RECOMMENDATIONS FOR

DOMESTIC SHEEP AND GOAT MANAGEMENT IN WILD SHEEP HABITAT

2025

WAFWA
WESTERN ASSOCIATION OF
FISH & WILDLIFE AGENCIES

Prepared by the
Wild Sheep Initiative

WILD SHEEP INITIATIVE MEMBERS

Daryl Lutz (Chair)	Wyoming Game and Fish Department
Brent Lonner (vice-Chair)	Montana Department of Fish, Wildlife, & Parks
Brad Wendling	Alaska Department of Fish & Game
Anne Hubbs	Alberta Fish & Wildlife Division
Erin Butler	Arizona Game & Fish Department
Bill Jex	British Columbia Fish, Wildlife & Habitat
Tom Stephenson	California Department of Fish & Wildlife
Andy Holland	Colorado Parks & Wildlife
Hollie Miyasaki	Idaho Department of Fish & Game
Todd Nordeen	Nebraska Game & Parks Commission
Mike Cox	Nevada Department of Wildlife
Katie Piecora	New Mexico Department of Game & Fish
Brett Wiedmann	North Dakota Game & Fish Department
Heather Sayine-Crawford	Northwest Territories Environment & Natural Resources
Don Whittaker	Oregon Department of Fish & Wildlife
Chad Lehman	South Dakota Department of Game, Fish, & Parks
Froylan Hernandez	Texas Parks & Wildlife Department
Rusty Robinson	Utah Division of Wildlife Resources
William Moore	Washington Department of Fish & Wildlife
Meghan Larivee	Government of Yukon Department of Environment
Brian Logan	USDA U.S. Forest Service
Elroy Masters	USDI-Bureau of Land Management
Nathan Galloway	National Park Service
Kevin Hurley	Wild Sheep Foundation

CONTRIBUTORS

Frances Cassirer	Idaho Department of Fish & Game
Nate LaHue	Nevada Department of Wildlife
Frank Quamen	USDI Bureau of Land Management
Melanie Woolever	WSI Risk of Contact Committee Chair

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Executive Summary

In 2007, the Wild Sheep Working Group (now the Wild Sheep Initiative) of the Western Association of Fish and Wildlife Agencies (WAFWA) published a unified set of recommendations for minimizing the risk of pathogen transmission from domestic sheep or goats to wild sheep; these recommendations were revised in 2012, and again in 2025. These recommendations were intended to guide state, provincial, and territorial wild sheep managers, federal or crown land management agencies, First Nation or tribal entities, wild sheep conservation organizations, private or public land domestic sheep or goat producers, and sheep or goat hobbyists to take actions that likely will reduce transmission of pathogens to wild sheep.

Transmission of *Mycoplasma ovipneumoniae* from domestic sheep to bighorn sheep causes all age die-offs that often are followed by low recruitment has
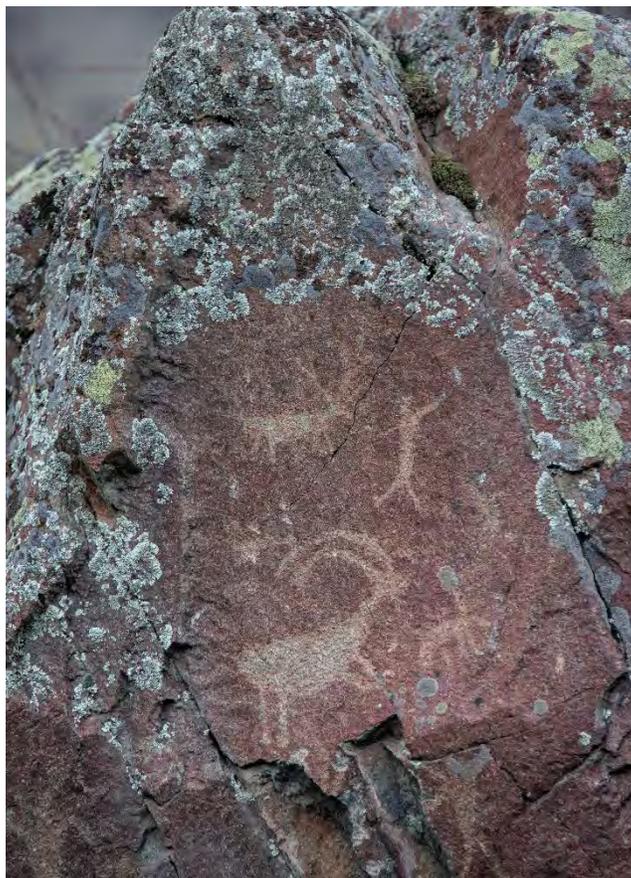

Photo by: Annie Warren, Northwest Public Broadcasting

been irrefutably demonstrated by numerous investigators, including Besser et al. (2010). Those results provide justification for preventing overlap and potential association of domestic sheep and goats with wild sheep populations that are federally or state listed, "sensitive species" status, native herds, herds used for translocation stock, herds in areas with no history of domestic livestock presence, and those with historical or indigenous cultural value. Wild sheep require greater precautionary and comprehensive management strategies that will help ensure separation between wild sheep and domestic sheep and goats.

Practical solutions will be difficult, if not impossible, to achieve until the risk of pathogen transmission from domestic sheep and goats to wild sheep is understood, acknowledged, and incorporated into conservation strategies. All parties benefit when the risk of contact is considered and then managed specifically to minimize the potential for transmission of pathogens. Recommendations contained herein help achieve that objective.

WAFWA agencies should:
(1) assess status of the subspecies or population of wild sheep and complete risk assessments of interspecies contact for all populations of wild sheep among which foray movements are anticipated; (2) remove wild sheep that have potentially associated with domestic sheep or goats, and follow or develop a policy to promptly respond to wild sheep moving into areas where they may contact domestic sheep or goats; (3) thoroughly explore the potential demographic consequences of translocations by considering risk of contact and habitat suitability analyses prior to implementing any such project; (4) coordinate with other agencies, indigenous governments, land owners, and other stakeholders regarding management of domestic sheep or goats on or near wild sheep habitat, whether occupied or not; (5) fully consider the risk of pathogen transmission when issuing or commenting on permits or regulations associated with public and private lands used for domestic sheep and goat production; and (6) develop educational materials and outreach programs to inform parties of the consequences of association between wild sheep and domestic sheep and goats.

Photo by: Rachel Curtis, Idaho Department of Fish and Game

Land management agencies should:
(1) provide effective separation between wild sheep and domestic sheep or goats; (2) quantitatively assess risk of contact between those species, and estimate the potential for pathogen transmission using the best available information including indigenous and local ecological knowledge; (3) as opportunities arise, reduce risk of association either by closing or converting (to another species with lower transmission risk) sheep or goat allotments, grazing permits, or tenures that overlap, or are within foray distance of, wild sheep habitat; (4) ensure annual operating instructions or their equivalent include measures to minimize association of domestic sheep and goats in time and space with wild sheep; (5) establish appropriate methods and protocols to remove stray domestic sheep and goats consistent with existing regulations; (6) manage wild sheep habitat to promote healthy populations of wild sheep in areas without domestic sheep or goats; and (7) support research on risk of pathogen transmission between domestic sheep or goats proximate to populations of wild sheep.

Wild sheep conservation organizations should:
(1) assist with educational or extension efforts to inform all parties; (2) initiate and maintain an open dialog with livestock producers, whether on public or private lands, and support negotiations for alternatives to the presence of domestic sheep and goats in or near wild sheep habitat; and (3) advocate for and support research on risk of pathogen transmission associated with domestic sheep or goats in proximity to wild sheep.

Domestic sheep and goat permittees or owners should:
(1) implement practices to prevent straying by domestic sheep or goats; (2) establish protocols to respond to straying domestic sheep or goats; (3) promptly report the potential or actual association between domestic sheep or goats and wild sheep to the appropriate land management or wildlife management agency; and (4) employ an active health monitoring program by testing domestic animals consistent with recommendations in the respective jurisdiction.

Private land producers should:
(1) work with wild sheep managers and advocates to support effective separation through site-specific mitigation measures; (2) promptly report any potential or confirmed association between domestic sheep and goats and wild sheep; and (3) participate in educational efforts to enhance understanding of the potential consequences of pathogen transmission from domestic sheep or goats to wild sheep.

Photo by: Montana Fish, Wildlife and Parks

Introduction

In January 2007, the Western Association of Fish and Wildlife Agencies (WAFWA), comprised of 23 state and provincial wildlife agencies from the western United States (U.S.) and western Canada, established a Wild Sheep Working Group (WSWG)—now the Wild Sheep Initiative (WSI)—to address conservation and management issues facing wild sheep. The Working Group's first task was to develop a collaborative report titled, "Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat" (WAFWA 2007). Unanimously endorsed by WAFWA Directors in July 2007, that report provided recommendations to which state, provincial, or federal agency could tier its management actions. In August 2007, the report was forwarded to the heads of the U.S. Forest Service (USFS), Bureau of Land Management (BLM), National Park Service, U.S. Fish and Wildlife Service, Bureau of Reclamation, and Department of Defense. The report was revised in 2010 and 2012) and has represented the official position of WAFWA on the management of domestic sheep, domestic goats, and wild sheep (WAFWA 2010, 2012).

Scientific literature available through November 2024 has been incorporated into this document to ensure the recommendations contained herein are current and robust, but the basic purpose, scope, and principles of the earlier versions remain unchanged. Information contained in this report is provided to assist employees of state, provincial, Tribal, federal or crown land management agencies, and BLM and USFS

Photo by: Bob Wick, Bureau of Land Management

administrators with development of a unified policy addressing the grazing of domestic sheep or goats in wild sheep habitat. This document also encourages the elimination of range overlap and, thereby, reduce opportunities for transmission of pathogens to wild sheep. This revision was approved by the WAFWA Directors and supersedes all previous versions. Definitions of the various terms used throughout this document are provided in Appendix A.

We do not review and synthesize all available information pertaining to the issue of pathogen transmission among wild sheep and domestic sheep and goats. We do, however, include relevant citations, results, literature, or analyses published since completion of our previous reports (WAFWA 2007, 2010, 2012). Our recommendations are based on the best available science and information and are intended to help achieve effective separation between wild sheep and domestic sheep and goats. Although it is nearly impossible to achieve zero risk of pathogen transmission, we recognize there are many ways to reduce the probability of association between these species with the overall result of lowered risk of epizootics occurring in wild sheep populations.

Photo by: Mike Cox, Nevada Department of Wildlife

Background

Many bighorn sheep populations in western North America were extirpated or greatly reduced following European settlement and, despite management efforts, have not recovered (Whiting et al. 2023). According to historical accounts, declines coincided largely with the advent of domestic livestock grazing on ranges occupied by bighorn sheep (Warren 1910, Grinnell 1928, Shillinger 1937, Honess and Frost 1942, CAST 2008). Investigators reported pneumonia and other diseases as causes of early die-offs, and pneumonia outbreaks are recognized as a major factor limiting bighorn sheep numbers today (Brooks 1923, Grinnell 1928, Cassirer et al. 2018). Contact with or proximity to domestic

Photo by: Montana Fish, Wildlife and Parks

Photo by: Bureau of Land Management

sheep or goats is a substantial risk to the health of free-ranging bighorn sheep (Onderka and Wishart 1984, Aune et al. 1998, Singer et al. 2000, Monello et al. 2001, George et al. 2008, Sells et al. 2015, Whiting et al. 2023), and is acknowledged as such by agricultural and animal health committees (CAST 2008, USAHA 2009). Experimental commingling of captive bighorn sheep with domestic sheep or mouflon (*O. aries orientalis*) has consistently resulted in pneumonia in bighorn sheep, with mortality approaching 100% within 90 days (Foreyt and Jessup 1982; Onderka and Wishart 1988; Foreyt 1989, 1990, 1992, 1994; Callan et al. 1991; Lawrence et al. 2010). Where thinhorn sheep (*Ovis dalli* ssp.) accidentally were exposed to domestic sheep, the contact event resulted in infection and respiratory disease in 100% of the thinhorn sheep, and all animals either died or were euthanized due to poor condition (Black et al. 1988). Experimental exposure of captive bighorn sheep to domestic goats also has been associated with pneumonia, although generally less lethal (Foreyt et al. 2009, Besser et al. 2018).

Numerous pathogens and parasites affect bighorn sheep health. Examples include bacteria causing keratoconjunctivitis, viruses causing contagious ecthyma and epizootic hemorrhagic disease, lungworm and mites that cause psoroptic mange. Morbidity and mortality associated with diseases other than bronchopneumonia tend to be less widespread, severe, or persistent, but can have substantial detrimental effects on individuals and populations. The disease that has the most widespread and severe impacts on bighorn sheep population abundance is a microbiologically complex (polymicrobial) pneumonia. The agent responsible for initiating most pneumonia outbreaks in bighorn sheep is the bacterium *Mycoplasma ovipneumoniae*, commonly referred to as "Movi" or "M. ovi"(Besser et al. 2012, 2013). *M. ovipneumoniae* causes pneumonia indirectly by impairing pulmonary defense mechanisms and allowing opportunistic pathogens to invade the lungs. Exposure of bighorn sheep populations to *M. ovipneumoniae* usually is followed by an all-age mortality

event. Following exposure, the pathogen can persist in bighorn sheep populations for decades, often causing high rates of pneumonia-induced mortality in lambs and thereby limiting recruitment rates and impeding population recovery. Bighorn sheep in infected populations can also spread *M. ovipneumoniae* to neighboring healthy populations. As a consequence, the demographic costs of disease persistence are often equal to or greater than the impacts of the initial exposure (Cassirer et al. 2018).

Domestic sheep and goats appear to be ancestral hosts of *M. ovipneumoniae*, and strains identified in these species form two genetically distinct clades, or phylogenetic lineages. Strains from both domestic sheep and domestic goat lineages have been detected in bighorn sheep, representing cross-species spillover (transmission) events (Maksimović et al. 2017, Kamath et al. 2019, Andrews et al. 2024). In a National Animal Health Monitoring System survey, "Sheep 2011", the Animal and Plant Health Inspection Service found most flocks (88%) of domestic sheep tested across the United States were positive for carriage of *M. ovipneumoniae* as determined by polymerase chain reaction (PCR) on nasal swabs.

Albeit less extensive, a similar survey of domestic goats reported 37.5–88% of herds to be PCR positive for *M. ovipneumoniae* (Heinse et al. 2016). Some unpublished surveys have reported a lower proportion of infected domestic goat herds (USDA Aphis Veterinary Services 2020). Large domestic sheep or domestic goat operations are more likely to be positive for carriage of *M. ovipneumoniae* than are small operations (USDA Aphis Veterinary Services 2015, Heinse et al. 2016).

Federal and state agencies have responded to conservation concerns with special designations providing enhanced protection and restoration guidance. Consistent with the National Forest Management Act

1982 Planning Rule (USDA Forest Service 1982) several administrative units of the USFS (Northern Region, Rocky Mountain Region, Southwest Region, Intermountain Region, the Pacific Southwest Region, and the Pacific Northwest Region) have designated bighorn sheep as a "Sensitive Species", thereby mandating special management emphasis. This emphasis includes thorough reviews and analyses of management actions that could affect populations of bighorn sheep, or their habitat, to ensure viability and preclude demographic trends that would result in the need for Federal listing. Forest Plan updates under the 2012 Planning Rule (USDA Forest Service 2012a) replaced the sensitive species designation with Species of Conservation Concern (SCC), representing those taxa for which the best available scientific information indicates substantial concern about their capability to persist over the long-term in the planning area. Maintenance of a viable population is required for SCC (36 CFR 219.9, USDA Forest Service 2016). Bighorn sheep currently are listed as a BLM Sensitive Species. Most western states have included bighorn sheep in their State Wildlife Action Plans (AFWA 2024) as a Species of Greatest Conservation Need, enhancing focus and funding on wild sheep conservation and management.

Photo by: Mike Cox, Nevada Department of Wildlife

Pathogen Transmission

*Mycoplasma ovipneumoniae i*s spread through direct contact or by droplets or aerosol particles over short distances. It is considered difficult to culture outside the host, lacks a protective cell wall, and there is no evidence that it persists in the environment (Citti and Blanchard 2013, Besser et al. 2014, Walsh et al. 2023). Not all contacts with domestic sheep or goats result in transmission of *M. ovipneumoniae* or other pathogens that result in disease in wild sheep (Drew et al. 2014, Fox et al. 2023), but any single contact could result in transmission, and the more frequent and prolonged the contacts, the more likely transmission will occur. Documenting specific cases of

Photo by: Mike Cox, Nevada Department of Wildlife

transmission between domestic sheep or goats and free-ranging wild sheep is difficult for logistical reasons. For example, domestic animals may stray or become feral and move into rugged and remote terrain occupied by wild sheep, or wild sheep may move into rangelands used by domestic sheep; thus, it often is not possible to identify when and where the transmission event occurred. In addition, there are many strains of *M. ovipneumoniae* and a single domestic flock may harbor numerous strains; tracing the outbreak strain of *M. ovipneumoniae* in wild sheep back to a particular domestic source can require intensive testing of domestic sheep or goat operations which is not always possible (Kamath et al. 2019). Advances in strain typing, however, have informed some of the potential origins of disease events where a strain is matched across species, thereby supporting the assumption there was contact and transmission occurred. Examples of this in wild sheep populations include two pneumonia outbreaks involving domestic sheep, and one involving a domestic goat (Kamath et al. 2019, Besser et al. 2021).

Caprinae (sheep, goats, and close relatives) are the primary hosts of *M. ovipneumoniae*, but detections also have been reported in other captive and free ranging ungulate species, including barren ground caribou (*Rangifer tarandus grantii*), deer (*Odocoileus hemionus, O. virginianus*), moose (*Alces alces*) and Beira antelope (*Dorcatragus megalotis*; Gull et al. 2014, Highland et al. 2018). The methodology used in some of these cases was not fully specified or confirmed by sequencing and may produce false positives (Noll et al. 2022). Detections in caribou have been sequenced, and represent a single strain from Alaska that also has been found in Alaskan Dall's sheep (*Ovis dalli dalli*). This strain falls in the domestic sheep lineage but has not yet been associated with any known widespread disease in Dall's sheep or caribou. Absence of confirmation is likely due to the remoteness of the Alaska habitat, and there is a possibility that a disease event has occurred but went undetected (Lieske et al. 2022, Andrews et al. 2024). The significance of detections (Highland et al. 2018) in mule deer (2 free-ranging animals), white-tailed deer (1 captive animal) and moose (3 free-ranging and 3 captive animals) is uncertain, and it is not known if these species are long term carriers, what the prevalence of infection in free-ranging populations is, and what strain types are involved.

It generally is acknowledged that thinhorn sheep in Alaska and northwestern Canada are immunologically naïve to exposure to many organisms commonly carried by domestic species of ruminants when compared to bighorn sheep occurring in southern Canada and the continental U.S. (Garde et al. 2005, CAST 2008). Where accidental exposure of captive thinhorn sheep to *M. ovipneumoniae* occurred, the contact event resulted in infection and respiratory disease in 100% of the animals, and all either died or were euthanized due to poor condition. Until the effects of exposure to infectious organisms are clearly understood, it is essential that no association occurs between thinhorn sheep and domestic sheep or goats.

Managing transmission of pathogens is a component of disease prevention strategies for most zoonoses and other spillover diseases (Ebinger et al. 2011, Viana et al. 2015). Currently, there is no effective vaccine or treatment for preventing or clearing *M. ovipneumoniae* infections from domestic sheep and goats, or from free-ranging wild sheep (Ziegler et al. 2014, Maksimović et al. 2022, Christensen et al. 2023, Wilson et al. 2024). *M. ovipneumoniae* is genetically diverse, and exposure to one strain likely does not provide immunity to other strains (Cassirer et al. 2017, Walsh et al. 2023). Avoiding contact with domestic sheep or goats offers the most direct and effective method for reducing the likelihood of disease outbreaks in wild sheep.

Photo by: Province of British Columbia

Effective Separation

The Western Association of Fish and Wildlife Agencies defines "Effective Separation" as spatial or temporal separation between wild sheep and domestic sheep or goats to minimize the potential for association and the probability of transmission of pathogens between species. WAFWA advocates that effective separation should be a primary management goal of the agencies or entities responsible for the conservation of wild sheep or wild sheep habitat, based on evidence that domestic sheep or goats can transmit pathogens to wild sheep. Literature and experimental evidence summarized by Wehausen et al. (2011) or discussed in this document emphasize that domestic sheep or goats should not concurrently occupy, or be within foray distance of, areas where conservation of wild sheep is a clearly stated management goal.

Effective separation does not necessarily require removal of domestic sheep or goats in all situations as long as temporal or spatial separation can be achieved. The option of removing domestic sheep or goats should, however, be included in an array of alternatives available to address this issue. For example, it is recommended that domestic goats not be allowed to graze in occupied bighorn sheep habitat because of their tendency to wander or disperse (USAHA 2009).

Reducing risk of pathogen transmission by minimizing or preventing association between wild and domestic sheep or goats on the landscape is a key management strategy for WAFWA agencies. Legislation or policy provides

Photo by: Montana Fish, Wildlife and Parks

direction, authority and responsibilities with respect to foraying bighorn sheep and feral or stray livestock that pose a risk of pathogen transmission. Further, court rulings (e.g., US District Court 2016 Idaho Case 09-0507-BLW; upheld in 9th Circuit Court) have mandated separation between domestic sheep or goats and bighorn sheep, including mandatory non-use of grazing allotments where effective separation could not be assured.

The principal federal land management agencies in the western United States, BLM and USFS, historically have reviewed, and continue to review, revise, and update policies and guidance on the management of domestic sheep or goats in wild sheep habitat (USDI Bureau of Land Management 1992, 1998, 2010, 2016; USDA Forest Service 2010a, 2011, 2012c, 2014, 2018). In 2016, the BLM issued the policy through Manual Section 1730: Management of Domestic Sheep and Goats to Sustain Wild Sheep. This policy similarly defines effective separation as the spatial or temporal separation between wild sheep and domestic sheep or goats, resulting in minimal risk of contact and subsequent transmission of respiratory pathogens between animal groups. Further, it states that physical separation of

Photo by: Wyoming Game and Fish Department

domestic sheep or goats from wild sheep currently is the only effective means to reduce the potential for pneumonia-type disease transmission. The policy requires the BLM to conduct a risk assessment in the land use planning process, when issuing or renewing domestic sheep or goat permits, or as determined by a BLM authorized officer.

An interagency GIS-based decision-support tool and GIS coverage maps that overlay current bighorn sheep distributions with vacant and active domestic sheep or goat grazing allotments and trailing routes for 14 western states (WAFWA Wild Sheep Initiative 2014) are updated periodically. These maps identify areas where association between domestic sheep or goats and bighorn sheep may occur on, or adjacent to, lands managed by BLM or USFS, and also identify areas that could provide spatial separation. The maps further provide a context for national policy development and help identify situations where proactive management is necessary to minimize risk of association. Although risk of pathogen transmission from domestic sheep or goats to wild sheep is widely acknowledged by wildlife and land management agencies, a unified set of management guidelines for minimizing this risk has not yet been adopted.

In some cases, results of contact between domestic sheep or goats and wild sheep have been severe and have endangered entire populations of wild sheep. In specific situations, implementation of best management practices (BMPs) might lead to a reduced risk of association. In particular, BMPs implemented in open, gentle terrain where domestic sheep or goats can be easily controlled and monitored can reduce risk of
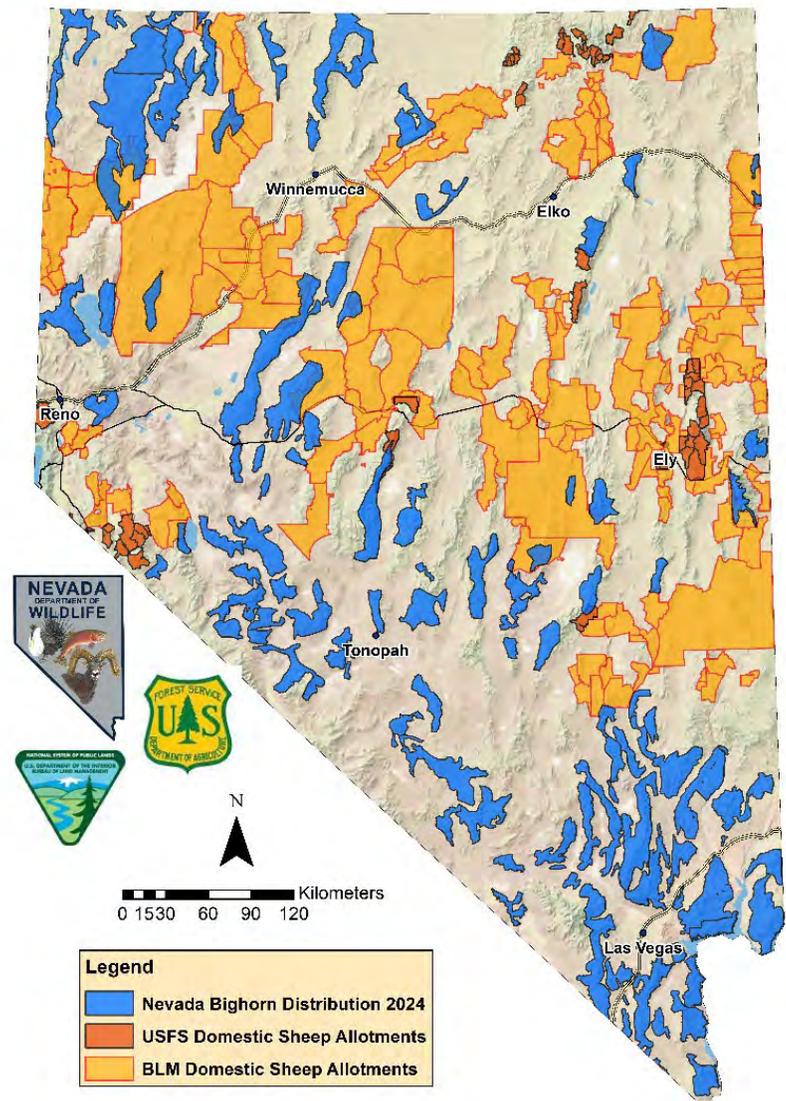
Provided by: Nevada Department of Wildlife (2024)

association (Schommer 2009). Nevertheless, BMPs that work in one situation may not work in other situations. Consequently, BMPs cannot be relied upon to ensure effective separation. If removal of domestic sheep or goats is not an option, BMPs may serve as a stopgap that could reduce risk, but evidence of such is lacking (Schommer 2009). Thus, we recommend that managers take appropriate steps to minimize opportunities for association and, thereby, the potential for pathogen transmission in all situations.

Management Recommendations

These recommendations can be applied to state, tribal, provincial, or territorial wildlife agencies; federal or crown land management agencies; wild sheep conservation organizations; and domestic sheep or goat permittees and producers, whether on public or private land. They have been strategically assigned to logical categories, and it is imperative that readers recognize these recommendations typically apply to multiple parties. Further, they must be aware that a multi-disciplinary and collaborative approach will produce the best outcomes for wild sheep and for the producers or permittees.

Although these recommendations have been developed by the Wild Sheep Initiative, which is comprised largely of wildlife agency personnel, cooperation among numerous parties is critically important to deriving on-the-ground solutions (USAHA 2009, Wild Sheep Foundation 2011). Among these are state, provincial, and territorial wildlife agencies; federal or crown land management agencies; First Nation or tribal representatives; domestic sheep or goat producers or grazing permittees; agricultural industry representatives; wild sheep conservation organizations; environmental groups; academic personnel; and otherwise interested individuals. It is our hope that collaborative discussions will occur, and that those discussions yield innovative site-specific solutions.

Many anthropogenic and environmental factors influence the demographics and viability of wild sheep populations. Some factors affecting wild sheep population performance can be managed while others cannot. Nevertheless, the one management tool currently available to minimize pathogen transmission to wild sheep is effective separation between wild sheep and domestic sheep or goats. There is no "one size fits all" assessment of the risk of respiratory pathogen transmission between domestic sheep or goats, and wild sheep. Thus, a comprehensive risk assessment, that is both qualitative and quantitative, is a critically important component for managing the potential for pathogen transmission.

Currently, there are two quantitative models available to assess risk of contact that consider foraying behavior of bighorn sheep (O'Brien et al. 2014). The Risk of Contact Tool developed by the USFS and BLM, which was based on the original work of Clifford et al. (2009), was used to develop the Payette National Forest model (O'Brien 2014). This tool is a geospatial desktop application for generalized west-wide use, and provides quantitative, repeatable, science-based risk analyses for situations in which data or resources are limited. The Tool is available for download (USDI Bureau of Land Management 2020, O'Brien et al. 2021), and uses multiple inputs including telemetry data, a core herd home range polygon, a habitat raster model, and a set of active domestic sheep allotments to estimate the probability and rate of contact between bighorn sheep and occupied allotments. This model has other applications and can also be used to calculate an estimated rate of contact between separate wild sheep herds, or to estimate the risk of a herd positive for *M. ovipneumoniae* coming into contact with a *M. ovipneumoniae*-negative herd.

The second method is a resource selection function model developed for Sierra Nevada bighorn sheep (*O. c. sierrae*). It is data intensive and requires extensive GPS location data for bighorn sheep (Anderson et al. 2022). It combines a resource selection probability function with a cost-distance analysis to quantify the risk of grazing domestic sheep in proximity to Sierra Nevada bighorn sheep core home ranges from a habitat perspective. This approach accounted for the spatial separation between those species, and the configuration of resources that influenced Sierra Nevada bighorn sheep movements. The model was developed to assess the potential for contact by predicting where Sierra Nevada bighorn sheep were likely to travel. A cost-distance analysis allowed for the optimization of grazing regimes based on results that defined a risk threshold and considered foray behavior by incorporating bighorn movements for an entire population.

In addition to assessing the risk of contact, we recommend that wild sheep managers design and implement management strategies based on an assessment and prioritization of the relative importance of wild sheep populations. The greater the risk of association with domestic sheep or goats, the more precautionary and comprehensive a strategy to ensure effective separation should be. To ensure that is the case, we offer the following:

Photo by: Idaho Department of Fish and Game

RECOMMENDATIONS TO WAFWA AGENCIES

WAFWA agencies should:

- assess status of the subspecies or population of wild sheep and complete risk assessments of the potential for interspecies contact for all populations of wild sheep among which foray movements are anticipated.
- remove wild sheep that potentially have associated with domestic sheep or goats and follow or develop a policy to promptly respond to wild sheep moving into areas where they may contact domestic sheep and goats.
- thoroughly explore the potential demographic consequences of translocations by considering risk of contact and habitat suitability analyses prior to implementing any such project coordinate with other agencies, indigenous governments, landowners, and stakeholders regarding management of domestic sheep or goats on or near wild sheep habitat, whether occupied or not.
- fully consider the risk of pathogen transmission when issuing or commenting on permits or regulations associated with public and private lands used for domestic sheep and goat production.
- develop educational materials and outreach programs to inform parties of the consequences

Photo by: Montana Fish, Wildlife and Parks

of association between wild sheep and domestic sheep and goats.

- identify, evaluate, and compare historical and suitable, but currently unoccupied, wild sheep range against currently occupied wild sheep distribution and existing or potential areas where 0domestic sheep or goats may occur.
- collect and share data to support risk assessments among management agencies.
- complete risk assessments at least once per decade, and more often if warranted (i.e. if circumstances change), for existing and potential wild sheep habitat. These assessments should specifically identify where and to what extent wild sheep could interface with domestic sheep or goats, and the level of risk within those areas.
- complete site or herd-specific risk assessments for any translocations, population augmentations, or other restoration. Management strategies for wild sheep should minimize the likelihood of association between wild sheep and domestic sheep or goats. Agencies should:

o avoid translocations of wild sheep into areas with no reasonable likelihood of effective separation from domestic sheep or goats.

o consider the health of wild sheep herds, including *M. ovipneumoniae* status and strain type, with potential connectivity when deciding on translocations.

o re-evaluate planned translocations of wild sheep to historical ranges as potential conflicts, landscape conditions, and habitat suitability change.

o recognize that augmentation of a wild sheep herd from discrete source populations poses a risk of pathogen transmission (CAST 2008) and only use source stock verified as healthy through a proper health assessment (WAFWA 2009) for translocations. Source herds should have extensive health histories and be regularly monitored to evaluate herd health. Wild sheep managers should evaluate tradeoffs between anticipated benefits such as demographic, behavioral and genetic interchange, and the potential consequences of mixing wild sheep from various source herds.

o develop and employ mapping or modeling technology as well as ground-based land use reviews prior to translocations to compare wild sheep distribution and movements with distribution of domestic sheep or goats, and use the results to inform decisions.

o anticipate exploratory movements by wild sheep shortly after translocation, as it may enhance risk of conflict. Removal or recapture of wandering wild sheep should be considered to prevent exposure to domestic sheep or goats.

▪ monitor and manage wild sheep herds more intensively as the risk of association increases. The higher the risk of association between wild sheep and domestic sheep or goats, the more intensively wild sheep herds must be monitored and managed. This is particularly important when considering "new" vs. "augmented" wild sheep populations. Agencies should:

Photo by: Bruce Mincher, Idaho Wild Sheep Foundation

o use technology such as GPS radio collars and geofencing to monitor movements and be alerted to mortality events that may indicate a disease event or forays that pose a potential risk of pathogen transmission.

o develop site-specific protocols when association with domestic sheep or goats is anticipated. For example, the proportion of translocated wild sheep that must be radio-collared for achieving desired monitoring intensities should, in part, be based on the anticipated level of risk of association with domestic sheep or goats.

o use intensive monitoring to provide a mechanism for determining proximity of wild sheep to domestic sheep or goats and for evaluating post-release habitat use and movements.

o Budgets for wild sheep translocation projects should include adequate funding for long-term monitoring.

▪ identify, analyze, and evaluate the implications of connectivity and movement corridors between largely insular herds comprising a meta-population relative to the consequences of opportunities for increased association with domestic sheep or goats. Analyses should include distribution and continuity (Mack 2008) among populations of wild sheep and the anticipated frequency of movement among or within wild sheep range. In doing so, the benefits of genetic interchange or demographic

connectivity and their resultant implications for population viability must be weighed against the risks of pathogen transmission (Bleich et al. 1990). This is especially important if dispersing or wandering wild sheep could travel across domestic sheep or goat grazing allotments or trailing routes, private land holdings, or other areas where the transmission of endemic pathogens from an infected wild herd to a naïve herd could occur.

- remove wild sheep known or suspected to have associated with domestic sheep or goats. This is considered to be an effective management tool. Exploratory movements by wild sheep can heighten the risk of association with domestic sheep and goats. Additional measures to achieve effective separation should be implemented if such association occurs, but removal of wild sheep from wild sheep range is not always the best option. This is because continuous risk of association exists during active grazing seasons when domestic sheep or goats are grazed within or in proximity to wild sheep range. As a result, removal of individual wild sheep can be an ineffective method for maintaining separation, and doing so has potentially negative consequences for population viability of wild sheep. Removal of wild sheep should occur only after critical evaluation and further implementation of measures to minimize association and enhance effective separation.

- develop a written protocol to be implemented when association between wild sheep and domestic sheep or goats is confirmed. Notification requirements, appropriate response, and post-contact monitoring options for both of the domestic species and any dispersing or wandering wild sheep should be included in such protocols. Moreover, wildlife agencies should collaborate with all appropriate parties to develop an efficacious and legal protocol when association is anticipated between feral or abandoned domestic sheep or goats for which no owner can be identified, and wild sheep.

Photo by: Wyoming Game and Fish Department

- develop databases to report, record, and summarize associations between wild sheep and domestic sheep or goats, and the subsequent outcomes. Further, wildlife managers should encourage the public and federal or crown land managers to promptly report any observations of wild sheep proximate to domestic sheep or goats. Consider the collaborative use of Citizen Science programs with universities, land management agencies, and NGOs to develop and post signs instructing the public to record sightings in available databases that incorporate a system to verify and validate reports, such as iNaturalist.

- coordinate with appropriate weed or pest management districts, or other local agencies or organizations involved with weed or vegetation management, to preclude use of domestic sheep or goats for vegetation control in areas where association with wild sheep is likely to occur.

Agencies should provide educational information and offer assistance to such districts regarding disease risks associated with domestic sheep or goats. Specific guidelines have been developed and implemented in British Columbia (Pybus et al. 1994).

- to the extent practical, develop and standardize across jurisdictions, specific protocols for sampling, testing prior to translocation, and responding to disease outbreaks. Capture and disease-testing protocols have been developed in some jurisdictions.
- coordinate and pool resources to support the ongoing laboratory detection and interpretation of important diseases of wild sheep. Wild sheep managers also should support data sharing, development, and use of standardized protocols (WAFWA 2014). Interagency communication between wildlife disease experts, such as the WAFWA Wildlife Health Committee, should be encouraged to enhance strategies for monitoring, managing, and improving health of wild sheep populations through cooperative efforts.
- develop educational materials and outreach programs to identify and interpret the risk of association between wild sheep and domestic sheep or goats and make them available to producer groups, owners of small and large farm flocks, animals used for packing, and 4-H animals.
- encourage and possibly incentivize testing domestic sheep and goats to create and maintain *M. ovipneumoniae* free status in those flocks or herds.
- create agreements with the appropriate partner agencies or encourage legislation to allow the rapid removal of stray domestic sheep or goats near wild sheep habitat. Established protocols will allow quick response to straying events.
- evaluate the disease risks of introduction, collection, importation, possession, and hunting of free ranging or privately owned exotic sheep and goat species and consider prohibition. Management authority varies by jurisdiction and may not include a WAFWA agency.

Photo by: Bruce Mincher, Idaho Wild Sheep Foundation

RECOMMENDATIONS TO BLM, USFS, NPS, PARKS AND PROTECTED AREAS AND OTHER APPLICABLE LAND MANAGEMENT AGENCIES

Land management agencies should:

- provide effective separation between wild sheep and domestic sheep or goats.
- quantitatively assess risk of contact between bighorn sheep and domestic sheep and goats and estimate the potential for pathogen transmission using the best available information including indigenous and local ecological knowledge.
- as opportunities arise, reduce risk of association either by closing or converting (to another species with lower transmission risk) domestic sheep or goat allotments, grazing permits, or tenures that overlap, or are within foray distances of, wild sheep habitat.
- ensure annual operating instructions or their equivalent include measures to minimize association of domestic sheep and goats in time and space with wild sheep.
- Establish appropriate methods and protocols to remove stray domestic sheep or goats and develop necessary protocols consistent with existing regulations (USDI Bureau of Land Management 2016, USDA Forest Service 2021).

Photo by: Bureau of Land Management

- manage wild sheep habitat to promote healthy populations of wild sheep in areas without domestic sheep or goats.
- support research on risk of pathogen transmission between domestic sheep or goats proximate to populations of wild sheep.
- Wild sheep are formally designated with special conservation status in some jurisdictions. Land management agencies should:
  - consider wild sheep for either Sensitive Species under the 1982 National Forest Management Act Planning Rule (USDA Forest Service 1982) or Species of Conservation Concern under the 2012 Planning Rule (USDA Forest Service 2012a, 2016) in the USFS forest plan revision process where risk of domestic sheep or goat contact has been identified or exists, or as recommended by state agencies (USDA Forest Service 2012b).
  - consider wild sheep as BLM Sensitive Species where risk of domestic sheep or goat contact exists, or as recommended by state agencies.
- develop and include in broad agency policy documents, joint federal land management agency guidelines on management of domestic sheep or goats in wild sheep habitat. Guidelines should be based on the need to minimize risk of association and provide effective separation between domestic sheep or goats and wild sheep with the understanding that natural attraction between the species remains problematic. Approved guidelines should not include an automatic "sunset" provision or expiration date.

If policy dictates such, however, and if an appropriate and timely review cannot be completed, existing guidelines should remain in effect until any mandated review has been accomplished.

- implement, where legislation or regulations are not already in place, an outreach program to inform potential users of the risks associated with use of domestic goats as pack animals. In some areas, the use of domestic goats as pack animals by people that travel or hunt in identified wild sheep habitat has already been prohibited.
- only authorize domestic sheep or goat grazing allotments, trailing routes, vegetation management, use as pack stock, or any other uses involving domestic sheep or goats outside of occupied wild sheep range.
- require immediate notification by permittees and their herders of association between wild sheep and domestic sheep or goats or stray events, and in no case should it be more than 24 hours of any such event. Notification procedures, including phone numbers and contact information for permittees and use of satellite communication devices in backcountry settings, should be outlined in Annual Operating Instructions for grazing allotments and trailing permits, and should include consequences for any failure to report.
- notify appropriate state, provincial, territorial, federal, crown, or tribal agencies immediately after reports of stray or commingling events.
- map active and inactive domestic sheep or goat grazing allotments and trailing routes, including information on dates of use and contact information for responsible grazing or trailing permittees.
- ensure that advance written instructions (such as USFS Annual Operating Instructions) exist, and that they address management, retrieval, and disposition of domestic sheep or goats present on public lands prior to or after permitted grazing or trailing dates.
- work collaboratively with state, provincial, and territorial wildlife and agricultural interests to

develop written agreements that address management, retrieval, and disposition of domestic sheep or goats occupying public lands where there is no permitted use. Such agreements should also address the presence of feral sheep, feral goats, and other exotic ungulates—especially ovines such as aoudad, red sheep, urial, or argali—on public lands.

- review domestic sheep allotment boundaries or other use areas, such as trailing routes, and reconfigure boundaries or routes to avoid overlap with occupied wild sheep habitat. Techniques available to accomplish this include the use of geographic or topographic barriers that enhance species separation, and temporal or spatial separation.

- ensure that Annual Operating Instructions require careful management and vigilant herding to minimize potential association between stray domestic sheep or goats and wild sheep. A count-on, count-off inventory of domestic sheep or goats must be required as a condition of operation with follow-up provisions to account for missing livestock.

- in areas of high risk of association, require trucking or some other means to minimize risks associated with trailing. Trucking domestic sheep or goats is preferred to trailing because there is less chance of straying and, thereby, less likelihood of association with wild sheep.

- require marking of all permitted domestic sheep and goats to help ensure that ownership of stray animals is quickly determined.

- in the event of trailing, require on-site compliance monitoring to minimize strays. Monitoring must be conducted by the permittee or the land management agency.

- ensure land use or resource management plans explicitly address the potential for domestic sheep or goats to associate with wild sheep. Land use plans should evaluate the suitability of permitting activities involving domestic sheep or goats and determine the best course of action with respect to wild sheep conservation. Plans should also identify general areas of public land where domestic sheep or goats cannot be permitted for weed control, commercial grazing, recreational packing, vegetation management, or other potentially conflicting uses.

- explicitly prohibit grazing of estrous domestic females in areas with potential for association with wild sheep. Ewes in estrous can attract wild ewes and rams.

- coordinate with appropriate entities involved in vegetation management programs that use domestic sheep or goats on public or Crown lands (Pybus et al. 1994), adjoining private lands, or state, provincial, and territorial wildlife habitat management areas to minimize risk of association between domestic sheep or goats and wild sheep.

- implement conversions of allotments from domestic sheep or goats to types of domestic livestock that pose a lower risk of pathogen transmission to wild sheep when allotments are within suitable wild sheep habitat, whether occupied or not, but where topography, vegetation, and other parameters allow, conversions.

- not convert cattle grazing allotments to domestic sheep or goat grazing, or allow trailing within suitable, historical wild sheep habitat that is not currently occupied by wild sheep, if restoration of wild sheep populations is an agency goal.

- under emergency conditions, complete an adequate risk assessment prior to stocking of allotments not currently under permit for domestic sheep or goats. Any such assessment must include appropriate documentation with the conclusion that effective separation can be assured. This can be accomplished via project-level NEPA analysis.

- incorporate state, provincial, or territorial wild sheep management plans either in, or as supplements to resource or land use management plans.

- collaborate with wildlife agencies to ensure the best available science is used for comprehensive risk assessments (Clifford et al. 2009, USDA Forest Service 2010b, O'Brien et al. 2014, Anderson et al. 2022) of domestic sheep or goat grazing allotments or trailing routes in wild sheep habitat. To accomplish this objective, adequate training to allow the preparation of such assessments must be provided.

- not permit grazing allotments and trailing routes identified as high or unacceptable risk by the risk assessment for use by domestic sheep or goats.

- strive to minimize or eliminate risk when making grazing permit decisions. This recommendation is in lieu of the previously recommended buffer zones, which have been replaced by more scientific and site-specific habitat modeling approaches.

- complete site-specific risk assessments to evaluate the efficacy of using natural or anthropogenic barriers. Topographic features or other natural or man-made barriers (e.g., fenced interstate highways) might be effective in minimizing association between wild sheep and domestic sheep or goats.

- in collaboration with jurisdictional domestic sheep or goat health agencies, work with producers and permittees to prevent turnout or use of sick or diseased domestic sheep or goats on grazing allotments or trailing routes. Sick, diseased, or injured domestic sheep or goats are more likely to be left behind and become strays than healthy animals. Sick or diseased animals observed on the range should be reported to land management agency personnel immediately, and interagency coordination to address the situation

Domestic Sheep and Goat Allotments and Trailing Routes
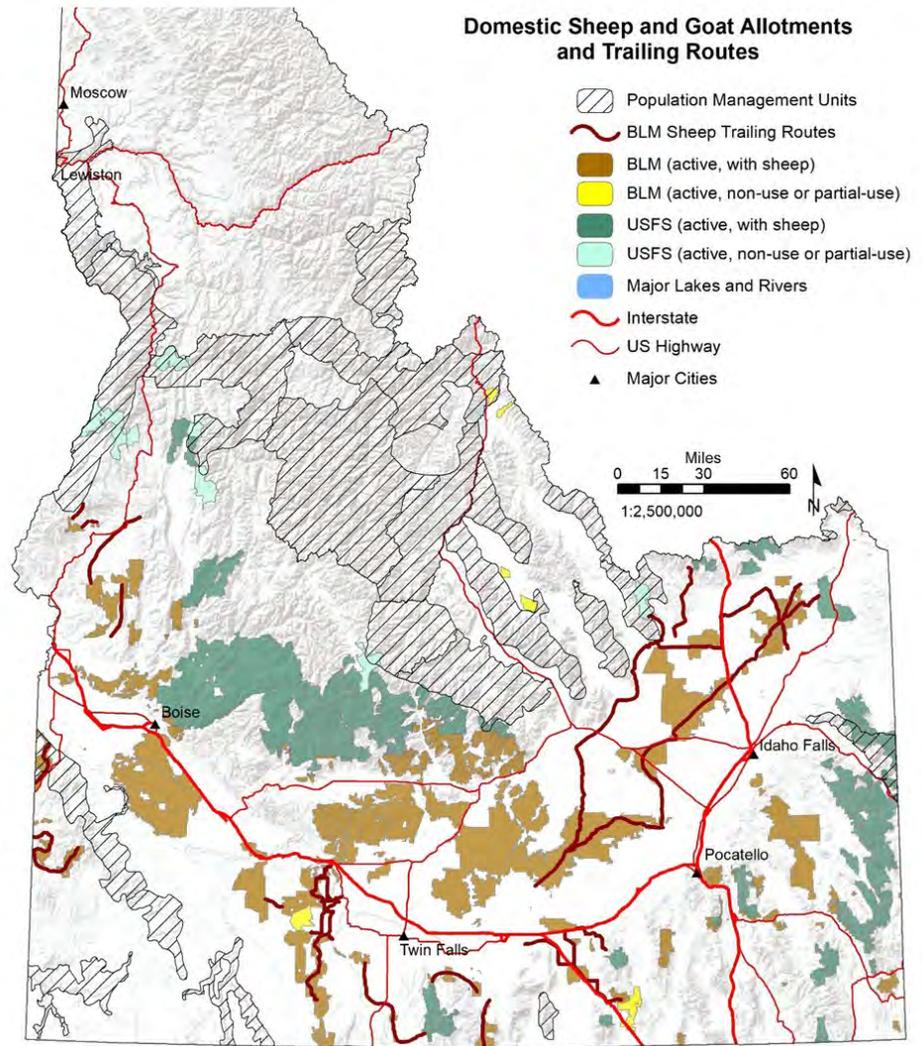
Provided by: Idaho Department of Fish and Game (2022)

should promptly occur. Further, responsible agencies must require that domestic sheep or goats are in good health before being turned out. For example, Alberta and British Columbia have developed health certification protocols (Pybus et al. 1994, British Columbia and Alberta 2021) that must be complied with before domestic sheep are turned out for vegetation management. We emphasize that the higher the risk of association between domestic sheep or goats with wild sheep, the higher the certainty of domestic animal health should be. Further, it must be recognized that even clinically healthy domestic sheep or goats can still carry pathogens that are transmissible to wild sheep, and thus, pose a significant risk to wild sheep.

- work with stakeholders and state wildlife management agencies to identify and implement a variety of management practices proportional to risk of association between domestic sheep or goats and wild sheep. Examples of such practices include use of herders, dogs or other guarding animals trained to repel animals foreign to domestic sheep bands or goat flocks (wandering wild sheep or various predators), regular counts, removals of sick animals, confinement of domestic sheep or goats at night, adequate fencing configurations, covenants, allotment retirements, conversion of class of livestock, trucking versus trailing, and others. Effectiveness of management practices designed to reduce risk of association have not been proven (Baumer et al. 2009, Schommer 2009) and alone should not be relied on to achieve effective separation. Such practices could, however, help achieve separation when applied outside of occupied or connected wild sheep range and potentially mitigate the potential impacts associated with straying domestic sheep or goats or wandering wild sheep.
- in collaboration with state wildlife management agencies, manage for quality wild sheep habitat and for habitat connectivity where appropriate, to include routine monitoring habitat to detect changes in condition.
- in areas where association between wild sheep and domestic sheep or goats is likely, post advisory signs at trailheads, campgrounds, and other high-use areas that are designed to educate visitors about the issue of interaction between those species; these signs should also encourage the prompt reporting of association of wild sheep with domestic sheep or goats. Further, agencies should ensure that individuals keep dogs under immediate voice control or on leash to prevent scattering of domestic sheep or goats in permitted areas, or to minimize disturbances to wild sheep.
- clearly define the processes, protocols, and timelines for short-term or emergency management actions when intervention is needed to minimize risk of association between wild sheep and domestic sheep or goats.
- in collaboration with state wildlife management agencies, develop programs to recognize and foster the benefits of compliance, cooperation, and cost-sharing in efforts to prevent commingling of wild sheep and domestic sheep or goats wherever they occur.
- conduct risk assessments at an appropriate geographic scale regardless of jurisdictional boundaries. Recognizing the limits of regulatory authority, land management agencies should consider private in-holdings and adjacent private lands when conducting risk assessments.
- closely evaluate the timing of permitted domestic sheep or goat grazing or trailing activities in an effort to reduce risk of pathogen transmission.
- in areas of high risk of association between wild sheep and domestic sheep or goats, ensure enhanced monitoring of grazing and trailing patterns by permittees using global positioning system (GPS) collars or other technology that provide detailed data on movements and grazing patterns. While enhanced monitoring will not reduce risk of association, it is essential for the development of meaningful risk assessments and to ensure appropriate management actions are taken to achieve effective separation.
- consider collaboratively using Citizen Science programs with WAFWA agencies, Universities, and NGOs to develop and post signs requesting the public to record sightings of wild sheep in proximity to domestic sheep and goats. Databases, such as iNaturalist, that support or otherwise include a system to verify or validate reports, are preferred.

RECOMMENDATIONS TO WILD SHEEP CONSERVATION ORGANIZATIONS

Wild sheep conservation organizations should:

- assist with educational or extension efforts to inform all parties.
- initiate and maintain an open dialog with livestock producers, whether on public or private lands, and support negotiations for alternatives to the presence of domestic sheep and goats in or near wild sheep habitat.
- advocate for and support research on risk of pathogen transmission associated with domestic sheep or goats in proximity to wild sheep.
- recognize and support efforts of wildlife agencies, land management agencies and the agricultural industry to maintain effective separation.
- work with political representatives and the agricultural industry to seek solutions that support healthy wild sheep populations, including the effective separation of domestic sheep or goats from wild sheep.
- assist wildlife and land management agencies with development of informational brochures and other materials that identify and explain risk of association between wild sheep and domestic sheep or goats.
- consider collaboratively using Citizen Science programs with universities, land management

Photo by: Bruce Mincher, Idaho Wild Sheep Foundation

agencies, and WAFWA agencies to develop and post signs requesting the public to record observations of wild sheep, and of domestic sheep or goats. Databases, such as iNaturalist, that support or otherwise include a system to verify or validate reports, are readily available and are preferred.

- assist wildlife and land management agencies with educational efforts regarding risks associated with the use of domestic sheep or goats as pack animals in wild sheep habitat. If use is authorized, encourage participants to closely control, tether, and night-pen their livestock. Encourage prompt reporting of association between wild sheep and domestic sheep or goats and promote a system for monitoring and reporting observed associations.
- maintain or establish open lines of communication with domestic sheep or goat producers and industry organizations in an effort to reduce polarization. Jointly organized and cooperatively funded workshops on risk assessment, identification of practical strategies to achieve effective separation, development and distribution of pamphlets or brochures, and public speaking opportunities are tangible examples of collaborative, multi-disciplinary approaches that can be employed to address the potential for and consequences of pathogen transmission.
- continue to negotiate alternatives or incentives for domestic sheep or goat permittees to shift their operations to grazing allotments outside of wild sheep habitat. Advocate that permittees convert to a different class of livestock with lower risk of pathogen transmission, or that they waive permitted domestic sheep or goat use in areas where risk assessments indicate a high potential for association with wild sheep.
- encourage and support development and funding of cooperative research and encourage agencies and conservation groups to commit resources necessary to maintain wild sheep populations.
- encourage and possibly incentivize testing domestic sheep flocks and goat herds to create and maintain *M. ovipneumoniae* free status.

SUGGESTED MANAGEMENT PRACTICES FOR DOMESTIC SHEEP AND GOAT PERMITTEES

The following suggestions are based largely on earlier recommendations (CAST 2008, Baumer et al. 2009, USAHA 2009), and are intended to provide a responsible and common-sense approach for reducing the risk of association. A science-based evaluation assessing the effectiveness of these actions to reduce risk or enhance separation is still needed (Schommer 2009).

Domestic sheep and goat permittees should:

- implement practices to prevent straying by domestic sheep or goats.
- establish protocols to respond to straying domestic sheep or goats.
- promptly report the potential or actual association between domestic sheep or goats and wild sheep to the appropriate land management or wildlife management agency.
- employ an active health monitoring program by testing domestic animals consistent with recommendations in the respective jurisdiction.
- implement the following reporting and record-keeping procedures:
  - Ensure prompt, accurate reporting of association or potential association by herders working on domestic sheep or goat grazing allotments where association of wild sheep with domestic sheep or goats is possible.
  - Support translation for foreign herders not

Photo by: Mike Cox, Nevada Department of Wildlife

Photo by: Carole Chamberlain

  fluent in English in order to facilitate accurate reporting.
  - Ensure sheepherders use available technologies to report and record grazing movements and encounters with wild sheep.
  - Ensure herders record GPS locations, counts, losses and other information.
- place experienced, informed, and responsible herders on allotments located near wild sheep habitat.
- ensure that all domestic sheep or goats are individually marked and traceable to source flocks or herds.
- conduct full counts when trailing, immediately any time scattering occurs and regularly during general grazing. Implement protocols developed for stray animals when domestic sheep or goats are missing.
- develop agreements between permittees and wildlife agencies that provide for locating and reacquiring all stray domestic sheep, either dead or

alive. In the event of missing domestic sheep, a thorough search should be initiated immediately, and the land manager and state wildlife agency must be notified of missing and subsequent recovery of animals.

- develop a detection and response protocol that includes:
  o reporting of wild sheep and domestic sheep associations (animal counts and GPS location) to the appropriate wildlife agency.
  o reporting of stray or missing domestic sheep to the land management agency that will, in turn, report that information to the wildlife agency.
  o removal of stray domestic sheep by the permittee, land manager, or wildlife agency personnel.
  o removal of individual commingling wild sheep by wildlife agency personnel.
  o working with wildlife agency personnel to collect standardized diagnostic samples from stray domestic sheep or commingling wild sheep.
- utilize the following trailing procedures:
  o conduct full counts when moving on and off each allotment or grazing site.

o truck domestic sheep through "driveway" areas that pass through occupied wild sheep habitat.
o truck in water (if needed) to reduce straying.
o immediately remove animals unable to stay with the flock or herd and move them to a base property.
o avoid trailing more than 5 miles per day and/or stop trailing when sheep or lambs show signs of fatigue.
o in the event that all animals cannot be accounted for, the permittee must advise the responsible agency and initiate efforts to locate missing animals and implement the removal protocol as necessary.

- remove sick domestic sheep from allotments immediately and they must never abandon them.
- utilize a sufficient number of effective guardian and herding dogs to assist herders with controlling domestic sheep and goats and thereby providing for separation from wild sheep.
- if grazing on public lands, comply with established "bed ground" standards. Where conditions permit, construct temporary electric or boundary fences to ensure that domestic sheep remain within bedding grounds.

SUGGESTED MANAGEMENT PRACTICES FOR PRIVATE LAND PRODUCERS

Private land producers should:

- work with wild sheep managers and advocates to support effective separation through site-specific mitigation measures.
- promptly report any potential or confirmed association between domestic sheep and goats and wild sheep.
- participate in educational efforts to enhance understanding of the potential consequences of pathogen transmission from domestic sheep or goats to wild sheep.
- recognize that domestic sheep or goat farming on private lands can influence the viability of wild sheep populations on adjacent public or other private lands.
- cooperate with wildlife agencies in reporting and removing feral sheep or goats and other exotic ungulates, such as aoudad, red sheep, urial, or argali, detected in or near wild sheep habitat.
- not release or leave unattended domestic sheep or goats in areas where they may seek or attract wild sheep.
- cooperate with appropriate agencies, agricultural and producer associations, conservation organizations, and other interested stakeholders to develop effective approaches to help ensure effective separation between wild sheep and domestic sheep or goats in or near wild sheep habitat, and that are consistent with private property rights.
  - Possible approaches include, but are not limited to, changing species or class of livestock, purchase of land or the domestic sheep or goats, use of methods to ensure physical separation, or development of conservation incentives, bylaws, covenants, or legislation.
- consider partnerships with non-governmental organizations and wild sheep advocacy groups for cost sharing on

risk management or mitigation strategies such as fencing, or other domestic sheep or goat management actions that reduce risk of pathogen transmission from private flocks to wild sheep.

- implement containment fencing that prevents domestic sheep and goats from running at large or becoming feral.
- implement fencing that is designed to prevent nose-to-nose contact and aerosol transmission through adequate physical distance, in order to reduce transmission of respiratory pathogens. A combination of fencing methods with the use of livestock guardian dogs may be most effective to ensure that wild sheep do not physically contact domestic sheep or goats on private land.
- participate in or support cooperative research to enhance understanding and test mitigation protocols for disease risk management.
- carefully consider the consequences of using domestic sheep or goats for weed control on private lands where association with wild sheep could occur. Work with agencies to develop alternative weed management strategies to reduce risk of association, while adequately managing weed problems.
- participate in programs to test domestic sheep and goats for *M. ovipneumoniae*.

Photo by: Idaho Department of Fish and Game

Glossary of Terms

Allotment: A portion of a landscape where livestock grazing of a plant community is prescribed according to a specific land use plan or legally defined regulatory authority.

Annual Operating Instructions: Specific language included in a term grazing or trailing permit file; reviewed each year with the permittee, prior to turnout of livestock on a grazing allotment or trailing route.

Association: Close proximity between wild sheep and domestic sheep or goats, potentially leading to direct physical contact and potential pathogen transmission.

Augment: To intentionally introduce wild sheep from one or more source populations into another existing wild sheep population, to enhance the recipient population demographically or genetically.

Buffer zone: A defined and delineated space on a landscape established by wildlife managers to reduce association and the potential for pathogen transmission between wild and domestic sheep or goats across that geographic space.

Bighorn sheep: A member of the species *Ovis canadensis* found throughout the mountains of western North America from the Peace River in Canada to northern Mexico and east to the Badlands of the Dakotas.

Contact: Direct contact between body parts of two animals during which a pathogen might be transmitted from one to another. In this document, "contact" typically refers to nose-to-nose or face-to-face interactions that may lead to the transmission of respiratory pathogens via secretions or aerosols. Synonymous with "Interaction."

Connectivity: Creating or maintaining networks of habitat that connect fragmented habitats, thus linking population segments of wildlife. Connectivity allows gene flow and enhances long-term species survival.

Conservation Incentives: In direct contrast to regulation-based conservation, incentive-based conservation provides economic, management or esthetic benefits to individuals or corporations to encourage them to conduct management activities that have positive conservation consequences for wildlife or wildlife habitat. Examples are: private land conservation easements, direct lease agreements for grazing rights for conservation purposes, and a trade or exchange of equal value grazing rights among various partners to minimize wildlife-domestic livestock conflict.

Die-off: A large-scale mortality event that impacts many animals from a population and may have significant demographic consequence for the long-term persistence of that population. In this report, such mortality events are usually caused by respiratory disease epidemics involving bacterial or other pathogens alone or in various combinations.

Disease: The word disease means literally "free of ease." Disease is any impairment that modifies or interferes with normal functions of an animal, including responses to environmental factors such as nutrition, toxicants, and climate. Typically, disease involves transmission of, and exposure to, some infectious agent but it may involve non-infectious causes such as congenital defects.

Dispersal: The process whereby individuals leave one habitat or landscape to seek another habitat or landscape in which to live.

Double fencing: Two fences running parallel around a landscape or pasture to prevent contact between animals across the fence line, designed to inhibit pathogen transmission.

Effective separation: Spatial or temporal separation between wild sheep and domestic sheep or goats, thereby resulting in minimal risk of contact and subsequent transmission of respiratory pathogens between animal groups.

Feral: An animal of a domestic species that resides in a non-domestic setting and is not presently owned or controlled.

Foray: Infrequent long-distance exploratory movement outside typical home range.

Global Positioning System (GPS) radio collar: A radio transmitter fitted on neckband material linked with orbiting satellites; animal locations can be precisely

triangulated from space, with the location data then electronically stored in a memory chip or transmitted by various methods for data retrieval.

Historical habitat: Based on historical records, landscape that was previously occupied by bighorn sheep and thought to have provided requirements necessary to sustain a wild sheep population through time.

Interaction: Direct contact between body parts of two animals during which a pathogen might be transmitted from one to another. In this document, "interaction" typically refers to nose-to-nose or face-to-face interactions that may lead to the transmission of respiratory pathogens via secretions or aerosols. Synonymous with "Contact".

Metapopulation: An assemblage of populations, or a system of local populations (demes) connected by movement of individuals (dispersal) among those population segments.

Movement corridor: Routes that facilitate movement of animals between habitat fragments.

Occupied habitat or range: Suitable habitat in which a wild sheep population currently exists.

Preferred: A specific management action that *should* be chosen over another, whenever possible.

Removal: Physical extraction of domestic sheep or goats, or wild sheep, to eliminate (permanently or temporarily) occupancy of that range or habitat.

Risk; Risk Assessment; Risk Management: In this context, evaluation of the probability that a wild sheep population could experience a disease event with subsequent demographic impacts. Identification of what factors might contribute to the probability of a disease event. Management actions taken to reduce the probability of exposure and/or infection among or between animals. Examples of risk management include separation of infected and non-infected animals, treatment of infected individuals, vaccination, manipulations of the host environment, or manipulations of the host population.
  • Qualitative Risk Assessment: Interpretation and analysis of factors that cannot necessarily be measured.
  • Quantitative Risk Assessment: Use of tangible data and measurements.

Spatial separation: A defined physical distance between animal populations.

Stray: A domestic sheep or goat physically separated from its flock or band.

Suitable habitat: Landscape that has all necessary habitat requirements to sustain a wild sheep population through time.

Temporal separation: Segregating animal populations over time to prevent association, such that they may occupy the same physical space but at different times.

Thinhorn sheep: A member of the species *Ovis dalli* occurring in Alaska, Yukon Territory, Northwest Territories, and northern British Columbia.

Transmission: The physical transfer (direct or indirect) of a disease agent from one animal to another, either within an animal population or between animal populations. In some instances, transmission can lead to full expression of disease in individuals or populations.

Translocation: An intentional movement of wild sheep from a source population to other suitable wild sheep habitat, either currently occupied or not. (Also called "transplant" in some documents.)

Trailing: The planned ambulatory movement of domestic sheep or goats across a landscape or within a corridor to reach a destination where grazing or use will be allowed.

Unoccupied habitat or range: Suitable habitat in which a wild sheep population does not currently exist.

Viability: The demographic and genetic status of an animal population whereby long-term persistence is likely.

Wandering Wild Sheep: Wild sheep occasionally traveling outside of normally anticipated or expected wild sheep range and adjacent habitat. Removal of wandering wild sheep typically does not have population-level implications for wild sheep. Conversely, failure to respond to wandering wild sheep may result in significant, adverse population-level impacts.

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