# Bighorn Sheep

## CONSERVATION CHALLENGES AND MANAGEMENT STRATEGIES FOR THE 21st CENTURY

WILD SHEEP WORKING GROUP
WESTERN ASSOCIATION OF FISH AND WILDLIFE AGENCIES

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# The Authors

## THE AUTHORS

| | |
|---|---|
| Clay Brewer | Texas Parks and Wildlife Department |
| Vernon C. Bleich | California Department of Fish and Wildlife (Retired) |
| Justin Foster | Texas Parks and Wildlife Department |
| Tricia Hosch-Hebdon | Idaho Department of Fish and Game |
| Doug McWhirter | Wyoming Game and Fish Department |
| Eric Rominger | New Mexico Department of Game and Fish |
| Matthew Wagner | Texas Parks and Wildlife Department |
| Brett Wiedmann | North Dakota Game and Fish Department |

## COVER PHOTOS

Top: Beau Patterson (WDFW)

Center: Doug McWhirter (WGFD)

Bottom: Earl Nottingham (TPWD), Ted Borda (Borda Land and Sheep Co.), Mark Jorgenson, Michael T. Pittman (TPWD)

## SUGGESTED CITATION

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# INTRODUCTION



PHOTO BY: MICHAEL T. PITTMAN (TPWD)

Occupying the most isolated, rugged and extreme habitats of North America, bighorn sheep and thinhorn sheep *(Ovis canadensis* and *O. dalli*, collectively referred to as wild sheep) are considered by many to be iconic wilderness species. Wild sheep have substantial ecological, economic, and cultural values, and they are a vital component of the natural heritage of North America.

Issues confronting wild sheep today are larger and more complex than ever. To address these challenges, the Western Association of Fish and Wildlife Agencies (WAFWA) created a Wild Sheep Working Group (WSWG) in 2007. Comprised of representatives from 19 state, provincial, and territorial jurisdictions having wild sheep, the Bureau of Land Management, and the US Forest Service, the WSWG was established specifically to 1) identify priority topics and management challenges to wild sheep in the western United States (U.S.) and Canada; 2) collaboratively develop solutions to those challenges; and 3) foster strong relationships between wild sheep agencies and wild sheep advocates.

Historically, the distribution of bighorn sheep extended southward from central British Columbia and Alberta, Canada to northern Mexico and from the Pacific coast eastward to the western areas of the Dakotas, Nebraska, and Texas. Reliable population estimates of bighorn sheep in North America prior to the 1800s are not available, but numbers in the hundreds of thousands have been reported. Following western settlement, numbers declined rapidly and bighorn sheep were extirpated from much of their historic range. Unregulated killing, diseases, competition with domestic, feral, or exotic hoofstock, and human encroachment which exacerbated an already naturally fragmented distribution have been implicated in the decline of bighorn sheep.

The restoration of bighorn sheep in North America is a remarkable conservation success story. They have been introduced to every western state from which they had been extirpated, with populations in some jurisdictions likely reaching historic levels. This has been accomplished through the dedication and cooperative efforts of hunters, wildlife and land management agencies, conservation organizations, native peoples, private landowners, and many other interested parties. Nevertheless, bighorn sheep occupy only a part of their former range and, on a continental basis, current numbers are far less than estimates of their historical abundance.

In this document, the WSWG has identified the most difficult and formidable management and conservation challenges faced by bighorn sheep and the professionals responsible for managing this important natural resource (see Table 1). Among these challenges are those related to habitat, disease, predation, population management, organizational hurdles, and climate change. The first of many steps, this publication highlights these substantial challenges, presents broad-based management goals and objectives, and suggests strategies for achieving results that will contribute to the viability of bighorn sheep throughout their historical distribution.

**DISTRIBUTION OF BIGHORN SHEEP IN NORTH AMERICA**
*(WILD SHEEP FOUNDATION AND WILD SHEEP WORKING GROUP)*



CIRCA 1850        CIRCA 1960        CIRCA 2012
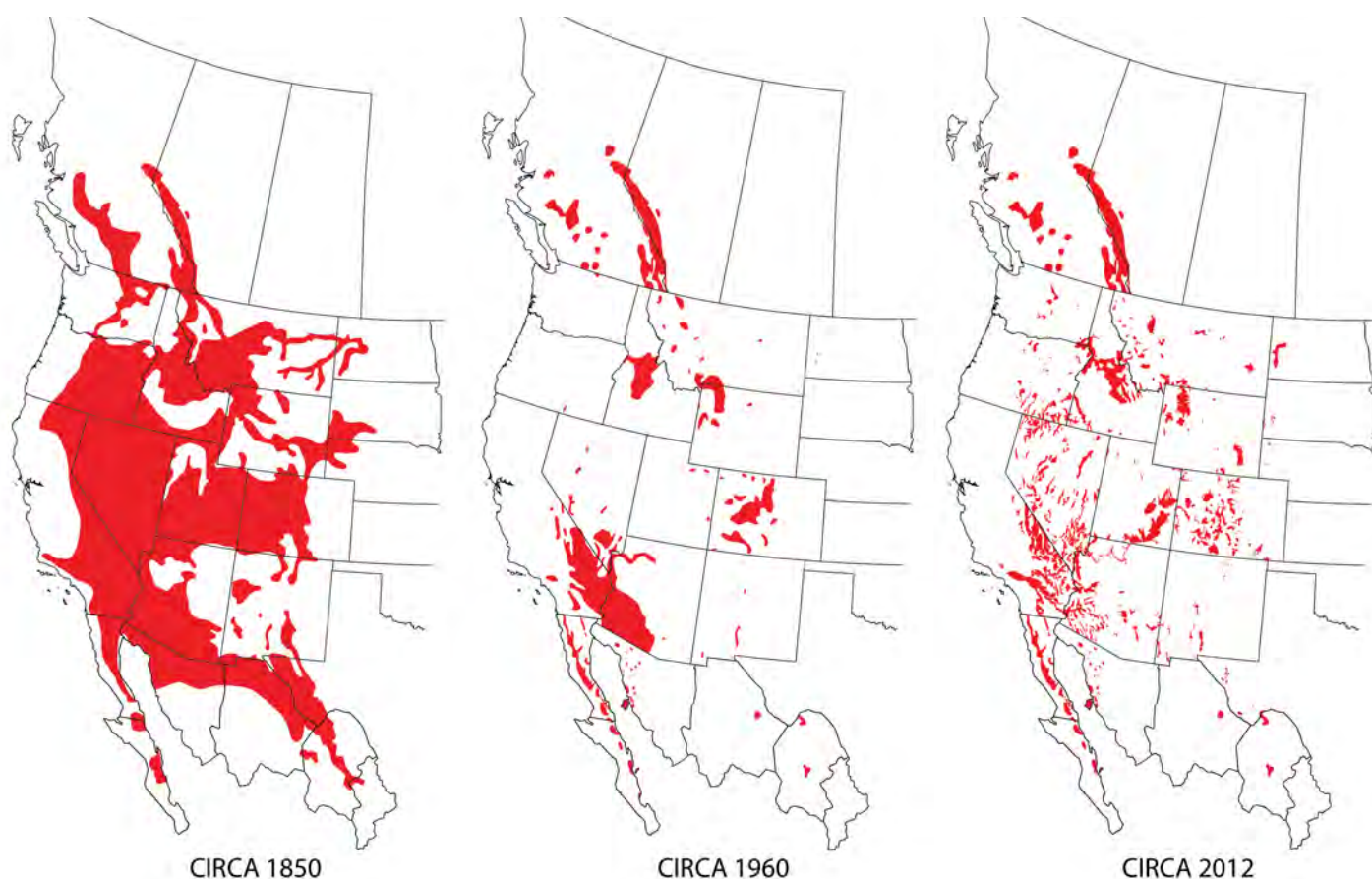
# OVERALL MANAGEMENT GOAL

Viable and sustainable populations and metapopulation function throughout suitable native habitat using science-based management of habitat, populations, diseases, predation, and human impacts.

# HABITAT

Dramatic images of head-butting clashes among bighorn sheep in the rugged mountains of western North America are well etched in the minds of wildlife enthusiasts. Current threats to the habitat in which they live may not, however, be clearly recognized. While broadly distributed throughout their historic range, bighorn sheep occur in only a fraction of the habitat they occupied at the turn of the twentieth century. Despite inaccessibility and isolation, adverse impacts to bighorn sheep habitat are complex, substantial, and increasing. Bighorn sheep are uniquely adapted to open habitats with precipitous rocky areas for escape and safety, and unobstructed corridors for movement between preferred habitat, seasonal ranges or proximate populations. Because of these specialized requirements, habitat conservation is a cornerstone of bighorn sheep management.

## HABITAT QUALITY AND QUANTITY

Habitat quality is the ability of the environment to provide conditions required for population persistence and, along with habitat quantity, strongly influences numbers and diversity of native species. Availability of suitable habitat ultimately determines the distribution and numbers of bighorn sheep that a given area can support. Bighorn sheep are highly opportunistic when it comes to foraging, and require a topographically diverse, open and rugged landscape to detect and evade predators. At the most basic level, bighorn sheep habitats must contain adequate amounts of forage, escape terrain, lambing and loafing areas, water, and they rely heavily on unobstructed movement corridors. These habitat components must be juxtaposed and well-distributed throughout bighorn sheep ranges to meet annual and seasonal needs. Ensuring adequate quality and quantity of bighorn sheep habitat is a significant challenge now and for the future, particularly with respect to
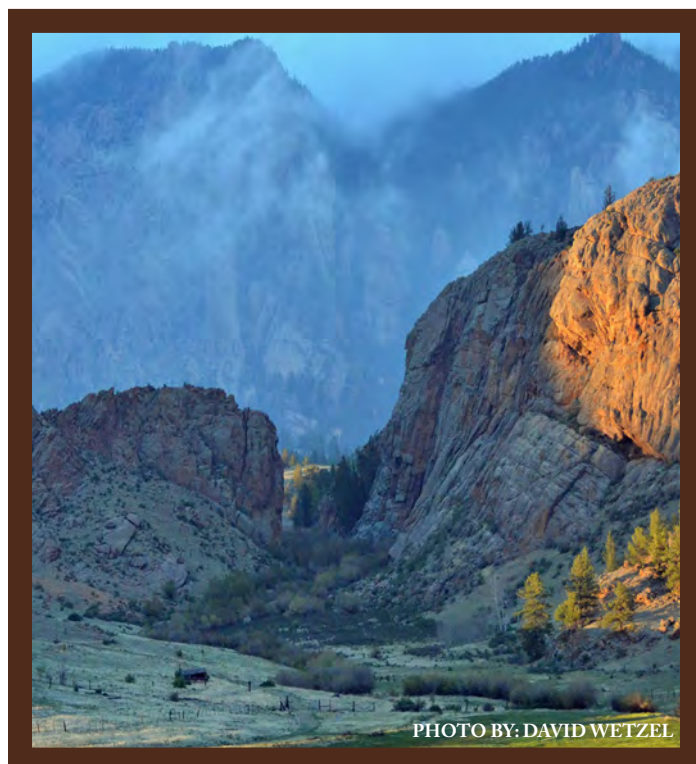


PHOTO BY: DAVID WETZEL

minimizing impacts associated with humans and resultant changes in ecological communities.

**Background**

Bighorn sheep occupy a diversity of ecosystems ranging from cold and high elevations in the north to the hottest and driest regions in the southern part of their distribution; factors that shape the quality and quantity of their habitat are just as diverse. Acting alone or in combination, direct and indirect human impacts and vegetative changes lead to degradation, fragmentation or loss of habitat and, ultimately, limit both viability and distribution of bighorn sheep populations.

Addressing the impacts of human encroachment is one of the greatest challenges faced by bighorn sheep and managers today. Direct impacts include energy development, mineral exploration and extraction, residential or industrial development, infrastructure development such as highways and roads, as well as others. Intensive recreational uses can also impact bighorn sheep populations through displacement of animals. Grazing by domestic animals or feral hoofstock on bighorn sheep ranges can degrade and dramatically reduce availability of preferred forage and contribute to the spread of invasive or

noxious plant species. In some desert mountain ranges, anthropogenic impacts to water availability, distribution, or quality have adversely affected bighorn sheep.

Some natural processes also have implications for bighorn sheep habitat. Ecological succession is the directional, predictable, and orderly process of community change involving replacement of one plant community by another. Vegetative succession, primarily encroachment of woody vegetation (trees and shrubs) into open foraging areas or movement corridors, can impact both quantity and quality of forage, reduce the ability of bighorn sheep to detect and evade predators, reduce access to escape terrain or security cover, and change or severely restrict traditional movement patterns. Further, establishment of invasive and exotic plant species can dramatically alter the quantity or quality of forage available to bighorn sheep.

In addition, conflicting goals or strategies among agencies sharing management responsibilities can hinder the effectiveness of habitat management for bighorn sheep. Most state, provincial, and territorial wildlife agencies have legal authority that extends only to resident wildlife. Much of the authority for managing bighorn sheep habitats exists with a federal or crown agency for the majority of public lands in the U.S. and Canada, respectively, or with private, corporate, or aboriginal landowners. The unique values and priorities reflected within these authorities often lead to differences in management objectives and capabilities for a given geographic area that may not be favorable to bighorn sheep. Managers must work cooperatively to protect all habitat currently in good condition, to improve habitats that are not, and to address other factors limiting the potential for populations of bighorn sheep to thrive.

**WAFWA:**
• Recognizes habitat conservation as the cornerstone of bighorn sheep management.
• Acknowledges the diversity of stakeholders responsible for managing bighorn sheep habitat throughout North America, including governmental resource agencies, industry, First Nations, private

landowners, and non-governmental organizations.
• Supports partnerships and collaborative approaches among stakeholders to protect, manage, and enhance habitat for bighorn sheep.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Optimize quality and quantity of bighorn sheep habitat throughout the range of this iconic species.

*Objectives and Strategies:*
1. Identify those factors that limit or threaten the ability of an otherwise suitable area to provide optimal habitat for bighorn sheep.
   A. Delineate occupied and potential habitat and movement corridors throughout the distribution of bighorn sheep.
   B. Prioritize habitat management efforts.
2. Protect, restore and manage bighorn sheep habitat.
   A. Develop and, if necessary, implement habitat management procedures to protect and maintain open landscapes, suitable escape terrain, and unobstructed movement corridors.
   B. Encourage use of natural or prescribed fire, proper grazing, management of livestock and feral or exotic ungulates, and other proven treatments to minimize encroachment of woody or exotic vegetation while enhancing opportunities for establishment of native plants to provide a sustainable forage base.
   C. Ensure adequate distribution of water through protection of existing perennial or ephemeral sources and provision of wildlife water developments when appropriate.
   D. Establish partnerships and develop collaborative approaches with land management agencies, First Nations, industry, private landowners, and non-governmental organizations to enhance the quality and quantity of bighorn sheep habitat.
   E. Develop standardized habitat management guidelines and implement habitat management strategies consistently across jurisdictional boundaries.
   F. Promote programs to acquire habitat through purchase or trade, implementation of conservation easements, reallocation of forage on

vacant allotments, or conversion of allotments from domestic sheep to cattle when in or near bighorn sheep habitat.

3. Minimize human impacts

  A. Participate in all levels of land-use planning and coordinate with industry,  municipalities, transportation departments, land management agencies, landowners, and others to:

  a. Discourage development within bighorn sheep habitat and movement corridors.

  b. Minimize disturbances associated with recreational use.

  c. Monitor impacts of anthropogenic disturbances, and implement corrective action(s) as necessary.

  d. Develop effective methods of mitigation or reclamation.

4. Education

  A. Develop and implement public education programs that emphasize habitat requirements of bighorn sheep, adverse impacts of development and other human disturbances, and the need for proactive habitat protection, restoration, and management.

## HUMAN ENCROACHMENT

The human population is rapidly expanding across western North America and has substantial influences on the restoration, management, and survival of bighorn sheep. The consequences of human activities are reflected in various ways, including physical effects to bighorn sheep and impacts to the habitat in which they live. Individually and collectively, the impacts of industrial development, energy development, urban development, agriculture, recreation, other land use practices, and climate change are substantial and growing. Continued human population growth and expansion across the western landscape is inevitable, but measures can be implemented to provide protection and the necessary requirements for ensuring the long-term viability of populations of bighorn sheep throughout western North America.

**Background**

Bighorn sheep occupy geographic areas that were among the last to be exploited. These habitats generally are sensitive to erosion and degradation,

and recover slowly from impacts because of topography, elevation, soil types, and climate. The "human footprint" largely appeared with the westward advancement of civilization during the mid-to-late 1800s. Establishment of urban centers, livestock grazing, mining, and industrial activities soon followed. Today, U.S. Census Bureau surveys indicate that the western U.S. is among the fastest growing regions in North America, and the growth rate of some western states is double that of the entire country. Similarly, Statistics Canada reports that most of the Canadian population lives in the southern part of the country near the U.S. border, with some of the largest concentrations located in Alberta and British Columbia — the only provinces with populations of bighorn sheep.

A review of the literature indicates that bighorn sheep often react strongly to direct and indirect sources of disturbance. Direct human impacts to bighorn sheep habitat include urban expansion, energy development, mining, gas and petroleum exploration, wind, solar, and others — and enhancement of infrastructure required for maintaining those developments (roads, buildings, transmission lines, and others). Current land use policies and practices, such as livestock grazing, overpopulation of feral animals, and fire suppression also impact habitat directly by altering natural communities and the processes that



PHOTO BY: JIM HEFFELFINGER (AZGFD)

sustain them. Indirect impacts occur through aerial disturbance and activities such as use by off-highway vehicles, hiking, mountain biking, rock-climbing, and other forms of recreation. Increased levels of stress (as indexed by flight distances and heart rates) and altered habitat use (as indicated by abandonment or avoidance of high-quality habitat or increased use of marginal habitat) also have occurred. Additional direct and indirect impacts of human disturbance include increased susceptibility to predation, reductions in nutrient intake as a result of decreased forage quality or quantity, habitat fragmentation, and interruption of seasonal movement patterns that reduce opportunities for metapopulation function. All of these potentially lead to decreased health, productivity, and viability at the individual and population levels.

The persistent pressure of humans and their activities are among the most difficult challenges with which managers are faced. Restoring bighorn sheep to suitable habitat depends on the ability of managers to employ effective strategies for addressing these impacts. Limiting development, eliminating the most onerous sources of recreational disturbance within bighorn sheep habitat, and creating effective public outreach programs are critically important to successfully confronting the challenge of human encroachment.

**WAFWA:**
• Recognizes that continued human population growth and expansion across the western landscape are inevitable.
• Advocates that measures be implemented to provide protection from human encroachment and other necessities to ensure the long-term viability of bighorn sheep.
• Supports efforts to eliminate, limit, or modify development within bighorn sheep habitat.
• Encourages efforts to minimize recreational impacts to bighorn sheep.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Minimize human encroachment on bighorn sheep habitat while providing appropriate levels of recreational opportunities.

*Objectives and Strategies:*
1. Eliminate, limit, or modify development within crucial bighorn sheep habitat.
   A. Delineate core habitat, lambing areas, seasonal ranges, and movement corridors for land use planning or land development decisions.
   B. Coordinate with governmental agencies, industry, energy, municipal, and other zoning authorities, and agricultural interests, to properly plan, implement, and adequately mitigate impacts to bighorn sheep habitat.
   C. Actively engage in planning efforts with transportation and land management agencies to facilitate movements by bighorn sheep and minimize vehicle collisions and other conflicts associated with highways and roads.
   D. Review public land and private livestock grazing plans and provide recommendations for grazing compatible with population management objectives for bighorn sheep.
   E. Investigate, and implement to the extent possible, the use of conservation easements, incentive programs, state or federal conservation programs, land acquisitions, and other potential mechanisms to protect bighorn sheep habitat.
2. Minimize recreational impacts to bighorn sheep habitat.
   A. Engage formally in land management planning efforts and operations to provide ample public opportunities while minimizing recreation-related disturbances.
   B. Limit those recreational activities known to have demographic consequences for bighorn sheep during critically important periods, such as breeding, lambing, and migration.
   C. Continually assess and monitor the responses of bighorn sheep to recreational activities, and collaborate with land management agencies and recreational interests to develop corrective strategies if warranted.
3. Initiate effective outreach efforts to educate the public concerning biological requirements of bighorn sheep, potential impacts of human disturbance, and strategies for managing them.

## COMPETITION

Exploitative competition occurs when two species utilize a resource that is in short supply (e.g., food, water, or cover) to the extent that use benefits one of those species at the expense of the other. Interference competition occurs when one species excludes or limits another from utilizing a particular resource, and thus inhibits survival, reproduction or other parameters as a result of behavioral interactions. In both cases, the degree of competition that occurs depends on the resource and the competitors involved. Despite the unique nature of the habitat in which they live, bighorn sheep share the landscape with other native ungulates, domestic livestock (cattle, sheep, and goats), feral horses and burros, and free-ranging exotic hoof stock. All of these are potential competitors for forage, water, or space, and all have the potential to impact bighorn sheep habitat both short- and long-term. Competition for limited forage and water resources, and direct impacts such as reduced habitat availability, habitat avoidance, reduced forage quality or quantity, or both, are well-described in the literature. The promotion of less desirable or highly invasive exotic vegetation and degradation of water sources and water quality can also occur. Further, the elimination of fine fuels through improper livestock grazing often results in the loss of opportunities to use prescribed burning or managed wildfires to improve habitat quality. Understanding and then addressing the impacts of domestic, feral, or exotic ungulates is a significant challenge for bighorn sheep managers.

**Background**
Domestic cattle, sheep, goats, horses, and donkeys arrived in North America as early as 1500, and their numbers increased dramatically as explorers and missionaries expanded their presence and the "human footprint." For many decades the distribution or numbers of domestic sheep and cattle were not regulated, and both species roamed across much of western North America. Simultaneously, feral equids became established in many areas, and landowners began to import exotic hoof stock, either as pets or for their potential as game animals.



PHOTO BY: ROSS HALEY (NPS)

Shortly after the turn of the century, U.S. Forest Reserves were created and, in 1934, the U.S. Grazing Service was formed. These became the U.S. Forest Service and Bureau of Land Management, respectively, and were formed, in part, to administer grazing on public lands. Regulations were developed, and fences and other infrastructure constructed; implementation of grazing seasons, and the concept of forage allocation followed. In the U.S., management of public rangelands is governed by federal and state laws, and those laws dictate that managers address the impacts of livestock grazing on all wildlife. In contrast, more recent legislation protected horses or burros occupying public lands, and considered those feral equids to be part of the natural system. A further complication arises when other exotic ungulates occur as free-ranging populations in bighorn sheep habitat.

In Canada, cattle were first introduced to areas containing bighorn sheep in the mid-1800s to support expanded settlement associated with the discovery of gold. The "Breeding Stock Act" of 1873 recognized the rights of ranchers to graze Crown lands and the "Cattle Ranges Act" of 1876 initiated regulated grazing on Crown lands. Additional protection was afforded in 1919 with passage of the "Grazing Act." Despite these efforts, degradation of rangelands continued through the 1940s. In the 1970s, the provincial governments began repatriating land for wildlife use, initiated a deferred-rotation grazing

program, and coordinated resource management plans to manage forage for both livestock and wildlife. Consequently, range condition on Crown lands continued to improve and, in 1978, the Forest and Grazing Acts were revised and reauthorized by the Legislature. Maximum production goals for both forest and range resources and long-term economic and social benefit were recognized.

Domestic, feral, and exotic ungulates all have the potential to be competitors with bighorn sheep, or to alter the habitats occupied by bighorn sheep. Hence, the presence and management of those non-native species is an important consideration with implications for conservation in western North America. For example, cattle frequently are sympatric with bighorn sheep, and share the same forage and water resources. Bighorn sheep have been reported to avoid areas that are occupied by cattle, and some investigators have reported that interference competition occurs. Overgrazing by cattle reportedly has changed the structure of rangelands to the detriment of bighorn sheep, and cattle may usurp resources that otherwise would be available to bighorn sheep.

Horses and burros both have the ability to behaviorally displace bighorn sheep, particularly in arid environments, from important resources such as water. By sheer numbers, burros are also known to out-compete bighorn sheep for water in areas where that resource is limited, and they also pollute sources of fresh water in desert environments with feces and urine. In extreme drought conditions, burros fare well relative to bighorn sheep, because they have a broader forage niche and are able to make use of poor quality or coarse forages.

Domestic sheep, grazing on high-elevation rangelands in western North America, reportedly competed for forage with bighorn sheep, and exploitative competition has been posited as a factor explaining the demise of some populations of bighorn sheep. Exotic ungulates such as Barbary sheep are behaviorally dominant to bighorn sheep, and compete with those native ruminants for resources where the two species are sympatric. It is probable that



PHOTO BY: MICHAEL T. PITTMAN (TPWD)

other exotic bovids also dominate bighorn sheep, or otherwise are competitors when resources are limited.

Additionally, under certain conditions some native ungulates also have the potential to compete with bighorn sheep and, thereby, have important implications for conservation. Interference competition by mule deer has been reported at water sources in arid environments, and mountain goats reportedly have displaced bighorn sheep or prevented them from using otherwise available resources. Mule deer and bighorn sheep generally occupy different types of terrain, but share some of the same forage resources; mule deer generally are more numerous, have greater biotic potential, and have recovered in numbers more rapidly than bighorn sheep following periods of resource limitation. Greater potential for competition occurs with elk, because they are larger than bighorn sheep, can utilize a broader range of forages, and sometimes gather in large numbers in alpine areas utilized by bighorn sheep.

**WAFWA:**
- Encourages land management decisions and use of management techniques that result in good to excellent ecological condition on public and private rangelands.
- Supports efforts to minimize competition from domestic or feral livestock and exotic hoofstock, to reduce adverse impacts to bighorn sheep habitat and

availability of resources.
• Encourages harvest management strategies that are intended to reduce negative competitive interactions between bighorn sheep and other native ungulates.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Minimize the adverse impacts of competition through proper management of domestic livestock, exotic hoofstock, and other native wildlife.

*Objectives and Strategies*
1. Encourage proper stewardship and land management decisions through participation in land-use planning for public lands and technical guidance on private lands.
   A. Encourage proper management of domestic livestock.
      a. Evaluate public land grazing allotments and private lands to identify potential conflicts with bighorn sheep.
      b. Assess grazing operations and encourage systems that benefit bighorn sheep, other wildlife, and livestock producers.
      c. Recommend alternatives to domestic sheep and goat operations within important bighorn sheep habitat.
      d. Prevent domestic livestock or exotic ungulates from utilizing water sources used by bighorn sheep, while simultaneously ensuring water availability for use by domestic livestock at alternative locations.
   B. Promote effective management of feral horses and burros at appropriate levels to prevent degradation of bighorn sheep habitat.
2. Preclude the future releases of exotic ungulates in bighorn sheep habitat, and work with land management agencies and landowners to remove existing populations.
3. Monitor other native ungulate populations, establish management objectives, and implement harvest strategies to achieve desired population objectives.

## DISEASE

Disease is one of the most important factors affecting populations of bighorn sheep. In contrast to other free-ranging wildlife, bighorn sheep experience population-level die-offs at consistently higher frequencies. These landscape-scale epizootic events limit bighorn sheep numbers and range expansion. They are costly to address, monitor and research, are difficult to manage both biologically and socially, limit use and enjoyment of the public resource, prevent jurisdictions from achieving restoration and management goals, and threaten long-term viability of some populations of bighorn sheep.

**Background**
Disease was a primary factor in the decline and extirpation of bighorn sheep across much of their historic range through the early-to-mid 1900s, and continues to affect numbers and distribution today. During the winter of 2009–2010 alone, 9 separate bighorn sheep pneumonia-related die-offs (an estimated mortality of 1,600-1,700 animals in total) occurred across 5 western states. Those losses represent >1% of the total number of bighorn sheep in the western U.S. and Canada, with individual herd losses ranging from 5% to 95%.

Wild sheep are susceptible to a variety of diseases and parasites that can affect herd viability. However, the most important health problem experienced by U.S. and Canadian bighorn sheep populations are respiratory infections that result in pneumonia. Pneumonia in wild sheep can result in all-age morbidity and mortality (collectively referred to as "die-offs") and is typically followed by extended periods of poor lamb recruitment and population declines. Bacteria of the family Pasteurellaceae (*Pasteurella multocida*, *Mannheimia haemolytica and Bibersteinia trehalosi*), and *Mycoplasma ovipneumoniae*, are the most common pathogens associated with population-level health events. Domestic sheep and goats commonly carry these organisms and do not frequently exhibit symptoms of disease. Research has demonstrated that these pathogens can be transmitted to bighorn sheep upon contact with, or proximity to domestic sheep or goats. Such pneumonia epizootics are frequently fatal to bighorn sheep within a few weeks, and there is currently no effective treatment once clinical signs are observed.

Maintaining effective separation between bighorn sheep and domestic sheep or goats is presently the most effective tool available for minimizing risk of respiratory disease. Effective separation is defined as spatial or temporal separation between bighorn sheep and domestic sheep or goats to minimize the potential for association and, thereby, the probability of transmission of diseases between species. In addition, many other bacteria, viruses, and parasites affect bighorn sheep. Parasites such as lungworms (*Protostrongylus* spp.), scabies (*Psoroptes* spp.), and others have been implicated in die-offs during the 20th century. However, most of these do not result in population-level all-age die-offs, as does respiratory disease.

Protecting and managing the health of bighorn sheep populations is essential to the continued success of restoration and management efforts in North America. Identifying the myriad of factors, such as pathogens, exposure history, physiological condition of affected individuals, and habitat issues that impact the level and persistence of diseases among bighorn sheep is critically important to future understanding and management. Managers must take appropriate steps to prevent epizootic events that result in die-offs and poor herd performance.

### WAFWA:

- Acknowledges the role of disease in natural ecosystems.



PHOTO BY: MIKE COX (NDOW)

- Recognizes the potential adverse effects of disease on bighorn sheep populations as the highest concern among all management challenges identified (Table 1).
- Encourages development of agency policies that support regular assessment and monitoring, implementation of appropriate health management strategies, and improved knowledge of pathogens and methodologies for identification, and treatment if possible.
- Advocates effective temporal and spatial separation between domestic sheep and goats and bighorn sheep as a primary management goal of state, provincial, territorial, and federal agencies responsible for the conservation of bighorn sheep.
- Supports science-based solutions at the local level through collaboration and consensus-building for the benefit of all stakeholders.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Maintain and increase healthy and productive bighorn sheep populations through assessment, monitoring, prevention, and management of diseases that impact population performance and viability.

*Objectives and Strategies:*
1. Develop agency policies that support improvement in the health of bighorn sheep populations.
2. Continually assess and monitor the health of populations of bighorn sheep.
   A. Review past and present herd performance and its relationship to environmental variables.
   B. Perform regular health-risk assessments and opportunistically collect and test blood and tissue samples for evidence of novel pathogens.
   C. Collect and evaluate bighorn sheep demographics, including recruitment and survival (adult, sub-adult and lamb), density estimates, age structure, and sex ratios to better evaluate differences between pre and post-disease event demographics and to assess the impacts and recovery from disease outbreaks.
   D. Assess source and recipient herd health prior to, and following translocations.
       a. Avoid translocations when confirmed or

substantial uncertainty exists concerning the disease status of either source or recipient herd.

   E. Investigate physical or behavioral abnormalities among bighorn sheep as reported by agency personnel and the general public.

   F. Monitor other factors, including habitat conditions and proximity of domestic sheep or goats, to populations of bighorn sheep.

3. Implement bighorn sheep management strategies that prevent or minimize epizootics while providing for recovery of populations following disease outbreaks.

   A. Maintain effective separation between wild sheep and domestic sheep or goats to prevent introductions of infectious or parasitic diseases.

   B. Coordinate with land management agencies, livestock industry, landowners, and other stakeholders to develop, implement, evaluate, and monitor safe and effective management practices.

   C. Develop and implement protocols for removing bighorn sheep or domestic sheep or goats when association is inferred or confirmed (according to agency philosophy).

   D. Evaluate the overall risks and consequences, short- and long-term, of allowing bighorn sheep survivors of a recent lethal disease outbreak to persist, and if warranted, remove them to prevent disease transmission to adjacent bighorn herds.

   E. Share information concerning bighorn sheep disease response protocols and post die-off demographics between and among agencies.

   F. Evaluate potential adverse consequences of translocations and conduct appropriate analyses of habitat suitability and risk of disease transfer prior to implementing any bighorn sheep translocations.

4. Improve knowledge through research and surveillance to identify key pathogens, and their sources, that prevent recovery of populations of bighorn sheep following epizootic events.

5. Develop educational materials and outreach programs concerning the risk of association between bighorn sheep and domestic sheep or goats, as well as the potential risk of disease transmission between populations of bighorn sheep.

6. Identify and support collaborative research and develop training opportunities focused on resolving impacts of endemic disease in bighorn sheep.

# PREDATION

Predation is a natural process and one that is of great importance in wildlife recovery or restoration efforts. The influences of predation on the population dynamics of bighorn sheep can be beneficial through regulation of numbers or natural selection. Conversely, predation can impede restoration efforts, reduce numbers below viable population levels under certain conditions, decrease availability of bighorn sheep for translocation purposes, and even lead to localized extirpations. Philosophies concerning the implementation of predator control (i.e., lethal removal of predators) in bighorn sheep conservation efforts differ widely. These differing points of view are not restricted to society in general, but also differ among and within the very agencies responsible for the conservation and management of bighorn sheep. The power of public opinion in shaping management decisions is substantial, and can be expected to remain so, despite scientific support for recommended actions.

**Background**
Predation on bighorn sheep is primarily a function of top carnivores that occur sympatrically with those ungulates. Mountain lions are the principal predators, and predation by coyotes, bobcats, and golden eagles has also been identified as important sources of mortality, particularly of lambs. Wolves can also be important predators of Rocky Mountain bighorn sheep, and mammalian predators having lesser impacts include lynx, wolverines, black bears, and grizzly bears. The very different hunting strategy of mountain lions (ambush predation) compared with wolves (coursing predation) potentially results in different impacts to bighorn sheep populations. Deaths by predation on populations at or near carrying capacity is generally compensatory, while predation among populations that are far below carrying capacity is apt to be additive; hence, rate of mortality due to predation is density dependent. Predation by wolves, depending on pack size, availability of alternate prey, and other circumstances

PHOTO BY: MICHAEL T. PITTMAN (TPWD)

can either be compensatory or additive. Mountain lion predation is generally considered to be less selective for vulnerable individuals and, therefore, more likely to represent additive mortality. Predation on bighorn sheep herds that are intrinsically small or that are far below carrying capacity, regardless of the predator responsible, have the potential to represent additive mortality. In extreme cases, an inverse density-dependent relationship can destabilize a system and result in the extirpation of small populations.

Top-down limitation by predators can delay restoration efforts by reducing the number of bighorn sheep available for translocation. In some situations, considerable funds have been expended by state or provincial agencies, and non-governmental organizations (NGOs) in efforts to reduce mortality or minimize risk of extinction that were attributed to high rates of predation.

While the importance of predators in ecosystems is clearly recognized, the effects of predation can be a challenge to bighorn sheep managers. Impacts of predation can be successfully managed through well-planned, science-based programs with specific goals, strategies, and established time-frames. Any such program must include a thorough evaluation of the factors potentially contributing to population declines. Population objectives and time-tables also must be clearly defined. Efforts to improve knowledge

concerning the impacts of predation and effects of predator management on ecosystem integrity, and implementation of outreach programs to inform the public are also important components of predator management programs.

**WAFWA:**
- Acknowledges the important role of predators in ecosystems.
- Recognizes and values the differing societal opinions and political realities among interest groups and stakeholders with respect to predator management, and simultaneously places great value on the opinions and recommendations of those professionals involved in the conservation and management of bighorn sheep.
- Recognizes predator removal as a valuable management tool for achieving conservation goals when predation is the factor keeping populations below management objectives.
- Advocates that predators be managed in a manner that ensures continuation of their ecological, scientific, and social values and in compliance with existing laws and regulations.
- Supports properly planned, science-based, and site-specific predator management that includes:
  - □ Sound scientific justification.
  - □ Specific and measurable management goals and objectives.
  - □ Specified scale, frequency, intensity, and duration.
  - □ Monitoring to determine whether the desired results are achieved.
  - □ Public outreach and education.
- Encourages sport-hunting as a primary method to manage predators.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Minimize impacts of predation on bighorn sheep populations while preserving ecosystem integrity.

*Objectives and Strategies:*
1. Develop and implement policies and plans that facilitate predator management if required to achieve bighorn sheep population objectives while meeting

public expectations and complying with existing laws.

2. Assess factors potentially limiting bighorn sheep populations in the context of a suite of management issues including habitat quality and quantity, disease, nutrition, predator and prey levels, human impacts, and others.

3. Outline site-specific and transparent prescriptions for predator management that have clearly identified goals, population objectives, and timetables for implementation.

4. Consider predator management if data indicate that predation is the primary factor in population declines, or when populations of bighorn sheep remain below viable levels.

    A. Commit adequate resources (time and funding) to achieve desired objectives.

    B. Evaluate and monitor the effects of predator management with respect to bighorn sheep population objectives using appropriate research methodologies.

    C. Properly plan translocations by selecting appropriate release sites that contain adequate habitat components, conduct any necessary predator management prior to translocation, and release large groups of bighorn sheep.

5. Improve understanding by the public concerning the important role that predators play in maintaining ecosystems and the potential of predator management to facilitate achievement of bighorn sheep conservation goals in some situations.

# POPULATION MANAGEMENT

Managing populations of bighorn sheep for long-term viability requires a proper balance between animals and their habitat. Managers must consider a number of demographic and ecological parameters before making decisions concerning appropriate bighorn sheep numbers and distribution for a given population and area. Population fluctuations of bighorn sheep occur in response to a variety of natural or human-induced factors, such as habitat condition, disease, predation, and weather, as well as others. While some of these issues are best addressed indirectly, population management is accomplished directly by manipulation of bighorn sheep numbers through regulated harvest or by translocations.

# TRANSLOCATIONS

Translocations have played an integral role in bighorn sheep restoration and management beginning in the 1920s; since then, approximately 20,000 bighorn sheep have been translocated in the U. S. and Canada. More than 1,400 separate projects have been implemented within the 17 WAFWA jurisdictions that manage bighorn sheep and, when combined with other strategies, have been remarkably successful in returning animals to their former range. Most jurisdictions that manage bighorn sheep view translocations as necessary for restoring those specialized ungulates to historic habitat, establishing new populations within suitable, but unoccupied, habitat, and augmenting existing populations. While captures and translocation are vital management tools, they are expensive and must be planned and implemented properly. Managers face additional challenges in locating adequate or appropriate sources of translocation stock, or when multiple jurisdictions are involved, particularly when crossing international borders.

**Background**

The decline of bighorn sheep populations and subsequent restoration efforts are well documented. A combination of regulated harvest, habitat management, and translocations has proven successful in increasing numbers and expanding the distribution of bighorn sheep. For the past 90 years, western states and provinces have captured and translocated bighorn sheep to accomplish a variety of objectives. Beginning in 1922 with the translocation of 12 bighorns from Alberta, Canada to Montana, USA, translocations have occurred within all WAFWA jurisdictions that manage bighorn sheep. These efforts have resulted in the successful establishment of self-sustaining populations on many historic ranges, increased numbers and genetic diversity of individual populations, and expanded the ranges of existing populations. Translocations continue to serve as one of the most important tools of bighorn sheep managers.

Despite these successes, a review of applicable literature indicates mixed results concerning the effectiveness of translocations in establishing viable

populations. While self-sustaining populations of <50 animals have been documented, small populations are especially vulnerable to the effects of disease, predation, inclement weather, declines in habitat quality or quantity, and loss of genetic diversity, as well as to unanticipated stochastic events. As a result, restoring bighorn sheep to areas from which they have been extirpated is difficult.

To increase the probability of successful translocations, biologists must thoroughly evaluate habitat suitability at the release site and the overall health and ecological characteristics of source and destination sites, and consider the number of animals available for translocation. Further, tradeoffs between anticipated benefits such as shifts in demographics, behavioral changes, and genetic interchange, must be considered in the context of the consequences of mixing bighorn sheep from various source herds, or the risk of increased connectivity and its implications for transfer of pathogens among populations.

**WAFWA:**
• Recognizes the translocation of bighorn sheep as an important management tool.
• Supports translocation of bighorn sheep for:
    □ Restoring bighorn sheep to historic habitat.
    □ Establishing new populations within suitable, but, unoccupied habitat.
    □ Augmenting existing populations to increase



PHOTO BY: EARL NOTTINGHAM (TPWD)

    numbers, expand distribution, or enhance genetic diversity.
• Supports the transfer of bighorn sheep from one jurisdiction to others to help achieve restoration and management goals.
• Encourages proper evaluations, planning, and implementation of translocations to enhance probability of success.
• Supports translocations that protect genetic integrity and distributions of subspecies within historic ranges.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Successful translocations for augmenting, establishing, or restoring sustainable populations of bighorn sheep through proper evaluations, planning and implementation.

*Objectives and Strategies:*
1. Develop and conduct thorough evaluations of source and destination populations and locations, and implement management strategies that avoid adverse impacts to existing populations and enhance the probability of translocation success.
    A. Determine availability of adequate levels of suitable habitat for translocated bighorn sheep, including areas suitable for range expansion.
    B. Identify and avoid source populations with historic disease, recruitment, or survival problems.
    C. Avoid introducing bighorn sheep into areas in which predation is anticipated to be problematic or when feral horses, burros and exotic ungulates are above acceptable levels.
    D. Avoid areas occupied by domestic sheep, and delineate and protect core bighorn sheep habitat and areas of anticipated range expansion to prevent overlap with domestic sheep following translocations.
    E. Determine health status of source herds prior to augmentation to minimize risk of disease transmission between source and recipient populations.
    F. Utilize appropriate source populations to maintain genetic integrity and distributions of subspecies within historic ranges.

G. Determine appropriate translocation rates that ensure protection of source populations while providing translocation stock in numbers sufficient to achieve objectives within destination populations.

2. Minimize adverse effects of removals on social structure and movement patterns of source populations.

3. Monitor population dynamics, distribution, movements, health, and habitat of source and destination populations, and the success — or lack thereof — of the translocated population of bighorn sheep.

4. Investigate population declines and implement appropriate management strategies for addressing the causes of those declines prior to undertaking any translocation or augmentation.

5. Coordinate with land management agencies, private-land owners, conservation organizations, and other interested parties to ensure support of proposed management actions.

6. Develop standardized protocols to facilitate translocating bighorn sheep between jurisdictions.

## VIABILITY AND CONNECTIVITY

Bighorn sheep generally exist as metapopulations, where the total population of a geographic area consists of smaller subpopulations occupying naturally fragmented patches of suitable habitat that are interconnected genetically and demographically by periodic movements of individuals among those subpopulations. Consequently, the viability of the greater metapopulation depends upon the persistence of the subpopulations of which it is comprised. Populations of bighorn sheep that are few in number and geographically isolated are more vulnerable to extirpation than larger populations, due to lower genetic diversity and an inability to replace individuals lost from a variety of causes. Maintaining the integrity and connectivity of individual subpopulations of bighorn sheep is, therefore, a priority for managers to ensure long-term viability of metapopulations distributed among a wide variety of habitat types. Encroachment of woody vegetation, the presence of domestic sheep or goats, habitat degradation and fragmentation, development, and anthropogenic

disturbances are known to be impediments to connectivity among subpopulations of bighorn sheep.

**Background**
Most populations of bighorn sheep throughout the U.S. were at historically low numbers by the early 1900s, a result of catastrophic losses caused primarily by introduced diseases and unregulated hunting. Degradation of habitat, lingering effects of introduced pathogens, competition with livestock, and anthropogenic development further threatened the viability of many of those remnant populations. Indeed, research has shown that habitat fragmentation, low numbers, and declines in habitat quality are the factors most likely affecting the long-term persistence of populations of bighorn sheep. Consequently, preservation of native populations of bighorn sheep was an early management strategy and became paramount to their restoration, or expansion into previously occupied habitats.

Because bighorn sheep are generally slow to disperse from natal ranges and colonize unoccupied habitats, wildlife agencies began translocating bighorn sheep during the 1920s. However, a marked increase in translocations occurred during the 1970s, following the formation of a number of bighorn sheep conservation organizations. These organizations, founded and supported largely by concerned hunters and bighorn sheep enthusiasts, provided opportunities for greater collaboration and coordination among wildlife agencies to effectively restore bighorn sheep to their former ranges. Because translocations are very expensive, those organizations also served as a major source of funding for translocation projects. Native populations throughout the western U.S. and Canada that had surplus animals were used as source-stock to augment extant populations that were vulnerable to extinction following correction of the factor(s) resulting in that vulnerability, and to restore extirpated populations to their historic ranges. These management actions not only stabilized many vulnerable populations, but resulted in greater connectivity and resultant genetic interchange among subpopulations that previously had been geographically isolated.

Although introductions to vacant habitats can promote genetic diversity among fragmented subpopulations of bighorn sheep, there are associated risks. For example, translocated stock could introduce novel pathogens to healthy animals or increase the likelihood of association with domestic sheep as bighorn sheep travel between subpopulations. Managers must, therefore, weigh the benefits of greater connectivity among subpopulations of bighorn sheep with the potential risk of disease transmission to otherwise healthy animals.

Contrasting behavior of migratory and non-migratory populations can also pose challenges to improving connectivity among populations of bighorn sheep. Migratory populations may travel many miles between seasonal ranges, whereas populations occupying lower elevations usually occupy a single seasonal range. Managers of migratory populations must not only consider connectivity to adjacent subpopulations, but also their access to seasonal ranges. Non-migratory bighorn sheep are more likely to be isolated from adjacent subpopulations due to their lack of seasonal migrations and expanses of marginal habitat that typically separate subpopulations occupying lower elevations.

Despite successful translocation efforts throughout much of their former range, impediments to natural movements continue to stifle genetic interchange among subpopulations of bighorn sheep. For example, proximity to domestic sheep or goats, encroachment of woody vegetation, construction of highways, and impassable fencing have stymied movements among native and introduced populations. Consequently, management efforts have achieved only nominal success in improving connectivity among geographically separated subpopulations of bighorn sheep.

**WAFWA:**
• Recognizes that connectivity among populations of bighorn sheep is important to their long-term viability and persistence.
• Acknowledges that the continued good health of extant populations takes precedence over the goal of greater connectivity and thus, discourages translocations if spatial separation with both domestic sheep and goats cannot be achieved.
• When justified, supports translocations of bighorn sheep to:
　□ Bolster extant populations.
　□ Restore animals to vacant habitats adjacent to extant populations.
• Encourages management actions that enhance connectivity among fragmented subpopulations of wild sheep including:
　□ Work cooperatively with livestock producers to remove or relocate domestic sheep and goats that are grazed within areas used by metapopulations of wild sheep.
　□ Reduction of woody vegetation via natural or prescribed fire.
　□ Construction of wildlife crossings over or under highways that have impeded traditional daily or seasonal movements of bighorn sheep.
　□ Modification of existing, or construction of new, fences to ensure those potential barriers do not impede movements of bighorn sheep.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES
**Management Goal:** Improve connectivity among


PHOTO BY: DAVID WETZEL

populations of bighorn sheep to increase genetic diversity and long-term viability.

*Objectives and Strategies:*

1. Refine information on the current distribution of bighorn sheep in North America.
   A. Distinguish populations that are isolated and whether suitable habitat exists adjacent to such populations for potential restoration.
   B. Map suitable bighorn sheep habitat in North America and identify migratory routes and likely travel corridors.

2. Introduce bighorn sheep to unoccupied habitat adjacent to extant populations.
   A. Introduce translocation stock from areas ecologically most similar to release locations to enhance prospects for success.
   B. Translocate stock from source populations that are disease-free to prevent introducing pathogens to healthy animals.
   C. Translocate bighorn sheep from indigenous populations when possible and release sufficient numbers of individuals to enhance prospects for success.
   D. Avoid translocating bighorn sheep to vacant areas if the potential for association with domestic sheep or goats exists.

3. Identify causes of fragmentation of bighorn sheep populations and whether the effects of those impediments can be lessened.
   A. Remove or relocate domestic sheep and goats to reduce risks of association with bighorn sheep.
   B. Collaborate with land management agencies to improve bighorn sheep movement corridors between seasonal ranges or adjacent subpopulations.
   C. Improve forage quality and quantity within bighorn sheep habitat to encourage range expansion.
   D. Consistent with agency philosophy, develop artificial water sources in xeric habitats while acknowledging historic winter ranges that lacked water, to encourage range expansion and enhance the likelihood of intermountain movements.
   E. Remove, or modify, anthropogenic barriers to natural movements of bighorn sheep, such as fencing or highways to enhance opportunities for interpopulation connectivity.
   F. Discourage anthropogenic development within core areas, migration routes, movement corridors and near water sources of bighorn sheep.

4. Collaborate with land management agencies, private land owners, conservation organizations, and other interested parties to achieve a broadly based management strategy that addresses inter-jurisdictional movements of bighorn sheep.

## HARVEST STRATEGIES

By the early 1900s, disease, unrestricted market hunting, and other impacts resulted in the extirpation of many bighorn sheep populations and greatly reduced numbers in other locations. Through establishment of regulated hunting and translocation efforts, bighorn populations increased or were re-established in many areas, and range-wide, bighorn numbers are currently higher than any time since European settlement of North America. Today, the opportunity to hunt bighorn sheep is among the most sought after hunting experiences. Sheep hunting appeals to those interested in the challenge, satisfaction, and experience of mountain hunting. Hunting bighorn sheep differs from that for most other big game because the quarry often occupies remote and rugged areas, and is logistically more difficult and physically demanding.

Even though many bighorn sheep populations have recovered, they currently occupy only a portion of their former range, and despite increases in their numbers, demand for hunting sheep is greater than current populations can provide. As bighorn sheep have recovered, it remains a challenge to maintain populations that provide an expected level of quality, while at the same time managing for appropriate densities and hunter opportunity.

### Background

As a result of unregulated harvest of bighorn sheep, most jurisdictions recognized the need for restrictive management by the early 1900s. Hunting seasons were established, or in some cases closed, to protect or rebuild bighorn sheep populations. Due to the low number of bighorn sheep, their importance to the hunting public, and concern over illegal harvest,

PHOTO BY: LARRY ALTIMUS

mandatory registration programs were established in many jurisdictions. This practice is now embraced by all jurisdictions that manage bighorn sheep, and allows for detailed information to be gathered from harvested animals, while simultaneously reducing illegal harvest.

The value of the opportunity to hunt bighorn sheep cannot be overstated. This is indicated by the persistent high demand for bighorn sheep hunting licenses, despite drawing odds of less than 1% in many jurisdictions. To address the high demand for this limited opportunity, many jurisdictions have implemented "preference point" or "bonus point" drawing systems that reward long-term applicants. This demand can also be seen in the prices paid for special fund-raising tags to hunt bighorn sheep, with many such permits auctioned for >$100,000.

Many jurisdictions manage bighorn sheep harvest with limited permits, although some jurisdictions offer general (unlimited) licenses and manage harvest through the use of horn-curl restrictions or harvest quotas. Some jurisdictions use a combination of limited permits and horn-curl restrictions. Whether by permit level, harvest quota, or horn-curl restriction, the primary goal is to harvest mature rams, which is reflected in an average age of about 7 years among rams harvested.

Most harvest management decisions take into account 1) population size and trend, 2) lamb recruitment (lamb:ewe ratios), 3) some index to the number or availability of rams in the population (ram:ewe ratios, the number of mature rams estimated or seen during surveys, average age of harvested rams), and 4) trends in hunter success or hunter effort, or both, from recent hunting seasons.

In some cases, bighorn sheep are susceptible to disease events or other density-dependent effects likely to be triggered as populations approach ecological carrying capacity. In such situations bighorn sheep are maintained at appropriate densities through translocations or the harvest of females. Ewe permits are very limited, and are usually based on achieving some desired population density in order to minimize or avoid the threat of disease-related die-offs or to protect forage resources that can be degraded when bighorn sheep are at high densities.

Over the last 20 years, harvest of bighorn sheep has increased primarily due to population increases, and nearly 1,500 bighorn sheep are harvested each year by hunters. Due to the success of translocation efforts, improved survey methodologies, enhanced disease awareness, and appropriate harvest management, the opportunity to hunt bighorn sheep has increased substantially, and quality of the sheep hunting experience has been maintained.

**WAFWA:**
• Recognizes bighorn sheep hunting as a highly desirable opportunity and the harvest of bighorn sheep as an important management tool for achieving management objectives.
• Supports appropriate and sustainable harvest of bighorn sheep, including the harvest of females.
• Recognizes the importance of basing harvest recommendations and other management decisions on defensible data such as population survey results, information from harvested bighorn sheep, and information from hunters.
• Supports law enforcement efforts to minimize illegal harvest or possession of bighorn sheep.
• Recognizes the importance of translocations, habitat enhancements, development of impact mitigation,

and disease prevention to maintaining or increasing hunting opportunities.

• Values the efforts of hunters in the conservation of bighorn sheep and their habitats.

• Promotes bighorn sheep viewing and other non-consumptive opportunities.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Greatest allowable bighorn sheep hunting opportunity through flexible management systems and monitoring.

*Objectives and Strategies:*

1. Monitor bighorn populations through the collection of appropriate information to ensure proper harvest management.

   A. Perform periodic population surveys, conducted in a consistent manner, to determine population structure, status, trend, and appropriate harvest levels.

   B. Conduct mandatory registration and marking of harvested bighorn sheep to collect age and other biological measurements or samples, and to preclude the harvest or sale of illegally obtained specimens.

   C. Collect and evaluate information gleaned from hunters that provide insight into bighorn sheep population status and condition, and the overall hunting experience.

   D. Coordinate monitoring efforts and harvest recommendations with other jurisdictions and management agencies to ensure proper harvest levels.

2. Develop and implement regulations that provide for greatest allowable hunting opportunities.

   A. Maintain flexible hunting seasons that provide high-quality experiences while providing for the biological needs of the animal.

   B. Consider "alternative weapon" regulations to facilitate bighorn sheep hunting opportunity.

   C. Implement harvest of female bighorn sheep when lower densities are desired and disease concerns, logistics of capture operations, or lack of suitable release sites limit translocation options.

3. Provide non-consumptive opportunities such as bighorn sheep viewing, photography and other activities.

## ORGANIZATIONAL CHALLENGES

In this period of shrinking fiscal resources, budgetary constraints, and differing points of view among bighorn sheep stakeholders, conservation programs for bighorn sheep often are viewed as a lesser priority than was the case in the recent past. Despite unresolved issues that warrant increased interest — among which are disease transmission, increasing development of oil or gas resources, political pressures to enhance the production of "renewable" energy on public lands, and increasing demands for a variety of recreational pursuits — resource management agencies are increasingly faced with demands to "do more with less." The inability to resolve that conundrum is realized by most agencies. Some have become almost entirely dependent upon bighorn sheep advocacy groups to carry out and fund many of the duties that formerly were viewed as agency responsibilities, including habitat enhancement projects and aerial surveys. In the absence of assistance from those non-governmental organizations, some bighorn sheep conservation activities would cease entirely. Nevertheless, those same organizations cannot continue their support and activities on an indefinite basis, particularly in the absence of agency guidance.

## FUNDING AND PERSONNEL RESOURCES

Like many other conversation programs, deficient funding and shortages of personnel severely limit the ability of resource agencies to achieve bighorn sheep management goals. Few agencies receive adequate financial support for bighorn sheep management, and most dedicate only a small portion of their overall agency budgets towards this endeavor. Budget

constraints and conflicting agency priorities force competition among other wildlife programs for limited funding and staffing, and often result in reactionary responses to catastrophic events rather than well-planned approaches to management. Consistent and sufficient funding and dedicated professional staff are critically important to the continued success of restoration and management of bighorn sheep in North America.

Agencies have employed a variety of creative strategies to leverage limited funding resources and other support for management. The sale of fund-raising tags to generate revenue for wildlife management and conservation has become a widespread phenomenon in western North America. Additionally, establishment of partnerships or sponsorships between public trust agencies and bighorn sheep conservation organizations has, in some cases, resulted in the continuation of programs that otherwise would have been reduced or eliminated as a result of budgetary constraints. Funding for management and conservation of bighorn sheep is provided in part or entirely by special auction or raffle tags (i.e., "Governor's" or "Minister's" licenses). Additional financial assistance is sometimes provided by conservation organizations and Crown or federal agencies. Further, state agencies are able to leverage funds through the Federal Aid in Wildlife Restoration Program. Such funds are used primarily for habitat enhancement or other on-the-ground projects, and may not necessarily be available for addressing many other bighorn sheep management needs.

Lack of staff dedicated to bighorn sheep management is one of the most important issues facing resource agencies. A recent survey of WSWG members indicated that approximately three-quarters of state, provincial, and territorial agencies currently experience staffing insufficiencies deemed important to bighorn sheep management programs. Similar staffing shortfalls are also reflected among the ranks of the federal land management agencies. Staffing constraints are among the toughest challenges for agencies to address, because legislative or policy restrictions generally limit the number of positions

available, and budgetary considerations largely affect how agency objectives or staffing assignments change. Ultimately, these considerations and across-the-board staffing shortfalls have led to, or will lead to, a shortfall of staff available for bighorn sheep management.

The long-term viability of bighorn sheep populations and restoration of bighorn sheep to suitable habitat throughout North America requires consistent and sufficient sources of funding, and personnel dedicated specifically to those purposes. Well-organized and efficient use of current resources is the first step in addressing this challenge. Success, however, ultimately depends on expanding partnerships between agencies, conservation organizations, and others, and the ability of agencies to acquire more non-traditional sources of financial support.

**WAFWA:**
- Recognizes the importance of and need for adequate funding and staff dedicated to achieve bighorn sheep management goals.
- Supports efficient use of available resources.
- Encourages pursuit of additional funding sources and creative strategies for addressing budget and staffing shortfalls.
- Encourages close cooperation with bighorn sheep advocacy groups to identify and synergistically enhance revenues available for bighorn sheep management programs.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Stable source of long-term financial and human resources dedicated to the restoration and management of bighorn sheep.

*Objectives and Strategies*
1. Ensure efficient use of existing financial and staff resources.
2. Identify future needs required for management, and plan staffing needs accordingly.
3. Develop collaborative approaches and partnerships among agencies and conservation organizations to address shortfalls.
   A. Identify and secure alternative funding sources.

B. Explore opportunities for sharing positions among other agencies or organizations that are dedicated to bighorn sheep conservation.

C. Investigate opportunities for creating endowment funds through private donation or other means to support bighorn sheep restoration and management.

D. Obtain support from major foundations with interests in the conservation of bighorn sheep.

## MANAGEMENT RESTRICTIONS



US. DEPARTMENT OF THE INTERIOR
Bureau of Land Management

Big Horn Mountains & Hummingbird Springs
WILDERNESS AREA

PHOTO BY: LEEANN MURPHY (USFS)

Management protocols and strategies differ from landowner to landowner and, similarly, from agency to agency. Some sideboards by which agency activities are constrained are founded on well-intentioned legislation that can have unintended consequences. If legislation does not preclude certain activities, policies or guidelines, regulations often do. Just as no two landowners are likely to agree on every aspect of how best to manage their respective properties or other resources, agencies, representatives of agencies, individuals, and special interest groups all have the ability to emphasize management actions that are potentially detrimental to conservation objectives for bighorn sheep. As with shared management responsibilities, agreements and disagreements between individuals or entities can have a profound impact on overall efforts to conserve bighorn sheep.

**Background**
Most populations of bighorn sheep occupy lands owned or managed by federal and Crown governments or First Nations, although some populations occupy lands owned or managed by state

and provincial agencies, or private landowners. Many areas that formerly were occupied by bighorn sheep are no longer suitable, but many populations have been introduced to areas from which they previously had been extirpated. Translocations or introductions of bighorn sheep to restore that species to historical ranges has been ongoing for nearly a century in North America, and has been the primary method by which populations have been re-established.

Mandates and philosophies can differ broadly among various agencies. Those differences can lead to situations where strategies implemented on lands managed by one agency are virtually impossible to implement on contiguous land for which another agency has authority, despite similar overall objectives for conserving bighorn sheep.

Throughout the U.S. and Canada, state, provincial, or territorial wildlife agencies are responsible for most resident wildlife, except those species that are managed through federal legislation. In Canada, this includes migratory birds, some aquatic species, and listed species at risk on federal lands. Among First Nations, the authority for management of resident wildlife rests with those entities. In situations involving privately owned lands, state, provincial, or territorial public trust agencies determine regulations regarding the protection or consumption of wildlife.

State, provincial, or territorial wildlife conservation agencies seldom are major landowners, particularly with respect to large tracts of habitat occupied by bighorn sheep. Thus, such agencies are constrained by laws, regulations, or policies that have been formulated largely as a result of politics, and affect the ability of managers to implement habitat enhancements on federal lands. The majority of such conflicts arise in situations where bighorn sheep occupy areas of legislated wilderness, and the use of prescribed fire, mechanical equipment, or aircraft are precluded, despite the potential benefits that may accrue to bighorn sheep. These constraints are further exacerbated by differing agency philosophies as they relate to interpretation of the various federal wilderness acts, differing philosophies among personnel responsible for administering wilderness,

and even personal opinions or preferences of individual personnel.

**WAFWA:**
• Recognizes and respects mandates affecting land management policies and programs carried out by federal agencies, First Nations, and private landown-ers.
• Views the restoration and conservation of bighorn sheep to be among the highest of priorities within areas formerly occupied by those ungulates.
• Recognizes wildlife conservation as one of the primary reasons for which wilderness areas have been established and strongly advocates that wildlife conservation be elevated to the same level of importance and recognition as other purposes for which wilderness areas were established.
• Emphasizes the importance of private lands and recognizes the value of positive relationships with those landowners to the long-term conservation of bighorn sheep in areas where public lands are scarce or otherwise not suitable for the restoration and management of bighorn sheep.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Work collaboratively with multiple jurisdictions, private landowners, non-governmental organizations, and other stakeholders to minimize and, if possible eliminate political and sociological impediments that could jeopardize the persistence of bighorn sheep at a landscape level.

*Objectives and Strategies*
1. Collaborate with federal agencies, wilderness organizations, and conservation organizations to elevate conservation of bighorn sheep and other wildlife to the same level of importance as other activities carried out on those public lands.
  A. Ensure that constraints on management actions imposed by wilderness or other designation are interpreted consistently by personnel and leadership, both within and among federal land management agencies.
  B. Engage in land management planning to ensure that bighorn sheep are considered.
2. Develop and implement standardized management

goals, objectives and strategies across jurisdictional boundaries so that activities designed to benefit bighorn sheep in one jurisdiction are not offset or negated by policies or philosophies on contiguous lands managed by another entity.
3. Work cooperatively with private landowners to develop appropriate management strategies that benefit restoration and conservation of bighorn sheep on private lands.

## SHARED MANAGEMENT RESPONSIBILITIES



Bighorn sheep are distributed widely across sociopolitical boundaries and, as a result, authority for management and conservation is shared among multiple entities. Lands owned or managed by governmental agencies, First Nations, or private landowners can be occupied by bighorn sheep. The responsibility for management or conservation of populations rests largely with state, provincial, or territorial wildlife agencies, although First Nations, private landowners, and some federal entities share those challenges. Conservation strategies can be complex because individual animals can move among geographic areas having disparate management or conservation strategies over short periods of time. For example, bighorn sheep have the capacity to move between areas open to or closed to hunting, private and public lands, grazed and ungrazed areas, wilderness and multiple-use areas, and even international boundaries. Thus, shared responsibility for the management and conservation of bighorn sheep results in sometimes complex challenges, and can become even more complicated as a result of bureaucratic inertia or interagency competition. These forces can result in duplication of effort, misappropriation of limited fiscal resources, interagency conflicts, and dissolution of previously approved management policies or strategies, all of which undermine efforts to ensure the viability of populations of bighorn sheep.

## Background



PHOTO BY: SALLY BUTTS (BLM)
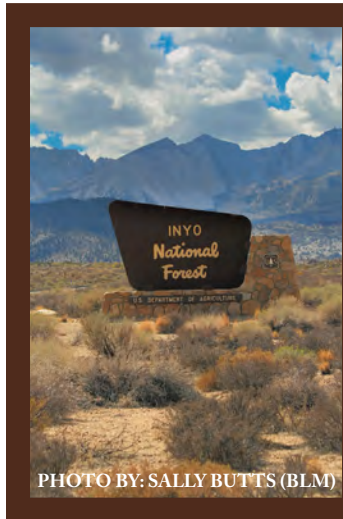
Shared management responsibilities, combined with different visions for conservation are challenging because government agencies have sometimes very different mandates. For example, bighorn sheep that occupy contiguous habitat managed by agencies with differing land-management philosophies can be plagued by "overprotection" of habitat on one side of a hypothetical boundary — as within a legislated wilderness that precludes habitat enhancement actions — yet can face virtually unregulated development by humans on the other side of such a boundary — as is the case with private lands abutting the Desert Wildlife Range in southern Nevada.

As a result of disparate land management strategies, shared management responsibilities have the potential to inhibit habitat enhancement activities, block movement paths, and can result in alterations to metapopulation function, preclude translocations, or otherwise affect the conservation of bighorn sheep. Disagreements among agencies with shared management responsibilities can, in some cases, result in the elimination of bighorn sheep populations, or prevent the establishment of populations intended to replace those extirpated as a result of human activities. Such disparities arise when partners do not share population or habitat goals, needs, or perceptions of viability, which often have their origins in agency cultures, advocacy groups, or personal opinions. Such disparities may be the results of a lack of biological knowledge, economic influences, historic relationships, or long-established traditions among or between concerned parties.

Bighorn sheep managers must be prepared to address the challenges of shared management responsibility through an understanding and appreciation of the difficulties associated with the mandates or interests of a variety of cooperators and stakeholders. In short, managers must have a method for resolving existing challenges, and be ever cognizant of the potential for new challenges to arise. Without question, mutual trust and respect between agencies or individuals with shared management responsibilities are the best means for resolving challenges facing the conservation of bighorn sheep. Establishing and maintaining meaningful relationships requires substantial investments in time by all parties, but has the potential to prevent disagreements before they become detrimental to the overall mission of conservation and to lessen frustrations among managers. Relationships built upon respect for the mutual goal of conserving populations of bighorn sheep and resultant ecosystem function will be critically important to maintaining bighorn sheep at a landscape level in the future.

Ensuring the viability of partnerships among those with shared management responsibilities requires persistent maintenance and nurturing by all parties. Regular and meaningful communication will fortify such relationships, and likely will lessen opportunities for disagreements. It is probable that conservation efforts will be most productive if focused on topics having consensus in the formative years of such partnerships, rather than on those that may be more contentious in terms of landowner objectives or agency mandates. Personnel sharing management responsibilities for bighorn sheep with other entities are apt to willingly share information, data, and literature regarding pertinent research or management strategies. When new ideas are identified, successful personnel will attempt to gain commitments from other partners by seeking consultations and, as goals are realized, all partners should receive credit for their contributions.

### WAFWA:

- Acknowledges the challenges associated with shared management and the potential of such to adversely affect conservation of bighorn sheep.
- Recognizes the diversity of entities involved in bighorn population and habitat management and the importance of developing partnerships with those with shared management responsibilities.

• Encourages cooperation among stakeholders through regular communication, trust, and mutual respect.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Develop partnerships among agencies and other entities, as appropriate, to further bighorn sheep conservation.

*Objectives and Strategies:*
1. Identify populations that are subject to shared management challenges and work cooperatively with stakeholders to develop goals, objectives and strategies; outline responsibilities; clarify communication avenues; and identify potential solutions to further the conservation of populations of bighorn sheep.
2. Engage in agency management planning efforts to ensure that bighorn sheep are considered when management strategies are developed.
3. Work closely with the WAFWA WSWG to develop appropriate training, projects, and publications that are intended to foster collaboration among stakeholders.

## CLIMATE CHANGE

Scientists worldwide acknowledge that the earth's temperature is warming at an accelerated pace. Some experts claim that minimum winter temperatures in the western U.S. have risen as much as 10 degrees Fahrenheit in the last 50 years. Associated with such climate shifts may be changes in precipitation patterns, frequency and intensity of periods of drought, shifts in the seasonal timing of plant growth, and other environmental influences. In turn, big game species across North America potentially will face shifts in forage availability or thermoregulatory needs, disease or parasite prevalence, and other ecological changes. Each of these factors will be exacerbated by habitat loss or fragmentation and, collectively, will result in unprecedented pressures on wildlife. Bighorn sheep will not be immune from these pervasive effects. It has been estimated that $6 billion will be needed annually for conserving species and ecosystems in the face of climate change. For nearly

100 years, resource managers have faced conservation challenges successfully, and will confront conservation issues associated with climate change in a professional manner.

**Background**
Over the next generation, scientists predict that as many as one third of all plants and animals will be at risk of extinction if the average rise in global temperatures exceed 3.6 degrees Fahrenheit. For each degree of temperature increase, average rainfall is expected to increase by 1%, but this water will likely not be available to primary producers due to increased evaporation and shifts in the distribution of precipitation.

Climate change is predicted to impact habitats occupied by bighorn sheep across their range, particularly at their southernmost distributions, at lower elevations, and in isolated mountain ranges. Reduction in snowpack or availability of surface water, coupled with changes in forage quality and availability, are some of the more pronounced habitat changes that have been suggested. Less snow and more rain will mean changes in the amount, duration, and timing of water available to plants, and the herbivores that are dependent upon them.



PHOTO BY: EARL NOTTINGHAM (TPWD)

As a result, the carrying capacity for bighorn sheep on some ranges likely will shrink. As the number of frost-free days increases, alpine habitats will likely be replaced as forests encroach up-slope, further reducing the quality of sheep habitat. Potentially milder winters will also mean increased susceptibility to invasive plants, or vectors of disease, that previously were limited by prolonged freezing temperatures. Ironically, any decrease in harsh winter conditions could offset mortality of bighorn sheep that previously resulted from low temperatures.

Down-scaled climate models will help predict future change to ecosystems or habitats and, ultimately, to species. State, provincial, federal, Crown, and non-governmental organizations must plan and implement strategies that will benefit the conservation of bighorn sheep in the future. Among such strategies are funds adequate to mitigate changes in habitat quality, and acceleration of restoration efforts.

**WAFWA:**
• Recognizes that climate change is a potential threat to populations of bighorn sheep in western North America.
• Acknowledges the need for expanding current conservation efforts to reduce stressors and build resiliency in natural systems.
• Opposes actions that are based on speculative climate-related impacts over long (century) timeframes.
• Encourages filling information gaps through research and adaptive management to meet increasing challenges associated with climate change.
• Supports collaboration among diverse partners to address the complex impacts of climate change.
• Promotes development of outreach programs to educate a diverse public about the conservation challenges associated with climate change, and to build support for ongoing bighorn sheep management efforts.

## MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

**Management Goal:** Ensure the persistence of

populations of bighorn sheep in the face of climate change.

*Objectives and Strategies:*
1. Develop down-scaled climate models for each eco-region where bighorn sheep occur.
2. Conduct vulnerability assessments for bighorn sheep and the ecosystems they occupy.
3. Engage partners in collaborative efforts to conserve bighorn sheep.
   A. Incorporate the conservation of bighorn sheep into state wildlife action plans.
   B. Ensure that bighorn sheep are conservation priorities in appropriate Landscape Conservation Cooperatives.
   C. Provide technical guidance or other incentives to landowners in cooperative efforts to conserve bighorn sheep habitat on private lands.
4. Develop ecoregional habitat conservation plans to facilitate latitudinal or elevational movements of bighorn sheep.
   A. Identify strategic habitat linkages and movement corridors for bighorn sheep and, where appropriate, encourage conservation easements on private lands.
   B. Seek opportunities for acquiring essential habitat.
5. Consider long-term effects of climate change on population size and demography when developing hunting regulations.
6. Advocate for additional funding to ensure the persistence of populations of bighorn sheep that may be impacted by shifts in climate.

PHOTO BY: MICHAEL T. PITTMAN (TPWD)

# SUMMARY

The WAFWA WSWG is committed to the restoration and conservation of bighorn sheep for the benefit of future generations. Recognition of the challenges to the conservation of bighorn sheep, followed by implementation of the broad-based management goals, objectives, and strategies associated with those challenges is the first of many steps necessary to ensure the persistence of the species across the landscape. This document was developed by wildlife professionals with substantial experience in the field of conservation and, specifically, with the management and conservation of bighorn sheep. Our intent is to encourage agency administrators, fellow professionals, and interested publics to take the steps necessary to ensure viable populations of bighorn sheep in the future. We have acknowledged the positions of the agencies comprising WAFWA, with the hope that the enthusiasm and cooperation of all concerned will result in a synergism that, in the end, will yield programs that result in viable and sustainable populations, and ongoing metapopulation function, of bighorn sheep throughout suitable native habitat.

**Table 1.**

**Jurisdictional Importance Levels – Bighorn Sheep Conservation Challenges**

| CHALLENGE | AB | AZ | BC | CA | CO | ID | MT | NE | NV | NM | ND | OR | SD | TX | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Habitat | | | | | | | | | | | | | | | | | |
|   Quality-Quantity | H | L | H | L | M | L | H | H | H | M | H | M | H | M | M | M | H |
|   Human Encroachment | L | H | H | M | M | L | M | H | L | M | H | H | M | L | M | H | L |
|   Competition | L | L | L | L | L | H | L | H | H | M | M | L | M | H | L | L | L |
| Disease | M | M | M | H | H | H | H | H | H | H | H | H | H | M | H | H | H |
| Predation | H | M | M | M | M | M | M | L | L | H | M | M | M | H | M | M | L |
| Population Management | | | | | | | | | | | | | | | | | |
|   Translocations | M | L | M | H | L | H | H | H | M | M | H | H | M | H | H | L | M |
|   Viability and Connectivity | M | M | M | H | M | H | H | M | L | M | H | H | L | M | H | M | L |
|   Harvest Strategies | H | L | M | L | M | L | M | L | L | L | L | H | L | H | M | M | L |
| Organizational Challenges | | | | | | | | | | | | | | | | | |
|   Funding-Personnel Shortfalls | H | L | M | M | H | M | M | M | M | L | L | M | H | H | L | M | H |
|   Management Restrictions | L | L | L | L | L | H | L | M | M | M | L | M | L | L | M | L | M |
|   Shared Management Responsibilities | L | L | L | L | L | L | L | L | L | M | L | M | L | M | M | L | L |
| Climate Change | M | L | L | M | M | L | L | H | M | M | L | L | L | L | M | L | L |

*Importance Level: L=Low, M=Moderate, H=High*

*"Delivering conservation through information exchange and working partnerships"*

Alaska Department of Fish and Game
Alberta Fish and Wildlife Division
Arizona Game and Fish Department
British Columbia Ministry of Forests, Lands and Natural Resource Operations
California Department of Fish and Wildlife
Colorado Parks and Wildlife
Hawaii Division of Forestry and Wildlife
Idaho Department of Fish and Game
Kansas Department of Wildlife, Parks and  Tourism
Montana Department of Fish, Wildlife and Parks
Nebraska Game and Parks Commission
Nevada Department of Wildlife
New Mexico Department of Game and Fish
North Dakota Game and Fish Department
Oklahoma Department of Wildlife Conservation
Oregon Department of Fish and Wildlife
Saskatchewan Ministry of Environment, Fish, Wildlife, and Biodiversity Branch
South Dakota Department of Game, Fish and Parks
Texas Parks and Wildlife Department
Utah Division of Wildlife Resources
Washington Department of Fish and Wildlife
Wyoming Game and Fish Department
Government of Yukon Department of Environment