elk from the N. Madison and Mill Creek populations to determine if these seropositive elk harbored the *B. abortus* bacteria. We submitted a comprehensive assortment of tissue samples from these 7 elk for culture and Polymerase Chain Reaction (PCR) testing and *B. abortus* was detected by culture and PCR in 1 elk, and by PCR only in a second elk. These necropsies concluded fieldwork for the epidemiology portion of the project that monitored pregnancy outcome of seropositive elk captured between 2011 and 2015 and sampled birth sites for presence of *B. abortus*. To evaluate the effects of brucellosis management hazing and hunting, we continue to collect elk movement data in the Madison population. We concluded similar data collection in Sixmile Creek. Data analysis evaluating elk response to hazing and hunting in these two populations is ongoing.

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, typically 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 populations, 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 targeted sampling efforts focused on 1 – 2 elk populations per year since 2011. Elk populations are identified through collaborative discussions between MFWP, the Montana Department of Livestock (DOL) and landowners. Selection is based on proximity to the known distribution of brucellosis and/or significant livestock concerns. Surveillance areas are both inside and outside the State of Montana brucellosis designated surveillance area (DSA, Figure 1).

SAMPLED POPULATIONS

Since 2011, we have sampled 18 elk populations (Figure 1). In January 2019, we sampled elk from 2 populations in the Tendoy Mountains (HD302, HD328) and 1 population in the southern Bangtail Mountains (HD 393). The purpose of sampling was to evaluate brucellosis presence and prevalence in the elk populations and identify elk movement patterns and interchange among populations.

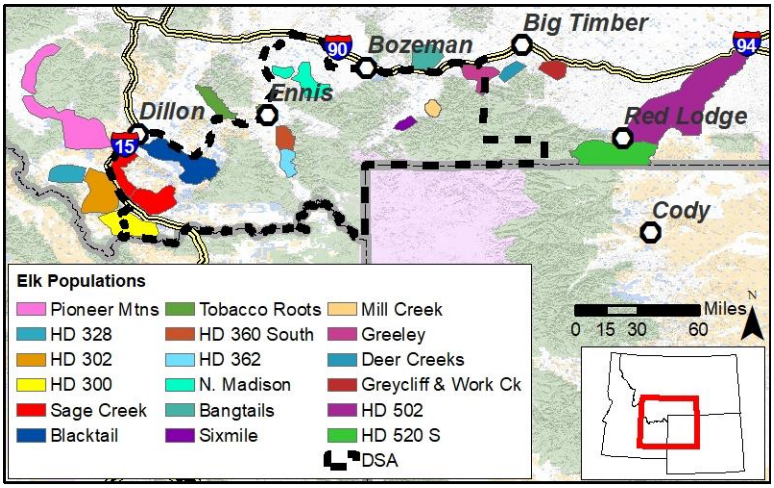

Figure 1. Populations sampled during the 2011 – 2019 targeted elk brucellosis surveillance project. The area inside the black dashed line is the Montana brucellosis DSA.

METHODS

To evaluate *B. abortus* presence and prevalence in the Tendoy and Bangtail Mountains populations, we captured adult female 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 within the surveillance areas. 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) 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 and Bangtail Mountains populations to track movements and evaluate risk of brucellosis transmission to livestock and other elk populations. We deployed satellite upload collars that allow for real-time movement tracking. The collars are programmed to record locations every hour and have a timed-release mechanism that releases the collar after 65 weeks, allowing collars to be retrieved and redeployed the following year. All collars have a mortality sensor that detects if the collar is stationary for > 10 hours.

We recaptured and euthanized the remaining 7 seropositive elk initially detected and collared during the 2011 – 2015 portion of this project. The purpose of maintaining a collared sample of seropositive animals was to monitor serostatus and birth events for 5 years to understand the epidemiology of the disease post-infection, and to determine the level of risk associated with exposed elk through time. We retested these seropositive elk annually for *B. abortus* exposure to determine if elk experience antibody titer loss following exposure. While testing blood serum annually determines if an elk has antibodies indicating exposure to *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* bacteria. We euthanized seropositive elk following 5 years of monitoring and sampled elk to detect *B. abortus* bacteria using culture testing of tissues. In 2019, we also submitted tissue samples for a Polymerase Chain Reaction (PCR) test recently developed at the University of Wyoming to evaluate if samples contain *B. abortus* based on DNA. The PCR test detects bacterial DNA, and unlike culture testing, does not require the bacteria to be alive during the test to detect an active infection. Two elk from the N. Madison study area were scheduled to be removed, and we also removed the remaining 5 seropositive elk from the Mill Creek study area after only 4 years of monitoring due to logistics and increasing capture difficulties. The Diagnostic Lab performed the necropsies and collected extensive

tissue samples (e.g., lymph nodes, organs) from all 7 elk. Samples were divided and submitted to both the National Veterinary Services Lab (NVSL) for culture testing and to the University of Wyoming for PCR testing to detect *B. abortus* bacteria.

To evaluate the effects of brucellosis management hazing and lethal removal on elk distributions and spatial overlap with livestock, we monitored elk movements and brucellosis management actions in the Sixmile Creek and Madison Valley areas. During 2019, brucellosis management included hazing elk from high-risk areas. Hazers conducting brucellosis management carried GPS units and recorded track logs during elk hazing events. In addition, lethal removal occurred at Sixmile Creek during a shoulder season hunt, and in the Madison Valley area during game damage hunts. Both hunts ended on February 15th. We will evaluate the effects of brucellosis management actions on elk movements to determine the amount of time elk stayed away from high-risk areas.

RESULTS

Brucellosis surveillance

Brucellosis sampling and surveillance in the Tendoy Mountains southwest of Dillon occurred in both 2018 and 2019 (Figure 2). In February 2018, we sampled 60 elk in HD300 and 40 elk in HD302. In January 2019, we sampled 43 additional elk in HD302 and 56 elk in HD328. Elk in these HD's comprise 3 populations, with semi-distinct winter ranges. 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 83 elk tested positive for exposure to *B. abortus*, and we deployed collars on 27 elk. In the HD328 population, 0 of 56 elk tested positive for exposure to *B. abortus*, and we deployed collars on 17 elk. Estimated seroprevalence was 2% (95% CI = 0.3-9%) in HD300, 0% (95% CI = 0-4%) in HD302, and 0% (95% CI = 0-6%) in HD328 (Table 1). The detection of exposure to *B. abortus* in elk from the HD300 population in 2018 was the first such detection. Previous hunter harvest samples of adult female elk have all tested negative for HD300 (n = 46; 2008-2011), HD302 (n = 19, 2008-2010) and HD328 (n = 2; 2009-2019).

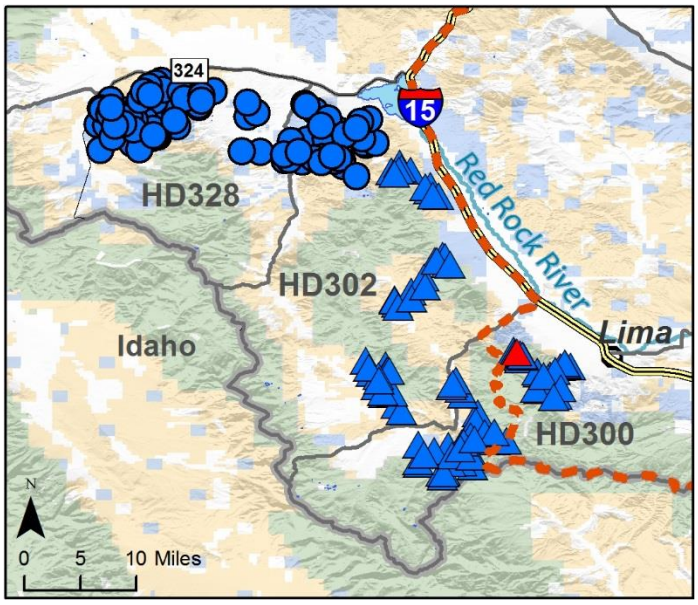

Figure 2. Capture and sampling locations of seropositive (red) and seronegative (blue) elk from the Tendoy Mountains populations during February 2018 (triangles) and January 2019 (circles).

In January 2019, we sampled 49 elk in the Bangtail Mountains and deployed collars on 15 elk (Figure 3). In addition, we tested 7 blood samples from hunter harvested elk, increasing our sample size to 56 elk. In the Bangtails, 0 of 56 elk tested seropositive giving the population an estimated seroprevalence of 0% (95% CI: 0-6%; Table 1). Previous hunter harvest samples of adult female elk from the Bangtail Mountains (n = 18; 2009-2019) all tested negative.

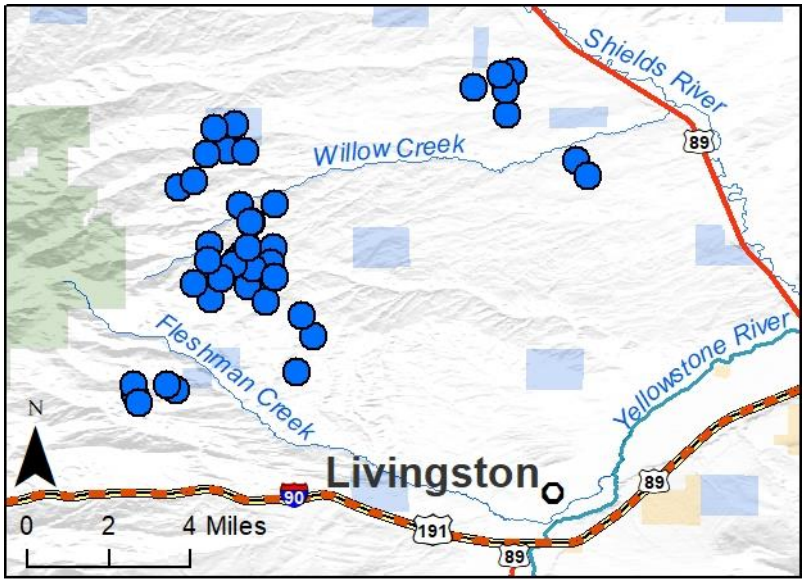

Figure 3. Capture and sampling locations of seronegative (blue) elk from the Bangtail Mountains population during January 2019.

Table 1. The elk populations, number of elk sampled for *B. abortus* exposure, number of elk testing seropositive for exposure, and the estimated seroprevalence with 95% confidence intervals (in parentheses) during January 2019 and February 2018 (Tendoy Mtns only).

Population	Number Sampled	Number Seropositive	Estimated Seroprevalence
HD 300	60	1	0.02 (0.003, 0.09)
HD 302	83	0	0 (0, 0.04)
HD 328	56	0	0 (0, 0.06)
Bangtails	56	0	0 (0, 0.06)

Based on data from the last 10 years of hunter harvest and targeted sampling, we estimate brucellosis seroprevalence in elk varies spatially across southwest Montana and ranges from 0 – 38% (Figure 4).

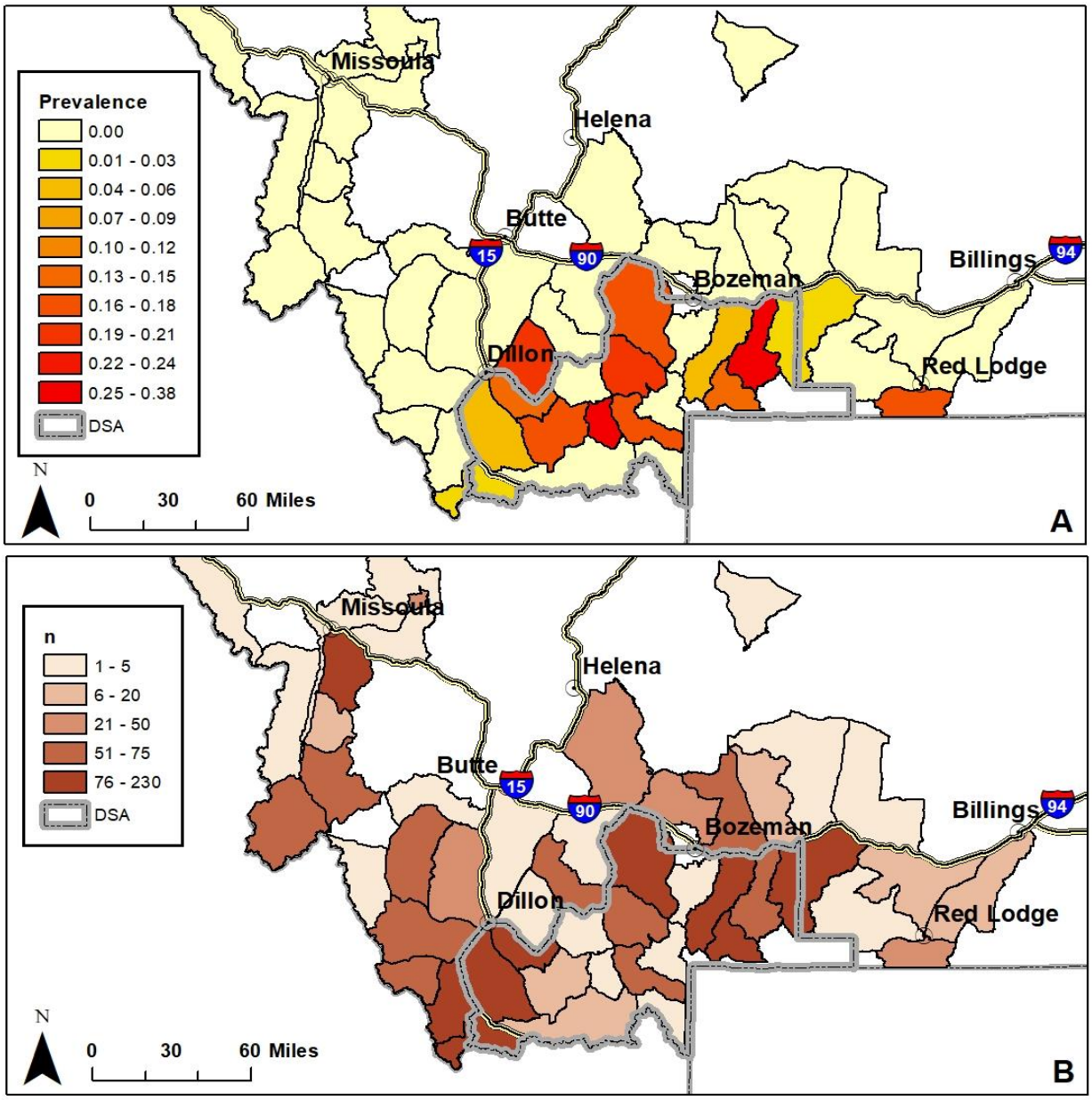

Figure 4. The estimated brucellosis seroprevalence (Panel A) and number of samples screened (n, Panel B) for adult female elk by hunting district* during 2009 – 2018. Samples include those collected during winter research captures and fall hunter harvest. Note some seroprevalence estimates are derived from a low number of samples. The gray line denotes the boundary of the Montana brucellosis designated 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 deployed collars in the southern Tendoy Mountains in 2018 and northern Tendoy Mountains in 2019. In February 2018, we deployed 16 collars in HD300 and 14 collars in the southern portion of HD302. The GPS ability on 1 collar from HD302 failed shortly after deployment in early April. One collared elk from HD302 died of capture related injuries the day after capture and her movement data are not included. The automatic release mechanism failed on 5 collars and loss of signal from an additional 4 collars limited our data recovery to 20 of 30 collars deployed in 2018. Two collared elk were harvested in October 2018, 1 from HD300 and 1 from HD302. A second collared elk from HD300 was harvested in November 2018 in Idaho. Another collared elk from HD300 was killed by a mountain lion in October 2018. In 2019, we deployed 13 collars in the northern portion of HD302 and 17 collars in HD328. The 2019 collars are satellite upload collars that provide real time location data. In total, we recovered or downloaded collar location data from 50 total elk (12 HD300 elk, 21 HD302 elk, 17 HD328 elk), representing movement data from February 2018 through 17 August 2019 (Figures 5 & 6).

In general, HD300 elk winter on the southeast side of the Tendoy Mountains, between Big Sheep and Little Sheep Creeks, with occasional use of the Lima Peaks area farther south. Three elk also used the Muddy Creek area north of Big Sheep Creek as winter range, including 1 elk that stayed north in HD302 year-round. Two elk were residents and never left the southeast side of the Tendoy Mountains, generally drifting farther south to the Lima Peaks area in summer. The remaining 10 elk migrated to summer ranges in April and May, returning to the same winter range sometime between October and January. Three elk migrated southeast through the Lima Peaks area to summer on the Montana-Idaho (MT-ID) border southwest of Monida. Five elk migrated southwest to the MT-ID

border between Nicholia Creek in Montana and Fritz Creek in Idaho. One elk migrated east across Interstate 15 in May and summered just south of Red Rock River, returning in late October.

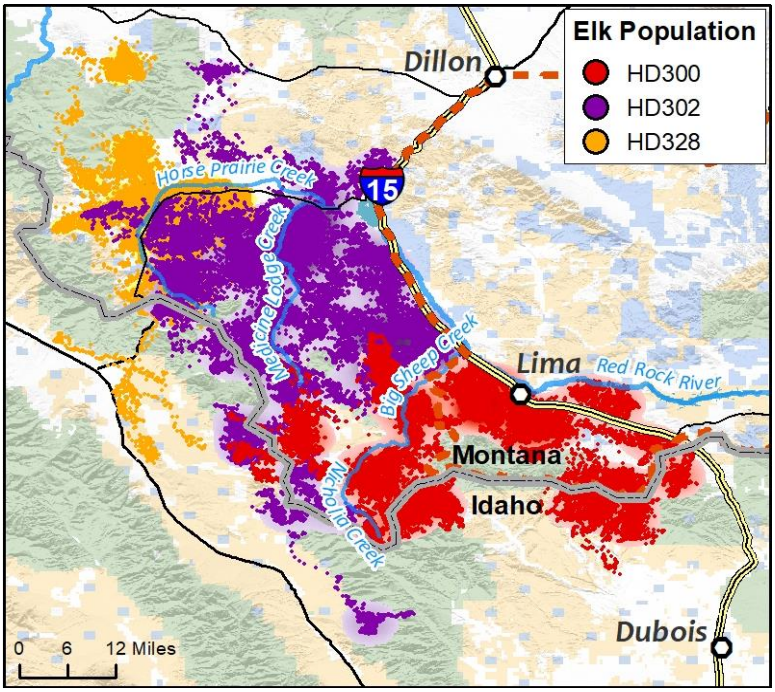

Figure 5. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from HD300 (red), HD302 (purple), and HD328 (orange) populations in the Tendoy Mountains, 2018-2019. The gray line represents the Montana-Idaho state boundary.

Elk captured in HD302 typically wintered along the east side of the Tendoy Mountains, staying north of Big Sheep Creek, and in the northwest between Garfield Canyon and Medicine Lodge Creek. Two elk moved west shortly after capture into HD328, wintering west of Medicine Lodge Creek. Three elk spent some of the winter north of Hwy 324 in the Rocky Hills and Henneberry Ridge areas. Three elk captured in the southern portion of HD302 were residents, remaining between I90 near Dell and Muddy Creek year-round. The remaining elk began migrating to summer ranges in April and May. Elk that wintered in the northwest portion of HD302 tended to migrate west of Medicine Lodge Creek into HD328 and the eastern side of the Beaverhead Mountains, summering between Barrett Creek and Tepee Mountain. Two elk summered on the west side of the Beaverhead Mountains in the Maiden Creek area. Seven elk migrated west to the MT-ID border stretching from Deadman Pass south to Nicholia Creek, with most spending time in Idaho. One elk that wintered in the north migrated south to Muddy Creek for the summer. Of the 8 elk captured in 2018, 6 returned to the same winter range sometime between October and January. The remaining 2

elk wintered in Idaho during 2019, one on the east side of Birch Creek Valley and the other in the Lemhi Valley. The Lemhi Valley elk had a collar with a failed GPS function, but the VHF allowed for collar recovery in April 2019.

HD328 elk largely wintered from Barrett Creek west to Magpie Gulch and along Horse Prairie Creek south to Maiden Creek. Most elk were residents, with a slight shift to the lower riparian areas of Bloody Dick Creek and Horse Prairie Creek for the summer. Six of the 17 elk did migrate in April and May. Three elk migrated north to summer between Grimes and Painter Creek. One elk migrated south of Maiden Creek to Deadman Pass, with some time spent in Idaho. A second elk migrated south to upper Horse Prairie and Divide Creeks. A third elk migrated south to the Lemhi Valley of Idaho in March but turned around and migrated north in May to summer between Fox and Andrus Creeks just south of Hwy 278.

During the February through June risk period (Figure 6), HD300 elk were on their winter range, generally from Big Sheep Creek south to the Lima Peaks area, as well as Muddy Creek. As the risk period progressed and migration began in April, elk moved southeast and southwest to the MT-ID border. One elk moved east across I15 staying south of Red Rock River. HD302 elk were spread out on winter and summer range in the Tendoy

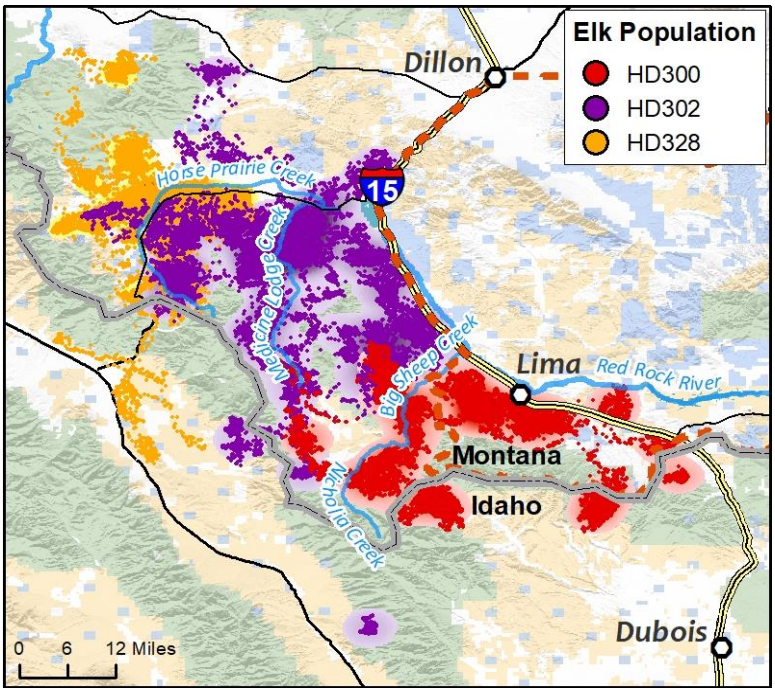

Figure 6. Risk period (Feb-June) locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from HD300 (red), HD302 (purple), and HD328 (orange) populations in the Tendoy Mountains, 2018-2019.

and Beaverhead Mountains, stretching from Nicholia Creek near the MT-ID border north to Horse Prairie Creek, east to Clark Canyon Reservoir and south to Big Sheep Creek. One elk was north near Hwy 278. HD328 elk were on their winter range along Horse Prairie and Bloody Dick Creek, except for 3 elk that migrated south to the MT-ID border area and 3 elk that migrated north to the Grimes and Painter Creek areas. One of the elk that migrated south also spent part of the risk period just south of Hwy 278 near Andrus Creek.

In January 2019, we deployed 15 satellite upload collars in the Bangtail Mountains. One collared elk was harvested 3 weeks after capture and her limited movement data are not included. We are currently collecting data from the remaining 14 elk (Figure 7). In general, Bangtail elk winter in the foothills from Canyon Creek south to I90, and east to Hwy 89. One elk migrated west shortly after capture in late January to Bridger Canyon and has remained there. Migration to summer range primarily occurred in May with limited movement in June. Two additional elk migrated west to Bridger Canyon. Two elk migrated west to the Bozeman Pass area, with 1 remaining on the north side of I90 and the other crossing I90 to the south in late May and summering in the Timberline Creek area. Five total elk migrated west, while the remaining 9 elk remained on the east side of the Bangtails all summer.

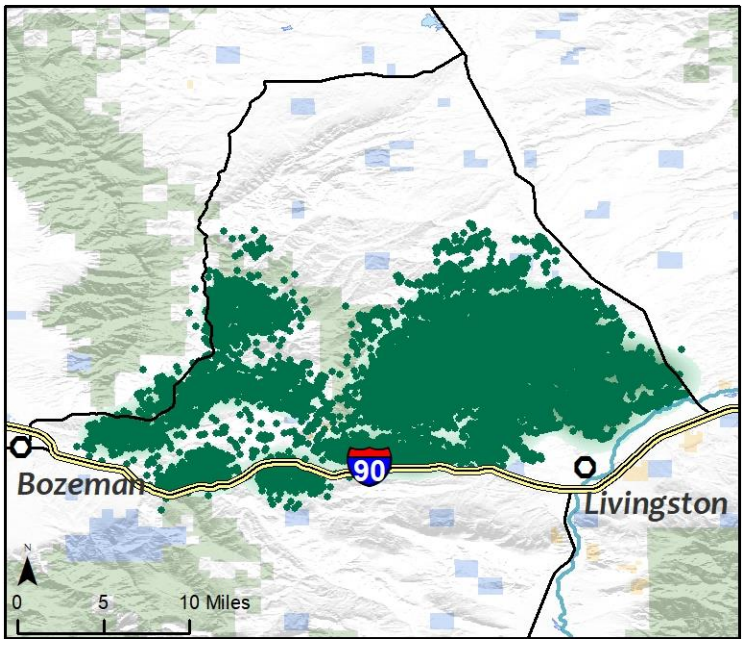

Figure 7. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Bangtail Mountains population, January – August 2019.

Brucellosis management actions

To study the effects of brucellosis management hazing and lethal removal on elk distributions and spatial overlap with livestock we deployed satellite upload collars on adult female elk in two areas that regularly receive management actions. In 2017, we collared 40 elk in the Sixmile Creek population (Figure 8) and in 2018 we collared 40 elk in the Madison Valley populations HD360 S & HD362 (Figure 9). The collars were programmed to record location data for 3 years. Data collection in Sixmile Creek concluded in May 2019 with approximately 75 elk-years of data after 6 mortalities and 30 premature collar failures. Data collection in Madison Valley will continue through April 2020, with 9 mortalities and 13 premature collar failures so far.

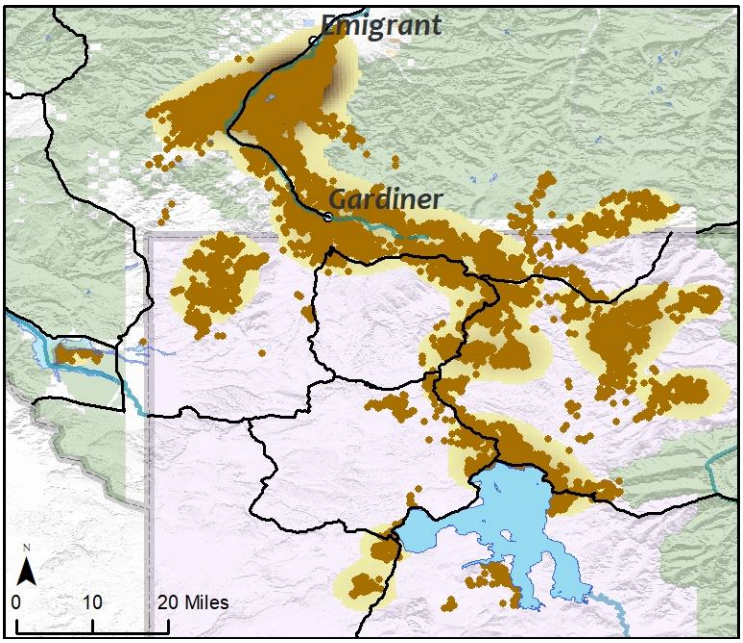

Figure 8. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the Sixmile Creek population.

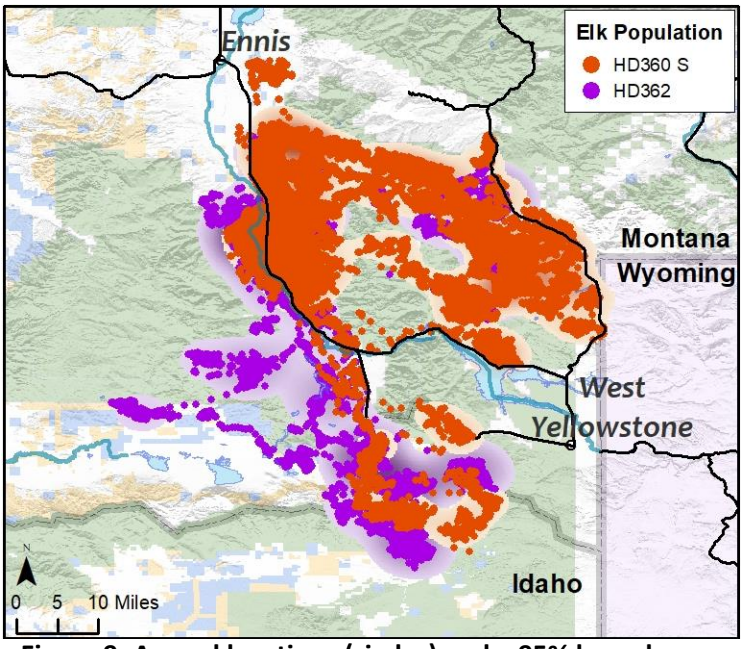

Figure 9. Annual locations (circles) and a 95% kernel utilization distribution (shaded area) of elk from the HD360 S (orange) and HD362 (purple) populations.

Management hazing in Sixmile Creek and Madison Valley occurred throughout the winter to move elk off

private property with cattle (Table 2). Management hazing in the Sixmile Creek area prior to February 15th occurred east of Sixmile Creek only. No brucellosis hunts were implemented in either area during winter 2018 – 2019. There were, however, management season hunts in Madison Valley and an elk shoulder season hunt in Sixmile Creek through February 15th.

Table 2. Number of days with brucellosis management hazing events in the Sixmile Creek and Madison Valley areas by month for winter 2018 – 2019.

	Dec	Jan	Feb	Mar	Apr	May	Jun
Sixmile Creek*	0	20	22	21	21	26	0
Madison Valley	0	0	7	19	16	15	0

*Prior to February 16th, hazing only occurred east of Sixmile Creek

We will continue to monitor brucellosis management actions and elk responses to management actions through 2020 in the Madison Valley, but have concluded our monitoring in the Sixmile Creek area. Analysis looking at the ability of management hazing and hunting to alter elk movement and distribution is ongoing. The efficacy of management actions at reducing commingling and elk to livestock transmission risk will be evaluated.

Seropositive elk recapture and necropsy

During January 2019, we recaptured 7 seropositive elk from the Northern Madison (n = 2) and Mill Creek (n = 5) populations. All elk were euthanized in the field, necropsied at the DOL Diagnostic Lab and had tissue samples submitted for culture testing at the NVSL and PCR testing at the University of Wyoming. *B. abortus* was detected by culture (popliteal lymph node) and PCR (placentome and plasma) in 1 seropositive elk from the Mill Creek population (Table 3). *B. abortus* was detected by PCR (retropharyngeal lymph node) only in a 2nd seropositive elk from the Mill Creek population (Table 3).

Table 3. Seropositive elk necropsied in 2019 by population, number of samples tested, and tissues where *B. abortus* was detected by culture and PCR. (--- indicates no detection)

Elk ID	Population	Samples	Culture Detected Tissues	PCR Detected Tissues
31113001	N. Madison	24	---	---
31113027	N. Madison	25	---	---
EC14006	Mill Ck	29	Popliteal lymph node	Placentome, Plasma
EC14014	Mill Ck	26	---	---
EC14018	Mill Ck	27	---	Retropharyngeal lymph node
EC14020	Mill Ck	24	---	---
EC14025	Mill Ck	27	---	---

Tissue samples submitted from elk included: lymph nodes (supramammary, popliteal, prefemoral, prescapular, iliac, hepatic, mesenteric, parotid, mandibular, bronchial, retropharyngeal), organs (kidney, liver, spleen, tonsil), reproductive tract (mammary gland, uterus, ovaries, cervix, placentome, placenta, fetus, amniotic fluid, abomasal fluid), swabs (vaginal, rectal, uterine, tonsil crypts), plasma, and feces. Not all samples were available for all elk due to decomposition and/or pregnancy status.

The annual serology results for these elk show that only 1 elk reverted to seronegative status in 2018 but was seropositive again in 2019. The rest of the elk remained seropositive throughout their monitoring period (Table 4). From 2015 – 2019, we documented pregnancy status and birth event outcome (Table 5). Visitation and sampling of birth event sites was limited by the open status of several elk across the years, as well as the failure of 4 Vaginal Implant Transmitters (VIT). Two abortions were documented and *B. abortus* was detected at 1 site. Limited samples available for testing at the second abortion made the lack of detection inconclusive. *B. abortus* was detected at 1 live birth site, and not detected at 14 live birth sites. Five of the 7 elk were determined to be pregnant during necropsy.

Table 4. Annual serology status for seropositive elk removed and necropsied in 2019 to test for *B. abortus* (--- indicates elk was not captured that year).

Elk ID	Population	2014	2015	2016	2017	2018	2019
31113001	N. Madison	Pos	Pos	Pos	Pos	**Neg**	Pos
31113027	N. Madison	Pos	Pos	Pos	Pos	Pos	Pos
EC14006	Mill Ck	---	Pos	Pos	---	Pos	Pos
EC14014	Mill Ck	---	Pos	Pos	Pos	Pos	Pos
EC14018	Mill Ck	---	Pos	Pos	Pos	Pos	Pos
EC14020	Mill Ck	---	Pos	Pos	Pos	Pos	Pos
EC14025	Mill Ck	---	Pos	Pos	Pos	Pos	Pos

Table 5. Annual pregnancy fate for seropositive elk removed and necropsied in 2019 to test for *B. abortus*. Detections of *B. abortus* at abortion and live birth sites are noted in bold italics with an asterisk, otherwise *B. abortus* was not detected at the birth event (--- indicates elk was not captured that year).

Elk ID	Population	2014	2015	2016	2017	2018	2019
31113001	N. Madison	Open	Live Birth	Live Birth	Open	Live Birth	Open
31113027	N. Madison	***Abortion****	Open	Open	VIT failure	Open	Preg
EC14006	Mill Ck	---	Live Birth	Live Birth	---	VIT failure	Preg
EC14014	Mill Ck	---	Live Birth	Live Birth	VIT failure	Live Birth	Preg
EC14018	Mill Ck	---	Open	Live Birth	***Live Birth****	Abortion^	Preg
EC14020	Mill Ck	---	Live Birth	Live Birth	Live Birth	Live Birth	Open
EC14025	Mill Ck	---	Live Birth	Open	Open	VIT failure	Preg

^ Limited samples at abortion site, fetus mostly consumed.

DISCUSSION

Brucellosis surveillance efforts did not detect exposure to *B. abortus* in elk from the HD302 or HD328 populations in the northern Tendoy Mountains but did detect a low level of exposure in the HD300 population in the southern Tendoy Mountains. The DOL expanded the brucellosis DSA boundary to include the eastern portion of HD300 in response to the documented exposure, as well as elk movement data provided by Idaho Fish and Game. This boundary change is shown in Figure 1.

Elk movement data shows that there is interchange among elk populations in the Tendoy Mountains and the known seropositive elk in the Sage Creek area east of I15. In addition, capture and collaring efforts by Idaho Fish and Game department have detected brucellosis in elk populations just south of the MT-ID border and collar movement data suggests these elk often spend part of their winter in the Tendoy Mountains of Montana. These movements identify the potential for westward brucellosis expansion in the Tendoy Mountains elk populations.

Brucellosis surveillance efforts did not detect exposure to *B. abortus* in the Bangtail Mountains elk population. The movement, however, of 1 elk south of I90 represents the potential for interchange between elk populations. Where the elk summered is immediately adjacent to the Wineglass Mountain elk population of HD314 in the northern Paradise Valley (Figure 10), where brucellosis has been detected. Interchange between these 2 populations would represent a potential transmission route for brucellosis to expand north and warrants additional surveillance efforts.

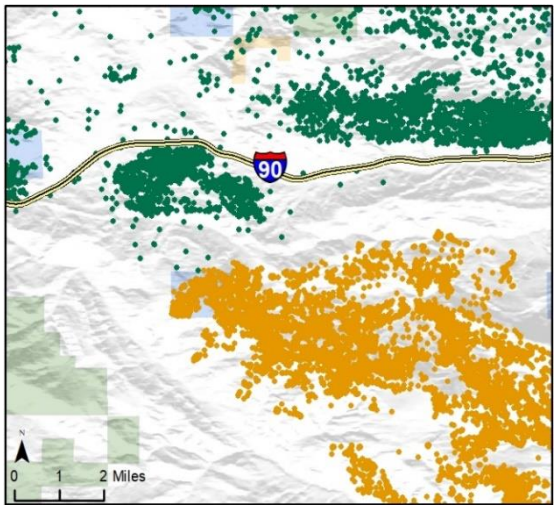

Figure 10. Annual locations (circles) of elk from the Bangtail (green) and Wineglass Mountain (orange) populations.

The sampling, culture and PCR testing of the 7 necropsied, seropositive elk in 2019 did detect *B. abortus* in 2 elk. Full necropsies and testing have been performed on a total of 18 seropositive elk since 2016 and we have examined a total of 427 tissue samples. Culture testing detected *B. abortus* in 1 of 22 samples from 1 seropositive elk in the N. Madison population in 2016, and in 1 of 28 samples from 1 seropositive elk in the Mill Creek population in 2019. In both instances, *B. abortus* was detected in the popliteal lymph node. PCR testing was used for the first time in 2019 and detected *B. abortus* in the culture positive elk, and a 2nd seropositive elk that had no detection on culture tests. *B.*

abortus was found in a placentome, plasma and a retropharyngeal lymph node via PCR testing. Our limited culture detection from tissues of seropositive elk suggests that (1) *B. abortus* is difficult to culture, and (2) seropositive individuals may not harbor widespread infections of *B. abortus*. PCR testing is still being developed but shows promise as an alternative or supplemental method for detection. Detection probability of culture and PCR testing is unknown. Bacteria in elk with chronic, low-level infections and low bacterial burdens may be difficult to detect. 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. Chronic *B. abortus* infections have also been known to become inactive or dormant, only to return and flare up during periods of decreased immune function (i.e., late in the 3rd trimester).

Data from elk collars has improved our understanding of elk movement and potential routes for the spatial spread of brucellosis or other diseases among elk populations (Figure 11). 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.

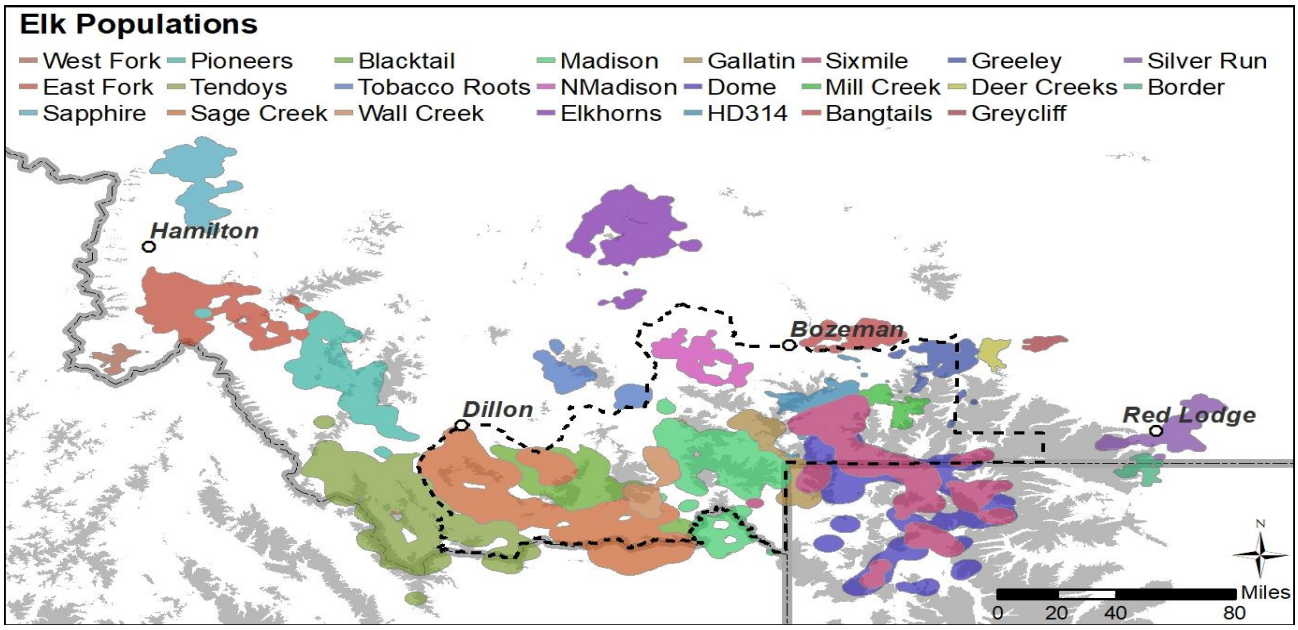

Figure 11. Annual kernel density distributions of elk populations in SW Montana with GPS collar data showing the potential overlap and interchange between populations. Gray polygons represent mountain ranges.

Next Steps

In 2020, we plan to continue brucellosis surveillance efforts in the southern Bangtail Mountains north of Livingston to achieve our sampling goal of 100 samples from this region (Figure 12). In addition, we plan to capture 100 elk in the Ruby Mountains (HD322; Figure 13). The Ruby Mountains are just outside the brucellosis DSA and movement data from the seropositive Blacktail population sampled in 2011 shows potential for interchange. The focus of next year's effort will be to 1) continue to document the spatial extent of the disease, and 2) 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.

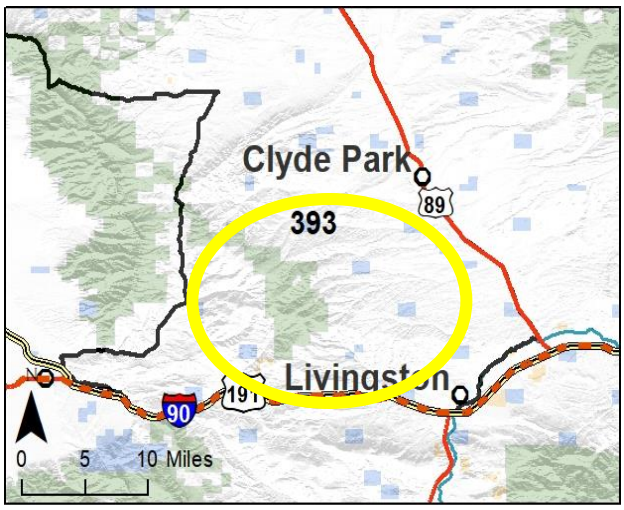

Figure 12. Planned sampling area for 2020 in the Bangtail Mountains north of Livingston, MT.

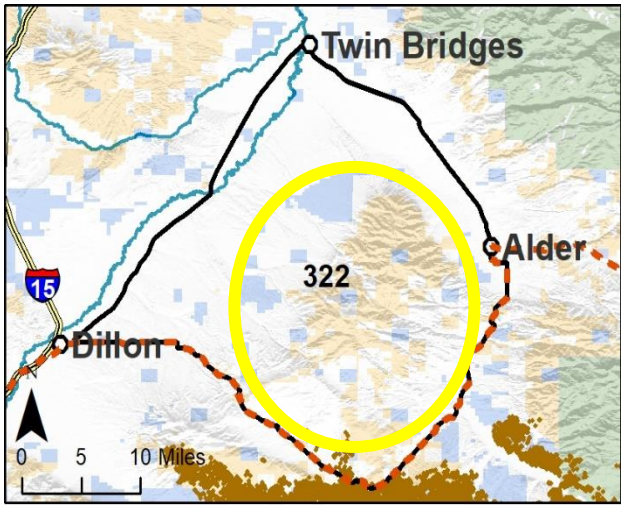

Figure 13. Planned sampling area for 2020 in the Ruby Mountains south of Twin Bridges, MT. Annual locations (tan circles) of elk from the Blacktail population, 2011-2015.

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Literature Cited

Cross, P. C., E. J. Maichak, J. D. Rogerson, K. M. Irvine, J. D. Jones, D. M. Heisey, W. H. Edwards, and B. M. Scurlock. 2015. Estimating phenology of elk brucellosis transmission with hierarchical models of cause-specific and baseline hazards. Journal of Wildlife Management 79:739-748.