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. The plan will provide overall guidance and direction to Utah's bighorn sheep management program. The 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. The plan will be used to help determine priorities for bighorn management and provide the overall direction for management plans on individual bighorn units throughout the state.

B. Dates Covered

The statewide bighorn sheep plan was approved by the Utah Wildlife Board on June 4, 2013 and will be in effect for 5 years from that date (Dates covered: June 2013 – June 2018).

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 one of the most impressive large mammals in 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 occurs from mid October to early December. 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 mid April to early June.

Bighorn sheep are native to Utah. 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 white men in the state also confirm the presence 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. 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 both 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 historic 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 demise 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 unexploited 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. DWR Regulatory Authority

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

The Utah DWR 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. Protected wildlife species are defined in code by the Utah Legislature.

2. Population Status

Rocky Mountain and California Bighorns

Rocky Mountain and California bighorns currently exist in the northern half of the state (Figure 1). The current statewide population estimate for Rocky Mountain bighorns in Utah managed by DWR is nearly 2200 sheep and has shown an increasing trend over the past 15 years (Figure 2). Of the total population, approximately 770 are considered California bighorn sheep and are found on Antelope Island, the Newfoundland Mountains, and the Stansbury Mountains. Utah currently has 12 distinct populations of Rocky Mountain and California bighorn sheep, all of which are the result of transplant efforts. Six of these populations are showing increasing trends, 3 are stable, and 3 are showing declining trends or have low numbers of sheep (Table 1). One

population, North Slope-Goslin Mountain was culled in 2009 due to disease issues and concerns about the disease spreading to nearby herds. Initial indications show that this effort was successful, and efforts will likely be made to attempt to reestablish this population in the future. In addition to the DWR 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 canyon areas of southern Utah (Figure 1). 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 DWR is 2000 sheep and has been relatively stable for the past 10 years (Figure 2). Utah currently has 12 distinct populations of desert bighorn sheep. Of those 12, 3 are showing increasing trends, 4 are stable, and 5 are showing declining trends or have low numbers of sheep (Table 2). In addition to those 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) according to Geist. 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-collared animals. 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 Foundation for North American Wild Sheep (FNAWS), and Sportsmen for Fish and Wildlife (SFW), DWR has conducted and participated in many bighorn sheep research projects. 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 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, bighorn sheep permits have generally been increasing. The highest number of desert bighorn sheep tags issued in Utah was in 2011 when 54 permits were issued. For Rockies, the highest number of tags was issued in 2012 with 40 permits being issued. From 1967 to 2012, a

total of 1378 people hunted bighorn sheep (324 Rocky Mountain, 1054 desert) resulting in the harvest of 1182 bighorn sheep (321 Rocky Mountain, 861 desert). Success rates for bighorn sheep in Utah are high and average 99% for Rockies and 82% for deserts. Demand for bighorn sheep permits is extremely high, and demand is increasing faster than supply (Table 4, Table 5). The odds of drawing a bighorn sheep permit are worse than any other species in Utah. In 2012, a total of 20,009 hunters applied for the 71 public draw permits available resulting in drawing odds of 1 in 283.

5. Transplants

Utah DWR, in partnership with local conservation groups including FNAWS, SFW, and the Wild Sheep Foundation, has been involved in an aggressive program to restore bighorn sheep to their native habitat for over 40 years. Extensive efforts have been made to reintroduce and supplement populations of both Rocky Mountain and desert bighorn sheep (Table 6, Table 7). Rocky Mountain bighorns were first reintroduced into the state near Brigham City in 1966, whereas desert bighorns were first reintroduced in Utah in 1973 in Zion National Park. Since restoration efforts began, over 1000 Rocky Mountain bighorn sheep (including 190 California bighorn sheep) and over 850 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.

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 have seasonal migrations with established winter and summer ranges, whereas desert bighorns generally do not migrate. Extensive historical bighorn habitat occurs throughout Utah. However, not all habitat is currently suitable for reestablishment of bighorn populations. Vegetative changes, human encroachment, and continued domestic sheep grazing make some areas unsuitable for bighorn restoration. Habitat management practices include conversions of domestic sheep grazing permits, vegetative treatments, and water developments. Utah FNAWS and other conservation groups have been extremely helpful in negotiating, funding, and participating in habitat projects.

III. ISSUES AND CONCERNS

A. Disease

Parasites and diseases are a major concern for bighorn sheep management in Utah. Parasites such as those that cause 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). *P. multocida* was one of the primary isolates from bighorn sheep collected during an all ages pneumonia die-off in Utah's Goslin Mountain bighorn sheep herd during winter 2010.

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 bacterium 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 (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. The cause of those die-offs have been attributed to 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).

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 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. 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 Utah Division of Wildlife Resources recognizes the economic importance of the domestic sheep industry, and it is not the intent of this plan or the UDWR to force domestic sheep 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 industry. Utah FNAWS 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.

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 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 bighorns in Utah. Coyotes, bobcats, and golden eagles may occasionally take bighorn sheep but are not considered to be a serious threat to bighorn sheep herds.

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 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, 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 many areas of Utah. Those disturbances include outdoor recreation activities such as off-road vehicle use, mountain biking, river running, and others. Bighorn sheep may change use 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 in bighorn habitat, if not properly regulated and mitigated, can result in direct loss of 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 need to 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 fire management 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 including 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.

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 which 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 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 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. 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). Bighorns should only be released in areas where there is a good probability of success as determined by GIS modeling and habitat evaluations. Furthermore, a disease profile 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.

Utah has 32 units/subunits for bighorn sheep that serve as potential augmentation or reintroduction sites for bighorn sheep (Table 8). 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, the DWR 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, the DWR 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 with known disease profiles as transplant source herds. This practice will also be important to minimize 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 using growing bighorn populations in Utah as source herds, the DWR will minimize the risk introducing a new disease to naïve populations and decrease the chances of having population die offs in both source and release herds.

As part of the reintroduction/transplant program within Utah, all bighorn sheep brought into Utah from other states will be tested for pathogens and antibodies for disease and must meet health requirements established by UDWR and the state veterinarian for the Utah Department of Agriculture and Food. All bighorn sheep relocated from source herds within the state will also be monitored for those same diseases to prevent the introduction of disease into wild or domestic sheep populations. Moreover, to prevent disease introduction, only wild sheep herds with known disease profiles will serve as source stock for intra and inter-jurisdictional transplants. The mixing of wild 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 Utah transplants (Foster 2004, WAFWA Wildlife Health Committee (WHC), UC-Davis 2007).

For all 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. 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 Psoroptic mange or contagious ecthyma will not be relocated and, instead, will be released at their capture site.

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 124:1 for residents and 2376:1 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 DWR 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 optimum populations of bighorn sheep in all suitable habitat within the state.

Objective 1: Increase bighorn sheep populations within the state as conditions allow and bring all populations to at least the minimum viable level of 125 bighorns.

Strategies:

a. Develop or revise management plans for individual units with population goals and objectives. During unit plan development, all affected cooperative agencies and sheep grazing permittees shall be invited to take part in the decision making process.
b. Survey all herd units by helicopter every 2–3 years to monitor population size and composition.
c. Use population or sightability models to determine the relationship between population surveys and population size.
d. Augment existing populations where needed to improve herd distribution, link small populations, and improve genetic diversity (Table 8).
e. Transplant bighorn sheep to establish new populations in accordance with Utah Code 23-14-21 (Table 8).
f. Develop an annual transplant plan based on availability of bighorn sheep, release sites, and consistent with Table 8.
g. Reduce bighorn numbers in specific areas of concentration through trapping and transplanting programs to help reduce potential for disease problems.
h. In areas where transplants are not an option, explore the possibility of establishing ewe hunts to help reduce population densities or remove sheep in areas of high risk of contracting disease.
i. 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 compatibility of each herd for transplants.
j. 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.
k. Follow established guidelines for dealing with domestic sheep and goats that wander into bighorn sheep units.
l. Participate in research efforts to find solutions to disease problems and low lamb survival.
m. 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.
n. Support law enforcement efforts to reduce illegal taking of bighorn sheep.

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

Objective: Maintain or improve sufficient bighorn sheep habitat to allow herds to reach population objectives.

Strategies:

a. Identify crucial 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.
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. Encourage land management agencies to use fire as a management tool to improve bighorn sheep habitat. When possible, allow fires that can have beneficial effects for bighorn sheep to burn.
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 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 conversions of domestic sheep grazing allotments by working with willing permittees in bighorn areas to minimize the risk of disease 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.

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

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

Strategies:

a. Recommend permit numbers based on 12-15% of the counted ram population (yearling and older) or 30-40% 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 DWR management needs.
d. Maintain high hunter success rates (> 90%) and/or high hunter satisfaction on all units.
e. Monitor size and age class of all harvested rams.

Objective 2: Increase public awareness and expand viewing opportunities of bighorn sheep.

Strategies:

a. Evaluate existing public viewing areas and identify potential new sites.
b. Install interpretive signs in bighorn sheep areas for public information.
c. Produce written guides or brochures to help educate the public and provide viewing opportunities which will not impact bighorn sheep.
d. Continue and expand bighorn sheep viewing events for interested publics.

Figure 1. Current management units and bighorn sheep habitat/distribution, Utah 2013.

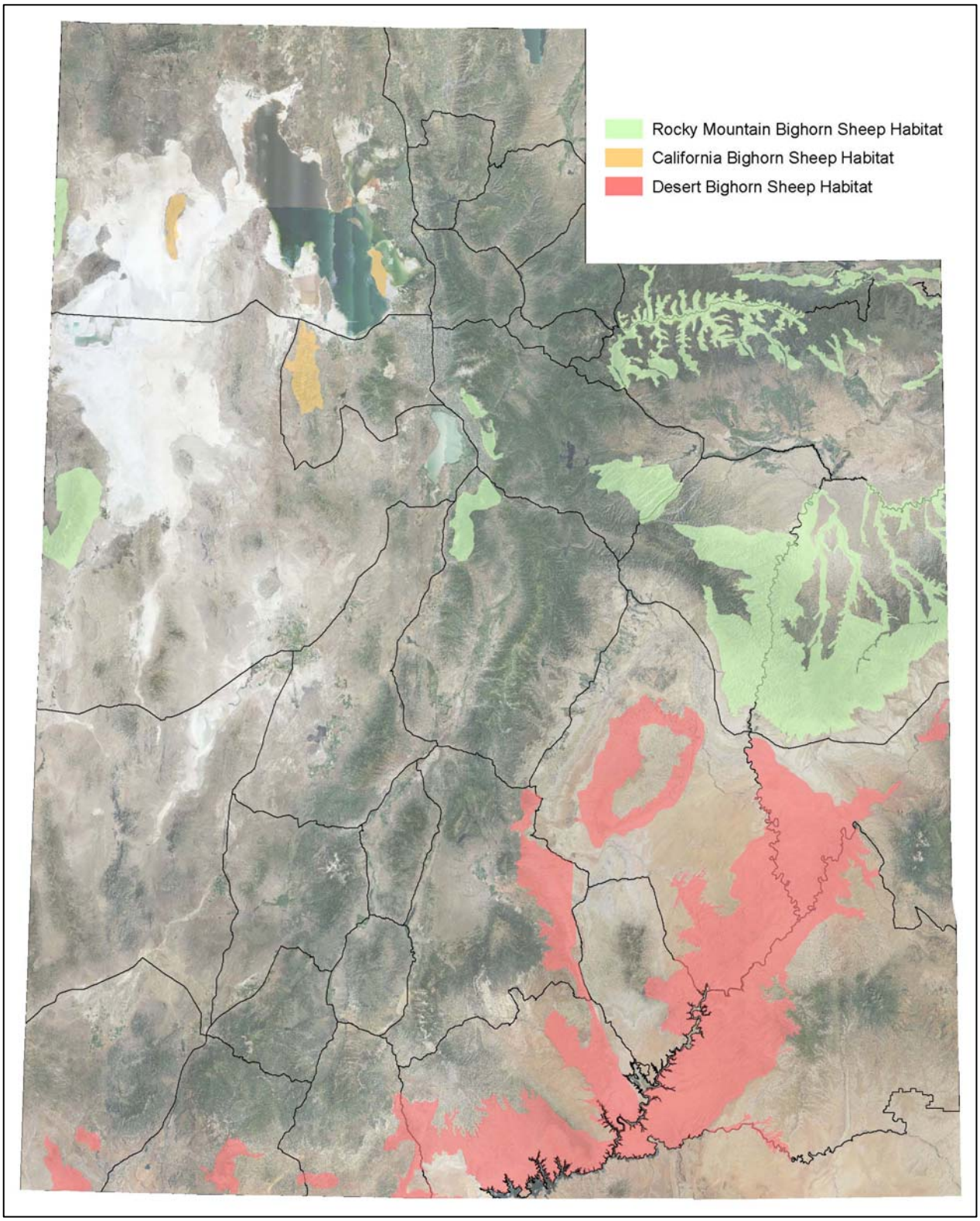

Figure 2. Statewide bighorn sheep population trends, Utah 2013.

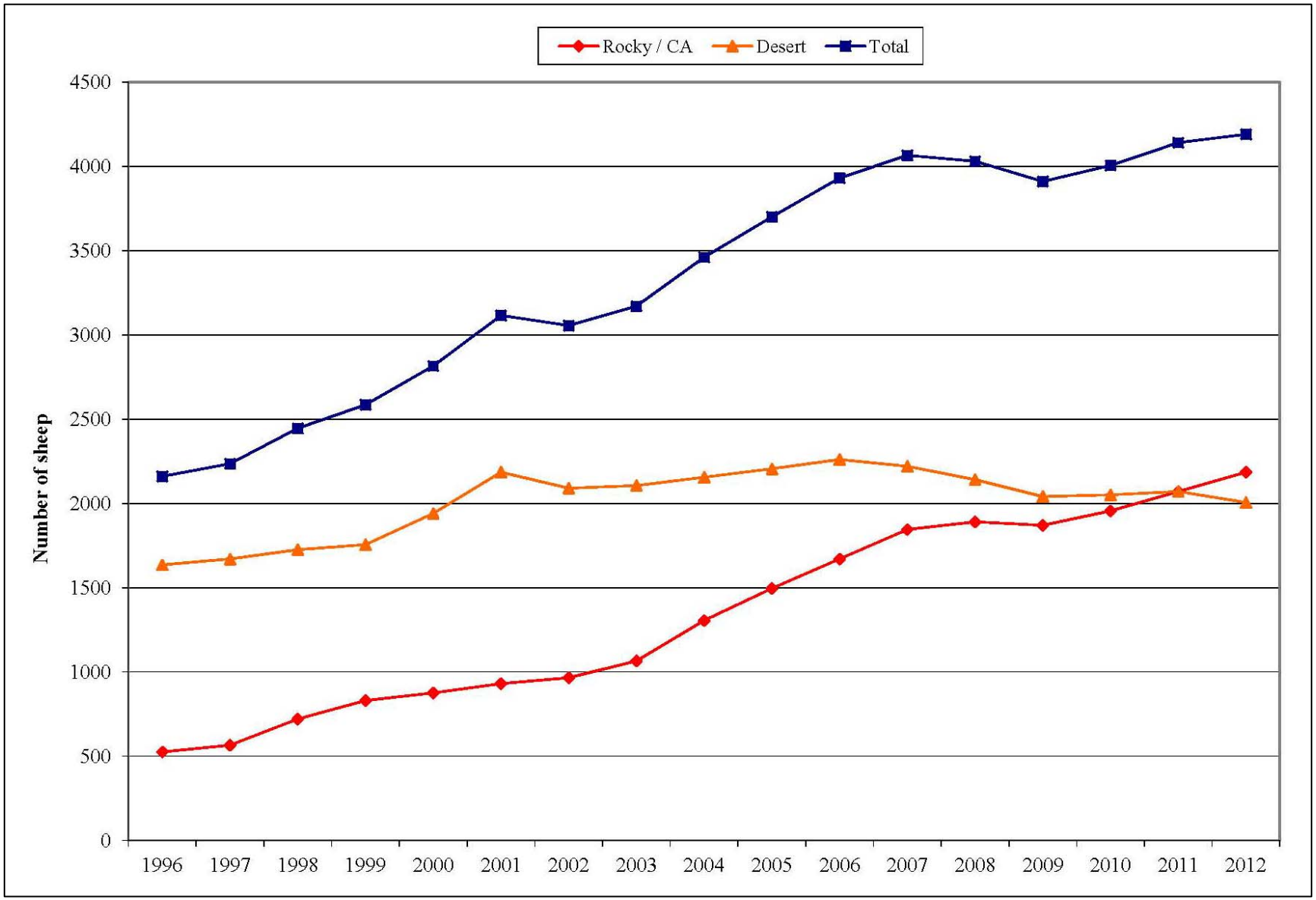

Table 1. Trend counts for Rocky Mountain and California bighorn sheep populations managed by UDWR, Utah 2007-2012.

Unit #	Unit name						
		2007	2008	2009	2010	2011	2012
1	Box Elder, Antelope Island	190	—	125	—	—	164
1	Box Elder, Newfoundland Mountains	135	—	173	—	—	198
8	North Slope, Bare Top Mountain	84	99	76*	104	72*	52*
8	North Slope, Goslin Mountain	79	33	0**	—	—	—
8	North Slope, Sheep Creek	37	53	32*	55	48*	61*
8	North Slope, Carter Creek/Red Canyon	27	20	32*	40	36*	39*
10	Book Cliffs, Rattlesnake	235	—	174	—	182	—
11	Nine Mile, Bighorn Mountain	346	—	384	—	418	—
16	Central Mountains, Nebo	35	26	22	—	—	—
17	Wasatch Mountains, Timpanogos	51	45	49	—	—	—
17	Wasatch Mountains, Provo Peak	41	12	7	—	—	—
17	Wasatch Mountains, Avintaquin	—	—	35	—	30	—
18	Oquirrh-Stansbury, Stansbury Mountains	70	137	—	—	—	163

*Incomplete count
**Population culled due to disease issues

Table 2. Trend counts for desert bighorn sheep populations managed by UDWR, Utah 2007-2012.

Unit #	Unit name						
		2007	2008	2009	2010	2011	2012
12	San Rafael, Dirty Devil	—	115	—	67	—	66
12	San Rafael, North	167	150	—	—	86	101
12	San Rafael, South	259	—	183	—	220	—
13	La Sal, Potash	—	105	—	118	—	69
14	San Juan, Lockhart	—	59	—	46	—	40
14	San Juan, North	—	—	—	17	—	13
14	San Juan, South	—	122	—	57	—	39
15	Henry Mountains, Little Rockies	—	54	—	24	—	63
26	Kaiparowits, Escalante	—	115	—	87	—	71
26	Kaiparowits, East / West	110	—	139	—	200	—
29	Zion	—	—	131	—	200	—
30	Pine Valley, Beaver Dam	38	23	—	73	—	72

Table 3. Summary of bighorn sheep hunting opportunities, Utah 1967–2012.

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

Table 4. Drawing odds of obtaining a Rocky Mountain bighorn sheep permit, Utah 1998–2012.

Year	Residents			Nonresidents		
	Applicants	Permits	Odds	Applicants	Permits	Odds
1998	283	3	1 in 94.3	0	0	—
1999	332	3	1 in 110.7	0	0	—
2000	414	6	1 in 69.0	0	0	—
2001	568	11	1 in 51.6	0	0	—
2002	831	10	1 in 83.1	0	0	—
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

Table 5. Drawing odds of obtaining a desert bighorn sheep permit, Utah 1998–2012.

Year	Residents			Nonresidents		
	Applicants	Permits	Odds	Applicants	Permits	Odds
1998	866	22	1 in 39.4	712	2	1 in 356.0
1999	1033	25	1 in 41.3	1026	2	1 in 513.0
2000	1292	27	1 in 47.9	1320	2	1 in 660.0
2001	1473	26	1 in 56.7	1583	2	1 in 791.5
2002	1997	33	1 in 60.5	2118	3	1 in 706.0
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

Table 6. History of Rocky Mountain and California bighorn sheep transplants, Utah 1966–2013.

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	20	Antelope Island, UT
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
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
19	West Desert, Deep Creek Mountains	1984	16	Whiskey Basin, WY
19	West Desert, Deep Creek Mountains	1989	14	Whiskey Basin, WY

Table 7. History of desert bighorn sheep transplants, Utah 1966–2013.

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, North	1998	6	Escalante, UT
14	San Juan, North	1999	12	Lake Mead, NV
14	San Juan, North	1999	13	Lake Mead, NV
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

Table 7. History of desert bighorn sheep transplants, Utah 1966–2013 (cont.).

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

Table 8. Potential bighorn sheep transplant sites. Utah 2013.[1] All suitable bighorn sheep habitat within the following units/subunits will be considered for augmentation/reintroduction.

Rocky Mountain / California Bighorn Sheep

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

Book Cliffs
Central Mountains – Nebo
Ninemile – Range Creek
North Slope – Summit, Three Corners, West Daggett
Oquirrh-Stansbury – Stansbury Mountains
Wasatch Mountains – Avintaquin, Rocky Canyon, Timpanogos
West Desert – Deep Creek Mountains

Reintroduction areas to establish new populations:

Beaver – Mineral Mountains
Book Cliffs – South
Fillmore – Oak Creek
South Slope – Diamond Mountain, Vernal, Yellowstone

Desert Bighorn

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

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

Reintroduction areas to establish new populations:

Paunsaugunt
San Juan – San Juan River

[1] In accordance with Utah Code 23-14-21.

Literature Cited

Arizona Game and Fish Department. 1989. Arizona Wildlife Views. September 1989.

Bailey, J. A. 1980. Desert bighorn forage competition and zoogeography. Wildlife Society Bulletin 8:208–216.

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.

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.

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

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.

Clark, R. K., and D. A. Jessup. 1992. The health of mountain sheep in the San Andres Mountains, New Mexico. Desert Bighorn Council Transactions 36:30–35.

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.

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.

_____. 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.

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

_____, V. Coggins, and P. Fowler. 1990. Psoroptic scabies in bighorn sheep in Washington and Oregon. Biennial Symposium of the North American Wild Sheep and Goat Council 7:135–142.

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.

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

Lange, R. E., A. V. Sandoval, and W. P. Meleney. 1980. Psoroptic scabies in bighorn sheep (*Ovis canadensis mexicana*) in New Mexico. Journal of Wildlife Diseases 16:77–82.

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

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. 1993. Evolutionary gentics and systematics of North American mountain sheep: implications for conservation. Dissertation, Cornell University, Ithaca, New York, USA.

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.

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.

Shackleton, D. M., C. C. Shank, and B. M Wikeem. 1999. Rocky Mountain and California bighorns. Pages 78–138 *in* R. Valdez and P. R. Krausman, editors. Mountain Sheep of North America. University of Arizona Press, Tuscon, Arizona, USA.

Shields, W. 1999. Rocky Mountain bighorns - Utah. Pages 108–111 *in* D. E. Toweill and V. Geist, editors. Return of Royalty - Wild Sheep of North America. Boone and Crocket Club and Foundation for North American Wild Sheep, Missoula, Montana, USA.

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.

Valdez, R. and P. R. Krausman. 1999. Description, distribution, and abundance of mountain sheep in North America. Pages 3–22 *in* R. Valdez and P. R. Krausman, editors. Mountain Sheep of North America. University of Arizona Press, Tuscon, Arizona, USA.

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.

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

_____. 2012. Recommendations for domestic sheep and goat management in wild sheep habitat.

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.