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2024 Bighorn Sheep and Mountain Goat Annual Report

Statewide Adaptive Management of Bighorn Sheep and Mountain Goats

Colton Padilla, PhD student, USGS MT Cooperative Wildlife Research Unit*
Dan Walsh, Unit Leader, USGS MT Cooperative Wildlife Research Unit†
Nick DeCesare, Research Wildlife Biologist, Montana Fish, Wildlife and Parks‡
Peter Iacono, Former Research Associate, USGS MT Cooperative Wildlife Research Unit

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*colton.padilla@umontana.edu
†dan.walsh@umontana.edu
‡ndecesare@mt.gov

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Background and Summary

Bighorn sheep (*Ovis canadensis*) and mountain goat (*Oreamnos americanus*) populations across western North America face many different challenges. These challenges can include climate change (White, Gregovich, and Levi 2018), habitat degradation (Bleich, Wehausen, and Holl 1990), infectious disease (Cassirer et al. 2018), and predation (Rominger 2018). Both bighorn sheep and mountain goat populations have seen major population declines particularly in the previous century (Buechner 1960). Bighorn sheep populations have primarily been impacted by pneumonia epizootics that are initiated by the bacteria *Mycoplasma ovipneumoniae* (Cassirer et al. 2018; Besser et al. 2013). In contrast, understanding population declines in mountain goats is hindered by the difficulty of monitoring population vital rates and cause-specific mortality (Gude et al. 2022). However, factors explaining past and present dynamics for mountain goats include predation, disease, and legacy effects of past over-harvest by hunters in some districts (Côté and Festa-Bianchet 2003; DeCesare and Smith 2018; Rice and Gay 2010; Hamel et al. 2006).

Across western Montana, bighorn sheep herds have experienced varying population trajectories (MFWP 2010). While many bighorn sheep herds across the state have rebounded following major declines related to disease, predation, and overhunting, some populations continue to struggle to maintain stable or increasing populations due to habitat degradation, disease, and predation. Population trajectories for introduced and native mountain goat populations have exhibited wildly different population dynamics (Casebeer, Brandborg, and Rognrud 1950; DeCesare and Smith 2018). While native populations of mountain goats have declined 71% since the 1940s, introduced populations have increased approximately 2500%. Reasoning behind these starkly different patterns is unknown which has prompted investigations into vital rates of mountain goats (Gude et al. 2022).

Along with concerns around vital rates, both bighorn sheep and mountain goats have been shown to be impacted by pneumonia (Garwood et al. 2020; Lowrey et al. 2018; Almberg et al. 2018; Wolff et al. 2019). While researchers have long known that pneumonia impacts bighorn sheep, detection of *M. ovipneumoniae* within mountain goat populations has prompted investigations into the impacts and risk of disease epizootics within mountain goats (Lowrey et al. 2018; Almberg et al. 2018; Wolff et al. 2019). Understanding and predicting the risk of disease epizootics can help managers prioritize herds for management actions focused on reducing risk-of-contact with domestic sheep (*Ovis aries*) and goats (*Capra hircus*) or removing chronic carriers from the wild population. Previously Sells et al. (2015), created an epizootic risk model to predict the probability of epizootics within multiple bighorn sheep populations across Montana. Results from these models indicated varying risk across populations.

Due to these concerns Montana Fish, Wildlife, and Parks has prioritized creating an adaptive management framework for both bighorn sheep and mountain goats where monitoring efforts can help evaluate the impact of management actions on population dynamics and risk of disease epizootics of these two mountain ungulates. Adaptive management is a structured system where managers can implement treatments, monitor the effects of the treatments within an experimental research framework, and adapt their efforts based on knowledge gained over time (Walters and Hilborn 1978). We aim to use this framework to improve management of bighorn sheep and mountain goats across Montana. Within this project, we will leverage previous data along with newly collected data to quantitatively assess population dynamics and risk of disease epizootics in bighorn sheep and mountain goat populations. Additionally, we will collect pathogen data for multiple mountain goat populations that have not been sampled previously.

Locations

We will be conducting research in 13 distinct bighorn sheep populations across western Montana. These populations include: Ural-Tweed, Kootenai Falls, Berray Mountain, Thompson Falls, East

Fork of the Bitteroot/Skalkaho, Rocky Mountain Front, Highlands, Tendoys, Greenhorns, Madisons, Sleeping Giant/Beartooth WMA, Little Belts, and Mill Creek.

For mountain goats, we are currently planning to capture individuals in 4 different area: Swan Range, Flint-Anaconda, Crazy Mountains, and the Gallatin Crest. The Crazy Mountains and Gallatin Crest areas have been sampled previously (Lowrey et al. 2018); however, the Swan Range and Flint-Anaconda areas have not. These areas represent 2 native and 2 introduced populations that will hopefully provide enough information to understand why native goat populations are dwindling while introduced populations are thriving. Additionally, in the future, we are hoping to sample more introduced herds that could be used as source herds for translocations if they are free of concerning pathogens.

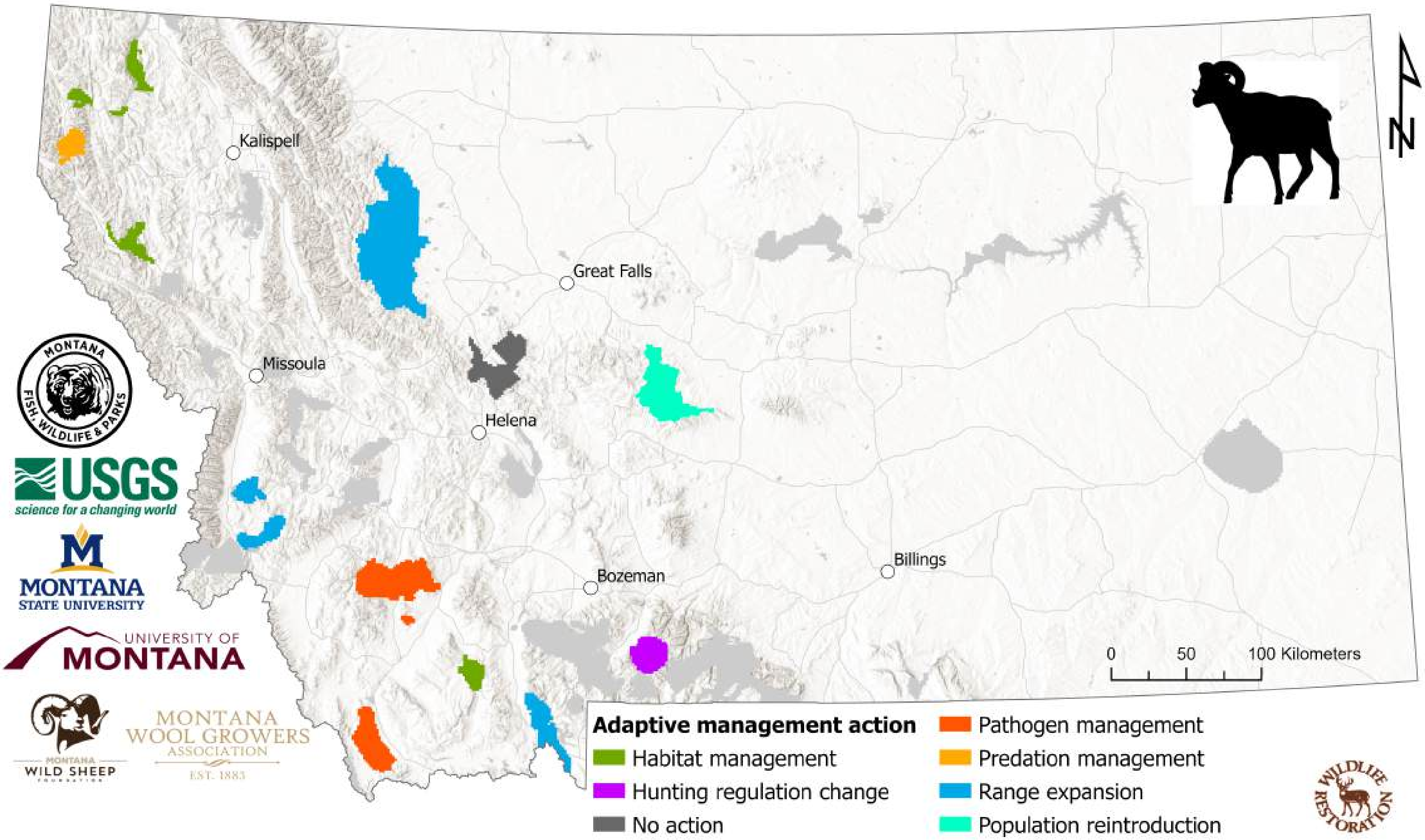

Figure 1: Map of bighorn sheep populations that will be sampled over the study along with the management actions they are slated to receive.

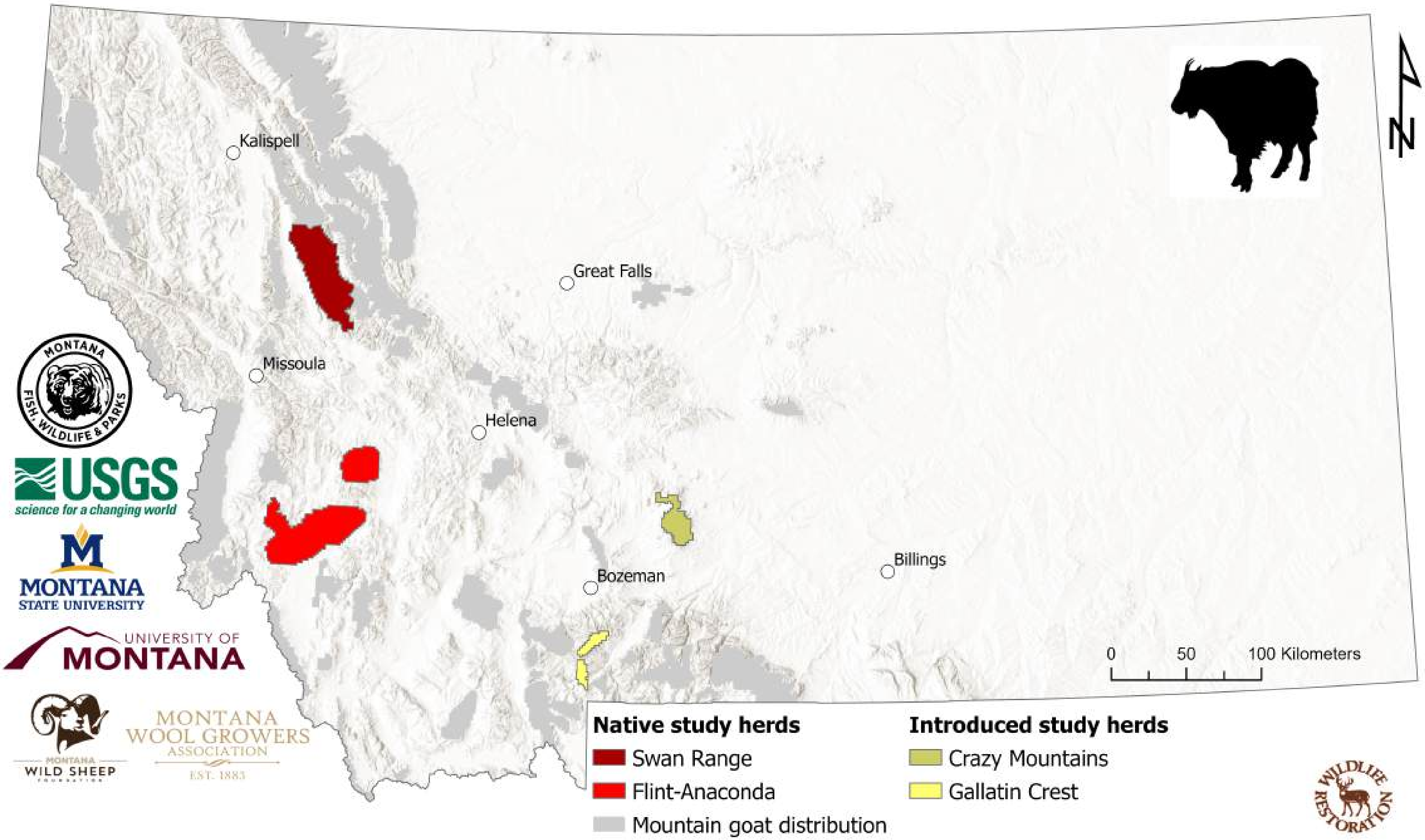

Figure 2: Map of mountain goat populations that will be sampled over the study. Native and introduced populations are signified within the legend.

Study Objectives (2023-2024)

During the 2023-2024 season the project's primary objectives were to:

1. Begin development of integrated population models by simulating data that are similar to what we will be collecting and compiling monitoring data from across the state.

2. Initiate captures of bighorn sheep and mountain goats in Montana.

   - Begin winter bighorn sheep captures across 6 study areas.
   - Begin monitoring vital rates of yearling and adult bighorn sheep.
   - Begin assessing cause-specific mortality of yearling and adult bighorn sheep.
   - Begin planning capture efforts for mountain goats.

3. Assess pathogen status of bighorn sheep and mountain goats.

Figure 3: A bighorn sheep ewe being sampled for *Mycoplasma ovipneumoniae*.

Objective #1 *Integrated Population Models*

Integrated population models (IPMs) are seeing increased use due to their ability to integrate multiple different data types into a single analysis to characterize population trajectories and vital rates (Schaub and Abadi 2011; Besbeas et al. 2002). One major advantage of IPMs is the ability to increase the amount of useable data within a model which offers increased precision of estimated parameters. This increase in precision can reduce uncertainty and improve our ability to predict how different rates would be impacted by management actions. Another advantage is the ability to estimate rates for which there are no available data. For example, researchers in Abadi et al. (2010)

were able to estimate the immigration rates of little owls (*Athene noctua*) without data pertaining to immigration. Within this analysis, all survival and fecundity parameters for the model were estimated with collected data while immigration rate was estimated without any data. The third advantage of IPMs, and Bayesian analyses in general, is the ability to include information from prior studies to supplement data deficient systems. When data are deficient in certain areas, IPMs created within Bayesian frameworks can help estimate rates and population sizes by extrapolating rates from other areas with more available data. Lastly, component models in Bayesian IPMs allow survival, fecundity, population size, and population growth rates all to be related to different covariates to explore how different biotic and abiotic factors impact each parameter.

Bighorn Sheep

We have made a small amount of progress towards the creation of IPMs for bighorn sheep. Currently, we are working to fine tune a discrete time model that can use the count data that have been collected along with survival data from GPS collared sheep, and pregnancy data from captured sheep to estimate population sizes for populations. This IPM will allow us to model previous population sizes while also allowing us to project population sizes into the future. Previous survival information is available in Proffitt et al. (2021) and we plan on gathering data from this study to improve our modeling of survival rates.

Along with the discrete time model, we are also developing a continuous time version of the model that would allow us to estimate population sizes at any given time during the year rather than just when counts are collected. The development of this continuous time model will improve our ability to model disease mortality and the proportion of individuals within a population that are infected with *M. ovi* at any given time. Development of the model is ongoing.

Mountain Goats

IPM development for mountain goats has not begun. While development has not been initiated, the models for mountain goats will likely mirror those for bighorn sheep. Survival and fecundity values for mountain goats in Montana are difficult to monitor and we have very little information currently, therefore, we have elected to wait until we have more information from collared mountain goats to conduct preliminary population modeling.

Figure 4: Nanny and kid mountain goats enjoying the shade at Goat Lick (Glacier National Park). Credit: Peter Iacono

Objective #2 *Capture events*

Bighorn Sheep (IACUC: FWP11-2023)

During January through March of 2024, Montana Fish, Wildlife, and Parks in partnership with the U.S. Geological Survey - Montana Cooperative Wildlife Research Unit collared 128 bighorn sheep across 6 herds in Regions 1, 2, 3, and 4: East Fork of the Bitterroot/Skalkaho (EFBR), Greenhorns (GRH), Kootenai Falls (KOOT), Sleeping Giant/Beartooth WMA (SGBT), Tendoys (TND), and Ural-Tweed (URTW). In summary, 101 sheep were collared via aerial net-gunning and 27 via ground darting. Sheep were instrumented with Lotek GPS-collars (Lotek Wireless Inc, lotek.com). Ewe collars were programmed to record locations at 2-hour intervals and are set to drop-off in 3 years. Ram collars were programmed to record locations at 2-hour intervals from January to September and 30-minute intervals from October to December to capture fine scale movement during breeding. Ram collars are set to drop-off in 2 years. Furthermore, collars in the EFBR, TND, GRH, and SGBT herds were programmed with Virtual Fencing boundaries to notify staff in real-time when collared sheep enter known domestic sheep grazing areas. Bighorn sheep captures also occurred in the Highlands but will be summarized separately in documentation specific to that study.

Special thanks to the many personnel from FWP, UM, USFS, BLM, private landowners, and volunteers that made this a successful capture season in each study area.

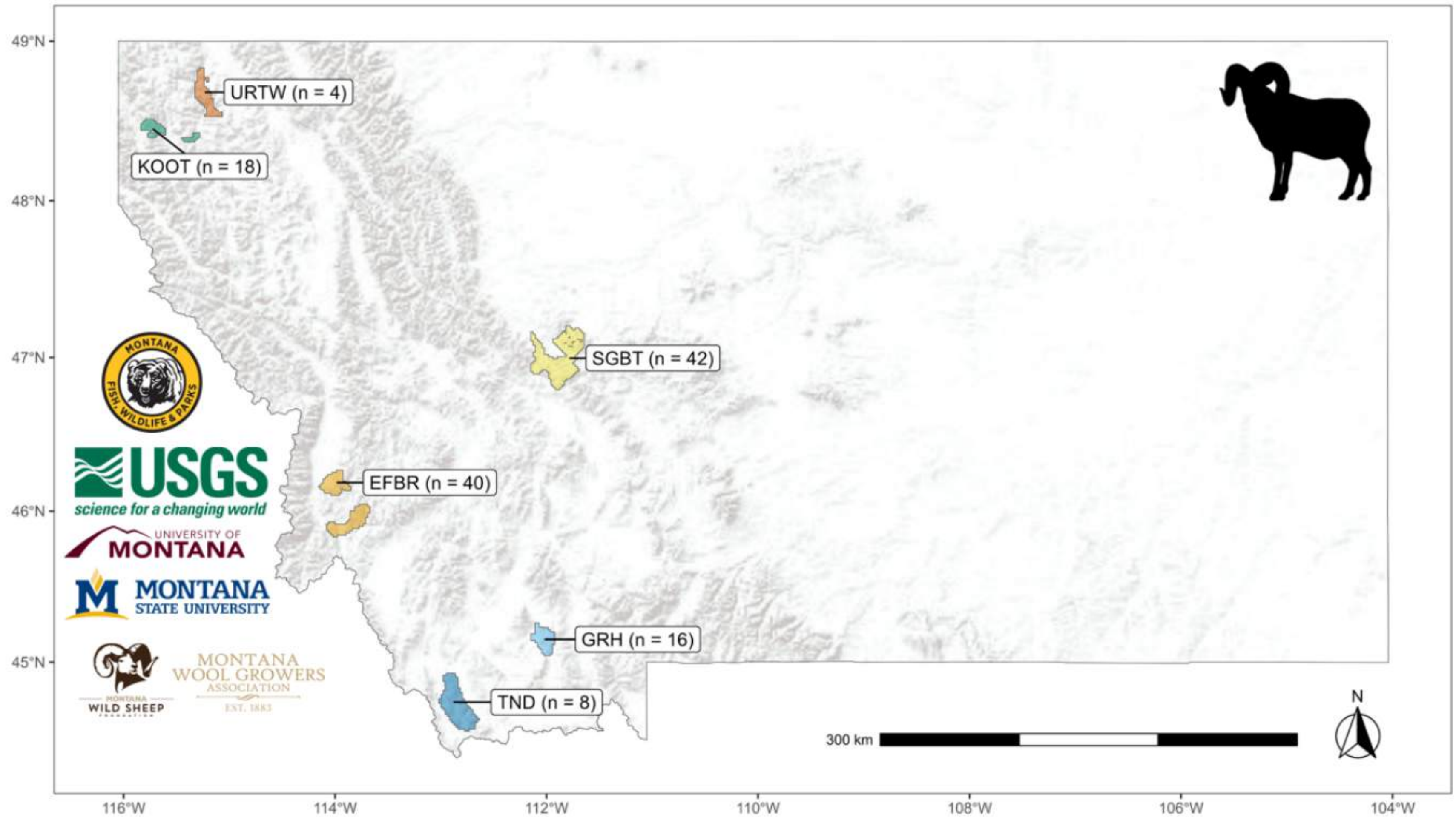

Figure 5: Number of captured and collared bighorn sheep from the 2024 capture season.

Figure 6: FWP-UM personnel along with volunteers administering a GPS collar to a male bighorn sheep in the East Fork of the Bitterroot.

Following collaring efforts, we began assessing vital rates and mortality causes of bighorn sheep across the study area. Since collars were placed on sheep, we have documented a total of 12 mortalities of collared sheep. Preliminary causes for these mortalities are attributed to 4 categories: predation, human-related, natural, pneumonia. In this context, the natural mortalities category could consist of any disease that is not pneumonia, falls, starvation, etc. Human-related mortalities could consist of harvest (both legal and illegal), vehicle collision, capture myopathy, etc.

Figure 7: Mortality site of a 2 year old bighorn sheep within the E. Fork of the Bitteroot population.

Preliminary analyses for survival from collaring data, and the probability of dying due to 5 specific causes are currently being conducted. The mean estimate for overall survival probability of bighorn sheep across all populations between 01/16/2024 to 08/29/2024 was 91%. Proportion of mortality attributable to each preliminary cause are shown in the figure below.

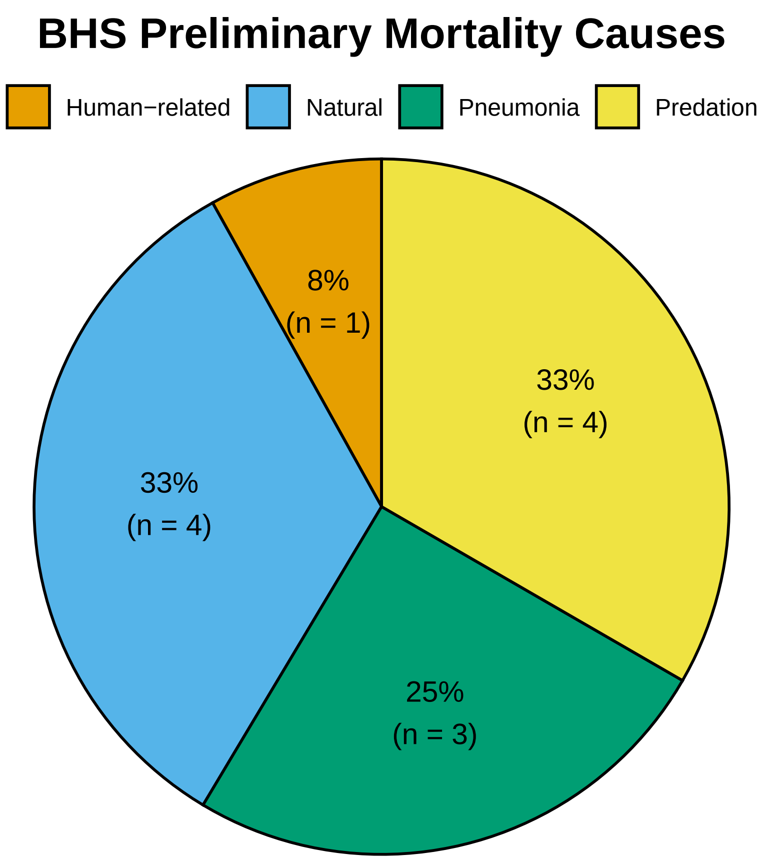

Figure 8: Distribution of preliminary mortality causes for bighorn sheep from the 2023-2024 capture season.

Figure 9: FWP-UM personnel collecting lungs, heart, and esophagus from a dead bighorn sheep.

Mountain Goats

We have not begun capture efforts for mountain goats as of 08/29/2024. However, we are in the process of ordering and preparing collars for deployment in the 2024-2025 capture season. We currently are aiming to capture mountain goats during the winter months of 2024 and 2025; however, if conditions prove to be too dangerous for goats and personnel, we will be exploring the possibility of summer captures during 2025.

Objective #3 *Pathogen Status*

Pneumonia can cause significant population-level declines in bighorn sheep (Cassirer et al. 2018). While disease epizootics do initiate initial declines, carriage of *Mycoplasma ovipneumoniae (M. ovi)* within the population can limit recovery (Almberg et al. 2022; Garwood et al. 2020; Spaan et al. 2021; K. Manlove et al. 2016). Infection with *M. ovi* paralyzes the cilia, small hairs within airways responsible for removing pathogens, which can allow pathogens to colonize the lungs and cause pneumonia morbidity and mortality. Lambs are particularly vulnerable to disease mortality when infected with *M. ovi* (K. R. Manlove et al. 2014). Thus, when the pathogen is carried by ewes within the population, lambs could become exposed prior to when their immune system can respond strongly to these pathogens. This results in high levels (>90%) mortality in lambs that are exposed to *M. ovi.* While *M. ovi* is the primary focus of managers at this point, other pathogens such as *Biberstenia trehalosi*, *Mannheimia haemolytica*, and *Trueperella pyogenes* are often found in the lungs of pneumonic bighorn sheep (Almberg et al. 2018).

Bighorn Sheep

During capture events, personnel collected swabs of nasal mucosa and tonsil crypts along with blood samples from bighorn sheep to assess pathogen status of each particular herd. Samples from bighorn sheep were tested for *M. ovi*, and Pasteurella species. Individuals that where Pasteurella species were detected were further screened for Leukotoxins (lktA). Using polymerase chain reactions (PCR) we detected active *M. ovi* infections only within the Sleeping Giant/Beartooth WMA population. However, use competitive enzyme linked immunosorbent assays (cELISA) we detected prevous exposure to *M. ovi* in three herds: East Fork of the Bitteroot/Skalkaho, Greenhorns, and Sleeping Giant/Beartooth WMA. Fortunately, all sampled bighorn sheep within the Ural-Tweed and Kootentai Falls populations tested negative for many major bighorn sheep pathogens.

Table 1: Sample size, prevalence, and seroprevalence for pathogens within each sampled bighorn sheep herd during the 2023-2024 capture season. Key to populations: East Fork of the Bitterroot (EFBR), Greenhorns (GRH), Kootenai Falls (KOOT), Sleeping Giant/Beartooth WMA (SGBT), Tendoys (TND), Ural-Tweed (URTW).

Herd	Pathogen	Test	Prevalence	N
EFBR				
EFBR	B. trehalosi	Nasal	0.05	40
EFBR	B. trehalosi	Tonsil	0.52	40
EFBR	Leukotoxins	Tonsil	0.38	40
EFBR	M. glucosida	Nasal	0.00	40
EFBR	M. glucosida	Tonsil	0.03	40
EFBR	M. haemolytica	Nasal	0.00	40
EFBR	M. haemolytica	Tonsil	0.00	40
EFBR	M. ovipneumoniae (Active Infection)	PCR	0.00	40
EFBR	M. ovipneumoniae (Exposure)	ELISA	0.03	37

EFBR	M. ruminalis	Tonsil	0.12	40
EFBR	M. spp	Tonsil	0.07	40
EFBR	T. pyogenes	Nasal	0.05	40
EFBR	T. pyogenes	Tonsil	0.03	40
GRH				
GRH	B. trehalosi	Nasal	0.06	16
GRH	B. trehalosi	Tonsil	0.69	16
GRH	Leukotoxins	Tonsil	0.44	16
GRH	M. glucosida	Nasal	0.06	16
GRH	M. glucosida	Tonsil	0.19	16
GRH	M. haemolytica	Nasal	0.06	16
GRH	M. haemolytica	Tonsil	0.19	16
GRH	M. ovipneumoniae (Active Infection)	PCR	0.00	16
GRH	M. ovipneumoniae (Exposure)	ELISA	0.17	15
GRH	M. ruminalis	Tonsil	0.00	16
GRH	M. spp	Tonsil	0.12	16
GRH	T. pyogenes	Nasal	0.12	16
GRH	T. pyogenes	Tonsil	0.44	16
KOOT				
KOOT	B. trehalosi	Nasal	0.00	19
KOOT	B. trehalosi	Tonsil	0.00	19
KOOT	Leukotoxins	Tonsil	0.00	19
KOOT	M. glucosida	Nasal	0.00	19
KOOT	M. glucosida	Tonsil	0.00	19
KOOT	M. haemolytica	Nasal	0.00	19
KOOT	M. haemolytica	Tonsil	0.00	19
KOOT	M. ovipneumoniae (Active Infection)	PCR	0.00	19
KOOT	M. ovipneumoniae (Exposure)	ELISA	0.00	10
KOOT	M. ruminalis	Tonsil	0.00	19
KOOT	M. spp	Tonsil	0.00	19
KOOT	T. pyogenes	Nasal	0.00	19
KOOT	T. pyogenes	Tonsil	0.00	19
SGBT				
SGBT	B. trehalosi	Nasal	0.05	42
SGBT	B. trehalosi	Tonsil	0.64	42
SGBT	Leukotoxins	Tonsil	0.31	42
SGBT	M. glucosida	Nasal	0.00	42
SGBT	M. glucosida	Tonsil	0.10	42
SGBT	M. haemolytica	Nasal	0.05	42
SGBT	M. haemolytica	Tonsil	0.12	42
SGBT	M. ovipneumoniae (Active Infection)	PCR	0.26	42
SGBT	M. ovipneumoniae (Exposure)	ELISA	0.56	40
SGBT	M. ruminalis	Tonsil	0.00	42
SGBT	M. spp	Tonsil	0.10	42
SGBT	T. pyogenes	Nasal	0.05	42
SGBT	T. pyogenes	Tonsil	0.19	42
TND				
TND	B. trehalosi	Nasal	0.00	10
TND	B. trehalosi	Tonsil	0.90	10
TND	Leukotoxins	Tonsil	0.20	10
TND	M. glucosida	Nasal	0.00	10
TND	M. glucosida	Tonsil	0.00	10
TND	M. haemolytica	Nasal	0.00	10

TND	M. haemolytica	Tonsil	0.00	10
TND	M. ovipneumoniae (Active Infection)	PCR	0.00	10
TND	M. ovipneumoniae (Exposure)	ELISA	0.00	10
TND	M. ruminalis	Tonsil	0.00	10
TND	M. spp	Tonsil	0.10	10
TND	T. pyogenes	Nasal	0.00	10
TND	T. pyogenes	Tonsil	0.00	10
URTW				
URTW	B. trehalosi	Nasal	0.00	4
URTW	B. trehalosi	Tonsil	0.00	4
URTW	Leukotoxins	Tonsil	0.00	4
URTW	M. glucosida	Nasal	0.00	4
URTW	M. glucosida	Tonsil	0.00	4
URTW	M. haemolytica	Nasal	0.00	4
URTW	M. haemolytica	Tonsil	0.00	4
URTW	M. ovipneumoniae (Active Infection)	PCR	0.00	4
URTW	M. ovipneumoniae (Exposure)	ELISA	0.00	3
URTW	M. ruminalis	Tonsil	0.00	4
URTW	M. spp	Tonsil	0.00	4
URTW	T. pyogenes	Nasal	0.00	4
URTW	T. pyogenes	Tonsil	0.00	4

Figure 10: FWP-UM personnel collecting tonsil swabs from a female bighorn sheep.

Mountain Goats

Due to the lack of capture efforts for mountain goats, we have not collected pathogen data for mountain goats in the 4 proposed study populations. We are planning to begin pathogen sampling in Fall of 2024. Sampling efforts will be multi-faceted by utilizing both hunted and live-captured mountain goats. We will be asking hunters to collect nasal and blood samples from harvested mountain goats and have begun sending sampling kits to successful applicants. We will also be sampling mountain goats during capture events in the next year.

Bighorn Sheep Data Summaries by Herd

East Fork of the Bitterroot/Skalkaho

Captures

Captures for the East Fork of the Bitterroot and Skalkaho occurred via aerial net-gunning during 2/10/2024 and 2/11/2024. Ground darting efforts continued through February and ended in April. A total of 40 sheep were collared, 37 via aerial net-gunning and 3 sheep via ground darting. One capture related mortality occurred a few days post-release and is included in our reported capture numbers. Capture locations are shown within the map below:

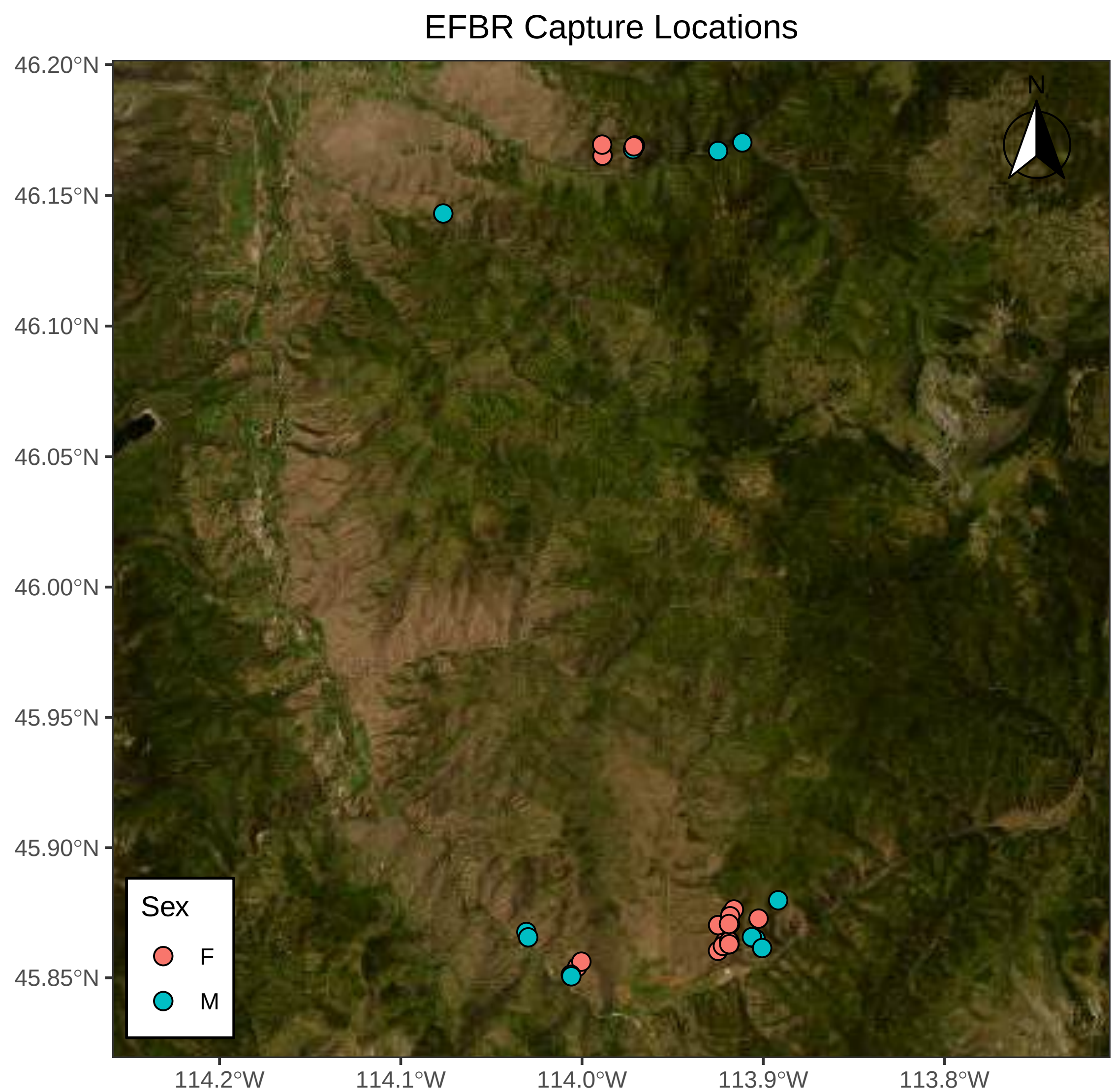

Figure 11: Capture locations for the East Fork of the Bitteroot/Skalkaho population from the 2024 capture season.

Within the East Fork of the Bitterroot and Skalkaho populations, we captured ewes at nearly a 2:1 ratio of rams with 26 ewes being captured and 14 rams being captured. Age structuring of capture events was near even for all age classes besides >3.5 year olds which dominated the age structure with 14 individuals. Other age classes included either 6 or 8 individuals.

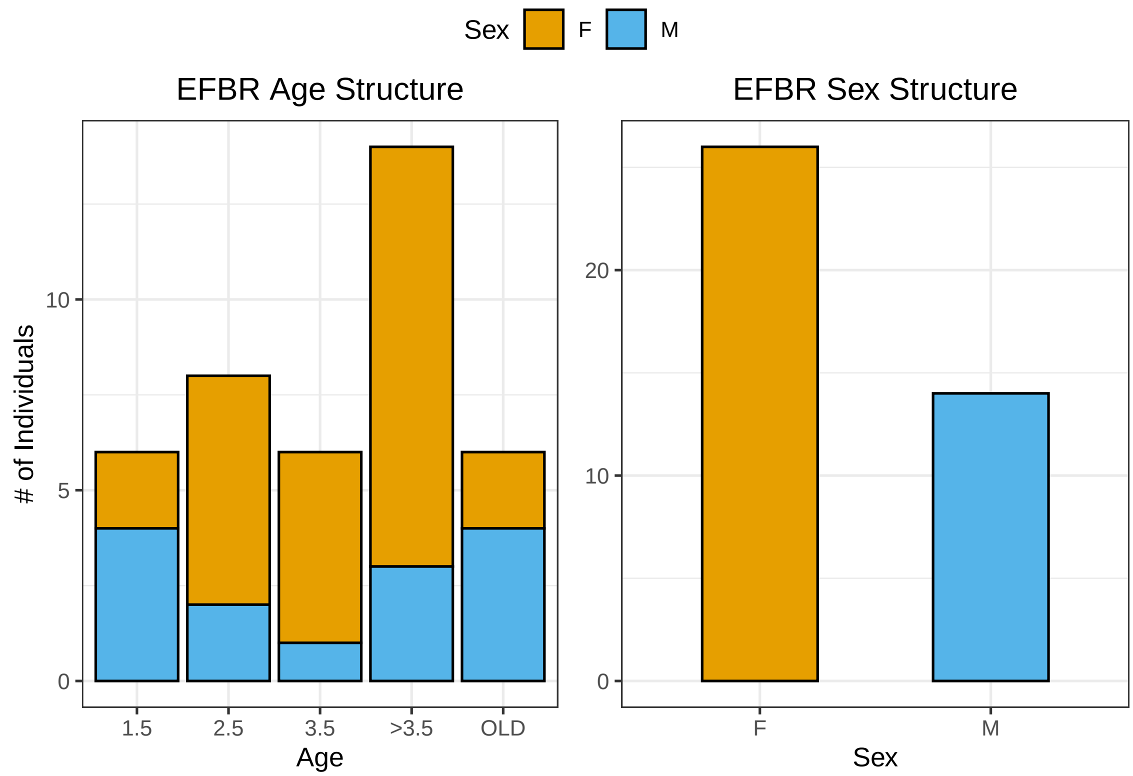

Figure 12: Age and sex structuring of the East Fork of the Bitterroot/Skalkaho population from the 2024 capture season.

Figure 13: Female bighorn sheep being transported to a processing site by helicopter.

Mortalities

Following captures of sheep in this population, we have recovered a total of 6 collared animals with preliminary mortality causes consisting of predation, pneumonia, natural causes, and one case of suspected capture myopathy. One of the two natural mortalities appeared to be caused by parasitism in the intestinal tract, while the other is still being investigated. In addition to these mortalities, we have collected a few more carcasses opportunistically from public information or highway mortalities. Those mortalities were related to highway collisions, falls, pneumonia, and predation.

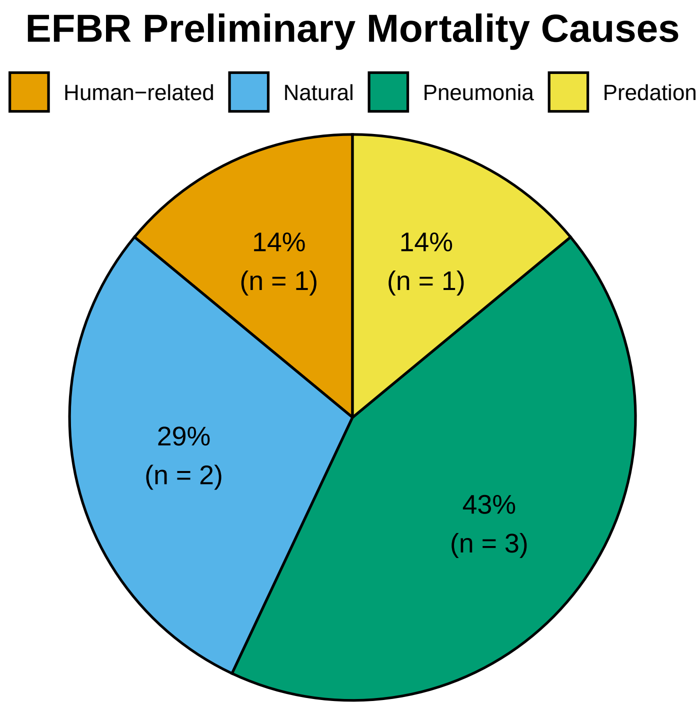

Figure 14: Proportion of mortality attributable to each cause for bighorn sheep within bighorn sheep within the East for the of Bitteroot/Skalkaho population.

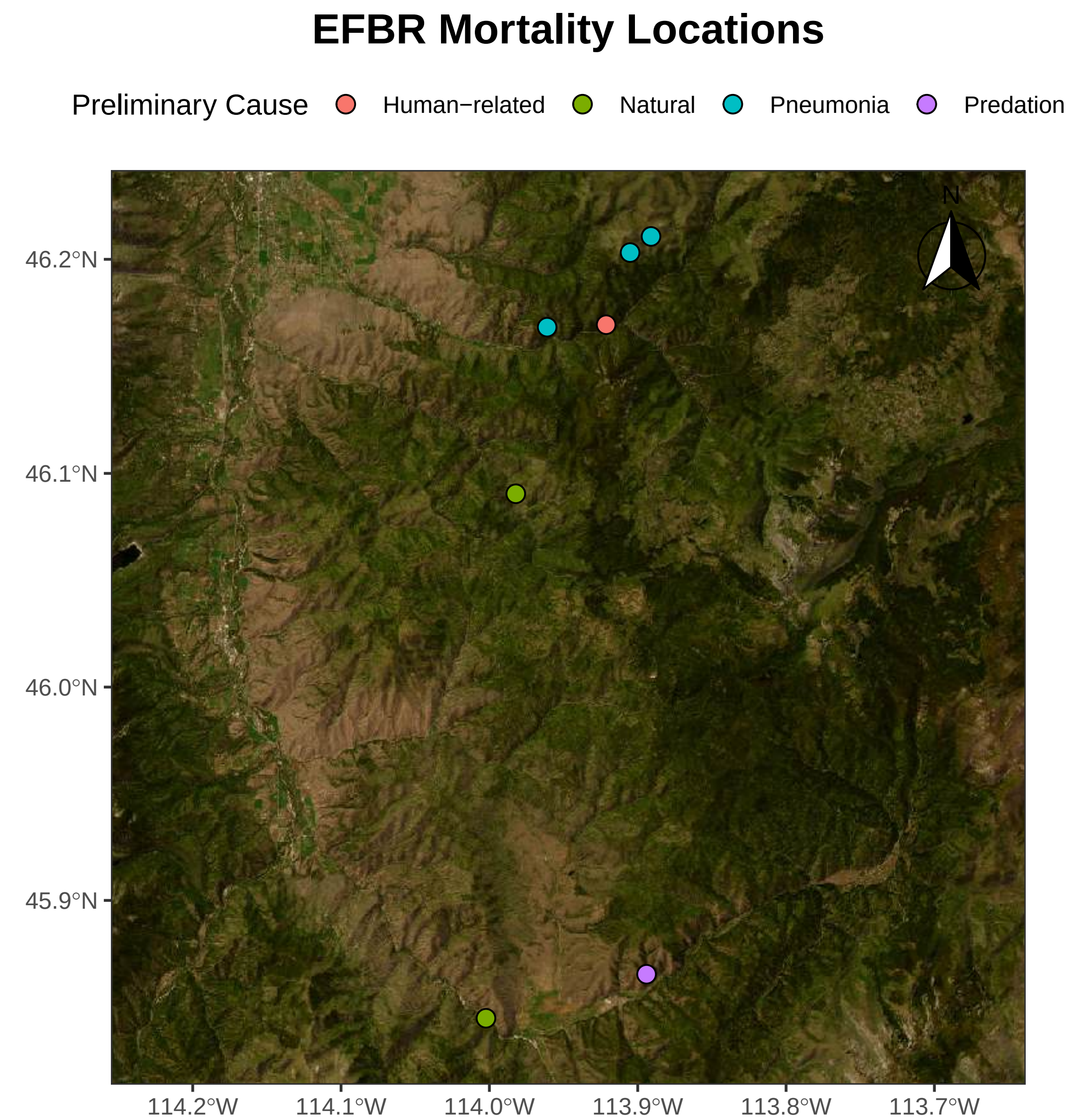

Figure 15: Mortality locations and preliminary causes of bighorn sheep within the East Fork of the Bitteroot/Skalkaho population.

Figure 16: Mortality site of a 2 year old male bighorn sheep within the East Fork of the Bitteroot/Skalkaho population.

Disease Diagnostics

At the time of capture, we did not detect active *M. ovipneumoniae* infections, however, one individual sheep was seropositive, indicating exposure to *M. ovi.* We are still awaiting aerobic culture, Leukotoxin A PCR, M. ovi PCR, and histology results for all sheep presumed to have died from pneumonia. We detected multiple species of Mannheimia pathogens along with *T. pyogenes* and *B. trehalosi.* Overall prevalence for each pathogen is shown in the table below.

Table 2: Pathogen prevalence data for the East Fork of the Bitteroot/Skalkaho population.

Herd	Pathogen	Test	Prevalence	N
EFBR	B. trehalosi	Nasal	0.05	40
EFBR	B. trehalosi	Tonsil	0.52	40
EFBR	Leukotoxins	Tonsil	0.38	40
EFBR	M. glucosida	Nasal	0.00	40
EFBR	M. glucosida	Tonsil	0.03	40
EFBR	M. haemolytica	Nasal	0.00	40
EFBR	M. haemolytica	Tonsil	0.00	40
EFBR	M. ovipneumoniae (Active Infection)	PCR	0.00	40
EFBR	M. ovipneumoniae (Exposure)	ELISA	0.03	37
EFBR	M. ruminalis	Tonsil	0.12	40
EFBR	M. spp	Tonsil	0.07	40
EFBR	T. pyogenes	Nasal	0.05	40
EFBR	T. pyogenes	Tonsil	0.03	40

Greenhorns

Captures

Captures in the Greenhorns occurred on 1/23/2024. A total of 16 sheep were collared via aerial net-gunning. Capture locations are shown below:

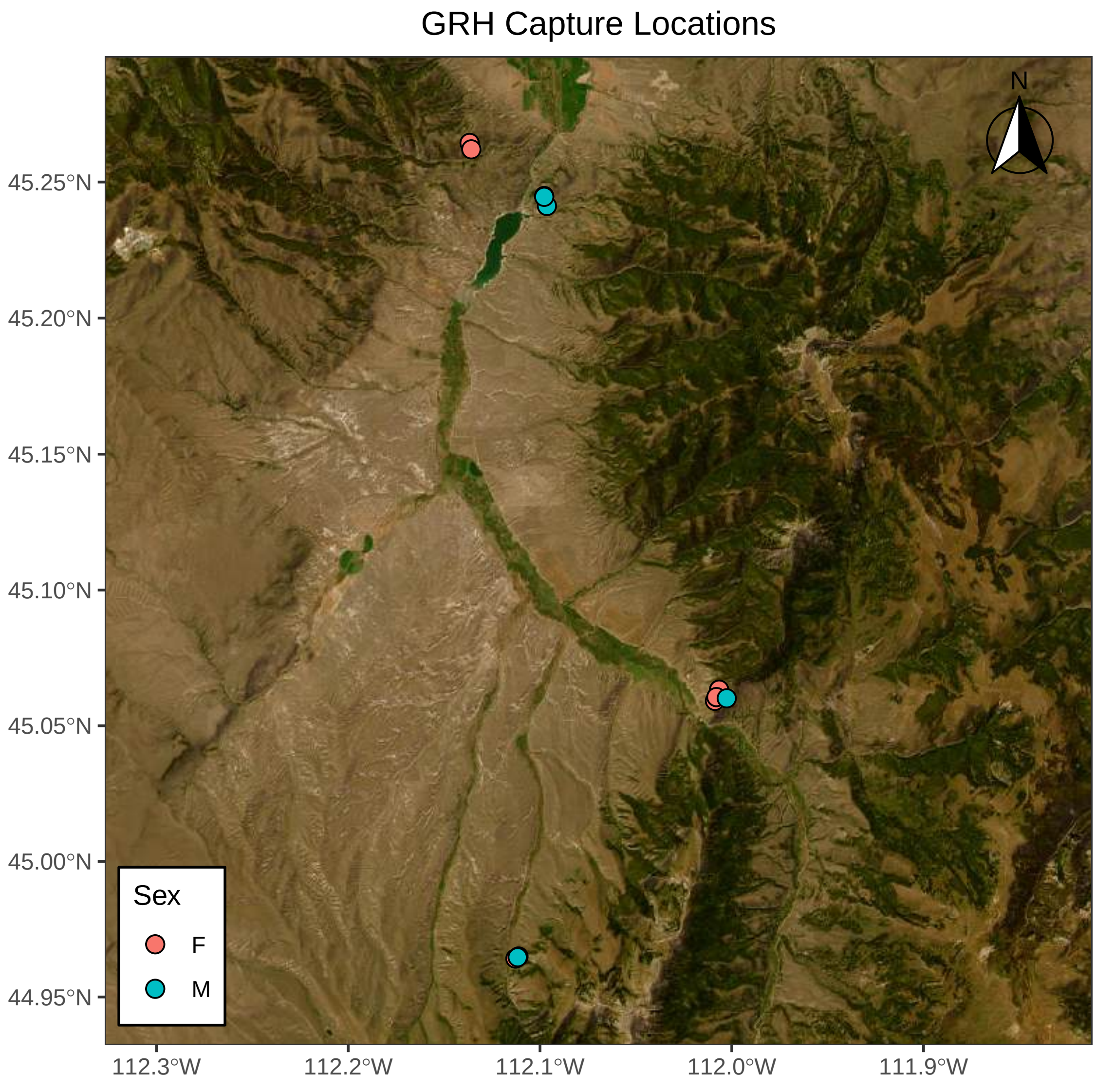

Figure 17: Capture locations of bighorn sheep within the Greenhorns population.

Figure 18: A male bighorn sheep being processed during capture in the Greenhorns population.

In the Greenhorns, we captured the highest number of individuals in age classes 2.5 and 3.5. Otherwise age structures were even across the board. Two individuals were not aged due to high body temperatures. We captured 11 ewes and 5 rams during the capture events.

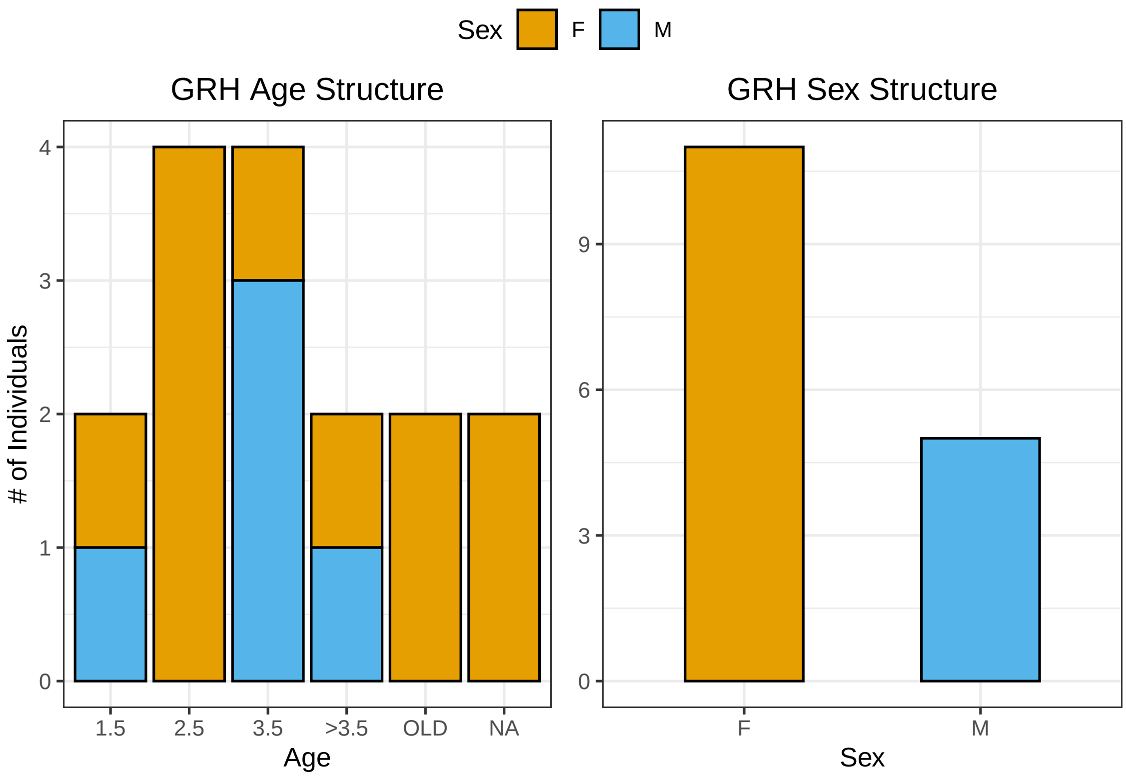

Figure 19: Age and sex distribution of captured bighorn sheep within the Greenhorns population.

Mortalities

To this point, no mortalities have occurred within the collared Greenhorns population.

Disease Diagnostics

Within the Greenhorns population, we did not detect active *M. ovi* infections, however, we did have sheep that were positive for exposure to *M. ovi*. We detected multiple other pathogens including multiple Pasturella species some of which were leukotoxigenic.

Table 3: Pathogen prevalence data for the Greenhorns population.

Herd	Pathogen	Test	Prevalence	N
GRH	B. trehalosi	Nasal	0.06	16
GRH	B. trehalosi	Tonsil	0.69	16
GRH	Leukotoxins	Tonsil	0.44	16
GRH	M. glucosida	Nasal	0.06	16
GRH	M. glucosida	Tonsil	0.19	16
GRH	M. haemolytica	Nasal	0.06	16
GRH	M. haemolytica	Tonsil	0.19	16
GRH	M. ovipneumoniae (Active Infection)	PCR	0.00	16
GRH	M. ovipneumoniae (Exposure)	ELISA	0.17	15
GRH	M. ruminalis	Tonsil	0.00	16
GRH	M. spp	Tonsil	0.12	16
GRH	T. pyogenes	Nasal	0.12	16
GRH	T. pyogenes	Tonsil	0.44	16

Kootenai Falls

Captures

Captures in Kootenai Falls occurred from January to March 2024. A total of 18 sheep were collared via ground darting. One capture related mortality occurred during processing and is not included in the final number of collared sheep.

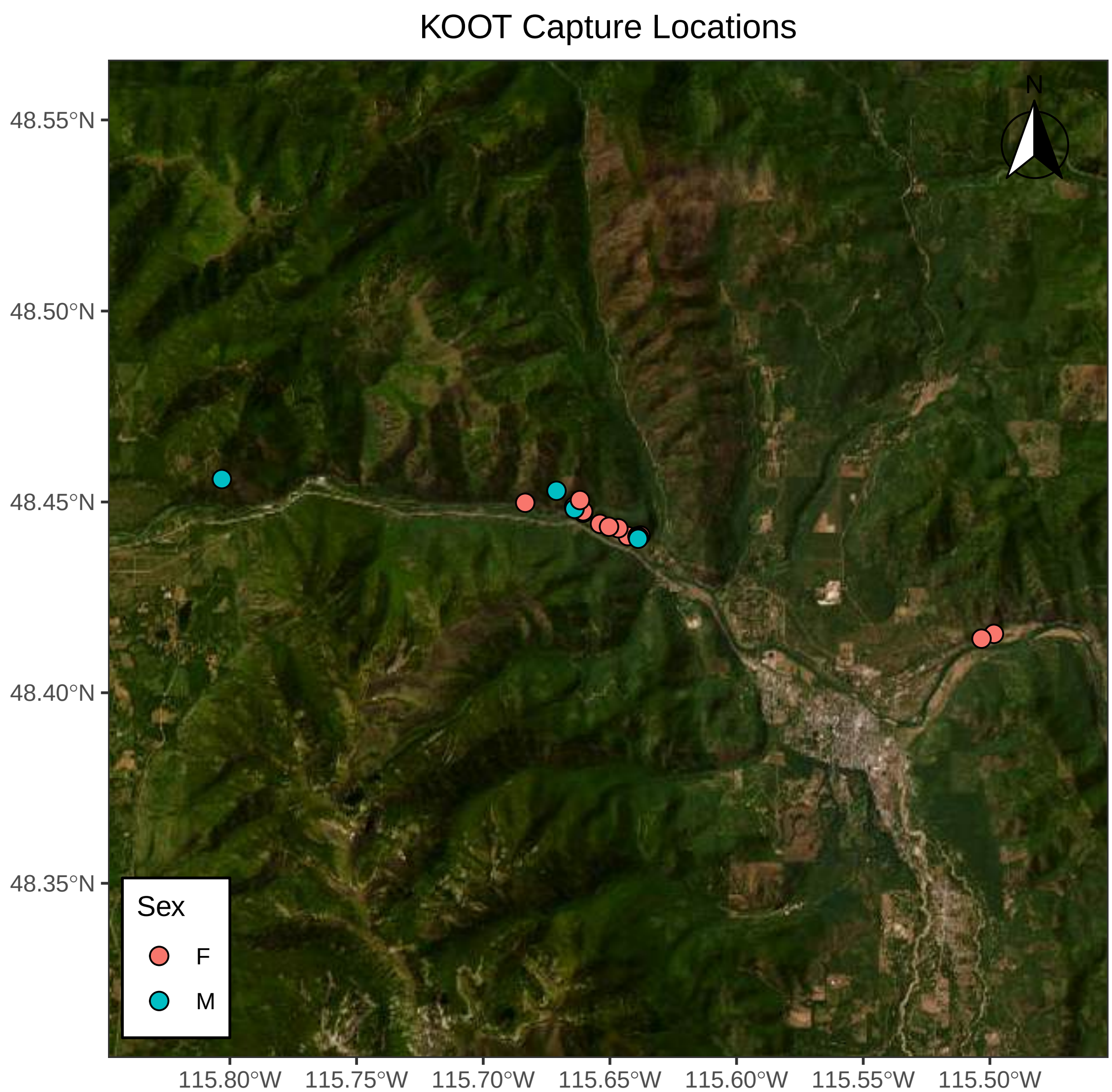

Figure 20: Capture locations of bighorn sheep within the Kootenai Falls population.

Figure 21: A male bighorn sheep being processed during a capture event within the Kootenai Falls population.

In the Kootenai Falls population, capture events were dominated by sheep in the age classes of 3.5 and >3.5. We captured fairly few individuals in other ages classes. Numbers of individuals in the 1.5 and 2.5 year old age classes were few and far between. Unfortunately, the only sheep that was captured as a 1.5 year old died in early June. We captured a total of 14 ewes and 4 rams during the capture season. The return of collars following mortalities has left us with extra collars that we plan to give back to the Kootenai Falls biologist to hopefully collar more sheep.

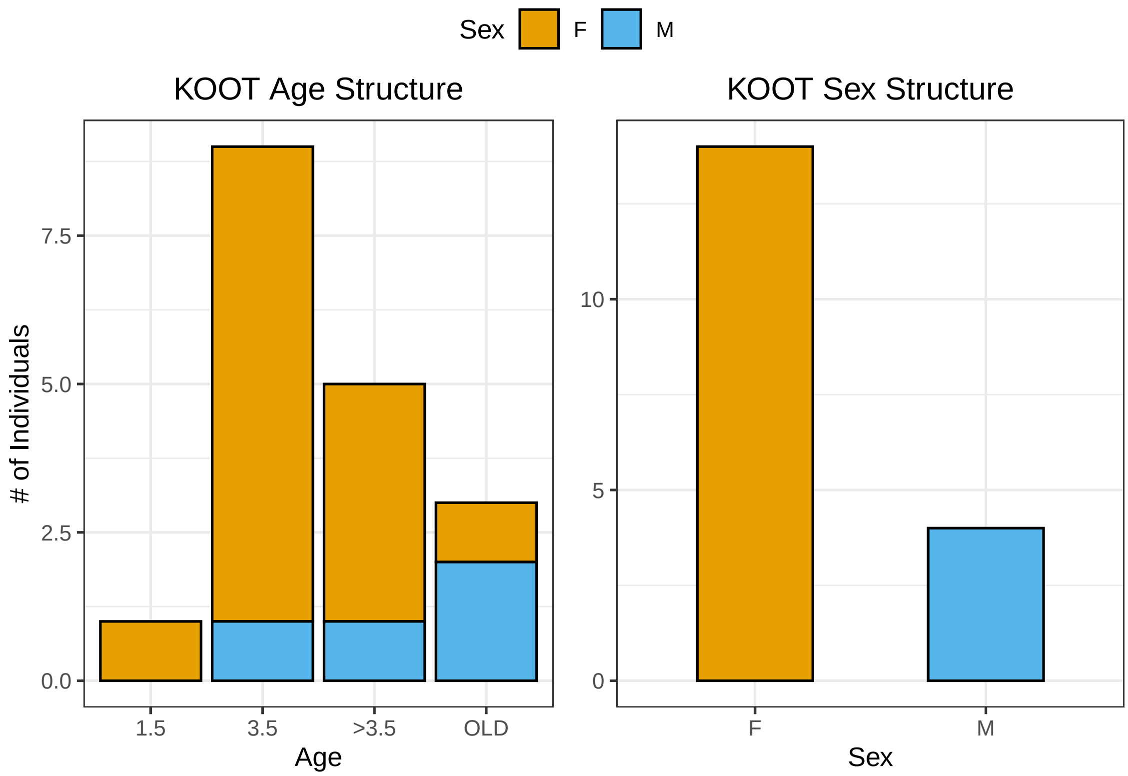

Figure 22: Age and sex distribution of captured bighorn sheep within the Kootenai Falls population.

Figure 23: FWP-UM personnel attempting to dart sheep within the Kootenai Falls population.

Mortalities

Since collaring efforts ceased, 3 different collared sheep and 1 uncollared sheep have been found dead in the Kootenai Falls herd. 2 of the collared sheep and the 1 uncollared sheep were killed by mountain lions. Within these 3 kills, 2 kills appeared to have happened simultaneously with both carcasses being found within 50 yards of each other in the same state of decomposition. The last mortality was thought to be natural due to lack of predation marks and sign.

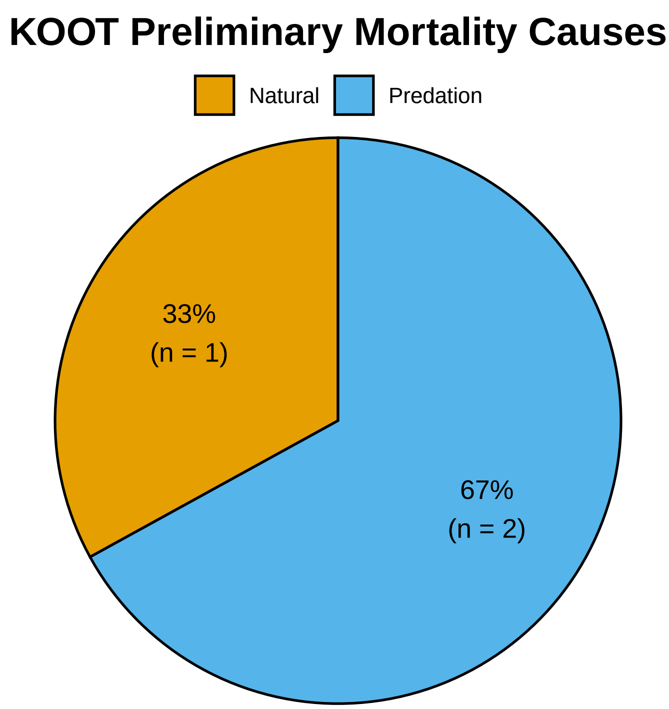

Figure 24: Proportion of mortality events attributed to different causes for the Kootenai Falls population.

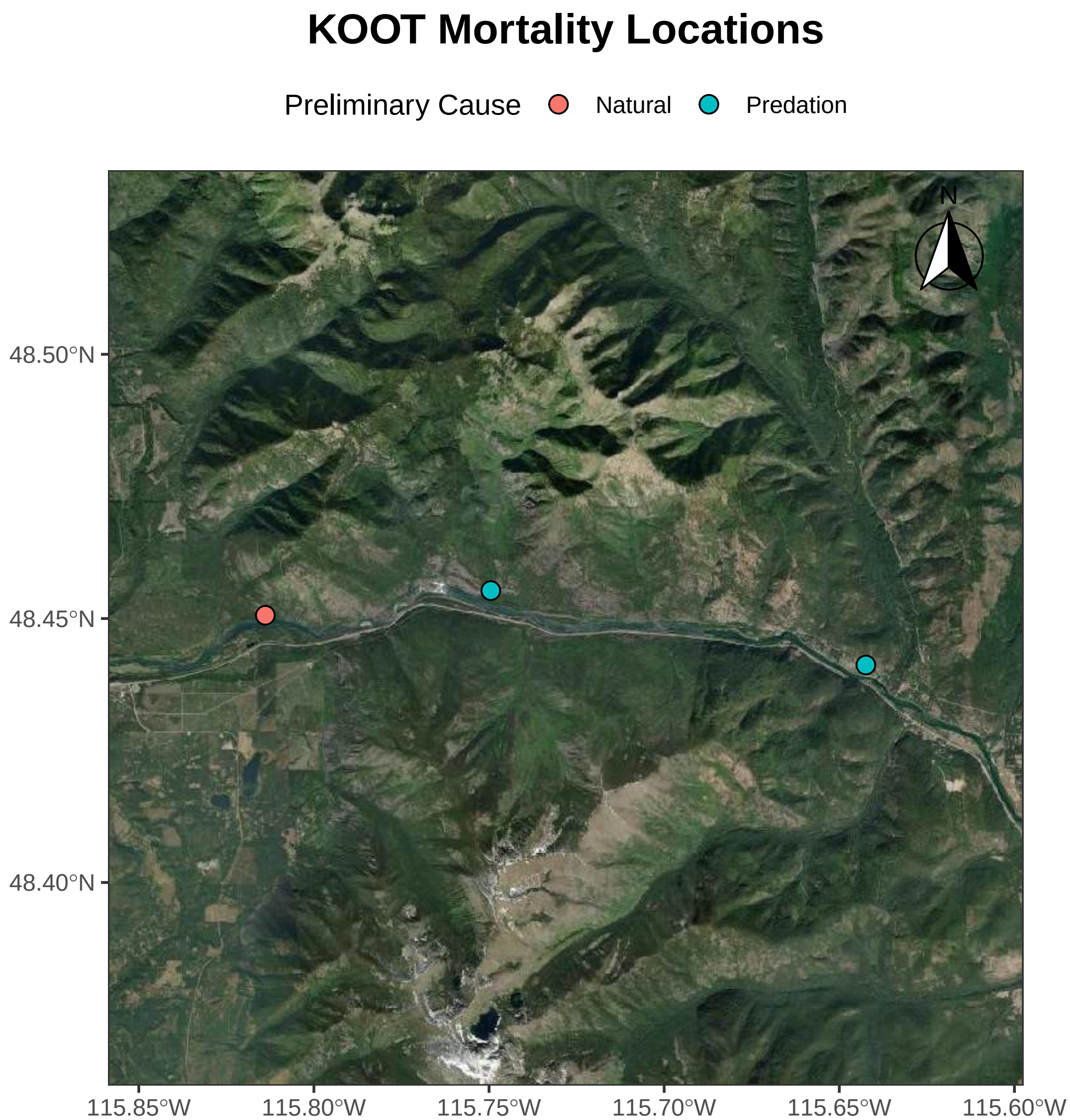

Figure 25: Mortality locations and preliminary causes of bighorn sheep within the Kootenai Falls population.

Figure 26: Mortality site of a female bighorn sheep within the Kootenai Falls population.

Disease Diagnostics

Of note, this herd did not test positive for any known bighorn sheep pathogens. We were concerned due to hobby farm activity just north of the primary population; however, it appears this herd has not been exposed to *M. ovi* or any Pasturella species.

Table 4: Pathogen prevalence data for the Kootenai Falls herd.

Herd	Pathogen	Test	Prevalence	N
KOOT	B. trehalosi	Nasal	0	19
KOOT	B. trehalosi	Tonsil	0	19
KOOT	Leukotoxins	Tonsil	0	19
KOOT	M. glucosida	Nasal	0	19
KOOT	M. glucosida	Tonsil	0	19
KOOT	M. haemolytica	Nasal	0	19
KOOT	M. haemolytica	Tonsil	0	19
KOOT	M. ovipneumoniae (Active Infection)	PCR	0	19
KOOT	M. ovipneumoniae (Exposure)	ELISA	0	10
KOOT	M. ruminalis	Tonsil	0	19
KOOT	M. spp	Tonsil	0	19
KOOT	T. pyogenes	Nasal	0	19
KOOT	T. pyogenes	Tonsil	0	19

Observations

Due to the the field crew being stationed in Libby for capture events, we were able to conduct observations of bighorn sheep within the Kootenai Falls herd. These observations came from both on the ground observers and camera traps throughout the area. Observations are tabulated below along with a map of observation locations.

Table 5: Bighorn sheep observations from the Kootenai Falls population.

Date	Observation_Type	Lambs	Ewes	Rams	Unk	Total
2023-10-18	Camera Trap	0	0	6	0	6
2023-10-18	Camera Trap	0	0	1	0	1
2023-10-25	Camera Trap	0	0	3	0	3
2023-10-31	Camera Trap	0	4	5	0	9
2023-11-16	Visual Observation	0	1	0	0	1
2023-11-21	Visual Observation	0	2	1	0	3
2023-11-24	Visual Observation	0	0	1	0	1
2023-11-24	Visual Observation	0	0	1	0	1
2023-12-05	Visual Observation	0	0	1	0	1
2023-12-09	Visual Observation	0	1	0	0	1
2023-12-09	Visual Observation	0	0	0	6	6
2023-12-13	Visual Observation	0	2	0	0	2
2023-12-13	Visual Observation	0	2	1	0	3
2023-12-22	Camera Trap	0	0	1	0	1
2023-12-28	Camera Trap	0	1	4	0	5
2023-12-31	Camera Trap	0	2	0	1	3
2024-01-02	Camera Trap	0	0	1	0	1
2024-01-04	Visual Observation	0	0	12	0	12
2024-01-05	Visual Observation	0	8	0	0	8
2024-01-05	Visual Observation	0	0	5	0	5
2024-01-05	Visual Observation	4	8	0	0	12
2024-01-05	Visual Observation	1	0	0	0	1
2024-01-05	Visual Observation	0	2	0	0	2
2024-01-08	Camera Trap	2	5	2	0	9
2024-01-09	Camera Trap	2	8	1	0	11
2024-01-16	Visual Observation	0	2	0	0	2
2024-01-30	Camera Trap	2	3	0	0	5
2024-02-01	Visual Observation	1	2	0	0	3
2024-02-02	Camera Trap	0	1	0	0	1
2024-02-02	Camera Trap	0	2	0	0	2
2024-02-05	Visual Observation	3	4	4	0	11
2024-02-05	Visual Observation	0	2	0	0	2
2024-02-10	Camera Trap	0	0	1	0	1
2024-02-13	Visual Observation	0	2	3	0	5
2024-02-15	Visual Observation	0	4	0	0	4
2024-02-16	Visual Observation	1	1	0	0	2
2024-02-16	Visual Observation	0	4	1	0	5
2024-02-16	Camera Trap	0	1	0	0	1
2024-02-16	Camera Trap	0	1	0	0	1
2024-02-17	Visual Observation	2	8	0	0	10
2024-02-17	Visual Observation	0	4	0	0	4
2024-02-18	Visual Observation	1	2	0	0	3
2024-02-18	Camera Trap	0	2	0	0	2

Date	Observation_Type	Lambs	Ewes	Rams	Unk	Total
2024-02-21	Visual Observation	0	3	0	0	3
2024-02-21	Visual Observation	3	4	0	0	7
2024-02-22	Visual Observation	0	3	0	0	3
2024-02-23	Visual Observation	0	0	6	0	6
2024-02-23	Visual Observation	1	3	7	0	11
2024-02-25	Visual Observation	2	13	0	0	15
2024-02-26	Visual Observation	0	2	0	0	2
2024-02-27	Visual Observation	2	2	0	0	4
2024-02-28	Visual Observation	0	2	0	0	2
2024-03-01	Visual Observation	0	3	7	0	10
2024-03-04	Visual Observation	0	10	0	0	10
2024-03-04	Visual Observation	0	9	7	0	16
2024-03-05	Visual Observation	1	6	0	0	7
2024-03-06	Visual Observation	1	3	2	0	6
2024-03-08	Camera Trap	1	6	2	0	9
2024-03-08	Camera Trap	1	6	2	0	9
2024-03-08	Camera Trap	0	2	0	1	3
2024-03-08	Camera Trap	2	9	2	0	13
2024-03-08	Camera Trap	0	4	0	0	4
2024-03-11	Visual Observation	1	12	2	0	15
2024-03-11	Visual Observation	1	5	2	0	8
2024-03-12	Visual Observation	2	8	2	0	12
2024-03-12	Visual Observation	1	4	2	0	7
2024-03-12	Visual Observation	0	2	0	0	2
2024-03-12	Visual Observation	0	0	1	0	1
2024-03-12	Visual Observation	0	0	1	0	1
2024-03-13	Visual Observation	0	0	2	13	15
2024-03-13	Visual Observation	0	1	4	0	5
2024-03-14	Visual Observation	1	4	2	0	7
2024-03-14	Visual Observation	1	5	2	0	8
2024-03-14	Visual Observation	1	9	2	0	12
2024-03-15	Visual Observation	2	9	5	0	16

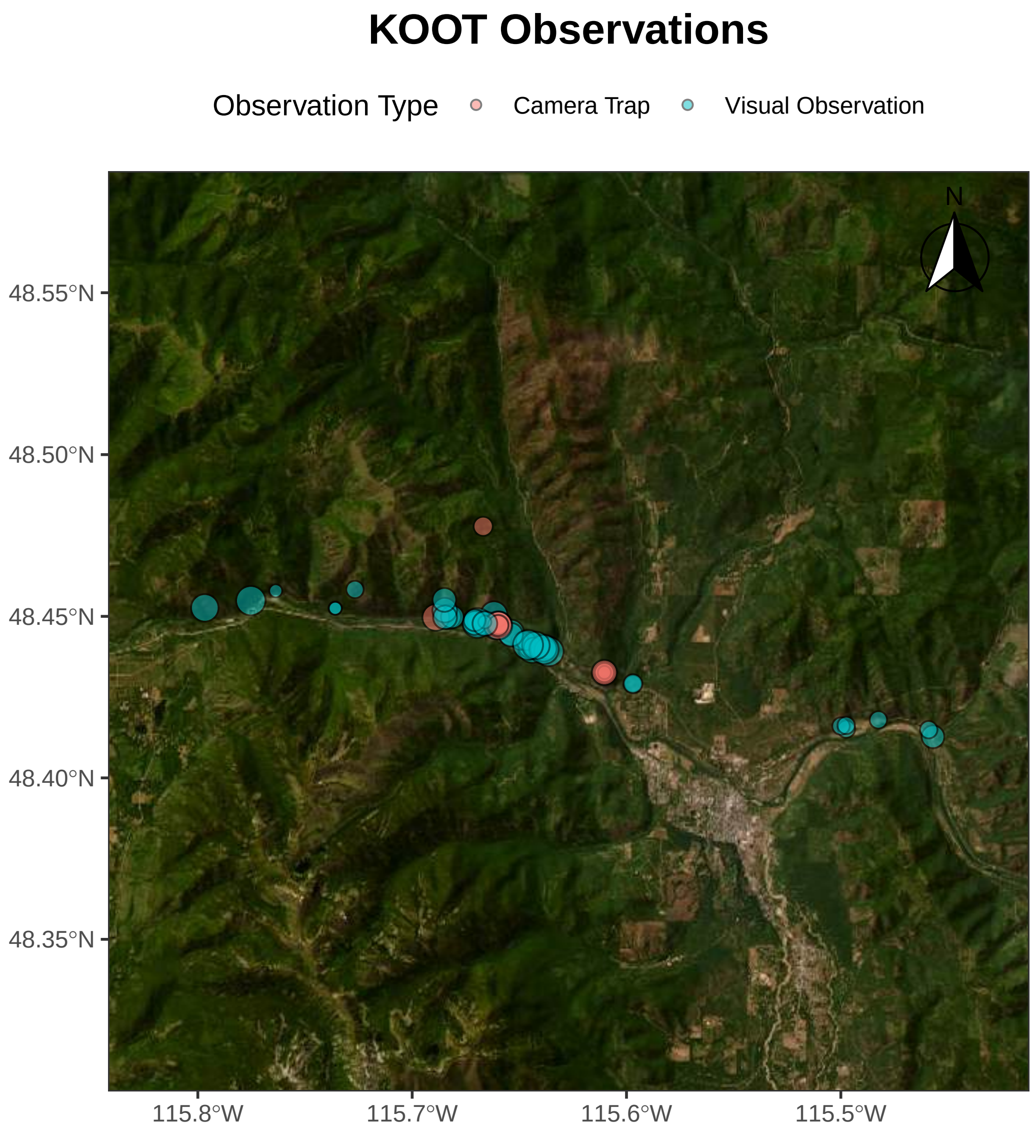

Figure 27: Locations of opportunistic and camera trap observations of bighorn sheep within the Kootenai Falls population. Size of points provides a proxy for the number of animals seen at the point.

Figure 28: Bighorn sheep captured on a trail camera within the Kootenai Falls Wildlife Management Area.

Figure 29: Two collared bighorn sheep observed by FWP-UM personnel in the Kootenai Falls population.

Sleeping Giant/Beartooth WMA

Captures

Captures in Sleeping Giant/Beartooth WMA occurred from via aerial net-gunning during 1/29/2024 and 1/30/2024. Ground darting efforts occurred in February. 41 sheep were captured via aerial net-gunning with only 40 receiving collars due to one capture-related mortality. Additionally, 2 sheep were collared via ground darting, for a total of 42 collared sheep.

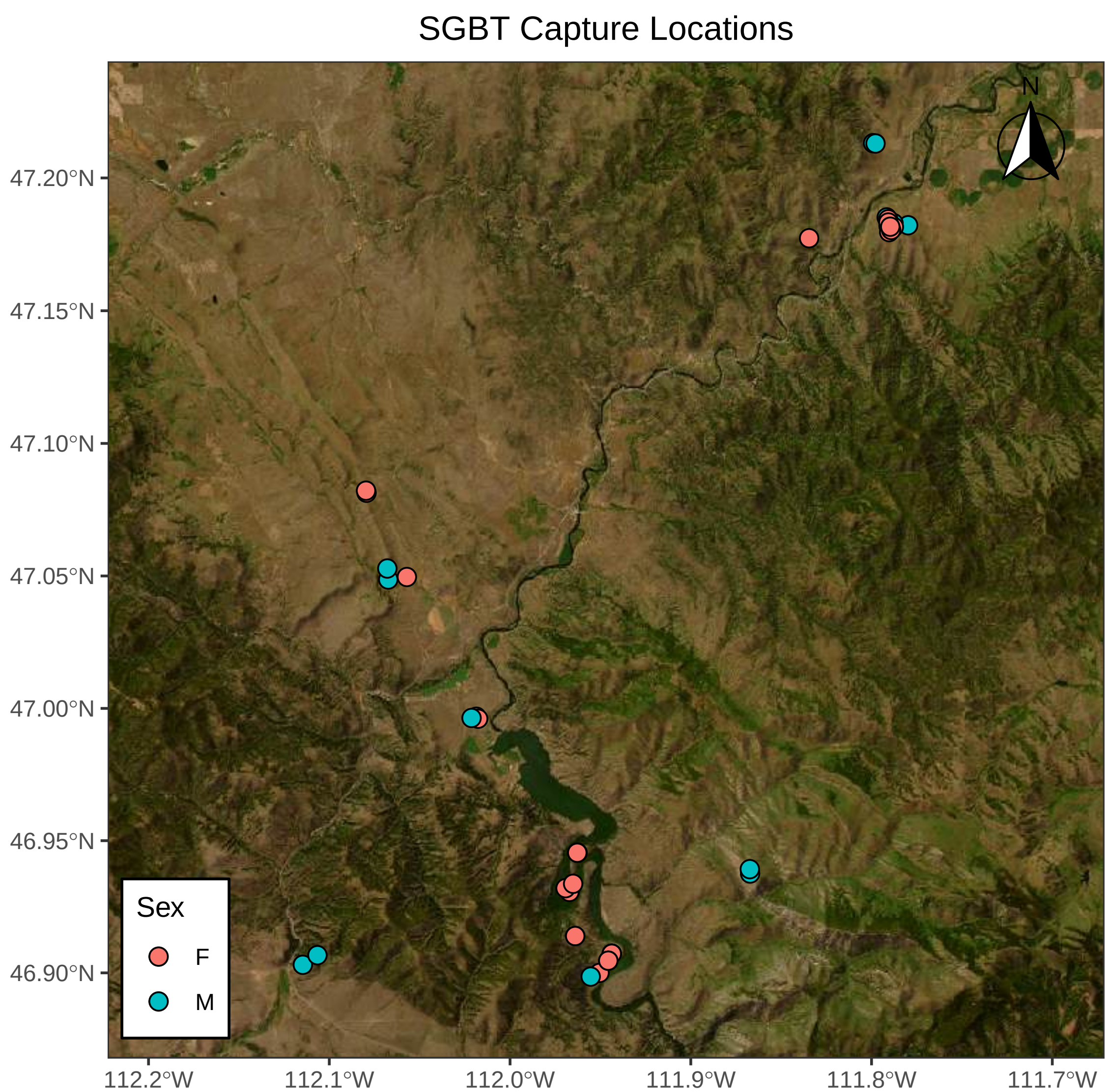

Figure 30: Capture locations of bighorn sheep within the Sleeping Giant/Beartooth WMA population.

Figure 31: Two male bighorn sheep being processed during captures within the Beartooth WMA.

Similarly to the Kootenai Falls population, this population was dominated by sheep in the >3.5 years old age class. This could have been due to our inability to distinguish ewes over the age of 4. Additionally, two ewes within this capture group were a part of an earlier translocation from Fergus in 2016 indicating that that those two ewes were at least 8 years old. However, it appears that the Sleeping Giant/Beartooth WMA population is comprised of older individuals with fewer individuals being captured in the younger age classes. We captured and collared 29 females and 13 males.

Figure 32: Age and sex distributions of captured bighorn sheep within the Sleeping Giant/Beartooth WMA population.

Figure 33: FWP game wardens releasing a bighorn sheep following processing. Special thanks to the Willo Ranch for allowing us to capture and process sheep on their property.

Figure 34: A female bighorn sheep waiting to be processed with the capture helicopter in the background.

Mortalities

Since collaring, 2 sheep have died within the SGBT herd. These two mortalities were attributed to cougar predation and natural causes. Unfortunately, the collar of the cougar-killed sheep was cached under a rock and samples could not be collected as the entire sheep had been consumed. The ewe that died of natural causes could have died due to pregnancy complications as her lamb was breech in her uterus.

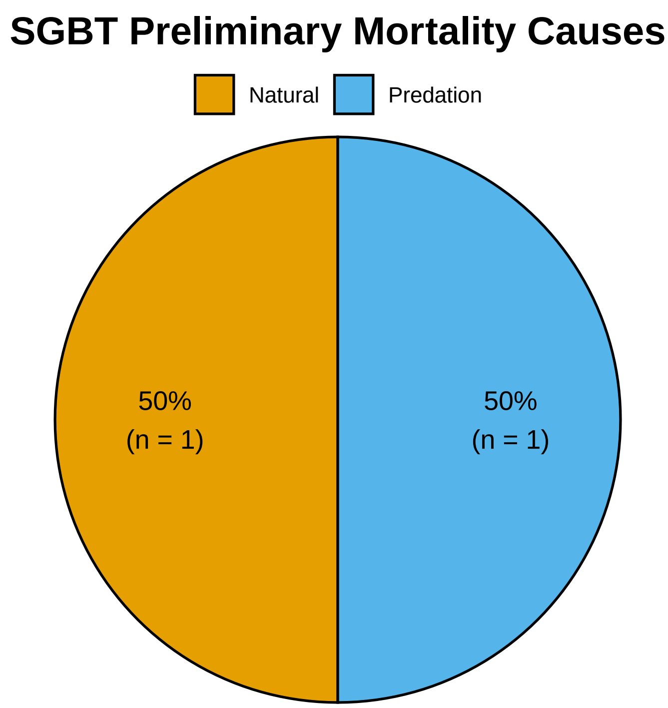

Figure 35: Proportion of mortality events attributed to different causes for the Sleeping Giant/Beartooth WMA population.

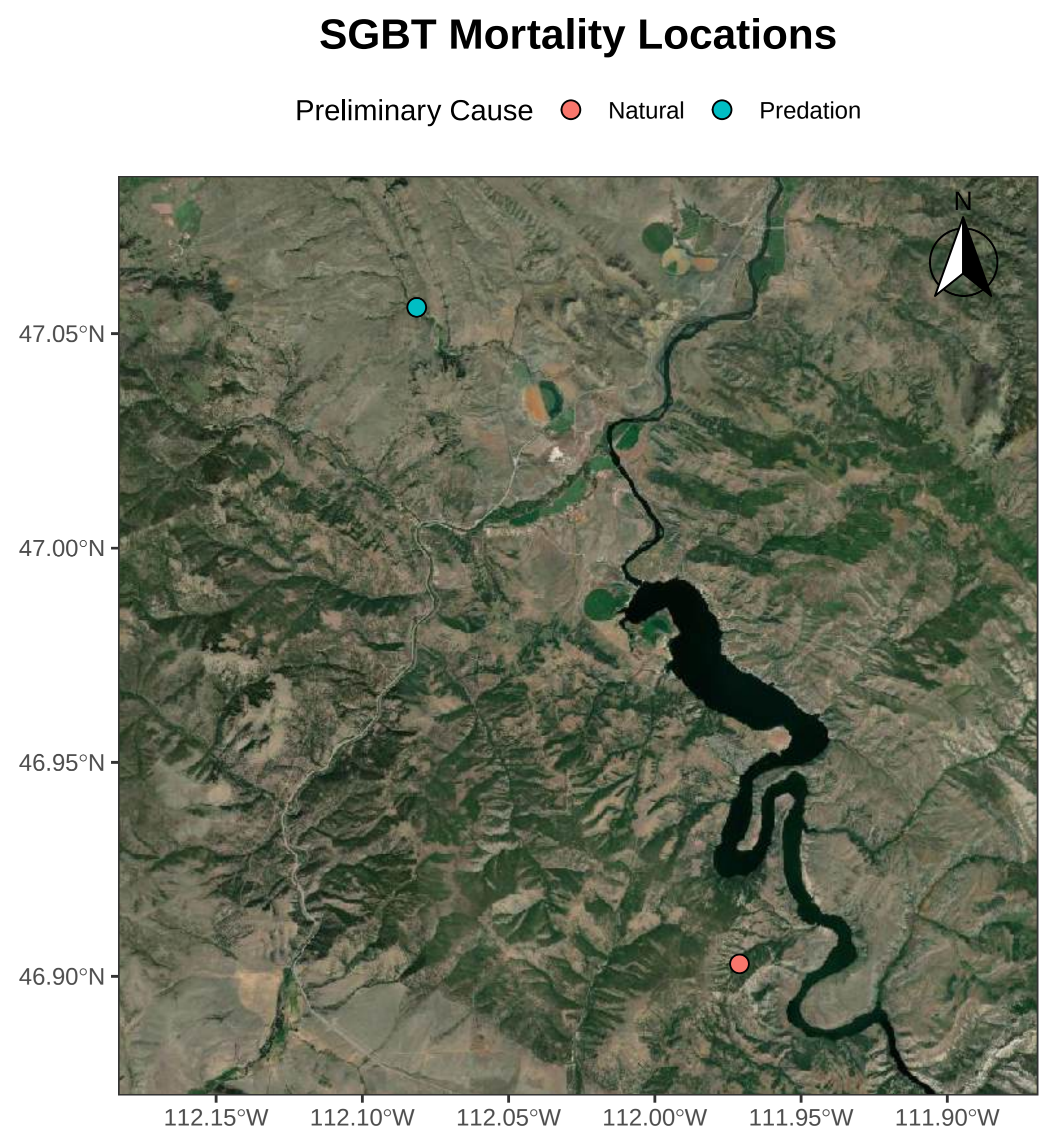

Figure 36: Mortality locations and preliminary causes of bighorn sheep within the Sleeping Giant/Beartooth WMA population.

Disease Diagnostics

We found evidence for active *M. ovi* infections at captures within the SGBT herd with prevalence rates of at least 26%. This number could increase should strain-typing of indeterminate nasal samples yield additional comfirmations of *M. ovi* presence. Additionally, over half of the sheep tested had been exposed to *M. ovi* at some point in their lives. We are awaiting results from samples collected at mortality sites. We found evidence of multiple Pasturella species during capture events within both nasal and tonsil swabs.

Table 6: Pathogen Prevalence Data for the Sleeping Giant/Beartooth WMA population.

Herd	Pathogen	Test	Prevalence	N
SGBT	B. trehalosi	Nasal	0.05	42
SGBT	B. trehalosi	Tonsil	0.64	42
SGBT	Leukotoxins	Tonsil	0.31	42
SGBT	M. glucosida	Nasal	0.00	42
SGBT	M. glucosida	Tonsil	0.10	42
SGBT	M. haemolytica	Nasal	0.05	42
SGBT	M. haemolytica	Tonsil	0.12	42
SGBT	M. ovipneumoniae (Active Infection)	PCR	0.26	42
SGBT	M. ovipneumoniae (Exposure)	ELISA	0.56	40
SGBT	M. ruminalis	Tonsil	0.00	42
SGBT	M. spp	Tonsil	0.10	42
SGBT	T. pyogenes	Nasal	0.05	42
SGBT	T. pyogenes	Tonsil	0.19	42

Tendoys

Captures

Captures in the Tendoys occurred on 1/22/2024. A total of 10 sheep were captured, although 8 sheep were collared via aerial net-gunning. Capture locations of sheep in the Tendoys reflect where sheep were processed and not where sheep were captured.

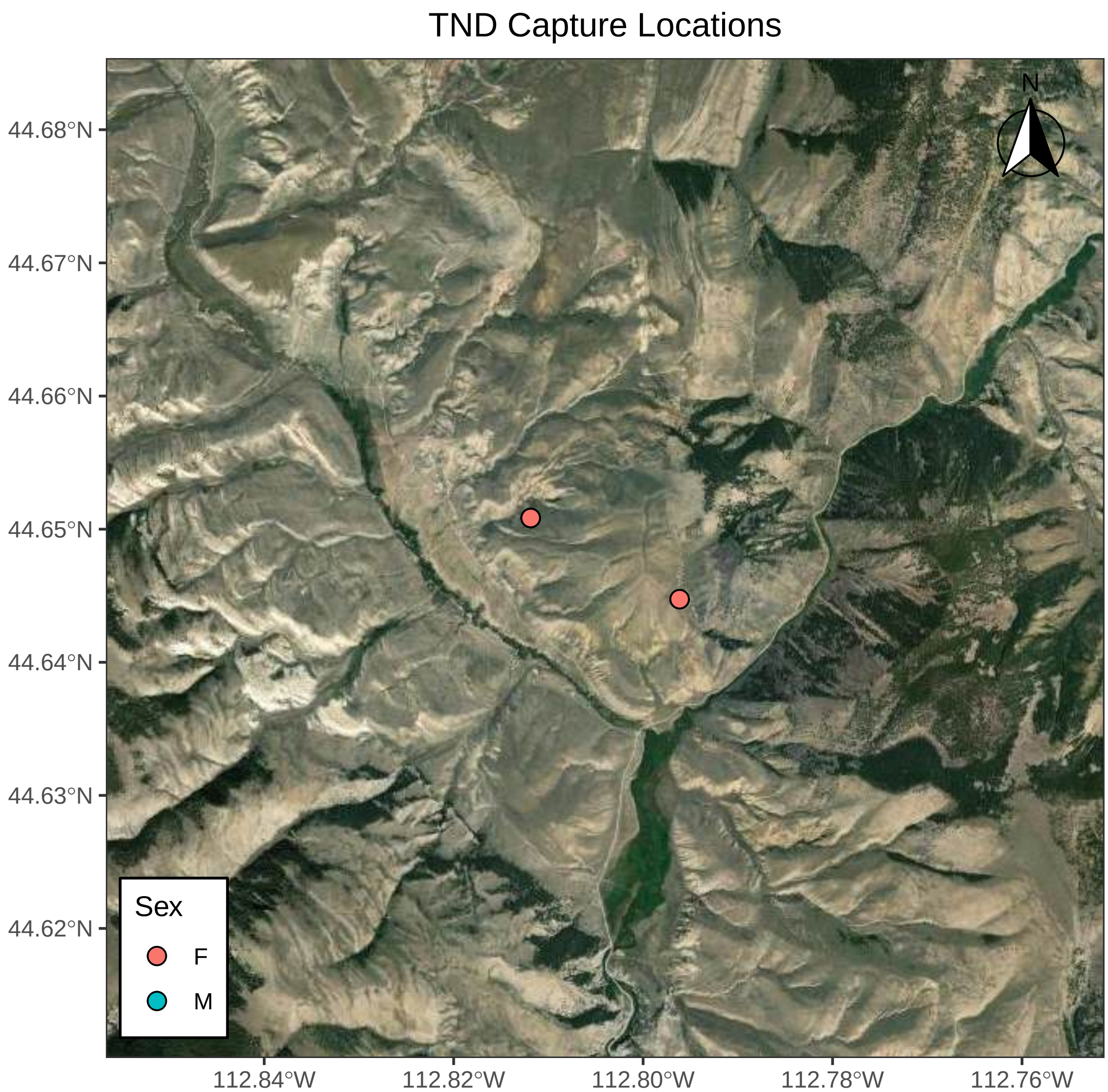

Figure 37: Capture locations of bighorn sheep within the Tendoys population. Locations represent where sheep were processed.

Age structuring within the Tendoys appeared to be split between 1.5 and >3.5 year olds with each class having 4 captured sheep within it. We captured 7 ewes and 3 rams during the capture event; however, we did not collar 2 rams leaving us with only a single ram. During the 2025 capture season, we will attempt to supplement this with 5 additional ram collars.

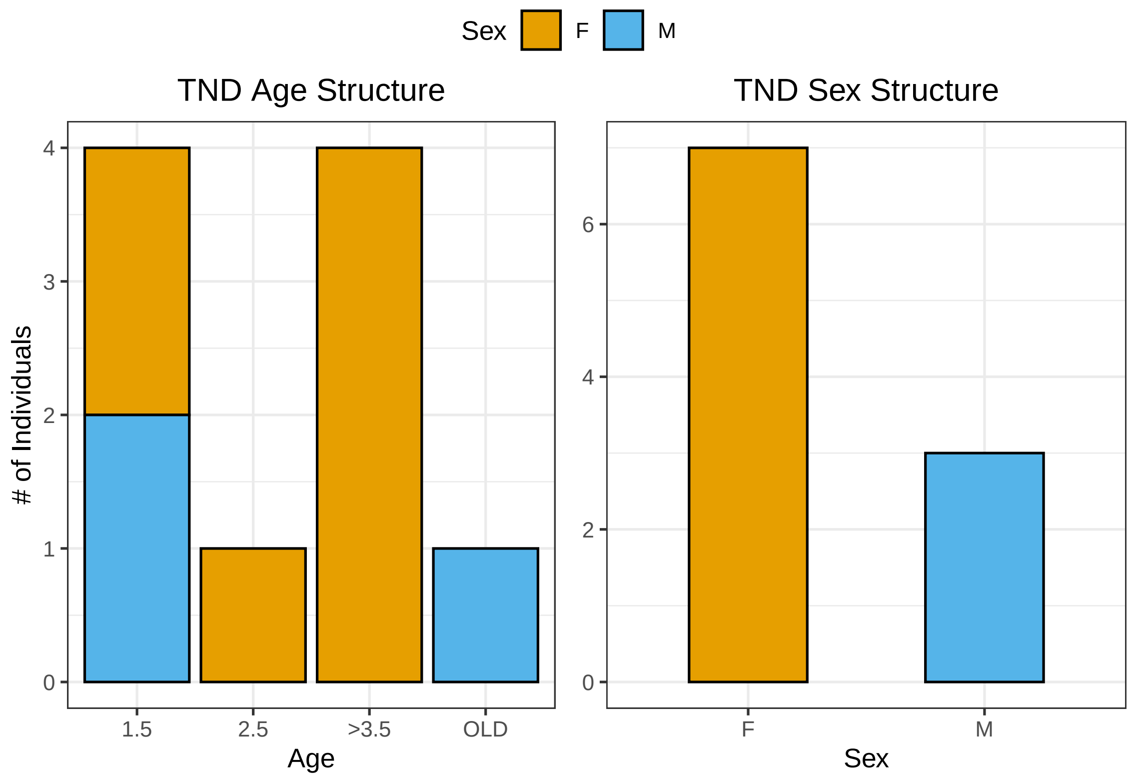

Figure 38: Age and sex distributions of captured bighorn sheep within the Tendoys population.

Mortalities

Since collaring, no mortalities have occured within the Tendoys herd.

Disease Diagnostics

Encouragingly, we found no evidence of active *M. ovi* infections nor exposure to *M.ovi*. However, we did see prevalence rates of 90% for *B. trehalosi* along with lower prevalence rates for leukotoxins and M. spp.

Table 7: Pathogen Prevalence Data for the Tendoys.

Herd	Pathogen	Test	Prevalence	N
TND	B. trehalosi	Nasal	0.0	10
TND	B. trehalosi	Tonsil	0.9	10
TND	Leukotoxins	Tonsil	0.2	10
TND	M. glucosida	Nasal	0.0	10
TND	M. glucosida	Tonsil	0.0	10
TND	M. haemolytica	Nasal	0.0	10
TND	M. haemolytica	Tonsil	0.0	10
TND	M. ovipneumoniae (Active Infection)	PCR	0.0	10
TND	M. ovipneumoniae (Exposure)	ELISA	0.0	10
TND	M. ruminalis	Tonsil	0.0	10
TND	M. spp	Tonsil	0.1	10
TND	T. pyogenes	Nasal	0.0	10
TND	T. pyogenes	Tonsil	0.0	10

Ural-Tweed

Captures

Captures in Ural-Tweed occurred from January through March. A total of 4 sheep were collared via ground darting. Conditions within the Ural-Tweed population are extremely difficult for ground captures indicated by the low number of sheep captured during the season. We may return to attempt to supplement this herd with the remaining collars. We hope to collar a total of 10 sheep prior to management action occurrence.

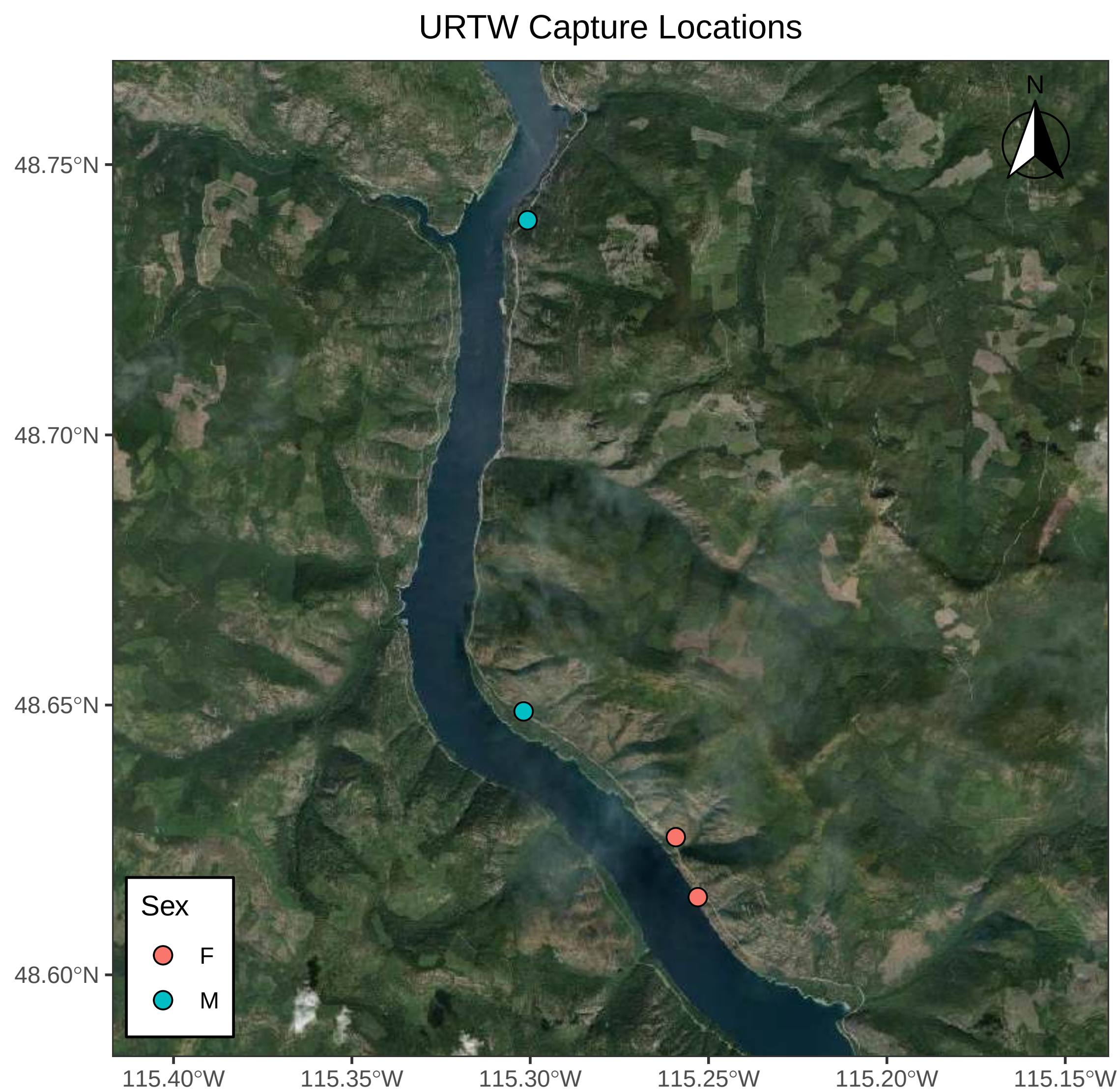

Figure 39: Capture Locations of bighorn sheep within the Ural-Tweed population.

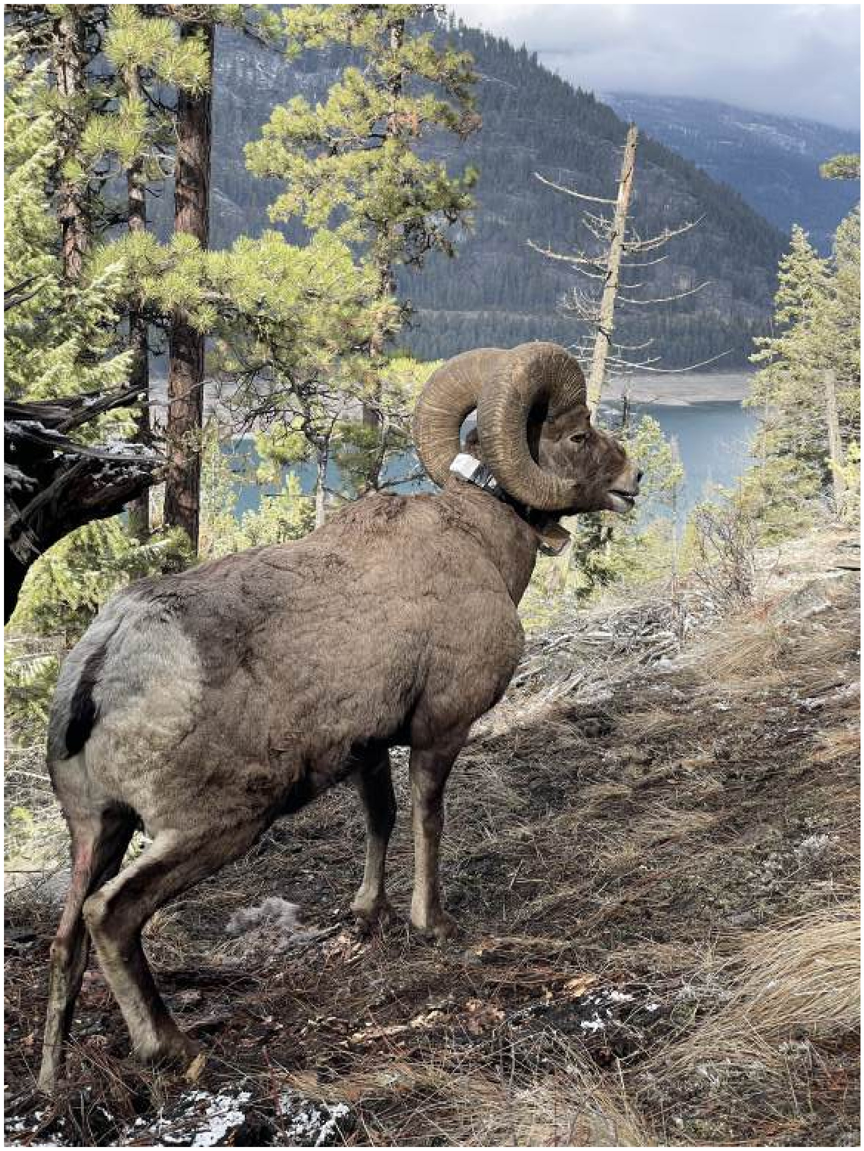

Figure 40: A male bighorn sheep being released from capture within the Ural-Tweed population.

Age structuring within collared Ural-Tweed sheep was centered on older age class individuals. Sex structure was split right down the middle.

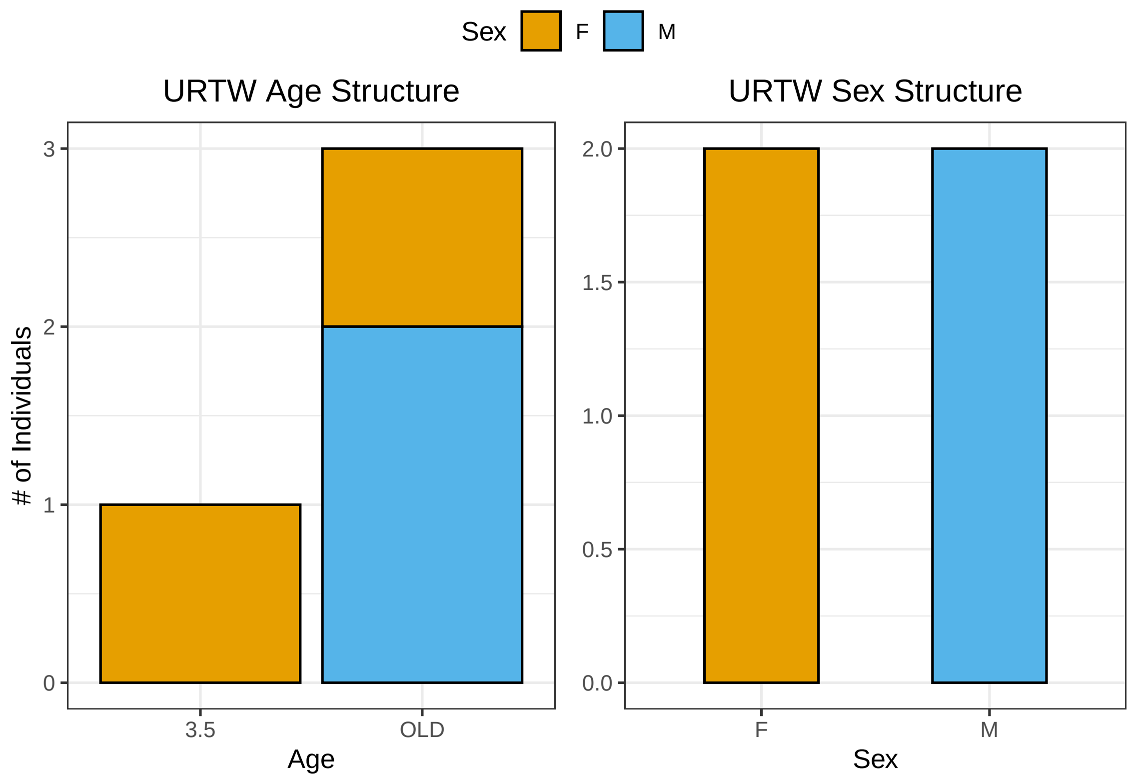

Figure 41: Age and sex distributions of captured bighorn sheep within the Ural-Tweed population.

Mortalities

Currently, no collared sheep have died within the Ural-Tweed population. However, during capture season, crews found at least 1 sheep that had died due to vehicle collision.

Observations

Like the Kootenai Falls herd, we were able to collect observational data for the Ural-Tweed herd. We relied heavily on camera trap data within this population; however, mitigation biologist, Ty Smucker, also assisted with observations. Using his drone, we were able to count a herd of 23 sheep via infrared camera, indicating that drone surveys could be an effective way to conduct counts in this population. We may push future efforts in this direction in an attempt to find a feasible way to monitor this population.

Table 8: Tabulated locations and herd compostion for bighorn sheep observations in the Ural-Tweed population.

Date	Observation_Type	Lambs	Ewes	Rams	Unk	Total
2023-11-27	Visual Observation	0	0	1	0	1
2023-11-27	Visual Observation	0	0	2	0	2
2023-11-29	Visual Observation	3	3	0	0	6
2023-12-07	Visual Observation	2	2	2	0	6
2023-12-12	Visual Observation	0	3	0	0	3
2023-12-18	Camera Trap	0	2	0	0	2
2023-12-20	Camera Trap	1	1	0	0	2
2023-12-20	Camera Trap	1	2	0	0	3
2023-12-25	Camera Trap	0	0	1	0	1
2023-12-25	Camera Trap	0	0	1	0	1
2023-12-27	Camera Trap	0	0	2	0	2
2023-12-28	Camera Trap	0	0	1	0	1
2023-12-28	Camera Trap	0	0	1	0	1
2023-12-28	Camera Trap	0	0	1	0	1
2023-12-28	Camera Trap	0	0	1	0	1
2024-01-02	Camera Trap	0	0	1	0	1
2024-01-05	Visual Observation	0	4	4	0	8
2024-01-10	Visual Observation	0	5	1	0	6
2024-01-11	Visual Observation	1	2	1	0	4
2024-01-12	Camera Trap	2	1	2	0	5
2024-01-12	Camera Trap	2	2	2	0	6
2024-01-12	Camera Trap	2	2	2	0	6
2024-01-15	Camera Trap	0	0	4	0	4
2024-01-15	Camera Trap	0	0	2	0	2
2024-01-17	Camera Trap	1	3	1	0	5
2024-01-17	Camera Trap	1	0	1	0	2
2024-01-18	Visual Observation	0	1	0	0	1
2024-01-18	Visual Observation	4	5	1	0	10
2024-01-18	Camera Trap	0	0	1	0	1
2024-01-19	Camera Trap	0	2	1	0	3
2024-01-19	Camera Trap	3	3	2	0	8
2024-01-19	Camera Trap	1	1	0	0	2
2024-01-20	Camera Trap	2	9	4	0	15
2024-01-20	Camera Trap	0	1	1	0	2
2024-01-20	Camera Trap	1	1	0	0	2
2024-01-20	Camera Trap	3	6	5	0	14
2024-01-21	Camera Trap	0	0	1	0	1
2024-01-21	Camera Trap	0	1	1	0	2
2024-01-21	Camera Trap	1	1	2	0	4
2024-01-21	Camera Trap	0	1	0	0	1

Date	Observation_Type	Lambs	Ewes	Rams	Unk	Total
2024-01-21	Camera Trap	0	3	0	0	3
2024-01-21	Camera Trap	1	2	3	0	6
2024-01-21	Camera Trap	2	3	2	0	7
2024-01-21	Camera Trap	2	8	5	0	15
2024-01-21	Camera Trap	1	1	0	0	2
2024-01-21	Camera Trap	1	2	0	0	3
2024-01-21	Camera Trap	2	5	3	0	10
2024-01-21	Camera Trap	1	1	1	0	3
2024-01-22	Camera Trap	1	0	0	0	1
2024-01-22	Camera Trap	1	3	1	0	5
2024-01-23	Camera Trap	2	3	2	0	7
2024-02-03	Camera Trap	0	1	0	0	1
2024-02-05	Visual Observation	1	3	2	0	6
2024-02-05	Visual Observation	0	2	0	0	2
2024-02-06	Camera Trap	0	1	0	0	1
2024-02-06	Camera Trap	0	1	0	0	1
2024-02-06	Camera Trap	0	2	0	0	2
2024-02-06	Camera Trap	1	0	0	0	1
2024-02-06	Camera Trap	0	1	2	0	3
2024-02-13	Camera Trap	0	2	0	0	2
2024-02-16	Camera Trap	0	1	0	0	1
2024-02-16	Camera Trap	1	0	0	0	1
2024-02-16	Camera Trap	1	1	0	0	2
2024-02-19	Visual Observation	3	1	0	0	4
2024-02-19	Visual Observation	0	0	1	0	1
2024-02-25	Camera Trap	0	5	1	0	6
2024-02-26	Camera Trap	0	1	0	0	1
2024-02-26	Camera Trap	1	2	0	0	3
2024-02-26	Camera Trap	0	0	1	0	1
2024-02-28	Visual Observation	4	4	0	0	8
2024-02-28	Camera Trap	0	0	1	0	1
2024-02-28	Camera Trap	2	5	0	0	7
2024-02-29	Visual Observation	0	3	0	0	3
2024-03-03	Camera Trap	1	1	0	0	2
2024-03-03	Camera Trap	1	0	0	0	1
2024-03-03	Camera Trap	1	1	0	0	2
2024-03-04	Visual Observation	0	0	2	0	2
2024-03-06	Camera Trap	1	2	0	0	3
2024-03-06	Camera Trap	1	2	0	0	3
2024-03-06	Camera Trap	1	2	0	0	3
2024-03-07	Visual Observation	1	2	3	0	6
2024-03-09	Camera Trap	0	0	0	1	1
2024-03-13	Camera Trap	0	1	0	0	1
2024-03-18	Camera Trap	1	1	0	0	2

Figure 42: Locations of opportunistic and camera trap observations of bighorn sheep from the Ural-Tweed population. Size of points provides a proxy for the number of animals seen at the point.

Figure 43: Drone imagery of a bighorn sheep herd within the Ural-Tweed population. Credit: Ty Smucker.

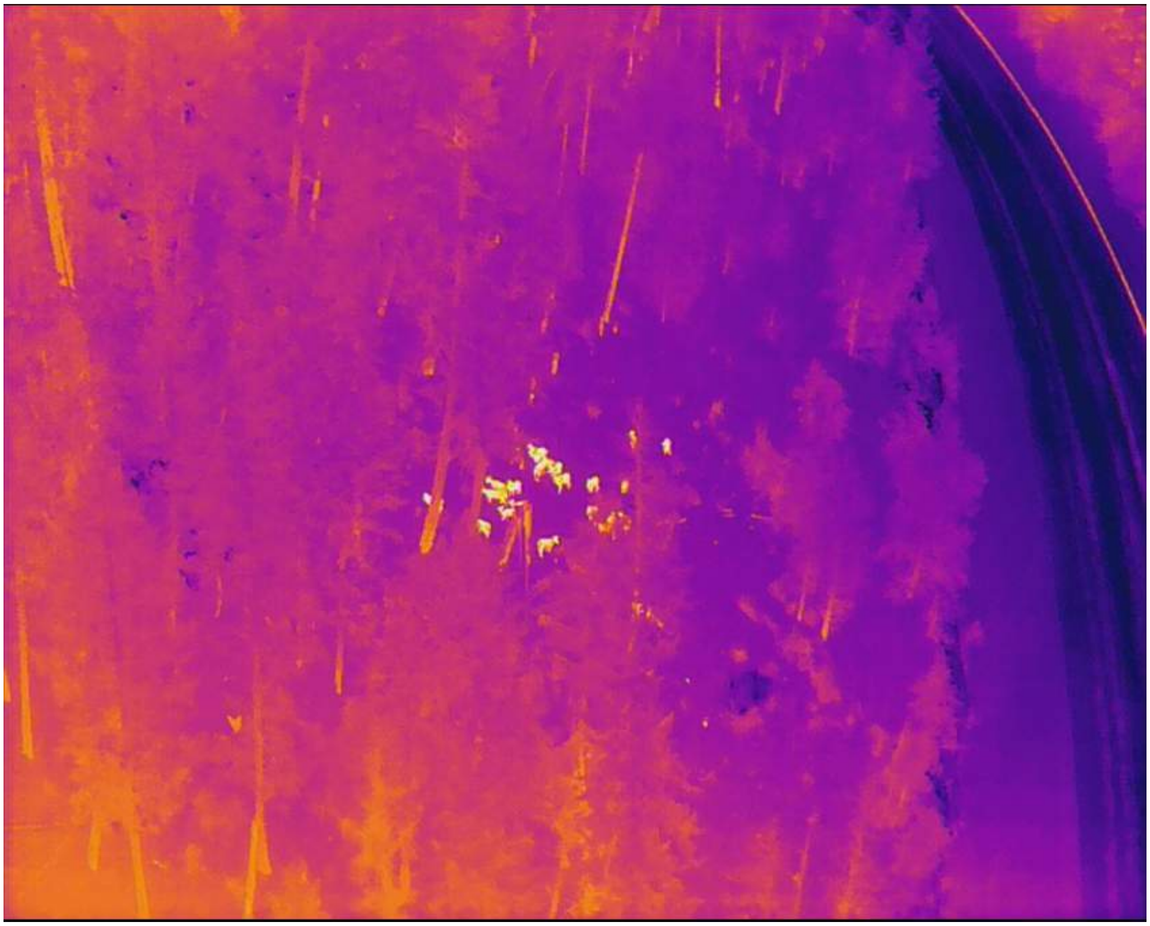

Figure 44: Drone infrared imagery of a bighorn sheep herd within the Ural-Tweed population. Credit: Ty Smucker.

Disease Diagnostics

Similar to the Kootenai Falls population, this population tested negative for all known bighorn sheep pathogens. We were encouraged by this result and feel confident that this population is likely very well protected from pneumonia mortality.

Table 9: Pathogen prevalence data for the Ural-Tweed population.

Herd	Pathogen	Test	Prevalence	N
URTW	B. trehalosi	Nasal	0	4
URTW	B. trehalosi	Tonsil	0	4
URTW	Leukotoxins	Tonsil	0	4
URTW	M. glucosida	Nasal	0	4
URTW	M. glucosida	Tonsil	0	4
URTW	M. haemolytica	Nasal	0	4
URTW	M. haemolytica	Tonsil	0	4
URTW	M. ovipneumoniae (Active Infection)	PCR	0	4
URTW	M. ovipneumoniae (Exposure)	ELISA	0	3
URTW	M. ruminalis	Tonsil	0	4
URTW	M. spp	Tonsil	0	4
URTW	T. pyogenes	Nasal	0	4
URTW	T. pyogenes	Tonsil	0	4

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