UTAH BIGHORN SHEEP
STATEWIDE MANAGEMENT PLAN

UTAH DIVISION OF WILDLIFE RESOURCES
DEPARTMENT OF NATURAL RESOURCES

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STATEWIDE MANAGEMENT PLAN FOR BIGHORN SHEEP

I. PURPOSE OF THE PLAN

A. General

This document is the Statewide Management Plan for bighorn sheep in Utah (hereafter referred to as the "Plan"). This Plan provides overall guidance and direction to Utah's bighorn sheep management program. This Plan assesses current information on bighorn sheep, identifies issues and concerns relating to bighorn sheep management in Utah, and establishes goals and objectives for future bighorn management programs. Strategies are also outlined to achieve goals and objectives. This Plan helps determine priorities for bighorn management and provide the overall direction for management plans on individual bighorn units throughout the state. Unit management plans will be presented to the Utah Wildlife Board when one of the following criteria are met: 1) a new bighorn sheep unit is being proposed, 2) the current unit requires a significant boundary change, 3) a change to the unit population objective is being proposed, or 4) the unit has not yet had a management plan approved by the Utah Wildlife Board. All other changes to unit management plans will be approved by the Division Director.

This Plan, among other things, outlines a variety of measures designed to abate or mitigate the risk of comingling and pathogen transmission between domestic and wild bighorn sheep. This Plan is not intended to be utilized to involuntarily alter domestic sheep grazing operations in Utah. The only mechanism acceptable to the Utah Division of Wildlife Resources (UDWR) for altering domestic sheep grazing practices to avoid risk of comingling is through voluntary actions undertaken by the individual grazers. UDWR does not support any form of involuntary restriction, reduction, limitation, termination, or conversion of permitted domestic sheep grazing for purposes of protecting bighorn sheep on public or private property.

The ability to successfully manage current populations of bighorn sheep and to restore bighorns to historical habitat is highly dependent on public tolerance for those existing and new populations. There are very few areas in Utah with suitable bighorn habitat that are not impacted by human development or are not in proximity to domestic sheep or domestic sheep grazing. Remaining areas of unoccupied suitable habitat have domestic sheep in the vicinity that create a moderate risk of comingling. Broad-based public support for new bighorn populations cannot be achieved if it comes at the expense of local domestic sheep operations. That public support, particularly with the agriculture industry, is critical to UDWR's ability to successfully maintain and expand bighorn sheep and other wildlife populations throughout the state. That public support is more vital to the successful conservation of bighorn sheep than abating the moderate risk of comingling and disease presented by domestic sheep. If UDWR adopts a zero sum game approach in abating comingling through involuntary grazing restrictions, conversions, and terminations, it will create a divide between agriculture and wildlife management detrimental not only to bighorn sheep conservation, but wildlife in general.

Statute charges the UDWR in Utah Code Section 23-14-3 to establish policies that "recognize the impact of wildlife on man, his economic activities, private property rights, and local

economies" and to "balance the habitat requirements of wildlife with the social and economic activities of man." Considering this, the UDWR will not manage bighorn sheep to the involuntary exclusion of domestic sheep. The two must both exist in Utah with a proper balance between the two entities.

B. Dates Covered

The Plan was approved by the Utah Wildlife Board on November 29, 2018 and will be subject to review within 10 years.

II. SPECIES ASSESSMENT

A. Natural History

Bighorn sheep are found in western North America from central British Columbia to Mexico and from California to the Dakotas and are beautiful and impressive large mammals native to North America. They are named for the massive horns grown by the males of the species. Horns grow throughout life and typically reach maximum size at 8 to 10 years of age. Females also have horns that are similar in size to yearling males. Males, females, and young of the year are called rams, ewes, and lambs respectively. Rams normally separate themselves from groups of ewes and lambs, except during the breeding season, which can occur from August to November for desert bighorns and from October to early December for Rocky Mountain bighorns. During that time, rams engage in impressive head butting clashes to establish dominance. Gestation is about 180 days. Lambs, which are nearly always singles, are born in February to May for desert bighorns and April to early June for Rocky Mountain bighorns.

Bighorn sheep are native to Utah with suitable habitat throughout the state (Figure 1). Archeological evidence indicates they were well known to the prehistoric inhabitants of Utah, since bighorns are depicted in pictographs and petroglyphs more than any other form of wildlife. Historical records of the first European explorers and settlers in the state also confirm the abundance of bighorns. Father Escalante noted in his journal as he crossed the Colorado River in Utah - "through here wild sheep live in such abundance that their tracks are like those of great herds of domestic sheep" (Rawley 1985). Explorers, trappers, pioneers and settlers also recorded numerous observations of bighorn sheep throughout the state. Evidence of bighorn sheep is so plentiful and suitable habitat so abundant, that it is believed bighorns inhabited almost every mountain range in Utah prior to European settlement (Dalton and Spillett 1971). Rocky Mountain bighorns *(Ovis canadensis canadensis)* are generally recognized to have inhabited northern and central Utah, whereas desert bighorns *(Ovis canadensis nelsoni)* were found in southern Utah. California bighorns *(Ovis canadensis californiana)* historically inhabited portions of the Great Basin in Nevada and Idaho. Although it is not known conclusively whether or not California bighorns inhabited Utah, recent studies indicate there is no genetic or taxonomic distinction between Rocky Mountain and California bighorns (Ramey 1993). Thus, they should be considered the same subspecies (Rocky Mountain bighorn sheep). Some mixing and interbreeding of Rocky Mountain and desert bighorns likely occurred where their ranges converged in Utah, making a clear distinction of historical ranges difficult.

Native populations of Rocky Mountain bighorn sheep were nearly extirpated following pioneer settlement. A few scattered sightings of bighorns persisted in northern Utah as late as the 1960's. Factors contributing to their decline included competition with domestic livestock for forage and space, vulnerability to domestic livestock-borne diseases, habitat conversions away from native grasslands towards shrub lands due to excessive grazing and fire suppression, and unregulated hunting (Shields 1999).

Utah's desert bighorn sheep populations also struggled to survive civilization. Whereas some herds suffered early extirpation, others remained relatively undisturbed until the 1940's and 1950's, when uranium was discovered on the Colorado Plateau. By the 1960's, only a small population of desert bighorns remained in Utah along the remote portions of the Colorado River. Desert bighorn populations were thought to have declined for the same reasons previously described for Rocky Mountain bighorns.

B. Management

1. UDWR Regulatory Authority

The UDWR presently operates under authority granted by the Utah Legislature in Title 23 of the Utah Code. UDWR was created and established as the wildlife authority for the state under Section 23-14-1. Title 23 of the Utah Code also vests UDWR with its functions, powers, duties, rights, and responsibilities. UDWR's duties are to protect, propagate, manage, conserve, and distribute protected wildlife throughout the state.

The UDWR is charged to manage the state's wildlife resources and to assure the future of protected wildlife for its intrinsic, scientific, educational, and recreational values. UDWR is further charged in Section 23-14-3(2) (b) to develop wildlife management policies that: 1) "recognizes the impact of wildlife on man, his economic activities, private property rights, and local economies;" and 2) "seek to balance the habitat requirements of wildlife with the social and economic activities of man." Protected wildlife species are defined in code by the Utah Legislature.

2. Population Status

Rocky Mountain Bighorn

Rocky Mountain bighorn sheep currently exist in the northern half of the state (Figure 2). The current statewide population estimate for Rocky Mountain bighorns managed by UDWR is approximately 1,500 animals (Figure 3). Utah currently has 14 individually managed populations of Rocky Mountain bighorn sheep, all of which are the result of transplant efforts. Three of these populations are showing increasing trends, 2 are stable, and 8 are showing declining trends or have low numbers of sheep (Table 1). The 14th population, the Stansbury Mountains, recently underwent a disease event and the area was subsequently depopulated. In January 2018, UDWR reintroduced 59 bighorn sheep to the Stansbury Mountain from other source herds within Utah.

In addition to UDWR managed herds, populations of Rocky Mountain bighorn sheep populations are also found in Dinosaur National Monument and on Ute tribal lands in northeastern Utah.

Desert Bighorn

Desert bighorns inhabit the slickrock canyons, rocky slopes, and canyonlands areas of southern Utah (Figure 2). Significant populations occur across the Colorado Plateau including the San Rafael Swell and throughout the Colorado River and its many tributaries. The current population estimate for desert bighorns in Utah managed by UDWR is nearly 2,900 animals (Figure 3). Utah currently has 13 individually managed populations of desert bighorn sheep. Five of these populations are showing an increasing trend while 7 are maintaining stable numbers (Table 2). The 13th population, San Juan North, was tested in 2017 and those animals found actively at risk of spreading disease were culled. Healthy bighorns were then translocated into this herd to augment the loss of sick bighorns. In addition to UDWR managed herds, desert sheep populations also occur in Arches, Canyonlands, Capital Reef, and Zion National Parks, and on Navajo tribal lands.

3. Population Surveys

In Utah, bighorn sheep populations are surveyed via helicopter every 2–3 years (Table 1 & Table 2). During these flights, biologists survey all potential bighorn sheep habitat during the peak of the rut in late October to December depending on the management unit. All observed animals are counted and classified as ewes, lambs, and rams, with rams being further classified as Class I (2.5 years old), II (2.5–5.5 years old), III (6.5–7.5 years old), or IV (8.5+ years old) (Geist 1971). Previous studies have shown that sightability on bighorn sheep populations varies between 60-70%, depending on the unit and conditions. In addition to the helicopter surveys, many bighorn sheep populations in Utah have radio and GPS collared bighorns. These collars allow biologist to monitor annual survival and movements. The collars also allow biologists to locate animals and collect ground classification data in years without helicopter surveys. In conjunction with Brigham Young University, Utah State University, Utah Wild Sheep Foundation (UWSF), and Sportsmen for Fish and Wildlife (SFW), UDWR has conducted and participated in many valuable bighorn sheep research project. Findings from those research projects have greatly improved the current knowledge of bighorn sheep and have improved management practices.

4. Hunting

Bighorn sheep are managed as an once-in-a-lifetime hunting species in Utah. The first hunt for bighorn sheep in Utah was held in 1967 for the desert subspecies on the San Juan Unit (Table 3). A total of 10 permits were issued, 9 hunters went afield, and all 9 harvested rams. The first hunt for Rocky Mountain bighorns in Utah was in 1991 on the Book Cliffs Rattlesnake Unit. Two permits plus 1 high-bid permit were issued and all 3 hunters harvested rams. Since the initial hunts, the total number of bighorn sheep permits has generally been increasing. The highest number of desert bighorn sheep permits issued in a given year in Utah was in 2017 when 59 permits were issued. For Rockies, the highest number of permits issued in a given year was in

2013 with 46 permits being issued. From 1967 to 2017, a total of 1,831 people hunted bighorn sheep (534 Rocky Mountain, 1,297 desert) resulting in the harvest of 1,622 bighorn sheep (529 Rocky Mountain, 1093 desert). Success rates for bighorn sheep in Utah are high and average 99% for Rockies and 84% for deserts. Demand for bighorn sheep permits is extremely high, and demand is increasing faster than natural reproduction can sustain (Table 4 & Table 5). In 2017, a total of 30,128 hunters applied for the 81 public draw permits available, resulting in drawing odds of 1 in 372.

5. Transplants

In partnership with local conservation groups including SFW and UWSF, and in coordination with federal land management agencies, UDWR has been involved in an aggressive program to restore bighorn sheep to their native habitat over the last 40 years. Extensive efforts have been made to reintroduce and augment populations of both Rocky Mountain and desert bighorn sheep (Table 6, Table 7). Rocky Mountain bighorns were first translocated into the state near Brigham City in 1966, whereas desert bighorns were first translocated into Utah in 1973 in Zion National Park. Since restoration efforts began, over 1,200 Rocky Mountain bighorn sheep and over 1,000 desert bighorns have been released in areas of historical habitat. Most desert bighorn transplants have been successful, whereas there have been some failures of Rocky Mountain bighorn transplants. Although the exact reasons behind the transplant failures are unknown, disease issues, predation, and not moving enough animals have all been hypothesized as potential reasons. UDWR will continue to pursue opportunities to transplant bighorn sheep when beneficial while coordinating efforts with federal land management agencies, private land owners, and local governments. As all current populations of bighorn sheep in Utah have been influenced by translocations in some form with variable degrees of success, UDWR recognizes, understands, and accepts the risk of failure associated with all future translocation efforts.

C. Habitat

Bighorn sheep are uniquely adapted to inhabit some of the most remote and rugged areas in Utah. They exist in some of the most hostile climatic conditions ranging from the hot, dry canyonlands of southern Utah to the cold, snowy alpine regions of Utah's northern mountains. Bighorns are sometimes referred to as a wilderness species because of the naturally remote and inaccessible areas they inhabit. Bighorns prefer open habitat types with adjacent steep rocky areas for escape and safety. Habitat is characterized by rugged terrain including canyons, gulches, talus cliffs, steep slopes, mountaintops, and river benches (Shackleton et al. 1999). The diet of mountain sheep is comprised primarily of grasses and forbs, although sheep may also utilize shrubs depending on season and availability. Most Rocky Mountain bighorns typically have seasonal migrations with established winter and summer ranges, whereas most desert bighorns generally do not have distinct summer and winter migrations. Extensive historical bighorn habitat occurs throughout Utah (Figure 1). However, not all habitat is currently suitable for reestablishment of bighorn populations. Vegetative changes, human encroachment, and domestic sheep grazing make some areas unsuitable for bighorn restoration. Habitat management practices include voluntary grazing allotment conversions from domestic sheep to cattle, vegetative treatments, and water developments. UDWR considers grazing conversions and restrictions "involuntary" when the party negotiating for the conversion/restriction threatens

to seek more burdensome grazing restrictions, reductions, or conversions in court or through other regulatory means unless the livestock grazer consents to the requested conversion/restriction. UDWR, in partnership with conservation groups and land managers has been extremely helpful in negotiating, funding, and participating in habitat projects.

III. ISSUES AND CONCERNS

A. Disease

Disease is a significant concern for bighorn sheep management. Respiratory diseases have resulted in large-scale population declines in bighorn sheep populations across the western U.S., including in Utah (Cassirer et al. 2017). Other diseases such as contagious ecthyma, bluetongue, and psoroptic mange have been detected in Utah's bighorn sheep populations with limited impacts.

The etiology of respiratory disease of bighorn sheep is thought to be polymicrobial, however, multiple members of the Pasteurellaceae family of bacteria as well as *Mycoplasma ovipneumoniae* have particularly been associated with respiratory disease, death, and reduced lamb recruitment in bighorn sheep (Miller et al. 2012, Besser et al. 2012b).

Within the Pasteurellaceae family, the bacteria *Pasteurella multocida*, *Mannheimia haemolytica* and *Bibersteinia trehalosi* are commonly detected during respiratory disease outbreaks of bighorn sheep (Besser et al. 2012b). Within each species of these bacteria, there are several biovariants and subtypes that may be further classified by virulence or ability to produce leukotoxin, which can cause extensive lung tissue damage when associated with pneumonia (Miller et al. 2012). *Mannheimia haemolytica* and *B. trehalosi* are also frequently detected in the upper respiratory tract of healthy wild and domestic ruminants and likely act as opportunistic pathogens in animals during times of stress, or secondary to primary infections with *Mycoplasma ovipneumoniae* (Besser et al. 2012b, Cassirer et al. 2017). *Pasteurella multocida* is less commonly cultured from the upper respiratory tract of bighorn sheep, but was detected in association with large die-offs of Rocky Mountain bighorn sheep in the Goslin Mountain, Mount Nebo, Rock Canyon, and Stansbury Mountains; as well as in respiratory disease outbreaks in bighorn sheep populations of Idaho, Washington, Oregon, Colorado, Montana, South Dakota (Spraker et al. 1984, Weiser et al. 2003, Besser et al. 2012b).

Over the last decade, much attention has focused on *M. ovipneumoniae* as an important component of pneumonia outbreaks in bighorn sheep (Besser et al. 2012b, Cassirer et al. 2017). *Mycoplasma ovipneumoniae* is primarily carried in the respiratory tract of asymptomatic domestic sheep and goats (Besser et al. 2012a, Besser et al. 2012b, Cassirer et al. 2017). While not a virulent pathogen all on its own, *M. ovipneumoniae* colonizes the respiratory tract, inhibiting the normal mucociliary clearance used to expel bacteria that enter the lungs under normal conditions. When this clearance is impaired, bacteria that enter the lungs, particularly virulent opportunistic bacteria such as the described Pasteurellaceae, start to replicate, overcoming the body's natural defenses and thus causing pneumonia. Bighorn sheep appear to be very susceptible to such infections. For example, *Mycoplasma ovipneumoniae* was detected in >95% of 44 affected bighorn sheep lungs sampled in eight pneumonia outbreaks that occurred

between 2009–2010 in the western U.S., but was absent in lung tissues of 5 animals obtained from two populations unaffected by pneumonia (Besser et al. 2012b). A wide variety of strains of *M. ovipneumoniae* have been detected (Cassirer et al. 2017), and infection with one strain does not appear to induce cross-immunity with other strains (Cassirer et al. 2017). Respiratory disease outbreaks can therefore occur repeatedly in the same population with introduction of new *M. ovipneumoniae* strains (Cassirer et al. 2017). While some bighorn sheep that survive an initial outbreak may be able to clear *M. ovipneumoniae* and other pathogens from their respiratory tract, others may become persistently infected and continue to shed the bacterium intermittently, resulting in reinfection of lambs that subsequently may succumb to pneumonia (Cassirer et al. 2017). The presence of persistently infected bighorn sheep in a bighorn population may therefore lead to long periods of recurrent disease and low lamb recruitment as immunity is not transferred from ewe to lambs (Cassirer et al. 2017). The presence of sinus tumors, which has been detected in multiple bighorn sheep populations across the western U.S., may also negatively affect the clearance of pathogens from the respiratory tract of surviving bighorn sheep and result in a higher number of persistently infected animals (Fox et al. 2015).

There are several examples of epizootic outbreaks of pneumonia in bighorn sheep due to contact with domestic sheep in the literature (Jessup 1985, Foreyt 1990, Martin et al. 1996). Furthermore, controlled experimental studies commingling domestic sheep infected with *M. ovipneumoniae* with healthy bighorn sheep resulted in fatal pneumonia of the bighorn sheep; whereas commingling of domestic sheep free of *M. ovipneumoniae* with healthy bighorn sheep did not result in development of respiratory disease or fatalities in 3 of 4 bighorn sheep for over 100 days (Besser et al. 2012a). Similarly, there are documented instances of contact between uninfected bighorn sheep and domestic sheep in Utah that have resulted in varying degrees of disease to the population of wild bighorns; in some cases the result being no perceived disease in the bighorns (Shannon et al. 2014). This makes it clear that pathogens like *M. ovipneumoniae* are the concern and not the domestic animals themselves. Commingling with domestic goats carrying *M. ovipneumoniae* resulted in sublethal pneumonia in bighorn sheep, suggesting that goat strains possibly are less virulent than domestic sheep strains (Besser et al. 2017). After introduction of disease into a bighorn sheep population, the disease may continue to be transmitted among bighorn sheep (Cassirer et al. 2017). Other factors that may contribute to the severity of a disease outbreak in bighorn sheep could include various forms of stress including overcrowding, poor nutrition, human disturbance, loss of habitat, weather conditions, infection with parasites such as lungworm (*Protostrongylus spp*) or mites (*Psoroptes ovis)* (Lange et al. 1980, DeForge 1981, Foreyt and Jessup 1982, Spraker et al. 1984, Clark and Jessup 1992, Bunch et al. 1999, Monello et al. 2001).

After introduction of respiratory disease into a bighorn sheep population, options for clearing the disease from the population through active management are limited. Augmenting actively diseased populations with healthy bighorn sheep, without efforts to stop the pathogen transmission prior to augmentation, is unlikely to be successful as the healthy bighorn sheep will likely become infected from the resident population. Because of the lack of cross-reactivity between *M. ovipneumoniae* strains and the role of other bacteria in inducing respiratory disease, augmentation with other infected bighorn sheep may cause renewed disease outbreaks in both the augmented population and augmenting animals. Targeted removal of chronic shedders may be an option in easily accessible populations with low *M. ovipenumoniae* prevalence that can be

tested repeatedly (Cassirer et al. 2017). In populations that are not easily accessible for repeated testing, targeted removal of shedding bighorns after a single test may also be an option, but those animals that may potentially clear the pathogen would also be removed from the population. Complete depopulation of infected herds followed by subsequent reintroduction with healthy bighorns may be effective in isolated populations with low numbers. UDWR will continue to seek options for management and improvement of bighorn sheep populations already affected by respiratory disease.

Although population connectivity is generally desirable for genetic flow, increased connectivity elevates the risk of transmission of respiratory disease between bighorn sheep herds. Therefore, maintaining more isolated bighorn sheep populations may outweigh the benefits derived from connected populations in some instances. Connectivity between herds of bighorn sheep is not always the goal of the UDWR. Genetic exchange, one of the core functions of population connectivity, can be achieved through managed translocations and other efforts. For those reasons, it is critical for future management that we understand herd connectivity and the distribution of pathogens in Utah bighorn sheep.

Because of the aforementioned disease concerns, the Western Association of Fish and Wildlife Agencies (WAFWA) Wild Sheep Working Group published the "Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat" in 2007, and updated that document in 2012 (Appendix A). That document provides general guidelines to state wildlife agencies, federal land management agencies, wild sheep conservation organizations, domestic sheep and goat producers/permittees, and private landowners for reducing conflicts between wild sheep and domestic sheep and goats. While the WAFWA guidelines are generally helpful, the unique social, political, and biological environment in Utah requires a tailored approach in managing bighorn sheep on a sustainable basis. For the purposes of this Plan, "sustainable" means preserving and maintaining bighorn sheep within the state at the species level using the management practices outlined in this Plan. Because bighorn sheep are heavily impacted by human activities, they often require intensive management. Therefore, management is essential to maintaining bighorn sheep within the state on a sustainable basis. The objective of UDWR and this Plan is to expand bighorn sheep populations, where feasible, and to maintain bighorn sheep on a sustainable statewide basis without requiring or causing involuntary relinquishment of livestock grazing opportunity on public and private lands. UDWR supports an active livestock industry exercising responsible grazing practices that: 1) maintain private lands as open space; 2) benefit rangeland health; 3) reduce frequency and intensity of rangeland fires; and 4) maintain water distribution facilities effectively expanding wildlife distribution to areas where water is the limiting factor for wildlife. All of these responsible grazing practices provide habitat that benefit wildlife. UDWR is charged in Section 23-14-3(2) (b) to develop wildlife management policies that: 1) "recognizes the impact of wildlife on man, his economic activities, private property rights, and local economics;" and 2) "seek to balance the habitat requirements of wildlife with the social and economic activities of man." UDWR recognizes the economic importance of the domestic sheep industry, and it is not the intent of this Plan or UDWR to force domestic sheep operators off public lands or out of business. Rather, the intent is to look for opportunities that will protect bighorn sheep populations while working with the domestic sheep industry. Because of the unique mosaic of bighorn sheep habitat in Utah and its pervasive proximity to domestic sheep and goats on private and public lands, and the susceptibility of bighorn sheep to diseases

harbored by domestic sheep and goats, it is impossible to completely remove all risk of pathogen transmission. UDWR fully understands and accepts the risks of disease in bighorn sheep populations, and will employ a variety of strategies to manage around this risk to ensure sustainable populations of bighorns can exist in balance with domestic sheep grazing.

UDWR recognizes that voluntary conversions, as defined in Section II. C. of this Plan, from sheep and goat to cattle or horse on public grazing allotments may be beneficial to promote healthy populations of bighorn sheep. UDWR also recognizes that voluntary conversions from cattle or horse to sheep or goat on public grazing allotments can be beneficial to promote healthy populations of bighorn sheep when such conversions allow a livestock operator to move domestic sheep or goats that present a risk of transmitting pathogens to allotments where that risk is diminished. UDWR does not support involuntary conversions or relinquishment of public land grazing AUMs or allotments for the benefit of wildlife. UDWR supports increases in public land grazing AUMs where the forage conditions that precipitated reductions have adequately improved. UDWR does not support the conversion of public land grazing allotments to domestic sheep or goats in established bighorn sheep management units. UWSF has been instrumental in resolving bighorn/domestic sheep issues, and their efforts have resulted in protection of many bighorn sheep populations by reducing the potential for the transmission of disease.

Section 23-14-3(2) charges UDWR to manage and maintain bighorn sheep on a sustainable basis, in general. It does not require individual population sustainability. As such, population objectives established by UDWR for individual bighorn sheep herds are flexible targets used to evaluate the effectiveness of past management strategies and to assist in identifying appropriate management strategies for the future. These population objectives are a balance between habitat carrying capacity, social tolerance, and managing the risk of pathogen transmission; they are not a metric for evaluating population sustainability or viability. They instead inform UDWR on possible management strategies at the individual population level that will help in managing for a sustainable statewide population of bighorn sheep.

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). Accurate cause of death should be determined for bighorn sheep through a full necropsy when possible. Bighorn sheep that are suspected of harboring infectious pathogens or that have been in contact with domestic sheep or goats, may pose a risk for pathogen transmission, and removal of such high risk animals should be decided on a case by case basis. The isolation of an affected bighorn sheep herd from other unaffected bighorn sheep herds should also be ensured to the largest extent possible. Many of Utah's isolated bighorn sheep populations present minimal risk of transmission to other bighorn.

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 bighorns in Utah. Coyotes, bobcats, and golden eagles

may occasionally take bighorn sheep but should not be considered a serious threat to bighorn sheep herds.

Mountain lion populations should be managed at levels that will allow for the establishment of healthy and sustainable populations of bighorn sheep. This may require removal of mountain lions that are negatively impacting bighorn populations until herds are well established. In established small herds where mountain lion harvest is typically low or non-existent because of topography and access, a consistent effort to improve mountain lion harvest opportunity may need to be considered. These efforts could include not closing sheep units to harvest (i.e., no quotas) and maintaining a liberal policy of removing lions on sheep units when there is opportunity. In some cases, the use of USDA Wildlife Services or other contracted personnel may also be needed to help control cougar populations. Bighorn sheep unit management plans and predator management should specify conditions for predator management in bighorn areas.

C. Habitat Degradation or Loss

Bighorn habitat can be degraded, fragmented, or lost to a variety of causes including human disturbance, energy 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 may cause bighorn sheep to change use areas and abandon certain habitats because of those disturbances. Loss of preferred habitat can compel bighorns into habitats that reduce productivity, decrease survival rates, and increase risk of pathogen transmission. 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). Working with federal land management agencies to protect the habitat needed for healthy herds may improve herd health.

Energy development is an important facet of Utah's economy. DWR recognizes the value of balancing this industry with the needs of bighorn sheep and other wildlife. However, energy development in bighorn habitat, if not properly managed and mitigated, can result in direct loss of habitat. Infrastructure and disturbance associated with energy development has the potential to displace bighorns from habitat that would otherwise be suitable. Best management practices should be employed in coordination with federal land management agencies when planning energy development in bighorn sheep habitat. Mineral exploration for oil, gas, uranium, and other minerals has been extensive in bighorn areas. Habitat managers for the Bureau of Land Management and U.S. Forest Service should carefully coordinate with the State of Utah and energy development companies to monitor those activities to minimize and mitigate impacts to 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 fire management and mechanical treatments, can restore and improve bighorn habitat to its condition prior to settlement times.

D. Wilderness and Park Management

Administration of wilderness areas and national parks has presented problems for bighorn sheep managers in some states (Arizona Game and Fish 1989 and Bleich 1999). Utah currently has a good working relationship with federal land management agencies, which has allowed and promoted good bighorn sheep management programs. Future wilderness designation and park expansions should specifically allow for activities required for proper management of bighorn populations such as the use of aircraft for surveys, transplants, research projects, and the ability to access and maintain water developments constructed specifically for bighorn sheep. It is critical to the future of bighorn sheep in those areas to maintain the use of those valuable management tools. Certain activities proposed in wilderness areas may necessitate coordination with appropriate land management agencies.

E. Poaching

Although poaching is not a problem for overall bighorn populations, it can have a detrimental effect on hunter harvest opportunities. Bighorn sheep are highly prized by hunters and legal hunting permits are difficult to obtain. Bighorns often inhabit very remote areas that are difficult to monitor and patrol. Thus, the incentives and opportunities for poaching exist.

F. Competition

Competition for forage and space by domestic livestock, feral animals, and other wild ungulates can affect bighorn populations (Bailey 1980). Competition is most likely to occur where habitat is limited such as in 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 Utah since bighorns utilize steep, rugged terrain generally not used by livestock. However, some feral animals, such as burros and goats, and some wild ungulates may use the same ranges as bighorn sheep making competition possible. Bighorn habitat should be monitored to assure proper range management and minimize competition.

G. Transplants

Transplanting bighorn sheep is a primary tool for restoration and management of bighorn populations. All bighorn sheep transplants in Utah will be done in accordance with Utah Code 23-14-21 and in coordination with federal land management agencies. Several issues need to be considered prior to releasing bighorns in new areas or into existing herds, and those issues are detailed in the 2012 WAFWA guidelines (Appendix A). Bighorns should only be released in areas where there is a high probability of success as determined by GIS modeling and habitat evaluations. Furthermore, pre-transplant health screening of both the source stock and receiving population is critical in order to evaluate the risk of disease introduction. Additional screening should be conducted on all individual bighorn sheep destined for translocation and any animal that appear unfit for translocation should not be moved. Sufficient numbers should be released to assure genetic diversity and to help new herds reach self-sustaining levels.

UDWR has established a current list of units/subunits that serve as potential augmentation or

reintroduction sites for bighorn sheep (Appendix B). All suitable bighorn sheep habitat found within those units/subunits will be available for augmentation/reintroduction. The exact release site for transplanted sheep depends on accessibility and weather conditions and will be determined closer to the time of release.

Currently, UDWR obtains bighorn sheep for transplants from source herds within Utah as well as surrounding western states and Canadian provinces. As Utah's bighorn sheep populations continue to grow, UDWR will work towards transplanting more sheep from Utah populations and reduce the reliance on sheep coming from out of state, with the ultimate goal of only using Utah bighorn sheep populations that are known to be healthy as transplant source herds. This practice will also be important to appropriately manage the number of bighorn sheep in thriving populations. Monello et al. (2001) found that 88% of pneumonia induced die-offs occurred at or within 3 years of peak population estimates. By monitoring growing bighorn herds and by using healthy bighorn populations as source herds, UDWR will minimize the risk of introducing a new disease to uninfected populations and decrease the chances of having population die offs in both source and release herds.

In addition to conducting pre-transplant health screening of source or receiving herds, all bighorn sheep brought into Utah from other states will be tested for diseases and must meet health requirements established by UDWR and the state veterinarian for the Utah Department of Agriculture and Food (UDAF). All bighorn sheep relocated from source herds within the state will also be pre-screened for those same diseases and tested during the translocation in order to prevent inadvertently moving disease between bighorn sheep populations. Current protocols for sampling, testing, and responding to disease outbreaks will be used as a standard for Utah transplants and disease monitoring (Foster 2004, WAFWA Wildlife Health Committee (WHC), UC-Davis 2007).

IV. USE AND DEMAND

Bighorn sheep are considered one of the most sought after and highly prized big game animals in North America. Demand for bighorn sheep hunting opportunities far exceeds the current availability of hunting permits (Table 4 & Table 5). Currently in Utah, applications exceed available permits by 161:1 for residents and 2,599:1 for nonresidents. Additionally, applications for both resident and nonresidents have increased every year since the initiation of Utah's draw system.

Great demand also exists for information concerning bighorn sheep and bighorn viewing opportunities. Many people who have no interest in hunting bighorns are very interested in learning more about bighorn sheep and observing them in the wild. Informational programs and viewing opportunities currently offered for bighorn sheep include UDWR sheep viewing days and guided hikes at Antelope Island State Park.

Finally, public interest and legal mandates require management of bighorn sheep for their intrinsic value. Bighorn sheep are an important part of fragile ecosystems throughout Utah and should be properly managed regardless of recreational uses.

V. CONCLUSION

A fitting conclusion to this section of the Plan is found in the book *Mountain Sheep of North American* by Raul Valdez and Paul Krausman (1999). It states:

> ***"****Mountain sheep, like all other native fauna and flora, are part of the structure and heritage of North America. Despite all of the efforts exerted toward their conservation, wild sheep face a precarious future. They are an ecologically fragile species, adapted to limited habitats that are increasingly fragmented. Future conservation efforts will only be successful if land managers are able to minimize fragmentation. According mountain sheep their rightful share of North America and allowing them to inhabit the wilderness regions they require is a responsibility all Americans must shoulder. It is our moral and ethical obligation never to relent in the struggle to ensure their survival."*

VI. STATEWIDE MANAGEMENT GOALS AND OBJECTIVES

A. Population Management Goal: Establish and maintain a sustainable statewide population of bighorn sheep by utilizing suitable habitat within the state to create and foster individual populations.

Population Objective 1: Increase bighorn sheep populations within the state as conditions allow (as outlined in this Plan).

Strategies:

a. Develop or revise management plans for individual units with population goals and objectives. During unit plan development, all affected cooperative agencies, private land owners, local governments, and grazing permittees shall be invited to take part in the decision making process.
b. Survey all herd units every 2–3 years to monitor population size and composition as conditions and budget allow. Dependent on the terrain and canopy cover, helicopter surveys or ground-based surveys will be employed to maximize accuracy and efficiency. When feasible, invite livestock producers and sportsmen to participate in surveys.
c. Refine population or sightability models to determine the relationship between population surveys and population size.
d. When possible, use radio collars, remote cameras, and GPS collars to better understand survival, distribution, and movements of each herd. Use this information to refine estimates of population size. Explore using similar technology with domestic animals in coordination with livestock operators to better understand resource partitioning and interactions with bighorn sheep.
e. In coordination with the appropriate land management agencies, augment existing populations where needed to improve herd distribution, link small populations when deemed beneficial, and improve genetic diversity (Appendix B).
f. In coordination with appropriate federal land management agencies, transplant bighorn sheep to establish new populations in accordance with Utah Code 23-14-21 (Appendix B).
g. Develop an annual transplant plan based on availability of bighorn sheep, release sites, and consistent with Appendix B.
h. Initiate predator management as specified in predator and bighorn sheep unit management plans. On remote or hard to access units, USDA Wildlife Services or other contracted personnel may be needed to help reduce cougar numbers.
i. Support law enforcement efforts to reduce illegal taking of bighorn sheep.

Population Objective 2: Actively manage individual populations of bighorn sheep to reduce risk of pathogen transmission, mitigate damages during disease events, and sustain or reestablish herds after contraction of disease.

Strategies: Reduce Risk of Pathogen Transmission

a. Strive for spatial separation between bighorn sheep and domestic sheep and goats that does not negatively impact livestock grazing by utilizing natural barriers (e.g. rivers or expanses of unsuitable habitat) and man-made barriers (e.g. fences or roads).
b. Strive for temporal separation between bighorn sheep and domestic sheep and goats by coordinating with livestock operators and federal land management agencies on active grazing allotments and private lands. If domestic sheep or goats are only present on an

allotment during defined dates, then the risk of pathogen transmission is reduced in that area outside of those dates.

c. Utilize current and emerging technologies to monitor movements of bighorn sheep and discourage temporal or spatial interaction. These technologies include but are not limited to satellite and camera collars, satellite geofencing, and remote cameras.
d. Continue to document instances of interaction between wild sheep and domestic sheep and goats so that it allows conflicts to be evaluated and dealt with in a timely manner.
e. Refine protocols that allow UDWR personnel to lethally remove bighorn sheep when high risk of pathogen transmission from domestic sheep, domestic goats, or other bighorns is suspected. This will be done to prevent bighorns that are likely infected from transmitting pathogens to healthy bighorns.
f. Pursue in good faith a protocol that would allow livestock operators to lethally remove bighorn sheep found comingling and in direct contact with domestic sheep or goats. If this protocol can be developed in ways that reduce the risk of pathogen transmission for bighorn sheep without impacting UDWR's ability to manage wildlife, then it will be proposed in the big game Rule (R657-5), presented to the Wildlife Board for approval, then implemented and enforced by UDWR. This management strategy would be unique to bighorn sheep because of the substantive peer-reviewed published research indicating the high risk of virulent pathogen transmission from domestic animals to wild sheep. Currently, this phenomenon is not proven in other species.
g. Pursuant to Section 4-25-202, UDWR personnel may immediately kill or remove estray domestic sheep and goats when their presence poses a risk of pathogen transmission to bighorn sheep. This event is a rare occurrence and should not apply to private property or permitted public allotments.
h. Utilize depredation hunts under R657-44-7, when appropriate, to remove bighorns that are outside management unit boundaries and their location presents an increased risk of pathogen transmission.
i. Reduce bighorn numbers in specific areas of concentration through trapping and transplanting programs to help reduce risk of pathogen transmission.
j. In areas where the density of bighorns is difficult to manage through capturing and translocating ewes, use ewe hunts to establish lower densities that will reduce the risk of pathogen transmission.
k. Establish lower ram to ewe ratios in areas with higher risk of contact with domestic sheep or goats. The goal being to minimize dispersal of rams when competing for breeding opportunities.
l. Utilize medicines or vaccines that have been proven to decrease the risk of pathogen transmission or decrease the negative effects of disease when determined to be acceptable by the DWR.

Strategies: Mitigate Damages during Disease Events

a. Use lethal removal of symptomatic infected bighorns that pose a risk of transmitting pathogens to other healthy bighorns.
b. Decrease hunting permit allocation, including suspending hunts, to maximize potential for rapid population growth.
c. Increase permit allocation, including creating new hunts, to cull infected bighorn sheep herds and reduce spread of the disease.
d. In cases of extreme morbidity and mortality, explore lethal depopulation of infected herds in preparation for potential repopulation with healthy bighorns.

Strategies: Sustain Herds after Contraction of Disease

a. Establish and maintain secure nursery herds of Rocky Mountain, California, and desert bighorn sheep. Locations for nursery herds will be selected with the goal of minimizing potential contact with domestic sheep or goats (measures including double fencing may be used to accomplish this goal). Nursery herds will be tested regularly to monitor for disease concerns.
b. Use healthy bighorns from nursery herds to reestablish depopulated herds or to augment infected herds when deemed appropriate.
c. Establish a monitoring rotation for all bighorn sheep herds to establish background disease profiles for each herd. This information will be used to determine overall herd health and the suitability of each herd for transplants.
d. Participate in research efforts to find solutions to disease problems and low lamb survival.
e. When mortality from a disease event does not merit depopulation, UDWR may capture and test bighorns from infected populations followed by selective culling of those individuals found to be harboring infectious pathogens. When multiple capturing events are feasible, this method has been proven to decrease morbidity and increase productivity
f. Improve and increase suitable habitat for bighorn sheep to reduce stress and increase productivity of the area.
g. Inform and educate the public of the potential risks to bighorn sheep from domestic-borne pathogens.
h. Work with UDAF, local governments, livestock operators, and animal industry programs to implement programs that reduce pathogen prevalence in noncommercial domestic sheep and goat herds, thereby improving health and productivity in domestic herds and reducing risk of pathogen transmission to bighorns.

B. Habitat Management Goal: Provide good quality habitat for healthy populations of bighorn sheep.

Objective: Maintain or improve bighorn sheep habitat to enhance individual herd success and thereby promote the overall sustainability of bighorn sheep statewide.

Strategies:

a. Identify valuable bighorn sheep habitats and work with land managers and private landowners to protect and enhance these areas.
b. Assist land management agencies in monitoring bighorn sheep habitat. Habitat monitoring by the land management agencies will be contingent on available funding and personnel.
c. Work with land managers to minimize and mitigate loss of bighorn habitat due to human disturbance and development.
d. Initiate vegetative treatment projects to improve bighorn habitat lost to natural succession or human impacts.
e. Under the correct circumstances, encourage land management agencies to allow fires to burn when such action improves bighorn sheep habitat.
f. Improve or maintain existing water sources and develop new water sources as needed to improve distribution and abundance of bighorn sheep.

g. Support research and monitoring efforts to evaluate bighorn sheep use of water sources to ensure the water sources are having the desired effect.
h. Work with land management agencies and private landowners to voluntarily implement agency guidelines for management of domestic sheep and goats in bighorn areas similar to those proposed by the WAWFA Wild Sheep Working Group.
i. Support conservation groups' efforts to pursue willing conversions of domestic sheep grazing allotments by working with willing permittees in bighorn areas to minimize the risk of pathogen transmission.
j. Inform and educate the public concerning the needs of bighorn sheep including the effects of human disturbance and the need for habitat improvements.
k. Create preferred habitat for bighorn sheep in areas not proximate to domestic sheep and goats to attract bighorns away from risks of pathogen transmission.

C. Recreation Goal: Provide quality opportunities for hunting and viewing bighorn sheep.

Objective 1: Increase hunting opportunities as populations allow while maintaining quality hunting experiences.

Strategies:
a. Recommend permit numbers based on 12-25% of the counted ram population (yearling and older) or 30-60% of the counted rams 6 years of age or older.
b. When feasible, use subunits and multiple seasons to maximize hunting opportunities, distribute hunters, and minimize hunter conflicts.
c. Recommend hunting seasons to provide maximum recreational opportunity while not imposing on UDWR management needs.
d. Use hunting as a tool to regulate density of bighorn sheep to reduce risk of pathogen transmission.
e. Monitor size and age class of all harvested rams.
f. Work with federal land management agencies' local access coordinators to maintain and improve access for hunting and viewing of bighorn sheep. Explore seasonal openings, modified motorized boat rules, and administrative access for surveys or maintenance.
g. Explore providing a greater variety of hunting opportunities by utilizing more primitive weapons, variation in season length, and more variable season dates.
h. Use ewe hunts to establish lower densities that will reduce the risk of pathogen transmission as well as provide recreational opportunity.

Objective 2: Increase public awareness, education, and expand opportunities to view bighorn sheep.

Strategies:
a. Look for ways to expand bighorn sheep viewing opportunities for the public.
b. Ensure that information about bighorn sheep published on the UDWR website, social media channels, and print products is current and accurate.
c. Work with partner entities (state and federal agencies, conservation groups, agricultural stakeholders) to help educate the public about the intrinsic and economic value of bighorn sheep on the landscape, as well as the threats the species face related to habitat degradation, predation, and disease.

Figure 1. Modeled suitable bighorn sheep habitat in Utah.

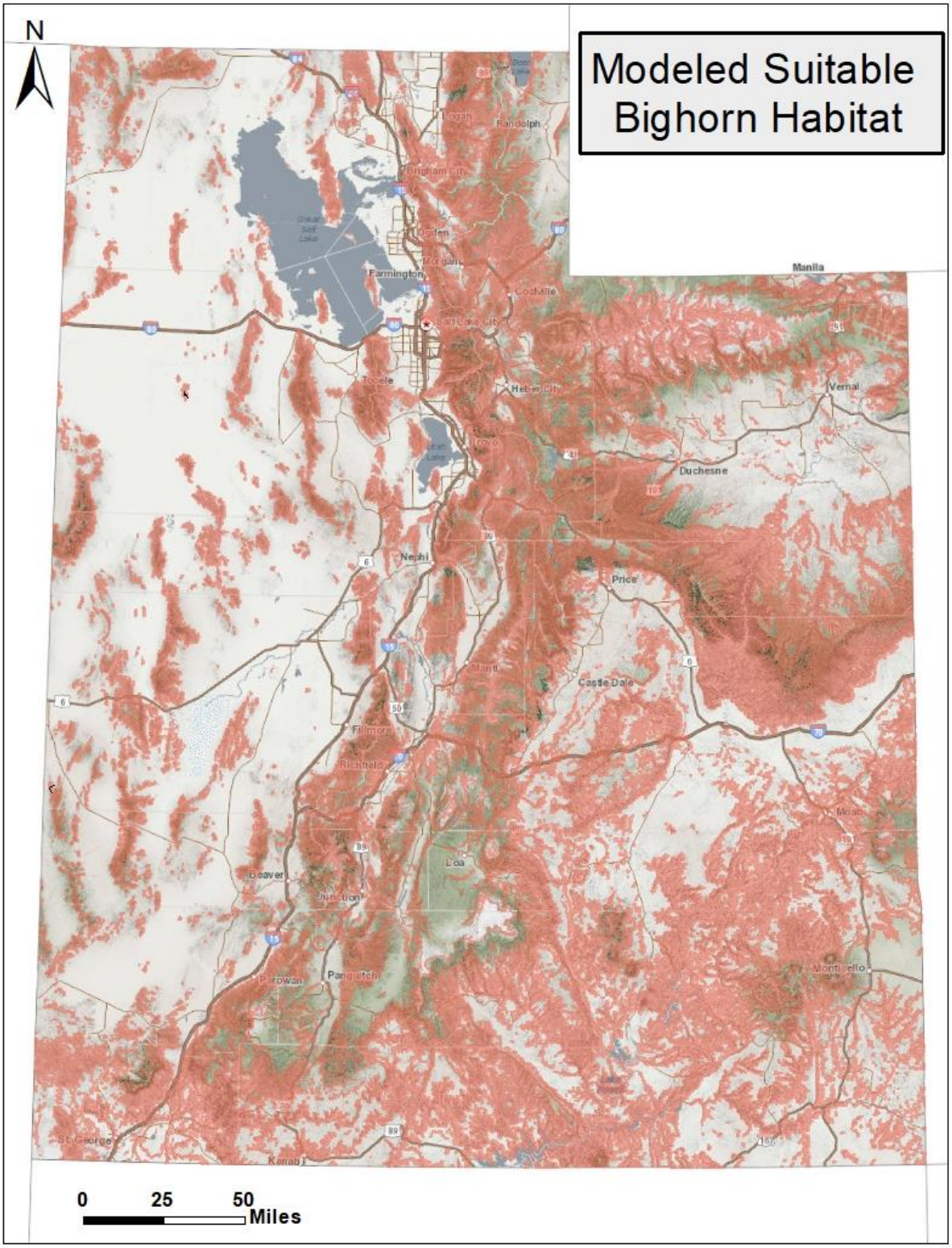

Figure 2. Bighorn sheep distribution in Utah, 2017.

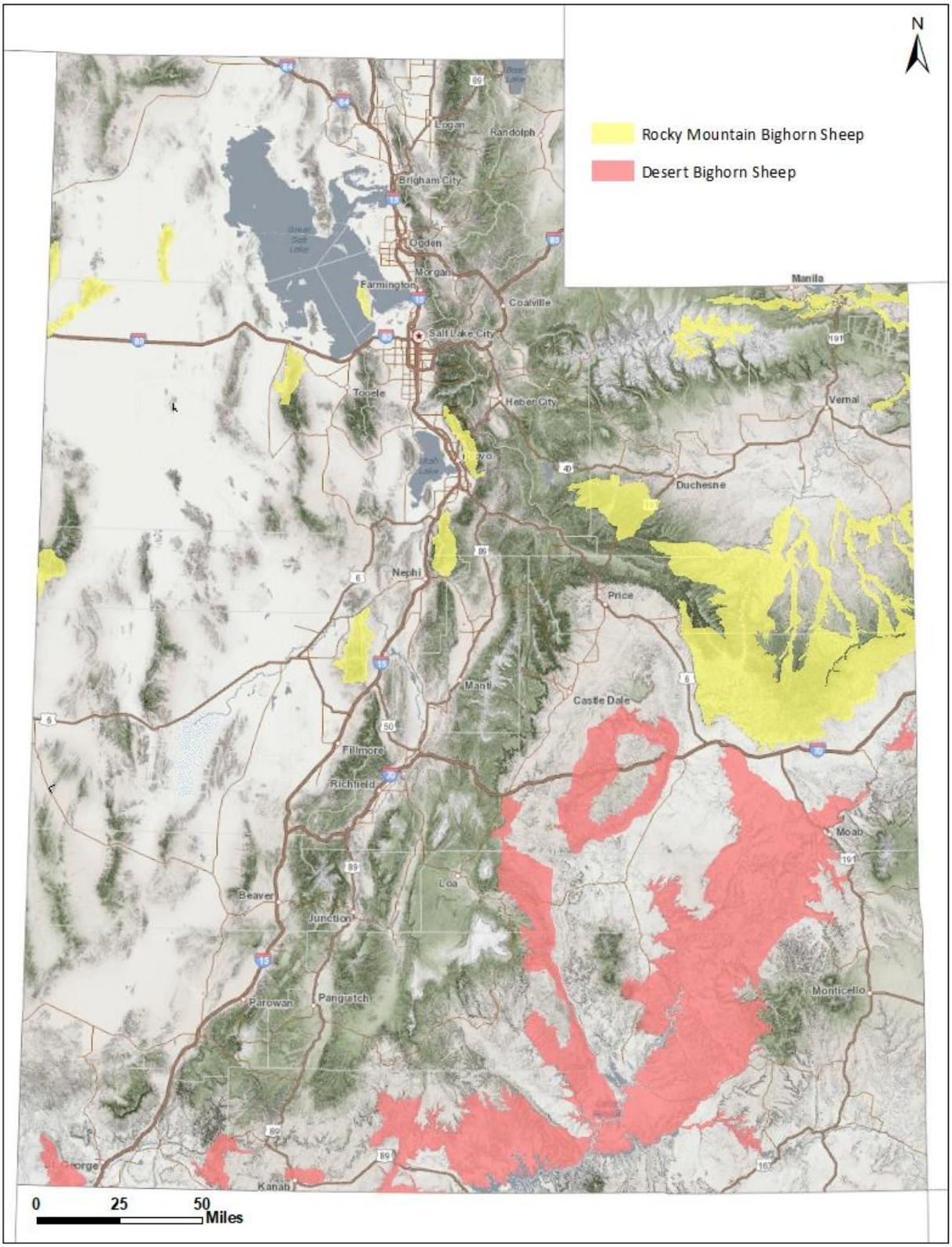

Figure 3. Bighorn sheep population trends in herds managed by the Utah Division of Wildlife Resources 1998-2017.

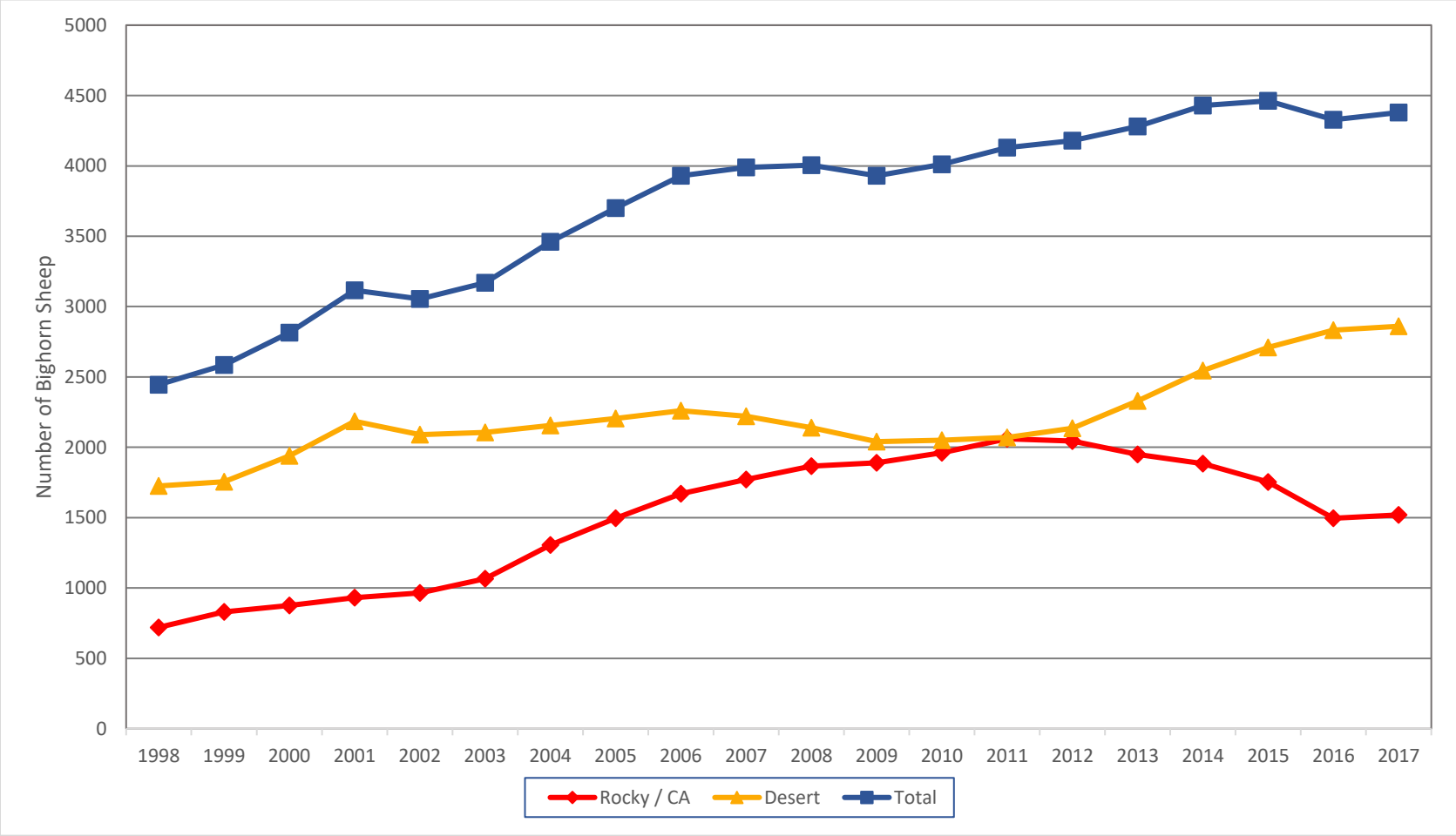

Table 1. Trend counts for Rocky Mountain bighorn sheep populations managed by UDWR, Utah 2012-2017.

Unit #	Unit name	2012	2013	2014	2015	2016	2017
1	Box Elder, Antelope Island	121	141	117	132	53†	112
1	Box Elder, Newfoundland Mountains	198	—	139	—	158	—
1	Box Elder, Pilot Mountain	42	39	28	—	24	—
8	North Slope, Bare Top Mountain	52	47	39	44	28	27
8	North Slope, Goslin Mountain	—	—	13	15	5	9
8	North Slope, Sheep Creek	63	24	33	38	27	23
8	North Slope, Carter Creek/Red Canyon	29	42	42	14	24	10
10	Book Cliffs, Rattlesnake	—	153	—	—	138	—
11	Nine Mile, Bighorn Mountain	—	333	—	—	264	—
16	Central Mountains, Nebo	—	16	—	14	—	—
17	Wasatch Mountains, Timpanogos & Provo Peak	—	33	—	32	—	—
17	Wasatch Mountains, Avintaquin	—	55	51	—	—	21
18	Oquirrh-Stansbury, Stansbury Mountains	163	—	—	140	0*	0
21	Fillmore, Oak Creek	—	—	—	—	—	67

*Population depopulated due to disease issues

†Incomplete count due to weather conditions

Table 2. Trend counts for desert bighorn sheep populations managed by UDWR, Utah 2012-2017.

Unit #	Unit name	2012	2013	2014	2015	2016	2017
12	San Rafael, Dirty Devil	66	—	60	—	86	—
12	San Rafael, North	101	94	—	124	—	—
12	San Rafael, South	—	188	—	216	—	—
13	La Sal, Potash	69	—	81	—	—	134
14	San Juan, Lockhart	40	—	84	—	—	55
14	San Juan, North	13	—	14	—	—	34*
14	San Juan, South	39	—	45	—	—	62
14	San Juan, River	—	—	38	—	—	42
15	Henry Mountains, Little Rockies	63	—	73	—	92	—
26	Kaiparowits, Escalante	71	—	92	—	—	88
26	Kaiparowits, East / West	—	339	—	355	—	—
29	Zion	—	504	—	498	—	—
30	Pine Valley, Beaver Dam	72	—	52	—	131	—

*Selective cull and augmentation took place after this survey

Table 3. Summary of bighorn sheep hunting opportunities, Utah 1967–2017.

Year	Rocky Mountain Bighorns		Desert Bighorns	
	Hunters afield	Rams harvested	Hunters afield	Rams harvested
1967	No hunt	—	9	9
1968	No hunt	—	10	3
1969	No hunt	—	10	6
1970	No hunt	—	10	4
1971	No hunt	—	10	1
1972	No hunt	—	8	1
1973	No hunt	—	No hunt	—
1974	No hunt	—	No hunt	—
1975	No hunt	—	5	2
1976	No hunt	—	10	4
1977	No hunt	—	25	10
1978	No hunt	—	23	7
1979	No hunt	—	18	3
1980	No hunt	—	19	10
1981	No hunt	—	18	5
1982	No hunt	—	11	6
1983	No hunt	—	10	9
1984	No hunt	—	14	5
1985	No hunt	—	15	12
1986	No hunt	—	14	10
1987	No hunt	—	12	7
1988	No hunt	—	15	12
1989	No hunt	—	12	10
1990	No hunt	—	15	12
1991	3	3	13	10
1992	3	3	11	10
1993	6	6	17	17
1994	6	6	19	18
1995	6	6	30	30
1996	6	5	29	28
1997	3	3	29	28
1998	5	5	31	31
1999	4	4	32	31
2000	9	9	33	33
2001	12	12	30	30
2002	13	12	40	39
2003	13	13	44	43
2004	12	12	42	40
2005	13	13	40	39
2006	20	19	41	37
2007	22	22	45	40
2008	27	27	41	39
2009	28	28	41	37
2010	34	34	50	46
2011	37	37	54	46
2012	42	42	49	41
2013	46	46	44	42

Year	Rocky Mountain Bighorns		Desert Bighorns	
	Hunters afield	Rams harvested	Hunters afield	Rams harvested
2014	44	44	46	45
2015	41	40	49	45
2016	40	39	46	41
2017	39	39	59	58

Table 4. Drawing odds of obtaining a Rocky Mountain bighorn sheep permit, Utah 2003–2017.

Year	Residents			Nonresidents		
	Applicants	Permits	Odds	Applicants	Permits	Odds
2003	1063	10	1 in 106.3	932	1	1 in 932.0
2004	1166	9	1 in 129.6	0	0	—
2005	1354	11	1 in 123.1	0	0	—
2006	1793	15	1 in 119.5	0	0	—
2007	2192	16	1 in 137.0	1131	1	1 in 1131.0
2008	2381	21	1 in 113.4	1015	1	1 in 1015.0
2009	2547	21	1 in 121.3	4323	1	1 in 4323.0
2010	2828	25	1 in 113.1	4776	2	1 in 2388.0
2011	3205	26	1 in 123.3	5001	2	1 in 2500.5
2012	3603	30	1 in 120.1	5400	2	1 in 2700.0
2013	3933	36	1 in 109.3	5759	3	1 in 1919.7
2014	4436	33	1 in 134.4	6365	4	1 in 1591.3
2015	4901	32	1 in 153.2	7187	3	1 in 2395.7
2016	5195	34	1 in 152.8	7783	3	1 in 2594.3
2017	5532	27	1 in 204.9	8712	3	1 in 2904.0

Table 5. Drawing odds of obtaining a desert bighorn sheep permit, Utah 2003–2017.

Year	Residents			Nonresidents		
	Applicants	Permits	Odds	Applicants	Permits	Odds
2003	2253	35	1 in 64.4	2266	3	1 in 755.3
2004	2653	32	1 in 82.9	3139	3	1 in 1046.3
2005	3051	32	1 in 95.3	3731	3	1 in 1243.7
2006	3467	33	1 in 105.1	3897	3	1 in 1299.0
2007	3814	35	1 in 109.0	4201	3	1 in 1400.3
2008	3827	33	1 in 116.0	3599	2	1 in 1799.5
2009	4042	33	1 in 122.5	5592	2	1 in 2796.0
2010	4386	40	1 in 109.7	6004	3	1 in 2001.3
2011	4367	39	1 in 112.0	6124	3	1 in 2041.3
2012	4607	36	1 in 128.0	6480	3	1 in 2160.0
2013	4846	30	1 in 161.5	6617	5	1 in 1323.4
2014	5147	35	1 in 147.8	7184	3	1 in 2394.7
2015	5420	37	1 in 146.5	7893	3	1 in 2631.0
2016	5777	47	1 in 122.9	8453	3	1 in 2817.7
2017	6404	47	1 in 136.3	9480	4	1 in 2370.0

Table 6. History of Rocky Mountain bighorn sheep transplants, Utah 1966–2018.

Unit #	Release Unit / Area	Year	# Released	Source
1	Box Elder, Antelope Island	1997	23	Kamloops, BC
1	Box Elder, Antelope Island	2000	6	Winnemucca NV
1	Box Elder, Newfoundland Mountains	2001	15	Antelope Island, UT
1	Box Elder, Newfoundland Mountains	2001	16	Hart Mt, NV
1	Box Elder, Newfoundland Mountains	2003	16	Antelope Island, UT
1	Box Elder, Newfoundland Mountains	2008	18	Antelope Island, UT
1	Box Elder, Pilot Mountain	1987	24	Basalt, CO
1	Box Elder, Pilot Mountain	1993	2	Bare Top Mountain, UT
1	Box Elder, Pilot Mountain	1998	13	Wells, NV
1	Box Elder, Pilot Mountain	1998	19	Contact, NV
3	Ogden, Box Elder Canyon	1966	14	Whiskey Basin, WY
3	Ogden, Box Elder Canyon	1966	20	Waterton, AB
3	Ogden, Box Elder Canyon	1969	12	Banff, AB
3	Ogden, Box Elder Canyon	1970	14	Banff, AB
8	North Slope, Bare Top Mountain	1983	19	Whiskey Basin, WY
8	North Slope, Bare Top Mountain	1984	17	Whiskey Basin, WY
8	North Slope, Sheep Creek	1989	21	Whiskey Basin, WY
8	North Slope, Sheep Creek	2000	6	Almont Triangle, CO
8	North Slope, Hoop Lake	1989	23	Whiskey Basin, WY
8	North Slope, Carter Creek / S Red Canyon	2000	10	Almont Triangle, CO
8	North Slope, Carter Creek / S Red Canyon	2001	18	Basalt, CO
8	North Slope, Carter Creek / S Red Canyon	2003	6	Desolation Canyon, UT
8	North Slope, Goslin Mountain	2005	34	Thompson Falls, MT
8	North Slope, Goslin Mountain	2007	42	Bonner, MT
8	North Slope, Goslin Mountain	2014	25	Green River, UT
10	Book Cliffs, Hill Creek	1970	9	Whiskey Basin, WY
10	Book Cliffs, Hill Creek	1973	12	Alberta, Canada
10	Book Cliffs, Hill Creek	1998	44	Kaleden, BC
10	Book Cliffs, Hill Creek	1998	20	Fowler, CO
11	Nine Mile, Bighorn Mountain	1993	26	Estes Park, CO
11	Nine Mile, Bighorn Mountain	1995	28	Georgetown, CO
11	Nine Mile, Jack Creek	2000	15	Bare Top Mountain., UT
11	Nine Mile, Jack Creek	2002	15	Sula, MT
11	Nine Mile, Trail Canyon	2009	40	Green River, UT
16	Central Mountains, Nebo	1981	27	Whiskey Basin, WY
16	Central Mountains, Nebo	1982	21	Whiskey Basin, WY
16	Central Mountains, Nebo	2004	18	Augusta, MT
16	Central Mountains, Nebo	2007	25	Augusta, MT
17a	Wasatch Mountains, Timpanogos	2000	25	Rattlesnake, UT
17a	Wasatch Mountains, Timpanogos	2001	10	Hinton, AB
17a	Wasatch Mountains, Timpanogos	2002	9	Sula, MT
17a	Wasatch Mountains, Timpanogos	2007	20	Sula, MT
17a	Wasatch Mountains, Timpanogos	2007	18	Forbes, CO
17a	Wasatch Mountains, Provo Peak	2001	22	Hinton, AB
17a	Wasatch Mountains, Provo Peak	2007	10	Sula, MT / Augusta, MT
17c	Wasatch Mountains, Lake Canyon	2009	30	Augusta, MT
17c	Wasatch Mountains, Indian Canyon	2009	30	Augusta, MT
18	Oquirrh-Stansbury, Stansbury Mountains	2005	12	Antelope Island, UT
18	Oquirrh-Stansbury, Stansbury Mountains	2006	44	Antelope Island, UT
18	Oquirrh-Stansbury, Stansbury Mountains	2008	36	Antelope Island, UT
18	Oquirrh-Stansbury, Stansbury Mountains	2018	18	Antelope Island, UT
18	Oquirrh-Stansbury, Stansbury Mountains	2018	41	Newfoundland Mountains, UT
19	West Desert, Deep Creek Mountains	1984	16	Whiskey Basin, WY
19	West Desert, Deep Creek Mountains	1989	14	Whiskey Basin, WY

Unit #	Release Unit / Area	Year	# Released	Source
21	Oak Creek Mountains	2014	24	Antelope Island, UT
21	Oak Creek Mountains	2014	9	Newfoundland Mountains, UT
21	Oak Creek Mountains	2015	16	Newfoundland Mountains, UT
21	Oak Creek Mountains	2016	49	Antelope Island, UT
21	Oak Creek Mountains	2018	15	Antelope Island, UT

Table 7. History of desert bighorn sheep transplants, Utah 1966–2018.

Unit #	Release Unit / Area	Year	# Released	Source
12	San Rafael, Dirty Devil	1991	22	North San Rafael, UT
12	San Rafael, Dirty Devil	1994	15	Potash, UT
12	San Rafael, Dirty Devil	1996	17	Potash, UT
12	San Rafael, Dirty Devil	2003	25	San Rafael, South, Chimney Cyn, UT
12	San Rafael, Dirty Devil	2007	15	San Rafael, South, UT
12	San Rafael, Dirty Devil	2007	15	Escalante, Steven's Canyon, UT
12	San Rafael, Maze (CNP)	1983	23	Island in the Sky, CNP, UT
12	San Rafael, Maze (CNP)	1985	2	Canyonlands NP, UT
12	San Rafael, North	1979	12	San Juan Unit, UT
12	San Rafael, North	1982	11	Island in the Sky, CNP, UT
12	San Rafael, North	1986	6	Canyonlands NP, UT
12	San Rafael, North	1986	18	Canyonlands NP, UT
12	San Rafael, North	1988	10	Coal Wash, UT
12	San Rafael, North Wash	1996	21	South San Rafael, UT
12	San Rafael, North Wash	1997	13	Escalante, UT
12	San Rafael, South	1983	12	Island in the Sky, CNP, UT
12	San Rafael, South	1984	16	Potash, UT
12	San Rafael, South	1985	12	Island in the Sky, CNP, UT
12	San Rafael, South	1997	4	Escalante, UT
12	San Rafael, South	1998	6	Escalante, UT
13	La Sal Potash	1991	10	Potash, UT
13	La Sal, Arches National Park	1985	6	Canyonlands NP, UT
13	La Sal, Arches National Park	1986	19	Canyonlands NP, UT
13	La Sal, Dolores Triangle	1979	7	San Juan Unit, UT
13	La Sal, Dolores Triangle	1990	20	River Mountains, NV
14	San Juan, Johns Canyon	2008	19	San Juan, South, Hite, UT
14	San Juan, Johns Canyon	2008	11	La Sal, Potash, Crystal Geyser, UT
14	San Juan, Johns Canyon	2013	16	Big Bend, Moab, UT
14	San Juan, Johns Canyon	2014	6	Big Bend, Moab, UT
14	San Juan, North	1998	6	Escalante, UT
14	San Juan, North	1999	12	Lake Mead, NV
14	San Juan, North	1999	13	Lake Mead, NV
14	San Juan, North	2017	50	Zion National Park, UT
14	San Juan, Nokai Dome	2014	26	Zion, UT
14	San Juan, Nokai Dome	2014	23	Zion, UT
15	Henry Mountains, Little Rockies	1985	18	Canyonlands NP, UT
15	Henry Mountains, Little Rockies	1985	12	Red Canyon / White Canyon, UT
25/26	Capitol Reef National Park	1984	21	Island in the Sky, CNP, UT
25/26	Capitol Reef National Park	1985	10	Canyonlands NP, UT
25/26	Capitol Reef National Park	1996	20	Island in the Sky, CNP, UT
25/26	Capitol Reef National Park	1997	20	Island in the Sky, CNP, UT
26	Kaiparowits, East	1980	20	Cataract/White Canyons, UT
26	Kaiparowits, East	1982	12	Canyonlands NP, UT
26	Kaiparowits, East	1993	13	Escalante, UT
26	Kaiparowits, East	1995	17	Escalante, UT
26	Kaiparowits, East	2009	20	Lake Mead, NV
26	Kaiparowits, East	2012	25	River Mountains, NV
26	Kaiparowits, East	2012	25	Muddy Mountains, NV

Unit #	Release Unit / Area	Year	# Released	Source
26	Kaiparowits, Escalante	1975	4	Gypsum Canyon, UT
26	Kaiparowits, Escalante	1976	12	Gypsum Canyon, UT
26	Kaiparowits, Escalante	1978	7	Cataract Canyon, UT
26	Kaiparowits, Escalante	1986	4	Canyonlands NP, UT
26	Kaiparowits, Escalante	1995	6	Escalante, UT
26	Kaiparowits, Escalante	1998	7	Escalante, UT
26	Kaiparowits, Escalante	1995	18	Escalante, UT
26	Kaiparowits, West	1995	21	Black Mountains, AZ
26	Kaiparowits, West	1995	2	Escalante, UT
26	Kaiparowits, West	1999	21	Lake Mead, AZ
26	Kaiparowits, West	2000	20	Lake Mead, NV
26	Kaiparowits, West	2006	20	Fallon, NV
26	Kaiparowits, West	1995	2	Escalante, UT
26	Kaiparowits, West	1996	20	Lake Mead, NV
29	Zion	2013	19	Zion, UT
29	Zion National Park	1973	12	Lake Mead, NV
30	Pine Valley, Beaver Dam	1994	25	Lake Mead, AZ
30	Pine Valley, Beaver Dam	2014	26	Zion, UT
30	Pine Valley, Beaver Dam	2015	12	Zion, UT

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APPENDIX A. WAFWA Wild Sheep Working Group "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 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, 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.

APPENDIX B. Potential Bighorn Sheep Translocation Sites Utah 2018

Notwithstanding the following list, any existing bighorn sheep populations can be augmented. All suitable bighorn sheep habitat within the following units/subunits will be considered for augmentation/reintroduction.

Rocky Mountain Bighorn Sheep

Augment existing populations/management units to meet population management objectives, including:

Antelope Island
Book Cliffs
Box Elder – Pilot Mountain, Silver Island Mtns, Newfoundland Mtns
Central Mountains – Nebo
Fillmore – Oak Creek
Nine Mile
North Slope – Summit, Three Corners, West Daggett
Oquirrh-Stansbury – Stansbury Mountains
Wasatch Mountains – Avintaquin, Rock Canyon, Timpanogos
West Desert – Deep Creek Mountains

Reintroduction areas to establish new populations:

Box Elder – Bovine Mountain, Goose Creek, Raft River Mountains, Stansbury Island
Ogden – Wellsville Mountains
South Slope Uintas
Wasatch Mountains – Wasatch Front
West Desert – Cedar Mountains

Desert Bighorn Sheep

Augment existing populations/management units to meet population management objectives, including:

Henry Mountains
Kaiparowits – East, Escalante, West
La Sal – Potash, Dolores Triangle
Paunsaugunt – Paria River
Pine Valley
San Juan – Lockhart, North, South, River
San Rafael – Dirty Devil, North, South
Zion

Reintroduction areas to establish new populations:

Beaver – Mineral Mountains
Paunsaugunt
West Desert – Fish Springs, Confusion Range, House Range