Arizona Bighorn Sheep
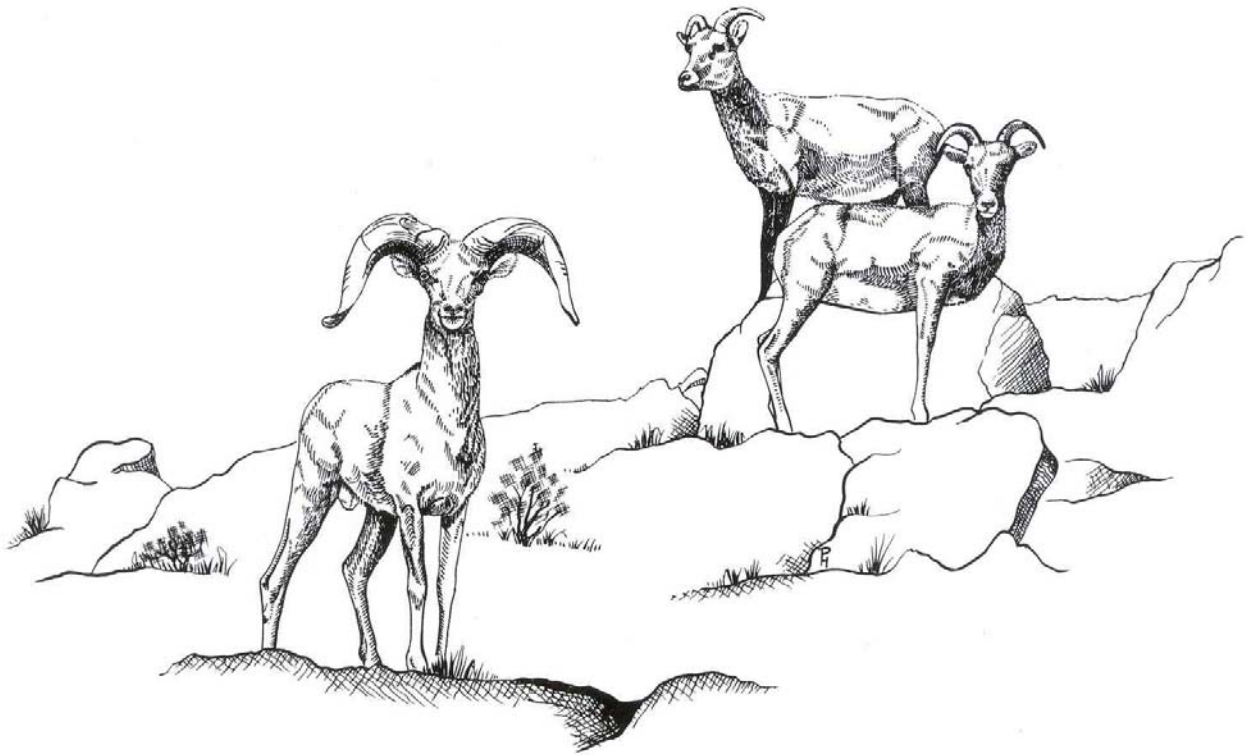# Management Plan

February 1, 2016

ARIZONA BIGHORN SHEEP MANAGEMENT PLAN

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I. PURPOSE OF THE PLAN

A. General

This document provides strategic direction for statewide management of bighorn sheep (*Ovis canadensis*) in Arizona. The Arizona Game and Fish Department (Department) manages bighorn sheep and their habitat to sustain or enhance bighorn populations. As a result of these efforts, Arizona bighorn populations have expanded into many historically occupied areas (Figure 1). Bighorn provide benefits to local communities by providing opportunity for public wildlife viewing, a source for translocations to initiate or supplement bighorn sheep populations throughout the western United States, and a sustainable resource for hunting. At one time, Arizona's bighorn sheep populations were in decline and numbered about 1,000, but with active management have expanded to about 6,000. Additionally, several states including Utah, Colorado, and New Mexico have established or supplemented bighorn sheep populations with bighorn sheep from Arizona.

Arizona's wildlife resources demand prudent and increasingly intensive management to accommodate numerous and varied public demands and growing impacts from people such as habitat loss and fragmentation. This action plan provides important information for the formulation of sound management which includes: the current status of bighorn sheep herds, habitat potential for new bighorn sheep areas, issues and concerns, management goals, objectives and strategies to guide management of this important resource into the future. This plan is intended to guide managers and biologists, and also aid in the decision-making process of the Department and the Arizona Game and Fish Commission.

B. Dates

The statewide bighorn sheep plan is a ten year plan to be reviewed and updated as management strategies are implemented and priorities are met. This plan will be in effect from the date listed on the plan for a period of 10 years. This plan will be reviewed annually and updated as accomplishments are completed or new issues arise.

II. SPECIES ASSESSMENT

A. Natural History

Arizona's bighorn sheep population consists of both desert and Rocky Mountain subspecies. Though the Department acknowledges recent literature that suggests that the *O. c. mexicana* does not represent a distinct subspecies (Ramey 1995), in Arizona for the purposes of management, the Department will continue to recognize two separate desert subspecies: *O. c. nelsoni* and *O. c. mexicana*. Bighorn sheep populations are thought to have once been much larger in number and distribution than what is present today, with large declines likely occurring predominantly between 1860 and 1920. Although, the primary causes for these declines are not well understood, disease, drought, and possibly unregulated hunting were important factors. Currently, the impact of these factors has been reduced and bighorn sheep numbers have increased through a combination of habitat protection, an aggressive translocation program, and construction of numerous water developments. This plan recognizes that in spite of recent successes from an

aggressive translocation program and abatement of some depressing factors, there are additional opportunities to continue to expand the distribution of bighorn sheep into vacant and low density habitats that were occupied historically.

Physical characteristics of bighorn sheep differ somewhat between desert bighorn sheep and Rocky Mountain bighorn sheep (RMBS). While it may be difficult to differentiate between the two sub-species by outward appearance, RMBS tend to be larger than desert bighorn sheep. Adult rams may weigh up to 300 pounds and ewes up to 190 pounds. For desert bighorn sheep, adult rams weigh 160 and 225 pounds and adult ewes average 110 pounds. Horns grow throughout life and typically reach maximum size for rams at 8 to 10 years of age. Females also have horns that are similar in size to yearling males. The biggest visual difference between the two sexes for both subspecies is size and shape of the horns. For desert bighorn sheep, ewe horns are generally 10 to 13 inches long with a circumference of three to six inches while adult ram horns generally measure up to 40 inches along the outside curl with a basal circumference between 13 and 17 inches. The horn core is honeycombed with chambers, or sinuses, which reduce the weight of the skull.

Newborn bighorn lambs weigh from 8 to 10 pounds, have dark eyes and fuzzy, dark-gray hair, and are active within minutes of birth. As the lambs mature, their eyes take on the characteristic amber color of the adult's eyes. After several months, they also take on the adult's pale buff to dark, chocolate-brown coloration. This overall coat color is accentuated by a white muzzle, a white rump patch, light-colored eye rings, and a white edging on the rear legs. The tail is black, bordered in white.

Bighorn sheep have a life expectancy of 10 to 12 years, but may attain an age of 17 years or older. Usually one, rarely two, lambs are born. Lambs typically stay with their mothers until two years of age. Young rams then leave the nursery herds of ewes and lambs and join a bachelor herd. Adults usually remain segregated according to sex except during the breeding season. Sexual maturity varies, both physiologically and behaviorally, between rams and ewes. Although rams as young as 6 months of age may be capable of breeding, they usually are precluded from breeding by the presence of older, dominant rams. Ewes do not breed until they are about two-years old, and rams usually not until at least three years of age. In Arizona, the breeding season extends from early summer and into fall. The breeding season for desert bighorn sheep extends from early summer and into fall, but the peak breeding activity takes place in August. The gestation period is about six months, and most lambs are born in late winter or early spring. The breeding season for Rocky Mountain bighorn sheep usually occurs in November and December with lambs being born in April to June.

Bighorn sheep are diurnal and are usually found in small groups, although herds of 50 or more are sometimes seen. When available, native grasses are important in the bighorn's diet; however, in desert populations, shrubs, forbs, and cacti become very important. Pincushion, barrel, prickly pear, and saguaro cactuses provide needed moisture. Preferred plants vary with habitat quality, locality, and species availability. Mountain lions are the principal predator of adult bighorn sheep, while lambs are preyed upon by coyotes, bobcats, and golden eagles.

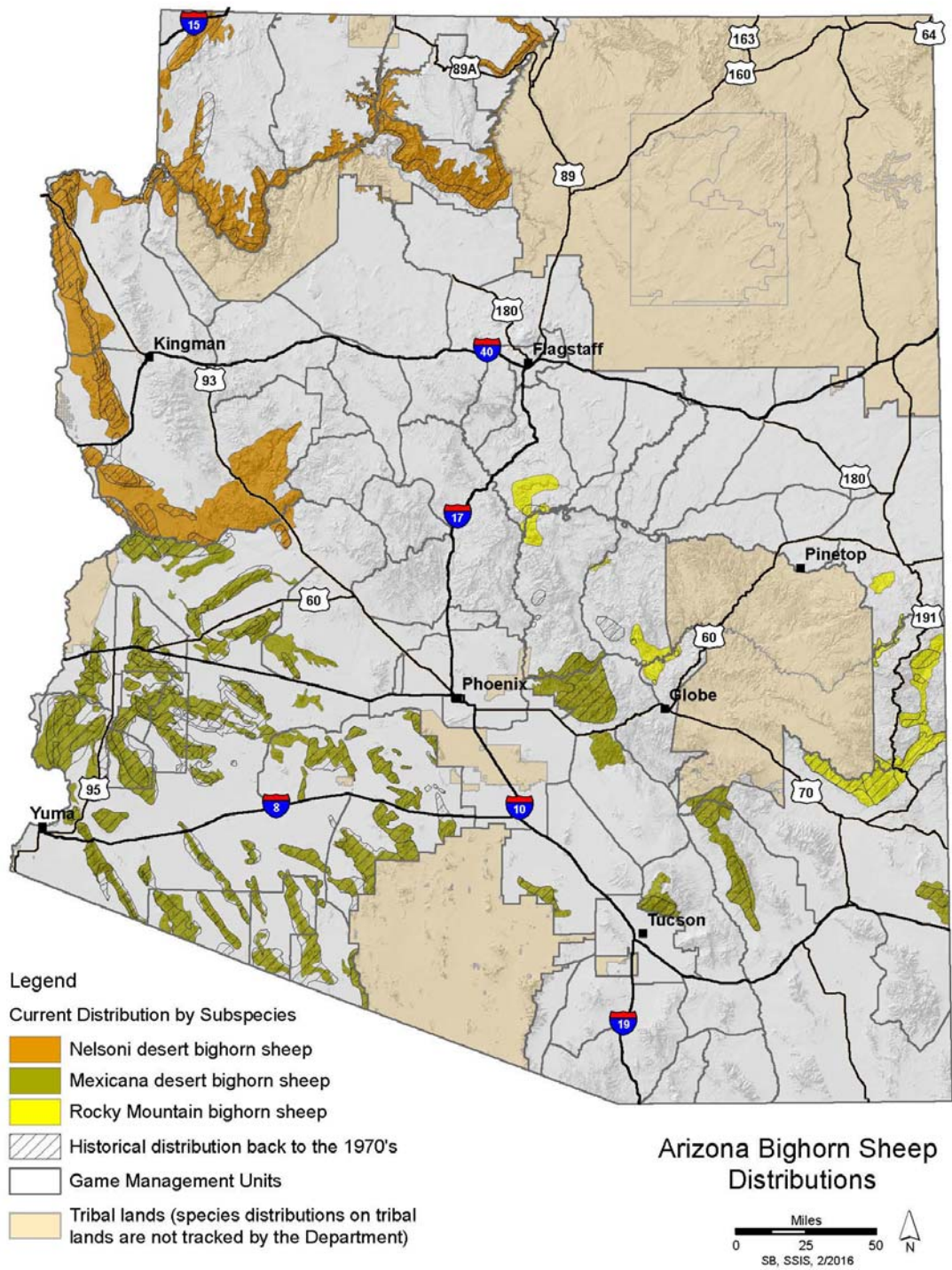# ARIZONA BIGHORN SHEEP MANAGEMENT PLAN

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Figure 1. Current distribution (2015 update) of bighorn sheep by subspecies in Arizona overlaid with the historical distribution.

B. Population Status

Desert Bighorn Sheep (DBS; *Ovis canadensis nelsoni and Ovis canadensis mexicana*)
Currently there are about 5,000 DBS across numerous mountain ranges in Arizona, most of which are substantial enough in size to allow regulated harvest from these populations. The Bill Williams River in west-central Arizona, though not a physical barrier to movement, is recognized as the approximate division ranges of *O. c. nelsoni* and *O. c. mexicana* subspecies (Figure 2). In the 1970s, most desert bighorn sheep populations were found in the desert mountain regions proximate to the Colorado River and isolated mountains in the southern portion of Arizona. Desert bighorn sheep are the most widely distributed subspecies in Arizona.

Objectives for and issues affecting desert bighorn sheep in specific mountain ranges are addressed in the Management Focus Area plan for that area.

Rocky Mountain Bighorn Sheep (RMBS; *Ovis canadensis canadensis*)
Currently there are about 1,200 RMBS in Arizona, of which most are in populations sufficient enough in size to allow regulated harvest from these populations. They are distributed between two main populations and three minor population (Figure 2): 1) Eagle Creek – Blue River population in Units 27 and northern 28, 2) West Clear Creek – Hellsgate population in Units 6A and northern 22, 3) Black River in Units 1 and 27, 4) South Fork in Unit 1, and 5) Black Mesa – Parker Creek population in Units 23 and 24A.

Eagle Creek – Blue River population
The Eagle Creek – Blue River population in Units 27 and northern 28 is comprised of sub-herds in the Eagle Creek drainage, San Francisco River drainage, and upper and lower Blue River drainage (Figure 1). The 2014 population estimate was about 1,000 bighorn sheep. Management concerns for this population continue to increase as a result of vehicle collisions on major roadways and within the Freeport–McMoRan Inc. Morenci Mine and nuisance issues in the towns of Clifton and Morenci. The Department's management goal for this population is multifaceted and includes reducing and mitigating for RMBS-vehicle collisions proximate to the mine, to expand the sub-herds north of Eagle Creek, in part, by introducing RMBS into areas with low RMBS population density and vacant habitat, and to use this herd unit as a translocation source to expand into new, suitable habitat for this subspecies.

Black River population
The Black River population along the border of Units 1 and 27 was established by bighorn sheep from the Blue River population migrating into the area in the 1980s. There are an estimated 150 RMBS in this population with seasonal variations and movement onto the Fort Apache and San Carlos Apache Indian Reservations. The Black River and White River combine to form the Salt River and this provides a migration corridor to Unit 23 and the likely origin of the Black Mesa-Parker Creek population.

South Fork population

In 2014, the Department initiated translocations of Rocky Mountain bighorn sheep from the Morenci Mine to the Little Colorado River/South Fork drainage in northern Unit 1, east of Greer, AZ. This area was presumed to be historically occupied by bighorn sheep. Measurements of a ram skull found in the canyon are not consistent with desert bighorn sheep morphometrics being much larger in scale. In 2012 a nearby domestic sheep allotment was converted to a cattle allotment, alleviating concerns about domestic and wild sheep interactions and potential disease issues. The Wallow Fire of 2011 also created more open habitat in the immediate area and generated more interest in returning sheep to the area. As of July 2015, 48 RMBS have been released into South Fork.

West Clear Creek – Hellsgate population

The West Clear Creek – Hellsgate population in Units 6A and northern 22 (Figure 2) is currently estimated at about 150 to 200 bighorn sheep. This herd is a transplanted population from the Eagle Creek sub-herd. Additional translocations occurred and have aided in the expansion of this population to the east and to the west. Moving to the east, RMBS from this population have been observed in the Mazatzal Wilderness near the Verde and East Verde rivers and in Hellsgate Wilderness along Tonto Creek. The Department with support from the Mogollon Sportsman's Association and the Arizona Desert Bighorn Sheep Society have radio-collared a small number of ewes and rams to aid in documenting further movements of this populations. Moving to the west, RMBS have been observed just west of Interstate 17 on the edge of the Black Hills and moving towards Sedona and Oak Creek Canyon. The Department's goal for this population is to allow for expansion into suitable habitat. A concern for the management of this population is the presence of two domestic sheep driveways that may pose threats if it continues to expand; the need for a risk assessment of these driveways is included in the Translocation section of this plan and is identified in the unit specific MFA plans. This population may be used as a translocation source in the future.

Black Mesa – Parker Creek population

The Black Mesa – Parker Creek population in Units 23 and 24A (Figure 2) was first documented in the early 2000s; at this time the only other RMBS population in Arizona was the Eagle Creek – Blue River population. It is assumed that these bighorn crossed through the Fort Apache or San Carlos Indian reservations and established themselves along Parker Creek (Latch et al. 2006). At one time, this population was of sufficient size to justify the issuance of one ram-permit hunt; however, after two years the hunt was discontinued as few rams were observed by hunters. With an increase in population, one permit was issued in 2015. Currently, the Department's goal is to monitor this population but not encourage growth. One of Arizona's most productive desert bighorn sheep populations is less than 50 air miles to the southwest, and the potential for hybridization between desert and RMBS is a management concern.
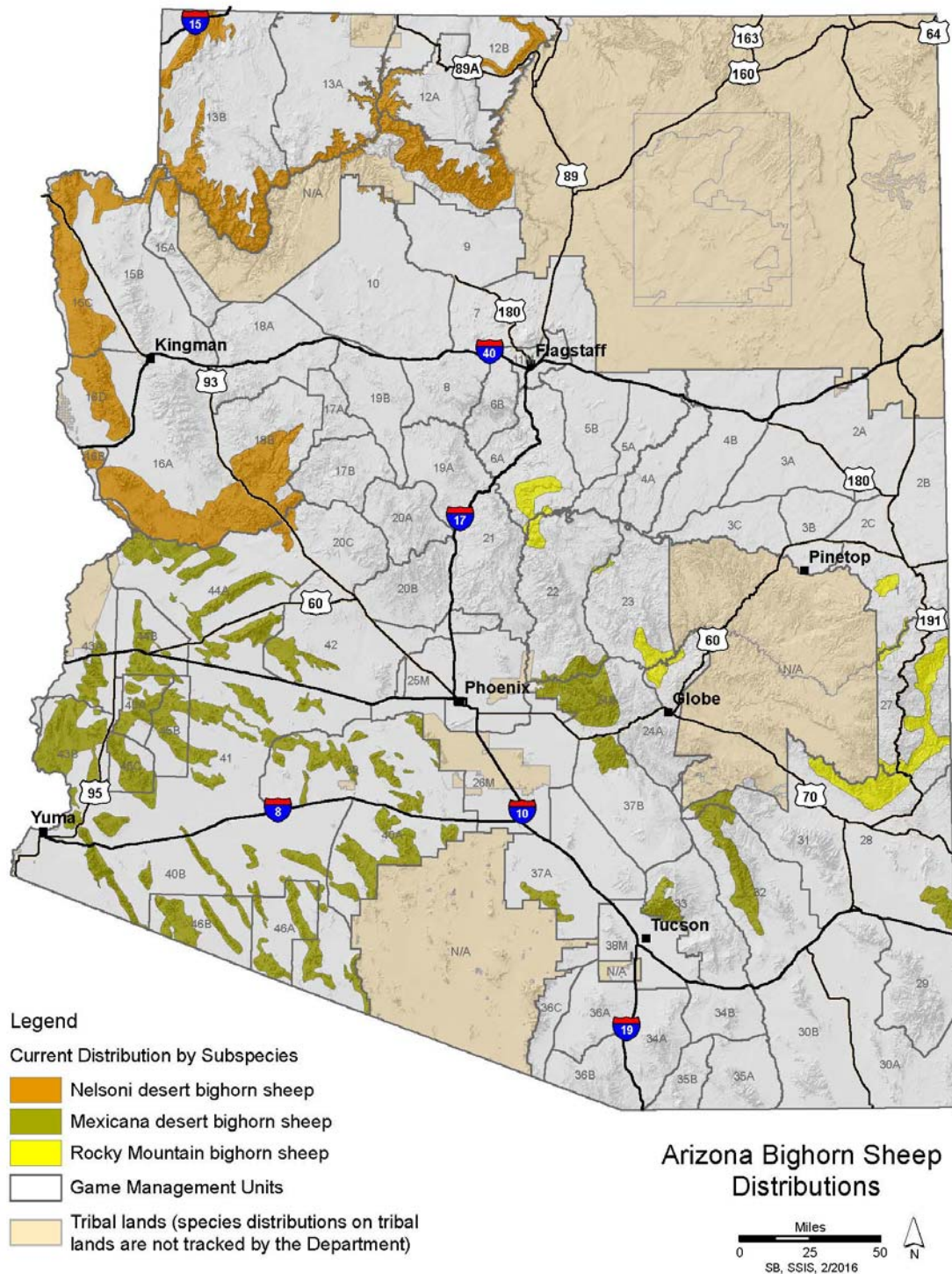
Figure 2. Current bighorn sheep distribution overlaid with Game Management Unit base map

C. Hunt History

Totally protected by the territorial legislature in 1893, bighorn sheep were not legal game in Arizona until 1953, when it was determined that the limited hunting of mature rams was justified. Two limited hunts of 20 permits each were authorized that year, and 20 bighorn were harvested by hunters. Since then, permit numbers, the number of units open to hunting, the number of rams harvested, and hunt success have gradually increased. Now, around 100 rams, mostly desert bighorn, are taken each year. One of the management goals directed by this plan is to continue the expansion of bighorn sheep populations and distribution in Arizona.

Hunt opportunity for bighorn sheep in Arizona is offered through a limited draw and is highly competitive. Bighorn sheep are managed as a once-in-a-lifetime subspecies in Arizona where one desert bighorn and one Rocky Mountain bighorn may be harvested by an individual.

III. MANAGEMENT

A. **Population Surveys:** Conduct surveys to determine population parameters including recruitment rates, ram to ewe ratios, and population trends. Sighting rates should be investigated whenever marked bighorn sheep are available for study. Population estimates will be derived using sighting rates whenever possible.

   1. Department personnel conduct fall surveys in each mountain range or geographic area having a bighorn sheep population. It is important that all survey protocols ensure to the extent possible that repeatability can be obtained. These surveys can include foot, horseback, and vehicle methods. Helicopter surveys should be conducted every third year to estimate population demographics including recruitment rates; ram to ewe ratios, age structure of ram population, and population trends. Surveys are conducted by helicopter between September 15 and December 1 for desert bighorn sheep and between June 1 and January 15 for RMBS. Helicopter surveys must be approved by the Regional Supervisor and the Big Game Management Supervisor. Interim monitoring may be conducted using remotely-triggered cameras, water hole monitoring, or ground surveys to document minimum numbers of rams by size class. If funds are sufficient and need is demonstrated, supplemental helicopter surveys and surveys of marginal sheep populations may be authorized through the Department's budgeting process.

   2. Surveys will be designed to sample representative bighorn sheep range in each unit. Surveys should be mapped by flight area on topographic maps and using the Global Positioning Systems (GPS) to ensure repeatability in subsequent years. For both safety and efficiency purposes, the pilot and the survey crew will be properly trained and familiar with bighorn sheep survey methods. The survey time needed for each mountain range will be based on relative sheep density, ruggedness of terrain, vegetation, etc. Generally, one hour of survey for every 10 square miles of habitat is an appropriate rate of survey coverage.

   3. Observed bighorn sheep will be classified as lambs (1-12 months), yearling ewes and rams (12-24 months), unclassified yearlings, ewes, and Class I, II, III, and IV rams. Animals that

cannot be positively classified will be recorded as "unclassified." Photographs taken during survey may be used to aid in classification (motion stabilized telephoto cameras are recommended). Each animal or group of animals observed will be recorded as one observation on Bighorn Sheep Survey Record. Those observations believed to be replicates will not be used in making calculations and summaries. Confidence intervals will be calculated for ram, lamb, and yearling to 100 ewe ratios for each herd unit.

B. Harvest Data Collection: Collect data on the ages and condition of harvested bighorn sheep.

1. Bighorn sheep hunters will be required to check-out their animals with the Department according to Commission Order 7 and R12-4-308. Hunters will be encouraged to check any bighorn sheep taken through the Regional Office of their hunt area. Hunters may be requested to collect samples of blood, tissue, feces, rumen contents, ticks, or other samples deemed necessary by the Department.

2. Field Operations and Game Program personnel will be familiar with check-out procedures. Only trained personnel will check out bighorn sheep. Bighorn sheep will be checked for general body condition, evidence of diseases including, but not limited to scabies, sinusitis, or any abnormalities. Left and right sides, frontal view, and back view photographs of each head should be taken. Checked bighorn sheep will be aged, the horns will be measured using the Boone and Crochet scoring method, and an aluminum plug with unique identifying information will be inserted in one horn. Abnormalities and other unusual characteristics will also be photographed. Data from all sheep checked will be recorded on the Bighorn Sheep Hunt Record. Copies of these forms will be forwarded to the Game Branch as sheep are checked in but at least within 5 days after the close of the bighorn sheep season. The original check in form will be sent to the region in which the hunt unit occurs. The Game Program will prepare a statewide hunt summary.

3. Regional personal will enter check in forms for their region into the Game Data Management System. Cumulative hunt data will be summarized by regional personnel on Bighorn Sheep Management Summary Form. These data will be used to formulate future hunt recommendations.

C. Hunt Recommendations: Use survey and hunt data to determine a prescribed annual harvest of bighorn sheep and formulate hunt recommendations to accomplish that harvest.

1. Survey data will be summarized by Wildlife Managers and Regional Terrestrial Specialist responsible for game management on the Bighorn Sheep Management Summary Form and Hunt Recommendation Templates. Survey effort, design, and data manipulation will be well documented.

2. A population estimate will be constructed for those herd units for which sufficient population data are available.

3. Hunt recommendations will be made in conformance with the Guidelines for Hunting Season Recommendations. Generally speaking, a population of 50 animals is considered to be sufficiently robust to support the annual harvest of sheep annually. Hunt recommendations should allow the harvest of 5-10% of the estimated ram population, which is generally 15-25% of the Class III and Class IV rams.

4. Unit hunt recommendations and survey data must be submitted to the Big Game Management Supervisor for review in accordance with the Hunt Recommendations Guideline schedule.

D. **Population Objectives:** Determine factors contributing to bighorn sheep population increases or declines. It is important to determine, to the extent possible, causes for both population increases or decreases so that these factors can be used to improve management of bighorn sheep populations to optimize robust populations throughout Arizona.

1. Past recruitment rates will be compared with various population influences such as climatological data to test for possible correlations between precipitation patterns, drought indices, and recruitment rates. Analyses should be a cooperative effort among appropriate Department or other entities with relevant expertise.

2. Specific disease investigations will be coordinated among appropriate Department personnel and work units and other interested parties. This could include other state agencies such as the Arizona Department of Agriculture, universities, private entities or regional organizations such as the Western Association of Fish and Wildlife Agencies Wildlife Health Committee. Cooperative investigations into bighorn sheep diseases will be a high priority for Department programs.

3. The Wildlife Health program in Research Branch will maintain a file on all samples collected and tested and the results of pertinent disease investigations. These data may be available to others doing or interested in research on bighorn sheep diseases via an approved data-sharing agreement.

4. When population viability is of concern, area-specific survival and cause-specific mortality will be monitored in a subset of collared animals.

5. Predator removal for the benefit of bighorn sheep populations will be considered in units where the objective for the area-specific bighorn sheep population is to serve as a source herd or where the population is below objectives for the herd unit, as identified in the Management Focus Area plan (MFA) or Hunt Guidelines. Any request for specific predator management must be identified in the MFA for that specific game management unit. An assessment of other influences on bighorn sheep survival must be completed before predator management is recommended. Written landowner permission is needed for private or leased land before any predator management program can proceed. Area-specific planning must be

done in accordance with the Commission's Predation Management Policy (DOM A2.31). Area-specific plans will be developed by Field Operations personnel.

6.   Department personnel will identify the need for predator management in the area-specific MFA and submit their predator management recommendations to the Big Game Management Supervisor or their designee. The Terrestrial Wildlife Branch and Executive Staff will evaluate recommendations and set priorities on the basis of need, control methods to be used, and funds available. Approved recommendations will be forwarded to the USDA, Wildlife Services or another appropriate entity, for an action program.

7.   When the area-specific MFA and supporting documentation for predator management receives appropriate approval, the Regional Terrestrial Specialist responsible for game management, in conjunction with the Predator-Furbearer Biologist, will document all data pertaining to the predator management program including the number of predators removed before and after control. These personnel will also be responsible for preparing the environmental compliance documentation required for predator management activities.

E. **Translocations:** One of the key goals for management of bighorn sheep in Arizona is to maintain the genetic integrity of the native subspecies, while expanding their distribution where possible using an aggressive translocation program.

1.   Potential bighorn sheep translocation sites will be determined according to the Evaluation of Bighorn Sheep Habitat described in "The Desert Bighorn Sheep in Arizona" (Cunningham 1989) and the modified Cunningham-Brown Analysis for RMBS. Bighorn sheep habitat suitability models developed around actual bighorn sheep habitat use may be used in conjunction with the above evaluation to prioritize translocation sites. Transplants will be accomplished in accordance with the Game Animal Translocation Procedures (DOM I1.2). Any translocation must be identified in the area–specific MFA for both the source and recipient area.

2.   When Department personnel recommend that a particular bighorn sheep population can be used as a source for bighorn sheep, bighorn sheep may be translocated from this population to an area within the historical range of that subspecies. Populations may be considered as a source when the population exceeds a minimum of 40 adult and yearling ewes and with at least a stable and preferably expanding population. Removals for translocations will not reduce source herds to less than 30 adult and yearling ewes. The Big Game Management Supervisor must approve all translocation sites. Actual release location will be determined jointly by Field Operations and Game Program personnel. Out-of-state requests for bighorn sheep must be made in accordance with Department Policy and procedures.

3.   A current Environmental Assessment Checklist (EAC) must be completed and in place for each proposed capture and release site. The EAC will be initiated by the translocation proponent, unless a valid EAC is already in place, and must include information regarding subspecies to be translocated, a description of the capture and release locations, discussion

of the capture methodology, a risk assessment to include a review of potential diseases from both the capture and release locations, and planned monitoring of the released animals.

4. Department personnel may capture bighorn sheep using helicopter and capture gun procedures (dart via chemical immobilization or net, as appropriate) or drop-net procedures which may be attempted throughout the year using suitable bait, such as apple mash. Other techniques may also be developed. Capture techniques are described in "The Desert Bighorn Sheep in Arizona" (Remington and Fuller 1989). Each release will require a minimum of 15 animals unless the release of a smaller number can be justified and approved by appropriate Department personnel. Preferably translocated groups will consist of about 65% ewes, 20% yearlings, and 15% medium aged rams (Classes II and III).

5. Captured bighorn sheep will be transported to the release area by trailer, helicopter, or other appropriate means. Transportation procedures are outlined in "The Desert Bighorn Sheep in Arizona" (Remington and Fuller 1989). Animals may be "free" released or kept in temporary holding pen(s) at the release site and "soft" released from 4 to 24 hours after arrival. A subset of released bighorn sheep (i.e., a minimum of 4 to 6 ewes dependent upon the total number of released bighorn sheep) may be radio-marked for monitoring purposes.

6. Released bighorn sheep will be monitored by Department personnel following the protocol identified in the implementation plan approved by the Regional Supervisor, Terrestrial Wildlife Branch Chief, and the Wildlife Management Division and Field Operations Division assistant directors. The need for supplemental releases shall be jointly determined by Field Operations and Game Program personnel with approval for this action following the same Department approval protocol as for any initial release.

7. Augmentation can follow an initial reintroduction at intervals providing the best opportunity for successful establishment and to maximize future genetic diversity by reducing the severity of founder effect (starting a population with only a few individuals).

8. Translocated bighorn sheep will be monitored and surveyed according the schedule established in the implementation plan for that translocation.

F. **Habitat:** Maintaining and enhancing bighorn sheep habitat is an essential component of effective management of bighorn sheep in Arizona.

1. Habitats deemed important to bighorn sheep will be identified, rated, and ranked in importance according to the Evaluation of Bighorn Sheep Habitat described in "The Desert Bighorn Sheep in Arizona" (Cunningham 1989) and the modified Cunningham-Brown Analysis for RMBS. If an area is deemed to be high quality habitat but has limiting factors such as lack of water or the presence of domestic sheep, efforts will be made by Department personnel and cooperators to abate these limiting factors to the extent that a translocation can occur.

2. Any area considered for translocation will be evaluated to determine if livestock grazing conflicts with bighorn sheep translocation exist in the area. Based on existing science and Western Association of Fish and Wildlife Agencies (WAFWA) policy (Appendix A), areas with active management of domestic sheep and goats pose high risk to the establishment of bighorn sheep populations. If there is a conflict with any domestic livestock operation in an area considered for translocation, efforts will be made to proactively reduce the conflict level to the point that bighorn sheep translocated to the area will have a high probability of successfully establishing a robust population.

3. Bighorn sheep watering requirements should be evaluated. If it can be demonstrated that bighorn sheep are watering with domestic or feral stock and that a conflict between these resources exist, an alternate source limited to bighorn sheep will be developed. Water development evaluations will be a joint effort of Game Program, Development Branch, Field Operations personnel with various land management agencies and interested bighorn sheep management organizations.

4. Wild horses and burros should be maintained at the lowest numbers possible, or as identified in herd management area plans, to minimize impacts to bighorn sheep and their habitat. Resolution of conflicts with feral horses and burros should be pursued with the appropriate land management agency. No release of exotic ungulates will be permitted in bighorn sheep habitat.

IV. ISSUES, CONCERNS, AND OPPORTUNITIES

There are many challenges associated with managing bighorn sheep populations in Arizona. The following issues/actions should be priorities for managing current and future bighorn sheep herds. It is important to note that full implementation of the elements in this plan will be costly and that no single source of funding will be adequate to meet the opportunity to repatriate bighorn sheep in Arizona. Funding for all elements of this plan can be obtained from sources such as the Habitat Partnership Committee (HPC), nongovernmental organizations contributions, Wildlife Restoration Act, donations, or any other funding source that becomes available.

A. Disease
Parasites and diseases can be a major concern for bighorn sheep management in Arizona. There are a multitude of bacteria, viruses, and parasites that can have little effect on the well-being of bighorn sheep and some that can cause wide-spread declines. Some of the more important of these are identified here.

Parasites such as those that cause contagious ecthyma and psoroptic mange (Boyce and Weisenberger 2005) and respiratory diseases such as those caused by Pasteurellosis have resulted in large-scale population declines in short periods of time (Jessup 1985, Foreyt 1990). Pasteurellacae are a wide array of bacteria that have been associated with respiratory disease, death, and reduced fecundity in bighorn sheep (Miller et al. 2012). Currently, there are 23 known Pasteurellacae isolates from bighorn sheep, and of these, 3 appear to be associated with severe

disease. These include *Pasteurella multocida*, *Mannheimia haemolytica* (formerly *P. haemolytica*) and *Bibersteinia trehalosi* (formerly *P. trehalosi*). Within each species there are several biovariants and subtypes that may be further classified by virulence, or ability to produce leukotoxin, which may cause enzyme production, cell lysing, and extensive tissue damage during a pneumonia event (Miller et al. 2012).

Pasteurella multocida is the most widely distributed of the 3 genera and has been associated with epidemic disease outbreaks in both domestic and wild mammals. *P. multocida* is rarely found or isolated from bighorn sheep and is not typically linked to disease outbreaks. However, it has been associated with large die-offs of Rocky Mountain bighorn sheep in the Hells Canyon area of Idaho, Washington, and Oregon (Weiser et al. 2003) and Colorado (Spraker et al. 1984).

Mannheimia haemolytica and *P. trehalosi* appear to be the genera that primarily affect both wild and domestic ruminants and are the most studied in bighorn sheep. Both can cause pneumonia or septicemia; however, they are also considered common commensal organisms in the upper respiratory tract. As commensal organisms, they likely act as opportunistic pathogens to animals under environmental stress or with lowered immunities (Foryet and Jessup 1982, U-C Davis 2007).

Other bacterium such as *Mycoplasma* spp. that have been associated with respiratory disease in many different mammal and avian species, including domestic sheep (Weiser et al. 2012), may contribute or lead to pneumonia events in bighorn sheep by allowing the overgrowth of Pasteurellacae (Besser et al. 2008, Dassanyake et al. 2010, Besser et al. 2012, Weiser et al. 2012). For example, research in bighorn sheep that were exposed to leukotoxin producing *M. haemolytica* did not develop fatal respiratory disease until after exposure to *M. ovipneumonia* (Dassanayake et al. 2010).

As mentioned above, many mammals can carry one or more of these bacteria as commensal flora in their upper respiratory system (Dunbar et al 1990, Miller 2001, U-C Davis 2007). Exposure of naïve bighorn sheep to domestic sheep and goats carrying strains of these bacteria can have devastating results and examples of epizootic outbreaks of respiratory disease in relation to contact with domestic sheep or goats exist in the literature (Jansen et al. 2006, Jessup 1985, Foreyt 1990, Martin et al. 1996, Rudolph et al. 2003). Conversely, respiratory disease attributed to Pasteurellosis has occurred in the apparent absence of contact with domestic sheep or goats.

It is believed that wild sheep to wild sheep interactions may also lead to respiratory disease when exposure of naïve bighorn sheep to other bighorn sheep carrying different strains of bacterium occurs (Monello et al. 2001, Weiser et al. 2003, U-C Davis 2007). Therefore proximity of bighorn sheep to domestic sheep grazing areas and the connectivity of habitats between other herds and seasonal ranges play a critical role in management of respiratory disease (Monello et al. 2001). For those reasons it is critical for future management that we understand the distribution and dynamics of disease and their pathogens in Arizona bighorn sheep. Because of the aforementioned disease concerns, the WAFWA Wild Sheep Working Group published the "Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat" in 2007.

Those guidelines clearly outline steps that should be taken by state wildlife agencies, federal land management agencies, wild sheep conservation organizations, domestic sheep and goat producers/permittees, and private landowners to reduce conflicts between wild sheep and domestic sheep and goats. The guidelines were updated in 2010 and once again in 2012. The 2012 WAFWA Wild Sheep Working Group recommendations for state wildlife agencies can be found in Appendix A of this plan. The complete and most updated version of the guidelines can be found at http://www.wafwa.org/html/wswg.shtml.

The Department recognizes the economic value of the domestic sheep and other livestock industry, and it is not the intent of this plan or the Department to force domestic sheep or other livestock operators off of their ranges or out of business. Rather, the intent is to look for opportunities that will protect bighorn sheep populations while working with the domestic sheep and other livestock industry.

Response and control of a disease outbreak will be conducted using standardized current protocols for sampling and testing (Foster 2004, WAFWA Wildlife Health Committee (WHC), UC-Davis 2007, and WAFWA Bighorn Sheep Herd Health Monitoring Recommendations 2015). Accurate cause of death should be determined through a full necropsy when possible. All bighorn sheep that are exhibiting signs or symptoms of illness should be considered for removal from the population and the impacts of stressors on populations experiencing a disease outbreak should be determined and if possible lessened. The isolation of an affected sheep herd from other unaffected sheep herds should also be ensured.

B. Predation
Predators have played an important role in the evolution and development of adaptive strategies in bighorn sheep (Geist 1999). However, predation can be a serious limiting factor to bighorn herd establishment or expansion. In some states excessive predation has resulted in substantial herd reductions (Wehausen 1996, Creeden and Graham 1997, Rominger et al. 2004). Mountain lions are the most significant predators of adult bighorn sheep in Arizona, while coyotes, bobcats, and golden eagles are more likely to prey on bighorn sheep lambs and yearlings.

Mountain lion populations should be managed at levels which will allow for the establishment of viable bighorn populations and allow bighorn population objectives to be met. That may require removal of mountain lions which are negatively impacting bighorn populations until herds are well established. In geographic areas where mountain lion harvest is typically low or nonexistent because of topography and access, and mountain lions are determined to be a cause of reduced population level, it is important to increase mountain lion harvest opportunity to assist in bighorn sheep population recovery. In some cases, the use of USDA Wildlife Services or other contracted personnel may be needed to help manage mountain lion populations. MFAs and predation management plans should specify conditions and triggers for implementing predator management in bighorn areas.

C. Habitat Degradation or Loss

Bighorn sheep habitat can be degraded, fragmented, or lost to a variety of causes including human disturbance, mineral development, and natural succession. Reductions in the quality or quantity of habitat can result in corresponding losses to bighorn populations (Deforge 1972, Hamilton et al. 1982). Human disturbance in bighorn sheep habitat is an increasing concern in some areas of Arizona. Those disturbances include activities such as off-road vehicle use, development of wind and solar farms, development of highway corridors and powerlines, and others. Bighorn sheep may change frequently used areas and abandon certain habitats because of those disturbances. Human disturbance is also thought to be a possible stress inducer, which may lead to disease problems in some populations (DeForge 1981, Bunch et al. 1999).

Mineral development for oil, gas, uranium, and other minerals in bighorn habitat, if not properly regulated and mitigated, can result in direct loss of habitat. Habitat managers for the Bureau of Land Management and U.S. Forest Service should carefully monitor and regulate those activities to avoid impacts on bighorn sheep.

Plant succession can also dramatically affect habitat quality. Encroachment by pinyon-juniper and other shrubs has resulted in the fragmentation and loss of large expanses of bighorn habitat. Vegetative treatments including prescribed fire and fire management can restore and improve bighorn habitat to desired or favorable conditions.

D. Water Developments

Drought has severely impacted Arizona over the past two decades. The western half of the state is extremely arid, especially in habitats supporting DBS. To compound this problem, many natural water sources have been degraded or eliminated from a wildlife standpoint by human development, livestock or burro use, or have been eliminated by groundwater pumping for either agriculture or urban development.

The Department has evaluated numerous of Arizona's mountain ranges as to their suitability to support bighorn sheep. Many have the topography and the vegetative resources to support bighorn sheep but lack adequate available water. The protection and development of water sources is one of the management activities that can be used to expand both bighorn sheep distribution and population size.

The Department actively engages in a program to provide water for bighorn sheep as a means to increase population levels and distribution in water deficient habitats. The protection and development of natural water sources or catchments is a high priority. The Department will pursue water developments in water deficient habitats to mitigate for habitat losses in other areas. Department personnel will evaluate water distribution across summer range to moderate impacts from failed water developments and focused predation. Additional water sources will be recommended for construction when appropriate. It is essential that field personnel include priority actions such as development of new water sources or repair to existing sources in the area-specific MFA.

Maintenance of existing water developments is also a high priority. A combination of approaches may need to be employed to ensure that all waters are maintained. The local Wildlife Managers are responsible for monitoring waters in their districts. Conservation groups, volunteer labor, and other area biologists often assist in monitoring waters. The Department will, where feasible, augment water in those water developments that are deemed critical and deficient in available water. If water hauling is needed, the local Wildlife Manager will notify the appropriate Department personnel and then follow up to ensure the water development has been filled. It is important to evaluate new techniques such as remote sensing to assist in monitoring developments in remote areas to minimize the amount of travel and associated cost to identify when water hauling is necessary. Future designs should expand capacity to the point that evaporation, water loss due to maintenance issues, and other issues are minimized.

The Department will use the best development design for a given site to provide adequate water in the most cost efficient and maintenance-free manner. Other factors will be considered when designing developments such as the merits of using one large development in an area versus several smaller units. In order to achieve water development objectives, the Department in cooperation with land management agencies will use employees, private contractors, conservation organizations, and volunteers for the installation of water developments.

E. Translocations

Translocating bighorn sheep is a primary tool for restoration and management of bighorn populations. Several issues need to be considered prior to releasing bighorns in new areas or into existing herds, and those issues are clearly stated in the 2012 WAFWA guidelines (Appendix A). Bighorn sheep should only be released in areas where there is a high probability of success as determined by habitat evaluations or GIS modeling. To the extent practicable, disease profiles should be established for the source stock and any existing herds where those sheep may be released. Sufficient numbers should be released to assure genetic diversity and to help new herds reach self-sustaining levels as soon as possible. Additionally, source stocks should come from the nearest available source with similar habitat and disease profiles as the release site animals. The exact release site for transplanted sheep depends on accessibility and weather conditions and will be determined closer to the time of release.

As part of the Department's reintroduction program, all bighorn sheep brought into Arizona from other states will be tested for pathogens and antibodies for disease and must meet health requirements established by the Department and the State Veterinarian. All bighorn sheep relocated from source herds within the state will also be monitored for those same diseases to more effectively manage disease issues. Moreover, to prevent disease introduction, only bighorn sheep herds with known disease profiles should serve as source stock for intra and inter-jurisdictional translocations. Mixing of bighorn sheep from various sources will be evaluated and current protocols for sampling, testing, and responding to disease outbreaks will be used as a standard for Arizona translocations (Foster 2004, WAFWA Wildlife Health Committee [WHC], UC-Davis 2007, and WAFWA Bighorn Sheep Herd Health Monitoring Recommendations 2015).

For all bighorn sheep used in relocation efforts, nasal and oro-pharyngeal swabs will be collected to test for *Pasteurella* spp. and *Mycoplasma* spp. additionally; blood samples will be collected for brucellosis testing, antibody testing for various diseases of concern, and serum banking. Bighorn sheep used for all relocation efforts will be treated with the appropriate antibiotics, wormers, and vaccinations prior to release. Sheep exhibiting signs or symptoms of contagious ecthyma or psoroptic mange will not be relocated and, instead, will be treated and released at the capture site.

F. Movement Corridor Protection

Bighorn sheep movement can be categorized into two general types. The first is daily movement where bighorn sheep move between watering areas, foraging areas and resting areas. These movements normally do not exceed more than a few miles in a day. The second is seasonal movements where bighorn move to other parts of a range or to other mountain ranges in response to changes in vegetation quality, water availability, weather, or reproductive activity. These movements can include several thousand feet in elevation change and a 20 or 30-mile movement to another mountain range. The impediment of either of these movements can be devastating to a bighorn sheep population.

The Department will work to maintain bighorn sheep movement corridors. The Department's HabiMap and Western CHAT will be used to identify and map important movement corridors. Any roads built in bighorn sheep habitat or movement corridors must be constructed in such a way as to allow continued bighorn movement. Some strategies could include under or over passes, ramps cut into steep side slopes, alternatives to continuous guard rails and/or fence specifications along roads that allow sheep movement. Appropriate Department personnel will work with land management agencies and the Arizona Department of Transportation to mitigate construction of roads and fences that inhibit bighorn sheep movement.

G. Wilderness and Park Management

Administration of wilderness areas, wildlife refuges, and national parks has presented problems for bighorn sheep conservation and restoration in Arizona and other states. Future wilderness designations, park expansions, or monument designations should specifically allow for activities required for proper management of bighorn populations including the use of, and potential landing of, aircraft (e.g., helicopters, airplanes, or drones) for surveys, capture and translocation, research projects, and the ability to access and maintain water developments constructed specifically for bighorn sheep or other wildlife. It is critical to the future of bighorn sheep in those areas to maintain the use of those valuable management tools. Coordination and collaboration with federal agencies in completing any required National Environmental Policy Act (NEPA) or relevant compliance documents should follow legal requirements as not to interfere with the State's mandated authority and public trust responsibility to manage wildlife in Arizona, including on federal lands.

H. Competition

Competition for forage and space by domestic livestock, feral animals, wild burros, and wild horses can impact bighorn populations (Bailey 1980). Competition is most likely to occur in

crucial habitats such as winter ranges and lambing areas and during periods of extreme weather such as droughts or heavy snow. Competition with livestock for forage is minimal for most bighorn populations in Arizona since bighorns use steep, rugged terrain generally not used by livestock. However, in some areas of Arizona, wild horses and burros use the same ranges as bighorn sheep making competition likely. Bighorn habitat should be monitored to assure proper range management and minimize competition. It is essential that the Department and collaborators strongly advocate that the appropriate land management agency maintain both feral burros and horses within appropriate areas and levels to minimize impacts to all wildlife, but with emphasis on bighorn sheep.

I. Hybridization
Hybridization between desert and Rocky Mountain bighorn sheep will be discouraged but recognizing that bighorn sheep have a propensity to make long-range movement (McCall and Brown 2011) and hence, co-mingling is a potential in areas where the two exist in proximity. Based on known distribution of both desert and Rocky Mountain bighorn sheep, the current distribution minimizes the potential for co-mingling of subspecies. In general, the desert subspecies occur proximate to the Colorado River and more arid mountain ranges in the southwest, central and southeastern portions of Arizona. Rocky Mountain bighorn sheep occupy more mesic, higher elevation areas in eastern and central Arizona. As indicated, translocations of wild sheep throughout western North America have resulted in greatly expanded occupancy by wild sheep and are foundational to the Department's sheep management plan. Consideration of translocations of one bighorn sheep subspecies should be intensely evaluated in order to avoid or at least limit hybridization; however, informed decisions will be made by Department staff on any translocation that might lead to mixing of desert and Rocky Mountain bighorn.

J. Contact with or Proximity to Domestic Sheep and Goats
As indicated in Appendix A, there are guidelines adopted on management of interaction of domestic and wild sheep. This document will guide the Department's management of issues where contact has been made between the domestic and wild sheep. Given the high potential for adverse impact to wild sheep when close contact has occurred between the two, priority for translocations will be given to areas where contact with domestic sheep is minimized.

V. TRANSLOCATION PRIORITIES

The Department has evaluated much of Arizona for potential release sites for both DBS and RMBS using the Evaluation of Bighorn Sheep Habitat described in "The Desert Bighorn Sheep in Arizona" (Cunningham 1989) and the modified Cunningham-Brown Analysis for RMBS.

Prior to any translocations into new areas or augmentations to existing herds, disease, habitat, and public access issues will be evaluated or re-evaluated and addressed. Once an evaluation is complete and all issues addressed or mitigated for, the Big Game Management Supervisor and Regional Terrestrial Specialist responsible for game management will identify a source population and prioritize the translocation in the one to two year implementation schedule. Translocations priorities will be review and updated annually. Multiple translocations may be

necessary to maintain and establish sufficient numbers to reach the desired population level and to maximize genetic diversity. It is important that source herds and recipient herds are identified in the appropriate MFA for both areas.

All source populations will be surveyed within a year of the translocation occurring; all translocations will be planned for implementation pending the results of this survey.

One of the key issues related to translocation of bighorn sheep is the widespread presence of domestic sheep or goats in areas that have been identified as being potential habitat for bighorn sheep. Based on the most current information on the adverse impact of co-mingling of domestic sheep and goats and wild sheep (Appendix A: Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat, WAFWA Wild Sheep Working Group), it is strategically most important to eliminate close contact between the two rather than experience catastrophic outcomes as has been experienced elsewhere. Conceptually, the items listed here are approaches that have been used elsewhere to minimize impacts to wild sheep from exposure to domestic sheep and goats.

- Removal of domestic sheep and goats from the area where DBS or RMBS would be translocated to.
    - Purchase and/or retirement of allotments
    - Fence areas where domestic sheep and goats are allowed to occupy.
    - Mandatory non-use of allotments.
    - Evaluations, re-evaluations or Environmental Assessments of domestic sheep driveways on Federal lands.
- Ensure the timely removal, including lethal options, for stray feral animals within areas occupied by DBS or RMBS.
- Conversion of allotments from domestic sheep and goats to cattle operations.
- Collaborative development of management plans to minimize contacts between these animal groups.
- Develop and implement a process to remove DBS or RMBS that are known to have had contact with domestic sheep and goats as soon as practical, to reduce the potential for an exposed bighorn sheep to amplify the exposure to other bighorn sheep in the population.

Once the identified strategies are addressed to the satisfaction of the Big Game Management Supervisor and the Regional Terrestrial Specialist responsible for game management will proceed with facilitating completion of all Department EAC requirements and steps identified in the Game Animal Translocation Procedures (DOM I1.2).

The following strategies should be considered and addressed before proceeding with any translocation.

Strategies for Addressing Potential Issues –

Strategy A. Monitor and pre-test all DBS populations for evidence of current or past respiratory disease.

Strategy B. Complete an assessment of the impacts of wild burros, wild horses, and feral hogs relative to competition with the DBS population and degradation of DBS habitat.

Strategy C. Complete an assessment for the need for predator management and incorporate the results of this assessment into the appropriate MFA for the area.

Strategy D. Work with the state and federal land management agencies on grazing allotments in DBS areas to ensure effective separation between bighorn sheep and domestic sheep and goats.

Strategy E. Regional personnel should complete an inventory of domestic sheep and goats, including hobby herds and pack goat operations and continue to document areas of known domestics through opportunistic field observations.

Strategy F. To accomplish Strategy B, develop partnerships with conservation and agricultural organizations to collect data on domestic sheep and goat locations.

Strategy G. Promote double-fence construction/modification in bighorn sheep ranges with domestic sheep and goats by providing technical and financial assistance to private landowners through the Department's Habitat Partnership Committee program or other landowner incentive program.

Strategy H. Work with conservation organizations to develop cooperative programs to acquire domestic sheep and goat permits in areas without effective separation, or provide financial incentives or cost-share options towards mitigation such as alternative livestock and double fencing.

Strategy I. Provide community outreach and education when establishing a bighorn sheep population near a community.

A. Desert Bighorn Sheep – *mexicana* subspecies

The Department has identified several areas to further review and evaluate for future potential DBS – *mexicana* populations. The source population location and disease profiles of both the source receiving populations will be evaluated to determine priority ranking for translocations. Strategies for addressing potential issues within each identified area are provided. Regional personnel will be responsible for working through these strategies unless otherwise noted.

1. *Region 4 – Areas of highest priority*
    – Belmont Mountains (Unit 42)
        This area has not yet been evaluated using the Modified Cunningham-Brown model. An evaluation should be completed before consideration for future augmentation.
    – East Buckskin Mountains (Unit 44A)
        Modified Cunningham-Brown model score: 42 out of 63
    – Maricopa Mountains (Unit 39) for genetic improvement only (we believe population is re-building)

This area has not yet been evaluated using the Modified Cunningham-Brown model. An evaluation should be completed before consideration for future augmentation.

- Black Mountains/ Ives Peak (Unit 44A) – lowered in priority as no new waters have been developed

    Modified Cunningham-Brown model score: 41 out of 63

- Harquahala/Granite Wash/Harcuvar Complex (Unit 44A)

    Modified Cunningham-Brown model score: 40 out of 63 for the Harquahala Mountains and 36 out of 63 for the Harcuvar Mountains

For long term consideration, the following mountain ranges were identified as candidates for future translocations:

- Sierra Estrella Mountains and the Gila Bend Mountains (Unit 39)

    Modified Cunningham-Brown model score: 50 out of 63 for the Sierra Estrella Mountains and 44 out of 63 for the Gila Bend Mountains

- Sand Tank/Sauceda Mountains (Unit 40A)

    This area has not yet been evaluated using the Modified Cunningham-Brown model. An evaluation should be completed before consideration for future augmentation.

2. *Region 5 – Areas of highest priority*
    - Galiuro Mountains (includes Redfield and Aravaipa canyons) (Units 31 and 32)

        Modified Cunningham-Brown model score: 46 and 47, respectively, out of 63

    - Peloncillo Mountains (Unit 28)

        Modified Cunningham-Brown model score: 48 out of 63

For long term consideration, the following mountain ranges were identified as candidates for future translocations:

- Whitlock Mountains (Unit 28)

    Modified Cunningham-Brown model score: 37 out of 63

- Picacho Mountains (Unit 37A)

    Modified Cunningham-Brown model score: 38 out of 63

3. *Region 6 – Areas of highest priority*
    - Gold Field Mountains in (Unit 24B North)

        Modified Cunningham-Brown model score: 46 out of 63

For long term consideration, the following mountain ranges were identified as candidates for future translocations:

- Consider establishment of a population in the McDowell Mountains in Unit 25M, specifically as a watchable wildlife population with potential for archery hunting opportunities in the future.

    Modified Cunningham-Brown model score: 23 out of 63

B. Desert Bighorn Sheep – *nelsoni* subspecies

The Department has identified several areas to further review and evaluate for future potential DBS – *nelsoni* populations. The source population location and disease profiles of both the source receiving populations will be evaluated to determine priority ranking for translocations. Strategies for addressing potential issues within each identified area are provided. Regional personnel will be responsible for working through these strategies unless otherwise noted.

1.   *Kanab Creek in Units 12A, 12B, and 13A*

Portions of this area currently have DBS in low, dispersed numbers. Potential issues that need to be investigated prior to augmentation include water distribution, disease presence and profile, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

Modified Cunningham-Brown model score: 55 out of 63, at Jumpup Canyon

2.   *Units 15A and 15B East in November 2016*

Portions of this area currently have DBS in low, dispersed numbers. Potential issues that need to be investigated prior to augmentation include water distribution, disease presence and profile, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

Modified Cunningham-Brown model score: 41 out of 63 for the Grand Wash Cliffs and 37 out of 63 for the Music Mountains

3.   *Grand Wash Cliffs in Unit 13B South*

Portions of this area currently have DBS in low, dispersed numbers. Potential issues that need to be investigated prior to translocation include water distribution, disease presence and profile, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

Modified Cunningham-Brown model score: 53 out of 63

4.   *Arrastra Wilderness, Poachie Mountains, and Hualapai Mountains*

Portions of this area currently have DBS in low, dispersed numbers. Potential issues that need to be investigated prior to augmentation include water distribution, disease presence and profile, and distance to nearest domestic sheep or goats (including hobby herds.

Modified Cunningham-Brown model score: 43, 41, and 40, respectively, out of 63

5. Cerbat Mountains in Unit 15B

This area is northeast of the Kingman. Potential issues that need to be investigated prior to augmentation include water distribution, disease presence and profile, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

This area has not yet been evaluated using the Modified Cunningham-Brown model. An evaluation should be completed before consideration for future augmentation.

6. Trout Creek in Units 18A and 18B

This area is east of the Kingman. Potential issues that need to be investigated prior to augmentation include water distribution, disease presence and profile, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

Modified Cunningham-Brown model score: 42 out of 63

C. Rocky Mountain Bighorn Sheep

The Department has identified five areas to further review and evaluate for future potential RMBS herds. One of the key issues related to translocation of RMBS is the widespread presence of domestic sheep in areas that have been identified as being potential habitat for RMBS. Based on the most current information on the adverse impact of co-mingling of domestic and wild sheep (Appendix A) it is strategically most important to eliminate close contact between the two rather than experience catastrophic outcomes as has been experienced elsewhere.

The source population location and disease profiles of both the source receiving populations will be evaluated to determine priority ranking for translocations. Strategies for addressing potential issues within each identified area are provided. Regional personnel will be responsible for working through these strategies unless otherwise noted.

1. Upper Blue River Potential Area (Unit 1) to include South Fork, Black River, Foote Creek, and Mother Hubbard/Turkey Creek areas

Portions of this area currently have RMBS in low, dispersed numbers. The area is north of the Eagle Creek – Blue River population and adjacent to the Alpine, Nutrioso, Springerville, and Eagar communities. Potential issues that need to be investigated prior to translocation include vehicle collisions, distance to nearest domestic sheep or goats (including hobby herds), and interactions with rural communities.

Modified Cunningham-Brown model score: 40 out of 63

Necessary actions before consideration for translocation:

1. Assess the potential to create effective separation between domestic and RMBS. Create an acceptable domestic sheep management approach exploring all options to achieve effective separation – Regional wildlife program personnel in coordination with the Big Game Management Supervisor.
2. Regional personnel should complete an inventory of domestic sheep and goats, including hobby herds, in the Upper Blue River Area and continue to document areas of known domestics through opportunistic field observations in the future.
3. Obtain all necessary federal authorizations – Regional wildlife program personnel.
4. Complete EAC documentation – Regional wildlife program personnel, Habitat Branch (PEP), and Terrestrial Wildlife Branch.

2. *Chevelon Canyon Potential Area (Units 4A and 4B)*

This area is northwest of the town of Heber and southeast of Winslow. Potential issues that need to be investigated prior to translocation include distance to nearest domestic sheep or goats and the path of the current domestic sheep driveway.

Modified Cunningham-Brown model score: 50 of 63 (revised score below)

According to the Modified Cunningham-Brown model, sites with domestic sheep or goats in the evaluation area may have warranted a 0 score for Exotic Ungulates. Chevelon Canyon received a score of 10. Although domestic sheep seldom venture into Chevelon Canyon itself, they do approach and reside on the rim of the Canyon. This is a concern and will need further research prior to initiating any translocation to the area.

Necessary actions before consideration for translocation:
1. Assess the potential to create effective separation between domestic and RMBS. Create an acceptable domestic sheep management approach exploring all options to achieve effective separation – Regional wildlife program personnel in coordination with the Big Game Management Supervisor .
2. Regional personnel should complete an inventory of domestic sheep and goats, including mapping of the Heber-Reno domestic sheep driveway which summers above Chevelon Canyon, and continue to document areas of known domestics through opportunistic field observations in the future.
3. Obtain all necessary federal authorizations – Regional wildlife program personnel.
4. Complete EAC documentation – Regional wildlife program personnel, Habitat Branch (PEP), and Terrestrial Wildlife Branch. Timeline dependent on completing actions 1 and 2.

3. *Sycamore and Oak Creek Canyons Potential Area (Unit 6B)*

This area is north and west of the communities of Cottonwood and Sedona. Potential issues that need to be investigated prior to translocation include distance to nearest domestic sheep or goats

(including hobby herds), path of the current domestic sheep driveway, potential for bighorn sheep-vehicle collisions, and interactions with rural communities.

Modified Cunningham-Brown model score: 55 and 42 out of 63 (revised scores below)

According to the Modified Cunningham-Brown model, sites with domestic sheep or goats in the evaluation area may have warranted a 0 score for Exotic Ungulates. Oak Creek Canyon received a score of 6 and Sycamore Canyon received a score of 8. Because both sites have domestic sheep present, it may have been appropriate to have received scores of 0, and they should receive low consideration as release sites for RMBS until the proximity to domestic sheep or goats is mitigated. The revised Modified Cunningham-Brown model scores are 47 for Sycamore Canyon and 36 for Oak Creek Canyon.

Necessary actions before consideration for translocation:
1. Assess the potential to create effective separation between domestic and RMBS. Create an acceptable domestic sheep management approach exploring all options to achieve effective separation – Regional wildlife program personnel in coordination with the Big Game Management Supervisor.
2. Obtain all necessary federal authorizations – Regional wildlife program personnel.
3. Complete EAC documentation – Regional wildlife program personnel, Habitat Branch (PEP), and Terrestrial Branch. Timeline dependent on completing actions 1 and 2.
4. Rregional personnel should complete an inventory of domestic sheep and goats, including mapping of the domestic sheep driveway which summers near Sycamore Canyon, and continue to document areas of known domestics through opportunistic field observations in the future.
    a. Evaluation area has four domestic sheep allotments and one domestic sheep driveway that permit nearly 12,000 domestic sheep in the area. These allotments are managed by the Coconino National Forest and Kaibab National Forest. Domestic sheep are driven north along Interstate 17 during May of each year. Then, domestic sheep are allowed to range throughout both forests on these allotments between June 1 and October 15 each year.
    b. Domestic sheep are held in holding pastures on Garland Prairie, located at the north end of Sycamore Canyon, during the summer and fall. It is common for bands of domestic sheep to elude capture in the fall and wander throughout the forest during the winter. Domestic sheep serve as a host of diseases for bighorn sheep.
5. Provide community outreach and education when establishing a bighorn sheep population near a community.
    a. Potential nuisance concerns if RMBS take up residence in the towns of Sedona and Oak Creek. Shortly after RMBS were released in West Clear Creek, a couple of young rams were observed in neighborhoods in Oak Creek resulting in nuisance calls to the Department.

4. Escudilla Mountain Potential Area (Unit 1)

This area is north of the Eagle Creek – Blue River population and east of the communities of Alpine and Nutrioso. We estimate this area could hold at least 75 RMBS. Potential issues that need to be investigated prior to translocation include distance to nearest domestic sheep or goats (including hobby herds) and interactions with rural communities.

Modified Cunningham-Brown model score: 40 out of 63

Necessary Actions before consideration for translocation:
1. Assess the potential to create effective separation between domestic and RMBS. Create an acceptable domestic sheep management approach exploring all options to achieve effective separation – Regional wildlife program personnel in coordination with the Big Game Management Supervisor.
2. Obtain all necessary federal authorizations – Regional wildlife program personnel.
3. Complete EAC documentation – Regional wildlife program personnel, Habitat Branch (PEP), and Terrestrial Wildlife Branch. Timeline dependent on completing actions 1 and 2.

5. Black Mesa and Parker Creek in the Sierra Ancha Mountains Potential Area (Unit 23/24A)
This area is north of Roosevelt Lake and south of the community of Young. The Department estimates this area could hold at least 75 bighorn sheep. Potential issues that need to be investigated prior to translocation include distance to nearest domestic sheep or goats, path of the current domestic sheep driveway, and potential for moving within proximity of DBS occupied areas resulting hybridization of populations.

Modified Cunningham-Brown model score: 50 out of 63

Necessary actions before consideration for translocation:
1. Assess the potential to create effective separation between domestic and RMBS. Create an acceptable domestic sheep management approach exploring all options to achieve effective separation – Regional wildlife program personnel in coordination with the Big Game Management Supervisor.
2. Regional personnel should complete an inventory of domestic sheep and goats, including mapping of the Heber-Reno domestic sheep driveway which summers near Chevelon Canyon, and continue to document areas of known domestics through opportunistic field observations in the future.
   a. The Heber-Reno domestic sheep driveway crosses through the area occupied by the Gisela RMBS population. Potential for disease transmission is a concern because of the proximity to this domestic sheep driveway and the likelihood of interchange between the Gisela and Black Mesa populations.
3. Obtain all necessary federal authorizations – Regional wildlife program personnel.

4. Evaluate proximity to desert bighorn sheep populations and increased potential for hybridization of subspecies; this area is within about 30 air miles of the Unit 22 and 24B desert bighorn sheep populations to the south.
5. Complete EAC documentation – Regional wildlife program personnel, Habitat Branch (PEP), and Terrestrial Wildlife Branch. Timeline dependent on completing actions 1 and 2.

In addition to these specific areas, other locations that warrant additional investigation are: San Francisco Peaks and Canyon Creek. Without in depth assessments of these areas, both appear to have large expanses of suitable RMBS habitat.

VI. Literature Cited

Besser, T. E., E. F. Cassier, K. A. Potter, J. VanderSchalie, A. Fischer, and D. P. Knowles. 2008. Association of *Mycoplasma ovipneumonia* infection with population-limiting respiratory disease in free-ranging Rocky Mountain bighorn sheep (*Ovis Canadensis canadensis*). Journal of Clinical Microbiology 46:423–430.

Besser, T. E., M. A. Highland, K. Baker, E. F. Cassrier, N. J. Anderson, J. M. Ramsey, K. Mansfield, D. L. Bruning, P. Wolff, J. B. Smith, and J. A. Jenks. 2012. Causes of pneumonia epizootics among bighorn sheep, Western United States, 2008–2010. Emerging Infectious Diseases 18:406–414.

Bleich, V. C. 1999. Impacts of wilderness management on wildlife conservation: some case histories of conflict. 2nd North American Wild Sheep Conference Proceedings.

Boyce, W. M., and M. E. Weisenberger. 2005. The rise and fall of Psoroptic scabies in bighorn sheep in the San Andreas Mountains, New Mexico. Journal of Wildlife Diseases 41: 525–531.

Brewer C. E., V. C. Bleich, J. A. Foster, T. Hosch-Hebdon, D. E. McWhirter, E. M. Rominger, M. W. Wagner, and B. P. Wiedmann. 2014. Bighorn sheep: conservation challenges and management strategies for the 21st century. Wild Sheep Working Group, Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA.

Bunch, T. D., W. M. Boyce, C. P. Hibler, W. R. Lance, T. R. Spraker, and E. S. Williams. 1999. Diseases of North American wild sheep. Pages 209–237 *in* R. Valdez and P. R. Krausman, editors. Mountain Sheep of North America. University of Arizona Press, Tuscon, Arizona, USA.

Creeden, P. J., and V. K. Graham. 1997. Reproduction, survival, and lion predation in the Black Ridge/Colorado National Monument desert bighorn herds. Desert Bighorn Council Transactions 41:37–43.

Cunningham, S. 1989. Evaluation of bighorn sheep habitat. Pages 135-160 *in* R. Lee, editor, The Desert Bighorn in Arizona. Arizona Game and Fish Department. Phoenix, AZ.

Dassanayake, R. P., S. Shaanthalingam, C. N. Herndon, R. Surbramaniam, P. K. Lawrence, J. Bavananthasivam, E. F. Cassirer, G. J. Haldorson, W. J. Foreyt, F. R. Rurangirwa, D. P. Knowles, T. E. Besser, and S. Srikumaran. 2012. Mycoplasma ovipneumonia can predispose bighorn sheep to fatal Mannheimia haemolytica pneumonia. Veterinary Microbiology 145:354–359.

DeForge, J. R. 1972. Man's invasion into the bighorn's habitat. Desert Bighorn Council Transactions 16:112–116.

DeForge, J. R. 1981. Stress: changing environments and the effects on desert bighorn sheep. Desert Bighorn Council Transactions 25:15–16.

Dunbar, M. R., A. C. S. Ward, and G. Power. 1990. Isolation of *Pasteurella haemolytica* from tonsilar biopsies of Rocky Mountain bighorn sheep. Journal of Wildlife Diseases 26:210–213.

Foreyt, W. J. 1990. Pneumonia in bighorn sheep: effects of *Pasteurella haemolytica* from domestic sheep and effects on survival and long-term reproduction. Biennial Symposium of the Northern Wild Sheep and Goat Council 7:92–101.

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

Foster, C. L. 2004. Wild sheep capture guidelines. Proceedings of the North American Wild Sheep and Goat Council 14:211–282.

Geist, V. 1999. Adaptive strategies in mountain sheep. Pages 192–208 *in* R. Valdez and P. R. Krausman, editors. Mountain Sheep of North America. University of Arizona Press, Tuscon, Arizona, USA.

Hamilton, K., S. A. Holl, and C. L. Douglas. 1982. An evaluation of the effects of recreational activity on bighorn sheep in the San Gabriel Mountains, California. Desert Bighorn Council Transactions 26:50–55.

Jansen, B. D., J. R. Heffelfinger, T. H. Noon, P. R. Krausman, and J. C. deVos, Jr. 2006. Infectious keratoconjunctivitis in bighorn sheep, Silver Bell Mountains, Arizona, USA. Journal of Wildlife Diseases 42:407-411.

Jessup, D. A. 1985. Diseases of domestic livestock which threaten bighorn sheep populations. Desert Bighorn Council Transactions 29:29–33.

Latch, E. K., J. R. Heffelfinger, B. F. Wakeling, J. Hanna, D. Conrad, and O. E. Rhodes Jr. 2006. Genetic subspecies identification of a recently colonized bighorn sheep population in central Arizona. Pages 1- 9 *in* J. W. Cain III, and P. R. Krausman, editors. Managing Wildlife in the Southwest. Southwest Section of The Wildlife Society, Tucson, Arizona, USA.

Martin, K. D., T. Schommer, and V. L. Coggins. 1996. Biennial Symposium of the Northern Wild Sheep and Goat Council 10:72–77.

McCall and Brown. 2011. Movement and survival of rocky mountain bighorn sheep in central Arizona. Desert Bighorn Council Transactions. pp: 11-16.

Miller, D. S., G. C. Weiser, A. C. S. Ward, M. L. Drew, and P. L. Chapman. 2012. Pasteurellacae isolate from bighorn sheep (Ovis Canadensis) from Idaho, Oregon, and Wyoming. American Journal of Veterinary Research 73:1024–1028.

Miller, M. W. 2001. Pasteurellosis. Pages 330–339 *in* E. S. Williams and I. K. Barker, editors. Infectious Diseases of Wild Mammals. Iowa State University Press, Ames, Iowa, USA.

Monello, R. J., D. L. Murray, and E. F. Cassirer. 2001. Ecological correlates of pneumonia epizootics in bighorn sheep herds. Canadian Journal of Zoology 79:1433-1441.

Ramey, R.R. 1995. Mitochondrial DNA variation, population structure, and evolution of mountains sheep in the southwestern United States and Mexico. Molecular. Ecology. 4, 429–439.

Rawley, E. V. 1985. Early records of wildlife in Utah. Publication number 86-2. Division of Wildlife Resources, Department of Natural Resources, Salt Lake City, Utah, USA.

Remington, R. and A. Fuller. 1989. Capture and transplant techniques. Pages 176-202 *in* R. Lee, editor. The Desert Bighorn in Arizona. Arizona Game and Fish Department.

Rominger, E. M., H. A. Whitlaw, D. L. Weybright, W. C. Dunn, and W. B. Ballard. 2004. The influence of mountain lion predation on bighorn sheep translocations. Journal of Wildlife Management 68:993–999.

Rudolph, K. M., D. L. Hunter, W. J. Foryet, E. F. Cassirer, R. B. Rimler, and A. C. S. Ward. 2003. Sharing of *Pasteurella* species between free ranging bighorn sheep and feral goats. Journal of Wildlife Diseases 39:897–903.

Spraker, T. R., C. P. Hibler, G. G. Schoonveld, and W. S. Adney. 1984. Pathologic changes and microorganisms found in bighorn sheep during a stress-related die-off. Journal of Wildlife Diseases 20:319–327.

U-C Davis. 2007. Respiratory disease in mountain sheep: Knowledge gaps and future research. University of California - Davis, Wildlife Health Center. Pp. 1–24.

Wehausen, J. D. 1996. Effects of mountain lion predation on bighorn sheep in the Sierra Nevada and Granite mountains of California. Wildlife Society Bulletin 24:471–479.

Weiser, G. C., W. J. DeLong, J. L. Paz, B. Shafii, W. J. Price, and A. C. S. Ward. 2003. Charactierization of *Pasteurella multocida* associated with pneumonia in bighorn sheep. Journal of Wildlife Diseases 39:536–544.

Weiser, G. C., M. L. Drew, E. F. Cassirer, and A. C. S. Ward. 2012. Detection of *Mycoplasma ovipneumonia* and *M. arginini* in bighorn sheep using enrichment culture coupled with genus-and-species-specific polymerase chain reaction. Journal of Wildlife Diseases 48:449–453.

Wild Sheep Working Group. 2007. Recommendations for domestic and goat management in wild sheep habitat. Western Associations of Fish and Wildlife Agencies.

Wild Sheep Working Group. 2012. Recommendations for domestic and goat management in wild sheep habitat. Western Associations of Fish and Wildlife Agencies.

Wildlife Health Committee. 2009. Wild sheep herd health monitoring recommendations. Western Association of Fish and Wildlife Agencies.

Wildlife Health Committee. 2015. 2014 Bighorn sheep herd health monitoring recommendations. Western Association of Fish and Wildlife Agencies.

Appendix A.
www.wafwa.org/documents/wswg/RecommendationsForDomesticSheepGoatManagement.pdf

RECOMMENDATIONS FOR

Domestic Sheep and Goat Management in Wild Sheep Habitat

Prepared by the
Wild Sheep Working Group

Western Association of
Fish and Wildlife Agencies

2012

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Executive Summary

Although the risk of disease transmission from domestic sheep or goats to wild sheep is widely recognized, a unified set of management recommendations for minimizing this risk has not been adopted by responsible agencies. These Western Association of Fish and Wildlife Agencies (WAFWA) recommendations were produced to help state, provincial, and territorial wild sheep managers, federal/crown land management agencies, private landowners and others take appropriate steps to eliminate range overlap, and thereby, reduce opportunities for transmission of pathogens to wild sheep.

Transmission of *Mannheimia haemolytica* from domestic sheep to bighorn sheep was irrefutably demonstrated by Lawrence et al. (2010) and provides justification sufficient for preventing range overlap and potential association of domestic sheep and goats with wild sheep. The higher the conservation value of a wild sheep population (e.g., federally or state listed, "sensitive species" status, native herds, transplant source stock, herds in areas with no history of domestic livestock presence), the more aggressive and comprehensive wild sheep and domestic sheep or goat separation management strategies should be.

Practical solutions will be difficult, if not impossible to achieve until the risk of disease transmission from domestic sheep or goats to wild sheep is acknowledged by those responsible for wildlife and agricultural management. All parties benefit when risk is assessed and actively managed to minimize the potential for transmission of pathogens. The recommendations contained within this report are intended to help achieve that objective to benefit all sectors and are summarized as follows:

WAFWA agencies should:
(1) assess wild sheep conservation value/status and complete risk assessments of interspecies contact in a meta-population context; (2) remove wild sheep that have likely associated with domestic sheep or goats and develop a policy to promptly respond to wild sheep wandering from occupied wild sheep ranges; (3) thoroughly explore demographic consequences of translocations and conduct appropriate analyses of habitat suitability and risk of disease transfer prior to implementing any translocations; (4) coordinate with other agencies, land owners and stakeholders regarding management of domestic sheep or goats on or near ranges occupied by wild sheep; (5) fully consider the risk of disease transmission when issuing or commenting on permits/regulations associated with private lands used for domestic production; and (6) develop educational materials and outreach programs to interpret the risk of association between wild sheep and domestic sheep or goats.

Land management agencies should:
(1) reduce risk of association by eliminating overlap of domestic sheep or goat allotments or grazing permits/tenures within wild sheep habitat; (2) ensure that annual operating instructions or their equivalent include measures to minimize domestic association with wild sheep and confirm appropriate methods to remove stray domestic sheep or goats; and (3) manage wild sheep habitat to promote healthy populations in areas without domestic sheep or goats.

Wild sheep conservation organizations should:
(1) assist with educational/extension efforts to all parties; (2) negotiate alternatives and incentives for domestic sheep or goat grazers on public land to find alternatives to wild sheep habitat; and (3) advocate for and support research concerning disease and risk associated with domestic sheep and goats in proximity to wild sheep.

Photo by: David Wetzel (Texas Bighorn Society)

Photo by: Tom Carlsen (MDFWP)

2   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat

Domestic sheep and goat permittees/owners should:
(1) implement best management practices (BMPs) to prevent straying by domestic sheep or goats; and (2) establish protocols to respond to straying.

Private landowners should:
(1) educate themselves and work with wild sheep managers and advocates to support effective separation through a variety of site-specific mitigation measures; and (2) promptly report the potential or actual association between domestic sheep or goats and wild sheep.

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) to develop a 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 and federal agencies could tier their 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. In July 2010, the report was revised (WAFWA 2010c) and has represented the official position of WAFWA on the management of domestic sheep and goats and wild sheep.

Scientific literature that has become available since July 2010 has been incorporated into this document to ensure that the recommendations contained herein remain current and robust, but the basic purpose, scope, and principles of the document remain unchanged. Additional editorial modifications are intended to improve the readability of the document. Information contained in this report is provided to assist BLM and USFS leadership with development of a unified policy addressing the grazing of domestic sheep or goats in wild sheep habitat on lands under the administration of those agencies. In addition, this document is intended to assist state, provincial, and territorial wild sheep managers, federal/crown land management agencies, private landowners and others take appropriate steps to eliminate range overlap, and thereby, reduce opportunities for transmission of pathogens to wild sheep. This revision was approved by the WAFWA Directors March 29, 2012, and supersedes all previous versions.

In this paper we do not review and synthesize all available literature or evidence pertaining to the issue of disease transmission among bighorn sheep and domestic sheep and goats. We do, however, include relevant citations, results,

Photo by: Earl Nottingham (TPWD)

Photo by: Dr. Peri Wolff (NDOW)

literature, or analyses published since completion of our previous reports (WAFWA 2007, 2010c). We provide reasonable and logical recommendations based on the best available information to 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; however, we also recognize there are many ways to reduce the probability of association between these species and, thereby, lower the overall risk of epizootics occurring in populations of wild sheep.

Introduction 3

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Photo by: Mike Pittman (TPWD)

Photo by: Brett Wiedmann (NDGFD)

Background

Throughout substantial portions of their range, bighorn sheep (*Ovis canadensis*) experience periods when populations are depressed; those episodes generally are associated with epizootics of respiratory disease (Ryder et al. 1994). Diseases have contributed to the decline of bighorn sheep populations in much of western North America (Beecham et al. 2007, CAST 2008) and many native herds declined to less than 10% of historical size. According to historical accounts, such declines coincided with the advent of domestic livestock grazing on ranges occupied by bighorn sheep (Warren 1910, Grinnell 1928, Schillinger 1937, Honess and Frost 1942, CAST 2008). Epizootics among native bighorn herds were reported in various locations following European settlement and establishment of domestic livestock grazing throughout the central and southern Rocky Mountains. These observations may reflect the introduction of novel bacterial pathogens (including some strains of *Pasteurella* (*Mannheimia*) spp.) to naïve bighorn populations beginning in the late 1800s (Grinnell 1928, Skinner 1928, Marsh 1938, Honess and Frost 1942, Miller 2001).

Over the past 30 years, increasing evidence has underscored the potential risk of disease transmission from domestic sheep or goats to wild sheep (McQuivey 1978, Hunt 1980, Jessup 1982, Foreyt and Jessup 1982, Goodson 1982, Onderka and Wishart 1984, Jessup 1985, Black et al. 1988, Coggins 1988, 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, Jenkins et al. 2007, Rudolph et al. 2007, George et al. 2008, Jeffress 2008, Lawrence et al. 2010). Moreover, a number of recent risk assessments and reviews (Beecham et al. 2007, CAST 2008, Baumer et al. 2009, USAHA 2009, WAFWA 2009, Croft et al. 2010, USDA Forest Service 2010a, b; Wehausen et al. 2011), conservation management strategies or plans (Colorado Division of Wildlife 2009, Montana Department of Fish, Wildlife, and Parks 2009), modeling exercises (Clifford et al. 2009, Cahn et al. 2011), 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 risks associated with contact between wild sheep and domestic sheep or goats. Many of the aforementioned investigators and participants in workshops conducted throughout the western US (California, Arizona, Utah, and Idaho),

have recommended temporal or spatial separation of domestic sheep or goats from wild sheep to reduce the potential for disease in the latter.

Disease Transmission

Although domestic animals have been selected for their ability to live at high densities and for their resilience to infectious diseases (Diamond 1997), 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 (Garde et al. 2005). However, the most important and ecologically significant transmission in this context is from domestic sheep or goats to wild sheep.

Winter 2009-2010 bighorn sheep pneumonia die-offs (totaling an estimated 880 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 (Edwards et al. 2010, WAFWA 2010b). Domestic sheep and goats were known to occur within or near occupied bighorn sheep ranges and within normal bighorn movement zones, and association between wild sheep and domestic sheep or goats is known to have preceded at least one of these die-offs, was likely in 2 others, and was possible in 4 more (WAFWA 2010b).

Die-offs of wild sheep populations and individual animals 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, the pattern and severity of die-off is typically greater than when otherwise is the case (Onderka and Wishart 1984, Martin et al. 1996, Aune et al. 1998, George et al. 2008).

It is generally acknowledged (Garde et al. 2005, CAST 2008) that thinhorn sheep (*Ovis dalli* spp.) in Alaska and northwestern Canada are likely naïve to exposure to many organisms commonly carried by domestic species, compared to wild sheep occurring in southern Canada and the continental U.S. Until this is confirmed and 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.

Photo by: Donny Martorello (WDFW)

Photo by: Ernie Finch

Disease Transmission 5

Effective Separation

Photo by: John Kanta (SDGFP)

Photo by: Ted Borda (Borda Land & Sheep Company)

Photo by: Ted Borda (Borda Land & Sheep Company)

Effective Separation

WAFWA 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 diseases between species. WAFWA advocates that effective separation should be a primary management goal of state, provincial, territorial and federal agencies responsible for the conservation of wild sheep, based on evidence that domestic sheep or goats can transfer pathogens to wild sheep. Literature (reviewed by Wehausen et al. 2011) and experimental evidence (Lawrence et al. 2010) support the goal that domestic sheep or goats should not concurrently occupy 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. However, the option of removing domestic sheep or goats should be included in an 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 because of their gregarious nature and tendency to wander. We are aware of the continuing debate and discussion (CAST 2008, USAHA 2009) between wildlife advocates and some domestic sheep or goat industry proponents and resource managers regarding the credibility or scientific merit of past findings; that debate is founded largely on criticisms of experimental design or rigor, and limitations of drawing inferences about natural disease events when compared to controlled experiments in confined settings. However, it is WAFWA's collective opinion that enough is known about potential pathogen transmission from domestic sheep or goats to wild sheep that efforts toward achieving effective separation are necessary and warranted.

Reducing risk of disease transmission on the landscape by minimizing or preventing association between wild and domestic sheep or goats is a key management strategy for WAFWA agencies (e.g., Colorado Division of Wildlife 2009, Montana Department of Fish, Wildlife and Parks 2009). Legislation in Utah (House Bill 240 Supplement, 2009), Wyoming (Senate Enrolled Act No. 30, 2009) and Idaho (Senate Bill 1232 amended, 2009) provides direction, authority and responsibilities for addressing feral or stray livestock that pose a disease transmission risk. Further, recent court rulings (e.g., U.S. District Court, Idaho Case 09-0507-BLW) 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.

6   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat
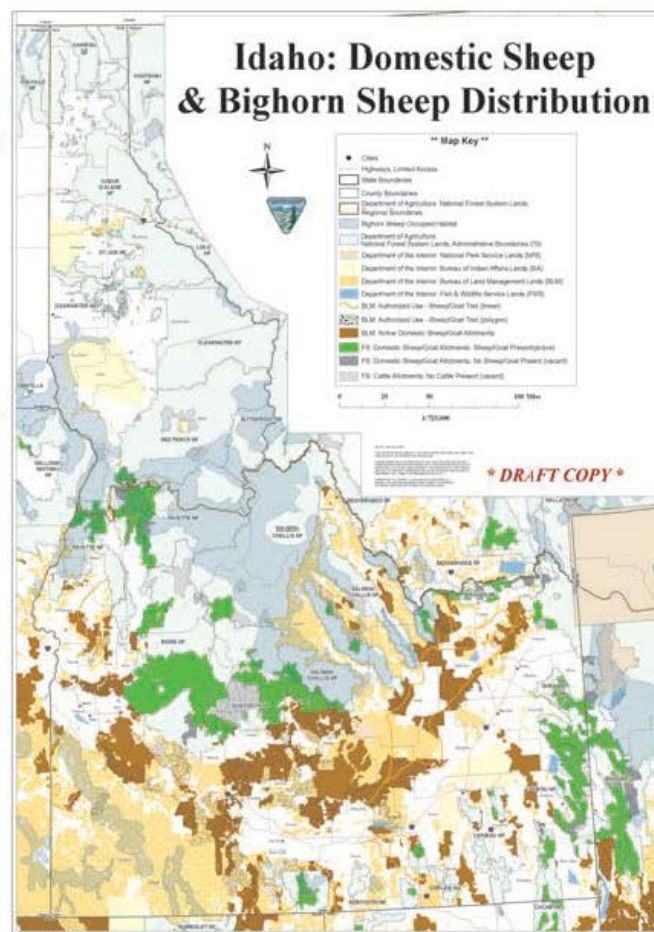
Principal federal land management agencies in the western U.S., BLM and USFS, continue to review, revise, and update policies on the management of domestic sheep or goats in wild sheep habitat (USDI BLM 1992, 1998, 2010; USDA Forest Service 2009). Additionally, several administrative units of the USFS (Northern Region, Rocky Mountain Region, Southwest Region, Intermountain Region, and the Pacific Southwest Region) have designated bighorn sheep as a "Sensitive Species," thereby mandating special management emphasis. This includes: thorough reviews and analyses of management actions that could affect populations of bighorn sheep or their habitat to ensure their viability and to preclude demographic trends that would result in the need for Federal listing.

An interagency GIS-based decision-support tool and GIS coverage maps that overlay current bighorn sheep distribution with vacant and active domestic sheep or goat grazing allotments and trailing routes were finalized for 14 western states (WAFWA 2010a). These maps identify areas where association between domestic sheep or goats and bighorn sheep could 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 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 adopted.

In some cases, results of contact between domestic sheep or goats and wild sheep have been severe enough to endanger entire populations of the latter. In Idaho, legislation (Senate Bill 1232 amended, May 2009) mandated collaboration between the Idaho Department of Fish and Game and domestic sheep grazing permittees that identified BMPs to achieve effective separation between domestic sheep and wild sheep on both public and private lands. In specific situations, implementation of BMPs could 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 association (Schommer 2009). Nevertheless, BMPs that work in one situation may not work in other situations (Schommer 2009).

Consequently, we recommend that managers take appropriate steps to minimize opportunities for association and, thereby, the potential for disease transmission in all situations.

Photo by: Bighorn Institute

Idaho: Domestic Sheep & Bighorn Sheep Distribution

* DRAFT COPY *

Provided by: Chans O'Brien (USFS)

Photo by: Rebecca Barboza (CDFG)

Photo by: Larry Kruckenberg

Management Recommendations

The recommendations that follow can be applied to state, provincial, and territorial wildlife agencies, federal/crown land management agencies, wild sheep conservation organizations, domestic sheep or goat producers or permittees, and private landowners, and have been strategically assigned to logical categories. It is imperative, however, that readers recognize these recommendations typically apply to multiple parties, and that they further recognize that a multi-disciplinary and collaborative approach will produce the best outcomes, both for wild sheep and for producers or permittees. Definitions of various terms used throughout this document are provided in Appendix A.

Although these recommendations have been developed by a working group largely comprised of wildlife agency personnel, cooperation between numerous concerned 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/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 institutions; and interested individuals. As a result of information contained herein, it is our hope that collaborative discussions will occur and that those discussions yield results in the form of innovative and collaborative site-specific delivery of programs such as the British Columbia Wild/Domestic Sheep Separation Program and the Wyoming Statewide Domestic Sheep/Bighorn Sheep Interaction Working Group.

Many anthropogenic and environmental factors (CAST 2008) influence the demographics and viability of wild sheep populations. 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. There is no "one size fits all" risk assessment of respiratory disease transmission between wild sheep and domestic sheep or goats. However, a comprehensive risk assessment (qualitative and quantitative) is a critically important component for managing the potential for disease transmission.

We recommend that wild sheep managers design and implement management strategies by taking the first step of assessing and prioritizing conservation value and relative importance of wild sheep populations. The greater the conservation value and the greater the risk of association with domestic sheep or goats, the more aggressive and comprehensive a strategy to ensure effective separation should be. To ensure that is the case, we offer the following:

8   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat

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 and existing or potential areas where domestic sheep or goats may occur.

Risk assessments should be completed at least once per decade (more often if warranted) 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.

Following completion of site or herd-specific risk assessments, any translocations, population augmentations, or other restoration and management strategies for wild sheep should minimize the likelihood of association between wild sheep and domestic sheep or goats. Agencies should:

• Avoid translocations of wild sheep into areas with no reasonable likelihood of effective separation from domestic sheep or goats.
• Re-evaluate planned translocations of wild sheep to historical ranges as potential conflicts, landscape conditions, and habitat suitability change.
• Recognize that augmentation of a wild sheep herd from discrete source populations poses a risk of pathogen transfer (CAST 2008) and thus, 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.
• 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. If a translocation is implemented and association with domestic sheep or goats occurs, or is likely to occur beyond an identified timeframe or pre-determined geographic area, domestic sheep or goat producers should be held harmless.

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

• Site-specific protocols should be developed when association with domestic sheep or goats is probable. For example, decisions concerning percentage of translocated wild sheep that must be radio-collared

Photo by: Mike Cox (NDOW)

Photo by: Chase Fountain (TPWD)

Management Recommendations 9

for achieving desired monitoring intensities should in part, be based upon the subsequent level of risk of association with domestic sheep or goats.

• Intensive monitoring provides a mechanism for determining proximity of wild sheep to domestic sheep or goats and for evaluating post-release habitat use and movements.

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

Wild sheep managers should identify, analyze, and evaluate the implications of connectivity and movement corridors between largely insular herds comprising a meta-population against 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
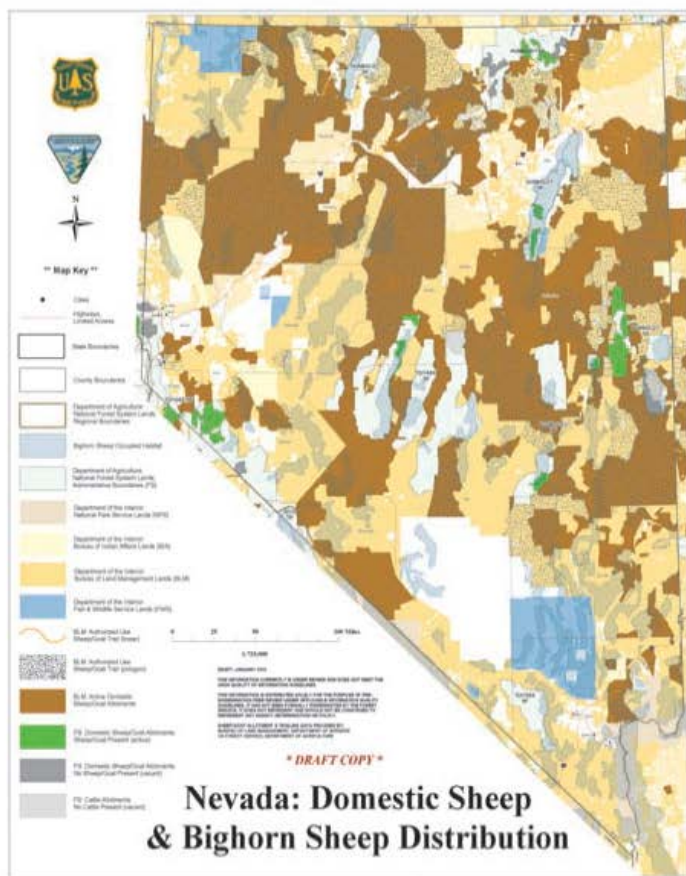
of genetic interchange and its resultant implications for population viability, must be weighed against the risks of disease transmission (Bleich et al. 1990), especially if dispersing or wandering wild sheep could travel across domestic sheep or goat grazing allotments or trailing routes, private land holdings or other areas where the potential transfer of endemic pathogens from an infected wild herd to a naïve herd could occur.

Removal of wild sheep known, or suspected to have closely associated with domestic sheep or goats is considered to be an effective management tool. Atypical movements by wild sheep can heighten risk of association with domestic sheep or goats. Additional measures to achieve effective separation should be implemented if such association occurs. However, removal of wild sheep from occupied, normally-anticipated wild sheep range is not always the best management option. Continuous risk of association exists during active grazing seasons when domestic sheep or goats are grazed within normally-anticipated wild sheep range. Thus, removal of individual wild sheep is an ineffective method for maintaining separation, and has potentially negative consequences for population viability. Removal of wild sheep should occur only after critical evaluation and further implementation of measures designed to minimize association and enhance effective separation.

Wild sheep populations should have pre-determined population objectives, and should be managed at agreed-upon densities to minimize the potential for dispersal. Because some dispersal occurs regardless of population density, some risk of association is always present if domestic sheep or goats are within range of dispersing wild sheep.

Agencies should 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 domestic sheep and goats and dispersing or wandering wild sheep should be included. Moreover, wildlife agencies should collaborate with agricultural agencies, land management agencies, producers and permittees, grazing industry representatives,

Nevada: Domestic Sheep & Bighorn Sheep Distribution

Provided by: Chans O'Brien (USFS)

10   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat

and wild sheep advocates to develop an effective, efficient, and legal protocol to be implemented when feral or abandoned domestic sheep or goats threaten to associate with wild sheep but for which no owner can be identified. Written protocol examples are provided in Appendix B (British Columbia Fish, Wildlife and Habitat Management Branch) and Appendix C (Wyoming Game and Fish Department).

Wildlife agencies should develop databases as a system to report, record, and summarize association between wild sheep and domestic sheep or goats and its outcome; the WAFWA WSWG website (http://www.wafwa.org/html/wswg.shtml) would be a logical host. Further, wildlife managers and federal/crown land managers should encourage prompt reporting by the public of observed proximity between wild sheep and domestic sheep or goats.

Wild sheep managers should coordinate with local weed or pest management districts, or other applicable agencies or organizations involved with weed or vegetation management, to preclude the use of domestic sheep or goats for noxious weed or 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 (Pybus et al. 1994) have already been developed and implemented in British Columbia, and are available at: http://www.for.gov.bc.ca/hfp/publications/00006/.

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

Agencies should coordinate and pool resources to support the ongoing laboratory detection and interpretation of important diseases of wild sheep. Furthermore, wild sheep managers should support data sharing and development and use of standardized protocols (WAFWA 2009). Interagency communication between wildlife disease experts such as the WAFWA Wildlife Health Committee (WHC) should be encouraged to enhance strategies for monitoring, managing and improving health of wild sheep populations through cooperative efforts.

Wild sheep management agencies should develop educational materials and outreach programs to identify and interpret the risk of association between wild sheep and domestic sheep or goats for producer groups, owners of small and large farm flocks, animals used for packing and 4-H animals. In some cases, regulation may be necessary to maintain separation.

RECOMMENDATIONS TO BLM, USFS, PARKS, PROTECTED AREAS 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. Guidelines should be based on the need to minimize risk of association and provide effective separation between domestic sheep or goats and wild sheep.
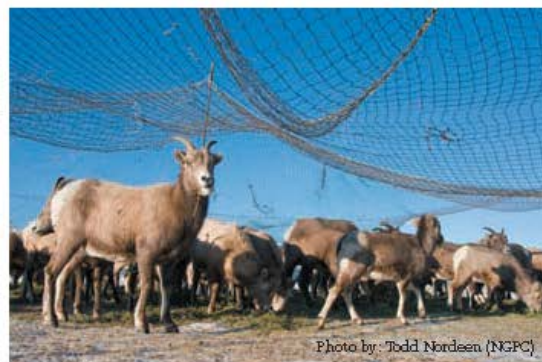

Photo by: Todd Nordeen (NGPC)

Photo by: Debra Hamilton (CDFG)

Approved guidelines should not include an automatic "sunset" provision or expiration date but, if there is a maximum longevity (i.e., a "sunset clause") specified by federal policy and if appropriate and timely review cannot be completed, guidelines should remain in effect, rather than becoming obsolete, until any mandated review can be completed.

The use of domestic sheep or goats as pack animals by persons that travel in identified wild sheep habitat should be prohibited by the appropriate management agency (e.g., USDA Forest Service 2011). Where legislation or regulations are not already in place, an outreach program to inform

Photo by: Ted Borda (Borda Land & Sheep Company)

Provided by: Chans O'Brien (USFS)

potential users of the risks associated with that activity should be implemented to discourage use of domestic sheep or goats as pack animals.

Land management agencies that regulate or are responsible for domestic sheep or goat grazing allotments, trailing routes, vegetation management, use as pack stock, or any other uses involving domestic sheep or goats should only authorize such use(s) outside of occupied wild sheep range.

Land management agencies should require immediate notification by permittees and their herders of association between wild sheep and domestic sheep or goats and in no case should it be more than within 24 hours of any such event. Notification procedures, including phone numbers and contact information for permittees and use of satellite phones in backcountry settings, should be outlined in Annual Operating Instructions for grazing allotments and trailing permits, and should include consequences for failure to report.

Land management agencies should 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.

Land management agencies must 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.

Land management agencies should 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 or goats and other exotic ungulates, especially ovines such as aoudad, red sheep, urial, or argali that are detected on public lands.

Land management agencies should review domestic sheep allotment boundaries or other use areas, such as trailing routes, and reconfigure boundaries or routes to avoid or minimize overlap with occupied wild sheep habitat. Techniques available to accomplish this include the use of geographic or topographic
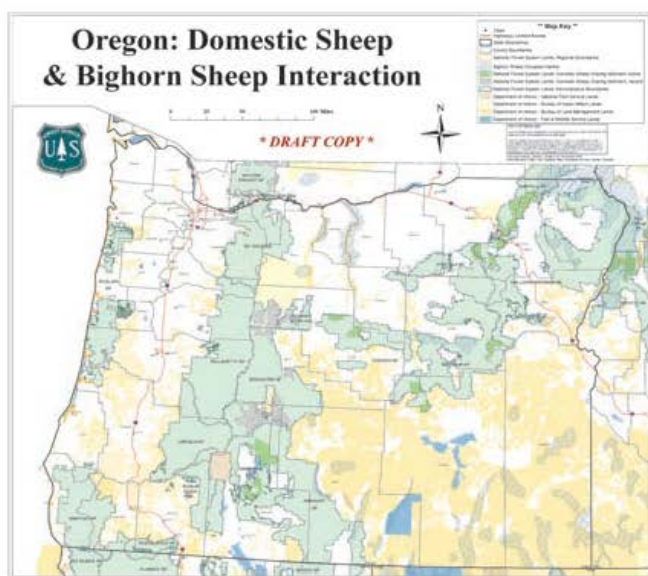
barriers that enhance species separation, and temporal or spatial separation resulting from implementation of novel domestic sheep or goat grazing management strategies.

Land management agencies should undertake habitat enhancements that improve wild sheep habitat outside allotment boundaries in an effort to attract wild sheep away from domestic sheep allotments.

Land management agencies should undertake water developments to divert wild sheep away from domestic sheep allotments or domestic sheep or goats away from areas used by wild sheep.

Land management agencies should ensure that Annual Operating Instructions 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 must be required as a condition of operation with follow-up provisions to account for missing livestock.

In areas of high risk of association, trucking should be required to minimize risks associated with trailing. Trucking of domestic sheep or goats is preferred to trailing because there is less chance of straying and, thereby, less likelihood of association with wild sheep, particularly when domestic sheep are in estrus.

Land management agencies should require marking of all permitted domestic sheep and goats to provide for rapid ownership identification of stray animals.

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

Land use or resource management plans should 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 uses.

Land management agencies should coordinate with appropriate entities involved in weed control 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.

Within occupied or suitable wild sheep habitat, where topography, vegetation, and other parameters allow, conversions of allotments from domestic sheep or goats to types of domestic livestock that pose a lower risk of disease transmission to wild sheep should be implemented.

Within suitable, historic wild sheep habitat not currently occupied by wild sheep, agencies should not convert cattle grazing allotments to domestic sheep or goat grazing, or allow trailing if restoration of wild sheep populations is an agency goal.

Photo by: AZGFD

Photo by: Justin Binfet (WGFD)

Under emergency conditions, stocking of allotments not currently under permit to domestic sheep or goats should be permitted only after an adequate risk assessment has been completed. Any such assessment must include appropriate documentation and the conclusion that effective separation can be assured, and can be accomplished via project-level NEPA analysis.

Land management agencies should incorporate state, provincial, or territorial wild sheep management plans either in, or as supplements to, federal resource or land use management plans, and collaborate with wildlife agencies to ensure comprehensive risk assessments (Clifford et al. 2009, USDA Forest Service 2010a, b) of domestic sheep or goat grazing allotments or trailing routes in wild sheep habitat are thorough and complete. To accomplish this objective, training adequate to allow the preparation of such assessments must be provided.

Photo by: Mike Cox (NDOW)

Photo by: Todd Nordeen (NGPC)

Where mandatory buffer zones (frequently cited as a minimum of 9 airline miles [14.5 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. In some cases, buffer zones have been effective in reducing association between wild sheep and domestic sheep or goats. However, in contiguous wild sheep habitat where movements by wild sheep have the potential to 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 be effective in minimizing association between wild sheep and domestic sheep or goats. Site-specific risk assessments should be completed to evaluate the efficacy of using natural barriers, defined buffer zones, or other actions to minimize risk of contact. Given the wide range of circumstances that exists across jurisdictions, buffer zones may not be needed in all situations. Conversely, buffer zones should not be precluded as an effective method to address potential association between wild sheep and domestic sheep or goats.

Land management agencies, in collaboration with jurisdictional domestic sheep or goat health agencies, should work with producers and permittees to prevent turnout or use of sick or diseased domestic sheep or goats on grazing allotments and trailing routes. Sick or diseased domestic sheep or goats can increase risk of association with wild sheep because they likely are less able to keep up with their bands and are more prone to straying. Sick or diseased animals observed on the range should be reported to land management agency personnel immediately, and inter-agency coordination to address the situation 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) that must be complied with before domestic sheep are turned out for vegetation management in conifer regeneration efforts (available at: http://www.for.gov.bc.ca/hfp/publications/00006/). 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.

14   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat

Proportional to risk of association between domestic sheep or goats and wild sheep, land management agencies should work with stakeholders to implement a variety of management practices. Examples include: 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, removal 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 are not proven (Baumer et al. 2009, Schommer 2009) and therefore should not be solely relied upon to achieve effective separation. Such practices could however, help achieve separation when applied outside of occupied wild sheep range or connected and potentially mitigate impacts associated with straying domestic sheep or goats, or wandering wild sheep.

Land management agencies and wildlife agencies should cooperatively manage for quality wild sheep habitat and routinely monitor habitat to detect changes in condition.

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 high-use areas that are designed to educate visitors about the issue of interaction and to encourage prompt reporting of association of wild sheep with domestic sheep or goats. Agencies should also ensure that individuals keep dogs under immediate voice control or on leash to prevent scattering of domestic sheep or goats in permitted areas, or disturbances to wild sheep.

Land management agencies should 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.

Land management agencies should develop programs to foster and recognize the benefits of compliance, cooperation, and cost-sharing in efforts to prevent commingling of wild sheep and domestic sheep or goats on shared ranges.

In collaboration with wild sheep management agencies, land management agencies should investigate and implement an option to allow the permittee or producer, or appropriate agency representatives, to remove commingling wild sheep and, 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 in-holdings and adjacent private lands when conducting risk assessments.

Land management agencies should closely evaluate timing of permitted domestic sheep or goat grazing or trailing activities to reduce risk of disease transmission. For example, grazing estrous domestic females heightens

Photo by: Robin Fehlau (BLM)

Photo by: Stephanie Steinhoff (CPW)

attraction and increases the probability of association between wild sheep and domestic sheep, and should be eliminated where benefits can be accrued.

In areas of high risk of association between wild sheep and domestic sheep or goats, agencies and permittees should ensure enhanced monitoring of grazing and trailing patterns 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 vital for development of meaningful risk assessments and to ensure appropriate management recommendations are taken to achieve effective separation.

Photo by: Mike Cox (NDOW)

Photo by: Helen Schwantje (BC FLNRO)

RECOMMENDATIONS TO WILD SHEEP AND OTHER CONSERVATION ORGANIZATIONS

Recognize and support efforts of wild sheep management agencies and industry leaders in maintaining effective separation.

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.

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 pack stock. Encourage prompt reporting of association between wild sheep and domestic sheep or goats, and promote a reporting system for monitoring association between wild sheep and domestic sheep or goats.

Maintain or establish open lines of communication with domestic sheep or goat producers and industry organizations 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 to address potential disease 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 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, and encourage agencies and conservation groups to commit resources necessary to maintain wild sheep populations.

SUGGESTED MANAGEMENT PRACTICES FOR DOMESTIC SHEEP AND GOAT PERMITTEES

The following suggestions are based largely on recommendations provided by CAST (2008), Baumer et al. (2009), or USAHA (2009), and are intended to provide a responsible and common-sense approach for reducing risk of association. However, there is no science-based evidence or evaluation that assesses the effectiveness of these actions to reduce risk or enhance separation (Schommer 2009).

16   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat

Implement the following reporting and record keeping procedures or use an existing standard such as the BC (Appendix B) or Wyoming (Appendix C) models:
- Require prompt, accurate reporting by herders working on domestic sheep or goat grazing allotments where association of wild sheep with domestic sheep or goats is possible.
- Support fluency in English or translators for foreign herders in order to facilitate accurate reporting.
- Require sheepherders to use cellular or satellite phones or two-way radios, and location equipment such as GPS receivers to report and record grazing movements and encounters with wild sheep. Seek cost-sharing partnerships for providing communications equipment when an operator changes grazing management practices for the sole purpose of minimizing domestic sheep association with wild sheep. Partnerships could include wildlife management agencies, federal land managers, or private organizations.
- Require herders to record GPS locations, counts, losses and other information in a log book.

Place only experienced, informed and responsible sheep-herders on allotments located near wild sheep habitat.

Ensure that all domestics are individually marked and traceable to source flocks.

Conduct full counts when trailing, immediately any time scattering occurs and regularly during general grazing.

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 comprehensive 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:
- Reporting of wild sheep and domestic sheep associations (animal counts and GPS location) to the appropriate wildlife agency.
- Reporting of stray or missing domestic sheep to the land management agency who will, in turn, report that information to the wildlife agency.
- Removal of stray domestic sheep by the permittee, land manager or wildlife agency personnel.
- Removal of individual commingling wild sheep by wildlife agency personnel.
- Collection of standardized diagnostic samples from stray domestic sheep or commingling wild sheep.

Utilize the following trailing procedures:
- Conduct full counts when moving on and off each allotment/grazing site.
- Truck domestic sheep through "driveway" areas that pass through occupied wild sheep habitat.
- Truck in water (if needed) to reduce straying.
- Immediately remove animals unable to stay with the flock/herd and move them to a base property.
- Avoid trailing 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.
- 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 removal protocol as necessary.

Sick domestic sheep should be removed from allotments immediately and must never be abandoned.

Photo by: Mike Pittman (TPWD)

Photo by: Aaron Reid (BC FLNRO)

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. Place mature and effective guard dogs and herding dogs with domestic sheep (at least 2 of each per 1000 animals) and do not use female dogs in heat.

If grazing on federal lands, comply with established 'bed ground' standards. Where conditions permit, construct temporary electric or boundary fences to ensure that domestic sheep remain within selected bedding grounds.

SUGGESTED MANAGEMENT PRACTICES ON PRIVATE LANDS

Recognize that domestic sheep or goat farming on private lands can influence wild sheep population viability on adjacent public or other private lands.

Report any observed association between wild sheep and domestic sheep or goats on or near private land to the appropriate wildlife conservation agency.

Cooperate with wildlife agencies in reporting and removing feral sheep or goats and other exotic bovine ungulates such as aoudad, red sheep, urial, or argali that are detected within or near wild sheep habitat.

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, or be sought, by wild sheep.

Cooperate with appropriate agencies, agricultural and producer associations, conservation organizations, and other interested stakeholders to develop effective, comprehensive risk management approaches to help ensure effective separation between wild sheep and domestic sheep or goats, consistent with private property rights in and near wild sheep habitat.
  • 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 advocate groups for cost sharing on risk management/mitigation strategies such as fencing, or other domestic sheep or goat management actions that reduce risk of disease transmission from private flocks to wild sheep.

Support "effective separation" fencing standards that are designed to prevent nose-to-nose contact and aerosol transmission through adequate physical distance, in order to reduce transmission of respiratory disease agents. Examples include: electric outrigger fences (2 feet from page (woven) wire fencing) and double fencing (two page-wire fences with a minimum spacing of at least 10 feet). A combination of fencing methods with or without the use of effective 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.

Photo by: David Wetzel (Texas Bighorn Society)

18   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat
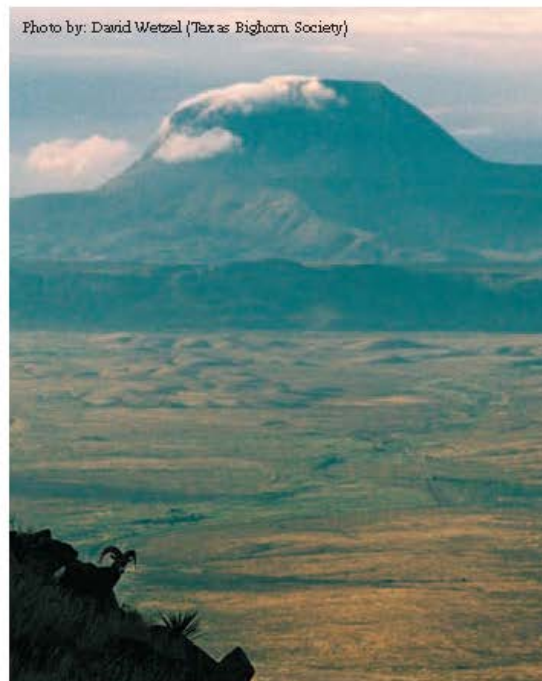
Aune, K., N. Anderson, D. Worley, L. Stackhouse, J. Henderson, and J. Daniel. 1998. A comparison of population and health histories among seven Montana bighorn sheep populations. Northern Wild Sheep and Goat Council Proceedings 11:46-69.

Baumer, A., N. East, J. Echnique, M. Haworth, M. F. Leinassar, C. Papouchis, T. Stephenson, D. Weaver, and G. Wilson. 2009. A Process for identifying and managing risk of contact between Sierra Nevada bighorn sheep and domestic sheep. Available at http://www.dfg.ca.gov/snbs/literature.html. Accessed 21 July 2010.

Beecham, J. J. Jr., C. P. Collins, and T. D. Reynolds. 2007. Rocky Mountain bighorn sheep (Ovis canadensis): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region, Ogden, Utah. Available at http://www.fs.fed.us/r2/projects/scp/assessments/rockymountainbighornsheep.pdf. Accessed 21 July 2010.

Black, S. R., I. K. Barker, K. G. Mehren, G. J. Crawshaw, S. Rosendal, L. Ruhnke, J. Thorsen, and P. S. Carman. 1988. An epizootic of Mycoplasma ovipneumonie infection in captive Dall's sheep (Ovis dalli dalli). Journal of Wildlife Diseases 24:627-635.

Bleich, V. C., J. D. Wehausen, and S. A. Holl. 1990. Desert-dwelling mountain sheep: conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.

British Columbia Ministry of Forests and Range. 2008. Sheep vegetation management guidelines. Available at http://www.for.gov.bc.ca/hfp/publications/00006. Accessed 21 July 2010.

Cahn, M. L., M. M. Conner, O. J. Schmitz, T. R. Stephenson, J. D. Wehausen, and H. E. Johnson. 2011. Disease, population viability, and recovery of endangered Sierra Nevada bighorn sheep. Journal of Wildlife Management 75:1753-1766.

Callan, R. J., T. D. Bunch, G. W. Workman, and R. E. Mock. 1991. Development of pneumonia in desert bighorn sheep after exposure to a flock of exotic domestic sheep. Journal of the American Veterinary Medical Association 198:1052-1056.

Cassirer, E. F., L. E. Oldenberg, V. L. Coggins, P. Fowler, K. M. Rudolph, D. L. Hunter, and W. J. Foreyt. 1996. Overview and preliminary analysis of a bighorn sheep die-off, Hells Canyon 1995-1996. Northern Wild Sheep and Goat Council Proceedings 10:78-86.

Clifford, D. L., B. A. Schumaker, T. R. Stephenson, V. C. Bleich, M. Leonard-Cahn, B. J. Gonzales, W. M. Boyce, and J. A. K. Mazet. 2009. Assessing disease risk at the wildlife-livestock interface: a study of Sierra Nevada bighorn sheep. Biological Conservation 142:2559-2568.

Coggins, V. L. 1988. The Lostine Rocky Mountain bighorn sheep die-off and domestic sheep. Northern Wild Sheep and Goat Council Proceedings 6:57-64.

Coggins, V. L. 2002. Rocky Mountain bighorn sheep/domestic sheep and domestic goat interactions: a management perspective. Northern Wild Sheep and Goat Council Proceedings 13:163-174.

Coggins, V. L., and P. E. Matthews. 1992. Lamb survival and herd status of the Lostine bighorn herd following a Pasteurella die-off. Northern Wild Sheep and Goat Council Proceedings 8:147-154.

Colorado Division of Wildlife. 2009. Colorado Bighorn Sheep Management Plan: 2009-2019. Colorado Division of Wildlife, Denver, USA.

CAST (Council for Agricultural Science and Technology). 2008. Pasteurellosis transmission risks between domestic and wild sheep. CAST Commentary QTA 2008-1. Council for Agricultural Science and Technology, Ames, Iowa, USA.

Croft, B., A. Resnock, M. Haworth, R. Mazur, L. Murphy, S. Nelson, R. Perloff, and T. Stephenson. 2010. Application of the document entitled a process for identifying and managing risk of contact between Sierra Nevada bighorn sheep and domestic sheep. Available at http://www.dfg.ca.gov/snbs/literature.html. Accessed 21 July 2010.

Diamond, J. M. 1997. Guns, germs, and steel: the fates of human societies. W. W. Norton, New York, USA.

Dubay, S., H. Schwantje, J. deVos, and T. McKinney. 2002. Bighorn sheep (Ovis canadensis) diseases: a brief literature review and risk assessment for translocation. Northern Wild Sheep and Goat Council Proceedings 13:134-152.

Epps, C. W., D. R. McCullough, J. D. Wehausen, V. C. Bleich, and J. L. Rechel. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology 18:102-113.

Edwards, V. L., J. Ramsey, C. Jourdannis, R. Vinkey, M. Thompson, N. Anderson, T. Carlsen, and C. Anderson. 2010. Situational agency response to four bighorn dieoffs in western Montana. Northern Wild Sheep and Goat Council Proceedings 17:in press.

Festa-Bianchet, M. 1988. A pneumonia epizootic in bighorn sheep, with comments on preventative management. Northern Wild Sheep and Goat Council Proceedings 6:66-76.

Foreyt, W. J. 1994. Effects of controlled contact exposure between healthy bighorn sheep and llamas, domestic goats, mountain goats, cattle, domestic sheep, or mouflon sheep. Northern Wild Sheep and Goat Council Proceedings 9:7-14.

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

Foreyt, W. J., K. P. Snipes, and R. W. Kasten. 1994. Fatal pneumonia following inoculation of healthy bighorn sheep with Pasteurella haemolytica from healthy domestic sheep. Journal of Wildlife Diseases 30:137-145.

Foreyt, W. J., and J. E. Lagerquist. 1996. Experimental contact of bighorn sheep (Ovis canadensis) with horses and cattle, and comparison of neutrophil sensitivity to Pasteurella haemolytica cytotoxins. Journal of Wildlife Diseases 32:594-602.

Foreyt, W. J., R. M. Silflow, and J. E. Lagerquist. 1996. Susceptibility of Dall sheep (Ovis dalli dalli) to pneumonia caused by Pasteurella haemolytica. Journal of Wildlife Diseases 32:586-593.

Foreyt, W. J., E. J. Jenkins, and G. D. Appleyard. 2009. Transmission of lungworms (Mullerius capillaris) from domestic goats to bighorn sheep on common pasture. Journal of Wildlife Diseases 45:272-278.

Foster, C. L. 2004. Wild sheep capture guidelines. Northern Wild Sheep and Goat Council Proceedings 14:211-282.

Garde, E., S. Kutz, H. Schwantje, A. Veitch, E. Jenkins, and B. Elkin. 2005. Examining the risk of disease transmission between wild Dall's sheep and mountain goats and introduced domestic sheep, goats and llamas in the Northwest Territories. Northwest Territories Agricultural and Policy Framework and Environment and Natural Resources Government of the Northwest Territories, Yellowknife, Canada.

George, J. L., D. J. Martin, P. M. Lukacs, and M. W. Miller. 2008. Epidemic pasteurellosis in a bighorn sheep population coinciding with the appearance of a domestic sheep. Journal of Wildlife Diseases 44:388-403.

Goodson, N. 1982. Effects of domestic sheep grazing on bighorn sheep populations: a review. Northern Wild Sheep and Goat Council Proceedings 3:287-313.

Grinnell, G. B. 1928. Mountain sheep. Journal of Mammalogy 9:1-9.

Gross, J. E., F. J. Singer, and M. E. Moses. 2000. Effects of disease, dispersal, and area on bighorn sheep restoration. Restoration Ecology 8(4S):25-37.

Honess, R. F., and N. M. Frost. 1942. A Wyoming bighorn sheep study. Wyoming Game and Fish Department Bulletin 1:1-127.

Hunt, E. G. 1980. Report on Lava Beds National Monument bighorn sheep die-off. Memorandum. California Department of Fish and Game, Sacramento, USA.

Jansen, B. D., J. R. Heffelfinger, T. H. Noon, P. R. Krausman, and J. C. deVos, Jr. 2006. Infectious keratoconjunctivitis in bighorn sheep, Silver Bell Mountains, Arizona. Journal of Wildlife Diseases 42:407-411.

Jeffress, J. 2008. Transmission of Pasteurella haemolytica between domestic sheep and a free-ranging bighorn ewe. Northern Wild Sheep and Goat Council Proceedings 16:160.

Jenkins, E. J., A. M. Veitch, S. J. Kutz, T. K. Bollinger, J. M. Chirino-Trejo, B. T. Elkin, K. H. West, E. P. Holberg, and L. Polley. 2007. Protostrongylid parasites and pneumonia in captive and wild thinhorn sheep (Ovis dalli). Journal of Wildlife Diseases 43:189-205.

Jessup, D. A. 1982. Bighorn sheep and domestic sheep: conflict in Nevada's Granite Mountains. Association of Wildlife Veterinarians Newsletter 14:4-5

Jessup, D. A. 1985. Diseases of domestic livestock which threaten bighorn sheep populations. Desert Bighorn Council Transactions 29:29-33.

Lawrence, P. K., S. Shanthalingam, R. P. Dassanayake, R. Subramaniam, C. N. Herndon, D. P. Knowles, F. R. Rurangirwa, W. J. Foreyt, G. Wayman, A. M. Marciel, S. K. Highlander, and S. Srikumaran. 2010. Transmission of Mannheimia haemolytica from domestic sheep (Ovis aries) to bighorn sheep (Ovis canadensis): unequivocal demonstration with green fluorescent protein-tagged organisms. Journal of Wildlife Diseases 46:706-717, and erratum (46:1346-1347).

Mack, C. M. 2008. Wandering wild sheep policy: a theoretical review. Northern Wild Sheep and Goat Council Proceedings 16:211-220.

Marsh, H. 1938. Pneumonia in Rocky Mountain bighorn sheep. Journal of Mammalogy 19:214-219.

Martin, K. D., T. J. Schommer, and V. L. Coggins. 1996. Literature review regarding the compatibility between bighorn and domestic sheep. Northern Wild Sheep and Goat Council Proceedings 10:72-77.

McQuivey, R. P. 1978. The desert bighorn sheep of Nevada. Nevada Department of Fish and Game. Biological Bulletin 6:1-81.

Miller, M. W. 2001. Pasteurellosis. Pages 330-339 in E. S. Williams and I. K. Barker, editors. Infectious diseases of wild mammals. Third edition. Iowa State University Press, Ames, USA.

Montana Department of Fish, Wildlife and Parks. 2009. Montana bighorn sheep conservation strategy. Montana Department of Fish, Wildlife, and Parks, Helena, USA.

Onderka, D. K. and W. D. Wishart. 1984. A major bighorn sheep die-off from pneumonia in southern Alberta. Northern Wild Sheep and Goat Council Proceedings 4:356-363.

Onderka, D. K., and W. D. Wishart. 1988. Experimental contact transmission of Pasteurella haemolytica from clinically normal domestic sheep causing pneumonia in Rocky Mountain bighorn sheep. Journal of Wildlife Diseases 24:663-667.

Onderka, D. K., S. A. Rawluk, and W. D. Wishart. 1988. Susceptibility of Rocky Mountain bighorn sheep and domestic sheep to pneumonia induced by bighorn and domestic livestock strains of Pasteurella haemolytica. Canadian Journal of Veterinary Research 52:439-444.

Pybus, M. J, R. A. Fenton, and H. Lange. 1994. A health protocol for domestic sheep used on forest grazing allotments in Alberta and British Columbia. Northern Wild Sheep and Goat Council Proceedings 9:20-24.

Rudolph, K. M., D. L. Hunter, W. J. Foreyt, E. F. Cassirer, R. B. Rimler, and A. C. S. Ward. 2003. Sharing of Pasteurella spp. between free-ranging bighorn sheep and feral goats. Journal of Wildlife Diseases 39:897-903.

Rudolph, K. M., D. L. Hunter, R. B. Rimler, E. F. Cassirer, W. J. Foreyt, W. J. DeLong, G. C. Weiser, and A. C. S. Ward. 2007. Microorganisms associated with a pneumonic epizootic in Rocky Mountain bighorn sheep (Ovis canadensis canadensis). Journal of Zoo and Wildlife Medicine 38:548-58.

Ryder, T. J., E. S. Williams, and S. L. Anderson. 1994. Residual effects of pneumonia on the bighorn sheep of Whiskey Mountain, Wyoming. Northern Wild Sheep and Goat Council Proceedings 9:15-19.

Schommer, T. 2009. Evaluation of "best management practices." In final supplement to the final environmental impact statement for the southwest Idaho ecogroup land and resource management plans, Appendix F. July 2010. USDA Forest Service, Intermountain Region, Ogden, Utah, USA.

Schommer, T., and M. Woolever. 2001. A process for finding management solutions to the incompatibility between domestic and bighorn sheep. USDA Forest Service, Washington, DC, USA.

Schwantje, H. 1988. Causes of bighorn sheep mortality and die-offs: literature review. Wildlife Working Report WR-35. Wildlife Branch, British Columbia Ministry of the Environment, Victoria, Canada.

Schillinger, J. E. 1937. Disease relationship of domestic stock and wildlife. Transactions of the North American Wildlife Conference 2:298-302.

Singer, F. J., V. C. Bleich, and M. A. Gudorf. 2000. Restoration of bighorn sheep meta-populations in and near western national parks. Restoration Ecology 8(4S):14-24.

Skinner, M. P. 1928. The elk situation. Journal of Mammalogy 9:309-317.

USAHA (U.S. Animal Health Association). 2009. Recommendations on best management practices for domestic sheep grazing on public land ranges shared with bighorn sheep. U.S. Animal Health Association Joint Working Group Committee on Wildlife Diseases and Committee on Sheep and Goats. Available at http://portals5.gomembers.com/ Portals/6/ Reports/2009/report-wd-2009.pdf. Accessed 21 Jul 2010.

USDA Forest Service (U.S. Department of Agriculture Forest Service). 2009. Briefing paper on disease transmission from domestic to bighorn sheep. Presented at the Biannual Meeting of the Western Association of Fish and Wildlife Agencies, January 9, 2010, San Diego, California, USA.

USDA Forest Service. 2010a. Update to the draft supplemental environmental impact statement, southwest Idaho ecogroup land and resource management plans. USDA Forest Service, Intermountain Region, Ogden, Utah, USA.

USDA Forest Service. 2010b. Final supplement to the final environmental impact statement, southwest Idaho ecogroup land and resource management plans. USDA Forest Service, Intermountain Region, Ogden, Utah, USA.

USDA Forest Service 2011. Shoshone National Forest Supervisor's Office Order 02-14-00-12-01. Temporary Area Closure to Domestic Goat Use. Available at: http://www.fs.usda.gov/detail/shoshone/alerts-notices/?cid=stelprdb5175892. Accessed 14 July 2011.

USDI BLM (U.S. Department of Interior, Bureau of Land Management). 1992. Guidelines for domestic sheep management in bighorn sheep habitats. Instruction Memorandum 92-264. USDI Bureau of Land Management, Washington, DC, USA.

USDI BLM. 1998. Revised guidelines for management of domestic sheep and goats in native wild sheep habitats. Instruction Memorandum 98-140. USDI Bureau of Land Management, Washington, DC, USA.

USDI BLM. 2010. Briefing paper on status of domestic sheep and goat management in native wild sheep habitat. Presented at the Biannual Meeting of the Western Association of Fish and Wildlife Agencies, January 9, 2010, San Diego, California, USA.

UC-Davis (University of California, Davis). 2007. Workshop summary: respiratory disease in mountain sheep: knowledge gaps and future research. School of Veterinary Medicine, University of California, Davis, USA. Available at: http://www.aavv.net/Members Only/April%2025-26%202007%20Respiratory%20Disease%20Workshop% 20Summary.pdf Accessed 21 July 2010.

Warren, E. R. 1910. The mountain sheep. Pages 9-12. In The Mammals of Colorado: An account of the several species found within the boundaries of the State, together with a record of their habits and of their distribution. G. P. Putnam's Sons, The Knickerbocker Press, New York, USA and London, England.

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

Western Association of Fish and Wildlife Agencies (WAFWA). 2007. Wild Sheep Working Group (WSWG), Recommendations for domestic sheep and goat management in wild sheep habitat. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA. Available at http://www.wafwa.org/html/wswg.shtml. Accessed 21 Jul 2010.

WAFWA. 2009. Wildlife Health Committee (WHC), Wild sheep herd health monitoring recommendations. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA. Available at: http://www.wafwa.org/html/wswg.shtml Accessed 21 Jul 2010.

WAFWA. 2010a. WSWG, GIS maps for 14 western states, showing bighorn sheep distribution overlain with vacant and active domestic sheep and goat grazing allotments and trailing routes. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA.

WAFWA. 2010b. WSWG, Summary on 9 bighorn sheep die-offs, winter 2009-2010. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA. Available at: http://www.org/html/wswg.shtml. Accessed 21 Jul 2010.

WAFWA. 2010c. WSWG, Recommendations for domestic sheep and goat management in wild sheep habitat. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, USA. Available at http://www.wafwa.org/html/wswg.shtml. Accessed 1 Mar 2012.

Wild Sheep Foundation. 2011. Wild Sheep Foundation Policy on Domestic Sheep & Goats. 4 pp. http://www.wildsheepfoundation.org/pdf/2012/domesticpolicies.pdf

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: 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 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 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 disease 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 disease 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 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 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 disease transmission.

Effective separation: Spatial 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: Based on historic records, landscape that was previously occupied by bighorn sheep and thought to have provided necessary requirements 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 interaction that may lead to the transmission of respiratory disease 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 various population segments.

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

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

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 by various methods for data retrieval.

Very High Frequency (VHF): A radio transmitter fitted to neckband material transmitting in the Very High Frequency range that can be located from the ground or aircraft using a telemetry receiver.

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.

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* occurring in Alaska, Yukon Territory, 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/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, 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 may result in significant, adverse population-level impacts.

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:
      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

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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.

"Conserving Wildlife - Serving People"

24   Recommendations For Domestic Sheep and Goat Management in Wild Sheep Habitat
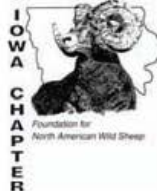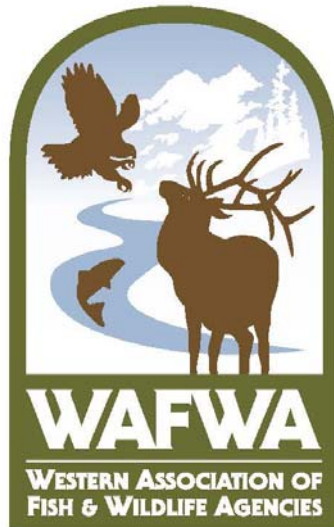
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