Western Association of Fish and Wildlife Agencies (WAFWA)
Wild Sheep Working Group
Recommendations for Domestic Sheep and Goat Management In Wild Sheep Habitat
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Executive Summary

Although the risk of disease transmission from domestic sheep or goats to wild sheep is widely recognized by wildlife and land management agencies, a unified set of management recommendations for minimizing this risk has not yet been devised or adopted by responsible agencies. This report has been prepared to assist BLM, USFS, and other land managers with development of a more-unified policy on grazing domestic sheep or goats in wild sheep habitat. We recommend that state, provincial, and territorial wild sheep managers, and federal land management agencies, take appropriate steps to eliminate range overlap, and thereby, opportunities for association and subsequent disease transmission.

We acknowledge that not all disease outbreaks in wild sheep are the result of contact with domestic sheep or goats. Nevertheless, there is sufficient evidence of disease transmission from domestic sheep or goats, followed by substantial mortality, that range overlap and potential association should be prevented. The higher the conservation value (e.g., federally or state listed, “sensitive species” status,

native herds, transplant source stock, naïve herds with no previous exposure) of a wild sheep population, and the greater the risk of potential association with domestic sheep or goats, the more aggressive and comprehensive that wild sheep and domestic sheep or goat management strategies should be, commensurate with level of risk.

Practical solutions will be difficult if not impossible to achieve until risk of disease transmission from domestic sheep or goats to wild sheep is widely acknowledged. We recognize that reaching this goal is likely to require additional scientific evidence and further research (Council for Agricultural Science [C.A.S.T.] 2008, U.S. Animal Health Association [USAHA] 2009). Recognition by stakeholders that all parties benefit when disease risk is actively managed is also critical.

Recommendations to WAFWA agencies include:

- Completion of risk assessments in a meta-population context.
- Removal of wild sheep that have likely associated with domestic sheep or goats, as an emergency action. If this action becomes routine, agencies must further examine why conditions lead to frequent association. A policy should be developed by each agency to promptly respond to wandering wild sheep which exhibit movements outside anticipated, occupied wild sheep range.
- Wild sheep translocations should be preceded by thorough disease surveillance; demographic modeling should be used to determine acceptable removals from source populations; and sufficient analyses of habitat suitability and disease risk must be fully explored. Following translocation, agencies should monitor response of source populations, and success of translocated animals.
- WAFWA agencies should coordinate with other agencies and involved stakeholders on management of domestic sheep or goats in wild sheep range within their respective jurisdictions.

Recommendations to land management agencies (e.g., BLM, USFS) include:

- Manage domestic sheep or goat grazing to achieve effective separation, reduce risk of association, and avoid range overlap with wild sheep.
- Ensure annual operating instructions (AOIs) issued to grazing permittees include measures to minimize association and identify strategies to deal with stray domestic sheep or goats.
- Manage wild sheep habitat to promote healthy populations in areas away from where domestic sheep or goats are permitted.
- Require use of Best Management Practices (BMPs) to reduce straying by domestic sheep or goats.

Recommendations to wild sheep conservation organizations include:

- Assist with education efforts about risks of disease from domestic sheep or goats to wild sheep.
- Negotiate alternatives and incentives for domestic sheep or goat permittees to shift operations outside of wild sheep habitat.
- Support research on understanding disease and risk.

Recommendations to domestic sheep or goat grazing or trailing permittees include:

- Implement Best Management Practices to prevent straying by domestic sheep or goats.
- Ensure protocols exist to respond to stray domestic sheep or goats.

Recommendations to private landowners include:

- Support effective separation and minimize range overlap.
- Promptly report observed or imminent association between domestic sheep or goats and wild sheep.

Introduction/Overview

In January 2007, the Western Association of Fish and Wildlife Agencies (WAFWA), comprised of 23 state and provincial wildlife agencies from the western U.S. and western Canada, established a Wild Sheep Working Group (WSWG). The first task undertaken by the WSWG was to develop a report (WAFWA WSWG 2007) titled "Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat" to which state, federal, and provincial agencies could tier to. This WSWG report was unanimously endorsed by WAFWA Directors on July 16, 2007 in Flagstaff, AZ, then forwarded to the heads of 6 federal agencies (i.e., USFS, BLM, NPS, USFWS, BoR, DoD) in late August 2007, representing the official position of WAFWA.

Throughout significant portions of their range, bighorn sheep (*Ovis canadensis*) experience periods when populations are depressed; those episodes generally are associated with respiratory disease epizootics. Diseases have substantially contributed to the decline of bighorn sheep populations throughout much of western North America (Beecham et al. 2007, C.A.S.T. 2008), with many native herds having declined to less than 10% of historical size. According to historical accounts, epizootics in some locations coincided with the advent of domestic livestock ("livestock" used in original citation) grazing in bighorn ranges (C.A.S.T. 2008). Epizootics in native bighorn herds were reported in various locations following European settlement and establishment of domestic livestock ("livestock" used in original citation) grazing throughout the central and southern Rocky Mountains. This trend may reflect the introduction of novel bacterial pathogens (including some strains of *Pasteurella [Mannheimia]* spp.) into naïve bighorn populations beginning in the late 1800s (Grinnell 1928; Skinner 1928; Marsh 1938; Honess and Frost 1942; Miller 2001).

In Alaska, British Columbia, Yukon, and the Northwest Territories, domestic sheep or goat grazing has not been widespread. "Thinhorn" sheep (*O. dalli*) do not have a history of catastrophic all-age die-offs (C.A.S.T. 2008). Thinhorn sheep are susceptible to pneumonia (Black et al. 1988, Jenkins et al. 2007), and have perished in intentional co-penning trials with domestic sheep (Foreyt et al. 1996). However, the lack of similar epizootics and significant wild sheep die-offs in thinhorn sheep habitats that have not experienced widespread domestic sheep or goat grazing reinforces the need to effectively separate domestic sheep or goats from wild sheep populations.

Over the past 30 years, there has been a steadily increasing body of anecdotal and empirical evidence underscoring potential risk of disease transmission from domestic sheep or goats to wild sheep (McQuivey 1978, Hunt 1980, Jessup 1980, Foreyt and Jessup 1982, Goodson 1982, Coggins 1982, Onderka and Wishart 1984, Jessup 1985, Festa-Bianchet 1988, Onderka and Wishart 1988, Onderka et al. 1988, Schwantje 1988, Callan et al. 1991, Coggins and Matthews 1992, Foreyt 1994, Foreyt et al. 1994, Cassirer et al. 1996, Foreyt and Lagerquist 1996, Martin et al. 1996, Coggins 2002, Rudolph et al. 2003, Rudolph et al. 2007, George et al. 2008, Jeffress 2008).

A number of recent qualitative and quantitative risk assessments (Beecham et al. 2007, Clifford et al. 2007, Epps et al. 2007, C.A.S.T. 2008, Baumer et al. 2009, Clifford et al. 2009, Croft et al. 2009, Croft et al. 2010, USAHA 2009, WAFWA WHC 2009, USDA-FS 2010), workshops (UC-Davis April 2007, Tucson, AZ September 2007, Salt Lake City, UT February 2008, Boise, ID March 2008), conservation strategies and management plans (Colorado Division of Wildlife 2009, Montana Department of Fish, Wildlife, and Parks 2009), and many wildlife biologists and wildlife veterinarians (Gross et al. 2000, Singer et al. 2000, Dubay et al. 2002, Epps et al. 2004, Garde et al. 2005, Jansen et al. 2006, Foreyt et al.

2009) have focused on risk associated with contact between wild sheep and domestic sheep or goats. Many authors have recommended complete separation between wild and domestic sheep or goats, in an effort to minimize disease transmission.

British Columbia's "Wild/Domestic Sheep Separation Program" is specifically designed to reduce risk of disease transmission by minimizing or preventing association between wild and domestic sheep or goats in the province, on both private and Crown lands. Legislation in Utah (House Bill 240 Supplement, 2009), Wyoming (Senate Enrolled Act No. 30, 2009), and Idaho (Senate Bill 1232 amended, 2009) addressed agency responses and responsibilities when bighorn sheep and domestic sheep or goats closely associate. A series of recent court rulings (e.g., U.S. District Court, Idaho Case 09-0507-BLW) and legal opinions on bighorn sheep viability 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.

In this 2010 report, we will not review and synthesize all available literature (e.g., both published and unpublished) and other evidence (e.g., letters, reports available in agency files). We do, however, intend to include relevant citations, results, literature, analyses, etc. published since our original report (WAFWA WSWG 2007) was completed. The current report provides what we believe are reasonable and logical recommendations based on the best available science, and that will help achieve effective separation between wild sheep and domestic sheep or goats. We recognize it is impossible to achieve zero risk of contact or disease transmission between wild sheep and domestic sheep or goats ; however, we also recognize there are many ways to work proactively toward minimizing association between these species, to help lower overall risk of epizootics in wild sheep.

The USDI Bureau of Land Management (BLM) and the USDA Forest Service (USFS), the two principal federal land management agencies in the western United States, continue to review, revise, and update their policies on the management of domestic sheep or goats in wild sheep habitat (USDI-BLM 2010, USDA-USFS 2009). Several USFS Regions (e.g., Rocky Mountain Region 2 (Beecham et al. 2007), Intermountain Region 4, California Region 5, Pacific Northwest Region 6) have designated bighorn sheep as a "Sensitive Species", mandating additional review and analysis of USFS management actions that might affect bighorn sheep habitats and populations.

An inter-agency GIS decision-support tool and GIS maps for 14 western states are being finalized. These maps overlay current bighorn sheep distribution with both vacant and active domestic sheep or goat grazing allotments and trailing routes (WAFWA WSWG 2010a). These maps will identify areas where association between domestic sheep or goats and bighorn sheep may occur on or adjacent to public lands managed by BLM and USFS, and will also identify areas that may provide spatial separation. These maps will help provide context for national policy development, and help identify situations where proactive management is necessary and beneficial to minimize risk of association. Although risk of disease 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 devised or adopted. This report is written to assist BLM and USFS with development of a more-unified policy for management of domestic sheep or goat grazing in wild sheep habitat.

WAFWA defines "Effective Separation" as spatial and/or temporal separation between wild sheep and domestic sheep or goats resulting in, at most, minimal risk of potential association and subsequent transmission of respiratory disease between animal groups. WAFWA collectively believes that effective separation between wild sheep and domestic sheep or goats should be a primary management goal of state, provincial, or territorial agencies responsible for wild sheep management. With respect to domestic sheep or goats, the concept of effective separation is based on the premise that these two domestic species are incompatible with wild sheep, because of potential fatal disease transmission to wild sheep. Domestic sheep or goats should not concurrently share or occupy the same range where conservation of wild sheep is a clearly-stated management goal.

We acknowledge that effective separation does not necessarily require removal of domestic sheep or goats in all cases. However, the option of removing domestic sheep or goats should be included in the array of alternatives available to address this issue. In fact, some collaborative working groups (USAHA 2009) have recommended domestic goats not be allowed to graze in occupied bighorn sheep habitat, due to their gregarious nature and tendency to wander. We acknowledge the continuing debate and discussion (C.A.S.T. 2008, USAHA 2009) between wildlife advocates and some domestic sheep or goat proponents and resource managers regarding credibility and scientific merit of past findings, criticisms of experimental design and rigor, and limitations of drawing inferences about natural disease events versus "controlled" experiments in confined settings. Nevertheless, there is a preponderance of evidence, taken collectively from a wide variety of observations and scientific research that indicates significant risk of disease transmission from domestic sheep or goats to wild sheep. Proof of transmission of *Mannheimia haemolytica* from domestic sheep to bighorn sheep was irrefutably demonstrated via recovery of green fluorescent protein-tagged *Mannheimia haemolytica* bacteria from bighorn sheep, when the only possible source of that pathogen was domestic sheep (Lawrence et al. 2010).

In some cases, consequences of contact between domestic sheep or goats and wild sheep have been severe enough to endanger entire populations of wild sheep. Consequently, we continue to recommend that wild sheep managers take appropriate steps to minimize opportunities for association and potential subsequent disease transmission. Recent legislation (e.g., Idaho Senate Bill 1232 amended, May 2009) mandated collaboration between the Idaho Department of Fish and Game and domestic sheep grazing permittees that identified Best Management Practices (BMPs) to hopefully achieve separation between domestic sheep and wild sheep, on both public and private lands. In specific situations, implementation of BMPs may lead to a reduced risk of association; in particular, BMPs implemented in open, relatively gentle terrain where domestic sheep or goats may be easily controlled and monitored may effectively reduce risk of association (Schommer 2009). It should be further recognized, however, that BMPs that work in one situation may or may not work in other situations (Schommer 2009); BMPs need to be developed for site-specific situations, and evaluated for effectiveness.

Concern about potential disease transmission between domestic livestock and wildlife, and management approaches directed at minimizing such risks, is certainly not unprecedented. An analogous situation presently exists with brucellosis in the Greater Yellowstone Area (GYA): transmission between wild ungulates (i.e., bison, elk) and domestic livestock (i.e., cattle) has occurred, and disease transmission from elk and bison to cattle has been proven in clinical, confined environments. It has been difficult, however, to confirm this transmission under field conditions. The economic and herd management implications of brucellosis are serious, and management of this disease problem has largely focused on

temporal and spatial separation of livestock and wildlife to minimize risk. In the GYA, significant, and what some may consider drastic steps (e.g., lethal removal of bison, test-and-slaughter programs for feedground elk) have been undertaken to minimize risk of association and possible transmission of *Brucella* between wild ungulates and domestic livestock. The situation is very similar for pasteurellosis in wild sheep caused by bacteria from the *Pasteurellaceae* (bacteria now classified in the genera *Pasteurella*, *Mannheimia*, and *Bibersteinia* families (Ward et al. 1990, Ward et al. 1997, Miller 2001): there is cause for concern that is supported by logic, experience, and clinical scientific study. As a result, there is a clear strategy for minimizing risk of disease transmission by separating reservoir and susceptible species. In the case of pasteurellosis between domestic sheep or goats and wild sheep, we believe a sufficient amount of reliable information is available to justify seeking effective separation.

Concept of Risk

Two-way transmission of certain diseases (e.g., paratuberculosis, some enteric pathogens and parasites) between wild sheep and domestic sheep or goats in shared habitats can occur. However, as domestic animals have evolved and have been selected for their ability to live at high densities and for their resilience to infectious diseases (reviewed by Diamond 1997), we believe the most important and ecologically significant transmission in this context is from domestic sheep or goats to wild sheep. It is widely recognized (Garde et al. 2005, C.A.S.T. 2008), but needs to be re-emphasized, that thinhorn sheep (Dall's sheep, Stone's sheep) in Alaska and northwestern Canada are immunologically naïve compared to wild sheep occurring in southern Canada and the remainder of the western U.S. Additional precautions should be taken to ensure that no association occurs between naïve thinhorn sheep and domestic sheep or goats.

We acknowledge that wild sheep die-offs have occurred in the absence of reported association with domestic sheep or goats (Aune et al. 1998, UC-Davis 2007). However, when contact between wild sheep and domestic sheep or goats has been documented, severity of the wild sheep die-off is typically more severe (Onderka and Wishart 1984, Aune et al. 1998, Martin et al. 1996, George et al. 2008).

Winter 2009-2010 bighorn sheep pneumonia die-offs (totaling an estimated 880 dead bighorns) in Montana, Nevada, Washington, Utah, and Wyoming have reduced bighorn numbers in at least 9 herds, either through direct mortality or agency removal (i.e., "culling") of bighorn sheep exhibiting symptoms of respiratory infections (WAFWA WSWG 2010b). Association between wild sheep and domestic sheep or goats is known to have preceded at least one of these aforementioned die-offs, was likely in 2 others, and was possible in 4 more, as domestic sheep or goats were known to occur within or near occupied bighorn sheep ranges, and within normal bighorn movement zones.

Although these recommendations have been developed by a working group comprised of state and provincial wildlife agency personnel, we recognize that cooperation between numerous concerned parties (e.g., state, provincial, territorial wildlife agencies, federal land management agencies, First Nation or tribal representatives, domestic sheep or goat producers and grazing permittees, agricultural industry representatives, wild sheep conservation organizations, environmental groups, academic institutions, and various interested publics) is critically important to deriving on-the-ground solutions (USAHA 2009). It is our hope that collaborative discussions and actions (e.g., British Columbia Wild/Domestic Sheep Separation Program, Wyoming Statewide Domestic Sheep/Bighorn Sheep Interaction Working Group, Idaho Governor's Bighorn Sheep Collaborative) will take place in each jurisdiction where this issue occurs, and that those discussions yield productive solutions.

We recognize there are many human-caused (e.g., displacement/disturbance) and environmental (e.g., predation, climatic) stressors (C.A.S.T. 2008) that also influence dynamics and viability of wild sheep populations. We also acknowledge that some factors affecting wild sheep population performance can be managed, while others cannot. Nevertheless, the guiding principle of our effort has been "to seek effective separation" between wild sheep and domestic sheep or goats. We believe that even though no "cookbook" exists for conducting risk assessments of respiratory disease transmission between wild sheep and domestic sheep or goats, comprehensive risk assessment is a critically important component for managing potential disease transmission.

Management Recommendations

The following recommendations have applicability to state, provincial, or territorial wildlife agencies, federal land management agencies, wild sheep conservation organizations, domestic sheep or goat producers or permittees, and private landowners. These recommendations have been strategically assigned to a category we have judged to be most logical and reasonable. However, it is imperative that readers recognize these recommendations are typically pertinent to multiple parties, and further recognize that a multi-disciplinary and collaborative approach will likely produce the best outcomes for wild sheep and for domestic sheep or goat producers or permittees. We have defined specific, frequently-used terms (e.g., "effective separation") in a glossary (Appendix A).

We recommend that wild sheep managers design and implement management strategies by prioritizing the conservation values (e.g., federal- and/or state-listed status, sensitive species status, native wild sheep herds that have never been extirpated or augmented, naïve wild sheep populations with no previous exposure to domestic sheep or goats) and relative importance of wild sheep populations. The higher the wild sheep conservation value, and the greater the risk of association with domestic sheep or goats, the more aggressive and comprehensive that wild sheep and domestic sheep or goat management strategies should be, commensurate with the level of risk.

Recommendations to WAFWA Agencies

- Historic and suitable but currently unoccupied wild sheep range should be identified, evaluated, and compared against currently-occupied wild sheep distribution by each state, province, or territory within historic range of wild sheep, and also compared to existing and potential areas where domestic sheep or goats are, or may be, authorized.

- Risk assessments should be periodically completed (at least once per decade, more often if situations warrant) for existing and potential wild sheep habitat, to specifically identify where and to what extent wild sheep might interface with domestic sheep or goats, and monitor changes in risk along that interface.

- Following completion of site-specific risk assessments, wild sheep translocation, population augmentation, restoration, and management strategies should be designed to minimize likelihood of association between wild sheep and domestic sheep or goats.

- Wild sheep managers should identify, analyze, and evaluate the implications (i.e., both positive and negative) of connectivity and movement corridors between largely insular herds within a meta-

population against the opportunity for increased association with domestic sheep or goats. Analyses should include the relative continuity vs. discrete occurrence (Mack 2008) of occupied wild sheep distribution, and the expected frequency of movement between/within normally-anticipated wild sheep range. Benefits of genetic interchange (and implications for population viability) must be weighed against heightened risks of possible disease transmission (Bleich et al. 1990), especially if dispersing or wandering wild sheep might travel through occupied domestic sheep or goat grazing allotments or trailing routes, or result in the transfer of locally endemic pathogens from an infected wild herd to a naïve herd.

- Removal of wild sheep known or suspected to have closely associated with domestic sheep or goats is an effective management tool to address disease transmission concerns, when applied to wild sheep found outside of expected wild sheep range. Although the probability of detecting physical contact is typically low, non-typical movements by wild sheep outside of normal wild sheep ranges can heighten risk of association with domestic sheep or goats. If frequency of suspected association occurs above defined, acceptable levels, additional measures to work toward effective separation should be implemented.

- Removal of wild sheep within occupied, normally-anticipated wild sheep range is not always recommended as the preferred, first management option to address disease transmission or maintain effective separation. When domestic sheep or goats are grazed within normally-anticipated wild sheep range, a continuous and frequent risk of association exists during active grazing seasons. High probability of association, coupled with low probability of detection, renders removal of wild sheep ineffective for addressing disease transmission or maintaining separation. In addition, removal of wild sheep within normally-anticipated range does not involve wandering wild sheep, but resident reproductive members of a population whose removal could have substantial negative impacts on population viability. When selected, the option to remove wild sheep should occur only after critical evaluation and further implementation of measures designed to minimize association and enhance effective separation.

- Do not translocate wild sheep where there is no reasonable likelihood of achieving effective separation between wild sheep and domestic sheep or goats.

- As potential agricultural conflicts, landscape conditions and habitat suitability change, stocking wild sheep onto historic range, particularly on public lands, should be re-evaluated.

- Wild sheep populations should be managed to reach pre-determined population objectives, and those populations should be maintained at agreed-upon densities, to minimize wild sheep dispersal. It should be recognized that wild sheep dispersal occurs regardless of population density, so some risk of association is always present, if domestic sheep or goats are within range of dispersing wild sheep.

- The higher the risk of association between wild sheep and domestic sheep or goats, the more intensively wild sheep herds need to be monitored and managed. Intensity of monitoring should be commensurate with level of risk and probability of domestic sheep and goat association when considering “new” vs. “augmented” wild sheep populations. If there are anticipated differences in likelihood of association with domestic sheep or goats, a site-specific protocol should be spelled out

for “new” vs. “augmented” wild sheep populations. For example, the percentage of translocated wild sheep that should be radio-collared (preferably with GPS collars) should, in part, depend upon subsequent risk of domestic sheep or goat association. Intensive monitoring allows for documenting proximity between wild sheep and domestic sheep or goats, and allows for evaluation of post-release habitat use and movements. Budgets to translocate wild sheep should be adequate to ensure long-term monitoring.

- Wild sheep managers should recognize that augmentation of a wild sheep herd from discrete source populations also poses a risk for moving pathogens. Wild sheep management agencies should only use healthy wild sheep herds as source stock 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 genetic benefits and potential health consequences of mixing wild sheep from various source herds, when conducting translocations.

- Prior to conducting a wild sheep translocation, a map of anticipated wild sheep distribution and movement should be developed and compared with domestic sheep and goat distributions. If a wild sheep translocation occurs, and association with domestic sheep or goats is confirmed or is likely to occur beyond an identified timeframe or beyond a mapped geographic area (possibly including historic, suitable wild sheep habitat), domestic sheep or goat producers should be held harmless.

- Agencies should develop, adopt, and widely distribute a written strategy to address dispersing or wandering wild sheep (e.g., British Columbia Ministry of Environment, Appendix B; Wyoming Game and Fish Department, Appendix C). These animals may physically contact domestic sheep or goats, and continue traveling, either back to their source herd or to other wild sheep herds, with or without infectious disease. This strategy should clearly identify what and when specific actions are to be taken (e.g., kill and medically evaluate wandering wild sheep), and specify who is authorized to take those actions. Furthermore, this strategy should be openly discussed with affected stakeholders, so there is clear and widespread understanding of subsequent management actions that could be implemented by state, provincial, or territorial wildlife agencies.

- Agencies should develop a response protocol for confirmed association between wild sheep and domestic sheep or goats. This strategy should include notification requirements, wildlife health intervention (if appropriate), and post-contact monitoring strategies. Furthermore, state, provincial, or territorial wildlife and agriculture agencies, land management agencies, producers and permittees, grazing industry representatives, and wild sheep advocates should collaborate to develop an effective, efficient, and legal response protocol for errant domestic sheep or goats (e.g., feral, abandoned) for which no owner can be identified and that threaten to associate with wild sheep.

- State, provincial, or territorial wildlife agencies should work together to develop a system (possibly internet-based) to report, record, and summarize association between wild sheep and domestic sheep or goats. Once established, the WAFWA WSWG website http://www.wafwa.org/html/wswg.shtml would be a logical place to host this incident reporting system. Furthermore, state, provincial, or territorial wild sheep managers and federal land managers should encourage prompt reporting by the public of observed proximity between wild sheep and domestic sheep or goats.

- The use of domestic sheep or goats as pack animals by hunters, anglers, and other recreational or commercial users that travel in identified wild sheep habitat should be prohibited. Where legislation or regulations are not already in place, an effective outreach and public education program should be implemented, to inform potential users of the risks associated with that activity and recommend that individuals not use domestic sheep or goats as pack animals in occupied wild sheep habitat.

- Wild sheep managers should coordinate with local Weed & Pest Districts or other applicable agencies or organizations involved with weed management to preclude the use of domestic sheep or goats for noxious weed control in areas where association with wild sheep is likely to occur. Agencies should provide educational information and offer assistance to Weed & Pest Districts regarding disease risks associated with use of domestic sheep or goats for weed control. Specific guidelines have already been developed by, and implemented in, British Columbia (http://www.for.gov.bc.ca/hfp/publications/00006/).

- Several capture and disease-testing protocols (pre-translocation, post-die-off) have been developed and are available to wild sheep managers (Foster 2004, UC-Davis 2007, WAFWA Wildlife Health Committee (WHC) 2009). Specific protocols for sampling, testing prior to translocation, and responding to disease outbreaks are useful and should be standardized to the extent practical across state and federal jurisdictions. Protocols should be reviewed and updated as necessary by the WHC and presented to WAFWA Directors for endorsement. Once endorsed by WAFWA Directors, wild sheep management agencies should implement the existing protocols, and the WHC should lead the effort to further refine and implement said protocols.

- Wild sheep management agencies should coordinate with each other and pool resources to support improvement in laboratory testing methods for important wild sheep diseases. Furthermore, state, provincial, and territorial wild sheep managers should support efforts on data sharing, and development and use of standardized protocols (WAFWA WHC 2009). Inter-agency communication between wildlife disease experts should be encouraged, to synergistically accomplish more than individual agencies or organizations are capable of by themselves.

- Wild sheep management agencies should pro-actively develop educational materials and outreach programs identifying and explaining the risk of association between wild sheep and domestic sheep or goat farm flocks and 4-H animals.

Recommendations to BLM and USFS (and other applicable Land Management agencies)

- Joint federal land management agency guidelines on management of domestic sheep or goats in wild sheep habitat should be developed and included in broad agency policy documents (e.g., USFS Manuals) and in local Forest Plan/Resource Management Plans. Guidelines should be based on the premise of minimizing risk of association and providing effective separation between domestic sheep or goats and wild sheep. Once guidelines have been approved, there should not be an automatic "sunset" provision or expiration date. If there is a specified longevity required by federal policy, and if appropriate and timely review cannot be completed, existing guidelines should remain in effect, rather than becoming obsolete.

- Land management agencies responsible for domestic sheep or goat grazing allotments, trailing routes, vegetation management (e.g., weed control, enhancement of conifer regeneration), use as pack stock, or any other uses involving domestic sheep or goats should only authorize such use outside of occupied wild sheep range.

- Land management agencies should require prompt (i.e., within 24 hours) notification by permittees and their herders of association between wild sheep and domestic sheep or goats. Notification procedures (including phone numbers/contact information for permittees, and use of satellite phones in backcountry settings) should be included in Annual Operating Instructions for grazing allotments and trailing permits.

- Land management agencies should map active vs. 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 stray domestic sheep or goats left on public lands prior to or after permitted grazing or trailing dates.

- Work collaboratively with state, provincial, or territorial wildlife and agricultural interests, to develop written agreements addressing management, retrieval, and disposition of stray domestic sheep or goats occurring on public lands where there is no permitted use. These agreements should also address feral sheep or goats as well as other exotic breeds (e.g., aoudad, Iranian red sheep, urial, argali) that range on public lands.

- Review domestic sheep allotment boundaries or use areas such as trailing routes. Reconfigure allotment boundaries or trailing routes where appropriate and feasible, to avoid or minimize overlap with occupied wild sheep habitat. Where feasible, use strategies and techniques including:
    - geographic/topographic barriers that enhance species separation;
    - seasonal or spatial separation through domestic sheep or goat grazing management.

- Undertake habitat enhancements that improve wild sheep habitats (both summer and winter range) outside allotment boundaries to attract wild sheep away from domestic sheep allotments.

- Undertake water developments to enhance bighorn sheep distribution or to move domestic sheep or goats away from preferred wild sheep foraging areas.

- Annual Operating Instructions should require careful management and vigilant herding to minimize potential association between wild sheep and stray domestic sheep or goats. A count-on, count-off inventory of domestic sheep or goats should be required as a condition of operation.

- In areas of high risk of association, trucking should be required, since trailing may result in additional management risks. Trucking of domestic sheep or goats is preferred to trailing, since there is less chance of straying, and thereby less chance of association with wild sheep, particularly when domestic ewes are in estrus.

- If trailing occurs, on-site compliance monitoring to minimize strays should be conducted by the permittee and/or the land management agency.

- Land Use or Resource Management Plans, where relevant, should specifically address the issue of potential for domestic sheep or goat association 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 address this issue and identify general areas of public land where domestic sheep or goats should not be permitted for weed control, commercial grazing, recreational packing, conifer regeneration, vegetation management, and other management activities.

- Land management agencies should coordinate closely with appropriate entities involved in weed control programs (e.g., local Weed & Pest Districts, University Experiment Stations, private landowners) using domestic sheep or goats on public lands, adjoining private lands, or state, provincial, or territorial wildlife habitat management areas.

- Where topography, vegetation, and other parameters are suitable, conversion of allotments from domestic sheep or goats to domestic livestock that pose a lower risk of disease transmission to wild sheep should be considered.

- Land management agencies should not convert cattle grazing allotments to domestic sheep or goat grazing or allow trailing in areas of suitable, historic wild sheep habitat. In suitable, historic wild sheep habitat not currently stocked with domestic sheep or goats, management strategies should emphasize options for restoring wild sheep populations.

- Stocking of allotments not currently under permit to domestic sheep or goats under emergency conditions (e.g., reduced forage availability in permitted allotment areas due to wildfire or drought) should only be permitted after adequate risk assessment has been completed, including documentation and a conclusion that effective separation can be assured. This assessment can be completed via project-level NEPA analysis.

- Land management agencies should incorporate state, provincial, or territorial wild sheep management plans either in, or supplemental to, federal Resource or Land Use Management Plans. Land management agencies should collaborate with state, provincial, or territorial wildlife agencies on comprehensive risk assessments (Clifford et al. 2007, Clifford et al. 2009, USDA-FS 2010) of domestic sheep or goat grazing allotments or trailing routes in wild sheep habitat, to assess risk of association with wild sheep. Adequate training (e.g., workshops, manuals) should be provided to agency staff to conduct risk assessments.

- Where mandatory buffer zones (frequently cited as a minimum of 9 airline miles [13.5 km]) between domestic sheep or goats and wild sheep have been used to minimize association, it should be recognized that buffer zones apply to herds or populations of wild sheep, rather than individual wandering wild sheep (e.g., most often sub-adult rams).

- In some cases, buffer zones have been a very effective strategy to reduce association between wild sheep and domestic sheep or goats. However, in continuous wild sheep habitat, where movements by

wild sheep may eventually exceed *a priori* expectations, buffer zones may not be effective or practical (Schommer and Woolever 2001).

- Topographic features or other natural or man-made barriers (e.g., fenced, interstate highways) can also be effective in minimizing association between wild sheep and domestic sheep or goats. Site-specific risk assessments should be completed, to evaluate efficacy of using natural barriers, defined buffer zones and other preventive actions to minimize risk. Given the wide range of circumstances across jurisdictions, buffer zones may not be needed in all situations; conversely, buffer zones should not be precluded as an effective strategy to address potential association between wild sheep and domestic sheep or goats.

- The presence of sick domestic sheep or goats may increase risk of association with wild sheep, as sick domestic animals may be less able to keep up with their bands and may be more prone to straying. Land management agencies, in collaboration with state, provincial, or territorial domestic sheep or goat health agencies, should work with producers and permittees to prevent turnout of sick or diseased domestic sheep or goats on grazing allotments or trailing routes, or use for weed control or as pack stock. Sick or diseased animals observed on the range should be reported to land management agency personnel as soon as possible; after that initial notification, inter-agency coordination should promptly occur. Analogous to requirements to use certified weed-free hay on public lands, or requirements to clean logging or other heavy equipment which have been operating in areas where noxious weed seed might be inadvertently scattered into new areas, domestic sheep or goats should be healthy before being turned out. Alberta and British Columbia (http://www.for.gov.bc.ca/hfp/publications/00006/) have developed specific health certification protocols that must be complied with before domestic sheep are turned out for vegetation management in conifer regeneration efforts. The higher the risk of association between domestic sheep or goats with wild sheep, the higher the certainty of domestic animal health should be. It must be recognized that even healthy domestic sheep or goats may still carry pathogens that can be transmitted to wild sheep, and thus, still pose a significant risk to wild sheep.

- Proportional to risk of association between domestic sheep or goats and wild sheep, land management agencies should work with producers and permittees, state, provincial, or territorial wildlife agencies, wild sheep advocates, and others, to implement a variety of management practices (e.g., herders, dogs or other guarding animals trained to repel animals foreign to domestic sheep bands or goat flocks such as wandering wild sheep or various predators, regular counts, removal of sick animals, confinement of domestic sheep or goats at night to minimize strays, adequate fencing configurations, covenants, allotment retirements, conversion of class of livestock, trucking vs. trailing, etc). We recognize that effectiveness of management practices to reduce risk of association are not proven (Baumer et al. 2009, Schommer 2009) and recommend that these practices not be solely relied upon to achieve effective separation. Such practices might, however, help achieve separation when applied outside of occupied wild sheep range, to mitigate impacts of straying domestic sheep or goats and wandering wild sheep.

- Land management and state, provincial, or territorial wildlife agencies should cooperatively manage for healthy wild sheep habitat. Agencies should routinely monitor wild sheep habitat to detect changes in habitat quality or condition and, as needed and appropriate, conduct habitat enhancements (e.g., prescribed burning, pre-commercial thinning, salting, mineral supplements,

water development, etc.) to encourage wild sheep to remain in wild sheep habitats, away from domestic sheep or goat use areas.

- In areas where association between wild sheep and domestic sheep or goats is likely, land management agencies should post advisory signs at trailheads, campgrounds, and other popular, high-use recreational areas, to educate visitors about the issue of interaction, and to encourage prompt reporting of wild sheep association with domestic sheep or goats. Furthermore, individuals accompanied by pets (i.e., dogs) should ensure that dogs remain under their control, and do not disturb or scatter domestic sheep or goats in permitted areas, or chase wild sheep.

- Land management agencies should clearly define the process, 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.

- Develop programs to foster and recognize compliance, cooperation, and cost-sharing in efforts to prevent commingling of wild sheep and domestic sheep on shared ranges.

- In collaboration with state, provincial, or territorial wild sheep management agencies, investigate and implement an option to allow the permittee or producer or appropriate agency representatives to remove commingling wild sheep.

- Where not already established, develop or clarify legal authority for removing stray domestic sheep from public lands by lethal means.

- Risk assessment should be conducted on an appropriate geographic scale, regardless of jurisdictional boundaries. Recognizing the limits of regulatory authority, land management agencies should consider private lands (i.e., either adjacent to, or inholdings of, federal land) when conducting risk assessments.

- Land management agencies should closely evaluate timing of permitted domestic sheep or goat grazing or trailing activities, to reduce disease transmission risk. For example, grazing domestic sheep when ewes are in estrus heightens attraction and increases possibility of association between wild sheep and domestic sheep.

- In areas with high risk of association between wild sheep and domestic sheep or goats, agencies and permittees should pursue enhanced monitoring of domestic sheep or goat grazing or trailing patterns via use of Global Positioning System collars or other technology that would provide detailed data on movements and grazing patterns. While enhanced monitoring will not reduce risk of association, it is vital for development of risk assessments and to ensure appropriate management recommendations are taken to achieve effective separation.

Recommendations to Wild Sheep (and Other) Conservation Organizations

- Recognize and support efforts of wild sheep management agencies.

- Assist state, provincial, or territorial wild sheep and federal land management agencies with education efforts to inform those who might enter or utilize wild sheep habitat to not use domestic

sheep or goats as pack animals, as they travel in, and through, wild sheep habitat. If use of domestic pack goats is authorized, close control, tethering, or night-penning to reduce strays should be encouraged. Encourage prompt reporting of association between wild sheep and domestic sheep or goats. Help agencies promote a reporting system for monitoring association between wild sheep and domestic sheep or goats.

- Assist state, provincial, or territorial wild sheep and federal land management agencies with development of informational, educational brochures and other materials identifying and explaining risk of association between wild sheep and domestic sheep or goat farm flocks and 4-H animals.

- Maintain or establish open lines of communication with domestic sheep or goat producers and industry organizations (e.g., woolgrowers associations) to reduce polarization on this issue. Jointly organized and cooperatively-funded workshops on risk assessment, identification of practical strategies to achieve effective separation between wild sheep and domestic sheep or goats, development and distribution of pamphlets or brochures, and public speaking opportunities are tangible examples of a collaborative, multi-disciplinary approach to address potential disease transmission.

- Continue to negotiate alternatives or incentives for domestic sheep or goat permittees to shift or move to grazing allotments outside wild sheep habitat; where suitable, convert to a different class of livestock with lower risk of potential disease transmission; or waive permitted domestic sheep or goat use in areas where risk assessment indicates high potential for association with wild sheep.

- Encourage and support development and funding of cooperative research on this issue. Encourage state, provincial, and federal agencies and other conservation groups to commit appropriate resources to maintain wild sheep resources.

Suggested Management Practices for Domestic Sheep and Goat Permittees

(While these suggestions [largely based on C.A.S.T. 2008, Baumer et al. 2009, USAHA 2009] provide a common-sense approach that might reduce risk of association, there is no science-based evidence or evaluation [Schommer 2009] that assesses effectiveness of these actions in reducing risk or enhancing separation).

- Support multi-lingual education for, and the need for prompt, accurate reporting of association by, foreign herders working on domestic sheep or goat grazing allotments where proximity between wild sheep and domestic sheep or goats is possible.

- Select only highly gregarious breeds of sheep (e.g., Merino, Rambouillet, “Western/white-faced ewes”, fine wools and crosses thereof) for grazing shared ranges.

- Use pregnant domestic ewes or ewe-lamb pairs for grazing near occupied wild sheep habitats; avoid grazing of open ewes, yearling replacement ewes and ewes that have lost their lambs because ewes in estrus may attract bighorn rams.

- Maintain a band size of less than 900 ewes with single lambs (1,800 total) or 700-800 ewes with twin lambs (2,100 to 2,400 total); if dry ewes or yearlings are grazed, maintain flock size of less than 1,500 head.

- Place more experienced, informed, and responsible sheepherders on allotments located nearest to wild sheep habitats.

- Place mature and effective guard dogs and herding dogs with domestic sheep (at least 2 of each per band). Female dogs in heat should not be placed on allotments.

- Conduct full counts of all individual ewes when moving onto and off of each allotment.

- Maintain an appropriate ratio of marker sheep within bands; depending on local needs and conditions, ratios should be no fewer than 1 marker for every 100 adult sheep. More markers may be required when dictated by local conditions.

- Count marker sheep on a regular basis, immediately any time sheep scatter and more frequently (e.g., once or twice per day) if required under local grazing agreements. It is customary to count marker sheep when they are bedded and this should be encouraged. After sheep scatter, complete a full count as soon as reasonably possible.

- Place bells on at least 1 in every 100 mature ewes to serve as warning, and for identification and location of sheep relative to other sheep.

- Select camp locations and bedding grounds that are acceptable and ensure domestic sheep remain within the bedding grounds.

- Select herder's camp, nighttime bedding ground, and midday bedding ground locations that maintain communication between guard dogs and herding dogs by smell, sound (barking) and sight, and to take advantage of differences in the sleep cycles of guard dog and herding dogs. If grazing federal lands, comply with established "bed ground" standards. Construct temporary electric or boundary fences in congregation areas (e.g., bed grounds), where feasible.

- Truck in water (if needed) to prevent straying.

- In situations where sheep are difficult to observe because of dense vegetation or difficult terrain, always count marker sheep after emerging from such conditions.

- Increase sheepherder vigilance on bright moonlit nights because sheep may rise to graze under these conditions.

- Truck domestic sheep through “driveway” areas that include occupied wild sheep habitat where interspecies association is considered likely.

- Do not trail more than 5 miles per day and stop trailing when sheep or lambs show signs of fatigue. Provide for a “babysitter” or removal of lagging sheep when trailing. Follow all agency guidelines on federal lands.

- Remove sick or physically disabled domestic sheep from the band.

- Require that sheepherders use communication equipment such as cellular or satellite phones or two-way radios, and use location equipment such as global positioning system (GPS) receivers to report and record grazing movements and encounters with wild sheep. Seek cost-sharing partnerships for providing electronic and other equipment when an operator changes grazing management practices for the sole purpose of minimizing domestic sheep association with wild sheep; these partnerships could include wildlife management agencies, federal land managers, or private organizations.

- Have sheepherders use a log book or other record keeping aids to record GPS locations, counts, losses, and other information as needed or required.

- Develop a detection and response protocol that includes the following:
  - reporting wild sheep (including a count and GPS location) that are in proximity to domestic sheep bands;
  - reporting stray or missing domestic sheep to the land management agency;
  - immediate, two-way notification (between permittee and land management agency) of actual commingling;
  - a post turn-off stray domestic sheep removal protocol;
  - a protocol for removing individual commingling wild sheep;
  - where feasible, collect standardized diagnostic samples on stray domestic sheep and commingling wild sheep;
  - instructions for domestic sheep herders to not leave sick domestic sheep behind.

- Develop and follow a plan for locating and reacquiring (dead or alive) stray sheep. If a domestic sheep is determined to be missing, the permittee will immediately initiate a comprehensive search and notify the land manager that domestic sheep are missing, or when those strays are located.

- Allow and encourage the permittee or producer and appropriate agency representatives to remove any stray domestic sheep in areas where interspecies association is likely to occur.

- Allow and encourage the permittee or producer and appropriate agency representatives to haze wild sheep that appear intent on commingling.

- Encourage voluntary allotment monitoring by permittees or independent observers in conjunction with federal and state agencies; where used, independent observers should receive prior training from permittees or agency personnel.

- Commensurate with risk of association between wild sheep and domestic sheep or goats, and recognizing the differential seasonal likelihood of wandering wild sheep, provide an adequate number of herders and guard animals, and employ other methods (e.g., volunteers, hazing of approaching wild sheep) to monitor and minimize potential association between wild sheep and domestic sheep or goats. Confine domestic sheep or goats at night where feasible, rather than loose herding/bedding, to minimize possible strays.

Suggested Management Practices on Private Lands

- Recognize that domestic sheep or goat husbandry on private lands may influence wild sheep population viability on adjacent public lands. Voluntarily participate in comprehensive risk assessments with state, provincial, territorial and federal agencies when private land or farm flocks adjoin public land with wild sheep resources.

- Any observed association between wild sheep and domestic sheep or goats on or near private land should be promptly reported to the state, provincial, or territorial wildlife agency.

- Participate in cooperative educational efforts to enhance understanding of the issues of disease transmission between domestic sheep or goats and wild sheep.

- Do not release or leave unattended domestic sheep or goats in areas where they may seek out, or be sought out by, wild sheep.

- Cooperate with the public, state, provincial, territorial, or federal government agencies, agricultural organizations, producer associations, wild sheep conservation organizations, and other interested stakeholders to develop effective, comprehensive risk management approaches to ensure effective separation between wild sheep and domestic sheep or goats, while recognizing private property rights in and near wild sheep habitat. Approaches may include but are not limited to changing species/class of livestock, buyouts of land and/or domestic sheep or goats , use of methods to ensure physical separation (e.g., fencing strategies, use of guarding animals), conservation-based resolutions, bylaws, covenants or legislation.

- Develop adequate risk management strategies by private producers on privately-owned land.

- Consider alternative domestic livestock management strategies if they can reduce risk of disease transmission without causing economic hardship or reducing profitability.

- Consider partnerships with non-governmental organizations and wild sheep advocate groups for cost sharing on fencing or other domestic sheep or goat management that reduces risk of disease transmission from private flocks to public wild sheep.

- Support “effective separation” fencing standards whenever feasible, including the options of electric outrigger fences or double fencing methods to reduce transmission of respiratory disease agents. The goal of separation fencing is the physical prevention of nose-to-nose contact, and an adequate physical distance to prevent aerosol transmission. Outriggers of electric wire 2 feet from page-(woven) wire fencing or double fencing consisting of two page-wire fences with a minimum spacing of at least 10 feet are considered effective. A combination of fencing methods may be most effective to ensure that wild sheep do not physically contact domestic sheep or goats on private land.

- Participate in cooperative research ventures to enhance understanding of this issue and test mitigation protocols for disease risk management.

- Carefully consider the use of domestic sheep or goats for weed control on private land areas where association with wild sheep may occur. Work with agencies to consider alternative weed management strategies to reduce risk of association, while adequately managing weed problems.

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Appendix A.
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 disease transmission.

Augment: An intentional introduction of wild sheep from one or more a 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 prevent possible disease 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. They occur from the Peace River in Canada to northern Mexico and east to the Badlands of the Dakotas. Eight races are reported if one counts the extinct Audubon's bighorn.

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

Close Management: A specific management prescription that requires intensive monitoring of animals in a population whose long-term persistence is at risk.

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: Incentive-based conservation is 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 consequence to wildlife or wildlife habitat. Examples are: private land conservation easements, direct lease agreements for grazing rights for conservation purposes, or a trade/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 to the long-term persistence of that population. In this report, such mortality events are usually caused by respiratory disease epidemics involving bacterial and/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 where 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 disease transmission.

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

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

Historic habitat: Landscape that at one time (most often at the time of European settlement) provided all necessary habitat requirements to sustain a wild sheep population through time.

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

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

Migration or migratory: A term used to refer to the movement of individuals or genes (gene flow) across a landscape; typically refers to movements from one seasonal habitat to another, or between breeding and non-breeding habitats.

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

Occupied habitat: Suitable habitat in which a wild sheep population currently exists (ca. 2007).

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

Radio Collars: Transmitters fitted on neckband material to monitor animal locations.

> Global Positioning System (GPS): 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 from a satellite system for data retrieval.
>
> Very High Frequency (VHF): Radio instrument fitted to neckband material transmitting in the Very High Frequency range that can be located from the ground and/or aircraft, using a telemetry receiver.

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

Required: A specific management action that ***must*** be chosen over another.

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 or temporally separated from its flock or band.

Stressor: A specific action or condition that causes an animal to experience stress and the subsequent physiological results of that stress.

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* ranging from Alaska, the Yukon, Northwest Territories, and northern British Columbia.

Transmission: The physical transfer (direct or indirect mechanisms) 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.

Transplant: An intentional movement of wild sheep from a source population to other suitable wild sheep habitat, either currently occupied or not. (Also called “translocation” 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: Suitable habitat in which a wild sheep population does not currently exist.

Unsuitable habitat: Landscape that does not provide all necessary habitat requirements to sustain a wild sheep population through time.

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

Wandering Wild Sheep: wild sheep, primarily but not always young, sexually-mature rams, 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 which may have known, likely, or suspected association with domestic sheep and/or goats may result in significant, adverse population-level impacts on wild sheep herds of origin, or of destination.

Appendix B.

British Columbia Domestic-Wild Sheep Separation Project Contact Protocol

The following protocols outline **the steps to be taken when reports of wild sheep contact with domestic sheep are received by the Ministry of Environment** in one of several ways:

1. **Regular report from public to regional office (Conservation Officer Service or Wildlife Section):**
   - Contact reported to Regional office.
   - Assessment of situation by sheep biologist and COS, in consultation with wildlife veterinarian
   - If close contact is confirmed and is considered a high risk situation, consider the following options:
     a. Kill bighorn and save carcass - sample bighorn and/or domestics in consultation with wildlife veterinarian
     b. Continue to monitor bighorn herd in area – observe and record general signs of health
     c. Do nothing – but keep records
   - If contact is unsubstantiated/considered low risk, continue to monitor bighorn herd in area, alert and encourage mitigation measures with domestic producers in area to ensure separation.

2. **Regular report from public to Call Line.**
   - Contact reported to Call Line; Call Line staff forwards to regional COS.
   - Assessment of situation by COS and sheep biologist, in consultation with wildlife veterinarian
   - If close contact is confirmed and is considered a high risk situation, consider the following options:
     a. Kill bighorn and save carcass - sample bighorn and/or domestics in consultation with wildlife veterinarian
     b. Continue to monitor bighorn herd in area – observe and record general signs of health
     c. Do nothing – but keep records
   - If contact is unsubstantiated/considered low risk, continue to monitor bighorn herd in area, alert and encourage mitigation measures with domestic producers in area to ensure separation.

3. **Out of hours call from public to Call Line.**
   - Contact reported to Call Line; Call Line staff forwards to regional COS officer-on-call.
   - Assessment of situation by COS officer-on-call - contacts sheep biologist and wildlife veterinarian, if possible for consultation
   - **If sheep biologist and wildlife veterinarian cannot be contacted, biologist and veterinarian will support COS decision and action. COS will inform sheep biologist and wildlife veterinarian by email of the situation and action taken.**
     - If close contact is confirmed and is considered a high risk situation, consider the following options:
     - Kill bighorn and save carcass - sample bighorn and/or domestics in consultation with wildlife veterinarian
     - Continue to monitor bighorn herd in area – observe and record general signs of health
     - Do nothing – but keep records
     - If contact is unsubstantiated/considered low risk, continue to monitor bighorn herd in area, alert and encourage mitigation measures with domestic producers in area to ensure separation.

Appendix C.

WYOMING GAME AND FISH DEPARTMENT

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April 5, 2006

MEMORANDUM

TO: Wildlife Division Employees

FROM: Jay Lawson, Chief, Wildlife Division

COPY TO: Terry Cleveland, Gregg Arthur, File

SUBJECT: **PROTOCOL FOR HANDLING THE COMMINGLING OF BIGHORN SHEEP AND DOMESTIC SHEEP/GOATS**

Due to the threat of disease transmission and subsequent bighorn sheep die-offs, the following protocol should be followed.

Wandering Bighorn Sheep:
Where there is known, suspected, or likely contact by a wandering bighorn sheep with domestic sheep/goats:

- If possible, that bighorn(s) should be live-captured and transported (one-way) to our Sybille Research Unit.
- If that bighorn(s) cannot be live-captured, that bighorn(s) should be lethally removed (per authority of Chapter 56) and, if possible, transported (either whole or samples) to our Sybille Unit or our WGFD Lab in Laramie.

Stray Domestic Sheep/Goat:
Where there is known, suspected, or likely contact by a stray domestic sheep/goat with bighorn sheep:

- The owner of such livestock should be notified and asked to remove the stray sheep/goat to eliminate the threat of disease transmission; however, it will be the owner's prerogative to determine what course of action should be taken.

Reporting:
All documented commingling and any actions taken must be reported to the employee's immediate supervisor, Wildlife Administration as well as the Bighorn Sheep Working Group Chairman, presently Kevin Hurley.