

**State:** South Dakota

**Project No.:** W-75-R

**Study No.:** XXXX

**Project Title:** Wildlife Research

**Study Title:** Determining the role of chronic shedders in respiratory disease persistence, annual lamb recruitment, and transmission in bighorn sheep.

**Need:**

Pneumonia disease in bighorn sheep (*Ovis canadensis*) is a major factor affecting the health and recruitment in free-ranging herds across the western North America (Bunch et al. 1999). The disease has negatively affected the potential of herds to restore the species throughout their distribution (Gross et al. 2000, Cassirer and Sinclair 2007). Pneumonia disease can result in large-scale epizootics during which > 90% of the population can die (Woodard et al. 1974, Spraker et al. 1984, Gross et al. 2000, Monello et al. 2001). Subsequent to these epizootics, surviving ewes continue to conceive and bear lambs but lamb recruitment can remain low due to peak susceptibility to mortality at 6–11 weeks of age (Woodard et al. 1974, Cook et al. 1990, Foreyt 1990, Cassirer et al. 2001, Cassirer and Sinclair 2007, Smith et al. 2014). Consequently, the disease can continue to persist and contribute to periodic or annual outbreaks causing greater than 90% mortality to lambs (Cassirer et al. 2013, Smith et al. 2014a).

Causal mechanisms for this persistence and mortality in juveniles are poorly understood, and little is known about patterns of respiratory pathogen infection and disease transmission dynamics in bighorn sheep. However, observations on herds following epizootics (Edwards et al. 2010, Sirochman et al. 2012, Cassirer et al. 2013, Plowright et al. 2013) indicate that 1) surviving ewes in populations that have experienced pneumonia epizootics have some level of resistance to the disease but continued lamb mortality likely results from some individuals acting as carriers of pneumonia pathogens, 2) age of lambs at death and life history characteristics of bighorn sheep indicate that pathogens are transmitted to susceptible lambs by chronically infected ewes post-parturition or by other infected lambs when ewes and lambs congregate in nursery groups, and 3) lambs born to disease-resistant ewes are susceptible to pneumonia; thus, transfer of passive immunity from ewes to lambs is not sufficient to prevent mortality.

These characteristics lead to the main hypothesis that respiratory disease persists within bighorn sheep populations through the survival of a small number of chronic shedders that extend epizootics via lamb mortality in bighorn sheep herds. Proof of concept data in support of this hypothesis were collected in 2014 (J. A. Jenks, F. E. Cassirer, T. E. Besser, D. P. Walsh, unpublished data): 6 pregnant ewes (3 classed as chronic shedders and 3 classed as non-shedders based on repeated testing) were transferred from free-ranging herds in Washington and Oregon to separate pens at South Dakota State University. All non-shedder ewes lambed and lambs remained alive. In contrast, 2 of 3 chronic shedder ewes lambed and both lambs died within 6 weeks of birth; cause of death was pneumonia and the pathogen present was *Mycoplasma ovipneumoniae* (*Mo*). Individual ewe shedding status remained constant. If chronic shedders extend pneumonia epizootics in bighorn sheep herds, then removal of individuals responsible for extending epizootics has the potential to enhance survival of lambs and subsequent recruitment in these herds.

Rocky Mountain bighorn sheep (*O. c. canadensis*) were introduced into Custer State Park (CSP) from Whiskey Mountain, Wyoming in 1964; the Park population increased to 150 animals by 1975 (Trefethen 1975). Bighorn sheep were reintroduced into the Stratobowl area of Spring Creek (SC) in the Black Hills National Forest from Georgetown, Colorado in 1991 and from Badlands National Park, South Dakota in 1992. This population, referred to as the Rapid City herd, increased and separated into 3 subherds; of which there is one non-migratory subherd, occupying the original transplant site (SC herd), and a migratory subherd, summering near Johnson's Siding and wintering in Dark Canyon (DC herd). Currently, the Rapid City herd includes the original Spring Creek subherds in addition to Rapid Creek and Hill City subherds (South Dakota Game, Fish and Parks 2013). The Rapid City and Custer State Park herds have experienced pneumonia epizootics (Demartini and Davies 1977, Smith et al. 2014a). Smith et al. (2014a) evaluated lamb survival in the Rapid City subherds and concluded that significant mortality occurred due to presence of *Mo*. Furthermore, biological samples from the Custer State Park and Rapid City herds indicate that the *Mo* present was of one stain, suggesting that contact and transmission of pathogens occurred between bighorn sheep and one or a few domestic herds within the Black Hills region (Besser et al. 2012, T. E. Besser, Washington State University, person. commun.). Preliminary serial data collected on pathogens in bighorn sheep in Rapid City (J. Smith, South Dakota State University, unpublished data) and Custer State Park (C. Lehman, South Dakota Game, Fish and Parks, unpublished data) indicate the potential presence of chronic shedders that are likely responsible for the extended epizootic and limited lamb recruitment in the Black Hills. Thus, information that would characterize these "chronic shedders" and result in their strategic removal could improve lamb survival and recruitment in the Black Hills Region.

### **Objectives:**

- Assess the efficacy of obtaining serial samples for classing free-ranging bighorn sheep as chronic shedders, indeterminate shedders, or negatives (non-shedders) in Custer State Park and Rapid City herds.
- Determine if bighorn sheep ewes surviving a past respiratory disease epizootic in Custer State Park and Rapid City herds as pathogen carriers exhibit differences in physical appearance and/or behaviors that are correlated with pathogen shedding status.
- Determine if removal of individuals that exhibit pathogen shedding patterns improve survival of free-ranging bighorn sheep lambs within the Custer State Park herd.

### **Approach:**

The study will be conducted using two bighorn sheep herds; Rapid City (RC) and Custer State Park (CSP). Both herds suffer from low recruitment due to pneumonia epizootics. The RC herd will serve as the control herd and the CSP herd will serve as the treatment herd. We will capture adult ewes using a drop-net baited with weed-free alfalfa hay, helicopter net gun, or by chemical immobilization with a dart gun from the ground (BAM; 0.43 mg/kg butorphanol, 0.29 mg/kg azaperone, 0.17 mg/kg medetomidine). We will evaluate pregnancy status of ewes via ultrasonography (Universal Ultrasound, Bedford Hills, NY, USA) at the time of capture and fit pregnant ewes with very high frequency (VHF) radio collars (Advanced Telemetry Systems; Isanti, MN) and vaginal implant transmitters (VITs, Smith et al. 2014a). To confirm the shedding-class assignment of ewes within CSP and RC herds, we will collect multiple samples from individuals using oropharyngeal and nasal swabs and nasal washes until lambing to confirm the documented shedding patterns of *Mo* and bacterial species within the family Pasteurellaceae. In particular, in addition to *Mo*, the shedding of leukotoxin A (lkt-A) positive *Mannheimia haemolytica*

(*Mh*) is of recognized importance. We will use conventional PCR methods to detect *Mo* and *Mh* after amplification in *Mycoplasma* broth and on blood agar plates, respectively. We also will quantify *Mo* and *lktA* in nasal and pharyngeal swabs, respectively, using real time PCR. Finally, we will employ conventional culture methods to detect and estimate the numbers of viable Pasteurellaceae. Based on monthly sampling results, bighorn sheep will be classed as Chronic Shedder, Indeterminate Shedder, or Negative.

Radio collared ewes will be monitored for movement patterns indicative of parturition, and for the presence of new born lambs via radio-telemetry and visual observation from a distance on a daily basis (Smith et al. 2014a,b). Behavior and condition of classed ewes will be evaluated by noting ears (upright or drooping), presence of nasal mucus, distance to nearest herd member, and other characteristics. New born lambs will be captured using the techniques outlined by Smith et al. (2014b). Lambs will be physically restrained, blindfolded, and fitted with an expandable, 62g VHF collar equipped with a 6-hr mortality switch (Model M4210; ATS). In addition, biological data of interest (e.g., sex, age, weight) will be collected from captured lambs. Lambs will be monitored post capture using telemetry to determine if lambs died or were abandoned as a result of our capture activities. Handling time will be limited to < 5 minutes.

Lambs and ewes will be monitored daily for 60-days post-capture and 3–4 times/week thereafter from the ground using a receiver and hand-held directional antenna or from a Cessna 182 airplane (Smith et al. 2014a). When detecting a mortality signal, we will immediately locate the collar, and record evidence at the site of mortality to determine cause of death. In addition, we will transport carcasses to the Washington Animal Disease Diagnostic Laboratory at Washington State University for further examination. Mortalities will be classed as predation (based on observations at the mortality site including, bite marks, caching, plucking, blood, and consumption of carcass), disease, or other. During the second year of the study, chronic shedders will be removed from the CSP herd (treatment herd) and transported to South Dakota State University. Transported chronic shedders will be used to further validate pathogen status and their impact on lamb survival. To estimate survival and determine factors influencing lamb survival for study herds, we will evaluate experimental (i.e., control, treatment) effects (pre and post removal of chronic shedders) and other sources of mortality (e.g., predation) using the known fate model in Program MARK (White and Burnham 1999).

### **Expected Benefits:**

Low to nonexistent recruitment post-pneumonia epizootic has frustrated managers of bighorn sheep populations because of the lack of options for facilitating herd recovery and growth. Development of techniques that will enhance survival of bighorn sheep lambs post pneumonia disease epizootic will improve recruitment in bighorn sheep herds in the Black Hills and other regions of the west in bighorn sheep range and thus, provide science-based options for bighorn sheep managers.

**Estimated Project Cost:**

	YR1	YR2	YR3	Total
Graduate Student	\$ 18,600.00	\$ 19,000.00	\$ 19,500.00	\$ 57,100.00
PI Salary	\$ 3,500.00	\$ 3,500.00	\$ 3,500.00	\$ 10,500.00
Travel and Mileage	\$ 10,000.00	\$ 10,000.00	\$ 500.00	\$ 8,500.00
Telemetry Equipment	\$ 54,000.00	\$ 36,000.00	\$ 00.00	\$ 18,000.00
Capture	\$ 25,000.00	\$ 25,000.00	\$ 00.00	\$ 50,000.00
Flight Time	\$ 2,000.00	\$ 2,000.00	\$ 00.00	\$ 4,000.00
Feed, Field Equip. Laboratory Analyses	\$ 12,000.00	\$ 9,000.00	\$ 9,000.00	\$ 33,000.00
<b>Sub-total</b>	<b>\$ 125,100.00</b>	<b>\$ 104,500.00</b>	<b>\$ 32,500.00</b>	<b>\$ 262,100.00</b>
Indirect (5%)	\$ 6,255.00	\$ 5,225.00	\$ 1,625.00	\$ 13,105.00
Tuition Remission	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 9,000.00
<b>Total</b>	<b>\$ 134,355.00</b>	<b>\$ 112,725.00</b>	<b>\$ 37,075.00</b>	<b>\$ 284,205.00</b>

**Location:**

Custer State Park and Hill City-Rapid City Region of the Black Hills, and South Dakota State University, South Dakota.

**Project Duration:**

Start date – 1 July 2015  
End date – 30 June 2018

**Personnel:**

- Jonathan A. Jenks, Distinguished Professor, Department of Natural Resource Management, South Dakota State University.
- Chad Lehman, Wildlife Biologist, South Dakota Department of Game, Fish and Parks, Custer State Park, South Dakota.
- John Kanta, Regional Wildlife Manager, South Dakota Department of Game, Fish and Parks, Rapid City, South Dakota.
- Frances E. Cassirer, Bighorn Sheep Biologist, Idaho Department of Game and Fish, Lewiston, Idaho.
- Thomas E. Besser, Professor, College of Veterinary Microbiology and Pathology, Washington State University, Pullman, Washington.
- Daniel P. Walsh, Disease Ecologist, USGS Health Services Laboratory, Madison, Wisconsin.

**Related Federal Projects**

Study No. 7552, Population parameters of bighorn sheep inhabiting the Elk Mountain region of South Dakota and Wyoming. Study No. 7556, Evaluation of the Deadwood bighorn sheep herd translocation.

### **Animal Welfare Act**

This project involves treatment of live animals. Methods will follow recommendations of the American Society of Mammalogists (Sikes et al. 2011) and will be approved by the Institutional Animal Care and Use Committee at South Dakota State University.

### **Threatened and Endangered Species**

This project involves the use of wild and captive bighorn sheep. We do not anticipate impacts to Threatened or Endangered Species.

### **Environmental Assessment**

This project involves the study of wild and captive bighorn sheep. This proposed project does not involve destruction of habitat or the introduction of terrestrial or aquatic organisms or contaminants into the environment. Therefore, this study qualifies as a categorical exclusion from the NEPA process as described in the Department of the Interior Manual, Part 516, Chapter 8, Section 8.5, B(1), dated 27 May 2004.

This proposal does not have significant adverse effects on public health or safety. This proposal does not have significant adverse effects on such natural resources and unique geographic characteristics as historic or cultural resources; park, recreation or refuge lands; wilderness areas; wild or scenic rivers; national natural landmarks; sole or principal drinking water aquifers; prime farmlands; wetlands (Executive Order 11990); floodplains (Executive Order 11988); national monuments; migratory birds (Executive Order 13186); and other ecologically significant or critical areas under Federal ownership or jurisdiction.

This proposal does not have highly controversial environmental effects or involve unresolved conflicts concerning alternative uses of available resources [NEPA Section 102(2)(E)]. This proposal does not have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks.

This proposal does not have a precedent for future action or represent a decision in principle about future actions with potentially significant environmental effects.

This proposal does not have a direct relationship to other actions with individually insignificant but cumulatively significant environmental effects.

This proposal does not have significant adverse effects on properties listed or eligible for listing on National Register of Historic Places as determined by either the bureau or office, the State Historic Preservation Officer, the Tribal Historic Preservation Officer, the Advisory Council on Historic Preservation, or a consulting party under 36 CFR 800.

This proposal does not have significant adverse effects on species listed, or proposed to be listed, on the List of Endangered or Threatened Species, or have significant adverse effects on designated Critical Habitat for these species.

This proposal does not have the possibility of violating a Federal law, or a State, local or tribal law or requirement imposed for the protection of the environment.

This proposal does not have the possibility for a disproportionately high and adverse effect on low income or minority populations (Executive Order 12898).

This proposal does not have the possibility to limit access to and ceremonial use of Indian sacred sites on Federal lands by Indian religious practitioners or significantly adversely affect the physical integrity of such sacred sites (Executive Order 13007). This proposal does not have the possibility to significantly contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area or actions that may promote the introduction, growth, or expansion of the range of such species (Federal Noxious Weed Control Act and Executive Order 13112).

### **Prime and Unique Farmlands**

This project involves the use of wild and captive bighorn sheep and will have no impact on prime or unique farmlands.

### **Historical and Cultural Resources**

This project does not involve soil disturbance activities.

### **Environmental Justice (Executive Order 12898)**

This project will have no impact on environmental justice issues.

### **Invasive Species (Executive Order 13112)**

This project will not promote the introduction or spread of invasive species.

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