TO: Parks and Wildlife Commissioners  
FROM: Rick D. Cables, Director  
RE: Approval to translocate bighorn sheep out of state  
DATE: March 1, 2013

CPW administrative directive W-23 requires that all movements of big game animals out of state require the approval of the Director and the Commission. In keeping with this directive, I am requesting that the Commission approve the transfer of the remnant bighorn ewes in Gribble’s Park to Washington State University or one of its collaborators, the Wyoming Game & Fish Department, for use in captive research on bighorn sheep respiratory disease. This action will also facilitate depopulation of this area so that future transplants of productive bighorn sheep into Gribble’s Park can occur.

Enclosed you will find a document that provides the background for this requested action, a letter of request from Washington State University, and a publication that highlights our efforts to try and treat these sheep and make them a productive population that subsequently failed.
TRANSFER OF “Gribble’s Park” bighorn ewes to WASHINGTON STATE UNIVERSITY

Background

Over the last decade, the remnant “Gribbles Park” bighorn herd (a part of bighorn sheep unit S-47) has dwindled in numbers to fewer than ~10 surviving individuals and has now reached the point that managers no longer regard the herd as viable (Figure). No lambs born into this herd have survived to December since 2009, and respiratory disease in young lambs appears to be the cause of the decline. The herd has not responded to exhaustive efforts to remedy the underlying disease problem (Table). (The recent history and CPW’s management effort are summarized in the attached publication.)

Responsible Southeast Region CPW managers and agency veterinarians met on 20 February 2013 and agreed that eliminating the remnant herd (followed by restocking this range with bighorns from a healthy herd) appears to be the best management strategy at this point in time based on previous success with this approach elsewhere in Colorado. Their plan calls for removing the remaining resident animals this winter (or next fall, if delays arise) and then reintroducing healthy bighorns next winter.

Of the choices for disposition of the few (~6) remaining females in Gribbles Park, capturing and donating them for use in respiratory disease research was identified as the preferred option. Washington State University has requested bighorn sheep from unhealthy herds for use in their research to study lamb pneumonia and strategies for its control. (Their request also is attached.) The proposed research complements ongoing studies on bighorn respiratory disease management in Colorado and elsewhere that involves several collaborating agencies including CPW and the Wyoming Game & Fish Department.

Because the remnant bighorn ewes in Gribbles Park meet the criteria outlined in the WSU request, we recommend that these bighorn ewes be captured and transferred to WSU or one of its collaborators (most likely WGFD) for captive research purposes.

Action

In keeping with existing policy, CPW staff requests that the Colorado Parks & Wildlife Commission approve the transfer of the remnant bighorn ewes in Gribbles Park to Washington State University or one of its collaborators for use in captive research on respiratory disease.
Dear Director Cables,

As you may be aware, Professor Srikumaran’s laboratory at Washington State University has undertaken research to investigate the transmission dynamics of lamb pneumonia in bighorn sheep. To help facilitate this important research, we are requesting 4–6 bighorn ewes that survived a recent pneumonia epizootic in Colorado for use in our study.

**Background:** Bighorn sheep (*Ovis canadensis*) once estimated at 2 million, have now declined to less than 70,000 animals. Multi-bacterial pneumonia, causing up to 90% mortality in affected herds, is the most important cause of this drastic decline. This problem initially manifests as an “all-age” die-off, but subsequently becomes enzootic and results in recurring lamb losses. Many affected herds have declined dramatically and become remnant due to poor lamb recruitment. It is, therefore, critical to understand the transmission dynamics of bighorn pneumonia to prevent future die-offs and to ensure herd viability.

**Our Study:** Our planned study will investigate factors underlying poor lamb survival in bighorn herds in the years following a pneumonia outbreak. We expect to develop a model for transmission of pneumonia in bighorns, especially transmission to lambs within a herd. Revealing factors that affect dynamics of pneumonia and survival in lambs will contribute to broader understanding of bighorn pneumonia and help identify potential management approaches. This work also will contribute to more general understanding disease dynamics in wildlife populations and the immunological basis for population susceptibility to diseases. This knowledge will help in conservation of bighorns and perhaps other wild sheep and goat species.

In order to investigate the transmission of pathogens to lambs in a herd, we plan to keep in captivity and sample pregnant ewes from herds with history of a pneumonia outbreak and/or recurrent lamb die-offs. These ewes would, in effect, be recovered ewes. We will determine the pathogen status of these ewes through regular sampling. Once their lambs are born, we will monitor them as well, for pathogen status and how/whether that determines their survival. Based on this information, we will develop a model for predicting lamb survival based on pathogen status of its ewe.

**Role of Colorado Parks & Wildlife:** Three groups of ewes, each from a geographically distinct area and each consisting of 4-6 recovered ewes, will be used for this study. One such group is already in captivity at WSU and was part of a pilot study that demonstrated transmission of pathogens from recovered to naïve animals. One other group will be donated by the Montana Game, Fish, & Parks Department. We are hoping that Colorado Parks & Wildlife can collaborate by providing us with the third group of recovered pregnant ewes. These animals will be housed at the Wyoming Game & Fish Department facility at Sybille. We would like to request the Colorado Parks and Wildlife Department to kindly donate up to 6 ewes that are pregnant (known, or likely to be) and that belong to a herd that has recovered from a pneumonia outbreak and that shows related persistent lamb mortalities.

**Importance and Impact of the Study:** We believe our findings will have long-term impact on disease management and conservation in wild sheep populations not only in North America, but all over the world. The results of this study will also be of great interest and benefit to several wild sheep-goat conservation and hunting organizations including WAFWA, the USFWS, the Foundation for Wild Sheep, Safari Club, Northern Wild Sheep-Goat Council, etc. We sincerely hope that you can help us out with this project and look forward to your cooperation and support. Kindly let us know if you require further information or clarifications regarding the project and outcomes.

Thank you for your consideration.

Sincerely,

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Evaluation of Management Treatments Intended to Increase Lamb Recruitment in a Bighorn Sheep Herd

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ABSTRACT: We administered a suite of treatments to a herd of Rocky Mountain bighorn sheep (Ovis canadensis canadensis) that was experiencing poor lamb recruitment and showing signs of respiratory disease. Despite 3 yr of treatment with various combinations of anthelmentics, antibiotics, vaccines, and hyperimmune serum products, recruitment was not improved.

Key words: Bibersteinia trehalosi, bighorn sheep, Mannheimia spp., Pasteurellaceae, pasteurellosis, Ovis canadensis, recruitment, respiratory disease.

Respiratory disease, typically observed as acute to chronic pneumonia, represents one of the most significant threats to the long-term viability of bighorn sheep (Ovis canadensis) populations throughout western North America. Pneumonia epizootics in bighorn herds occur with variable frequency and severity (Marsh, 1938; Cassirer and Sinclair, 2007; George et al., 2008; Wolfe et al., 2010; and references therein). Years of depressed recruitment often follow such epizootics, adding to population suppression and hindering recovery (e.g., George et al., 2008; Wolfe et al., 2010). Although lamb pneumonia appears primarily responsible for depressed recruitment, determining the cause of mortality is sometimes difficult because carcasses are not available for necropsy. Bacteria species in the family Pasteurellaceae are often isolated from pneumonic bighorn sheep and have been implicated in the associated pathology (Onderka et al., 1988; George et al., 2008; Wolfe et al., 2010; Miller and Wolfe, 2011). Few tools are available for wildlife managers to use in protecting or recovering bighorn sheep populations from respiratory disease (Cassirer et al., 2001; George et al., 2008, 2009; Wolfe et al., 2010). Here we describe a suite of treatments used in an attempt to increase lamb recruitment in a free-ranging bighorn sheep herd.

The Badger Creek bighorn sheep herd winters in the vicinity of Gribbles Park (38°38’34”N, 105°47’34”W), about 21 km northeast of Salida, Colorado, USA. The immediate area is characterized by mountainous terrain with open southern slopes and timbered northern slopes at an elevation of 2,680 m above sea level. Average annual precipitation is 38–50 cm. This herd was started with a translocation of 19 adult bighorns in 1990 from the Rampart Range herd (George et al., 2009) and reached an estimated peak size of about 62 animals in 2005 (K. J. Woodruff, unpubl. data). Annual lamb recruitment to winter (December–February) generally remained at ≥16 lambs prior to 2000 based on observation of animals on bait sites (K. J. Woodruff, unpubl. data). Annual lamb recruitment to winter (December–February) generally remained at ≥16 lambs prior to 2000 based on observation of animals on bait sites (K. J. Woodruff, unpubl. data). However, annual lamb recruitment has been depressed since at least 2004 with no more than seven lambs surviving (lambs: 100 females ±15.2 [SE=5.3]; Table 1).

Each winter from the late 1990s through 2007, the Colorado Division of Wildlife (CDOW) fed bighorns in this herd both alfalfa hay and apple pulp daily for an average of 5 wk, the latter laced once or twice each winter with fenbendazole (about 3 g per ewe per treatment) with the intent of reducing lungworm (Protostrongylus spp.) burdens (Miller et al., 2000; K. J. Woodruff, unpubl. data). Historically there had been no known die-offs of significant numbers of bighorns in the area; however, managers indicated that the adult population began...
decreasing around 2001, and reported finding at least five adult bighorn skulls in different locations between 2005 and 2009. No carcasses were recovered, so cause of death was not determined in any of these cases. In March 2008, local managers noted that some adults were coughing and had mucopurulent nasal discharge and that the 2007 cohort lambs were absent from the Badger Creek herd. We captured most of the known females in this herd (22 of 25) and two males under a drop net, collected blood for serology and oropharyngeal swabs for bacterial culture (University of Idaho, Caldwell, Idaho), and administered tulathromycin (Draxxin®, Pfizer Animal Health, New York, New York, USA); doramectin (Dectomax®, Pfizer Animal Health); Mannheimia haemolytica serotype 1 vaccine (One Shot®, Pfizer Animal Health); multivalent respiratory virus vaccine (Triangle® 4 + type II BVD, Fort Dodge Animal Health, Fort Dodge, Iowa, USA); intranasal hyperimmune sera (RP-Bridge and M-Bridge, VDx, Inc., Newburg, Wisconsin, USA); no treatments.

In February 2009 we captured 18 of the approximately 34 (50%) known animals in the herd by drop net for treatment (Table 1); this timing was based on when the animals would come consistently to bait. In addition to repeating treatments with tulathromycin and doramectin as above, we administered a Mannheimia haemolytica serotype 1 bacterin-toxoid (One Shot®, Pfizer Animal Health, 2 ml subcutaneously), a multivalent, killed respiratory virus vaccine (Triangle® 4 + type II BVD, Fort Dodge Animal Health), and two hyperimmune serum products (RP-Bridge and M-Bridge, VDx, Inc., Newburg, Wisconsin, USA, about 2 ml each, sprayed intranasally). Blood and oropharyngeal swabs were collected and screened as above. In addition, an enzyme-linked immunosorbent assay (ELISA; Confer et al., 2003) was used to measure serum antibody levels to both M. haemolytica leukotoxin and M. haemolytica T

<table>
<thead>
<tr>
<th>Winter</th>
<th>Herd treatments</th>
<th>Lambs</th>
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<th>Lambs: 100 ewes</th>
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<tr>
<td>2004–2005</td>
<td>F,B</td>
<td>7</td>
<td>46</td>
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<tr>
<td>2005–2006</td>
<td>F,B</td>
<td>5</td>
<td>35</td>
<td>14.3 (SE=5.9)</td>
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<tr>
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<td>F,B</td>
<td>2</td>
<td>34</td>
<td>5.9 (SE=4.0)</td>
</tr>
<tr>
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<td>F,T,D</td>
<td>0</td>
<td>25</td>
<td>0.0</td>
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<tr>
<td>2008–2009</td>
<td>F,T,D,M,R,H</td>
<td>2</td>
<td>23</td>
<td>8.7 (SE=5.9)</td>
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<tr>
<td>2010–2011</td>
<td>N</td>
<td>0</td>
<td>16</td>
<td>0.0</td>
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* F = fed hay and apple pulp daily; B = oral fenbendazole once or twice per winter; T = tulathromycin (Draxxin®, Pfizer Animal Health, New York, New York, USA); D = doramectin (Dectomax®, Pfizer Animal Health); M = Mannheimia haemolytica serotype 1 vaccine (One Shot®, Pfizer Animal Health); R = multivalent respiratory virus vaccine (Triangle®, 4 + type II BVD, Fort Dodge Animal Health, Fort Dodge, Iowa, USA); H = intranasal hyperimmune sera (RP-Bridge and M-Bridge, VDx, Inc., Newburg, Wisconsin, USA); N = no treatments.

Based on bacterial culture results and similarity to patterns seen in other affected bighorn herds (Cassirer and Sinclair, 2007; George et al., 2009; Miller and Wolfe, 2011; L. L. Wolfe, unpubl. data), we attributed the recruitment problems to respiratory disease. Despite treatment, lamb recruitment through December remained low in 2008 (Table 1).
whole cells (Oklahoma State University, Stillwater, Oklahoma, USA). Analysis of samples identified *B. trehalosi* (biogroup 4 and several biogroup 2 variants), *Mannheimia glucosida*, several *Mycoplasma* spp., and antibodies to PI3 virus. At the time of capture, levels of antibodies to both leukotoxin and whole cells were relatively low as indicated by mean ELISA optical density (OD) values (Fig. 1; Sirochman, 2011). Adult survival appeared stable and lamb recruitment through December remained poor in 2009 (Table 1). During January and February 2010 fewer bighorns came to bait at Badger Creek than in previous years. Managers believed that other individuals were alive but were avoiding the trap site. Because even the bighorns coming to bait became leery of the trap, only 10 were recaptured (via darting) and administered bacterin-toxoid, multivalent respiratory virus vaccine, tulathromycin, and doramectin (6 of 10 animals) as above (Table 1). Between 2 wk and 2 mo later, 8 of those 10 individuals were recaptured and all four treatments were again applied to each animal. Blood and oropharyngeal swabs were collected at each capture. Nine additional individuals were darted with doses of bacterin-toxoid that winter. Cultures still yielded *B. trehalosi* (biogroup 4 and biogroup 2 variants), several *Mannheimia* spp. strains, and *Mycoplasma* spp. Sera from bighorns captured in January and February 2010 (before receiving vaccine that year) had mean ELISA OD values that suggested concentrations of serum antibodies against *M. haemolytica* antigens were comparable to those measured in 2009 (differences in mean ± standard error OD values ≤ −0.02 ± 0.015; Fig. 1). However, mean OD values in sera from the eight recaptured individuals showed about a four-fold increase over mean values from samples collected earlier in the year (differences in mean ± standard error OD values ≥ 0.072 ± 0.018; Fig. 1), suggesting evidence of humoral immune responses to *M. haemolytica* antigens presumably stimulated by vaccination. No lambs from spring 2010 survived to December 2010 (Table 1).

Despite these aggressive herd health management efforts, the suite of treatments that we administered to the Badger Creek herd apparently did not improve lamb recruitment in any of the 3 yr in which these treatments were applied (Table 1). Overall, we do not know whether the treatments we applied were ineffective, or were insufficient or inappropriate with respect to remedying the cause of poor lamb recruitment in the Badger Creek herd. Weiser et al. (2009) noted that a single dose of antibiotics was unlikely to eliminate *Pasteurellaceae* from free-ranging bighorn sheep captured for translocation, and that antibiotic treatment with oxytetracycline actually appeared to increase the proportion of β-hemolytic isolates cultured after treatment. Miller et al. (1997) did not observe a change in *Pasteurellaceae* isolation rates as a result of vaccination with a *Pasteurellaceae* subcomponent vaccine despite stimulation of antibody responses. Cassirer et al. (2001) also were unable to improve
lamb survival by vaccinating female big-
horns in late pregnancy with an experi-
mental *B. (Pasteurella) trehalosi* and *M.
haemolytica* vaccine, and a commercially
available bovine *M. haemolytica* and
*Protostrongylus multocida* combination
vaccine (PRESPONSE7 H-M, Fort
Dodge Laboratories, Inc.). Treatments
may require repeated application to be
effective, and this may not be feasible in
a free-ranging population. Based on our
experiences, it seems clear that developing
alternative management strategies will be
necessary to control or eliminate respira-
tory-disease–associated recruitment prob-
lems in bighorn sheep effectively.

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