



# Summer Nutrition, Disease, or Predation? Quantifying causes of poor lamb survival in Northwest Wyoming.

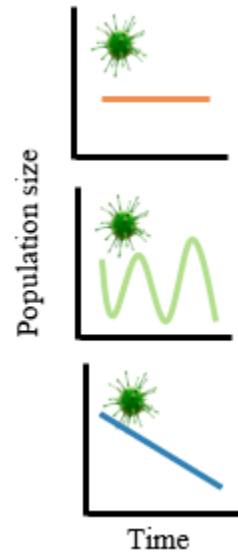
**Summer 2023**



## Project Background

The persistence of pneumonia poses a risk to bighorn sheep herds throughout their range, as it is often the culprit for massive population crashes. Following a crash, pneumonia can remain in the herd long after its initial introduction. Infected herds can experience very different population trends—some continue to decline, some undergo crash-recovery cycles, and some are able to tolerate it without significant mortality. It remains unknown why some herds can recover from the disease while others cannot, but this suggests ecological or environmental factors may be at play to influence population trends in the context of disease.

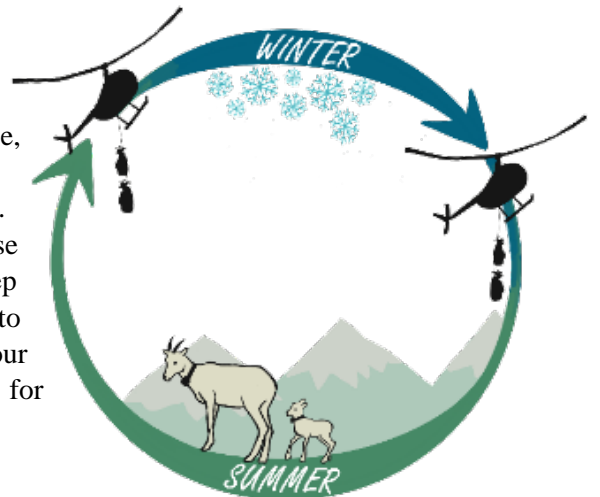
Wyoming's bighorn sheep herds have experienced pneumonia die-offs throughout the state, to which there has been variability in recovery. Once the largest Rocky Mountain bighorn sheep herd, the Whiskey Mountain herd experienced a pneumonia die-off in the early 1990's and has continued to decline with abysmal lamb survival ever since. Still, there are other herds nearby that have experienced similar die-offs but have not faced the long-lasting population decline affecting the Whiskey herd. The differences in trends across populations with the same pneumonia related pathogens motivates our investigation into the factors that influence population dynamics in the presence of disease.



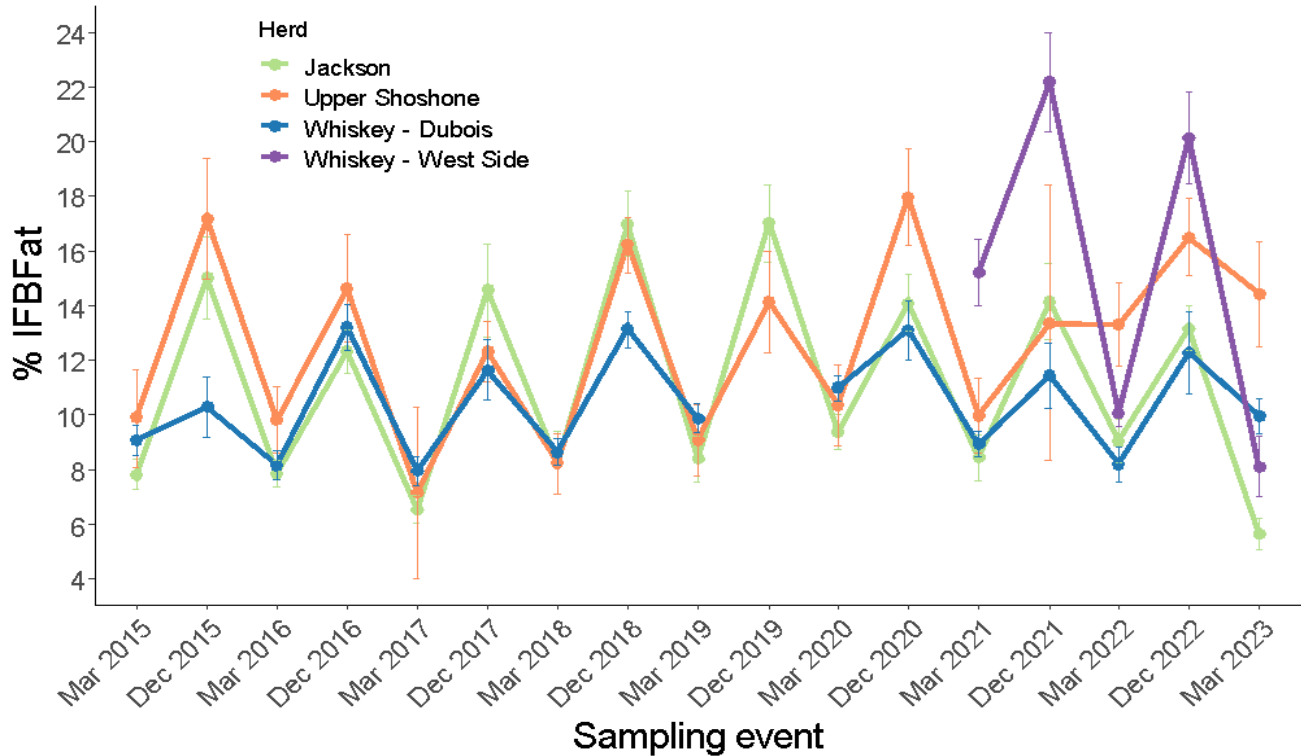
## Our Approach

We seek to identify how nutrition and disease interact to influence population dynamics. Our work focuses on the Whiskey Mountain (Dubois and West Side), Jackson, and Upper Shoshone bighorn sheep herds, which all hold the same bacterial pathogens associated with pneumonia but have much different population trends. The Whiskey Mountain herd is divided into migratory animals (Dubois) and high elevation residents (West Side). We aim to look beyond the disease itself and identify factors that influence the ability of sheep to tolerate or succumb to pneumonia.

Through our longitudinal study (i.e., monitoring the same animals through time), we are tracking pathogens presence, nutritional condition, reproduction, adult and lamb survival, mortality causes, and forage conditions of individuals over time. We aim to disentangle the relative roles of each of those components in crashes and recoveries of bighorn sheep populations. Identifying how disease and nutrition interact to influence population dynamics is critical to improving our understanding of pneumonia, developing management options for bighorn sheep, and ultimately, mountain sheep conservation.



Each spring, we determine pregnancy of captured females and during autumn captures, we assess lactation, which can provide corroborative evidence of recruitment (if a female is still lactating), or if she lost her offspring in the summer or fall (if she is no longer lactating). Pregnancy rates are usually high, but lamb recruitment fluctuates. Recruitment is quite low in the Whiskey herd.



Ingesta-free body fat (%±SE) of adult female bighorn sheep from March 2015 to March 2023 in the Jackson, Upper Shoshone, and Whiskey Mountain (Dubois and West Side) herds.

Some of the most interesting results stem from nutritional dynamics across the different populations. The Dubois herd appears to be nutritionally limited on their summer ranges, while experiencing adequate winter conditions. Conversely, the Jackson herd appears to have robust summer ranges, but experience poorer conditions when on winter ranges than the Dubois herd. Finally, the West Side herd appears to have almost no nutritional limitations. In March 2021 they had more fat than the Dubois sheep have ever carried. The Whiskey herd often has the poorest nutritional condition, despite having less energetic demands associated with lactation because recruitment has been so poor.

Nutritional condition of an animal is a product of its environment and therefore, represents the energetic gains and deficits experienced by an animal, as well as the nutritional reserves it carries into the upcoming season. Assessing nutritional condition of an animal is a critical step in understanding how disease, the environment, pregnancy, and recruitment interact to affect bighorn sheep populations throughout the state.



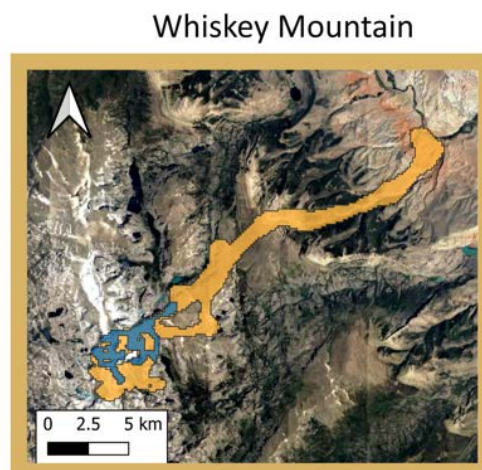
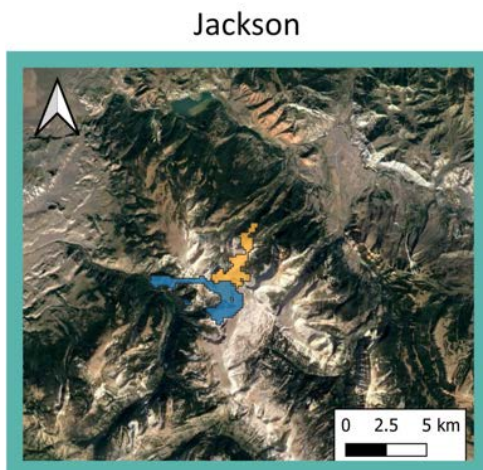
## Habitat Assessment

We began habitat assessment of the Dubois and Jackson summer ranges in 2019 and in 2021 for the West Side summer ranges. Our aim is to describe species abundance, species diversity, and nutritional quality (i.e., crude protein, digestibility, and trace minerals) of sheep core home ranges. Our goal is to compare the summer ranges and sheep diets between the three herds, as the Dubois herd appears to be limited on summer range and seek to see if their summer nutrition helps to explain their poor recruitment.



We sampled over 700 vegetation transects and quantified nutrient content of over 2,000 genera on summer ranges of Jackson and Dubois. The summer range of the Jackson herd (the herd experiencing growth, higher recruitment, and better nutritional condition) had over double the herbaceous biomass in core foraging areas than the summer range of the Dubois herd. Furthermore, the Jackson summer range had higher species diversity and plant cover than summer ranges in Dubois, and when accounting for nutrients available for consumption, the Jackson herd had higher digestible energy, crude protein, calcium, phosphorous, magnesium, potassium, sodium, iron, zinc, and copper. Of all the nutrients we measured, we only saw higher concentrations of one micronutrient (manganese) in Dubois. The ease of access to high quality forage in Jackson likely aids in their ability to recover from pneumonia epizootics and to cope with bacterial pathogens associated with pneumonia.

The nutritional differences observed in Jackson and Dubois scaled up to how animals use the landscape. Females in Dubois made drastic changes to their space use when their lamb died. When a mother in Dubois lost her lamb, she drastically increased the size of her home range likely because she needs to use more space to secure adequate resources. In contrast, when a mother in Jackson lost her lamb, she did not make any adjustments to her home range, indicating that Jackson animals have adequate resources in a smaller space. The home range increases we observed in Dubois are a further indication of a nutritional limitation occurring on summer range.



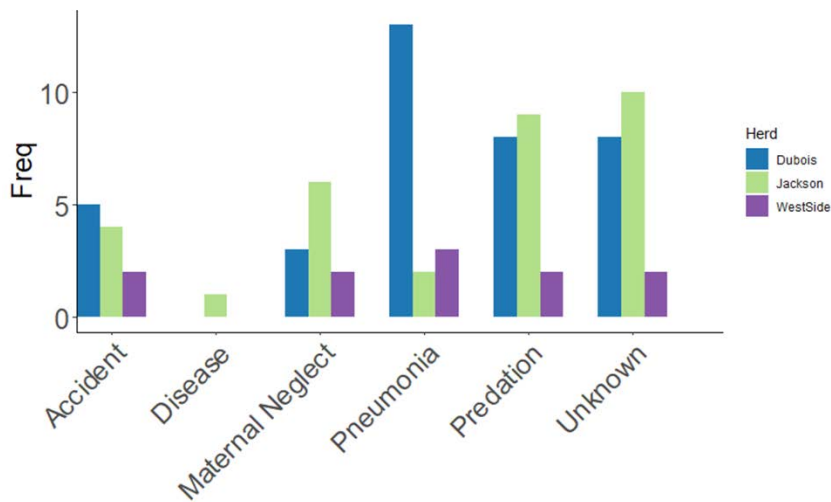
Examples of home ranges for sheep that have a juvenile and those that don't in Jackson and Whiskey Mountain - Dubois.

Recruitment status: ■ No juvenile ■ Live juvenile

## Lamb survival

In March 2019, 2020, 2021, and 2022 we fit pregnant ewes with vaginal implant transmitters (VITs) to facilitate capture and collar of lambs. When we capture a lamb, we take morphometric measurements, nasal swabs, draw blood, and fit the lamb with a GPS collar.

We observed similar patterns of mortality of lambs during all three summers. Just like we see in other neonatal ungulates, lambs seem to be most vulnerable to predation and accidents in their first few weeks of life. Once they are older, pneumonia is the primary cause of death for the lambs in the Dubois herd. However, we did observe some pneumonia deaths in the West Side and Jackson herd. In the Dubois herd, it appears that lambs that die of predation later in life may be predisposed by pneumonia.



Cause-specific mortality of the lambs captured 2019–2022.

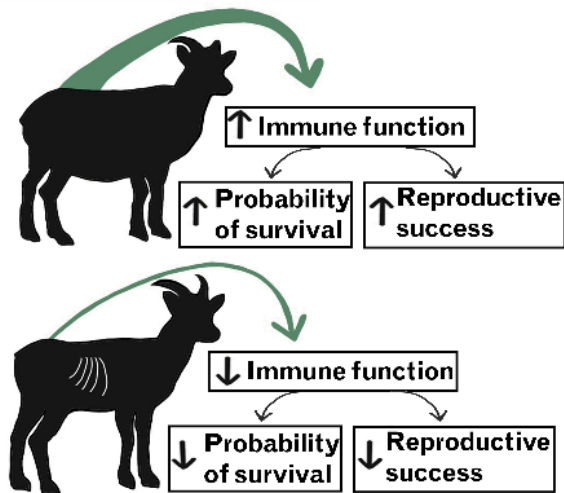


## Predation

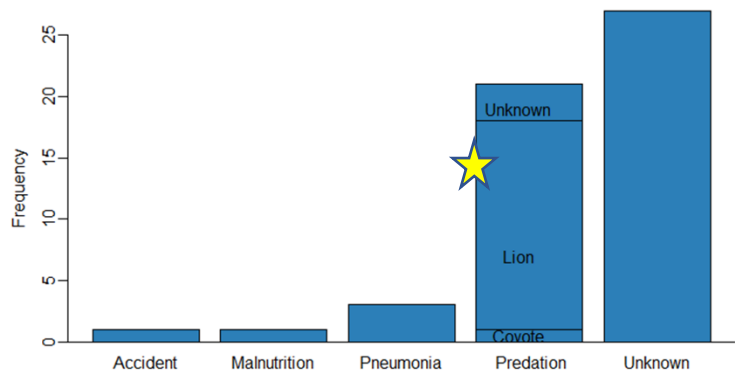
Though disease seems to be the primary limiting factor to recruitment of young, predation has been the largest source of adult mortality. More than 30% of mortalities have been mountain lion predation. This usually occurs in the spring, while animals are still on winter range. Interestingly, there is no correlation between an individual's age or nutritional condition (in December or March) and their probability to be killed by mountain lions. Indeed, as has become evident in many populations of bighorn sheep, mountain lions appear to be a primary contributor to adult mortality.

## Looking forward

We aim to continue these efforts in all herds. We are excited to see how the West Side herd is able to maintain such a high nutritional plane. Additionally, Wyoming Game and Fish Department has



Potential relationship between nutritional condition, immune function, survival, and reproductive rates. Thickness of arrows indicates relative energy available to investment in immune function to sheep in (a) good and (b) poor nutritional condition.



Cause-specific mortality of adults from 2015 to May 2023.



employed two management actions in the Jackson and Dubois herds—a female harvest in Jackson and a test and cull program in Dubois. We aim to continue this project to monitor any effects of these management actions on nutrition, pathogen presence, or lamb recruitment.

The fundamental components underlying any large ungulate population (e.g., habitat quality and quantity, density-dependent interactions, and predation) remain operational and yet, are commonly neglected when considering disease dynamics. We will piece together each female's history to describe how she interacts with her environment, understand her success to survive and reproduce or lack thereof, and how she fits within the population in which she resides. By piecing together the histories of each female we monitor, we hope to add an important piece to the puzzle of the complex interactions of environment, immune function, disease, predation, and dynamics of our cherished bighorn sheep populations.

For more information, please don't hesitate to contact us.

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