

requested. The Forest Service received approximately 12,000 public comments on the Update to the DSEIS. The full response to public comment is included in the FSEIS (Appendix A).

Disease Review

Considerable debate about the science behind disease transmission has emerged since the SEIS process began. Even so, the preponderance of scientific literature still supports disease transmission between domestic and bighorn sheep, and that this issue is significant and warrants consideration of effects analysis and management direction that prevents contact between the species.

Bighorn sheep are a New World species and are closely related to domestic sheep, which are an Old World species. Domestication and intense artificial selection have probably helped domestic sheep develop a resistance to important diseases (Jessup 1985). However, bighorn sheep can be highly susceptible to diseases carried by domestic sheep.

A long history of large-scale, rapid, all-age die-offs in bighorn sheep exists across Canada and the United States, many associated with domestic animal contact (Shackleton 1999). Although limited knowledge of transmission dynamics exists (Garde et al. 2005), extensive scientific literature supports the relationship between disease in bighorn sheep populations and contact with domestic sheep, including both circumstantial evidence linking bighorn die-offs in the wild to contact with domestic animals and controlled experiments where healthy bighorn sheep exposed to domestic sheep displayed subsequently high mortality rates (Foreyt 1989, 1990, 1992a,b; Foreyt et al. 1994; Onderka et al. 1988; Onderka and Wishart 1988; Garde et al. 2005). Recent serological analyses document the lethality of pathogens (e.g. *Mannheimia haemolytica* serotype A1) in bighorn sheep that are not lethal to domestic sheep (Dassanayake 2009), and the transference of pathogens from domestic sheep to bighorn sheep that result in bighorn sheep mortality (Lawrence et al. Forthcoming.).

In a summary of risk to wild sheep from *Pasteurella* and *Mannheimia* spp., Garde et al. (2005) makes the following conclusions:

- 1) These bacteria can cause pneumonia in bighorn sheep, but there are benign commensal strains in the upper respiratory tract
- 2) Domestic sheep, goats, and llamas have been reported with these bacteria species
- 3) Wild sheep and mountain goats have been reported with these bacteria species
- 4) Transmission is by direct contact and aerosolization
- 5) These bacteria species do not persist in the environment
- 6) Acute-to-chronic die-offs in bighorn sheep can result in low to 100 percent mortality, although they can be present in healthy sheep
- 7) These bacteria are considered opportunistic and can result in pneumonia outbreaks
- 8) These bacteria can cause clinical disease in domestic sheep and goats, but are rarely primary pathogens.

Alternative Arguments

There are scientists and others, primarily from agricultural disciplines, who contend disease transmission between bighorn sheep and domestic sheep is not a relevant factor in bighorn sheep distribution and population declines. The following contentions are summarized from comments received during the public scoping process and public meetings:

- The mechanisms and causal agents leading to epizootic disease events in bighorn sheep are not completely understood.
- The hypothesis that bighorn sheep have a high likelihood of contracting fatal respiratory disease following contact with domestic sheep has not been scientifically demonstrated in wildland conditions.
- Bighorn sheep die-offs have occurred in the absence of domestic sheep.
- Evidence that domestic sheep contact with bighorn sheep will result in a disease transmission does not exist.
- Sources of error or omission and data limitations have not been presented by those advocating that disease transmission does occur between the species.
- The peer review process does not support the contention that disease transmission occurs between the species.
- Research evaluating disease transmission between the species lacks proper experimental design that is not accounted for in the results.
- Current, ambient levels of pathogens occur in bighorn sheep, regardless of how those pathogens were introduced, making separation from domestic sheep irrelevant.
- Given the probabilities of contact from off-forest private lands sources, excluding domestic sheep on Federal lands is futile.

Some of these contentions are accurate. We do not understand all of the mechanisms involved in potential disease transmission between the species. However, we have learned a tremendous amount from recent research on pathogen transfer between the species, and the fact that some pathogens that are non-lethal in domestic sheep have high lethality in bighorn sheep (Dassanaye et al. 2009). We also know that specific pathogens are transmitted from domestic sheep to bighorn sheep, resulting in bighorn sheep mortality (Lawrence et al. Forthcoming).

Other arguments criticize publications where findings very clearly infer disease transmission between the species, citing improper experimental design or other flaws in research design. However, the referenced papers are in widely recognized scientific publications and underwent rigorous peer review prior to publication.

There are contentions that argue the lack of evidence of disease transmission between domestic sheep and bighorn in wildland environments. Arguably, much of the evidence is circumstantial; however, the compilation of cases throughout several decades does contribute to an increasing body of evidence that overwhelmingly demonstrates bighorn sheep near domestic are at risk for disease transmission, even though “contact” may not have actually been observed.

Monello et al. (2001) state that bighorn sheep herds classified in a “pneumonia induced die-off” category were located significantly closer (<24 km) to domestic sheep allotments than those in a non-die-off category (>40 km). George et al. (2008) document a winter die-off in Colorado that affected three bighorn sheep herds that were traced to contact with a single domestic ewe.

Additional arguments state that since disease pathogens have already been transferred to domestic sheep, separation at this point is moot, or that private lands provide risks to bighorn sheep that cannot be offset, regardless of actions taken on Federal lands. These contentions claim that management on Federal lands to provide separation will not be effective due to changed conditions that cannot be offset. The uncertainty in these contentions poses all of the risk to be borne by bighorn sheep. They do not consider that pathogens likely evolve as they move within and between species, or existing or new diseases that are virulent to bighorn sheep (e.g., mycoplasmas) may still be transferred between domestic and bighorn sheep. Recent serological research (Dassanayake et al. 2009), demonstrates that pathogens, in this case *Mannheimia haemolytica* serotype A1, that are not lethal to domestic sheep are transferrable to bighorn sheep and highly lethal to them. In another recent experiment (Lawrence et al. Forthcoming), pathogens were tagged and followed as they passed from domestic to bighorn sheep and resulted bighorn sheep mortality.

The disease review sections of this document, particularly Chapter 3, consider a large body of peer reviewed and published literature, spanning several decades, that redresses most of these allegations. While there clearly are gaps in the knowledge base on the causal factors and mechanisms of bighorn sheep die-offs and disease transmission between these species, the vast majority of literature supports the potential for disease transmission between the species, documents bighorn sheep die-offs near domestic sheep, and supports the management option of keeping these species separate to prevent disease transmission. Further, there is no peer reviewed literature that suggests bighorn sheep can be grazed with domestic sheep without concern for disease transmission between the species. Scientists from both sides of the issue also recommend that the species be kept separate until the disease transmission science is better understood.

The analysis conducted in this document recognizes these uncertainties but clearly focuses on the Forest Service's responsibility to provide habitats that support viable populations of bighorn sheep, particularly given the risks that the species currently faces relative to the devastating impacts of disease.

Management Recommendations

Leading bighorn sheep disease experts recommend separating bighorn sheep from domestic sheep, either spatially, temporally, or both, (Schommer and Woolever 2001, Singer et al. 2001, Garde 2005). Experts also recommend developing site-specific solutions for each bighorn sheep population and domestic sheep allotment and developing a management strategy appropriate for the complexity of the management situation (Schommer and Woolever 2001). Each of the alternatives takes this approach; however, given the complexity of the issue on the Payette National Forest, each alternative has pros and cons associated with minimizing the risk of contact between domestic and bighorn sheep.