

# Whiskey Mountain Bighorn Sheep Plan



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In the spirit of the North American Wildlife Conservation Model, WGFD is committed to the continuation of this collaborative process as we all strive to sustain a healthy bighorn sheep population in the Whiskey Mountain Bighorn Sheep (WMBS) herd. This effort represents an enormous investment in time and resources but without the enthusiastic and consistent participation of many members of the public this would have been nothing more than a hollow exercise.

We wish to acknowledge the many individuals who felt enough personal interest to forego evenings at home to travel to our workshops and actively make contributions to this effort. We are also grateful we benefitted from a wide range of stakeholder values and perspectives. WGFD provided the framework for this plan, but it was the public participation that provided the substance. This bighorn sheep herd is a resource that truly belongs to everyone and is cherished by many.

# EXECUTIVE SUMMARY

During the winter of 1990/91 the Whiskey Mountain Bighorn Sheep (WMBS) herd experienced a pneumonia outbreak that resulted in significant mortality. Sick bighorn sheep were initially noticed in the Torrey Rim group during a period of bitter cold and high winds in December, 1990. They were subsequently documented in other wintering groups on BLM Ridge, Sheep Ridge, and Red Creek between January and February, 1991. The disease outbreak resulted in significant mortality across all age classes but lambs had a higher mortality rate than adults. While the exact causative agent of the pneumonia was not identified, laboratory analysis found *Pasturella* spp. in samples taken from dead bighorn sheep. In the year prior to the pneumonia outbreak there was no documentation of bighorn sheep from this herd being exposed to known/suspected hosts, such as domestic sheep, associated with bacterial pathogens linked to pneumonia. When and how bacterial pathogens were introduced to the bighorn sheep population is unknown, but it is likely environmental stress associated with severe winter conditions resulted in the disease outbreak and die-off event.

Based on information from a number of all-age, bighorn sheep die-offs throughout the west, populations typically experience a pattern of low lamb recruitment for approximately 3-5 years following a pneumonia outbreak. After this period, recruitment often increases gradually and populations recover and begin to grow. In contrast, the WMBS herd has continued to decline due to low lamb recruitment the past 28 years.

During the workshops, stakeholders identified seven major factors influencing this bighorn sheep herd and its management including: Health/Diseases, Habitat/Nutrition, Predatory Animals, Population Management, Disturbance/Access, Research, and Funding. WGFD added Public Outreach and Communication. Through implementation of this plan, WGFD in cooperation with all stakeholders, will focus increased emphasis and attention on this important bighorn sheep herd and will continue to seek additional funding for research and management needs as is appropriate and necessary.

The proposed management actions to be implemented in response to public input during this collaborative process are described in greater detail in the body of this plan. They are also the result of continued collaboration with the U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Wind River Reservation, the National Bighorn Sheep Center, and the Wyoming Wild Sheep Foundation.

# INTRODUCTION

The Whiskey Mountain bighorn sheep (WMBS) herd encompasses the northern Wind River Mountain Range in west central Wyoming (Figure 1). The herd has been an important component in bighorn sheep management for Wyoming and other western states for many decades. Recognized for years as the largest congregation of wintering bighorn sheep (*Ovis canadensis*) in the country the herd has been a management focus for the Wyoming Game & Fish Department (WGFD), federal land management agencies, and non-government conservation groups for over half a century. From 1949 through 1995 over 1,900 bighorn sheep were captured and moved from the WMBS herd to establish new bighorn sheep herds or augment existing herds throughout the West. At its peak, the herd provided substantial recreational opportunity for hunters and photographers. In addition, the herd has become part of the identity for the town of Dubois. Following a large, all-age die-off caused by pneumonia during the winter of 1990/1991 the bighorn sheep herd has consistently experienced low lamb production leading to continued population decline. Observations of the bighorn sheep herd over the past 28 years also reveal the persistence of bighorn sheep (lambs and adults) exhibiting nasal discharge, coughing, parasites, viral infections, and low body mass. All of these symptoms indicate bighorn sheep in the herd are generally unhealthy, likely subject to environmental stressors and continually exposed to contagious or transmissible pathogens and parasites.

It is unknown how many bighorn sheep inhabited the northern Wind River Mountains prior to European settlement. Early explorers noted mountain sheep were easily found throughout the Wind River Range. It is known increased domestic livestock grazing in the late 1880s through the early 1900s had a dramatic impact on wild sheep populations throughout the West. In particular domestic sheep grazing contributed to large scale die-offs of bighorn sheep due to transmission of scabies and bacterial pathogens. By 1940, Honess and Frost (1942) estimated there were approximately 500 bighorn sheep in the Wind River Mountains. By the mid-1950s, WGFD acknowledged the importance of maintaining crucial bighorn sheep winter ranges on and adjacent to Whiskey Mountain for bighorn sheep persistence in the Wind River Mountains. As a result, the Wyoming Game and Fish Commission (WGFC) began purchasing crucial bighorn sheep winter range near Whiskey Mountain in 1954. At the same time, the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) began to emphasize bighorn sheep habitat on lands they managed in the area. The recognition by all three agencies regarding the importance of bighorn sheep winter range near Whiskey Mountain led to an inter-agency agreement to manage certain lands with a primary emphasis on bighorn sheep habitat. This agreement, signed in 1969, led to the formation of the Whiskey Mountain Bighorn Sheep Technical Committee (WMBSTC) and the development of the Whiskey Mountain Bighorn Sheep Comprehensive Management Plan in 1970. Under the agreement, all three management agencies have focused management emphasis on bighorn sheep habitat management in the Whiskey Mountain area for nearly half a century. The plan was updated several times since and most recently in 2006.

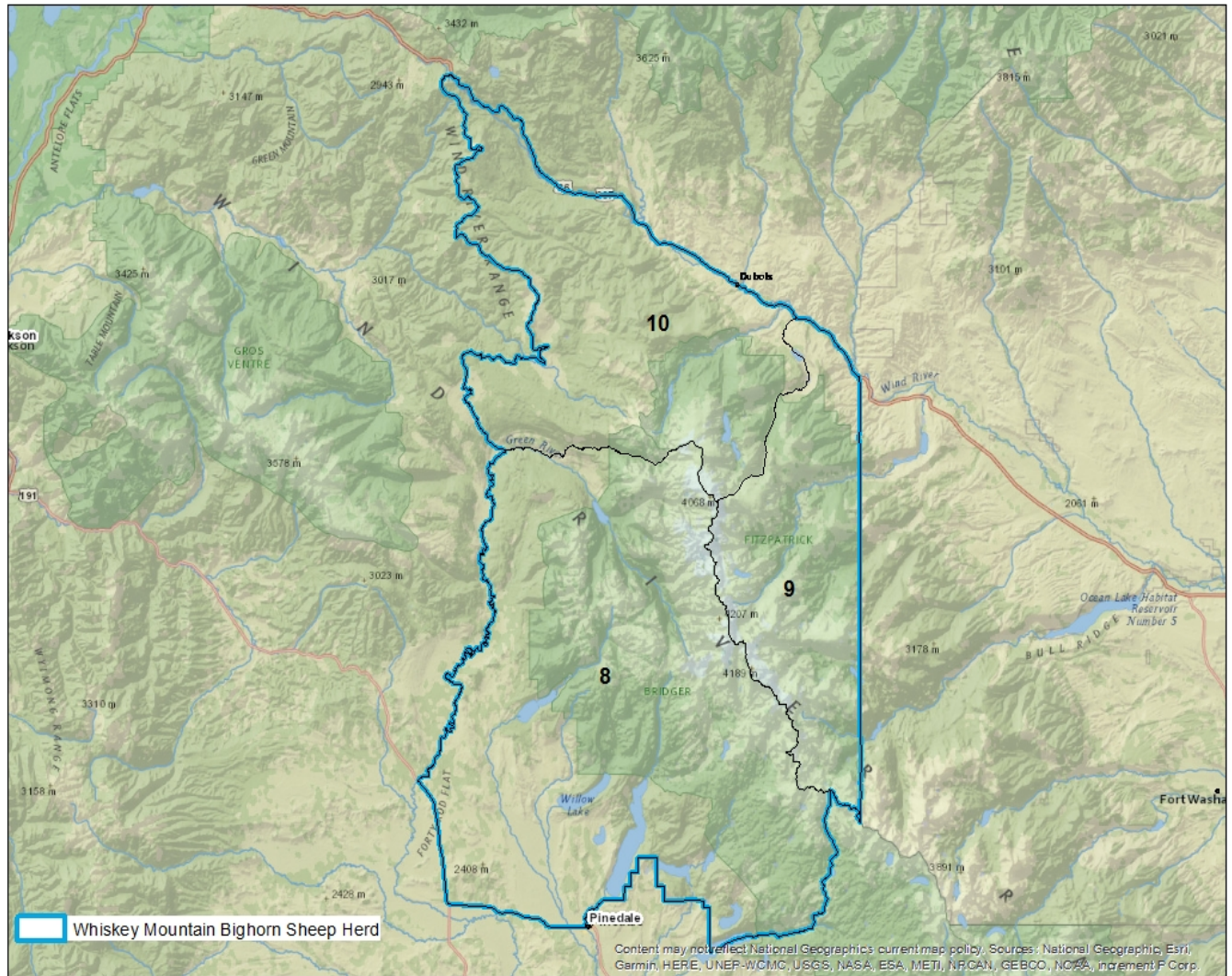


Figure 1. Whiskey Mountain Bighorn Sheep herd unit, Wyoming.

Estimates of bighorn sheep numbers in the WMBS herd unit are scarce for the time period between 1940 and the early 1970s. However, it appears bighorn sheep numbers increased substantially during this 30 year period. From 1958 through 1971, classification data yield an average lamb/ewe ratio of 42/100 on the three main winter ranges of Torrey Rim, Sheep Ridge, and BLM Ridge (Butler, 1977). Following a 13 year period of good lamb recruitment and population growth, WGFD personnel noted a significant decline in lamb/ewe ratios in the early 1970s including a ratio of 6/100 in 1974 on these three winter ranges. Concern about low lamb numbers led to a WGFD study that started in 1975. The study was designed to detail habitat use, migration routes, and nutritional status of bighorn sheep in the WMBS herd (Thorne et al., 1979). Over the three year study investigators noted indicators of poor health in the herd including low blood urea nitrogen (BUN) levels in wintering bighorn sheep, short suckling times for lambs, and low lamb weights. It was believed the poor health indicators were indicative of inadequate forage and overpopulation. Vegetation utilization plots indicated bighorn sheep wintering on BLM Ridge and Sheep Ridge were often consuming over 90% of the vegetation produced each year on their preferred wintering sites. Of particular interest, the presence of bacterial pathogens linked to pneumonia in the WMBS herd was found and noted during this study. Some of the conclusions were the WMBS herd appeared to be over carrying capacity in the mid-1970s, had indications of nutritional stress, and were exposed to a number of pathogens and parasites linked to pneumonia outbreaks in bighorn sheep elsewhere. They ominously predicted that extra environmental stress could easily result in a catastrophic disease outbreak.

Thorne et al.'s (1979) prediction came true during the winter of 1990/1991 when WGFD personnel documented coughing and sick bighorn sheep during a period of bitter cold and high winds on Whiskey Mountain. Bighorn sheep continued to die from pneumonia throughout the spring of 1991. Persistent low lamb recruitment and population decline following the 1991 pneumonia die-off led WGFD to implement another WMBS study in 1998 (Hnilicka et al. 2002) which also noted indications of poor bighorn sheep health thought to be related to nutritional deficiencies.

Recent data indicates the WMBS herd may now be below winter range carrying capacity. In particular, vegetation utilization plots conducted using the same methodology as in the 1970s indicate bighorn sheep are utilizing less than 50% of vegetation produced each year on preferred winter sites. This is a marked contrast to utilization above 90% at times in the 1970s and 1980s. Additionally, body condition monitoring of re-captured ewes from 2015-2018 indicate adult bighorn sheep are maintaining body condition throughout winter better than bighorn sheep in the nearby Jackson and Cody herds (Monteith 2017). However, there are indications bighorn sheep in the WMBS herd may be subjected to some unknown nutritional stress on summer range.

Underpinning the nutritional issues identified in this herd is now the persistence of bacteria and other pathogens believed to have serious health repercussions for the population. Multiple species of bacteria related to pneumonia in bighorn sheep have been consistently identified in the population during testing over the years. Recently, the presence of sinus tumors has been observed in the WMBS population. Other diseases and parasites such as contagious ecthyma (ORF) and lungworms are also known to be present. Undoubtedly population level impacts from disease and parasites are compounded by any nutritional stress whether on summer or winter range. At this point managers do not know if poor bighorn sheep health in the WMBS herd is strictly due to pathogens and parasites or if the persistence of pathogens and parasites is the result of nutritional

stress.

Most recently, increased wolf activity in and around Whiskey Mountain appears to have altered the behavior and distribution of bighorn sheep on winter range. Beginning in 2016, bighorn sheep on several core winter ranges began to spend considerably more time in less accessible, rugged escape terrain. This coincided with the appearance of a new wolf pack in the area as well as a noted change in wintering elk behavior. The impacts of the behavioral/distribution change are unknown but it is apparent bighorn sheep are spending less time on historically preferred winter ranges during the past three winters.

Over the past 28 years, WGFD has taken a number of management actions aimed at improving bighorn sheep health and spurring population growth in this herd. Actions have included forage enhancement on winter range including prescribed burns and fertilization, de-worming bighorn sheep, removing clinically ill bighorn sheep with symptoms of pneumonia, salt and mineral supplementation, and predator control. None of these actions have had any noticeable, positive impact on the population. In 2019, WGFD in conjunction with the University of Wyoming (UW) started a lamb survival study in an attempt to identify specific causes of lamb mortality in the herd. Many future management actions in the herd will necessarily be dependent on what is learned during this lamb survival study over the next three years.

Regardless of the reasons for the continued decline of the WMBS herd, it now appears the population size is similar to what it was in the 1940s at approximately 500 bighorn sheep. All parties with a vested interest in management of this bighorn sheep population would like to see more bighorn sheep in the herd. That said, it is important to keep in mind it may be unreasonable to manage for bighorn sheep numbers observed from the mid-1970s through the early 1990s. Indications are the WMBS herd was well above carrying capacity during that time period and it would be prudent to manage for fewer bighorn sheep.

The management challenges and considerations for the WMBS herd are complex as they affect the biology of bighorn sheep, our ability to sustain them, and the people who enjoy them. A part of complexity is change and for that reason this plan is not static, but is a “living” document and therefore will change as needed to best address the issues as we understand them and those issues that may yet arise. Because of this complexity and need for change, it is critical all who are affected continue to be engaged in the collaborative process.

During the workshops, stakeholders identified seven major factors influencing this bighorn sheep herd and its management including: Health/Diseases, Habitat/Nutrition, Predatory Animals, Population Management, Disturbance/Access, Research, and Funding. WGFD added Public Outreach and Communication. Through implementation of this plan, WGFD in cooperation with all stakeholders will focus increased emphasis and attention on this important bighorn sheep herd and will continue to seek additional funding for research and management needs as is appropriate and necessary.



# PUBLIC PARTICIPATION

Public involvement is vital to inform management of this bighorn sheep herd and attain support and buy-in for a management plan. This was accomplished through a collaborative process design that explored the issues and management options for WGFD and others to consider. The results of that collaborative process are presented in this document.

The first step was to conduct a situation assessment (Western, 2019). The purpose was to understand the beliefs of stakeholders who have an interest in the WMBS herd regarding the reasons for the herd's decline and whether a collaborative process could be beneficial to address them. This was accomplished through telephone interviews during the fall, 2018. The key points that resulted were:

- All respondents were willing to contribute to a collaborative process.
- All respondents are deeply concerned about the WMBS herd.
- There are a variety of causes respondents attribute to low lamb recruitment in the herd including disease, predation or presence of carnivores who elicit the movement of bighorn sheep to less nutritious areas, lack of nutritious forage, and either absence of people or too much presence of people. By far the most dominant causes that emerged from the interviews for the herd's decline were disease and low lamb recruitment.
- For a collaborative process to be effective, respondents suggested all stakeholders are invited, that there is facilitation or some form of leadership, that scientists and technical expertise is effectively included, and that there is a combination of a public engagement and scientific information sharing.

Using the results of the situation assessment WGFD engaged the public through a “collaborative learning” process. Collaborative learning enables stakeholders, including the initiating agency, to discuss issues in an open forum, allowing for meaningful dialogue, and active learning. Collaborative learning does not strive to achieve a final consensus or majority vote, but emphasizes learning and mutual understanding. The goal is to allow participants to be fully engaged in the process, learn from each other about the situation, and work toward improvement of issues identified. This process is effectively used when issues are complex and competing interests and values are represented (Daniels and Walker 2001). WGFD intends to continue the collaborative learning process through annual updates and open dialog regarding the status of the WMBS herd.

The issues and actions addressed in this plan were based on results of the collaborative learning process. From February 2019 through June 2019, WGFD, with financial support from the Wyoming Wild Sheep Foundation (WYWSF), Greater Yellowstone Coordinating Committee, Wild Sheep Foundation, and the Water for Wildlife Foundation conducted four public workshops in Dubois (Table 1). Approximately 200 people participated in the four workshops. In addition, two internal “decision making” meetings were conducted among WGFD personnel and then, most importantly, with the land and resource management agencies (USFS, BLM, and United States Fish and Wildlife Service (USFWS)) to review the public's input, review the scientific knowledge, explore potential actions, and craft language for this plan.

Meeting #	Meeting Time and Location	Purpose	Outcomes
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1	Feb 11, 6-9:00 p.m., Dubois – Public workshop – Summary of the Situation Assessment and Exploration of Issues	Introduce collaborative process. Provide information overview re. herd. Put all issues and interests on the table.	All the interests and issues will be listed, compiled and categorized for use in Steps 3 and 4.
2	March 14, 8 a.m. - 4 p.m., Dubois – Expert panel meets with herd managers	Explore levels of certainty and uncertainty related to information and data regarding the WMBS herd.	Scientifically grounded list of actions that are considered to have most potential to improve herd condition. To be used in Step 3 and 4.
3	March 14, 6-9 p.m. – Public Meeting – Expert panel and herd managers meet with public – Bighorn Sheep Summit	Collaborative learning and discussion regarding technical and scientific information regarding disease, predation, habitat and other aspects regarding this bighorn sheep herd.	Compile information for public use in next step (4) to inform solutions that have the greatest potential to improve herd condition.
4	April 3, 6-9 p.m., Dubois – public workshop – Create options for solutions.	Craft solutions that the public feels will have the best chance of improving herd conditions.	Compile and categorize solutions for use in Step 5.
5	May 1 and 2, 9 a.m. – 4p.m., Lander – internal manager meeting to create draft WMBS herd Strategy.	Convene meeting with related managers (WGFD, USFS, BLM, USFWS) and other implementation partners to use public input to Strategy. Create outline of Strategy.	The collaborative process, background information and resulting action items from this meeting will be compiled into a short Strategy.
6	June 5, 6-9 p.m., Dubois – Public workshop: present draft Strategy and seek feedback.	Present Draft Plan to the public for input, discussion and refinement where possible.	WMBS Strategy.
7	By August 2019	Finalize the Strategy.	

*Table 1. Whiskey Mountain Bighorn Sheep Collaborative Process Overview*

During the first public workshop, participants were provided information about collaborative learning, the public collaborative process, and presented information regarding the WMBS herd. They were then asked to break into small groups to list and prioritize the issues affecting the bighorn sheep. Issues included: habitat/nutrition, health/disease, predatory animals, disturbance/access, population management, research, funding, and public outreach/communication. The collaborative learning process was structured around these issues. Objectives, strategies and actions are presented to address each issue.

The second public workshop or the Bighorn Sheep Summit took place after a group of bighorn sheep scientists had met to identify problems and recommendations to address them. The

recommendations were shared with the public in the evening and there was an extensive period for the public and scientists to explore the scientific components related to bighorn sheep on Whiskey Mountain.

The third public workshop focused on actions to address the issues identified in the first workshop. Participants were given more in-depth information about each topic and then separated into groups to brainstorm actions. Their ideas were organized according to the category of issues addressed. Actions considered feasible in light of resources and statutory authorities are presented as strategies and actions in this plan.

The fourth and last workshop focused on the draft management plan. The draft plan was made available to the public about one week prior to the fourth round. Participants were presented with the “actions” for each issue and were once again separated into groups to provide input and recommendations for inclusion in the plan. Their input and recommendations were given consideration and were either included in the plan or in an appendix to the plan describing why they were not included as “actions”.

WGFD will continue this collaborative process to move management of the WMBS herd forward and continue to build on the momentum that has been created to conserve this bighorn sheep herd and its habitat.

# ISSUES, OBJECTIVES, AND STRATEGIES ADDRESSED

## HEALTH/DISEASE

Without question the central issue related to the long-term decline in the WMBS population is disease. The herd experienced an all-age die-off during the winter of 1990/1991 that was well documented (Ryder et. al. 1992). During the die-off, WGFD personnel documented 124 bighorn sheep mortalities attributed directly to pneumonia and it was suspected the total number of mortalities was closer to 450 bighorn sheep. While the pneumonia outbreak was attributed to environmental stress associated with a prolonged period of severe cold and high winds, the underlying pathogen responsible for bighorn sheep mortality was not definitively identified. Analysis did indicate the presence of *Pasturella haemolytica* (since re-classified as *Mannheimia haemolytica*) in a number of sick bighorn sheep. Significant advances in laboratory analytical techniques since the early 1990s now make it clear there could have been other numerous bacterial pathogens present in the bighorn sheep population at the time that were simply masked by the presence of *M. haemolytica*.

Currently, most researchers and managers agree there are four primary respiratory bacterial pathogens associated with pneumonia in bighorn sheep. These include three species of Pasteurellaceae (*Pasteurella multocida*, *Mannheimia haemolytica*, and *Bibersteinia trehalosi*) as well as *Mycoplasma ovipneumoniae*. There continues to be disagreement whether one of these four bacteria can be singled out as the primary cause of pneumonia outbreaks in bighorn sheep populations or if they act in combination. Confounding the issue is researchers continue to identify new strains of these bacteria with indications some strains may be benign and others may be pathogenic (Schommer and Woolever, 2008). That said, all four of these bacteria have consistently been isolated from samples collected from bighorn sheep in the WMBS herd (Anderson 2012 and 2014). Pneumonia caused by these organisms often results in all-age die-offs in bighorn sheep populations throughout the West. Sometimes, as is the case in the WMBS herd, an all-age die-off is followed by chronic disease with increased lamb mortality for many years.

Despite advances in the ability to identify respiratory pathogens in bighorn sheep, there continues to be no known, effective way to eliminate these pathogens from bighorn sheep populations (Cassirer et al. 2018). Management agencies have focused disease prevention efforts on keeping bighorn sheep separated from domestic livestock such as sheep and goats known to carry problematic bacteria (Brewer et al. 2014).

In the case of populations like WMBS herd, wildlife agencies simply do not have effective proactive measures to deal with the continued presence of respiratory pathogens and disease. Some methods commonly thought of such as vaccination, inoculation, and administering antibiotics are simply logistically impossible to implement on a scale that would rid the population of the pathogen(s) or disease. Instead, management agencies continue to work with researchers in hopes of developing ways of recovering bighorn sheep herds already infected. Because of this, management agencies typically concentrate efforts to ensure bighorn sheep aren't exposed to the

pathogens or on improving the overall health of bighorn sheep populations impacted by respiratory disease assuming healthier bighorn sheep will be less impacted by pneumonia.

Managers recognize there are additional diseases and parasites beyond respiratory pathogens that can negatively impact the health of bighorn sheep. These include scabies, lungworm and ORF, which have been found in the WMBS herd. These act as additional physiological stressors and may compound the effects of respiratory pathogens. Brewer et al. (2014) stressed protecting and managing the health of bighorn sheep populations is essential to successful restoration and management efforts. They further stated identifying the myriad of factors, such as pathogens, exposure history, physiological condition of affected individuals, and habitat issues that impact the level and persistence of diseases among bighorn sheep is critically important.

**Objective: Better understand and increase our knowledge of the effects of respiratory pathogens and pneumonia, other diseases, and parasites in the WMBS herd.**

***Strategy: Continue to utilize the best available science to test and monitor for the presence of pathogens and parasites in the WMBS herd.***

Actions:

- As part of the UW lamb survival study, bighorn sheep will be tested for respiratory pathogens, other diseases, and parasites each time they are captured.
- WGFD will create a document detailing all known disease and parasite testing conducted in the WMBS herd.
- If new information regarding pathogenic strain types of bacteria becomes available, WGFD will consider conducting comprehensive herd wide disease testing.

What's ongoing/been done:

- ✓ *WGFD tested sick/dead bighorn sheep during the 1990/1991 pneumonia outbreak to identify bacterial pathogens.*
- ✓ *In 2012 and 2014, WGFD conducted comprehensive, herd wide disease testing in the WMBS herd. This testing formed the basis for what we currently know regarding the species and strains of bacterial pathogens present in the population.*
- ✓ *WGFD currently tests all live bighorn sheep handled as part of management and research studies to update knowledge on the presence of bacterial pathogens, blood borne diseases, and parasites in bighorn sheep populations across the state.*
- ✓ *Experiments have been conducted to evaluate the potential for respiratory pathogen transference from elk, white-tailed deer, mule deer, horses, llamas, and cattle. There was little indication any of these animals posed a risk to bighorn sheep (Schommer and Woolever 2008, Besser et al. 2012a, and Besser et al. 2012b).*

***Strategy: Continue to work with other state wildlife management agencies and researchers to refine our knowledge of bacterial pathogens, their different strains, and how they interact resulting in pneumonia die-offs and chronic pneumonia in bighorn sheep populations.***

Actions:

- WGFD's Veterinary Services Branch will continue to be involved in bighorn sheep disease research and testing.
- WGFD will continue to participate in professional meetings concerning the latest research and management regarding bighorn sheep and pneumonia.

What's ongoing/been done:

- ✓ WGFD's Wildlife Health Laboratory (Lab) in Laramie has upgraded technology over the past decade in an effort to better identify and classify bacterial pathogens found in bighorn sheep.
- ✓ WGFD's Lab in Laramie has developed innovative techniques for culturing bacterial pathogens in the field to improve the ability to identify bacteria present in bighorn sheep populations.
- ✓ WGFD's Veterinary Services Branch is coordinating with other laboratories to identify specific strains of bacteria present in the WMBS herd.

***Strategy: Coordinate with other state wildlife management agencies and researchers to identify other diseases and parasites that may be impacting bighorn sheep populations.***

Actions:

- WGFD's Veterinary Services Branch will continue to be involved in bighorn sheep disease research and testing.
- WGFD will opportunistically collect fecal samples to determine parasite larvae loads.

What's ongoing/been done:

- ✓ WGFD continually monitors bighorn sheep in the WMBS herd for signs of pneumonia as well as other disease and parasites. In the past, personnel have noted bighorn sheep with cancerous lesions, ORF, scabies, and high lungworm loads. None of these factors are believed to be the cause of persistent, low lamb recruitment in the population, but are added stressors to bighorn sheep in the population.

**Objective: Separate WMBS from potential sources of disease from other animals.**

***Strategy: Remove clinically ill bighorn sheep***

Actions:

- WGFD will evaluate the efficacy of targeted lethal removal of clinically ill bighorn sheep. This evaluation will include an assessment or definition of what constitutes "clinically ill." All bighorn sheep removed will necropsied and disease tested.
- WGFD will evaluate the capture of clinically ill bighorn sheep and transfer to the Sybille research unit for potential research projects.

- WGFD will cooperate with other agencies and entities to help develop techniques to identify sinus tumors in the field.

What's ongoing/been done:

- ✓ *WGFD continually monitors bighorn sheep in the WMBS herd and frequently observes clinically ill bighorn sheep and has on occasion removed those bighorn sheep.*

***Strategy: Maintain and/or create separation of bighorn sheep from domestic sheep or goats.***

Actions:

- WGFD will monitor bighorn sheep and domestic sheep and goat distribution and when the potential for comingling arises, address the issue and work with the livestock owner to best prevent additional exposure of bighorn sheep to pathogens/disease from domestic sheep and goats.
- WGFD will coordinate with the NBSC to develop a strategy to provide educational materials to domestic sheep and goat owners.
- WGFD will coordinate with other agencies including the USFS, BLM, USFWS, and Wind River Reservation (WRR) to maintain separation of bighorn sheep and domestics sheep or goats.

What's ongoing/been done:

- ✓ *WGFD continually monitors bighorn sheep in the WMBS herd and while interaction with domestic sheep or goats hasn't been a concern, personnel vigilantly "keep an eye" out for potential sources of interaction.*
- ✓ *WGFD has consulted with WRR and USFWS personnel regarding the recently observed free ranging domestic goats along U.S. Highway 26 on WRR.*
- ✓ *The USFS has phased out all domestic sheep and goat grazing on Shoshone National Forest lands used by the WMBS herd. The last known record of domestic sheep use in the Whiskey Mountain area was in the early 1960s.*
- ✓ *In August 2018, the USFS signed a final decision that prohibits the use of domestic sheep, goats, and pack goats within areas of the Shoshone National Forest occupied by the WMBS herd.*

***Strategy: Address the potential impact of disease transmission from mountain goats to WMBS***

Actions:

- WGFD will evaluate the need to remove any mountain goats found within the WMBS herd unit.
- WGFD will coordinate any removal efforts with USFS, BLM, and WRR as necessary and appropriate.
- WGFD will evaluate management options to address the presence of wandering mountain goats in core, native bighorn sheep range in the WMBS herd.

***Strategy: Translocation of bighorn sheep into or out of the WMBS herd***

Actions:

- WGFD will not translocate bighorn sheep into or out of the WMBS herd in adherence to WGFD's disease testing protocol for translocations to ensure unknown strains of bacteria are not introduced into the WMBS herd.

**Objective: Evaluate and better understand the genetic status of the WMBS herd and assess the role of genetics in disease vulnerability.**

***Strategy: Continue to collect genetic samples in the WMBS herd and coordinate with genetic researchers to ensure the population is not susceptible to a genetic bottleneck.***

Actions:

- Consolidate genetic data and analysis currently available for the WMBS herd.
- Coordinate with a qualified geneticist to summarize and prepare a public presentation summarizing existing genetic data on the WMBS herd.
- Attempt to collect more genetic samples from sub-groups of bighorn sheep on the west slope of the Wind River Mountains to compare their genetic relationship to bighorn sheep wintering on the east side of the Wind River Mountains.
- Evaluate using fecal material for genetic analysis to expedite collection of genetic data in isolated sub-groups of bighorn sheep.

What's ongoing/been done:

- ✓ *A substantial amount of genetic material has been collected in the WMBS herd. UW researchers have compared genetic variability in this herd to other bighorn sheep herds around Wyoming.*

**Objective: Improve habitats and forage nutrition to increase the overall health of WMBS.**

***Strategy: Utilize habitat management prescriptions to decrease conifer cover and otherwise enhance known bighorn sheep migration paths.***

Actions:

- Consolidate all bighorn sheep collar data to identify migration habitats (e.g., routes, stopover sites, and bottlenecks) that are at risk.
- Coordinate with the USFS, BLM, and WRR to utilize management prescriptions (e.g. prescribed fire) to enhance bighorn sheep migration and other important habitats.

What's ongoing/been done:

- ✓ *Prescribed burns were conducted on Sheep Ridge and Whiskey Mountain in 2004 and 2005.*



- ✓ *The USFS has been working for several years to evaluate and authorize the necessary fuels preparation in the Glacier Addition of the Fitzpatrick Wilderness to conduct a prescribed burn. In May 2019, USFS Regional Office granted approval to treat conifers on crucial bighorn sheep winter range within the Glacier addition of the Fitzpatrick Wilderness. A decision-making process with public involvement (NEPA) will still have to occur prior to implementing the project.*
- ✓ *WGFD and WRR have conducted several bighorn sheep collaring studies/efforts.*

***Strategy: Assess and monitor nutritional status of WMBS and evaluate available nutrition on ranges utilized by bighorn sheep in the herd.***

Actions:

- Continue to monitor collared ewes as part of the UW lamb survival study to assess bighorn sheep body condition.
- Analyze nutrient content of forage available to bighorn sheep on summer range as part of the UW lamb survival study.

What's ongoing/been done:

- ✓ *Analysis of ewes from 2015 through 2018 provides a good baseline of body condition for bighorn sheep in the WMBS herd.*
- ✓ *A long-term data set provides information on available forage on low elevation winter range sites in the herd.*
- ✓ *Information from a lamb survival study in 1998-2001 (Hnilicka et al. 2002) provides data on nutritional content of forage on summer range.*

***Strategy: Develop habitat management/enhancement strategies to improve forage condition and increase available winter range***

Actions:

- Using historical and current photos and satellite imagery identify and inventory areas that once were likely available to wintering bighorn sheep that are now unavailable due primarily to conifer encroachment (e.g., Arrow Mountain, Whiskey Mountain, BLM Ridge, Sheep Ridge, Windy Mountain, etc.).
- Based on that inventory develop habitat management strategies to implement vegetative prescriptions to “open up” habitats to increase forage quantity and quality.
- Coordinate habitat planning and implementation with USFS, BLM, and WRR and others.
- Assess the efficacy of continued herbicide and fertilizer applications to winter ranges.
- WGFD will seek funding to assess mineral content in forage species to evaluate micro-nutrients and minerals such as selenium.

What's ongoing/been done:

- ✓ *Historical photos have been obtained.*

- ✓ *WGFD and the WMBSTC have implemented several habitat improvement projects over the past several decades.*
- ✓ *In May 2019, USFS Regional Office granted approval to treat conifers on crucial bighorn sheep winter range within the Glacier addition of the Fitzpatrick Wilderness. A decision-making process with public involvement (NEPA) will still have to occur prior to implementing the project.*

## HABITAT/NUTRITION

It is common for stakeholders to advocate management of wildlife at optimal population levels for aesthetic, recreation, sport harvest, and scientific purposes. Yet it is important to manage wildlife population levels commensurate with their habitats. The Bighorn Sheep Working Group of the Western Association of Fish and Wildlife Agencies (WAFWA) in Brewer (2014) defines habitat in terms of quantity and quality:

*“Habitat quality is the ability of the environment to provide conditions required for population persistence and, along with habitat quantity, strongly influences numbers and diversity of native species. Availability of suitable habitat ultimately determines the distribution and numbers of bighorn sheep that a given area can support.”*

At the most basic level, bighorn sheep habitats must provide adequate amounts of forage, escape terrain, lambing and loafing areas, water, and they rely heavily on unobstructed movement corridors. These habitat components must be in sufficient proximity to one another and well-distributed throughout bighorn sheep ranges to meet annual and seasonal needs. Bighorn sheep are highly opportunistic foragers and they require a diverse, open, and rugged landscape to optimally forage and to avoid predators.

The maximum number of bighorn sheep an area can support and sustain over time is commonly called “carrying capacity,” and is determined by the amount and quality of food, cover and water available in an area to support a given number of bighorn sheep over time. When a bighorn sheep population surpasses what the available resources can sustain, the herd has exceeded the habitat’s carrying capacity. Body condition and lamb productivity or recruitment typically decline. Chronic overuse further diminishes the capacity of the habitat to support bighorn sheep and may alter vegetation composition and productivity for many years.

Forage quality and accessibility is a key factor influencing how bighorn sheep use their habitat. The characteristics that most influence the kinds of plants bighorn sheep select seasonally are palatability, availability, and succulence. Bighorn sheep forage mainly on grasses, forbs, and some shrubs. Bighorn sheep require a sufficient amount of forage to survive, however large volumes of low quality forage may be inadequate. Bighorn sheep must obtain sufficient energy, protein, and nutrients from the plants they eat to maintain body condition and reproduce successfully. Nutrition influences overall body condition, ovulation, conception, gestation, lactation, survival, and immunity to a host of diseases and parasites. Nutrition also affects winter survival, size at birth, timing of birth, and survival of lambs. Ewes under nutritional stress give birth to smaller lambs, presumably predisposing them to increased mortality. Nutritional status also affects a bighorn sheep’s vulnerability to predation and disease, as well as its ability to compete for food and survive when severe weather persists for extended periods.

Many factors have contributed to loss and fragmentation of bighorn sheep habitats in the Whiskey Mountain herd. Of primary concern is ecological succession which is the directional, predictable, and orderly process of vegetation community change from one plant community to another. Conifer encroachment has dramatically altered many areas that were once open and dominated by grasses and forbs and were likely important foraging areas or migration corridors for bighorn sheep

and other wildlife. Also, establishment of invasive and exotic plant species have the potential to change the quantity and quality of forage for these bighorn sheep.

Managers have assumed bighorn sheep body condition in the herd was adequate if there was abundant feed on winter ranges indicated by low utilization of grasses and forbs. More recently, researchers have been closely monitoring bighorn sheep body condition in this herd twice annually for the past three years. Data from this study indicates WMBS are not accumulating body fat during summer months indicating habitats they utilize may be nutritionally limited (Monteith 2017). Conversely, evidence from Monteith (2017) suggest these bighorn sheep are able to maintain body condition throughout winter better than bighorn sheep in neighboring herds. This data supports managers' contention there is adequate available feed on winter ranges in the herd but indicate bighorn sheep may not be getting adequate nutrition on summer range. The UW lamb survival study is structured to investigate this issue further.

Over the years, agency personnel have done extensive work monitoring habitat status and quality in the WMBS herd. Most of the habitat monitoring has occurred on low elevation winter ranges. Forage production and utilization monitoring shows the bighorn sheep herd was likely over carrying capacity for much of the 1970s through the early 2000s. Monitoring sites over that time period show winter utilization by bighorn sheep at preferred foraging sites was commonly above the 60% threshold deemed desirable. At times, utilization approached 90% indicating far too many bighorn sheep feeding at these sites. Up until 1996, managers attempted to limit bighorn sheep numbers on low elevation winter ranges by trapping animals and transplanting them to areas throughout Wyoming and other western states. As the population continued to decline following the 1990-1991 pneumonia outbreak, forage utilization on winter ranges declined substantially and has typically been well below the 60% threshold for much of the 2000s (Figure 2).

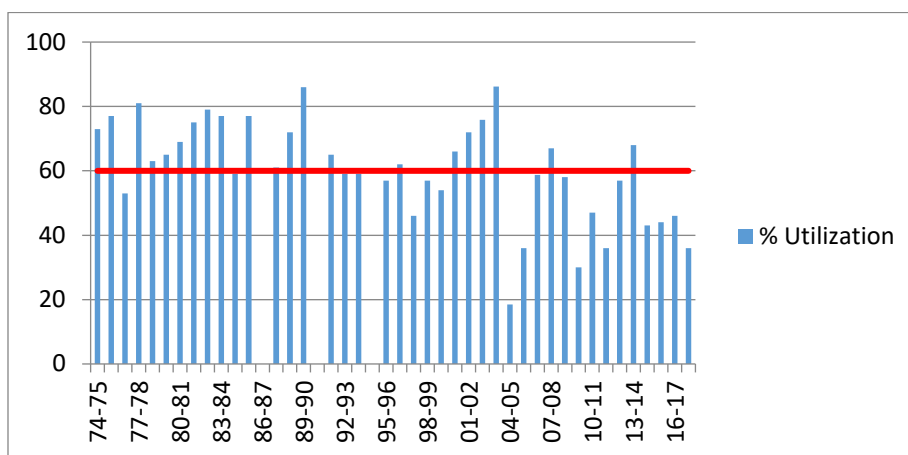


Figure 2. Historic forage utilization by WMBS on low elevation winter ranges.

While volume of feed and caloric content are important to bighorn sheep, other forage properties such as micro-nutrient content can have implications for bighorn sheep health. Work done by Hnilicka et al. (2002) provided some indication WMBS may be subject to a selenium deficient diet. Subsequent work and research has failed to conclusively link low selenium forage to poor bighorn sheep health (Anderson 2017). It has been demonstrated captive bighorn sheep

supplemented with selenium still suffered and died from pneumonia (Tom Besser – DVM, Washington State University and Mary Wood – DVM, WGFD, pers. comm.).

Forage availability for bighorn sheep in this herd can also be affected by inter-specific competition with other wildlife. Managers have expressed concerns over forage competition with elk in the WMBS herd for decades. Because of these concerns, the elk season has traditionally been quite liberal in elk hunt area 69 which encompasses habitat shared with WMBS. Currently managers do not believe competition with elk is a factor influencing bighorn sheep in this area borne out by the low forage utilization figures recorded over the past decade. In addition, annual elk counts corresponding to bighorn sheep winter range indicate elk numbers have declined from approximately 1,500 to 1,000 elk over the past decade.

**Objective: Improve habitats and forage nutrition to increase the overall health of WMBS.**

***Strategy: Develop a habitat management/enhancement plan to improve forage condition and increase available winter range***

Actions:

- Use historical and current photos and satellite imagery to identify and inventory areas that once were likely available to wintering bighorn sheep but are now unavailable due to primarily conifer encroachment (e.g., Arrow Mountain, Whiskey Mountain, BLM Ridge, Sheep Ridge, Windy Mountain, and etc.).
- Based on that inventory develop a habitat management plan to implement vegetative prescriptions to “open up” habitats to increase forage quantity and quality.
- Coordinate habitat planning and implementation with USFS, BLM, WRR and others.
- WGFD will seek funding to routinely assess mineral content in forage species to evaluate micro-nutrients and minerals such as selenium.

What’s ongoing/been done:

- ✓ *Historical photos have been obtained.*
- ✓ *WGFD and the WMBSTC have implemented several habitat improvement projects over the past several decades.*
- ✓ *In May 2019, USFS Regional Office granted approval to treat conifers on crucial bighorn sheep winter range Whiskey Mountain within the Glacier addition of to the Fitzpatrick Wilderness. A decision-making process with public involvement (NEPA) will still have to occur prior to implementing the project.*

***Strategy: Utilize habitat management prescriptions and wildfire to decrease conifer cover and otherwise enhance and expand winter ranges and bighorn sheep migration paths.***

Actions:

- Consolidate all bighorn sheep collar data to identify migration habitats (e.g., routes, stopover sites, and bottlenecks) that are at risk from continued conifer colonization.
- Coordinate and cooperate with the USFS, BLM, WRR, Bureau of Indian Affairs (BIA), and USFWS to utilize management prescriptions (e.g. prescribed fire) where possible to enhance bighorn sheep ranges and migration habitats.
- Support USFS, BLM, and WRR to evaluate and conduct prescribed burns and manage wildfires to improve bighorn sheep habitat while recognizing multiple considerations other than habitat management will dictate whether the fire can be managed for wildlife benefit. Arrow Mountain, Whiskey Mountain, Torrey Rim, BLM Ridge, Sheep Ridge, and Windy Mountain are areas of particular focus and opportunity.
- Continue to support the USFS to manage/enhance habitats within the Glacier addition of the Fitzpatrick Wilderness to benefit bighorn sheep.
- WGFD will restore the Whiskey Mountain Conservation Camp meadow.

What's ongoing/been done:

- ✓ *Prescribed burns were conducted on Sheep Ridge and Whiskey Mountain in 2004 and 2005.*
- ✓ *The USFS has been working for several years to evaluate and authorize the necessary fuels preparation in the Glacier Addition of the Fitzpatrick Wilderness to conduct a prescribed burn. In May 2019, USFS Regional Office granted approval to treat conifers on crucial bighorn sheep winter range within the Glacier addition of the Fitzpatrick Wilderness. A decision-making process with public involvement (NEPA) will still have to occur prior to implementing the project.*
- ✓ *WGFD and WRR have conducted several bighorn sheep collaring studies/efforts.*

***Strategy: Assess and monitor nutritional status of WMBS and evaluate available nutrition on ranges utilized by bighorn sheep in the herd.***

Actions:

- Continue to monitor collared ewes as part of the UW lamb survival study to assess bighorn sheep body condition coming off of summer range.
- Analyze nutrient content of forage available to bighorn sheep on summer range as part of the UW lamb survival study.
- Dependent on the results of the UW lamb survival study, WGFD may assess the value of mineral supplements in an experimental fashion.

What's ongoing/been done:

- ✓ *Analysis of ewes from 2015 through 2018 provides a good baseline of body condition for bighorn sheep in the WMBS herd.*
- ✓ *A long-term data set provides information on available forage on low elevation winter range sites in the herd.*
- ✓ *Information from a lamb survival study in 1998-2001 (Hnilicka et al. 2002) provides data on nutritional content of forage on summer range.*

***Strategy: Assess the efficacy of continued herbicide and fertilizer application designed to reduce native mat forming forb communities on winter ranges.***

Actions:

- WGFD will evaluate any beneficial and harmful effects of herbicide applications.
- WGFD will not plan any future herbicide or fertilizer applications treating native grasses and forbs until the evaluation is completed and deemed to be beneficial. If treatments are proposed, they will be designed to maintain a diversity of species on the landscape including fringed sagewort (*Artemisia frigida*).
- Vegetation composition data will be collected routinely and evaluated prior to any future herbicide applications.

What's ongoing/been done:

- ✓ *Baseline vegetation production and composition data have been collected and evaluated on treated and untreated sites.*
- ✓ *Forage analyses were conducted to track changes in forage quality associated with herbicide and fertilizer applications. Additional analysis will be conducted as future habitat treatments are considered.*

**Objective: Control invasive and noxious plants on bighorn sheep range.**

***Strategy: Decrease the prevalence and distribution of invasive plant species (e.g., cheatgrass and thistle) to protect and/or restore bighorn sheep habitat.***

Actions:

- WGFD will conduct an annual weed assessment on bighorn sheep winter range.
- On the Whiskey Basin Wildlife Habitat Management Area (WHMA), WGFD will treat weed patches immediately in an attempt to arrest spread.
- Implement, as a standard on all habitat projects, measures to prohibit or eliminate invasive and noxious weeds.
- Support and implement new research and methods to reduce prevalence of cheatgrass in critical bighorn sheep habitat.
- WGFD will coordinate with the NBSC to provide a method for citizens to report and map observed locations and species of invasive and noxious plants. WGFD will evaluate the Fremont County's Weed and Pest reporting application for this purpose.

What's ongoing/been done:

- ✓ *USFS currently works with the Fremont County Weed and Pest to manage invasive species in the Fitzpatrick wilderness.*
- ✓ *BLM works with Fremont County Weed and Pest to treat invasive and noxious plants and identify emerging or existing problem areas.*
- ✓ *WGFD has worked with Fremont County Weed and Pest to treat cheatgrass along the Torrey Valley Road.*

**Objective: Evaluate habitat differences between bighorn sheep that are non-migratory and stay at high elevation and migratory bighorn sheep that winter at low elevation.**

*Strategy: Assess why non-migratory high elevation bighorn sheep seem to be more productive than those bighorn sheep that migrate and winter at low elevations.*

Actions:

- WGFD will support research to collar bighorn sheep, collect genetic samples, assess habitat use, migratory movements, and disease status of bighorn sheep that are year-round residents on the west side of the Continental Divide in the Wind River Mountains. Some actions proposed within the Bridger Wilderness may require authorization from the Bridger-Teton National Forest.

**Objective: Minimize inter-specific competition for forage and space.**

*Strategy: Assess and minimize the potential for undue competition with elk.*

Actions:

- Continue to manage elk in Elk Hunt Area 69 to objective.
- Monitor changes in elk distribution on winter ranges for both elk and bighorn sheep.
- Seek funding to evaluate summer spatial and temporal relationships between elk, bighorn sheep, and wolves. Also, considering their distribution assess impacts on habitat quality and body condition of bighorn sheep.
- Continue to monitor forage utilization rates to ensure forage availability for bighorn sheep is maintained.

**Objective: Evaluate the effect of pollution in the northern Wind River Mountains.**

*Strategy: Assess the changes in acidification in lakes and waterways in the Wind River Mountains.*

Actions:

- WGFD, USFWS, and USFS will compile existing data on water chemistry in streams and lakes.

**Objective: Consider the effect of climatological changes on bighorn sheep and their habitats.**

*Strategy: Assess the effects of climate change and drought on habitats and habitat use.*

Actions:

- WGFD and UW researchers may evaluate the relationship between bighorn sheep body condition, lamb birth weights, observed lamb ratios and changes in precipitation.
- Explore the possibility of additional remote weather stations with USFS, UW,



Central Wyoming College, BLM, WRR and Wyoming Department of Environmental Quality.

***Strategy: Assess the value of providing water sources to allow bighorn sheep use of unused or underused habitats.***

Actions:

- Identify potential water development sites (e.g., Red Rocks) to increase bighorn sheep use of available habitats.
- Evaluate vegetation management (conifer removal) to restore or increase water availability at springs and seeps.

## PREDATORY ANIMALS

Bighorn sheep in the Northern Rocky Mountains have evolved with multiple predatory animals, including but not limited to: coyote (*Canis latrans*), wolf (*C. lupus*), mountain lion (*Puma concolor*), black bear (*Ursus americanus*), grizzly bear (*U. arctos*) wolverine (*Gulo gulo*) and golden eagle (*Aquila chrysaetos*). Carnivores with varied diets and avian predators are more likely to predate on lambs, whereas larger carnivore species can prey on both lambs and adult bighorn sheep. Sawyer and Lindzey (2002) provided an in-depth literature review and synthesis of predation on bighorn sheep, noting “*the efficient anti-predator strategies of bighorn sheep greatly reduce their vulnerability to predation*”. With the WMBS herd the critical question is to ascertain the level at which predation and predatory animal behavior may be limiting population potential and perhaps more importantly how the interactions between carnivores and this particular bighorn sheep herd may have detrimental impacts on this already stressed population. This section discusses ecological concerns regarding potential interactions between predatory animals and the WMBS herd, as well as identifying management and research actions that have and will occur to evaluate the role predation and predatory animals have on this iconic bighorn sheep herd.

While WMBS co-evolved with the aforementioned predators, it is imperative to note wolves and grizzly bears were extirpated from the region by the mid-1900s, with mountain lions and black bears existing at very low densities or perhaps functionally extirpated from the area of interest. This resulted in a bighorn sheep herd that was naïve to the return of apex predators, such as wolves. WGFD has records of wolf activity on Whiskey Mountain for the past decade; however pack dynamics have changed in recent years with increased wolf activity overlapping the distribution of WMBS. Fine-scale location data from ongoing bighorn sheep monitoring indicates increased wolf activity on preferred, low elevation bighorn sheep winter range near Dubois has impacted the WMBS herd over at least the past three years, primarily through distributional displacement. More recently, increased wolf activity on preferred, low elevation wintering areas has displaced bighorn sheep onto marginal, high elevation wintering sites apparently in search of better escape terrain. While direct wolf predation on bighorn sheep has not been observed, the displacement being caused by wolves adds another potential stressor to an already nutritionally and conditionally stressed population. While wolves are not generally considered to have negative population level impacts on mountain sheep in the West, the unique scenario that has unfolded with WMBS warrants further evaluation and management actions in regards to interactions among wolves and bighorn sheep. For example, the ability to combine movement of bighorn sheep in relation to body condition will assist in quantifying the impacts of predatory displacement of WMBS.

Much of the literature regarding bighorn sheep predation and documented population level impacts to mountain sheep (primarily desert bighorn sheep) deals with mountain lions (Sawyer and Lindzey 2002, Rominger et. al. 2004). In certain situations, individual mountain lions can key in on bighorn sheep, and in low density or environmentally stressed bighorn sheep populations, mortality from predation becomes increasingly additive. In situations where mountain lion predation is documented to be additive and limiting population growth, intervening management actions can remove that specific predation potential. It should be stressed that management removals or control actions are valid options when a problem individual can be identified and removed (Linnell et. al 1999). Since the most recent bighorn sheep radio-collaring effort in the WMBS herd was initiated in 2015, managers have documented two instances of verified mountain

lion predation on bighorn sheep. Ongoing monitoring/research will better illuminate any potential specialized predatory behaviors that may occur with mountain lions.

The underlying discussion regarding predatory animals and any ungulate population is whether the interactions between predator and prey are limiting the overall prey population. The importance of this bighorn sheep population warrants evaluation of the impacts from multiple sympatric predators on bighorn sheep. Although the ultimate causes that have driven this particular bighorn sheep population to its current status are certainly linked to disease and nutrition the proximate impacts of the interactions between predatory animals and bighorn sheep may function as additive stressors that further justify fine-scale explorations and investigation.

**Objective: Better understand and increase our knowledge of the interactions and potential impacts between predatory animals and the WMBS herd.**

*Strategy: Utilize the best available science, regional expertise, and current/past monitoring data to evaluate the potential impacts to WMBS from predators.*

Actions:

- Augment ongoing monitoring objectives for wolves in the area of influence, including potentially adding GPS collars on resident wolves.
- Analyze fine scale movement patterns between wolves and WMBS.
- Evaluate harvest and mortality for predatory animals overlapping WMBS focal areas.

What's ongoing/been done:

- ✓ WGFD has increased collaring efforts on wolves that occur near WMBS herd including use of GPS collars to further assess fine scale movement and cause/effect interactions between bighorn sheep and wolves.
- ✓ WGFD has augmented sample size of radio-collared bighorn sheep to evaluate fine scale movements of bighorn sheep and evaluate overall population demographics.
- ✓ WGFD provides annual evaluations of wolf population status.
- ✓ WGFD provides annual and tri-annual reports for mountain lion and black bear harvest and population status; including mortality and management actions occurring within the WMBS herd.
- ✓ WGFC has committed funds to the UW lamb survival study to address multiple impacts to the WMBS herd, including quantification of predation and indirect impacts of predatory animals on the herd.

*Strategy: Through focused research on WMBS, quantify the impacts from predatory animals on the population demographics of the bighorn sheep herd.*

Actions:

- Work with UW regarding current objectives of research occurring on the WMBS herd.

- Synthesize fine scale movement data, habitat/forage data and nutritional data in order to quantify indirect impacts of predatory animals on WMBS.
- Through evaluation of cause-specific mortality research (UW lamb survival study), quantify the level of predation on all age/sex cohorts of WMBS.
- Use bighorn sheep body condition data from the UW lamb survival study to assess if the displacement of bighorn sheep from preferred, low-elevation winter ranges is having a negative effect.

What's ongoing/been done:

- ✓ *Research objectives have been identified and efforts are underway to augment knowledge of WMBS, these objectives include an in-depth quantification of the impact (direct and indirect) of predation to the WMBS herd.*
- ✓ *Past research and monitoring efforts continue to evaluate direct and indirect impacts of predatory animals on this specific herd; evaluating changes in predator distribution (e.g. wolves) continue in an adaptive framework.*
- ✓ *Fine scale movement data has and continues to be collected for bighorn sheep and wolves.*
- ✓ *Annual collection of habitat data through vegetation sampling and clipping continues.*
- ✓ *Body condition data continues to be collected through body fat indices.*

**Objective: Evaluate use of harvest and predator management on carnivores sympatric with WMBS.**

***Strategy: Continue to evaluate use of harvest and agency management of trophy game animals (primarily wolves and mountain lions) and other predatory animals in areas overlapping the WMBS herd and evaluate population dynamics between them.***

Actions:

- Through ongoing research (UW lamb survival study), WGFD and researchers will further quantify the impacts of predators, specifically wolves, on the condition of WMBS and evaluate the range of management actions available for wolves and other predatory animals within WMBS range.
- WGFD will explore appropriate management actions for trophy game animals and predators that occur within the WMBS herd range.
- WGFD will evaluate targeted, lethal removal of individual trophy game or predatory animals when predation is documented to be additive and limiting population growth of the WMBS herd or segments of the herd.
- WGFD will evaluate the efficacy of targeted, lethal removal of coyotes. While coyote predation is generally not considered a limiting factor in healthy bighorn sheep herds, the use of coyote removal will be evaluated in concordance with the UW lamb survival study evaluating survival and mortality of all age classes of bighorn sheep.

What's ongoing/been done:

- ✓ WGFD has created a new wolf hunt area to direct wolf harvest toward Whiskey Mountain and surrounding areas.
- ✓ WGFD is currently collecting harvest and population data to further inform decisions regarding management actions for wolves related to behavioral and direct impacts to WMBS.
- ✓ WGFD continues to quantify harvest and mortality data for mountain lions and black bears in and around the WMBS herd to use in developing management recommendations.
- ✓ WGFD is currently developing hunting season proposals for mountain lions and wolves occurring in the area.
- ✓ Predator control actions on coyotes have targeted WMBS range in the past. WGFD has and will continue to coordinate with the Wyoming Animal Damage Management Board to request funding for coyote control. Ongoing research has the potential to elucidate the efficacy of coyote removal in regard to lamb predation; however, the scale of analysis will be difficult to determine cause/effect relationships.

**Objective: Provide feedback to the public and transparency regarding predators and WMBS as well as additional information on predation and carnivores.**

***Strategy: Update information regarding predatory impacts to bighorn sheep and general literature review on predators/large carnivores and predation.***

Actions:

- Provide additional transparency and information through multiple venues such as public/face to face interactions, hard copy handouts, and website development.

What's ongoing/been done:

- ✓ The current collaborative process is providing an additional level of public input and transparency. WGFD and partner agencies will ensure results and documents are made fully available to the public.
- ✓ WGFD developed a white paper - "Potential Impacts to Wildlife Ungulates from Large Carnivores in North America" (2013). In addition WGFD has given multiple publicly available presentations regarding impacts to ungulates from carnivores throughout Wyoming.
- ✓ WGFD has augmented the information available regarding large carnivore management on WGFD's website: <https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Large-Carnivore>
- ✓ WGFD has developed multiple documents regarding wolf population ecology and predation patterns. They are readily available on WGFD's website: <https://wgfd.wyo.gov/wildlife-in-wyoming/more-wildlife/large-carnivore/wolves-in-wyoming>

- ✓ *WGFD has drafted information regarding the historical aspects of wolf reintroduction into Wyoming and comparing subspecies of wolves that occur and have occurred in the Northern Rocky Mountains.*

## **DISTURBANCE/ACCESS**

Human-caused disturbance increases stress on bighorn sheep and if the disturbance is great enough it will displace them from important habitats. Bighorn sheep often react strongly to direct and indirect sources of disturbance. In fact, disturbances and increased stress could lead to poorer body condition and even decreased reproductive potential (Keller and Bender 2007).

While direct impacts such as energy development or urbanization are not issues in the WMBS herd, indirect impacts such as off-road vehicle use and other forms of recreation are concerns. When undisturbed, bighorn sheep select habitats to optimize food availability, nutrition, and escape cover to avoid predation. This ensures they are able to minimize energy expenditures and body weight loss and increase their chances of survival. While minimizing disturbance on winter range has always been an important issue in the WMBS herd, it is important to recognize recreational activities on summer range in this herd have increased substantially over the years and will likely continue to increase. This may become an issue in the future.

With the advent of vehicles, especially ATVs or OHVs, people are able to access landscapes easier than before. Increased motorized access provides recreation opportunity for some hunters, antler hunters, wildlife photographers and others enjoying the outdoors. It also increases stress on bighorn sheep (Schoenecker and Krausman, 2002) and other wildlife primarily during the winter and spring months when bighorn sheep are in physiological decline and are increasingly susceptible to mortality due to stress.

Winter ranges in the WMBS herd and elsewhere that are closed to motorized vehicle use during winter provide important security areas for these bighorn sheep. These winter closures exclusively restrict motorized access but remain open to provide some level of recreation opportunity while minimizing stress on the bighorn sheep. WGFD in collaboration with the WMBSTC conducted an evaluation of human presence and vehicle travel volume in the Torrey Valley (Walton et al. 1995). The evaluation concluded human use levels were within tolerances of wintering bighorn sheep and as a result it was recommended the Torrey Valley road remain open and that all other roads accessing winter range, including the Torrey Rim and Sheep Ridge roads, accessing winter range remain closed. The evaluation also recognized emergency closures may be necessary to restrict human or vehicular use of any road or wintering site in the event of a disease outbreak, harsh winter or unacceptable use levels.

Management and research activities such as helicopter captures cause disturbance and stress to bighorn sheep. It is recognized the benefit of the data and information gathered far outweigh any negative impacts to an individual bighorn sheep or the population as a whole. WGFD and researchers take all possible measures to conduct surveys and research in ways that minimize disturbance and stress. This is particularly true with helicopter captures. Helicopter captures are considered the most effective and least stressful technique to conduct necessary captures. Helicopter captures in Alaska, including lamb captures resulted in very few mortalities (Tom Lohuis – Alaska Department of Fish and Game, pers. comm.). Chemical immobilization or “darting” is often not effective and is, at least, as stressful to the animal, so this capture technique is used sparingly.

**Objective.** Manage the impacts of human disturbance while providing recreation access and opportunity on Wyoming Game and Fish Commission's Wildlife Habitat Management Areas (WHMA) and other public lands in concert with minimizing stress on bighorn sheep and other wildlife.

*Strategy: Minimize human disturbance to bighorn sheep. WGFD will minimize the impacts of human disturbance to the WMBS herd through current regulations and cooperation with land management agencies and the public.*

*Strategy: WGFD will continue to provide information to the public regarding the importance of protecting sensitive areas such as crucial winter range.*

*Strategy: WGFD will notify the public of sensitive areas and increase protective measures such as signing.*

Actions:

- WGFD will maintain the seasonal closure to motorized vehicles on the Whiskey Basin WHMA December 1<sup>st</sup> – May 15<sup>th</sup>. Maintaining the season closure was also recommended by the panel of bighorn sheep experts consulted during the Bighorn Sheep Summit.
- WGFD will continue to allow human presence within the Whiskey Basin WHMA, on foot or horseback, December 1<sup>st</sup> – May 15<sup>th</sup>.
- WGFD will continue to evaluate wintering bighorn sheep use and human presence in the Torrey Valley to ensure human activity is not adversely impacting winter bighorn sheep.
- WGFD acknowledges the potential of dogs to be problematic for bighorn sheep. WGFD will stress the importance of controlling dogs and will install signs to encourage visitors to keep dogs under their immediate control. This is especially important for people who let their dogs out of vehicles while driving the Torrey Valley Road.
- WGFD may seek funding to measure fecal glucocorticoid levels in bighorn sheep in close proximity to human disturbance and in bighorn sheep that occupy habitats where they are not exposed to disturbances to assess the level of stress caused by human disturbances (hiking, walking dogs, hunting, etc.).
- WGFD will continue enforcing existing travel management on WGFD managed lands encompassed by the Whiskey Basin WHMA.
- WGFD will coordinate with the NBSC to develop information and educational material regarding disturbance and stress and ways to minimize both.

What's ongoing/been done:

- ✓ *WGFD institutes a seasonal vehicle closure on the Whiskey Basin WHMA from December 1st – May 15<sup>th</sup>.*
- ✓ *WGFD has allowed foot or horseback access to the Whiskey Basin WHMA for recreation purposes such as hunting, hiking, and photography.*



- ✓ *WGFD coordinates with adjoining landowners and agencies to best manage Whiskey Basin WHMA.*

**Objective. Manage stress on bighorn sheep caused by management or research activities.**

***Strategy: Minimize disturbance and stress on bighorn sheep when conducting helicopter surveys and captures.***

*Actions:*

- WGFD and researchers will always minimize the number of captures to only those necessary to accomplish project goals.
- WGFD will continue to minimize time spent flying over bighorn sheep when conducting count/classification surveys.

## POPULATION MANAGEMENT

The WMBS herd occupies the northern Wind River Mountain Range. The majority of bighorn sheep winter at sites located along the very northern tip of the Wind River Mountains. Some bighorn sheep winter at high elevation along the continental divide and scattered throughout the west slope of the mountains. Bighorn sheep disperse from the low elevation wintering sites to populate the entire northern portion of the Wind River Mountains in the summer and fall. Much of the bighorn sheep habitat is located in wilderness areas and remains undisturbed. Important winter range sites in the upper Wind River Valley are part of WGFD's Whiskey Basin WHMA and are also relatively undisturbed.

The post-season population objective for this herd is 1,350 bighorn sheep and it is managed to provide average age of harvested rams between 6 and 8 years. The current objective was reviewed in 2013 and again in 2018. The herd has been below objective for over two decades following a catastrophic, all-age pneumonia die-off in 1991. The population continues to languish far below objective and is currently estimated at around 500 bighorn sheep. The population has declined to the point personnel are not able to collect adequate demographic data to model the population accurately. The population has not grown in over two decades, primarily due to low lamb recruitment associated with persistent pneumonia. Lamb recruitment was alarmingly low each of the last 3 years.

The lamb/ewe ratio has been extremely low the past three years with a near historic low level of 8/100 in 2017. In addition, to the low lamb/ewe ratios seen over the past 3 years, small classification sample sizes have been a concern. Prior to 2016, classification samples averaged 506 bighorn sheep over a 10 year period. In contrast, WGFD personnel were only able to classify 359, 339, and 278 bighorn sheep in 2016, 2017, and 2018 respectively. These are the lowest three classification sample sizes recorded for the herd and the sample size has declined each of the past three years. While the lamb/ewe ratio for the herd has been quite low, there are areas of better recruitment within the herd unit. In particular, the lamb/ewe ratio in Bighorn Sheep Hunt Area 8 has been significantly higher than the lamb/ewe ratios in Bighorn Sheep Hunt Areas 9 and 10 for the last several years. In fact, this is a long-running trend in the herd unit (Figure 3). Unlike Bighorn Sheep Hunt Areas 9 and 10 where the majority of bighorn sheep winter at low elevation sites at higher densities, bighorn sheep in Bighorn Sheep Hunt Area 8 all winter at high elevation in smaller, more isolated groups.

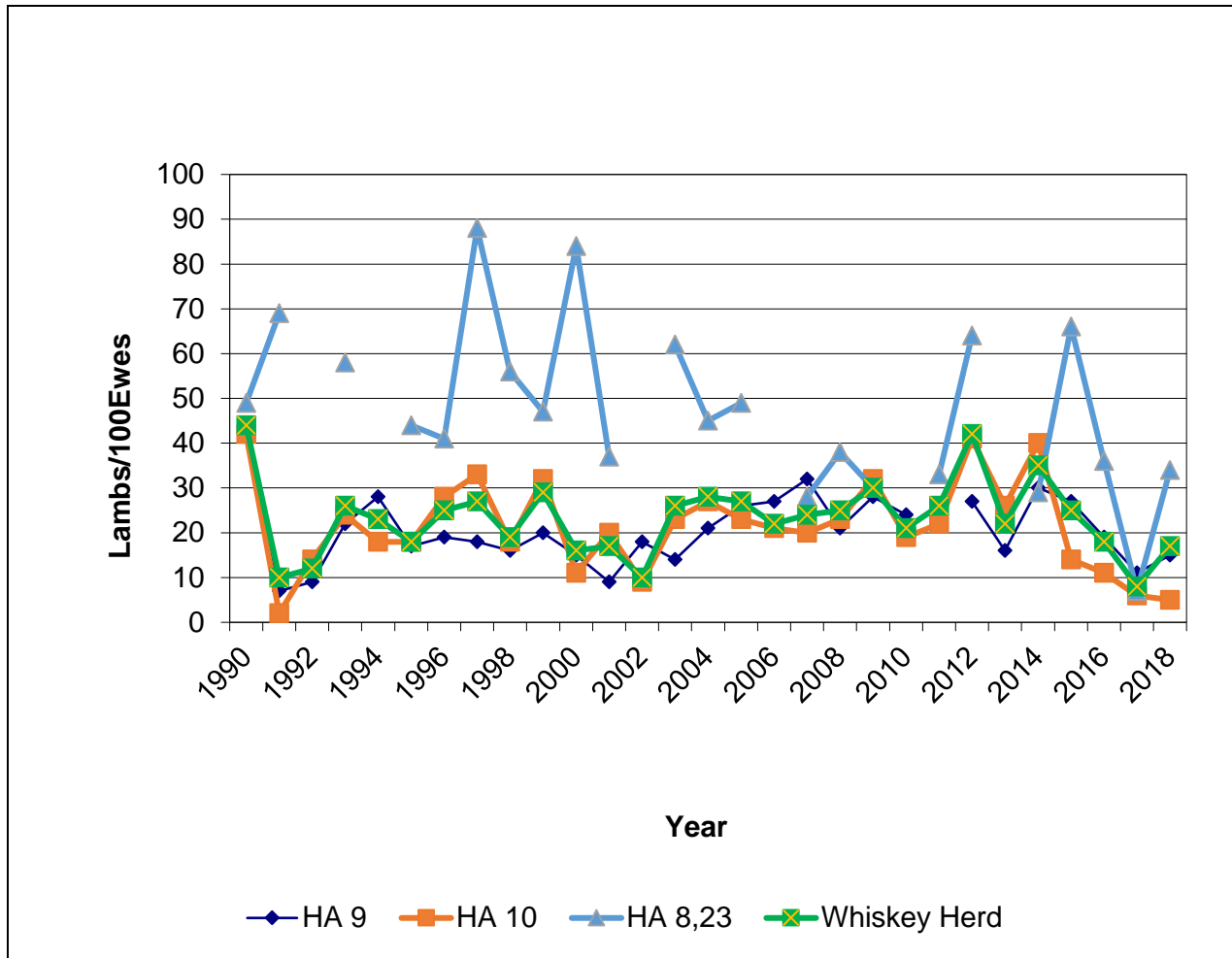


Figure 3. Historical lamb/ewe ratios for the WMBS herd by hunt area, Wyoming.

Despite low recruitment for much of the last 20-years, the ram/ewe ratio has been increasing over the past 10 years. Since 2010 the ram/ewe ratio has trended upward. It peaked at 62/100 in 2014 and was also quite high at 52/100 in 2018. Ordinarily, the high ram/ewe ratio would indicate the potential for increased recreational hunting. However, in this herd, the steadily increasing ratio is cause for concern. Recruitment has been quite low for a number of years and all indications are this population has declined over the past decade. Poor recruitment combined with an increasing ram/ewe ratio are a good indication the number of ewes (the reproductive engine for this herd) are declining at a faster rate than rams. This could have catastrophic implications for the population if the trend continues.

Winter range condition in the herd unit appears to be good and indications are winter range resources are sufficient for the current bighorn sheep population. Personnel have monitored herbaceous forage production on key winter ranges in this herd for over 40 years. Forage production in 2018 was higher than each of the previous two years and was well above the 20 year average. Indications are winter feed are not a limiting resource for this herd. As part of the UW lamb survival study, researchers will begin to assess habitat conditions on summer range to

determine if there are limiting nutritional factors at higher elevations.

In general, the average age of harvested rams increased over the last several years in Bighorn Sheep Hunt Areas 8 and 9. Recently, the average age of harvest for both these areas was above the historical average. The average age of harvest has always fluctuated significantly in Bighorn Sheep Hunt Area 9 due to the low number of licenses. In contrast to Bighorn Sheep Hunt Areas 8 and 9, the average age of harvest declined the last 2 years in Bighorn Sheep Hunt Area 10. It is expected average harvest age will begin to fluctuate more as the number of licenses in Bighorn Sheep Hunt Area 10 has declined.

Overall, indications are this population declined each of the past several years. Of particular note, is the extremely low lamb/ewe ratios observed the past three years. Also alarming is the significant decline in the classification sample sizes each of the past three years. Given indications of continuing population decline combined with historically low recruitment, license numbers in have been reduced the last two years in Bighorn Sheep Hunt Areas 8 and 10.

**Objective: Manage the WMBS herd to a population size that is sustainable.**

***Strategy: Evaluate the management objective.***

Actions:

- WGFD will evaluate the objective after the completion of the UW lamb survival study and develop a recommendation to maintain or change the current objective based on current conditions and circumstances.

What's ongoing/been done:

- ✓ *This herd's management objective was established in 2002 and reviewed in 2013 and 2018.*

***Strategy: Evaluate other techniques to collect demographic data and to estimate this herds population size.***

Actions:

- WGFD is exploring other methods to estimate wildlife population size.
- The current research and collar data will allow WGFD to evaluate techniques to estimate this herd's population size.
- WGFD is exploring the efficacy of drones to collect demographic data on wildlife populations.
- WGFD will continue to coordinate with the WRR to collect data needed to account for all bighorn sheep within the herd unit.

***Strategy: Evaluate and adjust hunting seasons accordingly.***

*Actions:*

- WGFD will continue to adaptively manage hunting seasons annually to best provide hunter opportunity while maintaining a viable bighorn sheep population.
- As long as this herd can sustain some level of harvest, WGFD will continue to provide hunter with the opportunity to harvest “any ram”.
- If it becomes necessary and desirable, WGFD will evaluate the use of “ewe” harvest as a management tool.
- If culling clinically ill bighorn sheep is deemed a valuable tool, WGFD may utilize agency take to best effect removal.

*What’s ongoing/been done:*

- ✓ *License issuance has been adjusted over the years according to population size and performance. License numbers were reduced in h Bighorn Sheep Hunt Area 10 in 2018 and in Bighorn Sheep Hunt Area 8 in 2018.*
- ✓ *WGFD has removed clinically ill bighorn sheep in the past primarily for disease testing.*

## RESEARCH

Given the amount of public interest in bighorn sheep, it is no surprise there is a long history of research on these animals. The body of research is far too extensive to summarize effectively in this plan. That said, much of the research conducted on respiratory pathogens and pneumonia in bighorn sheep is very pertinent to the WMBS herd. Research throughout the United States aimed at identifying bacterial pathogens in sheep, their various strain types, and mechanisms by which they persist in bighorn populations are all directly related to management of disease in the WMBS herd.

Managers responsible for monitoring this herd over the decades accumulated significant knowledge regarding bighorn sheep numbers, movement patterns, habitat use, and behavior. The first, detailed summary of much of this knowledge was compiled as part of a WMBS study conducted from 1975 through 1978 (Thorne et al. 1979). This study and report serves as a thorough base of knowledge regarding historical bighorn sheep numbers and habitat use that remains relevant today. In addition, the WMBS Comprehensive Management Plan (2006) provides a chronological list of management activities and research projects conducted in the herd unit including the following:

1. From 1992 through 1995, WGFD conducted a bighorn sheep/human interaction study to assess disturbance levels on bighorn winter range in the WMBS herd unit (Walton et al. 1995). Information from this study continues to provide a basis for managers to effectively minimize disturbance to bighorn sheep on winter range.
2. From 1997 through 2001, WGFD conducted a lamb survival study to determine reasons for low lamb production in the WMBS herd and a continued population decline following a pneumonia outbreak in 1990-1991 (Hnilicka et al. 2002). This study was unable to identify any definitive cause for poor lamb recruitment in the herd.
3. At the same time, Dean et al. (2002) conducted captive feeding trials to determine if trace mineral deficiency could be linked to poor lamb recruitment in the herd. The study did not document poor lamb health associated with a selenium deficient diet.
4. More recently, WGFD conducted extensive testing to identify respiratory pathogens in the WMBS herd in 2012 and 2014 (Anderson 2012 and 2014). Testing from these two years provided some of the most detailed information regarding the prevalence of various bacteria associated with the bighorn sheep/pneumonia disease complex in this herd.
5. Finally, UW researchers have been investigating bighorn sheep body condition in this herd from 2015 through 2018 (Monteith 2017). This study is ongoing and progressed in March, 2019 into the UW lamb survival study.

While a number of research projects have been conducted in this bighorn sheep herd, many questions regarding the health of the bighorn sheep remain in question. In particular, research has not provided managers with proactive measures to address the presence of respiratory pathogens in the population, low lamb recruitment, and apparent perennially poor body condition for Whiskey Mountain bighorn sheep. In addition, the effects of predators and their activities has become an increasing concern. A science-based understanding of these effects is critical to best manage predators such as wolves and mountain lions, and the bighorn sheep themselves.

**Objective: Conduct research to better understand the ecology and population dynamics of the WMBS herd.**

*Strategy: Propose and fund research projects to definitively identify causes of low lamb recruitment*

*Strategy: Propose and fund research projects to assess the nutritional status of the bighorn sheep including potential micro-nutrient deficiencies.*

*Strategy: Propose and fund research to assess and compare the genetics, habitats (quality, species composition, and nutrition), habitat use, and physiological status of yearlong, high elevation, resident bighorn sheep with migratory bighorn sheep that winter in larger groups on low elevation winter ranges.*

*Strategy: Propose and fund research to assess the impacts of predators, particularly wolves, on this bighorn sheep herd.*

Actions:

- WGFD, USFS, and BLM will provide personnel and logistical support for the UW lamb survival study started in March, 2019. This study was vetted through agency partners, including the USFS, BLM, and WRR as well as NGO partners such as the WYWSF and NBSC.
- Facilitate the development of funding requests for the UW lamb survival study to adequately address study objectives to assess the causes of lamb mortality, body condition, and nutritional status of the bighorn sheep.
- WGFD will assist researchers to develop a project to collar bighorn sheep, collect genetic samples, assess habitat use, and migratory movements, and disease status of bighorn sheep that are year-round residents on the west side of the Continental Divide in the Wind River Mountains. Some actions proposed within the Bridger Wilderness may require authorization from the Bridger-Teton National Forest.
- Support captive bighorn sheep studies to add to the body of research associated with bighorn sheep disease transmission.
- WGFD will attempt to capture and collar additional wolves to assess wolf and bighorn sheep distribution in concert with the UW lamb survival study.

What's ongoing/been done:

- ✓ WGFC supported the UW lamb survival study plan and provided \$350,000 for the first year.
- ✓ The USFS has secured necessary approvals for the UW lamb survival study, including long-term backcountry camps, habitat assessments, and experimental habitat treatments in the Fitzpatrick Wilderness through 2021.
- ✓ The USFS has secured necessary approvals for helicopter-based capture of bighorn sheep in the Glacier addition of the Fitzpatrick Wilderness through 2021.
- ✓ WGFD has collared wolves in the Arrow Mountain and Warm Springs packs and has started to assess their movements and distribution.

- ✓ *The lamb survival study completed in 2001 (Hnilicka et al. 2002) provides some historical data useful for comparison in the UW lamb survival study.*
- ✓ *Over the past three years, WGF D upgraded the Thorne/Williams Wildlife Research Center at Sybille to provide appropriate facilities for research trials on bighorn sheep respiratory diseases.*



## FUNDING

Over the years, WGFD's management emphasis in the WMBS herd has been trapping/transplanting, disease monitoring, habitat enhancement, and demographic data collection. A significant portion of the resources utilized to manage this population consists of department personnel time. This makes it difficult to estimate the exact dollar amount spent on these collective management activities in the herd. Statewide, WGFD expended more than \$2.2 million to fund bighorn sheep management in fiscal year 2017.

WGFD continues to identify gaps research and monitoring needs to better understand bighorn sheep population dynamics including lamb survival, disease ecology, seasonal habitat use, and the effects of predators in this herd. Due to the terrain and isolated nature of habitat used by WMBS, research is difficult and costly. Despite the difficulty in studying these bighorn sheep, WGFD has conducted two studies detailing migration patterns, habitat use, and habitat condition in the herd (Thorne et al. 1979; Hnilicka et al. 2002). Given more recent population decline, WGFD is committed to a three year study beginning in 2019 designed to explicitly identify causes of lamb mortality and assess summer habitat conditions. This will be a costly, time consuming study requiring significant fiscal resources. Following completion of the study, WGFD will assess the need for additional funding to potentially conduct proactive management in succeeding years.

In addition to field studies, research regarding respiratory pathogens in bighorn sheep is still important to the management of the WMBS herd. Much of this work is necessarily conducted in labs and captive research facilities. WGFD will continue to partner with researchers to seek proactive ways to treat pneumonia in bighorn sheep. These types of studies will require fiscal resources and while the work may not be done in the WMBS herd, the information may ultimately provide the best solution for mitigating pneumonia impacts to bighorn sheep populations.

**Objective: Fund bighorn sheep population and habitat management.**

*Strategy: Maintain funding for population monitoring.*

*Strategy: Seek funding to implement habitat improvement projects*

Actions:

- WGFD will continue to budget adequately on an annual basis to monitor this population.
- WGFD, USFS, and BLM will continue to seek funding and resources to actively manage the habitat for this herd.

What's been done:

- ✓ WGFD provides personnel and funding to collect needed demographic data.
- ✓ WGFD, USFS, and BLM cooperate to develop funding requests to implement habitat improvement projects.

**Objective: Seek new sources of funding to adequately fund priority research.**

***Strategy: Provide funding to conduct priority research needs in this herd (see the Research section).***

*Actions:*

- WGFD will continue to support the UW lamb survival study and assist with pursuing any needed funding to accomplish the project's goals.
- WGFD will continue to partner with researchers to seek proactive ways to treat pneumonia in bighorn sheep.
- WGFD, USFS, and BLM will continue to partner with NGOs and other sources of funding to accomplish needed research.

*What's been done:*

- ✓ *WGFC supported the study plan for the UW lamb survival study and provided \$350,000 for the first year of the UW lamb survival study.*

## PUBLIC OUTREACH AND COMMUNICATION

By any measure, bighorn sheep are among the most valued of Wyoming's natural resources. To many, the species is emblematic of the mountainous, high elevations of the West. Bighorn sheep are also among the most popular big game species sought by resident and nonresident hunters alike and are a popular subject for many wildlife enthusiasts such as photographers and eco-tourists.

Managing bighorn sheep entails a myriad of biological considerations. Social expectations must also be factored into management strategies and decisions. Integrating social preferences with biological considerations is one of the foundations of the North American Model of Wildlife Conservation. The most effective management strategies consider species' biology and are supported by society.

WGFD's public involvement program for the WMBS herd is focused on collaboration between managers and everyone interested in bighorn sheep management. Collaborative learning (CL) is the opportunity to share information among a diverse group of stakeholders. The CL process has been successful and is ongoing for other species and issues throughout the state. It has resulted in increased stakeholder participation and ownership of herd management plans and has given rise to other partnerships. CL is based on the following principles:

- 1. Interdependent parties work together to affect the future of an issue of shared interests;*
- 2. Improvement rather than solution is the goal;*
- 3. The situation and progress rather than problem and conflict are the focus.*
- 4. Learning and benefits are owned by all stakeholders. The creation, maintenance and progress of a collaborative learning process are collectively owned by WGFD and all stakeholders.*
- 5. Concerns and interests rather than positions are emphasized.*
- 6. Interrelated rather than linear thinking is emphasized.*
- 7. Through shared learning and transparency, collaborative learning creates equal access to information, allowing solutions to emerge that otherwise could not.*

CL can be a positive experience for everyone involved whether supporter or critic. Everyone has the opportunity and expectation of actively participating and being heard. People with similar or opposing points of view learn from one another when they gather around a table and can express their opinions, thoughts, and ideas. Often they begin to understand there is a lot of complexity in wildlife management. When we hear acknowledgement of that complexity from one another, our thinking becomes interrelated and less self-focused. This is powerful! In the end, this learning provides the capacity, or "social license" to effect change.

Public participation through CL ensures all stakeholders obtain an understanding of the art and science of wildlife management. That includes the science and biology of bighorn sheep and a better appreciation of diverse stakeholder expectations. Through CL, all biological, sociological data and information are brought to the table. Through the CL process we have successfully married the biological constraints or opportunities with society's expectations and desires. In further support of these collaborative efforts, a recent Wildlife Management Institute audit of

WGFD concluded that “task forces” or focus groups are a more effective means than public meetings for gathering input from a cross-section of our constituents.

**Objective: Increase and maintain awareness through exchange of information regarding various issues as they relate to the WMBS herd.**

*Strategy: Utilize all existing avenues to increase awareness regarding the many issues facing the WMBS herd, how those issues are being addressed, and how the public and other stakeholders can further engage and participate.*

Actions:

- WGFD will continue to coordinate with the NBSC to host an evening meeting to update the public on herd conditions, study results, habitat treatment plans, and etc.
- WGFD’s annual “Job Completion Report” chronicling current conditions and management data for the WMBS herd will be posted on WGFD’s website.

What’s ongoing/been done:

- ✓ WGFD provides presentations on an annual basis to the Dubois community regarding WMBS.
- ✓ WGFD continues to expand its list of public outreach tools. For example, WGFD is utilizing social media, has launched a Facebook<sup>®</sup> page, and has a channel on YouTube<sup>®</sup>. These outlets will be used to share information about the WMBS herd and its management.
- ✓ Currently, WGFD uses its website, Wyoming Wildlife magazine, informational video, and photos. The website currently features a page dedicated to the WMBS herd planning process that will be maintained and updated.
- ✓ WGFD will continue to periodically utilize public surveys to understand the values and attitudes of the stakeholders of the WMBS herd.

**Objective: Actively involve the public in the management of WMBS.**

*Strategy: Continue interaction through collaboration to manage this bighorn sheep herd.*

Actions:

- WGFD is committed to continuing the collaborative process. Starting winter, 2019/20, WGFD will hold a collaborative workshop (this could be the annual meeting hosted by the NBSC) to maintain contact with our many stakeholders to ensure future management of this herd meets public desires and expectations and the biological needs of the herd.

*Strategy: Develop material detailing methods for minimizing bighorn sheep contact with domestic sheep or goats.*

Actions:

- WGFD will coordinate with the NBSC to disseminate educational materials to domestic sheep or goat owners.

***Strategy: Provide a way for the public to report and document clinically ill or dead bighorn sheep***

Actions:

- WGFD will evaluate and implement a process for reporting and documenting observations by the public of clinically ill or dead bighorn sheep.

What's ongoing/been done:

- ✓ WGFD contacts owners of domestic sheep or goats to provide them with information regarding the potential of their livestock exposing bighorn sheep to disease.
- ✓ WGFD utilizes the Wild Sheep Foundation's "Separation is part of the Solution" brochure to communicate risks of interaction between bighorn sheep and domestic sheep or goats.

**Objective: Communicate with groups and others to activate and increase local involvement and community participation in the WMBS herd.**

***Strategy: Reach out to and involve all interested stakeholders regarding the WMBS herd.***

Actions:

- WGFD will continue with the collaborative process, conduct meetings, and presentations when appropriate to maintain contact with our many stakeholders.

What's ongoing/been done:

- ✓ WGFD currently holds post-season meetings to assess public opinion prior to developing hunting season recommendations.
- ✓ WGFD conducts frequent presentations on this herd in Dubois.

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## APPENDIX A – Results First Workshop

#	Whiskey Mountain Bighorn Sheep Issues February 2019	Main Theme	Sub-theme
1.	<p>More Access: Human access e.g. hunters and motorized and equal access for all.</p> <ul style="list-style-type: none"> <li>• There were more access points/ recreation back when sheep numbers were high (i.e. noon rock etc.)</li> <li>• Increased road closures have caused lack of access, leads to fewer predators taken. Increased road closures lead to lack of knowledge.</li> </ul>	Access	
2.	<p>Environmental groups: Communicate with local groups to activate local involvement. More enlargement locally.*</p>	Communications	
3.	<p>Elk herd increase – impact to winter and summer range? Habitat/Nutrition: poor body condition after summer*</p>	Competition	Elk
4.	<p>Competition on summer range? Elk (wild) and goats and sheep (domestic)*</p>	Competition	Summer Range
5.	<p>Increased stress and displacement levels due to increased human presence.</p>	Disturbance	
6.	<p>Sheep’s responses to dogs.</p>	Disturbance	Dogs
7.	<p>WGFD funding to figure out disease issues.* WGFD funding and accountability e.g. for summer range studies* Budget for sheep.</p>	Funding	Funding
8.	<p>There has been dramatic acidification in the Winds compared to other Mountain ranges. Some relation?</p> <ul style="list-style-type: none"> <li>• Pollution as driver of affecting habitat/nutrition ( e.g. air, water)</li> </ul>	Habitat/Nutrition	Acidification
9.	<p>Barren Ewe group – relating to habitat.</p>	Habitat/Nutrition	Barren Ewes
10.	<p>Habitat disturbed/negatively impacted by high recreational use summer and winter and negatively impacted by off-road ATV use.</p>	Habitat/Nutrition	Disturbance
11.	<p>Advanced succession on key areas/lack of fire* - Increase prescribed burns forest wide. Conduct thorough, robust forage study.</p> <ul style="list-style-type: none"> <li>• Poor body condition after summer.*</li> <li>• Examine fire use on summer/winter ranges – invite Wyoming Wilderness Association – burns in Wildernesses. *</li> <li>• Habitat: Fire – increased sheep.</li> <li>• Timber thinning and/or fire*</li> <li>• Wilderness regulations restrictive of habitat projects*</li> </ul>	Habitat/Nutrition	Fire

12.	Fringed Sage loss – anti-parasite plants	Habitat/Nutrition	Fringed Sage
13.	Herbicide effects on forage and sheep – current and long term. <ul style="list-style-type: none"> <li>• Effects on lamb recruitment or health overall?</li> <li>• Herbicide used on Torrey* - Selenium</li> </ul>	Habitat/Nutrition	Herbicides
14.	Presence of invasives species, poisonous, noxious weeds, nonnative plants. – various stages/seasons	Habitat/Nutrition	Invasives
15.	Grazing influence on forage stand composition and nutrients*	Habitat/Nutrition	Nutrition
16.	Comparing within the herd unit habitat and nutrition factors.*	Habitat/Nutrition	Nutrition
17.	Habitat/Nutrition: poor body condition after summer <ul style="list-style-type: none"> <li>• Summer habitat nutrition in question*</li> <li>• Unknowns in nutritional deficits on summer range.</li> <li>• Poor condition coming off summer range*</li> <li>• Summer Range Habitat quality: Specific variables influence summer range quality - Could be acid rain/snow influence.*</li> <li>• Poor summer range – decreased nutrition – decrease milk quality – increase disease susceptibility</li> </ul>	Habitat/Nutrition	Summer Range
18.	Mild winters affecting distribution, not moving to lower traditional winter ranges. <ul style="list-style-type: none"> <li>• Lack of data (or shortage) on winter ranges outside Whiskey/Torrey rim.</li> <li>• Winter range look good because of fewer sheep?</li> <li>• Increase winter range activity?</li> </ul>	Habitat/Nutrition	Winter Range
19.	Climatological changes impacting vegetation quality (i.e. drought, annual precipitation decrease).	Habitat/Nutrition	Climate Impact
20.	Predation and habitat/nutrition as added stressors that make sheep more vulnerable to disease – all tied together***	Habitat/Nutrition	Interrelatedness
21.	Industrial pollution possibly affecting nutrition, mineral uptake in forage (i.e. acid rain)*	Habitat/Nutrition	Pollution
22.	Disease: lack of science/understanding of effects of specific strains of bacteria leading to pneumonia.	Health	Bacterial Strains
23.	Disease: scrapie possible? CWD?	Health	CWD
24.	Expression of disease/asymptomatic sheep*	Health	Disease
25.	Disease and re-introduction/augmentation dynamics*	Health	Disease
26.	North side/Spring Mountain herd*- antibodies, genetics, difference to WMBHS	Health	Disease
	Disease: main problem that influences the rest of the issues – learn about possible new factors, their hosts* <ul style="list-style-type: none"> <li>• Disease transmission: carriers e.g. mites, black flies, eagles, etc.*</li> </ul>	Health	Disease Carriers

	<ul style="list-style-type: none"> <li>Parasite, etc. in water BHS are drinking: reduction of overall fitness: susceptible to disease</li> </ul>		
27.	Disease function weak genetics* <ul style="list-style-type: none"> <li>Herd genetics, bring genetics back – Genetic vigor.</li> <li>Control group of sheep* - move to see if habitat or animal genetics, compare Whiskey Mountain herd to other herds.</li> <li>Lack of genetic diversity</li> <li>Historically healthy herd: genetic changes?*</li> <li>Lack of knowledge on interactions of disease with nutrition and genetics.</li> </ul>	Health	Genetics
28.	Migration Corridors and Stress	Health	Migration
29.	Changes in composition relative to time when sheep populations were doing well, i.e. micronutrients. <ul style="list-style-type: none"> <li>Salt/mineral blocks.</li> <li>Other species' selenium levels.</li> </ul>	Health	Minerals
30.	Thin skulls relative to other hunt areas – bone density.	Health	Nutrition
31.	Decrease in nutrition: Disease susceptibility* <ul style="list-style-type: none"> <li>Forage quality*</li> <li>Small sheep suggest poor forage.</li> <li>Glacier Lake Meadow* - high protein, nutritious seed, basin wild rye, lions live there (cover)</li> </ul>	Health	Nutrition
32.	Lack of science and understanding – need more studying/education re. effects of specific strains of bacteria which lead to pneumonia.*	Health	Research Needs
33.	Forage nutrients analysis: selenium, summer habitat*	Health	Summer Range
34.	Local pockets of summer range provide disease sink/vector: decreased nutrition.	Health	Summer Range
35.	Disease: potential white muscle disease.	Health	White Muscle
36.	Estimate too high.	Population Mgmt.	
37.	Seen increases in late season hunting hunter numbers, increased road traffic.	Population Mgmt.	Hunting
38.	Hunting season – Any ram leads to fewer ram impacts.	Population Mgmt.	Hunting
39.	Don't hunt near conservation camp.	Population Mgmt.	Hunting
40.	Coordinate with tribes – hunting – management.	Population Mgmt.	Hunting
41.	Influence of capture and collaring on sheep?	Population Mgmt.	Research
42.	Coyotes at Red Creek? Impacts and behavioral response?* <ul style="list-style-type: none"> <li>Coyote vs. lion?</li> </ul>	Predators	Coyote

	<ul style="list-style-type: none"> <li>High coyote numbers.</li> </ul>		
43.	Predators: eagles?* plenty of eagles	Predators	Eagles
44.	Historical effects of predation vs. current conditions.*	Predators	History
45.	Winter access for predator hunting*	Predators	Hunting
46.	<p>Lion predation being high*</p> <ul style="list-style-type: none"> <li>Arizona had a similar problem with some lions (10%) and took out specific, collared Mountain Lions that were taking lambs = effective</li> </ul>	Predators	Lions
47.	Habitat: poor nutrition intake because of predator pressures.	Predators	Nutrition
48.	<p>Predators – indirect impacts – Harassment of BHS - BHS in poorer habitat *</p> <ul style="list-style-type: none"> <li>increased predators lead to fewer sheep.</li> <li>Stealth vs. coursing predators</li> <li>Predator hunting area closures*</li> <li>Reduced predation control.</li> <li>Other Predators.</li> </ul>	Predators	Nutrition
49.	Wolves: Canadian wolves vs. historical species (smaller)*	Predators	Wolves
50.	<p>Wolves: added stressor/increased stress*</p> <ul style="list-style-type: none"> <li>experimental status*</li> <li>1999 promise to “take them out” if impacting wintering wildlife*</li> <li>Honesty, transparency from WGFD on effect of wolves*</li> <li>Is the priority wolves or sheep (“choose or lose”). *</li> <li>Increased wolf activity/presence – longer/late wolf season.</li> <li>eliminate closing date, keep wolf season open until quota filled.</li> <li>wolves – area 9,</li> <li>control and hunting methods for wolves limited.</li> <li>sheep still learning how to deal with increase of wolves.</li> <li>predator zone? Increase take? Open WHMA Roads*</li> </ul>	Predators	Wolves
51.	Need results from UW lamb survival study to evaluate impact of predators....	Predators	Research Needs
52.	<p>Predation: We don’t know <u>overall</u> impacts of predators on BHS – need the science*.</p> <ul style="list-style-type: none"> <li>Understand underlying reasons predators and sheep relationship has changed*</li> </ul>	Predators	Research needs
53.	Wolves: Comparing effects of wolves within the herd unit, across ranges*	Predators	Research Needs
54.	Examination of historical protections, synthesis and gaps?...results.*	Research Needs	History

## APPENDIX B – Results Second Workshop

#	Whiskey Mountain Bighorn Sheep Issues February 2019	Main Theme	Sub-theme	Specific Recommendations April 2019
1.	<p>More Access: Human access e.g. hunters and motorized and equal access for all.</p> <ul style="list-style-type: none"> <li>• There were more access points/ recreation back when sheep numbers were high (i.e. noon rock etc.)</li> <li>• Increased road closures have caused lack of access, leads to fewer predators taken. Increased road closures lead to lack of knowledge.</li> </ul>	Access		<ul style="list-style-type: none"> <li>• open roads so hunters can access hunting areas</li> <li>• coordinate predator hunting with road closures-open little longer to examine herd response to above action</li> <li>• increase access to facilitate more predator harvest</li> </ul>
2.	<p>Environmental groups: Communicate with local groups to activate local involvement. More enlargement locally.*</p>	Communications		<ul style="list-style-type: none"> <li>• G&amp;F regional personnel should be the “boots on the ground” for UW research, also more active involvement from G&amp;F in resolving big game issues</li> </ul>
3.	<p>Elk herd increase – impact to winter and summer range? Habitat/Nutrition: poor body condition after summer*</p>	Competition	Elk	
4.	<p>Competition on summer range? Elk (wild) and goats and sheep (domestic)*</p>	Competition	Summer Range	
5.	<p>Increased stress and displacement levels due to increased human presence.</p>	Disturbance		<ul style="list-style-type: none"> <li>• conduct research on access/lack of access on bighorn sheep</li> </ul>

6.	Sheep's responses to dogs.	Disturbance	Dogs	
7.	WGFD funding to figure out disease issues.* WGFD funding and accountability e.g. for summer range studies* Budget for sheep.	Funding	Funding	<ul style="list-style-type: none"> <li>• provide as much funding as possible to UW research: more follow up on this study</li> <li>• encourage G&amp;F continued funding, encourage USFS/BLM fire funding for managing wildfires</li> <li>• Where did the disease cooperative funding mechanism go? <b>Resurrect this cooperative funding mechanism for disease research</b>, also-Is all research peer reviewed and done by scientists?</li> <li>• <b>Connect with interaction working group to incorporate all research, Researchers &amp; vets need to partner on all needed research, need to be transparent about all funding for research (where is it coming from? Where does it go?)</b></li> <li>• get more \$, have UW/graduate students do more of this work vs. G&amp;F or USFS employees</li> </ul>
8.	There has been dramatic acidification in the Winds compared to other Mountain ranges. Some relation? <ul style="list-style-type: none"> <li>• Pollution as driver of affecting habitat/nutrition (e.g. air, water)</li> </ul>	Habitat/Nutrition	Acidification	<ul style="list-style-type: none"> <li>• Find the source of acidification, and review historic data</li> <li>• Habitat comparison of Whiskey to Dubois Badlands herd</li> <li>• Mineral blocks: in 2000s bighorn sheep were observed waiting for mineral blocks to be dropped off, bighorn sheep are shown to move up and down from summer to winter range in summer 5x year or more, <b>place mineral blocks again with lots of mineral content, look at environmental data being collected already in summer range (lake surveys, etc.), also look at Dubois badlands herd die off in 1991-nitrate contamination? Look back at this information</b></li> <li>• For all habitat/nutrition: <b>Include expert panelists input</b></li> </ul>
9.	Barren Ewe group – relating to habitat.	Habitat/Nutrition	Barren Ewes	<ul style="list-style-type: none"> <li>• Indicator of problems with birthing, <b>need to sample this group and compare to ewes with lambs</b></li> </ul>
10.	Habitat disturbed/negatively impacted by high recreational use summer	Habitat/Nutrition	Disturbance	<ul style="list-style-type: none"> <li>• Assess impacts of helicopter use on bighorns (research)</li> <li>• increase citizen/hunters science opportunities (from expert panelists)</li> </ul>

	and winter and negatively impacted by off-road ATV use.			<ul style="list-style-type: none"> <li>• helicopter use stresses ewes to loose lambs, may last longer than the capture, “found dead sheep after helicopter captures”, <b>let G&amp;F know when dead sheep are found, look at stress with current lamb mortality study, get permission for public to bring dead bighorns down</b></li> </ul>
11.	<p>Advanced succession on key areas/lack of fire* - Increase prescribed burns forest wide. Conduct thorough, robust forage study.</p> <ul style="list-style-type: none"> <li>• Poor body condition after summer.*</li> <li>• Examine fire use on summer/winter ranges – invite Wyoming Wilderness Association – burns in Wildernesses. *</li> <li>• Habitat: Fire – increased sheep.</li> <li>• Timber thinning and/or fire*</li> <li>• Wilderness regulations restrictive of habitat projects*</li> </ul>	Habitat/Nutrition	Fire	<ul style="list-style-type: none"> <li>• Evaluate federal policy on wildfire management to encourage more burning</li> <li>• high support for the conservation camp meadow restoration and high support for prescribed fire treatment</li> <li>• prescribed burns: follow burns with impact study, where prescribed burns are not allowed/able conduct forest thinning projects, track other ungulate response and competition (also do this in summer range)</li> <li>• expand prescribed burns throughout bighorn sheep habitat and manage wildfire to benefit sheep</li> <li>• Fire/prescribed burns whenever possible, need to get WY Wilderness Association on board to work together as the language of the Fitzpatrick addition allows, monitor and record lactation periods to see why there is poor body condition after summer</li> </ul>
12.	Fringed Sage loss – anti-parasite plants	Habitat/Nutrition	Fringed Sage	<ul style="list-style-type: none"> <li>• from scientists list: set trail cameras to document presence of sheep and predators</li> <li>• use remote trail cameras to track predator numbers and identify chronically ill sheep (from expert panelists)</li> <li>• Bighorn sheep are targeting fringed sage on Torrey Rim when down on winter/fall range here, <b>Look at plant compounds and medicinal values to better know how important it is to bighorns and if we are causing issues by removing it</b></li> </ul>

13.	<p>Herbicide effects on forage and sheep – current and long term.</p> <ul style="list-style-type: none"> <li>• Effects on lamb recruitment or health overall?</li> <li>• Herbicide used on Torrey* - Selenium</li> </ul>	Habitat/Nutrition	Herbicides	<ul style="list-style-type: none"> <li>• are there adverse effects from herbicide application to wild sheep? If so, and if treatments are not gaining anything, reallocate resource to more productive treatments</li> <li>• Look at what type of herbicide is being used (24D-does it eliminate selenium from blood/bighorn sheep?), are herbicide treatments doing what we think? Does it affect production long term? Measure the importance/value of continuing herbicide treatments moving forward.</li> </ul>
14.	Presence of invasives species, poisonous, noxious weeds, nonnative plants. – various stages/seasons	Habitat/Nutrition	Invasives	<ul style="list-style-type: none"> <li>• Continued treatments for invasives, also map invasives, assess all vectors of spread</li> <li>• continue cheatgrass and other noxious weed mitigation</li> <li>• convert winter range areas and where lesser quality forage exists to higher quality forage (i.e. necessary grasses), fill in data gaps on winter range species composition, identify historic uses, use GPS collars that can identify when sheep are grazing, then assess site (reference UW extension project on Spring Mnt)</li> <li>• continued control of invasive species</li> <li>• Keep an eye on after any treatments for invasives, be prepared to treat</li> </ul>
15.	Grazing influence on forage stand composition and nutrients*	Habitat/Nutrition	Nutrition	<ul style="list-style-type: none"> <li>• compare subherds to compare disease resilience, use ultrasound to detect sinus tumors, focus on why healthy sheep survive vs. why sick sheep die</li> <li>• observation-when outfitter camps move off the forest, sheep come in and clean up discarded hay, recommend: determine whether this has negative impacts (health, congregation, predator attraction, etc.)</li> <li>• look at old information and compare to new information being collected on winter ranges (have there been changes over time?), look at potential nutritional problems with forage on summer range</li> </ul>



16.	Comparing within the herd unit habitat and nutrition factors.*	Habitat/Nutrition	Nutrition	<ul style="list-style-type: none"> <li>• conduct clipping habitat utilization on summer range</li> <li>• Habitat comparison of Whiskey to Dubois Badlands herd</li> <li>• compare habitat conditions between Pinedale and Whiskey Mountain herds</li> <li>• geology is different on Pinedale side of Winds (they don't move as much and have less predation from lions and coyotes), <b>Do similar work (samples, disease, etc.) with bighorns from WM herd on Pinedale side. Look at body size and other information from other transplant sites to where WM bighorns were sent</b></li> </ul>
17.	<p>Habitat/Nutrition: poor body condition after summer</p> <ul style="list-style-type: none"> <li>• Summer habitat nutrition in question*</li> <li>• Unknowns in nutritional deficits on summer range.</li> <li>• Poor condition coming off summer range*</li> <li>• Summer Range Habitat quality: Specific variables influence summer range quality - Could be acid rain/snow influence.*</li> <li>• Poor summer range – decreased nutrition – decrease milk quality – increase disease susceptibility</li> </ul>	Habitat/Nutrition	Summer Range	<ul style="list-style-type: none"> <li>• Go Montieth! Answer concerns-make sure his research is adequately funded</li> <li>• Look at potential of high-elevation salt/mineral blocks (with antibiotics in them)</li> <li>• emphasize research on nutritional quality of forage on summer range</li> <li>• fire: needs to be a plan to use both prescribed burns and wildfire for this area specifically, research needs to identify why sheep may not come off summer range in as good of shape as expected (let that drive the treatments)</li> <li>• range-wide survey/monitoring of rain/snow/water quality</li> <li>•</li> </ul>
18.	Mild winters affecting distribution, not moving to lower traditional winter ranges.	Habitat/Nutrition	Winter Range	<ul style="list-style-type: none"> <li>• convert winter range areas and where lesser quality forage exists to higher quality forage (i.e. necessary grasses), fill in data gaps on winter range species composition, identify</li> </ul>

	<ul style="list-style-type: none"> <li>Lack of data (or shortage) on winter ranges outside Whiskey/Torrey rim.</li> <li>Winter range look good because of fewer sheep?</li> <li>Increase winter range activity?</li> </ul>			<p>historic uses, use GPS collars that can identify when sheep are grazing, then assess site (reference UW extension project on Spring Mnt)</p> <ul style="list-style-type: none"> <li>range-wide survey/monitoring of rain/snow/water quality</li> <li>feel this is one of the reasons we are seeing bighorns in different places, <b>pray to the gods for moisture, mineral blocks as experimental tests, keep winter range closures in place</b></li> </ul>
19.	Climatological changes impacting vegetation quality (i.e. drought, annual precipitation decrease).	Habitat/Nutrition	Climate Impact	<ul style="list-style-type: none"> <li>track lamb weight gain relative to annual precipitation/look at historic information, examine need to place weather stations in area to assess landscape and microsite production</li> <li>identify correlation of areas where forage exists and water sources have changed (creeks dried up, trees sucking up water), if this has caused range shift, can we provide water supplementation</li> <li>ORP: Oxidation, Reduction Potential: nutrients change based on climate and moisture, <b>monitor the ORP in this area</b></li> </ul>
20.	Predation and habitat/nutrition as added stressors that make sheep more vulnerable to disease – all tied together***	Habitat/Nutrition	Interrelatedness	<ul style="list-style-type: none"> <li>study predation effect on winter range use</li> <li>use fire to decrease hiding cover for predators and open up high altitude country where sheep may feel more comfortable/safe</li> <li>consider predator control as a related variable</li> </ul>
21.	Industrial pollution possibly affecting nutrition, mineral uptake in forage (i.e. acid rain)*	Habitat/Nutrition	Pollution	<ul style="list-style-type: none"> <li>updated water sampling and review of old university study re: acid rain and forage mineral uptake in waterways (lakes, streams) in Wind Rivers, Utilize long-running USFS data collection for lake sampling in Wind Rivers</li> </ul>
	Disease	Health		<ul style="list-style-type: none"> <li>For all habitat/nutrition: <b>include expert panelists input</b></li> <li>Other/general: <b>test other species (i.e. elk, deer, antelope, horses, etc. for known pathogens), develop clear education strategy for how to communicate with domestic sheep/goat livestock owners with community assistance</b></li> </ul>

22.	Disease: lack of science/understanding of effects of specific strains of bacteria leading to pneumonia.	Health	Bacterial Strains	<ul style="list-style-type: none"> <li>Identify techniques to identify sheep with sinus tumors and remove “typhoid Mary’s”</li> <li>research air and water quality and its effect on forage quality and availability of nutrients</li> <li>look at current research and publications and address any potential concerns</li> </ul>
23.	Disease: scrapie possible? CWD?	Health	CWD	<ul style="list-style-type: none"> <li>don’t need to focus on scrapie/cwd right now for bighorns</li> </ul>
24.	Expression of disease/asymptomatic sheep*	Health	Disease	<ul style="list-style-type: none"> <li>educate the public: call when people see sick bighorns/are found, notify G&amp;F for sick and dead bighorns, education public on invasives, implement citizen science tools (let us help develop an app)</li> </ul>
25.	Disease and re-introduction/augmentation dynamics*	Health	Disease	
26.	North side/Spring Mountain herd*- antibodies, genetics, difference to WMBHS	Health	Disease	
27.	<p>Disease: main problem that influences the rest of the issues – learn about possible new factors, their hosts*</p> <ul style="list-style-type: none"> <li>Disease transmission: carriers e.g. mites, black flies, eagles, etc.*</li> <li>Parasite, etc. in water BHS are drinking: reduction of overall fitness: susceptible to disease</li> </ul>	Health	Disease Carriers	<ul style="list-style-type: none"> <li>better understand transmissions, need to evaluate other vectors of transmission</li> <li>test for other parasites like tapeworms</li> <li>expand blood testing to determine whether blood-borne diseases are factors (most testing seems to be for respiratory diseases), look at outside vectors and see if they are bringing in secondary diseases, look at neighboring states’ data re: testing</li> </ul>
28.	Disease function weak genetics*	Health	Genetics	

	<ul style="list-style-type: none"> <li>• Herd genetics, bring genetics back – Genetic vigor.</li> <li>• Control group of sheep* - move to see if habitat or animal genetics, compare Whiskey Mountain herd to other herds.</li> <li>• Lack of genetic diversity</li> <li>• Historically healthy herd: genetic changes?*</li> <li>• Lack of knowledge on interactions of disease with nutrition and genetics.</li> </ul>			<ul style="list-style-type: none"> <li>• scientifically evaluate genetics and bighorn’s relative resistance/immunology, look for whether or not there a genetic trait specific to furthering diseases, consider a controlled experiment to evaluate disease and nutrition and selenium, increase genetic research to evaluate genetic viability</li> <li>• introduce ram from a “healthy herd” to whiskey mountain to see what happens</li> <li>• Examine genetic drift through time as a result of declining herd (examining historic vs. current samples), determine if other studies have been conducted on high infant mortality rates in other relevant species, conduct research to assess if disease is being carried from winter congregated areas to summer range</li> <li>• identify genetics in herd unit-how does it compare with Pinedale side? Relative to bone density question from taxidermist</li> <li>• determine if genetics is bottle necks to herd health (identify genetic diversity of this herd), compare herd health of Pinedale herd, Whiskey Mnt herd and Dubois Badlands herds, compare lamb recruitment and between sub-herds that mingle with Pinedale herd and those that don’t, develop strategy to enhance ewe/shedders (#2 &amp; #15 on expert/science panel recommendations), sample all hunter harvest (#13 science panel), collar rams at Osborne and track dispersal</li> </ul>
29.	Migration Corridors and Stress	Health	Migration	<ul style="list-style-type: none"> <li>• use of fire to clear migration corridors and open up cover</li> </ul>
30.	Changes in composition relative to time when sheep populations were doing well, i.e. micronutrients. <ul style="list-style-type: none"> <li>• Salt/mineral blocks.</li> </ul>	Health	Minerals	<ul style="list-style-type: none"> <li>• supplement with selenium</li> <li>• continue soil/mineral analysis, review mineral block study data</li> </ul>

	<ul style="list-style-type: none"> <li>• Other species' selenium levels.</li> </ul>			
31.	Thin skulls relative to other hunt areas – bone density.	Health	Nutrition	<ul style="list-style-type: none"> <li>• scientifically evaluate genetics and bighorn's relative resistance/immunology, look for whether or not there a genetic trait specific to furthering diseases, consider a controlled experiment to evaluate disease and nutrition and selenium, increase genetic research to evaluate genetic viability</li> <li>• introduce ram from a "healthy herd" to whiskey mountain to see what happens</li> <li>• investigate nutrients in regards to bone density and sinus tumors, examine to see if whiskey transplants exhibit same trend in body size vs. local sheep, determine best tools to identify chronic shedders</li> <li>• identify genetics in herd unit-how does it compare with Pinedale side? Relative to bone density question from taxidermist</li> </ul>
32.	<p>Decrease in nutrition: Disease susceptibility*</p> <ul style="list-style-type: none"> <li>• Forage quality*</li> <li>• Small sheep suggest poor forage.</li> <li>• Glacier Lake Meadow* - high protein, nutritious seed, basin wild rye, lions live there (cover)</li> </ul>	Health	Nutrition	<ul style="list-style-type: none"> <li>• study mineral content in forage</li> <li>• determine cause-specific lamb/ewe mortality and causes, ensure proper staffing of Monteith lamb mortality study (volunteers, sufficient funding)</li> </ul>
33.	Lack of science and understanding – need more studying/education re. effects of specific strains of bacteria which lead to pneumonia.*	Health	Research Needs	<ul style="list-style-type: none"> <li>• better understand effects of different strains and transmission as it relates to lamb mortality timing</li> <li>• prioritize research on disease treatment and prevention</li> <li>• cull and capture chronically sick sheep, study opportunity at Sybille with chronically ill sheep, get states and research universities to pool resources and centralize research efforts</li> </ul>
34.	Forage nutrients analysis: selenium, summer habitat*	Health	Summer Range	

35.	Local pockets of summer range provide disease sink/vector: decreased nutrition.	Health	Summer Range	<ul style="list-style-type: none"> <li>Identify pockets of decreased nutrition, track chronic shedders of disease and cull herd (infected ewes), and transplant (incrementally-100%)</li> </ul>
36.	Disease: potential white muscle disease.	Health	White Muscle	
37.	Estimate too high.	Population Mgmt.		<ul style="list-style-type: none"> <li>better population counts and modeling, use drones as appropriate to aid in population counts</li> </ul>
38.	Seen increases in late season hunting hunter numbers, increased road traffic.	Population Mgmt.	Hunting	
39.	Hunting season – Any ram leads to fewer ram impacts.	Population Mgmt.	Hunting	<ul style="list-style-type: none"> <li>reduce harvest until a greater understanding of population impacts is gained</li> <li>continue any ram seasons</li> </ul>
40.	Don't hunt near conservation camp.	Population Mgmt.	Hunting	
41.	Coordinate with tribes – hunting – management.	Population Mgmt.	Hunting	<ul style="list-style-type: none"> <li>better coordination with Wind River Reservation on sheep management</li> </ul>
42.	Influence of capture and collaring on sheep?	Population Mgmt.	Research	<ul style="list-style-type: none"> <li>Look at other methods of capture and collecting information</li> <li><b>Other:</b> reevaluate carrying capacity of limiting range, make opportunities for hunting (culling ill sheep like bison quote list)</li> <li>examine novel use of sheep dogs to detect shedders</li> </ul>
43.	Coyotes at Red Creek? Impacts and behavioral response?* <ul style="list-style-type: none"> <li>Coyote vs. lion?</li> <li>High coyote numbers.</li> </ul>	Predators	Coyote	<ul style="list-style-type: none"> <li>consider coyote/predator control on bighorn sheep habitat</li> <li></li> </ul>
44.	Predators: eagles?* plenty of eagles	Predators	Eagles	<ul style="list-style-type: none"> <li>gain better understanding of lamb predators, graduate students count raptor species and ravens in lamb mortality study</li> </ul>
45.	Historical effects of predation vs. current conditions.*	Predators	History	<ul style="list-style-type: none"> <li>Consider “master hunters” program to maximize predator take (need a baseline for effectiveness measure)</li> </ul>

				<ul style="list-style-type: none"> <li>For all predators: where is/what was specifically expert panelist's Tom Lohius input (from AK?,) <b>include this or revisit with Tom Lohius to know what specifics we can relate to WM herd dynamics relative to predation</b></li> </ul>
46.	Winter access for predator hunting*	Predators	Hunting	<ul style="list-style-type: none"> <li>Assess hunting access on predators and bighorn sheep in seasonally closed G&amp;F units, allow vehicle access any time of the year to Torrey Rim to reduce predator numbers- specifically vehicle access for lion hunters (access only for predator hunting?), assess wolf harvest timing and management</li> <li>adjust predator (wolf, lion) seasons to overlap when access is more available, make wolf hunt area 13 a predator area, make wolf hunt area 13 a flex zone</li> <li></li> </ul>
47.	Lion predation being high* <ul style="list-style-type: none"> <li>Arizona had a similar problem with some lions (10%) and took out specific, collared Mountain Lions that were taking lambs = effective</li> </ul>	Predators	Lions	
48.	Habitat: poor nutrition intake because of predator pressures.	Predators	Nutrition	<ul style="list-style-type: none"> <li>investigate behavioral responses to predation risk</li> </ul>
49.	Predators – indirect impacts – Harassment of BHS - BHS in poorer habitat * <ul style="list-style-type: none"> <li>increased predators lead to fewer sheep.</li> <li>Stealth vs. coursing predators</li> <li>Predator hunting area closures*</li> <li>Reduced predation control.</li> <li>Other Predators.</li> </ul>	Predators	Nutrition	<ul style="list-style-type: none"> <li>Need to assess and address predator activity on Torrey Rim</li> <li>use of fire to improve sheep availability to detect predators</li> </ul>

50.	Wolves: Canadian wolves vs. historical species (smaller)*	Predators	Wolves	
51.	<p>Wolves: added stressor/increased stress*</p> <ul style="list-style-type: none"> <li>• experimental status*</li> <li>• 1999 promise to “take them out” if impacting wintering wildlife*</li> <li>• Honesty, transparency from WGFD on effect of wolves*</li> <li>• Is the priority wolves or sheep (“choose or lose”). *</li> <li>• Increased wolf activity/presence – longer/later wolf season.</li> <li>• eliminate closing date, keep wolf season open until quota filled.</li> <li>• wolves – area 9,</li> <li>• control and hunting methods for wolves limited.</li> <li>• sheep still learning how to deal with increase of wolves.</li> <li>• predator zone? Increase take? Open WHMA Roads*</li> </ul>	Predators	Wolves	<ul style="list-style-type: none"> <li>• Need to assess and address predator activity on Torrey Rim</li> <li>• if wolves are shown to have an impact on bighorns, they should be eliminated</li> <li>• better communicate the science to the public about the effects of predators</li> <li>• adjust hunt seasons and quotas-move away from date-based closures to quota-based closures</li> <li>• ensure adequate number of collared wolves</li> </ul>
52.	Need results from UW lamb survival study to evaluate impact of predators....	Predators	Research Needs	<ul style="list-style-type: none"> <li>• double down on #52</li> </ul>



53.	<p>Predation: We don't know <u>overall</u> impacts of predators on BHS – need the science*.</p> <ul style="list-style-type: none"> <li>• Understand underlying reasons predators and sheep relationship has changed*</li> </ul>	Predators	Research needs	<ul style="list-style-type: none"> <li>• need to assess impact of wildlife service's coyote control work from past</li> <li>• Need to assess and research the relationship of predators' impact on whiskey mountain herd (lambs, ewes, seasonality, age classes, etc.)</li> <li>• better communicate the science to the public about the effects of predators</li> <li>• study sources and rates of predation, if a problem is found, respond aggressively</li> <li>• collar more wolves, collar more lions and relate to bighorn movements</li> </ul>
54.	Wolves: Comparing effects of wolves within the herd unit, across ranges*	Predators	Research Needs	
55.	Examination of historical protections, synthesis and gaps?...results.*	Research Needs	History	<ul style="list-style-type: none"> <li>• Re-look at SE work and do again</li> </ul>

## APPENDIX C - Professional Panel Recommendations

<b>WHISKEY MOUNTAIN BIGHORN SHEEP HERD: SCIENTISTS' RECOMMENDATIONS: ACTION ITEMS AND RESEARCH NEEDS</b>	
#	Disease: Action Items
1.	What can we manage to mitigate the risk given the presence of the pathogens and the info we have now?
2.	Remove obviously ill sheep (ID clinical signs of sinus tumors?) ID's: observe yellow snot from nose.
3.	Remove mountain goats
4.	Talk to domestic sheep/goat owners in the area
5.	Communicate to the public the Pack goat decision on the SNF
6.	Consider the Teton Range herd risk list
7.	These pathogens are ubiquitous in sheep populations. We can't manage the pathogens. <ul style="list-style-type: none"> <li>• Reduce risk of introducing any other pathogens or source of stress.</li> </ul>
Disease: Research Needs	
8.	Determine cause-specific lamb and ewe mortality from Kevin's study <ul style="list-style-type: none"> <li>• Necropsy to ID pathogens</li> <li>• Ancillary sampling (nutritional condition, reproduction, pathogen presence, disease factors-ID strain type, movement, habitat use, interactions with other individuals, etc.)</li> </ul>
9.	Evaluate population performance within sub-herds (high & low elevation)
10.	Encourage or develop citizen/hunters science support with volunteers (NBSC & others): <ul style="list-style-type: none"> <li>• Develop a protocol/process for observational data collection regarding lamb pneumonia</li> </ul>
11.	Consider ewe harvest & sample all of them
12.	Work to use remote trail cameras
13.	Make hunter harvest sampling mandatory for all hunters to detect sinus tumors, m. ovi, etc.
14.	Collate data from mineral & nutritional across BHS ranges (WY & beyond)
15.	Test & Cull possibly using drop net captures if data bears out that there are chronically shedding ewes – not sure this is possible?

	<ul style="list-style-type: none"> <li>• Conduct side tests, xrays (concerns: baiting, sampling equally for various m. ovi strains, strain typing).</li> <li>• Look at differences between subherds.</li> </ul>
	<b>Nutrition/Habitat: Action Items</b>
16.	Conduct prescribed burns (Torrey Rim, in Fitzpatrick Wilderness)
17.	Manage wildfires for habitat
18.	Manage and control invasive plants (now & as part of fire management)
19.	
	<b>Nutrition/Habitat: Research Needs</b>
20.	Recognize mineral block supplements have not been effective reducing effects of disease in either captive or wild populations.
21.	Expand the Monteith study to the Pinedale sub-herds (high & low elevation populations) in order to assess nutritional status, disease, interactions between these factors in alpine resident populations
22.	Conduct soil & geology analysis (summer ranges)
23.	Assess imagery of landscape over time (summer range)
24.	Review GPS data for movement & energy expenditure between Whiskey Mountain, Jackson & Cody herds

## **APPENDIX D - Responses to actions not addressed in this plan**

### **Health/Disease**

#### **“Use ultrasound to detect sinus tumors.”**

- Regrettably, ultrasound simply doesn't work for this purpose. Portable x-ray machines have been used in the field with varying degrees of reliability. To date, there is no reliable technology for field detection of sinus tumors, but WGFD will remain vigilant regarding new veterinary and technological innovations.

#### **“Determine whether outfitter camps that have been vacated for the year have negative impacts (health, congregation, predator attraction, and etc).”**

- WGFD has observed some activity of sheep at the Glacier trailhead congregating around the corrals and “picking clean” the remaining hay, etc. and it does not appear to be a concern with regard to increased risk of disease transmission.

#### **“Test other species (i.e., elk, deer, antelope, horses, etc) for known pathogens.”**

- Decades of research definitively indicates, and the expert panel agreed, these species are not a component of the sheep disease complex.

#### **“Do not need to focus on scrapie/CWD right now for bighorns.”**

- Agreed. Scrapie or CWD is not a disease found in bighorn sheep.

#### **“Disease and reintroduction/augmentation dynamics.”**

- WGFD agrees with the “expert panel” that introduction of bighorn sheep into this herd would be counter-productive because it could introduce additional unknown strains of bacteria or other pathogens into the WMBS herd.

#### **“Introduce a ram from a “healthy herd” to Whiskey Mountain to see what happens.”**

- Here too, the “expert panel” astutely pointed out this action could introduce additional unknown strains of bacteria or other pathogens into the WMBS herd. WGFD strongly agrees with this assessment.

#### **“North side/Spring Mountain herd- antibodies, genetics, difference to WMBS.”**

- This comparison will be a component of the UW lamb survival study.

#### **“Examine to see if Whiskey transplants exhibit same trend in body size vs. local sheep.”**

- This idea has merit and may be completed in time, but is not considered a high enough priority to include as an “action” item in the plan considering other action items that demand a more immediate investment of energy and funds.

#### **“Use remote trail cameras to track predator numbers and identify chronically ill sheep.”**

- This idea has some merit to document the presence of predators, but would be ineffective tracking predator numbers. Using cameras to identify chronically ill sheep may have some merit, but to act on that information would be difficult because of the time lapse between the photo being taken and then retrieved and acted upon.

**“Look for environmental contaminants (lead, mercury, etc.) via sperm analysis to assess possible genetic transfer of abnormalities in lamb’s immune system.”**

- It would be very difficult to collect sperm samples from either harvested rams or during capture operations outside of the breeding season. Also, the UW lamb survival study will provide information regarding the effect of disease on the WMBS herd.

## **Habitat/Nutrition**

**“Habitat comparison of Whiskey to Dubois Badlands herd.”**

- These two herds occupy markedly different kinds of habitats, migratory behaviors are different, and they both have experienced disease caused all-age die offs so WGFD prefers to invest energy and resources into other more promising actions..

**“Find the source of acidification.”**

- Pending the results of the UW lamb survival study, and its assessment of soil and vegetation composition, WGFD will assess whether this issue has an impact on bighorn sheep survival.

**“Conduct clipping for measuring utilization on summer range.”**

- WGFD is anticipating the UW lamb survival study will provide some indication whether forage is limiting on summer range. So, it seems prudent to await those results before expending this effort.

**“Look at potential of high-elevation salt/mineral blocks (with antibiotics in them)” and “Mineral blocks as an experimental test.”**

- Dependent on the results of the UW lamb survival study, WGFD will re-assess the value of mineral supplements in an experimental fashion. WGFD also recognizes the consensus of the “expert panel” that mineral block supplements have not been effective in reducing effects of disease in either captive or wild populations.

**“Track lamb weight gain relative to annual precipitation.”**

- Recapturing lambs multiple times would be detrimental to them and the resulting data would not outweigh the risks. In addition, the UW lamb survival study will provide information regarding birth weights that can be correlated with annual precipitation.

**“ORP: Oxidation Reduction Potential – nutrients change based on climate and moisture. Monitor the ORP in this area.”**

- The UW lamb survival study should provide some insight. If necessary or deemed important once this study is complete, plans to monitor ORP may be considered.

**“Use cages for monitoring in addition to habitat assessments”**

- WGFD has monitored vegetation production and use in a consistent fashion for nearly six decades and it is important to maintain this dataset without change in data collection technique.

## **Predators**

### **“Make Wolf Hunt Area 13 a predator area or a flex zone.”**

- Wolf Hunt Area 13 is currently within the Wolf Trophy Game Management Area, in accordance with Wyoming State Statute § 23-1-304 (2013). WGFD does not have the authority to change the management status of wolves in Wolf Hunt Area 13, but will maximize harvest opportunity within.

### **“Wolves: Canadian wolves vs. historical species (smaller).”**

- Regardless the relationship of the wolves here today with those that historically occupied Wyoming, wolves are designated and managed as a trophy game species or as a predator in accordance with Wyoming State Statute § 23-1-304 (2013) and WGFC Regulations (Chapters 21 and 47).

### **“Consider “master hunters” program to maximize predator take.”**

- WGFD will provide hunting opportunities to all of the public not just to one group.
- WGFD will continue to evaluate management strategies for predators in the focal area.

## **Population Management**

### **“Don’t hunt near the conservation camp.”**

- Current restrictions around the camp provide an adequate buffer and WGFD believes there isn’t a need to further restrict hunting around the conservation camp.