

A Review of Bighorn Sheep Articles used for the Payette DSIES  
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Introduction

The Payette National Forest DSEIS calls for separation between bighorn sheep and domestic sheep. The result will be closure of some domestic sheep grazing allotments and reduction of grazing area for domestic sheep on others. The end result will be the going out of business of several if not all of the permittees on the Payette National Forest. Furthermore, the acceptance of this plan will, no doubt be the template for closure of all other allotments all over the West which have the potential of bighorn sheep visitation.

Transmission of disease to the bighorns by the domestic sheep is the only reason cited for disallowing the domestic sheep on parts of the forest. The purpose of this paper is to review the information cited to justify the closures. The Payette DSEIS is relying heavily on wildlife biologists and their testimony. Unfortunately, wildlife biologists are not disease experts and they are relying heavily on assumptions. The "Risk Analysis of Disease Transmission Between Domestic Sheep and Bighorn Sheep on the Payette National Forest" the (RADT), a document prepared by 6 wildlife biologists, none disease experts, microbiologists or mathematicians is such evidence. Another document authored by two wildlife biologists specifically for ammunition against the domestic sheep is "A Review of Disease Related Conflicts Between Domestic Sheep and Goats and Bighorn Sheep" (Conflict Review), a review using other reviews and interpretation of other non-disease expert authors. Therefore, this document will concentrate on many of those references and examine exactly what they did report plus other papers which were significant in the fact that they were left out of the above reviews.

The Disease in Bighorns

T.R. Spraker and C.P. Hibler describe the clinical aspect of the pneumonia complex of bighorn sheep in "*An overview of the clinical signs, gross and histological lesions of the pneumonia complex of bighorn sheep*" in the Proceedings of the Third Biennial Symposium of the Northern Wild Sheep and Goat Council (1982) 3: 163-172, and is just one of the articles not included in either of the above documents.

*"The pathogenesis of this fibrinopurulent bronchopneumonia that occurs in the all-age die-offs appears to be stress induced. Animals normally carry bacterial agents of low pathogenicity in their upper respiratory system and have low to heavy lungworm burdens. These sheep become stressed by some means such as encroachment by man or his domestic animals, loss of range, crowding, change of range conditions, lack of water, inclement weather, deep snow, malnutrition, captivity, dust, etc. This "stress" leads to an adrenal cortical hyper function and elevated serum cortisol. Increased cortisol causes the animal to be less resistant to the*

57 *microbiological agents of low pathogenicity already within the animal. This either allows the*  
58 *bacteria to proliferate and invade the depths of the lungs or inhibits the body's mechanisms of*  
59 *removing bacteria that are inhaled into the depths of the lungs. The bacteria then proliferate*  
60 *within small bronchioles and induce inflammation. If the bacteria multiply rapidly and are*  
61 *moderately pathogenic, such as with Pasteurella, the animal may die quickly; or if the bacteria*  
62 *multiply more slowly, a subacute to chronic bronchopneumonia will develop. Heavy burdens of*  
63 *lungworms alone can initiate a bronchopneumonia as with the verminous pneumonia of lambs,*  
64 *but in many cases, the lungworms, as with many of the bacteria, are one of the low pathogenic*  
65 *agents that proliferate under stress conditions. (p. 168-169).*  
66

67 Here, Dr. Spraker, a wild life veterinarian from Colorado State University, acknowledges  
68 that stress is a major factor in the pneumonia caused by bacteria already present in their system,  
69 causing the die-offs experienced by free roaming bighorn sheep. This reference oddly enough  
70 was not included in either the Risk Analysis or the Conflict Review, perhaps because it did not  
71 implicated domestic sheep as causing the condition.  
72

73 It should be noted that the *Protostrongylus spp.* lungworm present in bighorns is host-  
74 specific to bighorns and does not occur in domestic sheep. In times past, however, lung worms,  
75 too, were blamed on domestic sheep. However, they are recognized as one of the players in the  
76 pneumonia complex. "*Transplacental transmission of heavy lungworm burdens with maturation*  
77 *of the parasites when the lambs are 3.5 to 4.5 weeks old appears to be the most important*  
78 *predisposing factor for the verminous type of summer-lamb mortality", according to Spraker and*  
79 *Hibler.*  
80

81 Callan, et al. in the Journal of Veterinary Medicine, Mar. 1991, also describe several  
82 hypotheses concerning pasteurellosis in bighorn sheep. They state: "*Pasteurella spp. are*  
83 *obligate bacteria (meaning it can't live outside the live animal for any period of time.), localized as*  
84 *a potential pathogen in respiratory tracts of carrier animals. Just prior to an epizootic, the carrier*  
85 *rate may rise precipitously. (This has been shown to happen in feedlot lambs) When stresses are*  
86 *applied to a bighorn sheep population (e.g. poor forage conditions, high population density,*  
87 *inclement weather, and human disturbance), the host's resistance is lowered, concomitantly with*  
88 *increased virulence of Pasteurella spp, and the clinical disease ensues. He describes the*  
89 *following possibility as well, "Pasteurella spp are ubiquitous bacteria found in the nasal passages*  
90 *and sinuses and throats of various animals including bighorn sheep, suggesting that it is a normal*  
91 *flora of the upper respiratory tract. Pasteurella would then be considered as opportunist or*  
92 *secondary invader when the clinical disease develops. This has given support to the pneumonia*  
93 *complex theory that pasteurellosis is triggered by predisposing viruses or lungworm infection."*  
94 *(This is the scenario seen in the shipping fever complex affecting cattle.) His third hypothesis is*  
95 *"Pasteurella spp. may not be a part of the normal flora in the upper respiratory tract of bighorn*  
96 *sheep, and whenever a bighorn sheep contracts natural carriers, pasteurellosis ensues and leads*  
97 *to high mortality" He goes on to say, "In reality, all 3 postulates might be valid under specific*  
98 *circumstances."*  
99

100 Since Callen wrote his paper, isolation and identification of several species and  
101 numerous biotypes of *Pasteurella spp.* from normal as well as sick bighorn sheep by Caine  
102 Center researchers and others point to the first and second hypothesis and likely account for die-  
103 off of free- ranging bighorn sheep. Work by Fisher et. al, 1999 Am. J. Vet. Res. and Stiffow , et  
104 al. 1994. Susceptibility of phagocytes from elk, deer, bighorn sheep and domestic sheep to  
105 *Pasteurella haemolytica cytotoxins.* J. of Wildlife Disease. have revealed that some *Pasteurella*  
106 *spp.* possess virulence factors which enhance their ability to cause disease in the face of  
107 stresses. Many of the "commensals" contain various virulence factors i.e. leukotoxin and SOD C.  
108 Whereas, in studies where the two species have been penned together, the third hypothesis is  
109 quite likely the situation as some highly virulent biotypes of *Pasteurella*, more common, but not

110 exclusive to domestic sheep have appeared to be transmitted when the animals are forced to  
111 have prolonged contact.

112  
113 However, contrasted to the penned experiments, extensive culturing and use of  
114 fingerprinting techniques for identity of organisms causing the death of free ranging bighorn in  
115 die-offs studied by the Caine Veterinary Teaching Center, there have been no common  
116 organisms found.

117  
118 A number of reports mostly found in Proceedings of wildlife meetings cite lists of bighorns  
119 dying after coming into contact with domestic sheep. At best, these incidences have all been  
120 based on circumstantial evidence and when examined more closely, most of these incidents  
121 implicate other causes.

122  
123 Analysis of a review article cited three times in the DSEIS.

124  
125 Kevin Martin, Tim Schommer and Victor Coggins authored a document referenced in  
126 both the RADT and the Conflict Review document and the DSEIS, entitled Literature Review  
127 Regarding the Compatibility Between Bighorn and Domestic Sheep, which is found in the 1996  
128 Proceedings of the Tenth Biennial Symposium of the Northern Wild Sheep and Goat Council  
129 (NWS&GC).

130  
131 The abstract to the review stated: "*In both fenced studies and free ranging herds, most*  
132 *contact between bighorn sheep and domestic sheep has resulted in pneumonia in bighorns and*  
133 *the deaths of all or most bighorns while domestic sheep remained healthy. No studies reported*  
134 *any bighorn herds, fenced or free-ranging, that have come into contact with domestic sheep and*  
135 *remained healthy. With the current information, almost all wildlife professionals, wildlife*  
136 *veterinarians and researchers have concluded that bighorn sheep and domestic sheep should not*  
137 *occupy the same ranges or be managed in close proximity to each other, because of the potential*  
138 *adverse effect from disease on bighorn sheep.*"  
139

140  
141 Unbiased observers should take issue with several of the far-reaching statements made  
142 in this abstract. First, the sentence beginning with "*In both fenced studies and free ranging herds,*  
143 *most contact between the species has resulted in the deaths of the bighorns*", is not true.  
144 Domestic sheep have grazed in mountain pastures in Wyoming for approximately 100 years. It is  
145 reasonable to assume that contact between the species has occurred in that period of time, yet  
146 both bighorns and domestic sheep still survive in these areas. Other studies demonstrate that  
147 commingling between wild and domestic sheep has occurred and that both species survived the  
encounters.

148  
149 The Sierra herd in California has had remarkable recovery of their population since 1999.  
150 They have gone from 100 to over 400 head in the last 7 years. Actually they have not had a  
151 reported die-off in that region for at least 25 years. Dr. John Wehausen, after studying the herd  
152 for 30 years, remarked that he had never seen so much as a snotty nose. Predation, however,  
153 has been noted to be as high as 54.5% at times. It wasn't until the cougar population was  
154 decreased, that the population numbers began to increase. But there has always been domestic  
155 sheep on that range. (*Rink and Wehausen taken from the Bighorn Meeting Transcript, February*  
*25, 2005 at Reno, Nevada*).

156  
157 However, it is true that the biologists involved with this herd are extremely fearful that a  
158 die-off is eminent (*Bighorn Meeting, Apr. 25-26, 2007, University of Calif, Davis*). —but why, if a  
159 chance contact with the domestic sheep is so likely to cause disease, has disease not happened  
in 30 years?

160 Dr. Ward (CVTC) et. al. in Pasteurella spp in Sympatric Bighorn and Domestic Sheep.  
161 1997. J of Wildlife Disease. did discover sharing of a identical *Pasteurella* organism between  
162 bighorn sheep and domestic sheep in a Nevada bighorn herd. No disease was occurring at the  
163 time and no disease occurred later. (Reviewed more in depth later in the paper)

164 Bighorn sheep routinely came down for years into the flocks of Fred Fulstone of Nevada.  
165 This bighorn herd had multiple contacts with domestic sheep over many years. There have yet to  
166 be a die-off in the Nevada bighorn herds that have had contact with his domestic sheep. Now,  
167 however, the Forest Service has required numerous management practices to insure that no  
168 contact take place even though no disease has occurred in the past.

169 Dr. Wayne Ayres, assistant professor at the Caine Center recounts experiences growing  
170 up on his Dad's ranch in the mountains of Montana where bighorn sheep and elk ate hay with his  
171 father's cattle and neighbor's sheep every winter. There have not been die-offs reported in that  
172 area.

173 Dr. Keith Aune of Montana Department of Fish Wildlife and Parks tells in the transcript of  
174 the Reno Bighorn Meeting of 2005 about the Highlands bighorn sheep herd in Montana, a very  
175 successful herd with a lot of what sportsmen call "trophy animals". A domestic sheep flock resides  
176 in the middle of its winter range. There were some interactions known to occur but no disease  
177 happened for 20 years. Then they had a severe die-off and lost most of the herd. Was it the fault  
178 of the domestic sheep after 20 years of interaction?

179 Dr. Aune also points out that in that same meeting that in Montana, spatial separation  
180 won't work for Montana because there are so many domestic sheep on private land. In spite of  
181 the fact that their bighorn sheep are not separated from domestics, an article appeared on March  
182 8, 2007, in the *Tribune Outdoor Editor* entitled "The battle of the Bighorns" that stated: "*Wildlife*  
183 *officials struggle to balance populations, habitat and hunter demand. Wildlife managers in*  
184 *Montana this winter trapped and transplanted more than 200 bighorn sheep, ewes, many of them*  
185 *pregnant, to states like North Dakota, Nebraska, Wyoming and Utah to try and keep the highly*  
186 *prized big game animals within population objectives.*"

187 Secondly, the statement, "*No studies reported any bighorn herds, fenced or free-ranging,*  
188 *that have come into contact with domestic sheep and remained healthy,*" most certainly is not true  
189 as has just been pointed out. It should be noted that Martin, et.al. most-cited source, (Goodson  
190 1982:306) made this statement: "*Interpretations of these observations is complicated by the fact*  
191 *that some bighorn herds have not increased following domestic sheep removal and that some*  
192 *herds have survived for many years with domestic sheep on their ranges.*" Further, it does not  
193 appear that there has been any major attempt to study healthy free-ranging bighorn sheep  
194 populations that do come into contact with domestic sheep. Instead, most papers have  
195 specifically focused on bighorn herds experiencing die-offs where domestic sheep are suspected  
196 of being involved.

197  
198 It should also be noted that two of the three reviewers(Tim Schommer and Victor  
199 Coggins) who authored the review were at the time working for the Wallowa-Whitman National  
200 Forest. The review was requested by the Regional Forester, who was in the process of both  
201 transplanting bighorn sheep into, and banning domestic sheep from, the Hells Canyon National  
202 Recreation Area.

203  
204 While the Martin paper recognizes that bighorns demonstrate less tolerance for poor  
205 range conditions, interspecific competition, overhunting and stress caused by lack of habitat and  
206 presence of other ungulates, the paper emphasizes susceptibility to disease from domestic  
207 sheep. The reviewers claim "*there is strong evidence*" that *the presence of domestic sheep will*  
208 *result in the deaths of bighorn*". The authors rely on a table entitled "Bighorn declines and die-  
209 offs believed to have resulted from contacts with domestic sheep" which lists 30 incidents. It is to

210 be assumed that the table's title reflects the opinion of the reviewers, since such a conclusion was  
211 not found in the source documents for the specific incidents cited. Because the conclusions of  
212 Martin's review rely on the incidents listed in the table, those incidents need to be examined in  
213 more depth.

214  
215 Of the 30 incidents, listed under "cause of die-off," six are recorded as "unknown," but are  
216 still included in a table alleging "*bighorn declines and die-offs believed to have resulted from*  
217 *contacts with domestic sheep.*" Five of the six cases with unknown causes are cited from  
218 "Goodson, 1982." In fact, 12 of the 30 incidents in the table actually are taken from the Goodson  
219 paper. It would be wise, then, to examine Goodson's paper.

220  
221 **Goodson 1982: Proceedings of the biennial Symposium of the Northern Wild sheep and**  
222 **Goat Council (NWS&GC).**

223  
224 Nike Goodson's "Effects of domestic sheep grazing on bighorn sheep populations: a  
225 review." is often offered as proof by many biologists that domestics cause problems for bighorns.  
226 Although Martin's paper was a literature review, it appears that its major source of information  
227 was Goodson 1982 article which, interestingly, is also a literature review.

228  
229 Goodson writes that the introduction of domestic livestock onto bighorn sheep ranges in  
230 the late 1800s and early 1900s was followed by severe and widespread die-off of bighorn sheep  
231 due to Scabies. Early observers (Packard 1939, Couey 1950, Buechner 1960, even up to 1973  
232 Bear and Jones) noted the same and were convinced that the bighorn sheep contracted scabies  
233 from domestic sheep. However, Wright, Guillot and Meleny showed in 1981 (J of Wildlife  
234 Diseases) that mites taken off of bighorn sheep which supposedly came from domestic sheep"  
235 *established infestations easily in the ears of rabbits, established reproducing colonies on cattle*  
236 *with difficulty but did not establish infestation in ears or on the bodies of domestic sheep.*" This is  
237 in spite of putting sheep in stanchions to prevent grooming, tying tents of wool over the  
238 transplanted mite and taping the ears shut so that mites could not escape or fall out. Goodson  
239 and later Jessup in Dessert Bighorn Council, 1985 Transactions, suggests these studies were  
240 inconclusive. However, the data reported in the published and reviewed article is quite clear that  
241 the scabies mite is inherently host specific. They didn't come from domestic sheep and they won't  
242 go to domestic sheep. Goodson, nonetheless, continues to incorrectly blame the scabies-  
243 induced bighorn die-offs on domestic sheep. (page 293). Schommer and Woolever also continue  
244 to put forward this theory, pg 2.

245  
246 Goodson presents table 2 in her paper as "Historic examples of bighorn declines during  
247 periods of grazing by domestic sheep," with this introduction: "*A few examples illustrate declines*  
248 *occurring throughout bighorn range in the western United States. In each case grazing by*  
249 *domestic sheep alone or in combination with cattle coincided with a decline or die-off of bighorn*  
250 *sheep.* The four incidents listed in Goodson's table as bighorn declines during periods of grazing  
251 by domestic sheep (and not discussed any further) automatically made it into Martin's table (as  
252 **entries 1, 9, 10 and 11**) for bighorn declines and die-offs believed to have resulted from contacts  
253 with domestic sheep. So four incidents that were reported as "*bighorn declines during periods of*  
254 *grazing by domestic sheep*" were skewed into becoming "*declines and die-offs believed to*  
255 *resulted from contacts with domestic sheep,*" which are now being used as part of the "**strong**  
256 **evidence - over 30 published cases**" justifying incompatibility— when that was not what was  
257 originally reported. It certainly may have been what Martin, Schommer and Coggins believed, but  
258 there was absolutely no evidence to substantiate the accusation.

259  
260 The second Goodson citation in **Martin's table (entry 2)** refers to the Upper Rock Creek,  
261 Montana die-off as "*believed to have resulted from contact with domestic sheep.*" But Goodson's  
262 1982 paper noted: "*Contact between bighorn sheep and domestic sheep was possible during*  
263 *June. An unusually cool and wet summer and fall may have been a factor in the decline.*

264 Domestic sheep grazing was reduced in the following year. However, the bighorns continued to  
265 decline, dying out completely in the early 1960s. (Goodson, 1982:296). "Contact was possible" ---  
266 --This is overwhelming evidence?  
267

268 This die-off is also discussed in NWS&GC (1980:135), noting, "The condition of much of  
269 the range was poor in the mid to late 1960s. By the mid-1970s range trend was up and condition  
270 was generally good to excellent."  
271

272 For same herd, NWS&GC 1982:78 reported, "Numerous reasons for the decline were  
273 cited, including overgrazing by domestic stock, competition from large numbers of mule deer and  
274 encroachment on the winter range by human development."  
275

276 Inbreeding was also cited as a factor: "The inbred native population was unable to  
277 tolerate the stress of deteriorating habitat conditions, while the genetically healthy Sun River  
278 stock thrived under similar conditions." (NWS&GC 1982:78).  
279

280 **Martin's entry 3** in the table of domestic sheep-caused die-offs again uses a Goodson  
281 1982 citation. Goodson reported this: "The Thompson Falls bighorn herd in northwestern  
282 Montana was estimated at 50 head in 1942. From 1940 through 1955, 200 to 500 domestic  
283 sheep grazed the bighorn range. Bighorn sheep disappeared from the area during the early  
284 1950s. In 1959, bighorn were reintroduced (after removal of domestic sheep) and increased  
285 rapidly to an estimated 240 in 1974." No supporting evidence of domestic sheep-induced die-offs  
286 is provided, nor is there any discussion of any other factors affecting this herd. Could competition  
287 for forage be a factor here? This is hardly hard evidence of disease transmission.  
288  
289

290 **Martin's entry 4** again cites Goodson, who stated: "In 1939, approximately 100 domestic  
291 sheep were introduced into the range of the Radium-Stoddard bighorn sheep herd near Kootenay  
292 National Park. In the fall of 1939, bighorn rams were observed breeding domestic ewes. A die-off  
293 of bighorn **began the following winter**. Hemorrhagic septicemia (pneumonia) was diagnosed as  
294 the proximate cause of death. Over the next several years the die-off spread through adjacent  
295 bighorn herds."  
296

297 **Martin's entry 5** is also from Goodson. Goodson stated: "A second die-off began in the  
298 Bull River bighorn herd in January 1965. Domestic sheep had not been grazed on this range  
299 except for a period in 1955. In 1961, or 1962, a sheep rancher began grazing about 150 head of  
300 domestic sheep on the bighorn range. In January 1965, bighorn sheep were observed feeding on  
301 haystacks in the rancher's field with his domestic sheep. Several bighorn died, apparently from  
302 rumen compaction. A die-off in the bighorns followed which reduced the herd from about 250  
303 head to 8 head.  
304

305 Goodson continued: "The die-off spread north through 6 contiguous bighorn ranges  
306 covering an (80 mile) span during the next two years. About 70 percent of the bighorns in 6 herds  
307 died. The Radium-Stoddard, Wigwam and Kootenay Park herds were affected. Bighorn died from  
308 acute pneumonia. *Pasteurella multocida* bacteria were isolated from bighorn during the die-off.  
309 **Heavy lungworm (*protostrongylus spp.*) burdens were also found in the bighorn.** The die-  
310 off was sudden and unexpected since the bighorn herds had maintained stable population  
311 densities for over 10 years. Most of the herds involved in the die-off recovered to pre die-off levels  
312 with the next 10-20 years; however, the Bull River herd has recovered very slowly and is currently  
313 estimated at 50 head".  
314

315 Could the fact that these sheep had heavy lungworm loads had anything to do with this,  
316 and interestingly, the fact was not mentioned in Martin's paper.  
317

318 **Martin's entry 6** again refers to Goodson, who stated: "A third die-off began during the  
319 winter of 1981-82 on the Maquire Creek-Red Canyon bighorn range. This traditional year-round  
320 range supported about 50 bighorn prior to the die-off. Domestic sheep grazing began about 1978.  
321 Generally, domestic sheep were grazed for 3 weeks to 2 months during the summer, however in  
322 October 1981, the bighorn herd was known to be in direct contact with about 60 domestic sheep.  
323 The die-off began in December with at least 26 bighorn dying during December-January.  
324 Necropsies of 2 bighorn indicated acute pneumonia was the cause of death. *Pasteurella spp.*  
325 bacteria were isolated from one ram. **Both bighorn had heavy lungworm burdens."**  
326

327 **Martin's entries 7 and 12** were detailed in: Fatal pneumonia of bighorn sheep following  
328 association with domestic sheep. By Foreyt and Jessup. Journal of Wildlife Diseases, Vo. 18, No.  
329 2, April 1982, pages 163-168. This paper documents two case histories **admittedly** built upon  
330 "circumstantial evidence:" one in Washington and the other in California.  
331

332 In Jan. 1979, two yearling rams and six adult ewes (wild bighorns) were placed into a 2.5  
333 ha (6 acres) enclosure in a remote area of the Methow Game Range. In March, each of the six  
334 ewes had a single lamb, so total bighorns in the pen were 14. On November 11, adult crossbred  
335 domestic ewes (3-4 yrs old) were added to the pen now making a grand total of 25 animals in the  
336 6 acre pen. "*All animals were fed at a common source but the bighorns and domestic sheep were*  
337 *not seen to associate with each other. No behavioral problems were observed."* (p.164). "*Twenty-*  
338 *six days later, seven bighorns were found dead. Death had occurred within 5 days of the last visit*  
339 *... Due to the deteriorated condition of the carcasses, only histological examination of selected*  
340 *organs was accomplished."*  
341

342 "The domestic sheep were removed from the pen on Dec. 8, 1979, and at that time, the  
343 seven (remaining) bighorns appeared to be healthy. Six of the remaining seven bighorns were  
344 found dead on Jan. 29, 1980. They also had been dead for several days, and postmortem  
345 examination was similar to that conducted on the first group. In both groups of dead bighorns,  
346 animals were found together in one part of the pen in their beds, and no external lesions were  
347 observed. Examination of 10 of the 13 dead bighorns was conducted, but "*bacterial and viral*  
348 *cultures were not done because tissues were autolyzed."* Acute pneumonia was apparent in all  
349 animals from both episodes. One bighorn ewe survived the pneumonia episode and produced a  
350 lamb in 1980. All domestic sheep survived for four months after removal from the enclosure, with  
351 no signs of disease apparent.  
352

353 In California, bighorn sheep acquired from British Columbia in 1971, were confined to a  
354 445 ha (1,100 acres) enclosure at the Lava Beds National Monument. In 1980, there were 37  
355 bighorns in the pasture, after 16 were captured for transplant and six died from "capture  
356 myopathy" in February. One of the dead animals had low selenium levels. In mid-June domestic  
357 sheep were intensively grazed along the north and west boundaries of the enclosure and nose-to-  
358 nose fence line contact was noted. Changes in weather, range condition, movement of people,  
359 etc., were not observed. Approximately 8 bighorns died during the first 10 days of July. A  
360 presumptive diagnosis of pasteurellosis was made on July 12 ... "*All 43 bighorn sheep were*  
361 *presumed dead by Aug. 15, 1980, since no live animals could be located."*  
362

363 The results reported in this paper stated, "*Pasteurella sp. and Corynebacterium*  
364 *pyogenes were isolated from several individuals in one outbreak and suspected in the second*  
365 *one. Possibly a bacterial pathogen was introduced into the bighorns by domestic sheep and was*  
366 *responsible for the pneumonia which resulted in mortalities in the bighorns"* "*The outbreaks in*  
367 *bighorns from California and Washington occurred during captive and semi-captive conditions,*  
368 *however, animals appeared to be well adapted to captivity and isolated from noise and contacts*  
369 *with humans and most other animals."*  
370

371 But in the California outbreak, "several possible predisposing stresses may have  
372 contributed to initial infection," including selenium deficiency and "a respiratory irritant in the form  
373 of a cloud from a chemical fire was known to have transited the area 90 days prior to the first  
374 pneumonia-related fatalities.--- *In these two geographically separated outbreaks, inclement*  
375 *weather, temperature, terrain, husbandry practices, physical exertion, nutritional disorders,*  
376 *excessive lungworm infections or other major stress factors were not identified and probably were*  
377 *not present. However, the presence of domestic sheep in close proximity to these bighorns may*  
378 *have been an important stress which initiated or compounded the outbreaks".*

379  
380 No bacteria were isolated from the bighorn sheep that died in the Washington group of  
381 bighorn sheep discussed in that article. *Pasteurella multocida* was isolated from one and a  
382 nonspecieated *Pasteurella* organism was isolated from another of the California bighorn sheep  
383 that died in that enclosure, but the authors provided no scientific evidence that the domestic  
384 sheep were the source of those bacteria. The authors lead one to believe that all 43 California  
385 bighorns died of *Pasteurella* ( "*All 43 bighorn sheep were presumed dead by August 15 1980,*  
386 *since no live animals could be located.*"), however, they stated that prior to the sheep demise in  
387 Feb 1980, 16/43 were captured, and 6 died of capture myopathy. Eight were then found dead 4  
388 months later with lesion of pneumonia, and 1 month later none of the remaining animals could be  
389 found. Thus, 12 animals were actually unaccounted for. Predation had presumably been  
390 responsible for 4 missing animals in the group a year before. Also one ram was seen to jump in  
391 and out of the enclosure during the previous year. (*Patton, 1979 Desert Bighorn Council*  
392 *Transactions*) Thus, the known facts of the case is that 8 bighorns died of pneumonia which may  
393 have been brought on by Bluetongue of which the herd had a prior history and the time of year  
394 was right. *Bleisdell, 1976 Dessert Bighorn Council Transactions*).

395  
396 What was startling about this study was that in the Washington case, the 25 animals in a  
397 6 acre pen were not watched or checked or fed even on a daily basis. Presumably they were fed  
398 as the statement is made that they were fed at a common source. At a stocking rate of 4.2  
399 animals per acre, there couldn't have been much to eat in that pasture. Animals were found "*up*  
400 *to five days after their deaths*". The animals died in two groups on their beds. It is unknown what  
401 factors actually played a role in their deaths. Since they were never seen together, one may  
402 presume that the domestic sheep, used to being fed and eating hay, probably ate the feed and  
403 the bighorns got the short end of the feed line. Mismanagement was certainly documented but  
404 the disease transmission is still questionable.

405  
406 **Martin's entry 8** in the table cites Goodson, who stated: "*Jessup reported an all-age die-*  
407 *off of bighorn sheep in the Mormon Mountains of Nevada. Although domestic sheep normally are*  
408 *grazed only at the base of the Mormon Mountains, prior to the die-off two domestic sheep were*  
409 *observed running with a band of bighorn. Bronchopneumonia was identified in 4 hunter-killed*  
410 *bighorn examined. Counts indicated a 50 percent decline from approximately 600 to 300 sheep."*  
411 Once again, there was no discussion provided of any investigation to learn the cause of the  
412 sheep die-off, only that hunters killed supposedly healthy appearing bighorns that had evidence  
413 of pneumonia.

414  
415 **Martin's entry 9** regarding Dinosaur National Monument in Colorado was also listed as a  
416 Goodson 1982 citation, but no supporting documentation whatsoever could be found in  
417 Goodson's paper.

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419 **Entry 11** in Martin's table, referred to the Rocky Mountain National Park, Colorado die-  
420 off. According to David R. Stevens: 1982: 245, "Bighorn Sheep Management in Rocky Mountain  
421 National Park, NWS&GC: "*This decline was probably related to competition on the range with*  
422 *domestic livestock, but disease may also have been an important factor. Packard believed*  
423 *mineral deficiencies to be the most important factor and mentioned lungworm and*  
424 *pneumonia a possible contributing factor.*

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In 1970, it was recognized that increased human visitation in the park was negatively affecting bighorns, and that stress may have been a major entity in bighorn sheep pneumonia and lungworm infestations. Sheep were being turned back from needed mineral licks by human presence. As a result, visitation is now controlled to reduce stress, thus reducing sickness and die-offs. Stevens 1982 244-253.

**Martin's entries, 13 and 14** in the table, lists the sources of "Weaver 1988" and "Sandoval 1988" which are not in Martin's literature citations page, so no information could be obtained about these incidents. The table notes these sources are also cited in the 1990 Desert Bighorn Council's "Guidelines for management of domestic sheep in the vicinity of desert bighorn habitat. Again it appears to be a review citing a review without studying the original source.

Three of Martin's other citations (**entries 15, 16 and 17**) come from one sentence in Goodson's paper. It stated: "*Incidents of apparently healthy adult bighorn in captivity dying from pneumonia shortly after exposure to domestic sheep have occurred at Utah State University, University of British Columbia, and Colorado State University*" To support her statement, Goodson cited personal communications which were never published and thus cannot be checked for accuracy. Yet Martin's paper, in conclusion 2, cites 13 fenced studies (of which these three are included) in which "*all bighorns died after contact with domestic sheep*". Strangely, this is not what Goodson's statement said. Her statement did not declare how many animals died, nor under what circumstances.

**Martin's entry 18** cites Victor Coggins, his co-author. Coggins wrote, "*Circumstantial evidence linked the die-off to contact with domestic sheep*." What happened was that an outfitter reported seeing 2 bighorn rams and a ewe with a domestic ewe. The domestic ewe was shot and found to have foot rot and lung adhesions. A few weeks later, an old bighorn ram (not identified as one of the rams found with the ewe) was found dead 10 miles away, and a month and a half later, during rut, the die-off began. "*The contact mentioned earlier could have been a source of the disease*". Coggins wrote. No clinical work was conducted on the domestic ewe to determine if she carried the same bacteria, or had signs of disease, etc.

**Martin's entry 20** is addressed in the following paper: Experimental contact transmission of *Pasteurella haemolytica* from clinically normal domestic sheep causing pneumonia in Rocky Mountain bighorn sheep. By D. Onderka and W.D. Wishart. J of Wildlife Diseases, 24 (4) 1988, p 663-667. This article describe two male bighorn lambs captured at 3 months of age in southwestern Alberta that tested negative for *Pasteurella* on nasal swab cultures and were housed individually on straw bedding for 30 days in well lit indoor stalls for 30-day adaptation period. The animals were then released together into a gravel floor chain link fenced outdoor pen measuring 7x7x3 m, where they were observed for 90 days for clinical signs of disease and their behavioral reactions were studied. On day 121, two clinically normal domestic 2-yr-old Suffolk ewes were added to the pen with the now 7 month old bighorns. Within hours the wild and domestic sheep intermingled calmly, fed together from the same heap of hay and drank from a common water source.

"*During the adaptation period the bighorn lambs showed no clinical signs of disease except for a transient mucoid nasal discharge on day 17 in the stalls.*" By day 26 after introduction of domestic sheep, both bighorns were showing clinical signs of pneumonia. Environmental temperatures varied between -10 and -30 degrees C. On day 29 and 30 after exposure to the domestic sheep, the bighorns were euthanized.

"*The bighorn lambs were observed for 120 days without showing any clinical signs of disease despite confinement and very low environmental temperatures. After the introduction of domestic sheep, sudden onset of respiratory disease leading to extensive bacterial pneumonia*

479 occurred in the bighorns within 26 days. The intimate contact between the two species of sheep  
480 in this experimental design rarely occurs in the wild except when young bighorn ram seeking-out  
481 domestic ewes. Close contact, however, was necessary for the possible transmission of  
482 *Pasteurella* spp. since this organism does not persist in the environment.”

483

484 “The lambs may have harbored *Pasteurella* spp. organisms in their tonsils where they  
485 might have proliferated if the lambs were stressed by the presence of domestic sheep. However,  
486 daily observations showed no behavioral evidence of stress. There were no dominance fights and  
487 food was supplied so that all four sheep could feed at the same time. “The recovery of a specific  
488 serotype not commonly found in bighorns also **suggests** that a transfer of *P. haemolytica* may  
489 have occurred.”

490

491 Pinned experiments should not be an issue in the Payette National Forest DSIES as the  
492 conflict that we are interested in is that of free ranging bighorns. However, interestingly, this  
493 paper also noted that “the 1981-1982 epizootic in bighorn sheep in southern Alberta probably did  
494 not originate from pathogen transmission between domestic sheep and bighorns.”

495

496 **Martin's entry 23** in the table lists Callan, 1991, as the source. But Callan's work  
497 involved an intended exposure to a flock of exotic wild and domestic sheep in a pen experiment,  
498 again, not an issue in the DSIES.

499

500 **Martin's entries 27 and 28** refer to die-offs in Nevada, although one of these die-offs is  
501 also listed as an “unknown” cause. The sources for these two incidents were personal  
502 communications, but information about these cases can be found in the following literature:  
503 “*Pasteurella* spp. in sympatric bighorn and domestic sheep.” A. Ward, D. Hunter, et al in J of  
504 Wildlife Diseases 33 (3) 1997: 544-547 reports on the research conducted on bighorn sheep and  
505 domestic sheep on four Nevada sheep ranges (East Range, Tobin Mountain, Desatoya and  
506 Granite Range). In the fall of 1992, two areas of Nevada, the Desatoya Range and the Granite  
507 Range, a domestic sheep and her lamb were found in direct contact with bighorn sheep. In both  
508 cases the entire bighorn herd and the domestic sheep were net-gunned and captured. On the  
509 Desatoya Range, both biotype A2 and biotype 3 *Pasteurella* isolates were found in both domestic  
510 and wild sheep, suggesting transmission from domestic animals to the bighorns at some point in  
511 time. This herd was established in 1986 with 31 animals, there were 71 bighorn in November  
512 1993 and 99 in October 1995. This herd continued to thrive regardless of the contact and  
513 possible transmission of *Pasteurella* even though the A2 biotype is considered to be quite virulent  
514 to bighorn sheep.

515

516 On the Granite Range the single domestic sheep caught with the bighorns and 15  
517 bighorns were cultured. Biotype 3, biogroup 11, *Pasteurella* was found in both domestic and wild  
518 sheep and appeared to be biochemically identical both at the time when the domestic sheep was  
519 culture and subsequently from one bighorn 3 mo. later. These were established to be the same  
520 by using REA patterns. This herd was established in 1980 and augmented in 1983 bringing herds  
521 numbers to 24. There were 76 in 1992, 83 in 1994 and 96 in 1995. This population has tripled  
since establishment in spite of sharing a *Pasteurella* sp. with a domestic sheep.

522

523 On the Tobin Range, 10 domestic sheep from a adjacent ranch that were known to have  
524 spent time on the bighorn allotment the year before (1991) and were believed to have had contact  
525 with the bighorns were cultured as well as the only bighorn that was found on the Tobin Range in  
526 1992. The *Pasteurella* spp isolated from the domestic sheep were not the same as those isolated  
527 from the bighorn. The Tobin bighorn herd was established in 1984 with 45 bighorn sheep and  
528 augmented with 18 more bighorn from a different area in October of 1991. Only one bighorn was  
529 found in January of 1992. None of the bighorn sheep on Tobin range were observed to be ill nor  
530 were any carcasses sighted. It was **speculated** that the potential pathogenic strains of  
531 *Pasteurella* spp in the augmented population of bighorn sheep may have triggered disease in the  
entire population.

532 On the East Range in the fall of 1991, 4 domestic ewes were captured within 400 meters  
533 of a water source used by a bighorn herd. It was **speculated** that contact had occurred. The  
534 domestic sheep were caught and penned in Winnemucca. In January 1992, 4 bighorn sheep  
535 were captured and tested for *Pasteurella*. In January 1993, three more bighorns were tested.  
536 This herd was established in 1984 when 24 bighorns were moved in. There were 36 in this herd  
537 in 1989, 31 in 1990 and 22 in 1991, indicating that the population was declining. Nine bighorns  
538 were sighted in 1993 and none in 1994. They were never seen to be ill and no carcasses were  
539 found. Cougar reports and conflict in the region had increased significantly since 1989. One can  
540 **speculate** that they were eaten by cougars.

541 No disease was observed in any of these herds then or since, thus the cause of the  
542 disappearance of the bighorn sheep from the East and Tobin Ranges was never established.  
543 Neither disease or cougar predation cannot be ruled out.

544 Another source of information is "*Pasteurella* transmission in bighorn sheep" by M.  
545 Bulgin, A, Ward, M. Jaworski, D, Hunter, et al. This paper stated, "*Both bighorns and domestic*  
546 *sheep yielded *Pasteurella* spp. in these cases, but the fingerprinting of cultures revealed that*  
547 *there was apparently no sharing of bugs.*" (p.2). Bulgin's paper also provides information  
548 regarding **Martin's entry 26** incident at the Idaho Fish and Game Laboratory, Caldwell, Idaho, in  
549 which it is noted that 2 of 4 bighorns died. Again, this incident happened in a penned  
550 circumstance.

551  
552 "In Idaho's case, the subjects were 4 young bighorn males, 1-2 years old, placed next to  
553 9 domestic ewes serologically positive to ovine progressive pneumonia virus (OPPV), an agent  
554 related to the leukemia viruses, and targets, among other things, the lungs of sheep. Two of the 9  
555 domestic ewes were showing signs of OPP, somewhat debilitated, although not showing clinical  
556 signs of bacterial pneumonia when the bighorns were placed next door. The 2 species seemed  
557 quite interested in one another and spent time at the common fence checking each other out.  
558 One bighorn lamb was observed to be licking the nose of a domestic sheep.

559  
560 On April 23, 48 hours after the introduction, a domestic ewe was found dead; the  
561 necropsy showed the cause of death to be a combination of OPP and *Pasteurella* pneumonia.  
562 April 25, one bighorn was found dead while the others looked clinically normal. Necropsy  
563 revealed a severe pneumonia. April 26, the second bighorn was found dead. The third was found  
564 to have a temperature >104 and was treated with antibiotics. April 27, the second domestic was  
565 found dead also from an acute *Pasteurella* pneumonia. April 29, the fourth bighorn was found to  
566 have an elevated temperature. Bighorn 3 and 4 survived after intensive treatment.

567  
568 "*Pasteurella haemolytica* Biotype A, biogroup 1, with identical fingerprints were isolated  
569 from the lungs of all dead sheep, bighorn and domestic, and tonsillar swabs of the 2 remaining  
570 bighorn rams. The *P. haemolytica* biotype A, serotype 1 was particularly interesting as that  
571 serotype is common to cattle but not generally found in domestic sheep. Prior to the bighorn  
572 introduction, this fingerprint had been found in two other domestic sheep besides the ones that  
573 died. The major disease-causing *Pasteurella* of domestic sheep is usually biotype A, serotype 2.

574  
575 The surviving two bighorns fully recovered their strength and stamina and they continued to carry  
576 the "killer" type A after their recovery, although it died out completely in the domestic sheep  
577 shortly after the disease outbreak. In Dec, the domestic sheep and the bighorns were given 500  
578 mg/head/day of oxytetracycline for 14 days in their feed to determine the effect of antibiotics on  
579 the presence of *Pasteurella* in the respiratory tract. The gross amount of *Pasteurella* from nasal  
580 and tonsillar swabs was reduced, as were the number of biogroups isolated. Twenty-seven  
581 different biogroups were reduced to only 10, of which four were discovered to be resistant to the  
582 antibiotic.

583

584 On Jan. 1, 1994, all the animals were given injections of 5 mg/lb of ampicillin (to which  
585 the 10 groups of *Pasteurella* were sensitive) for 5 consecutive days. The killer group disappeared  
586 from the 2 remaining bighorns. After treatment, the bighorns carried a biotype identical to the one  
587 they originally carried prior to exposure to domestic sheep. After the treatments, the bighorns  
588 were reintroduced to the domestic sheep and remained in good health. This incident suggests  
589 that bighorns can mount an immunity and be protected against specific *Pasteurella* agents.  
590 Vaccination may very well work, if they are vaccinated against the right strain or biotype.  
591 However, the strains do not give cross immunity so knowing which biotypes to vaccinate with is  
592 the key because in most cases, it is not the domestic livestock's virulent biotype A1 or A2 that  
593 they die with on the range.

594  
595 Thus far, the incidents in free-ranging herds cited in Martin's review provide precious little  
596 evidence that domestic sheep were responsible for any of the free ranging bighorn sheep die-  
597 offs. Where sources were listed as "personal communications" information could not be obtained,  
598 including entries 19, 29 and 30.

599  
600 In reviewing some of the cases cited by Martin, using Goodson as a source, it becomes  
601 apparent that one literature reviewer citing another literature reviewer may be a bad idea. It  
602 seems in the telling and re-telling; the actual story of what happened is skewed and eventually  
603 lost. To observe that contact with domestic sheep may have occurred, with die-offs following at  
604 some later date really adds nothing substantial to the argument. One could also state that agency  
605 biologists or other humans were in the area, and die-offs followed at a later date.

606  
607 In addition, there was obviously no effort put forth at searching other sources to learn  
608 what the actual researchers or biologists studying these herds had observed. Had such an effort  
609 been made, the reviewers would have learned some very critical information. When scanning  
610 other papers in the NWS&GC proceedings, a few interesting papers regarding specific incidents  
611 listed in Martin's domestic sheep-induced die-offs were discovered and pointed out in the above  
612 discussions. However, there doesn't seem to be any attempt on the part of the Martin et.al. or the  
613 "Conflict Review" to determine any other factors involved in causing die-offs other than the role  
614 the domestic sheep might possibly played.

615  
616 **Transmission in controlled or penned experiments.**

617  
618 No one is contesting that when penned with domestic sheep, bighorn sheep generally  
619 die. It appears, in most cases, that transmission of a virulent biotype of *Pasteurella* may well  
620 occur. There is no doubt that bighorns die, but the assumed transmission in most cases is not  
621 always well established.

622  
623 The remaining incidences in Martin's table are referred to as "University Controlled  
624 Conditions." Unfortunately, however, controls were lacking during the majority of these  
625 experiments.

626  
627 **Martin's entry 21 is addressed in Fatal Pasteurella haemolytica pneumonia in bighorn**  
628 **sheep after direct contact with clinically normal domestic sheep.** By W. Foreyt. American J of  
629 Veterinary Research, Vol. 50, No. 3, pages 341-344. This article describes an experiment in  
630 which six captive bighorns (three males and two females yearlings) and one two-year old male  
631 were vaccinated three times, four weeks apart, with killed *Pasteurella* organisms, and combined  
632 one week later with three adult female domestic sheep (2-6 yrs old) in a 2 ha pen and 3 5-month  
633 old female lambs.

634  
635 All six bighorns died from 4 to 71 days later of pneumonia. Large numbers of *Pasteurella*  
636 were isolated from all bighorn sheep, but were primarily of **three different serotypes** not related  
637 to the vaccine. When this experiment began, only nasal swabs were collected from the bighorns,  
638 which, as the author later learned and admitted, is of limited value as tonsillar swabs are a far

639 more dependable source of *P. haemolytica* than nasal swabs. Thus, we don't know what types of  
640 *Pasteurella* the bighorns carried at the start of the experiment. Foreyt explained, "*However, on*  
641 *the basis of data in this laboratory, routine isolation of P. haemolytica in healthy bighorn sheep is*  
642 *uncommon*". (p. 343)--a statement now known to be false. Another inconsistency found in this  
643 paper, the ages of the bighorns are listed incorrectly in Table 1 of this paper, calling five animals  
644 "lambs" when they were yearlings, and listing the 2-yr-old ram as a "yearling."

645  
646 **Martin's entry 22** is addressed in *Pneumonia in bighorn sheep: effects of Pasteurella*  
647 *haemolytica from domestic sheep and effects on survival and long-term reproduction*. W. Foreyt.  
648 1990, NWS&GC 7:92-101. In the first experiment recorded in this paper, two 1-1/2 yr old bighorn  
649 rams were maintained in a 7 x 10 m room (13 x 23 feet) with concrete walls and floor. "*After 3*  
650 *months of acclimating the bighorns, 2 domestic yearling wether Suffolk sheep, about 6 months*  
651 *old, were introduced into the room.*"

652  
653 Yes, the same animals are described both as yearlings and 6-mo-olds, so we have no  
654 idea which is correct. Considering that all 4 animals are placed in a 13 x 23 ft room, the age is a  
655 significant item. A yearling Suffolk wether is a large animal and Suffolks are aggressive eaters.  
656 A consistent problem with Foreyt's work has been that it is sloppy which makes interpretation  
657 difficult. Another is the fact that he only used nasal swabs with bighorns, even though he must  
658 have known (if he read the literature at all) that nasal swabs were of limited use. That information  
659 was available in 1990 in: *Isolation of Pasteurella haemolytica from tonsillar biopsies of Rocky*  
660 *Mountain bighorn sheep*. M. Dunbar, A. Ward, G. Power. J Wildlife Disease, 1990, 26: 210-213.  
661 This article reported that culture results of tonsillar biopsies and pharyngeal swabs from bighorn  
662 and domestic sheep revealed that many bighorn and domestic sheep are carriers of *P.*  
663 *haemolytica*, even though bacteria cannot be isolated from nasal swabs.

664  
665 So, information about the bighorn's status as *Pasteurella* carriers in entry 22 is really  
666 unknown.

667  
668 Bighorns developed respiratory disease on day 13 of the experiment. On day 14, one  
669 bighorn died and the other "*was recumbent and moribund, and was euthanized.*" **But the**  
670 **serotypes of *Pasteurella* isolated from the domestic sheep and from the dead bighorns**  
671 **were different.**

672  
673 The second experiment in this paper was amazing: *Pasteurella* from domestic sheep  
674 "*was accidentally introduced into a captive herd*" of bighorn at WSU, and resulted in respiratory  
675 disease in the 10 sheep and the death of 3 bighorns. The laboratory personnel used a tube to  
676 collect cells from the lungs of several live domestic sheep which had *Pasteurella* in nasal  
677 secretions. "*Following this lavaging procedure .... the same tube was then used within an hour to*  
678 *lavage 3 captive bighorn sheep which were maintained in a 2 ha (5 acre) pen containing 7 mature*  
679 *and 3 immature bighorn ewes. Between 7-12 days following this procedure, all 10 bighorns*  
680 *developed respiratory disease*". Three sick sheep were captured and treated "*but it was decided*  
681 *that the stress of capture was too detrimental and treatment was discontinued.*" It should also be  
682 noted that selenium levels in these three sheep were determined to be marginal and selenium  
683 supplementation was then boosted from 20 to 90 parts per million.

684  
685 Once again, the numbers of animals involved in this "experiment" don't add up. By  
686 comparing information in tables 2 and 3, this much can be learned. In Nov. 1987, Foreyt reported  
687 there were 10 sheep in the pen; one ram was added in December, making a total of 11 head, yet  
688 table 2 records that 12 head of adult bighorns were tested. (More animals than were involved in  
689 experiment).

690  
691 In 1988, assuming the same 11 head were there at beginning, 3 died, leaving 8 head in  
692 the pen, 3 lambs were then born (making total 11 now) and died within weeks (back to a total of  
693 8), but table 2 represents that 15 animals were tested.

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In Jan. 1989, again starting with 8, two new animals were added (total is now 10) and 8 lambs were born (total 18). Of the 18, all the lambs died (back to 10) as did 2 ewes (8 now) and the ram died (now down to 7). But table 2 claims that 28 adults were tested in the May-July period for that year, and 16 were tested in Oct-Nov, both scenarios involving more sheep than in the infected pen. My conclusion that there were 7 ewes in existence at the end of the experiment is supported by the statement in the discussion portion of the paper that seven ewes survived the pneumonia episode and became clinically normal. However, no explanation is provided for the discrepancy in numbers. This research project leaves little confidence in the conclusion: "*It is likely that P. haemolytica from domestic sheep initiated the pneumonia in the captive bighorn herd.*"

Martin's entry 24 refers to Foreyt, 1991, which is not included in his literature citations and no other literature searches resulted in a citation for Foreyt that year.

Martin's entry 25 is: Failure of an experimental *Pasteurella haemolytica* vaccine to prevent respiratory disease and death in bighorn sheep after exposure to domestic sheep. W. Foreyt. 1992, NWS&GC 8: 155-163. This experiment involved placing four adult domestic sheep (known carriers of *P. haemolytica*.) with 6 bighorns in 2.4 ha pen that included three vaccinated bighorns (3 yr-old female, 5-yr old female and yearling male) and three unvaccinated bighorns (2, 3-yr old males and a 3-yr old female.) Only a three year old unvaccinated female lived: she remained healthy at least a year after the study. **But--the pathogen found in dead bighorns was not found in the domestic sheep.** The study noted: "*Serotypes of P. haemolytica that are usually nonpathogenic in domestic sheep are likely transferred to bighorn sheep, resulting in fatal pneumonia in bighorn populations.*" (p. 155).

The study used only nasal swabs again to detect bacteria in bighorns, which, *again*, are not a reliable culture sample for *Pasteurella*. It is wondered why Foreyt persists in using nasal swabs when he must have known by now that they were essentially useless. One wonders if it on purpose. At any rate, no *Pasteurella* was detected in bighorns prior to introduction of domestic sheep **but the untypeable strains of *Pasteurella* detected during necropsy were differed from the type in the vaccine and was not found in the domestic sheep.**

The article goes on to state: "*However, based on available data, bacteria transferred from domestic sheep to bighorn sheep likely resulted in bighorn deaths. Unusual human activity, noise, inclement weather, nutritional deficiencies, adverse social encounters, population density factors, or other stressors could not be identified specifically before or during the experiment, but stress in various forms could have occurred. Stress parameters were not eliminated. ... Effects of unapparent stressors that could be important in the epizootiology of bacterial pneumonias in bighorn sheep remain to be evaluated.*" (p. 160).

The paper states "*If animals developed respiratory disease, they were euthanized,*" but the paper does not detail which animals were killed or whether they would or could have survived.

None of Foreyt's series of experiments were conducted with any kind of a uniform method. In the contact experiment, Effects of controlled contact exposure between healthy bighorn sheep and llamas, domestic goats, mountain goats, cattle, domestic sheep or mouflon sheep. 1994 Proc 9<sup>th</sup> biennial Symposium of the NWS & GC, the animals (6 bighorns and 5 mouflons) were placed in a small pen (0.4 ha pen) compared to the pen twice its size used in the mountain goat experiment (9 bighorns and 2 mountain goats in 0.8 ha pen). When the domestic sheep were placed into with two bighorns, it was into an indoor isolation facility 4 x 7 m. (13 X 23 foot). The bighorn experiment was the only one involving placing the animals into an indoor isolation facility.

749 A review of the numbers of bighorns used in the experiments indicate that the two  
750 yearling bighorns put into the small indoor isolation facility with domestic sheep (experiment 6)  
751 were actually animals that had been used in experiment 1 with the mouflon sheep, but were not  
752 identified as such. Simply adding up the number of bighorns used (by the number assigned to  
753 each) indicates 20 bighorns were used, to conduct experiments involving 23 bighorn sheep.  
754

755 While the record indicates the two yearling bighorn rams appeared to have been used in  
756 both experiment 1 with mouflons, and experiment 6 with domestic sheep, there is also one other  
757 discrepancy with the numbers. The text indicates that the same nine bighorns were used in  
758 Experiments 3 and 4, but the tables indicating biotypes for each animal only show 8 animals were  
759 used.  
760

761 In addition, all the other experiments explained where the bighorns originated, but not the  
762 ones used in experiment 6.  
763

764 One other item of interest is that except for the mouflon and domestic sheep  
765 experiments, Foreyt indicates that the animals shared the same pasture for 60 to 68 days prior to  
766 the experiment. The mouflons supposedly shared the same pasture, but for how many days is not  
767 clear. The domestic wethers and the bighorn rams were dumped into the equivalent of a shed  
768 together without being put on pasture first.  
769

770 What did they think would happen? Domestic sheep are bred to handle a higher level of  
771 stress than wild animals, but I can't think of a more stressful situation than what was done to  
772 these bighorn rams. Why do you suppose that such a small space was selected for the bighorn  
773 and domestic sheep experiment? Did Dr. Foreyt think that perhaps the bighorns would not get  
774 sick unless they were smashed up against the domestics in a shed where the ventilation had to  
775 be poorer than the out of doors.  
776

777 From this, Foreyt provides a broad management recommendation: "*All contact between*  
778 *bighorn sheep and domestic sheep or mouflon sheep must be prevented ...*" According to the  
779 foreword of the NWS&GC volume, this paper was reviewed but not refereed. The foreword  
780 stated: "The reader is responsible for critically evaluating the information contained in these  
781 papers - as is always the responsibility of a professional biologist."  
782

### 783 **Findings of Martin's paper**

784

785 This document has now addressed every incident in Martin's table, demonstrating the  
786 flaws and unsupported allegations made therein. Martin's paper states, "*In wild situations,*  
787 *domestic sheep and bighorn sheep association often results in the death of the bighorns and*  
788 *does not affect the domestic sheep,*" but the cases presented provide no convincing evidence.  
789

790 Twelve of the 30 supposed disease transfers from domestic sheep to bighorns occurred  
791 in captivity leaving 18 possible cases of disease transfers in the wild. Four cases were listed as  
792 declines in populations during periods of domestic sheep grazing. Two cases were reported that  
793 contact with domestic sheep was possible, range conditions were poor due to overgrazing, and  
794 sheep had heavy burdens of lung worms. One case had contact with domestic sheep and the  
795 die-off started the following winter. There were 6 cases with no further information or references.  
796 Six cases were extirpated herds but the cause was originally listed as unknown. Of the 30  
797 supposedly confirmed die-offs due to transmission of disease from domestic sheep, none were  
798 confirmed, most were highly questionable and the others were correlated with heavy lung worm  
799 burdens, mineral deficiencies, range deterioration, human encroachment and other environmental  
800 problems.  
801

802 Several of the penned experiments involved concentrating animals in highly stressful  
803 confined situations with no effort to reduce other stresses. Other experiments involved injecting

804 *Pasteurella* (taken from dead bighorns) intertracheally (into the windpipe) of bighorns. Neither of  
805 these situations comprises a scenario that could be expected to occur in the wild.

806

807 Not mentioned in Martin's, Schommers or the RADT review is the fact that in 1988, the  
808 United States Animal Health Association, Committee on Wildlife Diseases reviewed the issue.  
809 The late Dr. E. T. Thome of the Wyoming Game and Fish Department was chairman of the  
810 committee. The final report from the committee said this: "*Reports of recent die-offs in California,*  
811 *Washington and Oregon and a study conducted in Washington suggested that contact between*  
812 *bighorns and domestic sheep results in the transmission of disease from domestic sheep to*  
813 *bighorns, causing death in bighorns. However, in each of these cases other factors (crowding,*  
814 *adverse environmental conditions, human harassment, the presence of other potential disease*  
815 *causing agents, etc.) were present that could have been initiating factors in the die-offs. In at*  
816 *least two of these die-offs, domestic sheep have been grazed in the areas for many years without*  
817 *adverse effect on the bighorn populations.*"

818

819 Martin's, Schommer's and the conclusions in the RADT, tend to build on unsubstantiated  
820 beliefs of early biologists and encourage proliferation of false and inaccurate information and are  
821 far from unbiased, factual review of the literature available on the issue.

822

#### 823 **Other bighorn/domestic sheep articles not referred in DSEIS.**

824

825 "*Pasteurella transmission in bighorn sheep*" by M. Bulgin, A. Ward, M. Jaworski, D,  
826 Hunter, et al. This paper stated, "*Both bighorns and domestic sheep yielded Pasteurella sp in*  
827 *these cases, but the fingerprinting of cultures revealed that there was apparently no sharing of*  
828 *bugs.*" (p.2). Bulgin's paper also provides information regarding Martin's entry 26 incident at the  
829 Idaho Fish and Game Laboratory, Caldwell, Idaho, discussed above in which it is noted that 2 of  
830 4 bighorns died. Again these cases were in penned experiments.

831

832 Naturally occurring pneumonia in cesarean-derived Rocky Mountain bighorn sheep  
833 lambs, A Ward, D Hunter and M Jaworski, et al., NWS&GC 8:164-173. Ward et al states.  
834 "*Pasteurella haemolytica is a diverse group of bacteria which appears to be ubiquitous in*  
835 *ruminants. These opportunistic pathogens rarely initiate disease but are generally associated with*  
836 *disease only if other factors, such as viruses or lungworms, reduce the resistance of the host.*" (p.  
837 172).

838

839

840 See also: "An overview of the clinical signs, gross and histological lesions of the  
841 pneumonia complex of bighorn sheep" by T.R. Spraker and C.P. Hibler in NWS&GC 3: 163-172  
842 for discussion of transplacental transmission of parasites, particularly lung worms.

843

844 Susceptibility of Dall Sheep to pneumonia caused by *Pasteurella haemolytica*. By W.  
845 Foreyt, R. Silflow and J. Langerquist. Journal of Wildlife Diseases 32 (4): 1996. 586-593. This  
846 study involved intratracheal inoculation of *Pasteurella* into Dall sheep, which of course is of no  
847 value in hypothesizing conditions in the wild. Results indicated that Dall sheep appear to be as  
848 sensitive as bighorns to *P. haemolytica* A2 of domestic sheep origin. One interesting piece of  
849 information revealed by the research was the isolation of an untypeable *Pasteurella* cytotoxic  
850 biotype A from an apparently healthy bighorn with no population history of respiratory disease.  
851 Here again we have bighorn sheep carrying the "killer bugs" without disease.

852

853 One important item shouldn't be overlooked when reviewing this research project: the  
854 Dall sheep used in this experiment were used "*because they had potentially been exposed to a*  
855 *nonverified tuberculosis reactor and the USDA mandated their termination. Therefore we decided*  
856 *to use them in this experiment for the 52 hr before they were killed.*" No further discussion of the  
857 animal's tuberculosis status was given. Tuberculosis is often found in the lungs.

858

859 Pharyngeal Microflora of Dall and domestic sheep in Alaska: Management implications?  
860 By W Heimer, R Zarnke, F Mauer. 1982. NWS&GC 8:198: "*Dall sheep in the remote parts of the*  
861 *Brooks Range have, in all probability, never been in contact with domestic sheep. Still, these Dall*  
862 *sheep carry P. haemolytica biotypes A 5, T 3, T4, and T 10, as well as untypeable varieties of A*  
863 *and T. These are presumably the same Pasteurella spp. biotypes which produce fatal pneumonia*  
864 *in bighorns, yet no disease-related die-offs have been documented in Dall sheep. ... Hence, it is*  
865 *unnecessary to postulate domestic sheep as the source of all Pasteurella spp. bacteria which*  
866 *have been implicated in bighorn pneumonia.*" (p. 198).

867  
868 Effect of pneumonia on population size and lamb recruitment in Whiskey Mountain  
869 Bighorn sheep. By T Ryder (WG&F), E Williams (UW Vet Sciences), K Mills (UW Vet Sciences),  
870 K Bowles (WG&F) and T Thorne (WG&F). 1994. NWS&GC 8:136-146. Concerning a die-off--  
871 "*Onset of the die-off was attributed to increased physiological stress resulting from several weeks*  
872 *of -40 C temperatures and 80 km/hour winds during peak rutting activities and human visitation.*"

873  
874 This was the first large-scale die-off in history of this herd. Only three carcasses and  
875 tissue samples from eight additional animals were cultured. All lungs were grossly pneumatic.  
876 *Pasteurella haemolytica* was isolated from all tonsils cultured, but from only one lung.

877  
878 "*Apparently, even though these bacteria are carried in the oropharynx, it may not be*  
879 *important in initiating bronchopneumonia even in the face of considerable environmental stress.*"  
880 The bighorn with *P. haemolytica*. was in poor body condition, although some other animals that  
881 died were in good condition, and two sick animals that were shot were in excellent body  
882 condition.

883  
884 Residual effects of pneumonia on the bighorn sheep of Whiskey Mountain, Wyoming. T  
885 Ryder (WG&F), E Williams (UW Vet Sciences), S Anderson (WG&F Research Lab). 1994,  
886 Biennial Symposium of NWS&GC 9:15-19. This paper has some interesting information on the  
887 1990 pneumonia die-off. Bighorn sheep utilization rates of winter range increased each year,  
888 corresponding to increasing sheep numbers. When the population peaked at 1,474 animals,  
889 utilization rates approached 90 percent. The die-off occurred the next year. Authors note that  
890 body condition did not appear to be a factor though.

891  
892 Authors recommend: forage utilization rates should continue to be monitored yearly "*as they may*  
893 *provide a means of predicting an impending pneumonia outbreak.*"

894  
895 There are several problems associated with sheep on Whiskey Mountain. First, in March  
896 1998, WG&F did a transplant to Little Red Creek, taking 19 sheep, 10 which were radio-collared  
897 ewes. Three of the 10 were killed by mountain lions within a matter of months. This one-third loss  
898 due to lions shows a significant depredation factor.

899  
900 Second, according to the WG&F, 1998, Job Completion Report: "*Preliminary findings*  
901 *from 1998 indicate that the majority of lambs exhibit poor health while on summer range*  
902 *(respiratory congestion, stiff-leggedness, unthriftiness) and that ewes and lambs moved from high*  
903 *mountain summer range to lower elevation winter range one time or more per month during the*  
904 *summer to acquire mineral from mineral licks. Forage testing indicates that summer forage is*  
905 *extremely deficient in some trace minerals, especially selenium. Symptoms in lambs are*  
906 *suggestive of a selenium deficiency. Also, lion depredation on adults and lambs was*  
907 *documented, especially along migration routes to and from the mineral licks and summer/fall*  
908 *range. To address these concerns, the Whiskey Mountain Technical Team decided to provide*  
909 *mineral supplementation to sheep on summer and fall range. In early April 1999, mineral blocks*  
910 *containing 78% salt, 17 ppm selenium, 17 ppm cobalt, 95 ppm iron, 4 ppm zinc, 2% magnesium*  
911 *and 160 IU/lb Vitamin E were flown to the high country on Whiskey and Middle Mountains and at*  
912 *Lake Louise. Supplementation will hopefully entice sheep to remain in the high country during the*

913 *summer and provide deficient lambs with minerals.*” However, 17 ppm of selenium is probably  
914 not enough. Ninety ppm is commonly used for domestic sheep in selenium deficient areas.

915

916 **These references are not included in the Schommer and Woolever\_review**

917

918 Nevada wildlife Trail. A History of Nevada Wildlife and Wildlife Management. A book  
919 written by Dave Mathis 1997. Recounts that in the mid-1970, U. S. Fish and Wildlife personnel at  
920 the Desert National Wildlife Range (a refuge for desert bighorns near Las Vegas) contacted Dr.  
921 Robert Taylor, veterinarian at UNR’s College of Agriculture. A small herd of desert bighorns were  
922 kept at Corn Creek and they reported that lamb survival was low and they wanted to know why.  
923 His diagnosis was *Pasteurella pneumonia*. These lambs and many generations that preceded  
924 them both at Corn Creek and the Refuge had no association with domestic sheep.

925

926

927 Bighorn sheep movements and summer lamb mortality in Central Idaho, by James and  
928 Holly Akenson, 1992. NWS&GC 8:14-27. Central Idaho experienced an all-age die-off in 1990, at  
929 the same time as the Whiskey Mountain, Wyoming, die-off. While lamb production was good,  
930 lamb survival had dropped substantially by July of each year, for ratios of 7 lambs:100 ewes  
931 when lambs were 4 to 6 weeks old. *“Ewes sampled in spring 1989 and 1990 had extremely low  
932 serum selenium, with a mean of 0.01 PPM. This value was much lower than the mean selenium  
933 level in an adjacent population and the normal value for selenium, which should be greater than  
934 0.08 PPM.”* (p.21).

935

936 A minor die-off of bighorns from pneumonia in southern Alberta, by W Wishart, J  
937 Jorgenson, M Hilton. NWS&GC 1978 (1980 proceedings) 229-247. This refers to the Sheep  
938 River, Alberta area. *“The Sanctuary (since 1973) may be creating a death trap for bighorns from  
939 secondary lungworm infections, since the herd is returning early, and concentrating for longer  
940 periods on the winter range as a result of avoidance behavior to hunters and/or hikers.”* p. 229.

941

942 A 10% die-off was experienced- all dead sheep in good to excellent condition. Heavy  
943 spring rains equaled high lungworm loads. More and more sheep were returning in late summer  
944 and early fall to avoid humans *“re-exposing them to a large concentration of infective snails* (the  
945 intermediate host of the lungworm) *on the winter range.”* (p.238).

946

947 Study recommended: *“Management measures should be undertaken immediately to  
948 frighten or harass bighorns away from their winter range during the summer and early fall.  
949 Hunting seasons should be delayed until mid-September or later to discourage bighorns from  
950 congregating too early on their contaminated retreats.”*

951

952

953 **Other citations in Schommer and Woolever’s literature review**

954

955 Sharing of Pasteurella spp between free-ranging bighorn sheep and feral goats. Rudolph,  
956 Hunter Foreyt Cassierer, Rimler, Ward. 2003. Journal of Wildlife Diseases. 39: 897-903. The  
957 most thoroughly studied die-off of bighorn sheep was the Hell’s Canyon die-off of 1995-96. Three  
958 hundred and twenty seven bighorn sheep died in that epidemic. Ninety seven bighorn sheep were  
959 cultured. Six domestic sheep on private land near the area (the only domestic sheep identified  
960 anywhere close to the bighorns) were cultured. None carried organisms similar to those isolated  
961 from the dead and sick bighorn sheep. A feral goat discovered with a small group of bighorn  
962 sheep in the early phase of the epizootic was also cultured and a *Pasteurella multocida* and a  
963 *Pasteurella (Mannheimia) haemolytica* strain isolated from the goat were also cultured from  
964 samples taken from two and one bighorn sheep, respectively, that were in contact with the goat.  
965 However, those two organisms were not found in any of the other 94 bighorn sheep associated  
966 with the epizootic.

967 So, In spite of extensive sampling and culturing, there was no known transfer of bacteria  
968 between Hells Canyon bighorn sheep and domestic sheep (Cassirer et al., 1996; Rudolph et al.,  
969 2003; Rudolph et al., in press.) Cassirer, et al 2006, in fact, states "in most cases, *Pasteurella*  
970 bacteria isolated from the bighorn sheep in that die-off was not indicative of a single point source  
971 but was more indicative of involvement of multiple opportunistic pathogens present in that bighorn  
972 sheep population."

973 Concerning the goat cultured in that die-off, Rudolph et al. (2003) stated that "evidence  
974 suggests transmission ... from goats to bighorn sheep"-- "however, direction of transmission  
975 could not be established" However, I would like to point out that a sick BHS would be much more  
976 likely to be shedding organisms in far greater numbers than a healthy goat.

977 A more in depth report concerning the bighorns of Hells Canyon is "Ecology of Disease in  
978 Bighorn Sheep in Hells Canyon, USA" a PhD thesis by Elizabeth Frances Cassirer. This 129  
979 page document outlines the results of a 5 year study. Some conclusions are: "Pneumonia was  
980 the most common known cause of lamb mortality (86%) and pneumonia-related mortality was  
981 detected whenever summer lamb survival was less than 50%." She also states, "Survival and  
982 pneumonia outbreaks were not related to population size, growth rates, climate, or nutrition. Sex  
983 and source (resident or transplant) were the best predictors of adult survival and disease-related  
984 mortality. Individuals that died from pneumonia were not closer to domestic sheep or  
985 goats than those that did not."

986 Woolever and Schommer (GTR 209, May 2008) have no trouble at all incriminating the  
987 goat, though. They state: "Recently, however, domestic goats have been implicated in fatal  
988 disease transmission to bighorn sheep---The transmission of these diseases from goat to bighorn  
989 sheep was believed to have resulted in the death of about 300 bighorn sheep in an 8-week period  
990 over 40 air miles and affected 6 different bighorn sheep herds." This is another example where  
991 bighorn advocates appear to purposely misinterpret the data and many of them repeat it a  
992 *infinitum*.

993 Mountain sheep, an article referenced in many, many documents offering evidence that  
994 domestic sheep are responsible for the die-offs of bighorn sheep can be found in the J of  
995 Mammalogy, 1928, 9, 1-9. This very interesting article by George Grinnell describes the former  
996 range of bighorn sheep from his own observations and stories told by old hunters and army  
997 scouts such as Charles Reynolds, killed in Custer's last stand, Dr. D. G. Elliot and Hugh Monroe.

998 He recounts that wild sheep were found in the neighborhood of buttes and on the  
999 Northwestern plains. He states that in New Mexico and Arizona, they were once abundant.  
1000 "Everywhere on rocks near the habitation of the ancient cliff dweller, the sheep is represented in  
1001 pictograph." He continues, "---but so far as may be gathered by talking with the Indians I have  
1002 met, there remains scarcely a tradition of the existence there of sheep in the lower country. They  
1003 must have disappeared long ago." And then he says "It seems possible that with the  
1004 importation of domestic sheep into New Mexico and Arizona some diseases new to the wild  
1005 sheep may have been brought in and that these disease proved to the native species as fatal as  
1006 measles, small pox and whooping cough were to the Indians when first they were exposed."

1007 He also mention that Col Edward L. Munson expressed the belief that epidemic of  
1008 anthrax communicated to them from domestic sheep feeding on the plains below had  
1009 exterminated the wild sheep of the Bear Paw Mountains in Montana. However, we know that  
1010 Anthrax is an environmental disease and not transmissible from animal to animal. Just last year,  
1011 an Anthrax outbreak killed a large number of elk on the Ted Turner Ranch in the same area as  
1012 reported by Dr. Dave Hunter at the US Animal Health Association Meeting at Reno, Nevada in  
1013 2007. Domestic sheep had nothing to do with it.

1014 That is the extent of his comments on disease. He doesn't say that the Indians describe  
1015 seeing sick sheep. He doesn't recount that others have seen sick or dead sheep. He merely  
1016 surmises that it seems possible that some disease may have been brought in by domestic sheep.

1017 Yet, this is evidence supplied by such articles as "Epidemic Pasteurellosis in a Bighorn  
1018 Sheep Population Coinciding with the Appearance of a Domestic Sheep. George, Martin Lukacs  
1019 and Miller. J of Wildlife Disease. 2008. 385-403, which states, " [this provides one more replicate](#)  
1020 [of epidemiologic and mortality patterns reported following association of these two species for](#)  
1021 [over a century](#)". Grinnell's paper is also offered up as evidence of disease epidemics in bighorn  
1022 sheep following European settlement and establishment of domestic livestock grazing.

1023 The above article attempts to link the finding of a domestic sheep in the vicinity of bighorn  
1024 sheep to a die-off which involved 3 populations of bighorn sheep over a two year period.  
1025 However, the authors admit, "[Thus, despite gathering overwhelming circumstantial](#)  
1026 [epidemiologic evidence regarding the most plausible and parsimonious explanation for the origins](#)  
1027 [of this epidemic, laboratory finding failed to prove this apparent explanation.](#)"

1028  
1029 Since the laboratory finding didn't substantiate the preconceived blame placed on the  
1030 domestic sheep, the authors raise questions about the interpretation of the laboratory data and  
1031 the use of epidemiological evidence such as biogrouping in field investigations. They question  
1032 the ability to track an introduced *Pasteurella* strain through the course of an epidemic under  
1033 natural conditions.

1034  
1035 The authors also question the laboratories' results since apparently the two laboratories  
1036 they used didn't report the same strains. However, one of the two laboratories doesn't use  
1037 biotyping to identify the strains, thus comparing the one laboratory with the other is useless.  
1038 Additionally, delays in shipping of some specimens, difference in disease progression and  
1039 carcass preservation are also hypothesized to cause the differences in the strains isolated. In  
1040 spite of these problems, the authors report that "[with one exception,  \$\beta\$ -hemolytic \*P. \(m.\)\*](#)  
1041 [haemolytica \(primarily reported as biogroup 1<sup>G</sup> or 1<sup>aG</sup>\) was isolated from the lung tissues of all](#)  
1042 [cases evaluated during winter 1997-1998](#)".

1043  
1044 I'm sure that all of the tissues weren't shipped as timely as others, that all the tissues  
1045 weren't in the same stage of decay, and all cases weren't in the same stage of disease  
1046 progression, yet all yielded the same strain of *Pasteurella* on culture. The exception yielded a  
1047 "very hemolytic" *E. coli* from lung tissue which certainly can cause disease without the help of a  
1048 *Pasterella sp*, however there is no mention of the stage of decay or disease progress in this  
1049 animals to attempt to explain why it was the exception. A number of other *Pasterella* strains were  
1050 also identified in various combinations from pneumonic bighorns sampled opportunistically  
1051 throughout the epidemic. The problem arises because although the domestic sheep yielded  
1052 various combination of  $\beta$ -hemolytic *P (m) haemolytica (biogroup 3<sup>A</sup>)*, nonhemolytic *P. trehalosi*,  
1053 *Streptococcus bovis*, and *P. fluorescens* from its nasal, pharyngeal and tonsillar areas, it didn't  
1054 not yield a *P. (m.) haemolytica* 1<sup>G</sup> or 1<sup>aG</sup>.

1055  
1056 It is highly likely that if the domestic sheep was carrying and shedding enough *P. (m.)*  
1057 *haemolytica* 1<sup>G</sup> or 1<sup>aG</sup> to transmit disease to a recipient, it would be there in enough numbers to  
1058 isolate from a nice fresh carcass. (The domestic sheep was shot, necropsied and cultured.)

1059  
1060 George et. al. compares the mortality and depressed recruitment patterns of the Tarryall-  
1061 Kenosha Mountains pneumonia epidemic to that of the die-off of Whiskey Mountain, WY,( already  
1062 discussed earlier) and the Hell's Canyon, Idaho 1996, (also discuss earlier in this paper). The  
1063 Whiskey Mountain die-off was associated with poor forage availability and severe selenium  
1064 deficiency; while the Hell's Canyon die-off was not indicative of a single point source but was

1065 more indicative of involvement of multiple opportunistic pathogens already present in that bighorn  
1066 sheep population.

1067 George et. al. point out "In the Tarryall-Kenosha Mountains bighorn population and  
1068 elsewhere, pneumonia epidemic tended to occur in fall and winter with index cases detected in  
1069 November or early December". They feel that these conditions coincide with or subsequent to  
1070 the introduction of novel pathogens. As a matter of fact, they hypothesize that exposure most  
1071 likely first occurred during the summer following the initial 1997-98 epidemic. They relate it to the  
1072 domestic ewe that Coggins reported seeing in October associated with three bighorns in the  
1073 paper, The Lostine Rocky Mountain Bighorn Sheep Die-off and Domestic sheep. 1988. Proc. of  
1074 the Biennial Symposium of the NWS&WGC The bighorns, though, died in late November. The  
1075 penned experiments reviewed earlier in the document indicate that the incubation time of  
1076 *Pasteurella* pneumonia in bighorns is 3 to 21 days with no weather or nutritional stress. If the  
1077 *Pasteurella spp.* transmitted by the domestic sheep cause death in 3 days after exposure in  
1078 supposedly non-stressed bighorns, how does one explain the same organism sitting around in  
1079 the bighorn population all the summer causing no problems until the winter months?

1080 These same authors also explain die-offs of bighorn where no domestic sheep are  
1081 implicated by suggesting that the domestic sheep were really there spreading death, but the  
1082 predators ate them before anybody saw them. Really? Then how many times have these  
1083 unseen domestics contacted bighorns and no disease occurred?

1084 Many authors, including George, et. al. have correlated the poor recruitment of young  
1085 bighorn following die-offs to the same *Pasteurella* organism that caused the die-off. "bighorn  
1086 sheep abundance appears to be limited by recurrent pasteurellosis epidemics. ---compounded by  
1087 pneumonia and septicemia in neonatal lambs that may suppress recruitment for years afterward."  
1088 There is some new information concerning bighorn lamb deaths which may cast doubt on that  
1089 supposition. Besser, et. al. in a paper titled, Association of *Mycoplasma ovipneumoniae* with  
1090 population limiting respiratory disease in Free Ranging Rocky Mountain Bighorn Sheep (*Ovis  
1091 canadensis Canadensis*) 2008\_ Journal of Clinical Microbiology found that nine lambs from 3  
1092 populations of bighorn sheep and one adult ram in the Hells Canyon area submitted for necropsy  
1093 and diagnosis yielded *Mycoplasma ovipneumoniae*. A culture-independent method. (16 S rRNA  
1094 gene amplification method) was utilized as culturing is difficult. *Mycoplasma ovipneumoniae* was  
1095 found as the predominant member of the pneumonic lung flora in the 9 lambs and 1 ram with  
1096 early lesions of broncho-pneumonia.

1097 *Mycoplasma* serology was done on the 12 populations of Hells Canyon and a strong  
1098 correlation was found between populations which have experienced die-offs in the past and  
1099 serological titers. Data from this study suggests that *M. ovipneumoniae* may be the sole  
1100 pathogen in young lamb pneumonia. However, there are still other unknown factors involved.  
1101 Challenge experiments showed that repeated inoculation of bottle raised bighorn lambs with 10<sup>7</sup>  
1102 organisms intranasally every 2 weeks, beginning at 7 to 10 days resulted in no substantial clinical  
1103 illness although high serologic titers did occur. It may be that adequate nutrition and lack of other  
1104 stresses enable these lambs to withstand the massive exposure to this organism, whereas in the  
1105 wild, conditions are not so optimal.

1106 This scenario, i.e. *Mycoplasmaspp.* infection, certainly mirrors the situation seen in  
1107 domestic animals where an instigator is generally part of the pneumonia complex

1108 Ecologic Correlates of Pneumonic Epizootics in Bighorn Sheep Herds by Monello,  
1109 Murray and Cassirer 2001. Canadian Journal of Zoology. 79:1423-1432. evaluated the  
1110 relationship between pneumonia-induced die-offs in bighorn sheep and environmental and  
1111 biological factors. They analyzed demographic information for 176 herds across the species'  
1112 geographic range. Their analysis revealed that 88% of pneumonia-induced die-offs occurred at or  
1113 within 3 years of peak population numbers," which implies that density-dependent forces such as

1114 [food shortage or stress contribute to bighorns' susceptibility to pneumonia.](#)” This was the first  
1115 range wide study that documented a widespread, common tendency for bighorn herds to die off  
1116 at peak numbers.

1117  
1118 Herds in the die-off category were interestingly largely reintroduced (71%). The herds in  
1119 the non-die-off category were more likely to be native. When pneumonia outbreaks were  
1120 separated into late summer - fall (August to November,  $n = 6$ ) and winter-spring (December to  
1121 April,  $n = 6$ ), it was found that summer and fall pneumonia outbreaks occurred in years and  
1122 months with lower than average precipitation and higher than average temperatures (drought  
1123 periods), and winter and spring outbreaks occurred in years and months with higher than average  
1124 precipitation (deeper snow) and lower than average temperatures. Obviously weather and  
1125 environmental stress plays a big part in bighorn disease.

1126  
1127 They also reported that more of the pneumonia related die-off herds tended to be closer  
1128 to domestic sheep grazing areas distance-wise, but really how close to domestic sheep per se  
1129 was not clear. They report that herds in the pneumonia-induced-die-off category were located  
1130 significantly closer to domestic sheep allotments than those in the non-die-off category (an  
1131 average of 15 miles, for pneumonia induced-die-off and 24 miles for the non-die-off herds,  
1132 respectively). However, since the authors did not list the individual distances of the various  
1133 herds, we really don't know how convincing that evidence is. One die-off herd very close to the  
1134 domestic herds could skew the figures. Since most all of the data discussed in the paper was  
1135 graphed, charted or tabled, it seems odd that the authors did not present a chart or table with the  
1136 distances from domestic sheep grazing of each herd. The evidence would have been much more  
1137 convincing if they had done so.

1138  
1139 Regardless, this article is one of the most scientific and possibly persuasive of any of the  
1140 articles reviewed.

1141  
1142 Another interesting publication is, Rebecca Biglow's, Master's thesis: [“Herd Health and  
1143 Habitat Quality in Relationship to \*Pasteurella spp\* Induced Pneumonia in Rocky Mountain Bighorn  
1144 Sheep \(\*Ovis canadensis canadensis\*\) 2006](#), which investigated and compared a number of  
1145 parameter from the Big Creek, Idaho, bighorn population which has not done well and the  
1146 Spanish Peaks, Montana bighorns which seem to be flourishing. One finding was the blood  
1147 selenium values for the Big Creek herd were abnormally low (mean 0.045 ppm). Normal values  
1148 from domestic sheep range from 0.05- 0.12 ppm. Selenium levels are correlated with glutathione  
1149 peroxidase, an enzyme necessary for maintenance of cell membranes. Capture myopathy due to  
1150 selenium deficiency is a common occurrence in bighorn sheep. Selenium also works in  
1151 conjunction with vitamin E as an antioxidant and affects, among other things, the macrophages of  
1152 the immune system. Together, vitamin E and selenium are integral for maintaining the function of  
1153 lymphocytes and phagocytes, in short, the entire immune response.

1154  
1155 A publication that indicates that species other than domestic sheep may affect bighorns is  
1156 [“Interactions between Feral Horses and Desert bighorn Sheep at Water.”](#) 2008, Kelm, Atwell,  
1157 Rubin, et. al. J of Mammalogy 89:459-466. This reported a study of interactions of feral horses  
1158 on the range and bighorn sheep in Coyote Canyon in Anza-Borrego Desert State Park in San  
1159 Diego and Riverside counties in southern California. Their study showed that bighorn sheep  
1160 avoided sites with horses nearby and resulted in a 76% reduction in the number of groups of  
1161 bighorn sheep coming to water at that location. [“Temporal partitioning of water resources by  
1162 populations of desert bighorn sheep in Nevada and Arizona has been documented in response to  
1163 human disturbance”](#) but it hadn't been documented in conjunction with other animal species. [“---  
1164 the avoidance behavior we documented likely underestimated the potential impact of feral horses  
1165 because the band sizes of feral horses can range from 4-16. Larger numbers of free-ranging  
1166 horses in and near water sources would be expected to have a greater effect on behavior ob  
1167 bighorn sheep”](#). I suspect this situation could increase stress levels for the bighorns.

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Susceptibility of Rocky Mountain Bighorn Sheep and Domestic Sheep to Pneumonia induced by bighorn and domestic livestock strains of *Pasteurella haemolytica*. By D. Onderka, S. Rawluk and W. Wishart. Can. J. Vet. Res. 1988: 52:439-444. This experiment involved the intratracheal injection of *Pasteurella* into bighorns. It noted: "*Successful infection usually required large numbers of bacteria to be introduced into the lung, which may not mimic the circumstances of a natural infection. ... The present study was not designed to investigate the pathogenesis of P. haemolytica pneumonia as it occurs in the wild but to demonstrate the susceptibility of bighorn sheep to various Pasteurella strains under controlled situations.*"

Under the experiment involving domestic sheep *Pasteurella* inoculated into bighorns, two wild yearling bighorns were used. One died 16 hours post inoculation, while the other died at 42 hours. It should be noted that these bighorns were captured in the wild and housed individually "in quiet, well lit indoor stalls measuring 300 x 140 cm (10 feet long x 4.5 feet wide) and 180 cm high (6 feet) at 15-20 degrees C. Due to the intense flight reaction of wild sheep, the stalls consisted of three solid walls, a gate of dense wire mesh and a ceiling of chain link fencing wire. During the adaptation period of about two weeks, the ceiling was covered with plywood, and the gate darkened with black, roll down plastic. ... Regular cleaning was done while the sheep were blindfolded, which kept them calm and made them easy to handle.

Why such articles are even included in a review of conflicts between domestic sheep and goats and bighorn sheep is a mystery? It should be pointed out that these controlled experiments where intratracheal injections are done to bighorns have absolutely no relevance to natural situations involving contact between domestic sheep and wild sheep. To use them to suggest that domestic sheep pose a risk to bighorns on the forest isn't responsible science.

This review is definitely not complete but looks at much of the literature that is used to suggest that domestic sheep are responsible for disease transmission to bighorn sheep . On reviewing the literature, it is fairly obvious that the statement made in the Payette National Forest DSEIS "The overwhelming majority of published science supports this assumption" is false. It seems very clear, though, that bighorn die-offs are related to many things. Over population, poor range conditions, winter environmental conditions, mineral deficiencies, parasitism, predation, re-introductions and human intervention are common threads in the explanation of bighorn die-offs in the all of the literature reviewed.

Since bighorn sheep have been reintroduced into areas where domestic sheep have historically grazed and domestic sheep graze where bighorn sheep historically live, it is natural that there would be periodic interaction. Since disease in bighorn sheep also happens periodically, it is not surprising that an occasional disease outbreak coincides with sighting of domestic sheep in the area. As indicated above, many interactions do occur with no resulting disease problems. Studies, involving multiple necropsies and cultures of numerous animals involved in range interactions have been done over a long period of time (20 years) and in no case have die-offs been tied to organisms carried by domestic sheep. So, the evidence linking die-offs of free ranging bighorns to domestic sheep is, at best, circumstantial. Many bighorns are captured and cultured annually, so we do know that occasional healthy bighorns do carry "killer bugs", however, even though wildlife managers have this information, none of these animals have been followed, so it is unclear whether they remain healthy for long periods of time. Apparently, there are no management practices in place to deal with animals carrying the more pathogenic leukotoxin carrying *Pasteurellas spp.* and in some cases are used to augment other established populations.

It is obvious that we are dealing with a very fragile species. Thinking that the solution to making them into a healthy, vigorous large population across the modern West today by removing the domestic sheep from the range is extremely naïve and dangerous--dangerous because the bighorns will continue to die-off and we still won't know how to solve the problem.. .

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Work in Montana and Wyoming improving range, improving access to needed minerals, reducing wildlife competition, reducing predation, providing safe corridors for winter/summer movement have all had positive effects on bighorn numbers; so it appears that these types of activities are beneficial for bighorn health. None of it involved removing domestic sheep from the range. Without incorporating this kind of management, removing domestic sheep from the range will just provide more tinder for wild fires, drive sheep producers out of business, insure that rural private lands are developed thus removing more winter range for the present wildlife, including bighorn sheep, a real lose-lose scenario.

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*Michael S. ...*