Toward Resolving the Domestic/Wild Sheep Grazing Issue on Public Lands: A Suggested Paradigm Shift in Government Policy

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ABSTRACT: The conflict between the interests of wild and domestic sheep on public lands arising from risk of pathogen spillover has embroiled public agencies in the U.S., frequently invoking lawsuits and interest-based legislation. I review the long and frustrating history of efforts to protect bighorn sheep from contact with commercially-raised domestic sheep in central Washington State, USA. I suggest that such seemingly intractable conflicts result from outdated public policy that fails to acknowledge the legitimate interests both of wildlife advocates and of those livestock producers who have premised their business model on access to public land. A useful analogy is the response by public agencies to attitudinal changes toward large predators. For decades, public policy favored eradication of wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), and mountain lions (*Puma concolor*), allowing livestock producers in the western U.S. to set up their operations with modest risk of depredation. As public views evolved and resource agencies changed course these predators began a comeback, albeit with attendant costs to producers. However, public policy did not expect producers to shoulder the entire burden. Instead, governments acknowledged the altered landscape by instituting programs to assist producers in minimizing conflicts, and to compensate them monetarily when losses occurred. Similarly, sheep grazing on public land began well before wide recognition of their ability to transmit pathogens (primarily *Mycoplasma ovipneumoniae*) to their wild cousins. Public support of bighorns on public lands, along with awareness of the conflict with domestics, has since increased. However, unlike the analogous policy toward large predators, publicly funded programs in the U.S. that could facilitate moving domestics well away from wild sheep (or retiring grazing allotments entirely) have not been instituted. Thus, wild sheep advocates and domestic producers are faced with a zero-sum situation, in which one side must absorb considerable losses for the other to achieve its goals. Unsurprisingly, both sides dig in, solicit outside support, and decisions are informed more on the basis of political power than on comprehensive and fair public policy. I suggest public funding should reflect both the public's uncontested support for wildlife on public lands as well as fairness for producers for whom the rules have changed and could provide the needed catalyst to transcend the current impasse.

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There are no villains in this story. This discussion paper is not about individual people; rather it is about systems of governance. My contention is that good and honorable people have acted rationally given the prevailing incentives created by existing laws, regulations, and institutions. But those laws, regulations, and institutions—which I collectively term "governance"—have failed to successfully transform public desires for wild bighorn sheep (*Ovis canadensis*) on one hand, and for fairness and consistency on the other hand, into policy that would direct on-the-ground decisions and actions. The result has been dead bighorn sheep, reduced bighorn populations, polarized debate, defensiveness, science denialism, lawsuits, and general frustration in every direction.

In this discussion paper, I briefly review the history of attempts to protect bighorn herds in central Washington State, USA from pneumonia-causing pathogens transmitted by commercially-raised domestic sheep (*Ovis aries*) that legally graze on public lands (Appendix A). Following that, I consider how governance has framed the incentives that produced the standoff. First though, a caveat: to my knowledge, we lack definitive—at least of the sort that would stand up in a court of law—that the

diseases documented in the bighorn herds at issue were caused via contact with commercially-raised domestic sheep. To the possible objection that my premise (i.e., that commercially-grazed domestic sheep pose a threat to the wellbeing of certain bighorn herds) is too speculative to merit this level of discussion, I would offer 2 responses: First, circumstantial evidence clearly implicates domestic herds as the cause of at least some disease events in central Washington (Bernatowicz et al. 2016, Appendix B). Second, even if *Mycoplasma ovipneumoniae* in wild bighorns had other origins, we know from well-documented events elsewhere (Cassirer et al, 2017, Manlove et al. 2019, Besser et al. 2021) the risk to bighorns from commercial herds was, and remains, substantial.

1. Brief overview of governance relevant to protecting bighorns in Washington from pneumonia (see Appendix A)

Bighorn sheep were extirpated from Washington by the early 20th century (Johnson 1983, 1996), in contrast to other jurisdictions in western North America, which although experiencing marked declines in bighorns from historic numbers nonetheless retained remnant populations (Buechner 1960). Documentation of the causes for the extirpation is scant, but it is likely that pneumonia-causing pathogens transmitted from formerly abundant domestic sheep (Oliphant 1948, Galbraith and Anderson 1991) were a substantial contributor to the factors of overhunting and habitat loss that are frequently invoked for historic bighorn declines (Johnson 1983, Cassirer et al 2017). Thus, extant bighorn sheep populations in Washington have all come about through translocation which began in 1957, with sheep sourced primarily from British Columbia and Montana. Whether by design or serendipity, the geographic distribution of bighorns in Washington by the early 21st century closely resembled our best estimates of their historic range (Figure 1), albeit with increased insularity and reduced connectedness among core habitats (Lyman 2009, WDFW 2015).

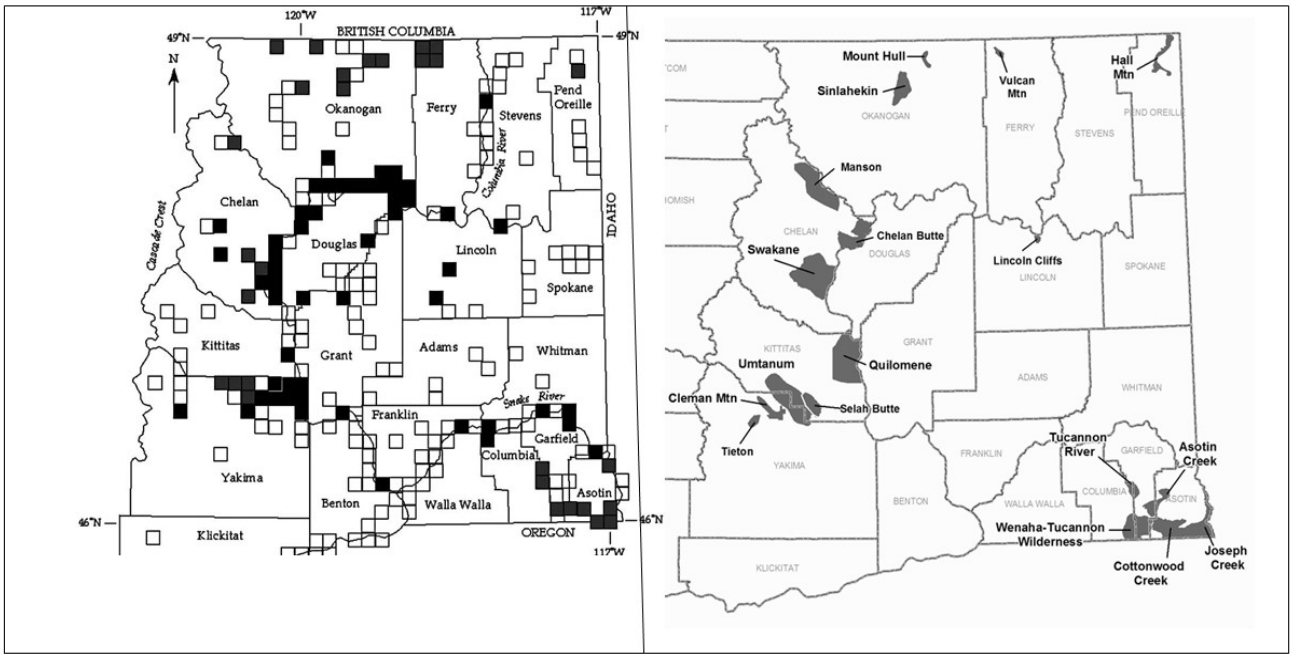

Figure 1. Maps showing approximate locations of bighorn sheep (*Ovis canadensis*) herds in Washington State, USA as of 2013 (right-hand panel), and townships sampled for palaeozoological remains by Lyman et al. (2009) (boxes) with the subset of those townships in which bighorns were either reported, or remains of bighorns were identified (prior to European settlement) indicated by filled-in boxes (left-hand panel). Note substantial correspondence between the two geographic distributions. Left-hand panel adapted from Lyman et al. (2009). County boundaries are shown in both panels for reference.

As is common in western U.S. states, large-scale commercial sheep farming in Washington declined in importance and scale during the 20th century (National Research Council 2008, Rousso 2020), with a notable exception being a large operation based southeast of Yakima that began in 1920. That family-run operation had as many as 12,000 sheep, although by 2017 had been reduced to less than half that number, but had always premised its business model on access to public lands for grazing during summer. Thus, by the time bighorns were returned to many historic habitats by the Washington Department of Fish and Wildlife (Johnson 1996), domestic sheep were already a seasonal presence on the landscape (Figure 2). Further, the owners/managers of sheep operations were well known and respected in the community and enjoyed a reputation of being both responsible and responsive to public and agency concerns.

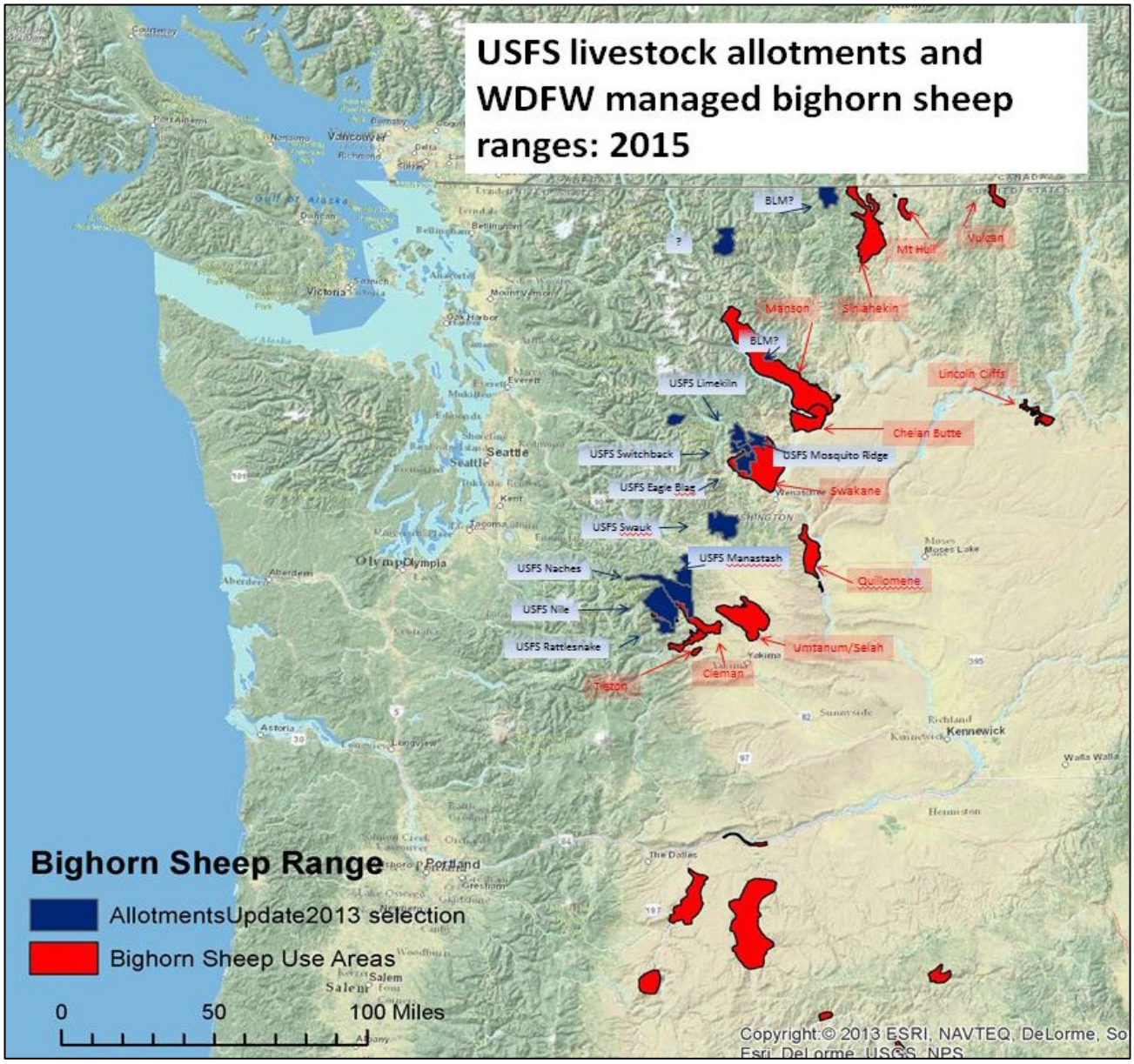

Figure 2. Map showing approximate locations of bighorn sheep (*Ovis canadensis*) herds in Washington State, USA as of 2013 (red polygons) and domestic sheep allotments on the Okanogan-Wenatchee National Forest and legally occupied by commercially-raised animals seasonally (blue polygons). Also shown are bighorn herd ranges in Oregon, not discussed in this paper.

From the outset, both wildlife managers at the Washington Department of Fish and Wildlife (WDFW) and land managers with the Okanogan-Wenatchee National Forest (OWNF) were aware that conflicts might arise between the newly repatriated bighorns and commercially-raised domestic sheep, primarily in the form of pathogen transmission (Foreyt and Jessup 1982, Wehausen et al. 2011). Until the late 20th century, neither the details of pneumonia nor the extent of movements by either wild or domestic sheep that could lead to pathogen transmission were fully appreciated. However, by 1998, with the reintroduction of bighorns in the Tieton River area near Naches, WA, a memorandum of understating (MOU) between the 2 agencies (WNF 1998) acknowledged that pathogen transmission from domestics could occur, and that spatial separation was desirable. Useful as this recognition was, the wording in this MOU maintained a somewhat detached tone regarding pathogen transmission, noting only that bighorns had previously been extirpated "for various reasons", relegating to WDFW the responsibility for evaluating "risks associated with bighorn sheep found mixed in with domestic sheep" and recommending "practices to prevent contact and potential transmission of diseases between wild and domestic sheep". However, the MOU tasked the OWNF not only with notifying WDFW when bighorns were known to enter a domestic allotment or when domestics were observed outside allotment boundaries, but also with taking "immediate action to remove those [domestic] animals" (Appendix A).

The following year, a similar agreement specific to the newly reintroduced Swakane and Manson bighorn sheep herds was signed by both agencies (WNF 1999).This second MOU went slightly further in articulating that "bighorned [sic] sheep and domestic sheep are incompatible due to disease transmission and cannot be allowed to interact" and required the Forest Service to keep domestic sheep "…outside agreed upon bighorn sheep management areas as a buffer for disease". However, the MOU acknowledged that domestic allotments existed within the bighorn management area and deferred until an unspecific future date resolution of that conflict.

Despite these MOUs and the increasing recognition generally of disease dynamics in sheep, grazing of domestic sheep continued under fundamentally unchanged policies during the early 2000s. If disease events occurred among bighorns, they were minor or at least failed to elicit substantial concern or controversy, perhaps because the bighorn herds remained small (albeit were growing both in abundance and distribution, Wampole 2023). Shortly after 2000 however, most bighorn herds managed by WDFW in the Cascade foothills began increasing markedly, as did the risk of pathogen transmission.

What had simmered as a hypothetical concern first came to a boil in November 2009 when pneumonia was first documented in the Umtanum/Selah bighorn herd, resulting in considerable mortality and (fruitless, if well-intended) agency-implemented culling of diseased bighorns (Bernatowicz et al. 2016). Although the source of infection was never identified—and indeed this herd was among the furthest from active domestic allotments—the risks to bighorns from domestics were highlighted by the occurrence of this herd collapse, which was similar to those that had occurred hundreds of miles away in the Hells Canyon Area for years (Cassirer et al. 2013), but which the Cascade foothill herds had not heretofore experienced.

About 2 years later, documents produced by the OWNF suggested that it might be taking the risks to bighorns from nearby domestic sheep increasingly seriously. In June 2011, it published a proposed action in preparation for updating its outdated forest plan, in which it hypothesized that its future course of action would be to "provide temporal or spatial separation between bighorn sheep and domestic sheep to reduce the risk of potential disease spread." In August 2011, a memo from the United States Forest Service (USFS 2011b) Deputy Chief in Washington, DC to all Regional Foresters spoke specifically and directly to the need to assess bighorn sheep viability "where management objectives include maintenance or enhancement of bighorn sheep populations". By March of 2012 the OWNF had completed a draft viability assessment of bighorns, but it was never finalized or formalized.

A second outbreak of pneumonia among bighorns on the OWNF in April 2013 appeared to elicit increased expressions of concern (if not actual regulatory actions) by the USFS (Appendix A). This time it was the previously thriving Tieton Herd that was affected, and the strain of *M. ovipneumoniae* involved was particularly virulent, killing about 90% of the herd within only a few weeks. Of relevance is that the Cleman Mountain herd was located directly adjacent to the Tieton Herd, and, despite documented movements

between the two herds in the recent past, had yet to become infected. Thus, to protect the Cleman Herd from this evidently quite lethal strain, WDFW removed the few surviving Tieton animals (Bernatowicz et al. 2016).

In the wake of the dramatic collapse of the Tieton herd, the OWNF organized several presentations and discussions focused on the evident conflict between domestic and wild sheep from May 2013 to March 2016, some of which the public was invited to attend, others designed primarily as opportunities for agency staff to share views. During this time, a report that OWNF had contracted was finalized detailing the findings of the agency-sanctioned model quantifying the risk of contact between domestics legally grazing on allotments and each bighorn herd (Lyons et al. 2016). This report confirmed that most bighorn herds with ranges near or on the OWNF were at considerable risk. At almost the same time, however, the OWNF issued new ten-year grazing permits for domestic sheep on the existing allotments without formal review, new analyses, or public announcements.

During regularly scheduled meetings with regional USFS staff, WDFW biologists and leadership evinced increasing frustration with the lack of substantive actions by OWNF staff to prevent recurrences of the 2 disease outbreaks (Appendix A). Independently, groups representing the sheep industry (or the lessees themselves) produced letters to the agencies (as well as newspaper editorials) casting doubt on the notion that permitted domestic sheep might have had a role in the disease outbreaks, and even questioning the validity of the science that formed the understanding of the bacteria and the risk it posed to bighorns when in close proximity to domestic sheep.

In June 2016, the OWNF held an open meeting in Ellensburg, Washington, at which agency and Yakama Tribal staff (as well as academic researchers) updated the public on the science and the management issues, and where the OWNF announced that a formal reassessment of the sheep grazing allotments would soon commence. However, any plans the OWNF may have had to assess the allotments directly (as had been suggested in Ellensburg) were subsequently shelved in favor of a reevaluation of the allotments within the context of the Forest Plan. This alternative process was not initiated until May 2019, almost 3 years after the public meeting, and 2 months after pneumonia associated with *M. ovipneumoniae* had been diagnosed in yet another Cascade foothill herd (Mt. Hull). The first interagency, multidisciplinary team meeting associated with this new process occurred in September 2019, but progress on the analyses and writing of the associated document was slow.

In October 2020, dead rams and *M. ovipneumoniae* were found in a fourth bighorn herd (the aforementioned Cleman, which WDFW had earlier gone to great lengths to protect), and 12 additional bighorns were prophylactically removed from yet a fifth herd (Quilomene) after a domestic sheep belonging to the commercial operator (and later confirmed to harbor *M. ovipneumoniae*) was euthanized following a comingling event (Wampole 2023). In short, while the OWNF moved formal analyses forward at a snail's pace, it continued to permit commercial sheep grazing in the high-risk allotments at a time when pathogen transmission and disease events continued to occur. If the costs and benefits of permitting commercial sheep grazing were integrated into OWNF's decision-making, the externalities associated with them (i.e., costs to the public's interest in healthy bighorn populations) were evidently passed on to others.

In November 2020, a pair of wildlife advocacy groups sued the OWNF over its repeated failure to address the disease transmission issue, asking that the court enjoin the agency from authorizing domestic sheep grazing until analyses demonstrating compliance with its own laws and policies was complete. In June 2022, the judge ruled that because the OWNF was engaged in its environmental review, the plaintiffs had nothing to challenge and thus ruled against them. After appealing to the 9th Circuit Court, the plaintiffs and the OWNF agreed to a settlement on June 12, 2023 (Ninth Circuit 2023) that required the agency to complete its analysis and publish a decision by December 31, 2027. It also stipulated that should the ultimate decision require closing of any allotments, a 2-year prior notice to the lessee would be required. Thus, the 2022 settlement agreement resulted in the OWNF doing essentially what it had committed to doing 11 years earlier, albeit with a 5-year timeline followed by a 2-year delay, and this time presumably enforceable by a federal court.

In summary, beginning at least as early as 1998, it was clear to OWNF managers that bighorns would, at best, be detrimentally affected, and at worst be unable to establish self-sustaining populations if domestic

sheep were permitted to graze within reasonable proximity. But it evidently required not only repeated (and ofttimes redundant) internal analyses and formal processes but also a lawsuit to bring the situation to a point where allotment closures may (and not "shall") take effect in early 2030. That said, nothing in this long history provides grounds for concluding that the USFS acted dishonorably, much less illegally, at any point. The methodical pace at which OWFN moved created a positive feedback loop, inducing yet further delays as staff—and critically, decision-makers such as District Rangers and Forest Supervisors—retired or moved to other positions, seemingly resetting the clock (or at least introducing a continual series of learning curves) for new staff.

Still, it is difficult for a dispassionate observer to conclude that bureaucratic processes alone kept the agency from acting more decisively to ensure adequate separation of domestic from bighorn sheep. It seems plausible that reasonable solutions would not have required 35-plus years of consideration, during which 2 herds suffered major outbreaks and 3 others became infected (but fortunately escaped relatively unscathed), had governance been clearer in pointing out a way to satisfy the seemingly conflicting mandates faced by the OWNF.

I believe that something else in the system was acting to prevent resolution of the problem in a fair and equitable way. Some other factor, unaddressed by laws or regulations and beyond the reach of the judicial system, was getting in the way of protecting bighorns while treating the legally permitted and well-respected private business fairly. My thesis is that the operating laws and regulations had, perhaps inadvertently, set up the problem as a classic zero-sum game, in which for one side to achieve its objectives the opposing side would be forced to absorb a total loss. In short, the solution to protecting the bighorns from pneumonia transmitted by domestic sheep, which was clearly the public interest, was to discontinue domestic sheep allotments that had any reasonable chance to pose a risk. But that solution would force the operator to radically alter their business model with no help or compensation whatsoever from the public that stood to benefit from that decision. Conversely, the way to assure that the livestock owner could remain in business was to retain the status quo, but that solution would put the public's bighorn sheep at continual risk because of the likelihood of additional disease outbreaks. What was missing was fairness, and a mechanism to assure that the true costs of a desired outcome (disease-free bighorn sheep in this case) would be borne by those who sought it.

2. How governance has approached two similar issues

In this section, I briefly examine 2 areas of U.S. public policy in which attempts have been made to provide a benefit that has been clearly articulated as being in the public interest, while treating with fairness and compassion private interests that are adversely affected: natural resource policy toward large carnivores, and acquisition of private property through eminent domain. Neither provide exact templates for the sheep issue but are worthy of consideration both for the general approach they have adopted, and because they have been largely successful.

2a. Large carnivores in the western U.S.

In the 19th century, and through most of the 20th, public policy, as practiced by natural resource management agencies at both federal and state levels, held that wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), and mountain lions (*Puma concolor*) —large carnivores hereafter—were undesirable and should be eliminated (Leopold et al. 1963, Kellert et al. 1996, Schwartz et al. 2003). This was rather successfully accomplished, and the extirpation of large carnivores eased the way for private individuals and companies to apply to public land management agencies for permits to graze their livestock on public lands. There were, of course, restrictions and conditions, and the issue of predation was not completely absent, but at least livestock grazers in the west didn't have to deal with large carnivores.

By the late 20th century, public policy toward large carnivores had generally, if not universally, changed. By this point in time, large carnivores were seen (again, formally via policy, if not necessarily by livestock interests) as an integral part of ecosystems, and in parts of the west where people are suitably scarce, their recovery and persistence supported (Leopold et al. 1963, Kellert and Westervelt 1983, George et al. 2016). That said, public lands agencies acknowledged that large carnivores sometimes killed livestock otherwise legally grazing on public lands, or caused indirect, sublethal losses (e.g., Hoag et al. 2011, Ramler et al. 2014). In a sense, policy recognized that we had

changed the rules applied to these law-abiding livestock grazers in the middle of the game. Whereas livestock operators began and expanded their businesses under one set of assumptions (large carnivore-free public lands), they were now (and without their personal consent) facing a different set of public priorities.

There could have been 2 alternative public policy positions taken to the new reality. On one extreme, policy could have said, in essence, "*Oops, we hadn't realized that bringing back large carnivores was going to cause economic hardship to otherwise law-abiding business people, so never mind, roll back the clock, we're changing our mind and no longer support large carnivore recovery, at least where livestock on public land might be affected*". The other extreme could have been to say "*Sorry Mr. Rancher, but times have changed. Tough luck, you've gotta' like it or lump it. It's a new world out there, we have a more comprehensive view of nature and better science than we used to and if that's to your economic detriment, too bad*". But from a comprehensive public policy perspective, a better position – and the one most agencies have implicitly adopted – was to say "*Yes, the world has changed, yes, we continue to support large carnivore recovery, but no, livestock businesses shouldn't be asked to shoulder the entire burden created by this new reality. Instead, public agencies are going to help livestock operators adjust, help protect their livestock, and pay reasonable compensation when losses occur, because this wasn't the situation they'd earlier signed up for."* The help given to livestock interests would not be complete or perfect, and they had no doubt must absorb some losses. But at least this policy approach recognized both the changing values of the majority (favoring restoration of large carnivores), while also acknowledging the responsibility of that majority to livestock interests that would be disproportionately burdened by those changes.

A few examples illustrate the way public agencies have stepped up to help livestock interests in western U.S. states without abandoning support, generally, for large carnivores. In Montana, where all three large carnivores are now reasonably common in mountainous areas close to private ranches, the state wildlife agency has invested considerable resources in supporting regionally-based staff whose job is to minimize carnivore-livestock conflicts. As of early 2024, Montana Fish, Wildlife and Parks (MFWP 2024a) employed 12 full-time field staff focused on conflicts with bears (albeit not all in areas with heavy livestock presence), as well as a statewide education specialist for whom preventing conflicts with bears was a high priority. When state legislation in Montana restricted the geography on which these staff could work, the U.S. Fish and Wildlife Service hired federal staff to augment the state technicians. Even the U.S. Department of Agriculture's Wildlife Services, which already (and more typically) became involved only when lethal removal of an offending wild animal was required, hired staff focused on nonlethal conflict prevention. Montana Fish, Wildlife, and Parks employed an additional 5 full-time field staff focused on reducing conflicts with wolves, in addition to a statewide carnivore coordinator (MFWP 2024b). These staff worked with ranchers (as well as smaller-scale, artisanal livestock producers) to minimize the chance that their operations would attract large carnivores, to help protect livestock when carnivores were close–by, and when prevention efforts failed, to move, or when necessary, remove depredating carnivores. Similar programs existed in the states of Wyoming, Idaho, and Washington.

When preventing depredation fails, Montana has, since 2007, publicly funded a separate program, administered under the aegis of its Department of Livestock, which compensates livestock owners for verified losses to wolves, grizzly bears, and mountain lions the fair market value of the animals lost (Montana Department of Livestock, 2024). In doing so, Montana is hardly unique. As of 2021, almost all western U.S. states and Canadian provinces with emerging populations of large carnivores had initiated some variant of a livestock damage and loss compensation system (Table 1; Nyhus et al. 2003, 2005; Muhly and Musiani 2009; Dickman et al. 2011; Lee et al. 2016), with most funds coming from public sources.

Now, let us go back and apply this rough template to the way public policy in the U.S. has approached bighorn sheep. In the 19th century, large bands of domestic sheep were grazed—

Table 1. Summary of livestock compensation programs in North America including grizzlies, wolves, and/or lions. Adapted from Morrison (2012) and Morehouse et al. (2018) and supplemented where possible with updated information.

Jurisdiction	Predators considered (W = wolves, GB = grizzlies, L =lions)	Livestock considered: C = cattle, S = sheep, G = goats, H = horses, 0 = other	Value of confirmed kills paid (FMV= fair market value)	Probable losses of livestock compensated	Injuries to livestock compensated	Missing animals compensated	Preventive measures required	Funding F = federal; S = state/province, H = hunters; P = private group
Alberta	W, GB, L + black bear, eagle	C,S,G,O	FMV	Yes, FMV* 0.5 if within 90 days and 10 km of confirmed loss	Yes, for veterinary expenses	?	No	F: 48%; H: 52%
Arizona/New Mexico	Mexican wolf	C (others at discretion of Council)	Calf: $750, Yrlg: $1K; Cow: $,1.2K; Bull $2K	Yes = 50% of confirmed	Yes	?		F:100%
British Columbia	W, L + coyote (some sources indicate GB)	C	FMV* 0.8 (Calves< 4 mos: $300(Cdn): older claves 75% FMV; bulls, dairy cattle) up to $2K.	No	No	No	Yes	F: 60%; S: 40%
Colorado	L + black bear	?		?	?	?	Yes[1]	F, S, H
Idaho	W	C,S,+dogs	FMV, possible multiplier on case-by-case basis	Yes: FMV if funds available	Yes	Yes, case-by-case	Yes (50% match)	F: 100%
Idaho[1]	GB[4]	C,S,G	FMV -- $1,000 deductible	unclear	uncle	No	Unclear	H: 100%
Manitoba	W, L + black bear, coyote, fox	C,S	90% FMV up to $2K	Yes: 50% FMV	Yes	No	Yes	F:60%, S:40%
Michigan	W, L + coyote	C,O	FMV	?	?	Depends	No	S: 100%
Minnesota	W	?	FMV up to $2K	No	Yes	No	?	S: 100%
Montana	W, GB, L	C,S,G,H,O	FMV	Yes	Yes if funds available	No	No	~ F 10%, S 85%: P 5%
Ontario	W, L + others	C, others	FMV (specified in a table)	No	Yes	No	Yes	F,S
Oregon[2]	W	C,S,G,H,O	FMV	Yes	Yes	Depends[3]	Yes	F: 100%
Saskatchewan	W, L + black bear, coyote, lynx, fox, eagle	C,S G,H,O		Yes: 50% FMV	Yes: up to 80% FMV	No	Yes	F: 60%, S:40%
Yukon	B, ?	?	Determined by board	?	?	?	Yes	F, S
Washington	W	C,S,H,O	FMV if on site of < 100 acres; FMV*2 if > 100 acres	Yes, half of confirmed values	Yes	Yes	Yes, cooperative agreement with WDFW	F (wolves only); S for other species
Wisconsin	W	C,S,G,H,O	FMV	Yes; FMV	Yes	Yes, over 'normal' levels	Yes	S: 100%
Wyoming[1,2]	W, GB, L+ black bear	C,S,G,H	FMV*7 if wolf near Yellowstone; FMV*3.5 if grizzly; otherwise, FMV	unclear	Yes	Yes (via multiplier)	No	H: 100%

[1] Claimant must allow big-game hunting.

[2] Administered on county basis.

[3] See Schick 2017 for details.

[4] Applicable only after grizzly bears are delisted.

sometimes freely, sometimes with some oversight —on what were, or later became, public lands. In the early 20th century, when public land agencies became involved, grazing became more regulated but was still common. Nobody considered, because nobody really knew, that domestic sheep essentially killed bighorns. Bighorns disappeared, but nobody really noticed or knew why. Regardless, this was the regulatory world inherited by today's remaining commercial sheep operators. Similar to being in a large carnivore-free world, those that grazed near historic bighorn habitat lived in a bighorn-less world.

Values gradually changed and wildlife agencies started reintroducing bighorns to their former ranges. And before long, it became increasingly clear that domestic and wild sheep didn't mix. You simply couldn't have both in the same area, or even in close proximity to one another.

At this point, policy could have taken either of two extreme positions (similar to carnivore scenario, above). Policy could have said, essentially, "*Oops, we hadn't realized that bringing back bighorns was going to cause a conflict with existing domestic sheep grazing practices and potentially cause economic hardship to otherwise law-abiding business people. So never mind, roll back the clock, we're changing our mind and no longer support bighorn sheep recovery, at least where that might affect domestic sheep grazing on public land*". Alternatively, the other extreme could have said, essentially, "*Sorry Mr. Sheep Rancher but times have changed. Tough luck, you've gotta like it or lump it. It's a new world out there, we have a more comprehensive view of nature and better science than we used to, if that's to your economic detriment, too bad*".

But at this point, the analogy between public policy approaches toward large carnivores and bighorns breaks down, because no comprehensive and fair public policy position has been institutionalized that would recognize both the newer social/ecological values (bighorns, in this case) as well as the value of compensating those who played fairly by rules (that had been changed on them). Instead, public policy *writ large* has stopped, effectively handing off this unresolved conflict to individual, local levels to somehow work out. Either domestic sheep are permitted to continue grazing near bighorns (with attendant costs to the public interest), or sheep allotments are discontinued (regardless of the impacts to the livestock operator). We should not be surprised to find that dealing with the conflict on any given local scale has been fraught, because policy failed to provide a mechanism to formally legitimize the interests and values of both sides. Instead, local level contests have been left to resolve conflicts either in an "I win, you lose" way, or by some sort of compromise.

In short, it makes little sense to expect fair or ethical resolution to this kind of conflict when done only at a local level, lacking the larger policy framework, similar to what we have (imperfectly) worked out for large carnivores. We need the public at large to recognize both values and help by providing resources to allow a fair resolution.

2b. Eminent domain as practiced in the U.S.

Most of the general public probably harbor negative views of government's use of its power of eminent domain, imagining the courageous owner of a historic, if dilapidated, shack fighting off the powerful and despotic government coveting that land for a new highway overpass. But although abuses have doubtless occurred, it is useful to recall that the reason eminent domain exists in U.S. law is because it advances a public good. There are instances in which the public's interest in a commonly-supported project simply must outweigh the interests of a private individual or corporation, no matter how noble or Quixotic their opposition may appear. But equally important are the 2 Constitutional caveats to use of eminent domain: first, that it can be exercised only when doing so clearly advances a public good, and second, that it must be accompanied by just compensation.

However, even granting that cancellation of a grazing lease on public land is not the same as a legal "taking" (see Raymond 1997), only the first of the 2 elements are provided for by existing law and regulation when it comes to the bighorn pathogen issue. The U.S. Forest Service clearly has the legal authority to revoke, or at least to not renew, a livestock allotment when environmental concerns justify doing so. But it has neither authority nor funds to compensate an operator who is thereby financially disadvantaged.

One reasonable alternative policy to that suggested by the eminent domain analogy is for

privately-funded organizations to fill the void, by offering to purchase leases otherwise owned by a livestock operator. This has been implemented, in some cases with great success, by organizations such as the Wild Sheep Foundation (WSF) and the National Wildlife Federation (NWF; Fischer 2019). I see at least 3 problems with reliance on private organizations to provide the financial resources required to achieve just compensation. First, even the largest organizations may be unable to raise enough funds to make whole a grazing operation that may have to fundamentally change its business strategy (or liquidate completely). Second, any arrangements among private parties remain voluntary. While that is ideally a virtue, it leaves the prospective funder at a disadvantage in promoting the public good if the grazing operator simply declines to participate, because there is no legal stick to accompany the financial carrot. Finally, and most fundamentally, it entrusts to privately–funded organizations what ought to be a legitimate function of government, i.e., providing for habitats in reasonable abundance for a publicly-valued wildlife species on public land. Wildlife advocacy groups such as WSF and NWF deserve the public's enduring gratitude for stepping up, but it trades one type of injustice for another if one special interest (typically, although not entirely, bighorn sheep hunters) is required to bear the burden of compensating another special interest (commercial sheep grazing operators) so that the public at large can benefit.

3. A suggested paradigm shift

Are there alternatives that honor the desire of residents of states harboring native bighorn populations to have thriving populations of bighorn sheep where habitat conditions allow but still provide justice for businesses that might be asked to bear burden seen as unfair? I think there are, but they will require financial resources, probably at the statewide level. The approach providing the most risk reduction to bighorns is clearly to prohibit domestic sheep grazing on any public lands associated with a non-negligible risk of contact. But this would entail an economic loss to operators, perhaps to the point of requiring them to change their business model entirely. As a matter of public policy, it seems unjust to insist that they alone bear this cost. If purchasing allotments (or entire herds) is the only effective solution, which seems clear is the case in central Washington, it seems appropriate for the citizens of Washington to bear that cost. Although expensive if viewed from the perspective of an individual landowner or business operator, a one-time, special allocation that would provide the necessary funds would be minor if communalized across Washington's almost 8 million people.

An operator might still argue that they have been hurt even if made financially whole: they may wish to continue their business because it is their tradition, not simply because it is a way to make a living. But as with large carnivores, society should not lose sight of greater values to avoid any and all inconvenience to those disadvantaged. Monetary compensation for a killed calf may be viewed as a poor substitute for the live calf, but livestock operators can reasonably expect fairness, not necessarily special accommodation. Providing for financial compensation to the private party harmed would allow the government agency to forthrightly address the public interest in bighorns that is implicit in law and regulation, while simultaneously achieving the public's expectation of fairness.

4. Management Implications

Neither of the templates I have offered that might undergird a paradigm shift to public policy regarding risk to bighorns on public lands are perfect models, ready for direct application. In the case of large carnivore depredation on livestock, the risks at issue are to the domestic animals whereas for sheep, the risks are to the wild ones. As well, policies to ameliorate the risks to livestock from carnivores, whether preventative or compensatory, are largely intended to allow for some measure of coexistence between the two (or perhaps put more precisely, temporal/spatial segregation on a small scale). In contrast, substantial evidence has accumulated that effective separation between the 2 types of sheep on a spatial scale that recognizes the likelihood of forays and mutual attraction remains the sole approach to assuring that risk to bighorns is acceptably low (Schommer and Woolever 2008, Whiting et al. 2023). Coexistence between domestic and wild bighorns while preventing transmission of potentially lethal pathogens is a meaningful concept only if such coexistence is to be interpreted on a large spatial scale, where domestic sheep are zoned as allowable where bighorn populations are absent or undesired, and are proscribed in and around those regions where bighorn populations have persisted or been restored.

The concept of eminent domain is also an imperfect analogue for allotments permitted to private

entities on public land. Acknowledging that some still disagree with this interpretation, settled case law has held that livestock allotments on public lands in the U.S. are not considered private property, but rather are privileges accorded when the public interest allows (36 CFR § 222.3(b); Public Lands Council v. Babbitt, 2000). Here, a useful concept was elucidated by the U. S. Supreme Court in United States v. Fuller ((1973): "*The constitutional requirement of just compensation derives as much content from the basic equitable principles of fairness…as it does from technical concepts of property law."* (for a similar perspective, see Raymond 1997) Thus, in arguing that substantial consideration be afforded to private interests that would be greatly harmed by eliminating a grazing permit, I am expressly not making an argument that permit revocation would constitute a legal taking.

Despite these important ways in which these 2 public policy examples differ from the sheep pathogen issue, they both embody fundamental principles that seem applicable. First, they clearly support the supremacy of the public good, as expressed in law, regulation, and more informally by opinion surveys, even where private interests are harmed. But importantly, they also acknowledge the "basic equitable principles of fairness" so baked into human nature, by accepting that the costs associated with that public good should be shouldered by the public, and not by the private interest that is thereby harmed. No doubt, many livestock owners would prefer to operate on public lands with no large carnivores at all than on lands where these predators are accepted and valued (despite assistance being provided to cope with them). I would not argue that livestock owners happily accept the public's relatively new support of large carnivores as long as they benefit from technical and financial support; many no doubt remain resentful. Similarly, a private party whose property is subjected to an eminent domain acquisition may well retain a sense of grievance toward the government despite receiving fair compensation. My argument supporting financial support of dispossessed domestic sheep operators is not premised on making everybody happy. Rather, it is premised on the value of the government doing as well as possible by all competing interests.

The notion that some government entity should step up to provide financial compensation for commercial sheep operators where necessary is not one that can easily (or perhaps even legally) be promoted by staff at wildlife agencies. However, that does not preclude non-governmental entities, or even legislators themselves, from proposing solutions along these lines. A precedent (in fundamental concept if not in detail) was provided by the state of Washington in 1989 (and again via revision in 2023) when the governor signed HB 1460 that created the Trust Land Transfer (TLT) program. This program provides a funding mechanism for transferring state trust lands of high ecological value (but that are otherwise mandated to generate revenue for trust beneficiaries) to protected status (RCW 79.17.300, WDNR 2024). The program requires a formal appraisal of any land parcel subject to transfer and includes oversight to ensure objectivity and fairness. Because the TLT program is specific to State Trust Lands and the need in the bighorn case is for funding that would safeguard wildlife from otherwise lawful economic activity, it does not provide a precise template. However, it plausibly paves the way for mobilizing public funds where high priority conservation actions are otherwise poorly accommodated by existing legal structures.

At the federal level, the Multi-Use Conflict Reduction Act (2005) introduced in the 109th Congress would, had it been adopted, have compensated holders of leases for relinquishing permits in ecologically sensitive areas. Among the rationales it cited for compensating ranchers were that doing so would "help recapitalize an ailing sector of rural America, by providing economic options to permittees and lessees...and allowing them to restructure their ranch operations, start new businesses, or retire with security". Following along similar lines could facilitate federal land managers in narrowing the gap between public and private interests, a gap that has seemingly frustrated attempts to protect bighorn sheep from pathogens.

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LITERATURE CITED

Bernatowicz, J., D. Bruning, E.F. Cassirer, R. B. Harris, K. Mansfield, and P. Wik. 2016. Management responses to pneumonia outbreaks in three Washington State bighorn herds: Lessons learned and unanswered questions. *Northern Wild Sheep and Goat Council* 20: 38–61.

Besser, T. E., E. F. Cassirer, K. A. Potter, and W. J. Foreyt. 2017. Exposure of bighorn sheep to domestic goats colonized with *Mycoplasma ovipneumoniae* induces sub-lethal pneumonia. PlosOne 12(6): e0178707.

Besser, T. E., E. F. Cassirer, A. Lisk, D. Nelson, K. R. Manlove, P. C. Cross, and J. T. Hogg. 2021. Natural history of a bighorn sheep pneumonia epizootic: Source of infection, course of disease, and pathogen clearance. Ecology and Evolution 11: 14366–14382.Buechner, H. K. 1960. The bighorn sheep in the United States, its past, present and future. Wildlife Monographs 4: 3–174.

Cassirer, E.F., R. K. Plowright, K. R. Manlove, P. C. Cross, A. P. Dobson, K. A. Potter, and P. J. Hudson. 2013. Spatio-temporal dynamics of pneumonia in bighorn sheep. Journal of Animal Ecology 82: 518–528.

Cassirer, E. F., K. R. Manlove, E. S. Almberg, P. Kamath, M. Cox, P. Wolff, A. Roug, J. Shannon, R. Robinson, R. B. Harris, R. K. Plowright, P. J. Hudson, P. C. Cross, A. Dobson, and T. E. Besser. 2017. Pneumonia in bighorn sheep: Risk, reservoirs, and resilience. *Journal of Wildlife Management* 82:43–45.

Dickman, A. J., E. A. Macdonald, and D. W. Macdonald. 2011. A review of financial instruments to pay for predator conservation and encourage human-carnivore coexistence. Proceedings of the National Academy of Sciences 108: 13,937–13,944.

Federal Register 2019. Department of Agriculture. Forest Service. Okanogan-Wenatchee National Forest; Washington; Forest Plan Amendment for Planning and Management of Domestic Sheep and Goat Grazing Within the Range of Bighorn Sheep. Volume 83, Number 96: 22, 432–22,434.

Fischer, K. "NWF protecting bighorn sheep in the high divide". NWF Blog. https://blog.nwf.org/2019/09/nwf-protecting-bighorn-sheep-in-the-high-divide/. Accessed 6/12/2024.

Foreyt, W. J., and D. A. Jessup. 1982. Fatal pneumonia of bighorn sheep following association with domestic sheep. Journal of Wildlife Diseases 18: 163–168.

Gaines, W. L., B. C. Wales, L. H. Suring, J. S. Begley, K. Mellen-McLean, and S. Mohoric. 2012. Draft Terrestrial Species Viability Assessments for the National Forests of Northeastern Washington. USDA Forest Service, unpublished report, Okanogan−Wenatchee National Forest.

Galbraith, W. A., and E. W. Anderson. 1991. Grazing history of the Northwest. Rangelands 13: 213–218.

George, K. A., K. M. Slagle, R. W. Wilson, S. J. Moeller, and J. T. Bruskotter. 2016. Changes in attitudes toward animals in the United States from 1978 to 2014. Biological Conservation 201: 237–242.

Heinse, L., L. Hardesty, and R. B. Harris. 2016. Risk of pathogen spillover to bighorn sheep from small domestic sheep and goat flocks on private land in Washington. *Wildlife Society Bulletin* 40: 625–633.

Hoag, L. K., R. B. Boone, and N H. Keske. 2011. The cost for agriculture to coexist with wildlife in Colorado. Human Dimensions of Wildlife. 16: 318–329.

Johnson, R. 1983. Mountain goats and mountain sheep of Washington. PR. Project W-88-R. Biological Bulletin 18, 196 pp.

Johnson, R. L. 1996. History of transplanting goats and sheep - Washington. Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 10: 200–204.

Kamath, P. L., K. Manlove, E. F. Cassirer, P. C. Cross and T. E. Besser. 2019. Genetic structure of *Mycoplasma ovipneumoniae* informs pathogen spillover dynamics between domestic and wild Caprinae in the western United States. Scientific Reports 9: 15,318.

Kellert, S. R., and M. O. Westervelt. 1983. Historical trends in American animal use and perception. International Journal for the study of animal problems. 4: 133–146.

Kellert, S. R., M. Black, C. R. Rush, and A. J. Bath. 1996. Human culture and large carnivore conservation in North America. Conservation Biology 10: 977–990.

Lee, T., K. Good, W. Jamieson, M. Quinn, and A. Krishnamurthy. 2016. Cattle and carnivore coexistence in Alberta: the role of compensation programs. Rangelands 39: 10–16.

Leopold, A. S., S. A. Cain, C. M. Cottam, I. N. Gabrielson, and T. L. Kimball. 1963. Wildlife Management in the National Parks. U.S. Department of the Interior, National Park Service.

Lyman, R. L. 2009. The Holocene history of bighorn sheep (*Ovis canadensis*) in eastern Washington state, northwestern USA. The Holocene 19: 143–150.

Lyons, A. L., W. L. Gaines, and J. Begley. 2016. Application of the Bighorn Sheep Risk of Contact Model on the Okanogan-Wenatchee National Forest. Final Report. February 2016. Washington Conservation Science Institute. Leavenworth, WA.

Madson, S. L. 2017. Science, sheep and the power of headlines. The Spokesman-Review (Spokane, Washington). July 21, 2017.

Maksimović, Z., De la Fe, C., Amores, J., Gómez-Martín, Á. & Rifatbegović, M. 2017. Comparison of phenotypic and genotypic profiles among caprine and ovine *Mycoplasma ovipneumoniae* strains. Veterinary Records. 180: (7) doi: 10.1136/vr103699. Epub 2016 Nov 28. PMID: 27895290.

Manlove, K. R., M. Branan, K. Baker. D. Bradway, E. F. Cassirer, K. L. Marshall, R. S. Miller, S. Sweeney, P.C. Cross, and T. E. Besser. 2019. Risk factors and productivity losses associated with *Mycoplasma ovipneumoniae* in United States domestic sheep operations. Preventive Veterinary Medicine 168: 30–38.

Montana Department of Livestock. 2024. Livestock Loss Board. https://liv.mt.gov/Attached-Agency-Boards/Livestock-Loss-Board/index. Accessed 6/12/24.

Montana Fish, Wildlife and Parks. 2024a. Bear Management. https://fwp.mt.gov/conservation/wildlife-management/bear/contact. Accessed 6/13/2024.

Montana Fish, Wildlife and Parks. 2024b. Wolf Management. https://fwp.mt.gov/conservation/wildlife-management/wolf. Accessed 6/13/2024.

Morehouse, A. T., J. Tigner, and M. S. Boyce. 2018. Coexistence with large carnivores supported by a predator-compensation program. Environmental Management 61: 719–731.

Morrison, C. 2012. Carnivores and conflict: A community approach to carnivore compensation. Report 1: Summary of carnivore compensation programs. Waterton Biosphere Reserve Association Carnivore Working Group.

Muhly, T. B., and M. Musiani. 2009. Livestock depredation by wolves and the ranching economy in the Northwestern U.S. Ecological Economics 68: 2,439–2,450.

Multi-Use Conflict Reduction Act of 2005. H. R. 3166, 109th Congress (2005). https://www.congress.gov/bill/109th-congress/house-bill/3166/all-actions

National Research Council. 2008. Changes in the Sheep Industry in the United States: Making the Transition from Tradition. Washington, DC: The National Academies Press. https://doi.org/10.17226/12245.

Ninth Circuit Court. 2023. Settlement Agreement in WildEarth Guardians v. Bail. E.D. Wash No. 2:20-CV-0440-TOR. 9th Circuit No 22–35,635.

Nyhus, P. J., H. Fisher, S. Osofsky, and F. Madden. 2003. Taking the bite out of wildlife damage: the challenges of wildlife compensation schemes. Conservation in Practice 4: 37–40.

Nyhus, P. J., S. Osofsky, P. Ferrero, F. Madden and H. Fisher. 2005. Bearing the costs of human-wildlife conflict: the challenges of compensation schemes. Pp. 107–121 in People and Wildlife: Conflict or coexistence. Woodroffe, R., S. Thirgood, and A. Rabinowitz, editors. Cambridge University Press.

Okanogan Wenatchee National Forest (OWNF) 2004. Decision notice and finding of no significant impact. Manastash Allotment Complex. USDA Forest Service, Okanogan and Wenatchee National Forests, Naches and Cle Elum Ranger Districts. Yakima and Kittitas Counties, Washington.

Okanogan Wenatchee National Forest (OWNF) 2023. Bighorn sheep EIS reinitiated. https://www.fs.usda.gov/detail/okawen/news-events/?cid=FSEPRD1091014. Accessed June 2, 2024.

Oliphant, J. O. 1948. History of livestock industry in the Pacific Northwest. Oregon Historical Quarterly 49: 3-29. Public Lands Council v. Babbitt, 529 U.S. 728 (2000). https://supreme.justia.com/cases/federal/us/529/728/. Accessed 6/12/24.

Ramler, J. P., M. Hebblewhite, D. Kellenberg, and C. Sime. 2014. Crying wolf? A spatial analysis of wolf location and depredation on calf weight. American Journal of Agricultural Economics 96: 631–656.

Raymond, L. 1997. Viewpoint: Are grazing rights on public lands a form of private property? Journal of Range Management 50: 431–438.

Revised Code of Washington (RCW) 79.17.300. Trust land transfer program. *https://app.leg.wa.gov/RCW/default.aspx?cite=79.17.300*. Accessed 7/15/2024.

Rousso, N. 2020. Sheep farming in Washington. History Link.org. https://www.historylink.org/File/21012. Accessed 5/31/2024.

Schommer, T. J. 1998. Wenatchee NF Bighorn sheep habitat review. October 14–15, 1998. Unpublished memo.

Schommer, T. J, and M. M. Woolever. 2008. A review of disease related conflicts between domestic sheep and goats and bighorn sheep. Gen. Tech. Rep. RMRS-GTR-209 Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 17 p.

Schwartz, C. C., J. E., Swenson, J. E., and S. D. Miller. 2003. Large carnivores, moose, and humans: a changing paradigm of predator management in the 21st century. Alces 39: 41–63.

US Forest Service 1988. Master Memorandum of Understanding, 2610. Washington Department of Fisheries, Washington Department of Wildlife, USDA Forest Service Region 6, and USDA Forest Service, Pacific Northwest Research Station. December 1988.

US Forest Service 2011a. Proposed Action for Forest Plan Revision. Okanogan-Wenatchee National Forest. June 2011. USDA Forest Service. Pacific Northwest Region.

US Forest Service. 2011b. Four step outline for conducting bighorn sheep viability analysis (at Forest Planning Level). Memo from Deputy Chief, National Forest System, to Regional Foresters R-1, 2,3,4,5 and 6. File code 2620/2200.

United States v. Fuller, 409 U.S. 488 (1973).

Wampole, E. 2023. Bighorn sheep status and trend report: Region 3. Pp. 285-295 in Washington Department of Fish and Wildlife. 2023. 2023 Game status and trend report. Wildlife Program, Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Wehausen, J. D., S. T. Kelley, and R. R. Ramey II. 2011. Domestic sheep, bighorn sheep, and respiratory disease: a review of the experimental evidence. California Fish and Game 97: 7–24.

Whiting, J.C., V. C. Bleich, R. T. Bowyer, and C.W. Epps. 2023. Restoration of bighorn sheep: History, successes, and remaining conservation issues. Frontiers in Ecology and Evolution. 11:1083350.doi: 10.3389/fevo.2023.1083350.

WDFW 2015. Washington Department of Fish and Wildlife Game Management Plan. July 2015–June 2021. Olympia, Washington. https://wdfw.wa.gov/sites/default/files/publications/01676/wdfw01676.pdf

WDNR 2024. (Washington State Department of Natural Resources). Trust Land Transfer. *https://www.dnr.wa.gov/managed-lands/land-transactions/trust-land-transfer*. Accessed 7/15/2024.

WNF 1998 (Wenatchee National Forest). MOU 0698-1708001. Memorandum of Understanding between the Washington Department of Fish and Wildlife and the USDA Forest Service, Wenatchee National Forest for the Restoration of Bighorn Sheep Populations in the Tieton River Area.

WNF 1999 (Wenatchee National Forest). MOU 699-1720004. Memorandum of Understanding between the Wenatchee National Forest and Washington Department of Wildlife on California Bighorn Sheep Restoration.

WNF 2000 (Wenatchee National Forest). Leavenworth Range District. Decision Notice for the Leavenworth, Entiat, Lake Wenatchee Range Allotment Environmental Assessment.

APPENDIX A: Partial timeline of agency actions related to protecting bighorns in central Washington State, USA: 1988–2024.

1. December 1988. The (then) Washington Department of Wildlife and the Pacific Northwest Region of the USDA Forest Service sign a memorandum of understanding clarifying the roles and responsibilities of both agencies in "protecting, perpetuating, and managing" fish and wildlife on US Forest Service lands, and providing for close cooperation between both agencies. Among other stipulations, this MOU called for annual meetings between regional USFS staff and state wildlife officials to share issues of concern (USFS 1988).
2. March 1998. A Memorandum of Understanding between the (then) Wenatchee National Forest and the Washington Department of Fish and Wildlife (WNF 1998) is finalized that clarifies roles and responsibilities for the newly restored Tieton bighorn sheep herd. The USFS agrees to require that domestic sheep be "carefully herded to keep them from straying outside the approved area for domestic sheep use, and WDFW agrees to investigate exposure and evaluate risks associated with bighorn sheep found mixed in with domestic sheep and recommend practices to prevent contact.
3. August 1998. A Memorandum of Understanding between the (then) Wenatchee National Forest and the Washington Department of Fish and Wildlife is finalized (WNF 1999) that clarifies objectives for restoring the Manson and Swakane bighorn sheep herds. Among other objectives are to "prevent interactions that transmit disease between domestic sheep and bighorn", and to "complete … a risk assessment" and to "maintain domestic sheep outside agreed upon bighorn sheep management areas as a buffer for disease" but delays resolution of allotments that are acknowledged to be within the area in question.
4. October 1998. In a memo to the (then) Wenatchee National Forest, regional and national bighorn sheep biologist Tim Schommer strongly urges the Forest to look at all opportunities to reduce contact between domestic and bighorn sheep, including converting some domestic sheep allotments to use by cattle (Schommer 1998).
5. May 2000. The Supervisor of the (then) Wenatchee National Forest signs a decision notice providing for continued domestic sheep use of 4 grazing allotments near bighorn sheep herds (WNF 2000). The decision commits the Forest to complete a habitat assessment for the Swakane Herd within a year, that grazing would only be permitted on a year-to-year basis in the southern portion of the area if the Swakane Herd was increasing within a previously defined core area, and that grazing on 3 of the allotments would be terminated if the Swakane Herd expanded outside of the area previously defined by WDFW in 1995.
6. September 2004. The (newly combined) OWNF Supervisor signs a Record of Decision (OWNF 2004) renewing 4 additional grazing allotments adjacent to the Cleman Mountain and Tieton bighorn herds, albeit with "adaptive management" that calls for rerouting some domestic sheep trailing if "*domestic sheep encounters with bighorn sheep become a problem as determined by the District Range Specialist in consultation with WDFW*".
7. May 2008. USDA RMRS-GTR 209, entitled "A review of disease related conflicts between domestic sheep and goat and bighorn sheep" is published (Schommer and Woolever 2008). It concludes that *"Pressing resource management decisions cannot wait for a complete understanding of all aspects of respiratory disease processes in bighorn sheep. In landscapes where management objectives include the maintenance or enhancement of bighorn sheep populations, the risk of potential of disease transmission between domestic sheep/goats and bighorn sheep must be addressed. The available information supports creating spatial and/or temporal separation between domestic sheep/goats and bighorn sheep as a prudent management technique to manage the risk of disease transmission.*
8. November 2009. Pneumonia is documented in the Umtanum/Selah bighorn herd; substantial mortality and culling continues through spring 2010 (Bernatowicz et al. 2016).
9. May 2010. The Confederated Tribes and Bands of the Yakama Nation writes to the Chief of the USFS, indicating that they have not been adequately represented in previous interactions, and that failure to ameliorate threats to bighorns in the area they consider to have cultural and subsistence significance would be in violation of the Treaty of 1855.

10. September 2010. OWNF Supervisor requests that WDFW nominate and authorize representatives for an interdisciplinary team to consider management and conservation of bighorn sheep on the Forest. Names are subsequently provided by the Governor of Washington.
11. June 2011. OWNF publishes a Proposed Action for Forest Plan Revision, which includes bighorn sheep as a focal species (USFS 2011a). Anticipating what a new Plan might include the document states "Management direction would be to provide temporal or spatial separation between bighorn sheep and domestic sheep to reduce the risk of potential disease spread."
12. August 2011. A memo from the Deputy Chief of the USFS to all Regional Foresters (USFS 2011b), ends with the text "Where viability assessments indicate a high likelihood of disease transmission and a resulting risk to bighorn sheep population viability across the forest, the goal of spatial and/or temporal separation between domestic sheep/goats and bighorn sheep is the most prudent action we can use to manage risk of disease transmission."
13. March 2012. The Draft Terrestrial Species Viability Assessments for the National Forests in Northeastern Washington (Gaines et al. 2012) completed. Bighorn sheep are a focal species; the risk of disease transmission from domestic sheep is considered high if > 20% of a buffered area (1 mile surrounding mapped bighorn habitat) overlaps an active allotment. Priority actions suggested to improve connectivity among bighorn habitats include "reducing the risk of disease spread."
14. April 2013. The Tieton bighorn sheep herd is decimated by virulent strain of *M. ovi.* WDFW lethally removes the few survivors (Bernatowicz et al. 2016).
15. May 2013. The OWNF convenes a round-table meeting to discuss pneumonia in both wild and domestic sheep, including top researchers, at the local district office in Naches, WA.
16. December 2013. The OWNF asks the multi-agency Tapash Collaborative to convene additional stakeholders (including Yakama Tribes, Washington Department of Natural Resources, and local offices of the U.S. Bureau of Land Management) to investigate if suitable areas for domestic sheep grazing might be found on lands beyond the OWNF. This effort quickly founders and is abandoned after it becomes clear that no other land manager can offer alternative grazing areas for the commercial herd.
17. May 2014. Regional USFS staff and WDFW statewide staff meet in Olympia. Concerns are shared about risk of disease transmission from commercially-grazed domestic sheep to bighorn sheep in the OWNF.
18. February 2015. Regional USFS staff and WDFW statewide staff meet again in Olympia. Concerns are again shared about risk of disease transmission from commercially-grazed domestic sheep to bighorn sheep in the OWNF.
19. March 2015. The WDFW director writes to USFS regional director reiterating the state's concern about disease transmission to bighorn herds in the OWNF.
20. June 2015. OWNF, USFS Region 6, and WDFW staff meet in Wenatchee to discuss plans for moving forward with minimizing the risk of disease transmission where wild bighorn herds exist, and domestic sheep allotments are of concern.
21. February 2016. Regional USFS staff and statewide WDFW staff meet in Olympia once again, bighorn issues are once again raised.
22. February 2016. The Washington Conservation Science Institute, under contract from the USFS, issues its final report entitled "Application of the Bighorn Sheep Risk of Contact Model on the Okanogan-Wenatchee National Forest" (Lyons et al. 2016). It concludes "*The Cleman Mountain and Tieton bighorn sheep herd home ranges overlap active sheep allotments and thereby might be considered a top priority for updating the NEPA* [National Environmental Policy Act] *analysis, including the qualitative information about disease transmission and herd management this Risk of Contact Tool did not address. Additionally, because the results indicated the Chelan Butte, Cleman Mountain, Swakane, Tieton and Umtanum bighorn sheep herds may be expected to experience a disease outbreak within 50 years, they would be another possible priority for updating the NEPA analysis, including the qualitative information about disease transmission and herd management this Risk of Contact Tool did not address.*
23. February 2016. OWNF, USFS Region 6, and WDFW staff meet again in Wenatchee to revisit plans for

moving forward with minimizing the risk of disease transmission where wild bighorn herds exist, and domestic sheep allotments are of concern now that the Risk of Contact final report is complete.

24. March 2016. The WDFW director writes again to USFS regional director reiterating the state's concern about disease transmission to bighorn herds in the OWNF.
25. June 2016. The OWNF Supervisor publishes an open letter committing the USFS to begin a formal NEPA process focused on domestic sheep allotments by autumn 2016.
26. August 2016. The OWNF and the Tapash Collaborative invites the public to hear presentations in Ellensburg, WA from agency staff and academic researchers regarding bighorn sheep, domestic sheep, and the risk of disease transmission. However, the public is not invited to ask questions because, it is announced, a formal EIS process to examine domestic sheep allotments would soon commence, which would provide avenues for public involvement.
27. The Consolidated Appropriations Act of 2016 passes the US Congress. The accompanying explanatory statement includes the following: "*…the Service…[shall] complete risk of contact analyses using appropriate data sources… and identify all allotments that are suitable for sheep grazing. The Service also [is] directed to identify and implement actions to resolve issues on allotments with a high risk of disease transmission, including, if agreeable to the directly affected stakeholders, the relocation of domestic sheep to allotments with a low risk, pending any site-specific environmental analysis…and to report to the Committees on implementation of these directives within 60 days of enactment of this Act."*
28. April 2017. Regional USFS staff and statewide WDFW staff meet yet again in Olympia, bighorn issues are yet again raised.
29. July 2017. WDFW convenes a small, informal face-to-face discussion with the permittee and a few supporters, to share ideas and clear the air (Madsen 2017). Among those the permittee invited to participant was a staffer for the local, sitting member of the U.S. House of Representatives.
30. January 2018. The OWNF informs WDFW that it will be amending its forest-wide plan to update consideration of pathogen transmission to bighorns, and requests that specified WDFW staff participate in the interdisciplinary team; WDFW agrees and assigns the requested staff.
31. August 2018. The OWNF supervisor formally requests WDFW participation in preparation of the EIS needed to amend the forest plan regarding domestic grazing with the range of bighorn sheep (see above). An internal timeline calls for a record of decision in August 2020.
32. March 2019. Pneumonia associated with *M. ovipneumoniae* is diagnosed for the first time in the Mt. Hull bighorn sheep herd.
33. May 2019. The OWNF begins public scoping on a proposal to amend the Forest Plan to provide new direction for management of domestic sheep grazing within the range of bighorn sheep. Federal Register (May 17, 2019).
34. June 2019. A public meeting is held by OWNF as part of the scoping process in Cle Elum, WA.
35. September 2019. The OWFW ID team begins considering alternatives.
36. September 2020. The OWNF acknowledges that it is "several months behind schedule".
37. October 2020. *M. ovipneumoniae* is found in bighorn sheep in the (formerly uninfected) Cleman Mountain herd, following a report of deceased lambs. Separately, WDFW lethally removes 15 bighorns from the Quilomene herd after a domestic sheep that had been associating with bighorn sheep rams was euthanized and found to be infected with *M. ovipneumoniae.* Meanwhile, OWNF announces that it expects to release a draft Forest Plan and EIS that would overview policy on the sheep issue (but not analyze or recommend actions on specific allotments until later) in February 2021, with a final EIS expected in November 2021.
38. November 2020. Two advocacy groups, WildEarth Guardians and Western Watersheds, file suit against the OWNF for failing to address disease transmission to bighorns from permitted domestic sheep grazing and thus violating NEPA and/or the National Forest Management Act of 1976.
39. February 2023. The OWNF reinitiates scoping on the Environmental Impact Statement that originally began in May 2019 (OWNF 2023).
40. June 2023. On appeal to the 9th Circuit after losing the lawsuit, a settlement agreement is reached

with the plaintiffs, requiring the USFS to complete a new NEPA process to amend the Forest Plan (which it was already doing, see above), and in so doing, identify which existing grazing allotments are suitable or unsuitable for domestic sheep grazing due to risk of pathogen transmission to bighorn sheep.

41. December 2027. Final EIS and Record of Decision (ROD)—from above—are due.

42. January 2030. Date that any allotment closures identified by the ROD would take effect.

APPENDIX B

This paper makes no claim that *M. ovipneumoniae* in central Washington bighorn herds was transmitted by commercial herds of domestic sheep legally permitted on USFS lands. It would be exceedingly difficult to show that definitively, and I cannot exclude other possibilities as the source of infection. That said, the following information informs our understanding of the risk of such transmission:

1) A yearling ram domestic sheep belonging to the lessee was lethally removed from the range of the Tieton bighorn herd (during the epizootic) and tested positive for *M. ovipneumoniae.* Permission from the owner to conduct strain typing on this animal was not obtained from the lessee.

2) Substantial efforts were made by regional WDFW biologists to identify small flocks of domestic sheep and/or domestic goats in close enough proximity to the Cleman, Quilomene, Swakane, Tieton, Swakane, and Umtanum/Selah herds that could plausibly have caused infection (see also Heinse et al 2016.). No herds of domestic sheep were identified. A herd of domestic goats located on private land quite near the Tieton herd's range was tested shortly after the epizootic and found to be positive for a strain of *M. ovipneumoniae,* but the strain differed from that which infected the Tieton sheep.

3) Strain typing conducted on deceased animals following the collapse of the Tieton herd demonstrated that the infection came from a single source (all strain types were identical), and that the origin was from domestic sheep rather than from domestic goats (the strains are separate and can be distinguished using molecular methods; Besser et al. 2017, Maksimović, 2017, Kamath et al. 2019).

4) With permission from the lessee, the WDFW district biologist removed 1 domestic sheep from near the Tieton herd area in 2013 and found the carcass of another (the latter being too decomposed for pathogen testing).