



Thinhorn 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

Jeremy B. Ayotte
Vernon C. Bleich
Clay E. Brewer
Darren L. Bruning
Troy M. Hegel
Bill A. Jex

Nicholas C. Larter

Rebecca A. Schwanke
Helen M. Schwantje

Matthew W. Wagner

British Columbia Sheep Separation Program
California Department of Fish and Wildlife (Retired)
Texas Parks and Wildlife Department
Alaska Department of Fish and Game
Yukon Department of Environment
British Columbia Ministry of Forests, Lands and Natural
Resource Operations
Northwest Territories Department of Environment and
Natural Resources
Alaska Department of Fish and Game (Retired)
British Columbia Ministry of Forests, Lands and Natural
Resource Operations
Texas Parks and Wildlife Department

Cover and back cover photos: Tim Shinabarger

Distribution Map (WSWG 2016):

Data sources: Darren Bruning (AK), Troy Hegel (YT), Bill Jex (BC), and Nic Larter (NT)

Map Author: Cristy Burch (TPWD)

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“Delivering conservation through information exchange and working partnerships”

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Photo courtesy of Andrew Walker, BC FLNR



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INTRODUCTION

Distributed across western North America, wild sheep occupy some of the most remote and challenging terrain in the world. These iconic species (*Ovis canadensis* and *O. dalli*) have substantial ecological, economic, and cultural value, and they are a vital component of the natural heritage of North America.

Indeed, the distribution of wild sheep in western North America extends northward from the Sierra Madre of Mexico to the Mackenzie Mountains in

the Northwest Territories and the Brooks Range in Alaska. The variety of issues affecting wild sheep is as diverse as the people who support their conservation or otherwise rely on them.



Photo courtesy of Conrad Thiessen, BC MFLNRO

To address the complexity of issues facing wild sheep, the Western Association of Fish and Wildlife Agencies (WAFWA) in 2007 created the Wild Sheep Working Group (WSWG). Comprised of representatives from 19 state, provincial, or territorial jurisdictions inhabited by wild sheep, the Bureau of Land Management, and the U.S. 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 federal, state, and First Nations or Tribal organizations, and wild sheep advocates, with the intent of enhancing the conservation of North American wild sheep.

The Wild Sheep Working Group recently published a review of the conservation challenges with which bighorn sheep (*O. canadensis*) are faced. Issues identified include those associated with habitat, disease, predation, population management, organizational challenges, and climate change. Recent research has indicated that challenges associated with the conservation of thinhorn sheep (*O. dalli*) differ somewhat from those identified for bighorn sheep, particularly with respect to the priority of various issues and their relationship to conservation. In this document, the WSWG has identified the most formidable management and conservation challenges faced by thinhorn sheep and those professionals responsible for managing this important natural resource (Appendix 1). Among these challenges are the general absence of management plans; an absence of legislation or regulations intended to minimize the risk of disease transmission from domestic sheep and domestic goats to thinhorn sheep; the potential for motorized access to impact thinhorn sheep populations; predation and its role in thinhorn population dynamics; a paucity of population-specific demographic information; a need to improve communication and collaboration among governmental and non-governmental stakeholders in private and public sectors; protection or enhancement of areas occupied by thinhorn sheep; and the potential impacts of a warming global climate. This publication is the first of many steps needed to help address those concerns and highlights these challenges, presents broad-based management goals and objectives, and suggests strategies for achieving the results that will help to ensure the viability of thinhorn sheep throughout their historical

distribution (Appendix 2). As such, it emphasizes the conservation challenges and management goals for jurisdictions in which thinhorn sheep occur. Thus, this document should be viewed as aspirational in nature and it is not intended to supersede management guidelines or objectives for thinhorn sheep populations currently in place within any jurisdiction.

**Distribution of Thinhorn Sheep in North America
(WSWG 2016)**



HABITAT

Thinhorn sheep are found in mountainous regions of northwestern North America and occupy some of the most expansive, rugged, and picturesque landscapes on the continent. The challenges of surviving in these habitats include extreme weather events such as winter rain-on-snow and prolonged cold spring rain events, wide ranges in seasonal and daily temperatures, heavy snowfalls and avalanche hazards, and severe windstorms. The intensity of these conditions varies both with geographic location and the effects of marine weather systems influenced by global climatic events, such as the Pacific Decadal Oscillation. Nevertheless, thinhorn sheep have adapted to these conditions and have evolved to exploit available refugia when these events occur, allowing them to persist in a remarkable variety of northern landscapes. Habitat conservation is a fundamental cornerstone of thinhorn sheep conservation and management.



Photo courtesy of Darren Bruning, ADF&G

HABITAT QUALITY AND QUANTITY

Habitat quality is generally dictated by two variables: (1) habitat capability, a measure of the potential ability of the environment to provide requisite habitat conditions; and (2) habitat suitability, which affects the ability of those capable habitats to help ensure population viability. These factors, along with habitat quantity, strongly influence the numbers and diversity of species. Availability and quality of suitable habitat ultimately determines the distribution, numbers, and density of wild sheep that a given area can support, all of which co-vary with other environmental factors.

Background

Thinhorn sheep require open, yet rugged terrain to forage efficiently and to provide for detection and evasion of predators. At the most basic level, thinhorn sheep habitats must contain adequate amounts of forage, escape terrain, birthing, loafing or respite areas, and unobstructed corridors through which they can move during their annual cycles. The value and juxtaposition of these specific habitat attributes to seasonal range selection and use cannot be overemphasized. While rugged lambing habitat is essential, thinhorn populations are most sensitive to availability of high-quality ranges during winter, when animals are physiologically and nutritionally most challenged. Variable weather, and its influence on soil moisture and growing conditions, is the factor most apt to influence habitat quality and carrying capacity for thinhorn sheep.

Despite the wide and largely contiguous distribution of thinhorn sheep throughout their historic

geographic range, there is consensus that most suitable habitat is currently occupied. In some jurisdictions, enhancement activities (e.g., prescribed burning of early successional sub-alpine habitats to enhance nutritional quality and availability of forage) have been undertaken to maintain existing habitat quality or create additional suitable habitat. The goal of such projects is to increase the distribution of higher-quality seasonal habitats and, ultimately, to increase population sizes. However these habitats can also promote interspecies grazing competition by supporting range expansion and higher numbers of other native ungulates, among which are elk and bison.



Photo courtesy of Kevin Hurley, Wild Sheep Foundation

Addressing the impacts of human encroachment will, in the future, become one of the greatest challenges faced by thinhorn sheep and those charged with the conservation of that species. Although most areas occupied by these specialized ungulates currently are "pristine," ensuring adequate levels of quality and quantity thinhorn sheep habitat will become much more challenging. Minimizing impacts associated with resource extraction activities, a growing human population, increased interest in backcountry recreational opportunities, climate change, and the cumulative or synergistic impacts of these factors on ecological communities and processes will require innovative strategies and supportive science in order to develop and apply effective social license and public stewardship to the thinhorn sheep resource.

The increase in anthropogenic impacts to thinhorn sheep habitat will be confounded by natural processes, such as the Pacific Decadal Oscillation and, potentially, by habitat succession associated with climate change. The Pacific Decadal Oscillation strongly influences climate at both local and continental scales and, thereby, has enormous implications for thinhorn population performance. These vagaries, however, will become more complicated if anticipated climate warming influences vegetative succession with a resultant decrease in the openness of habitats upon which thinhorn sheep are dependent. Thus, succession in the form of encroachment or densification of shrubs or trees can impact the availability and quality of forage, reduce the ability of thinhorn sheep to detect or evade predators, reduce the amount of functional escape terrain, and alter or severely restrict traditional movement patterns or migration routes.

Conflicting goals, strategies, and legislation affecting agencies with shared management responsibilities also can hinder the effectiveness of habitat conservation and management for thinhorn sheep. Within the U.S., most state wildlife agencies have legal authority that extends only to resident wildlife, with much of the authority or responsibility for managing thinhorn sheep habitat existing with a federal agency for public lands, or with private, corporate, or aboriginal landowners. In Canada, responsibility for managing thinhorn sheep habitat exists within provincial or territorial government; this often occurs with input from First Nations Co-Management Boards or a Cooperative Fish and Wildlife Working Group. Among agencies and

landowners, unique values and priorities often lead to differences in management objectives and capabilities that may not be favorable to thinhorn sheep within specific geographic areas or jurisdictions. Managers and advocates must work cooperatively to protect all habitat currently in good condition, to improve habitats that are not or that will become poorer quality in the future, and to address and mitigate other factors limiting the potential for populations of thinhorn sheep to thrive.



Photo courtesy of Kevin Hurley, Wild Sheep Foundation

WAFWA:

- Recognizes habitat conservation as a cornerstone of thinhorn sheep conservation and management.
- Acknowledges that a diversity of agencies and other active participants are responsible for managing thinhorn sheep habitat throughout the range of that species, including governmental resource agencies, First Nations or Tribal organizations, industry, landowners, and non-governmental organizations.
- Supports development of partnerships that result in collaborative approaches to protect, manage, or enhance habitat for thinhorn sheep.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

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

Objectives and Strategies:

1. Identify factors that limit or threaten the ability of an otherwise suitable area to provide optimal habitat for thinhorn sheep:
 - A. Delineate habitat and movement corridors throughout the distribution of thinhorn sheep.
 - B. Develop management plans that prioritize habitat management prescriptions.
2. Complete habitat assessments and prescribe appropriate actions for protection, restoration, or management of thinhorn sheep habitat.

3. Develop and implement habitat management activities to protect or maintain open landscapes, suitable escape terrain, or unobstructed movement corridors.
4. Encourage use of natural or prescribed fire, and other proven treatments, to minimize encroachment of woody or invasive non-native vegetation as a means of maintaining visual openness and an adequate forage base.



Photo courtesy of Darren Bruning, ADF&G

- A. Consider the implications of post-burn immigration by other ungulates and invasive plant species that could result in unfavorable competition with thinhorn sheep, an increase in the numbers or species of predators, and other impacts to thinhorn sheep.
5. Establish partnerships and develop collaborative approaches with land management agencies, First Nations or Tribal organizations, industry, private landowners, and non-governmental organizations to protect or enhance the quality or quantity of thinhorn sheep habitat.
6. Develop and implement standardized and conservative habitat management guidelines and best management practices and apply them consistently across jurisdictional boundaries.
7. Promote programs to acquire or protect important habitat through purchase or trade, implementation of conservation easements, or legislation that is intended to protect seasonal ranges.
8. Implement management frameworks or regulatory regimes that support wildlife health objectives and address risks related to the issuance of land-use tenures or public land leases for grazing, silvicultural purposes, and recreational use of domestic sheep or goats in or near areas occupied by thinhorn sheep.
9. Minimize human impacts.
 - A. Participate in all levels of land-use planning and coordinate with First Nations or Tribal organizations, industry, local governments, transportation departments, land management agencies, landowners, and others to:
 - a. Discourage anthropogenic development within identified thinhorn sheep habitat and movement corridors.
 - b. Minimize disturbances associated with recreational use.

- c. Monitor impacts of singular and cumulative anthropogenic disturbances, and implement corrective action(s) as necessary.
- d. Ensure implementation of effective methods for mitigating reclamation of development projects (e.g., mines, energy extraction activities) within thinhorn sheep range.



Photo courtesy of Larry Kruckenberg

10. Develop and implement public education programs that emphasize:

- A. Habitat requirements and the importance of protecting thinhorn sheep habitat.
- B. The potential for adverse impacts from contact with domestic sheep or goats.
- C. The concept of proactive habitat protection, enhancement, restoration, and management associated with resource development activities and other sources of human disturbance.

HUMAN ENCROACHMENT

Thinhorn sheep occupy geographic areas that are among the last in North America to be exploited by humans. However, the richness of mineral resources and the exceptional terrain for backcountry recreation (e.g., heli-skiing, off-road vehicle use) in and adjacent to thinhorn sheep range is drawing human activity and its concomitant impacts to wildlife habitat ever closer and at an increasing rate. Because of topography, elevation, soil types, and short growing seasons in the north, much of thinhorn sheep habitat is sensitive to erosion and degradation, and recovers slowly, if ever, from impacts. Human activities in the remote areas inhabited by thinhorn sheep are often of minimal concern until the cumulative effects become too great to ignore. Individually and collectively, the impacts of energy and mineral development, urban expansion, recreation, military activities, and other land use practices must be addressed through appropriate conservation strategies. Continued human population growth, resource extraction, and access to the remote regions of northern North America are inevitable. It is increasingly important to recognize these eventualities, raise awareness, and address these issues in order to implement precautionary and conservative policies or safe-guards that help ensure the long-term viability of thinhorn populations.

Background

Studies intended to measure thinhorn responses to changes in habitat and to human-related disturbances are limited. It is reasonable, however, to assume that thinhorn sheep will likely respond to anthropogenic disturbances, habitat fragmentation, and loss of habitat in a manner similar to bighorn sheep, mountain goats, or other mountain ungulates, including short-term negative reactions and potential impacts to individual fitness.

Adverse effects of humans and their activities on thinhorn sheep habitat are reflected in a variety of ways. Impacts include aircraft disturbances, urban expansion, military training or operations, and increased backcountry activity such as hiking, snow-mobiling, use of off-road vehicles, and heli-skiing. Further, more direct impacts are associated with mineral or oil extraction activities that have the potential to destroy or isolate habitats upon which thinhorn sheep depend.



Photo courtesy of Bill Oestreich, Blue Stone Guiding & Adventures LTD

The increased popularity of recreational activities, coupled with improvements in technology and mechanical capabilities of motorized vehicles, can greatly increase accessibility to areas occupied by thinhorn sheep. Assessments of the degree of impacts associated with specific areas and recreational user groups have not been performed; however, abandonment of lambing habitat and decreased fidelity to natal ranges that resulted in lower recruitment rates in areas of increased recreational activity have been documented.

Impacts of energy development, mining, gas and petroleum exploration, wind projects, and enhancement of infrastructure required for maintaining those developments continue to increase. These activities affect habitat in two ways: (1) by creating conditions in which thinhorn sheep abandon areas traditionally used to meet their life-history requirements (i.e., geographic areas used for birthing or rearing of young, seasonal ranges, mineral licks, or foraging); and (2) through the overt destruction of suitable habitat. Range abandonment has been observed among bighorn populations and should not be overlooked as a potential consequence of the aforementioned impacts on thinhorn sheep. Any disturbance that reduces nutrient intake or increases energy expenditure, particularly in winter months, has the potential to lead to declines in body condition, with resultant impacts to health, productivity, and viability at the individual and population levels.

A review of the literature indicates that thinhorn sheep react strongly to helicopters or fixed-wing aircraft in many situations, and may be less tolerant than bighorn sheep of such disturbance. As noted above, the energetic costs associated with behavioral reactions such as fleeing or disrupted

feeding patterns and its resultant influences on nutrient intake and, ultimately, body condition, are of substantial concern.

While the “human footprint” within thinhorn range currently is small, it can be large on a local (herd) scale. For example, a mining operation could destroy a critically important area used by a local population of thinhorn sheep or, indirectly, cause animals to abandon use of the same area. Limiting development, eliminating the most onerous sources of recreational disturbance, and creating effective public outreach programs all are critically important to successfully confronting the habitat conservation challenges associated with human encroachment. As encroachment inevitably increases, baseline assessments and monitoring of these cumulative effects is critically important for understanding, developing, and implementing appropriate management strategies at various scales.



Photo courtesy of Darren Bruning, ADF&G

WAFWA:

- Recognizes that continued human population growth and the northward expansion of recreational, renewable energy, and resource extraction activities are inevitable.
- Advocates the proactive implementation of precautionary measures to minimize impacts to thinhorn sheep habitat resulting from human encroachment.
- Supports efforts to eliminate, limit, modify or mitigate development in thinhorn sheep habitat.
- Encourages efforts to minimize recreational impacts to thinhorn sheep.

MANAGEMENT GOAL, OBJECTIVES, AND STRATEGIES

Management Goal: Minimize destruction of, or encroachment into, thinhorn sheep habitat while providing appropriate levels of use for economic and recreational purposes.

Objectives and Strategies:

1. Delineate core habitats, lambing areas, winter and summer ranges, and movement corridors for use in informing land-use planning or land development decisions.
2. Eliminate, limit, or modify development within thinhorn sheep habitats.
3. Coordinate with government agencies, First Nations or Tribal organizations, industry, energy, municipal and other zoning authorities, and agricultural producers to proactively identify opportunities to mitigate impacts to thinhorn sheep habitat through strategic land-use

planning or project-related operating processes.

4. Investigate and implement use of conservation easements, incentive programs, provincial, state, or federal conservation programs, protected area designations (e.g., parks and conservancies), land acquisitions, or other appropriate mechanisms to protect thinhorn sheep habitat.



Photo courtesy of Brian Churchill, BC MFLNRO

5. Minimize recreational impacts to thinhorn sheep habitat.
 - A. Engage in land management planning efforts and operations to remove, mitigate, or minimize negative impacts associated with recreation-related disturbances.
 - B. Restrict those recreational activities known to have demographic consequences for thinhorn sheep to times outside of important periods such as breeding, lambing, and seasonal movements.
 - C. Continually monitor the responses of thinhorn sheep to recreational activities and evaluate resulting impacts; collaborate with land management agencies or recreational interests to develop corrective strategies as needs arise.
6. Minimize impacts to thinhorn sheep populations and habitat on military installations and other training areas while accommodating military training and operational needs.
 - A. Participate in planning efforts to minimize or eliminate impacts related to military operations and training exercises.
 - B. Assist in preparing and implementing a thinhorn sheep management component to be incorporated into natural resource management plans for each military installation within thinhorn sheep habitat.
 - C. Assist in developing and implementing thinhorn sheep monitoring strategies and adapt management where needed to better conserve thinhorn sheep.
7. Implement effective outreach efforts to educate the public concerning biological requirements of thinhorn sheep, potential impacts of human disturbance, and strategies for mitigation and conservation.

COMPETITION

Exploitative competition occurs when two species utilize a resource that is in short supply (e.g., food, water, mineral licks, or cover) to the extent that occupation and use of the site or resource benefits one of those species at the expense of the other.

Interference competition occurs when one species excludes another from, or limits access to, a particular resource, and thus inhibits survival, reproduction, or other parameters as a result of behavioral interactions. In both cases, the degree of competition depends on the resource and the competitors involved. A third type of competition, termed *apparent competition*, occurs when one species (e.g., thinhorn sheep) indirectly competes with one or more others, but each serves as prey of a predator. This situation is common when one (or more) species increases in number(s), and results in an increase in predator numbers in a particular area. As a result, there are more predators hunting for individuals belonging to the initial group (i.e., thinhorn sheep) occupying that area.



Photo courtesy of Darren Bruning, ADF&G

Given the rugged nature of the habitat in which thinhorn sheep generally live, *exploitative* competition with other species is somewhat limited. In terms of wild species, mountain goats may reside in proximity to thinhorns in escape terrain and in habitats used during winter, and caribou can occupy foraging areas proximate to areas grazed by thinhorn sheep. In specific areas in British Columbia, Rocky Mountain elk and bison have colonized habitats that were traditionally winter ranges used only by Stone's sheep, potentially resulting in both *interference* and *apparent* competition. In other areas, as a result of grazing and other land-based tenures or public land leases, domestic horses, cattle, and feral animals now occur in areas once used exclusively by thinhorn sheep. Where these competitive effects occur at low intensity, impacts to thinhorn sheep productivity and health may be minor, but such situations need to be further evaluated.

Background

Interspecific competition, and its resultant effects, may be exacerbated by location, habitat fragility, primary productivity, and species persistence. For example, in specific locations mountain goats, caribou, moose, elk, or bison may be sympatric with thinhorn sheep. Thus, the potential for exploitative competition exists. Research in southwest Yukon indicates, however, that the likelihood of late-winter competition between thinhorn sheep and caribou and moose is limited based on patterns of co-occurrence.

Competition for resources resulting from habitat-enhancement burning programs is also an important consideration. For example, burning has promoted an increase in early seral habitats

and an associated increase in use of burned areas by elk, deer, moose and bison.

Persistent occupation of habitats by those larger herbivores is likely to result in some level of behavioral interaction and, thus, the potential for interference competition to be detrimental to thinhorn sheep. Those mountain ungulates may benefit from additional forage available as a result of fires—whether intentional or accidental ignitions. Post-fire seral vegetation can, however, result in an altered predator-prey system—a trade-off for increased herbivore forage. That is to say, apparent competition can come into play, with negative impacts to thinhorn sheep. Indeed, increased densities of predators—wolves, grizzly bears, and black bears among them—can occur as a result of immigration of large herbivores into previously less suitable or less accessible habitat. Thus, the potential for resource competition and interference competition are further confounded by apparent competition, which involves increased numbers of predators hunting both the novel taxon and thinhorn sheep. Such an influx of predators in response to increased availability of prey is likely to impact thinhorn sheep, with the likelihood that sheep populations will be held at lower densities than otherwise would be the case. This aspect of competition, which is antithetical to the intent of burn programs, will be discussed in more detail later in this document.



Photo courtesy of Larry Kruckenberg

WAFWA:

- Recognizes effective conservation of seasonal habitats is important to reduce the impacts of interspecific competition.
- Acknowledges the diversity of stakeholders and interests responsible for managing thinhorn sheep habitat throughout North America, and encourages land management decisions and use of management techniques that result in satisfactory ecological conditions on public and private lands.
- Encourages the use of harvest management to decrease the potential for competition when deemed to be detrimental to thinhorn sheep.
- Supports outreach and encourages stakeholders to address the potential negative effects from high levels of competition and to recommend actions that are likely beneficial to thinhorn sheep.
- Supports the development of partnerships and resulting collaborative approaches among stakeholders to protect and manage habitat for thinhorn sheep.



MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Maintain and, where possible, enhance natural quality and quantity of thinhorn sheep seasonal habitats, distributed throughout their range, while simultaneously limiting the opportunity for competition from other large herbivores and the potential for unintended consequences associated with an altered prey base and potential shifts in the predator landscape.

Objectives and Strategies:

1. Identify factors that limit or threaten the ability of areas to provide optimal habitat for thinhorn sheep.
2. Identify important seasonal habitats, movement corridors, and landscape linkages throughout the distribution of thinhorn sheep that should be protected or enhanced for the benefit of thinhorn sheep.
3. Prior to undertaking enhancement work:
 - A. Consider the potential for habitat enhancements to encourage invasive plant species that attract other species and result in range expansions of non-target ungulates, thereby resulting in exploitative or interference competition, or both, with thinhorn sheep.
 - B. Acknowledge the trade-offs associated with habitat enhancement programs, among which are negative outcomes from competition and increased rates of predation, as well as the potential for new predators or feral domestic animals to take advantage of enhanced habitat conditions.
 - C. Develop domestic livestock mitigation strategies prior to undertaking habitat management projects or issuing land-use tenures or public land leases in thinhorn sheep habitat.
 - D. Promote funding for and conduct research to address knowledge gaps related to habitat management and associated risks that could result from competition with other species of ungulates or livestock.
 - E. Consider the short-term benefits of habitat manipulations versus the long-term negative consequences associated with artificially elevated populations as related to harvest management decisions and subsequent expectations of the public.
4. Establish partnerships and develop collaborative approaches with governmental land management agencies, First Nations or Tribal organizations, industry, private landowners, and non-governmental organizations to maintain quality and quantity of thinhorn sheep habitats when considering domestic grazing tenures or public land leases that could reduce availability of forage.

5. Develop standardized habitat management and assessment guidelines and implement strategies that offset the impacts of specific activities, land use tenures, or public land leases, and encourage consistent application across jurisdictional boundaries.
6. Develop and implement education programs that:
 - A. Emphasize habitat requirements of thinhorn sheep.
 - B. Describe the potential benefits and adverse impacts of various management actions.

DISEASES AND PARASITES

Similar to bighorn sheep, thinhorn sheep can carry, and are susceptible to, a variety of pathogens. There is, however, limited evidence of substantial disease impacts or epizootic events in thinhorn sheep. This is likely a consequence of lower rates of exposure to other wildlife or domestic animals, and the challenges associated with the remote and extreme nature of thinhorn sheep habitat and climatic conditions that, collectively, make sampling very difficult. Indeed, health assessments of thinhorn sheep have demonstrated far less exposure to various pathogens when compared to bighorn sheep.



Photo courtesy of Tom Lohuis, ADF&G

The remote and rugged areas occupied by thinhorn sheep can also be challenging when it comes to extensive laboratory-based disease investigations. Techniques in place to assess bighorn sheep health have not been used extensively for thinhorn sheep, but have been employed to identify past pathogen exposure. Studies have indicated that thinhorns have the same vulnerabilities and exposure pathways that would result in pathogen transmission from contact with domestic animals. As a consequence, contact with domestic animals such as domestic sheep or goats should be avoided. Where translocations of thinhorn sheep or expansion of domestic land-based tenures or public land grazing leases are being considered, and where potential contact between domestic livestock and thinhorn sheep exists, risk assessments should be performed to assist in decision-making and in the development of mitigation measures to reduce the potential for transfer of pathogens. Wildlife managers, livestock producers, and other stakeholders should work cooperatively to develop solutions for minimizing impacts to both wildlife and livestock.

Background

Disease was a primary factor in the decline or extirpation of bighorn sheep populations across much of their historic range through the mid-1900s, and continues to affect numbers and distribution of bighorn sheep today. In general, both bighorn sheep and thinhorn sheep are susceptible to a variety of diseases and parasites that can have both individual and population-level consequences.

The most important health issue for wild sheep is respiratory disease. Generally associated with exposure to pathogens common to domestic sheep or goats, the disease usually leads to a fatal bacterial pneumonia and, in many cases, all-age morbidity and mortality (collectively referred to as “die-offs”). These events can involve a high percentage of a population, tend to be progressively transmissible to adjacent populations, and are typically followed by extended periods (years, and perhaps decades) of poor lamb recruitment that result in population declines. Evidence exists that thinhorn sheep are as sensitive as bighorn sheep to some respiratory pathogens.



Photo courtesy of Tom Lohuis, ADF&G

Bacteria of the family Pasteurellaceae (*Pasteurella multocida*, *Mannheimia haemolytica*, *Bibersteinia trehalosi*), and *Mycoplasma ovipneumoniae* are the most common and likely the most important pathogens associated with population-level respiratory disease events in populations of bighorn sheep. Domestic sheep and goats commonly carry these organisms and may not exhibit symptoms of disease. Research has demonstrated that these pathogens can be transmitted to bighorn sheep upon contact with, or as a result of proximity to domestic sheep or goats. Such epizootics manifest themselves as pneumonia, infections are frequently fatal to bighorn sheep, and there is currently no effective treatment once clinical signs are observed. Individual herd losses have ranged from 5% to 95% of the population existing prior to exposure.

Populations of thinhorn sheep are not known to have experienced wide-spread or large-scale disease related die-offs similar to those described above. Thinhorn sheep are considered to be naïve, or unexposed, to most respiratory pathogens and have simply escaped large-scale epizootic events as a result of their distance from sources of those pathogens. However, a warming climate could result in increased exposures if northern climates become more conducive to livestock production. Evaluating current health status and implementing protection through proactive management approaches in advance of changing habitat conditions and land-use practices is vital.

Effective separation is defined as spatial or temporal separation between thinhorn sheep and domestic sheep or goats. Reducing the potential for association between those taxa and the likelihood of transmission of pathogenic organisms or parasites between species is critically important. Maintaining effective separation is presently the only meaningful tool available for minimizing pathogen transfer and the risk of respiratory disease.

WAFWA:

- Acknowledges the existence and role of pathogens and disease in natural ecosystems.
- Recognizes the potential adverse effects of disease on thinhorn sheep populations as a high priority among management challenges (Appendix 1).

- Encourages development of agency policies that support:
 - Baseline research, health assessments, monitoring strategies, disease investigations, implementation of appropriate health management strategies, and efforts to improve knowledge concerning pathogens and methodologies for identification and treatment.



Photo courtesy of Tom Lohuis, ADF&G

- Provision of wildlife health sampling kits and training for staff and trained volunteers that facilitate opportunistic collection and sampling of thinhorn sheep.
- Advocates effective separation between domestic sheep or goats and thinhorn sheep as the primary management goal of state, provincial, territorial, and federal agencies.
- Supports outreach and development of science-based solutions at the local level through collaboration and consensus-building for the benefit of all stake-holders.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

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

Objectives and Strategies:

1. Develop agency policies that support understanding and proactive management of thinhorn sheep health.
2. Continually assess and monitor the health of thinhorn sheep populations.
 - A. Review past and current herd demographics and performance and its relationship to environmental variables.
 - B. Perform baseline and periodic risk and health assessments, and opportunistically sample and archive blood, tissue, and hair following the WAFWA Wildlife Health Committee *Bighorn Sheep Herd Health Monitoring Recommendations*.

- C. Investigate reported disease outbreaks or evidence of pathogen exposure among thinhorn sheep populations.
 - D. Educate and work cooperatively with stakeholders to obtain samples from harvested animals to be archived for future investigations.
 - E. Implement wildlife health monitoring and sampling programs that incorporate education, and community or stakeholder involvement in sample collections for the purpose of providing valuable supplemental data.
3. Perform herd health assessments and risk analyses of source and recipient herds prior to and following translocations or augmentations.
- A. Avoid translocations when confirmed or substantial uncertainty exists about the disease status of either the source or recipient herd.
 - B. Maintain awareness of other factors, including habitat conditions and proximity of domestic sheep or goats, to populations of thinhorn sheep.
 - C. Develop mitigation and management strategies that are designed to eliminate the potential for exposure to lethal pathogens.
4. Implement thinhorn sheep management strategies and policies that prevent or minimize exposure to infectious disease.
- A. Maintain effective separation between thinhorn sheep and domestic sheep or goats to prevent transfer of pathogens.
 - B. Avoid using domestic sheep or goats in or adjacent to thinhorn sheep habitat for any purpose, including their use as pack animals for backcountry trekking, or for vegetation management.
 - C. Avoid issuing grazing tenures or permits for sheep or goats on public lands in or adjacent to thinhorn sheep habitats.
 - D. Work with landowners to discourage the grazing of domestic sheep or goats on private lands proximate to areas occupied by thinhorn sheep.
5. Work cooperatively with stakeholders to develop, implement, evaluate, monitor and regulate safe and effective health management practices for thinhorn sheep.
- A. Develop and implement protocols for removing thinhorn sheep or domestic sheep or goats when association between those species is suspected or confirmed.



Photo courtesy of Tom Lohuis, ADF&G

- B. In the event of a respiratory disease outbreak:
 - a. Assess the overall risks and consequences, both short- and long-term, of allowing thinhorn sheep survivors to persist and take appropriate action based on that evaluation.
 - b. Coordinate with other government agencies, First Nations or Tribal organizations, and affected landowners to develop a strategic policy for depopulation to lessen the potential for disease transmission to adjacent populations of thinhorn sheep.
 - C. Share information among resource agencies concerning wild sheep disease response protocols and demographics associated with die-offs.
6. Expand efforts to help the public understand the consequences of disease outbreaks and the implications thereof for conservation, harvest, and culture.
 7. Obtain and use educational materials developed for bighorn sheep and adapt those materials for application to thinhorn sheep.
 - A. Provide outreach programs on the risks posed by domestic sheep or goats to North American wild sheep.
 - B. Partner with stakeholder organizations, First Nations or Tribal organizations, or other community-members in a wildlife health monitoring and sampling program as a means of incorporating education, community, or stakeholder involvement and obtaining high quality samples for analysis.
 8. Identify and support collaborative research and develop training opportunities focused on methods of assessing and monitoring health of thinhorn sheep populations.

PREDATION

Predation is a natural process that can sometimes have substantial consequences for populations of large ungulates. The influence of predation on the population dynamics of thinhorn sheep is, when balanced, beneficial through regulation of numbers and has minimal impacts on populations, particularly when populations are near nutritional carrying capacity (K).

Conversely, when prey populations are far below K , predation can have substantial effects on the ability of the population to increase, because predation under such situations is largely additive.

Philosophies concerning the relevance of predator control (i.e., the lethal removal of predators)



Photo courtesy of Tom Lohuis, ADF&G

in thinhorn sheep conservation efforts differ widely, just as do the potential impacts of predation. These differing points of view are not restricted to society in general, but also differ among and within the same governmental agencies responsible for the conservation and management of thinhorn sheep. The power of public opinion in shaping management decisions is substantial, and is expected to remain so despite scientific support for actions informed by science.



Photo courtesy of Larry Kruckenberg

Background

Predation on thinhorn sheep is primarily a function of the presence of sympatric carnivores. Thinhorn sheep have a broad complement of predators within their distribution, among which are wolverines, golden eagles, bears (black, brown, and grizzly), lynx, wolves, and coyotes. Stone's sheep may also fall prey to cougars, but those felids are generally absent or occur at very low densities throughout the majority of thinhorn sheep range.

Predation by some species can be substantial on a seasonal basis. For example, predation on lambs by golden eagles may be higher in late winter and during the lambing period than at other times of the year. Predation by grizzly bears is considered low during winter months, yet is greater in the lambing season. Lynx may shift predation to include more thinhorn sheep when snowshoe hares become less available. Depending on the geographic area, terrain, predator densities, availability of alternate prey, and environmental factors such as annual snow load or relative availability of nutrients, predation may or may not be an important factor in the population dynamics of thinhorn sheep.

Among populations that are near K , predation generally can be considered to be compensatory, while predation on populations far below K and not limited by habitat carrying capacity, can be largely additive. Thus, the level of mortality due to predation is density dependent. Populations of thinhorn sheep that are intrinsically small or that are far below carrying capacity can be especially vulnerable to the impacts of predation. Among declining populations of thinhorn sheep and in extreme circumstances, an inverse density-dependent relationship can destabilize a system and predation can result in the extirpation of small populations.

When compared with bighorn sheep, thinhorns may be especially vulnerable to an increase in the number of predators resulting from the presence of a novel, additional prey species. This situation has been documented following habitat enhancement projects that encourage the presence of additional species of large ungulates, and is termed "apparent competition." Among thinhorn populations, apparent competition can occur when one or more other large herbivores (e.g., moose, elk, deer, bison) expand into an area previously occupied solely by thinhorn sheep. All species then (including thinhorn sheep) become prey for various carnivores. Expanded numbers of prey species can result in increased predator numbers and, ultimately, increased predation on thinhorn sheep. Thus, such unintended population-level impacts warrant serious consideration prior to implementation of habitat enhancement projects.

Predation has been shown to be especially impactful to lambs, but the adverse effects of predators on adult mortality can also be substantial. Wolves are present across the majority of thinhorn range and are thought to be a primary predator of thinhorn sheep. In British Columbia, wolves and wolverines are considered the most common terrestrial predators of Stone's sheep. However, following an intensive wolf control program in southwest Yukon, thinhorn sheep populations demonstrated little to no change in population size. Since predators are opportunists and severe winters are known to affect nutrition and overall condition of thinhorn sheep, it is logical that thinhorn sheep may experience higher rates of predation during extreme winters. For example, wolves are likely to benefit from deep snow and strong crusting during severe winters, conditions during which thinhorn sheep movements are limited.



Photo courtesy of Tom Lohuis, ADF&G

The importance of predators is clearly recognized; however, the effects of predation can sometimes be a challenge to manage when competing with other human interests. Management through well-planned, science-based programs with specific goals, strategies, and established time-frames is imperative. Programs 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, combined with outreach programs to inform the public, are also important components of predator management programs.

WAFWA:

- Acknowledges the important role of predators in healthy ecosystems.
- Acknowledges the complex predator-prey relationships associated with thinhorn populations in that:
 - Multiple predators affect thinhorn populations in varying degrees across their range and in different ways and at different times.
 - Annual weather patterns and conditions play a substantial role in predator-prey dynamics.
 - Availability of alternate prey such as moose, caribou, elk, deer, or hares plays a substantial role in predator population dynamics, subsequently affecting thinhorn sheep.

- Recognizes and values the differing societal opinions and political realities among interest groups and stakeholders with respect to predator management, but also values the opinions and recommendations of those professionals involved in the conservation and management of thinhorn sheep.
- Recognizes predator removal as a valuable management tool for achieving conservation goals when predation has been confirmed as a factor keeping populations below management objectives.



Photo courtesy of Bill Jex, BC MFLNRO

- Advocates that predators be managed in a manner that ensures healthy populations and recognizes their ecological, scientific, and social values, within compliance of 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.
 - General hunting and trapping as primary methods for managing predator densities and population levels.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Minimize population-level impacts of predation on thinhorn sheep through well-planned, well-communicated, and well-implemented management programs that incorporate monitoring of predator-prey dynamics and improve knowledge of existing and potential impacts of changes in habitat.

Objectives and Strategies:

1. Assess factors potentially limiting thinhorn sheep populations in the context of management issues: habitat quality and quantity, disease, nutrition, predator and prey levels (including

availability of alternate prey), human impacts (both positive and negative), weather patterns, and others as appropriate.

2. Consider management of predators as part of a suite of options if data indicate that predation is a primary factor in population declines, or when populations of thinhorn sheep remain below management objective levels and predation has been confirmed as the factor preventing the population from increasing.
 - A. Outline site-specific and transparent prescriptions for management of predators that have clearly identified goals, population objectives, and timetables for implementation.
 - B. Commit adequate resources to predator management projects to achieve desired objectives and to monitor and evaluate the effects of management.
3. Improve public understanding of the important role that predators play in ecosystem function and the realistic expectations of using predator management to facilitate achievement of thinhorn sheep management goals.

POPULATION MANAGEMENT

Thinhorn sheep are distributed widely and are abundant across their range in North America. Population fluctuations occur in response to a variety of factors, and not all of those are well understood. Habitat quality and quantity, as well as the effects of predation, are largely influenced by annual weather patterns and are factors that agencies have no control over. Managing populations of thinhorn sheep for long-term viability requires a proper balance between

animals and their habitat. Wildlife and land managers must consider numerous demographic and ecological parameters before making management decisions. For populations of thinhorn sheep that predominantly occupy remote landscapes, many of those parameters have undergone limited assessments and few demographic data are available. Habitat condition, connectivity, disease, predation, weather, and other factors influence thinhorn sheep numbers and distribution. While some of these are best addressed indirectly, population management often provides opportunities for regulated harvest, and in some cases requires implementation of other options, such as translocations.



Photo courtesy of Darren Bruning, ADF&G

VIABILITY AND CONNECTIVITY

Background

In the context of this document, a metapopulation of thinhorn sheep is defined as a group of subpopulations that extend across the geographic extent of one or more specific mountain ranges. The expansive nature of northern mountain ranges dictates that each metapopulation be classified into a number of largely distinct subpopulations, and the assumption is that these subpopulations interact with each other in a metapopulation context. The subpopulations are based on landscape

geography, movement patterns, phenotypic features, genetic relationships, or a combination of these and other factors. Across their current range, thinhorn sheep metapopulations remain mostly intact, with good landscape connectivity. These linkages, however, complicate the wild sheep manager's ability to define discrete populations at varying management scales. Threats associated with increasing human activities in thinhorn range are becoming more common. Managers must remain diligent in their efforts to minimize or prevent landscape fragmentation and immitigable impacts.

Many of the metapopulations of thinhorn sheep and, in particular, the subpopulations that comprise them, exist in remote areas where accessibility is extremely limited. Given the high level of interest in harvest, thinhorn managers are obligated to implement sustainable management practices and provide direction on resource development activities or mitigation to reduce impacts associated with development, despite limited agency resources and scientific data.

WAFWA:

- Recognizes connectivity among subpopulations of thinhorn sheep as necessary to their viability, persistence, and resilience.
- Acknowledges the potential consequences of future changes in climate such as shifts in distribution, habitat occupancy, and survival rates, and increased access by humans into areas occupied by thinhorn sheep.



Photo courtesy of Tom Lohuis, ADF&G

- Acknowledges that the continued good health of extant populations takes precedence over the goal of greater connectivity and, thus, discourages translocations if there is a risk to maintaining spatial separation of thinhorn sheep from domestic sheep or domestic goats, or other risk of disease exposure to naive populations.



Photo courtesy of Darren Bruning, ADF&G

- Encourages management actions that avoid landscape fragmentation between subpopulations of thinhorn sheep, including:
 - Removal or relocation of domestic sheep or goats that occur near habitat occupied by thinhorn sheep.
 - Reduction of woody vegetation that results in enhanced ingress and egress via natural (i.e., ‘let it burn’ policies) or prescribed fire in appropriate habitats.
- When justified, supports translocations of thinhorn sheep to:
 - Bolster extant populations.
 - Restore animals to vacant habitats adjacent to extant populations.

Management Goal: Maintain and enhance range connectivity, and mitigate negative impacts to range connectivity or habitat fragmentation to ensure conservation, viability, or restoration of thinhorn sheep populations and to maintain metapopulation function.

Objectives and Strategies:

1. Refine information on the current distribution of thinhorn sheep in North America.
 - A. Map thinhorn sheep habitat in North America and identify potential movement corridors and, if appropriate, migration routes.
 - B. Identify areas occupied by thinhorn sheep that are isolated genetically or by fragmented landscapes, and determine whether suitable habitat exists adjacent to such populations for restoration of connectivity among proximate areas also occupied by thinhorn sheep.

2. Where supported by opportunity and scientific rationale, introduce thinhorn sheep to historically occupied habitat adjacent to extant populations, and consider augmentation where it is deemed appropriate.



Photo courtesy of Tom Lohuis, ADF&G

- A. To enhance prospects for success, introduce translocation stock that is genetically most similar and from areas ecologically similar to release locations and recipient herds.
 - B. To prevent introducing pathogens to healthy animals, translocate stock only from source populations that have been categorized as disease-free through proper health assessments.
 - C. When translocating thinhorn sheep, select individuals from indigenous, rather than artificially established, populations and release sufficient numbers of individuals to enhance prospects for success.
 - D. Avoid translocating thinhorn sheep to vacant habitats if the potential for association with domestic sheep or domestic goats exists.
3. Take action to mitigate sources of fragmentation of habitat occupied by thinhorn sheep populations when those impediments can be lessened.
 - A. Promote or provide incentives to remove or relocate domestic sheep or goats along interfaces with human settlements in an effort to reduce risk of association with thinhorn sheep.
 - B. Collaborate with land management agencies to maintain, or enhance where possible, corridors used by thinhorn sheep to move between requisite habitat components, seasonal ranges, or adjacent subpopulations.
 - C. Improve forage quality and quantity within thinhorn sheep habitat to enhance range suitability and increase carrying capacity, and to optimize utilization of existing range.
 - D. Discourage anthropogenic development within thinhorn sheep habitat, migration routes, and movement corridors. In areas where development cannot be prevented, encourage implementation of effective mitigation measures that are intended to avoid

creating barriers to natural movements of thinhorn sheep and help ensure that inter-population connectivity and metapopulation function remain intact.

4. Collaborate with land management agencies, First Nations or Tribal organizations, private landowners, conservation organizations, and other interested parties to achieve a broadly based management strategy that addresses the positive and negative impacts of inter-jurisdictional movements of thinhorn sheep.

TRANSLOCATIONS

Background

Translocation has been used extensively to augment or restore populations of bighorn sheep. However, it is not a tool widely used to manage thinhorn sheep. Historic records indicate only three translocations (one each within Alaska, Yukon Territory, and Northwest Territory) of Dall's sheep in the past, and none conducted between jurisdictions.

Between 1964 and 1967, 15 Dall's sheep were translocated from the Kenai Peninsula in southcentral Alaska to neighboring Kodiak Island in an effort to establish a new population.

By the mid-1970s, however, no sheep remained on the island. No Dall's sheep have been translocated within Alaska since that failed effort.

In British Columbia, two attempts at translocation of Stone's sheep have been undertaken. The first effort occurred in the Peace region in 1990 for the purpose of establishing a viable population in the vicinity of Mt. Frank Roy and Mt. Monteith. Although some of the translocated animals survived, the effort was considered unsuccessful because the population failed to increase and did not meet the target of 100 individuals.

A second effort was conducted in 1994 and 1995 in an effort to restore thinhorn sheep to an area from which they had been extirpated in the 1950s as a result of unregulated subsistence harvest or market hunting. A total of 24 Fannin sheep were translocated from native range east of Atlin Lake to historic, but unoccupied, habitat in the Table Mountain area west of Atlin Lake. In July 2012, a minimum of 57 individuals were observed in the range. Although the translocation is considered successful in that thinhorn sheep now occupy the Table Mountain landform, population growth almost two decades later has not met the management goal of providing an opportunity for harvest.

Based on disease issues associated with historic bighorn translocations, northern managers remain cautious when it comes to translocating thinhorn sheep between natural habitats and administrative jurisdictions. Moreover, current analyses of genetic profiles among thinhorn



Photo courtesy of Tom Lohuis, ADF&G

sheep, combined with potential changes to the distributional boundaries of subspecies, will likely confound the potential for translocations in the future. Translocation may, however, become more important for achieving management goals as changes in habitat and thornhorn distributions occur. To increase the probability of successful translocations, biologists must thoroughly evaluate habitat suitability, the overall health of thornhorn sheep, and the ecological characteristics at the source and destination sites. In addition, the number of animals available for translocation must be considered. Further, trade-offs between anticipated benefits such as demographic changes, behavioral changes, and genetic interchange must be considered in the context of the consequences of mixing thornhorn sheep from various source herds, as well as the risk of increased connectivity and its implications for transfer of pathogens among populations.

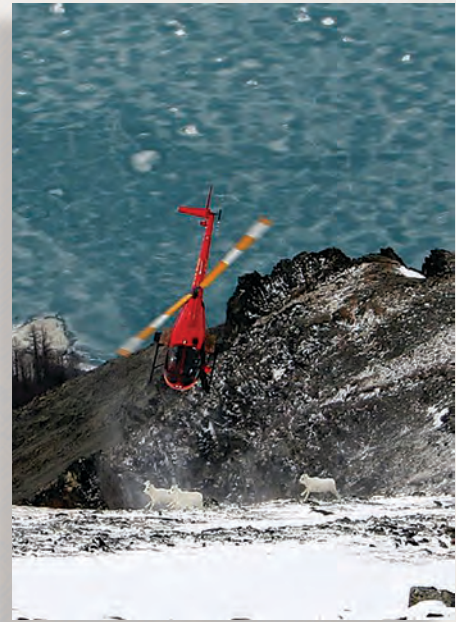


Photo courtesy of Thomas McDonough, ADF&G

WAFWA:

- Recognizes that translocation is currently not an important management tool for thornhorn sheep, but acknowledges that future ecological and distributional changes may increase its utility.
- Supports a cautionary approach in use of translocations for restoring thornhorn sheep to historic habitat or augmenting existing populations to increase numbers, expand distributions, or enhance genetic diversity.
- Supports inter-jurisdictional translocations of thornhorn sheep to assist in achieving management goals.
- Encourages habitat and health risk assessments and evaluations, and adequate planning of translocations to enhance the probability of success.
- Supports translocations that protect genetic integrity and distributions of subspecies within historic ranges whenever practical or required by agency policy.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Successful translocations to ensure conservation, viability, or restoration of thornhorn sheep populations in the event that extirpations or population declines occur.

Objectives and Strategies:

1. Minimize extirpations, range reductions, or fragmentation within metapopulations of thornhorn sheep in order to decrease the need for management intervention.

2. Investigate population declines and implement appropriate management strategies for addressing the causes of those declines prior to undertaking more aggressive efforts, including translocations.

3. Use translocation as necessary to decrease the probability of extirpation or to restore thinhorn sheep to historic areas.



Photo courtesy of Jim Dau, ADF&G

A. Avoid or minimize adverse impacts to social structure or movement patterns within source populations.

B. Avoid translocations of thinhorn sheep from source populations with historic disease, recruitment, or survival problems.

C. Avoid introducing thinhorn sheep into areas in which predation is anticipated to be problematic, those where competition with other ungulates is anticipated, or into areas adjacent to range used by domestic sheep or domestic goats.

D. Avoid the use of source populations that occur near areas occupied by domestic sheep or domestic goats.

E. Determine the health status of source and recipient herds prior to augmentation to minimize risk of disease transmission from source to recipient populations.

F. Utilize appropriate source populations to maintain genetic integrity and distributions of subspecies within historic ranges when practical or required by agency policy.

4. Monitor population dynamics, distribution, movements, health, and habitat of source and destination populations, and evaluate the success or failure of each translocation.

5. Coordinate with land management agencies, First Nations or Tribal organizations, landowners, conservation organizations, and other stakeholders to foster support for proposed management actions.

6. Develop standardized protocols to facilitate translocations of thinhorn sheep among jurisdictions.

HARVEST STRATEGIES

Thinhorn sheep have long been hunted by aboriginal peoples in Alaska and Canada for food, clothing, and other uses.

During the late 1800s and very early 1900s, unrestricted market hunting of big game helped to feed road and railroad crews, Klondike miners, and tourists, all of whom were drawn to the northern wilderness. The resulting infrastructure precipitated the commodification of wildlife and the origins of the hunting economy, wherein species like thinhorn sheep were among a highly prized suite



Photo courtesy of Gray Thornton, Wild Sheep Foundation

of trophy species. Over time, interest in harvesting thinhorn sheep has grown among those seeking mountain adventures and the physical challenge of pursuing one of North America's greatest natural treasures. Whether hunting Dall's sheep or Stone's sheep, hunters from all over the world have proven willing to endure a great deal of physical hardship and exertion, demonstrate extreme patience, and incur substantial financial expense to harvest a majestic northern mountain sheep.

While thinhorn sheep populations occur throughout their historical range, it remains a challenge to effectively manage for appropriate population densities while providing desired demographic or social structures, hunter opportunity, hunter success, and trophy quality. Among the four jurisdictions with management responsibility for thinhorn sheep, there are differences in philosophies, management objectives, and legislation, all of which affect the conservation of thinhorn sheep. The prevailing constraints within each jurisdiction are discussed individually.

Background

Hunting in Alaska is allowed for at least a portion of all recognized wild sheep populations in the state except for portions of some populations that occur across jurisdictional boundaries. On state and private lands in Alaska, sheep hunters are classified as state residents or non-residents/non-resident aliens. On federal lands, hunters are classified into local state residents, non-local state residents, and non-residents. Non-residents must be accompanied in the field by a guide. All hunting for Dall's sheep in Alaska is managed by either the state of Alaska or the federal Office of Subsistence Management. Hunting opportunities include an open general season, registration permit, federal subsistence (general season and registration permit), and drawing permit. Hunting seasons and bag limits are diverse across the state, providing for a wide array of management objectives and harvest opportunities. Bag limits vary across the state and fall within 3 primary categories: full-curl, any ram, and any sheep. Season dates typically run from August 10 to September 20, with longer seasons for some subsistence hunts. In hunts with horn size restrictions, horns must be presented for permanent sealing by an Alaska Department of Fish and Game representative within 30 days of the kill.

Thinhorn sheep hunters in Canada are categorized into two groups: aboriginals, or licensed hunters (i.e., provincial or territorial resident hunters and non-residents, which includes out-of-province or out-of-territory Canadian residents and non-resident aliens). Harvest by aboriginal persons can occur without a license, and in some jurisdictions non-residents must use the services of a licensed guide or outfitter.



Photo courtesy of ADF&G

In Yukon, licensed harvest is restricted either to full-curl rams for all thinhorn sheep or, if not full-curl, a ram that is at least 8 years-of-age. For game management subzones where harvest is allowed, most thinhorn sheep harvest occurs through an open general season. If harvest rates or hunter pressure is deemed too high in a specific game management subzone, a lottery-based permit hunt can be instituted. Most areas of the Yukon where a lottery-based permit system occurs are in the Southern Lakes Region, from Whitehorse southward to the border with British Columbia, or in the North Richardson's population in the northeast corner of Yukon. Seasons typically run from August 1 to October 31. Within Zone 1 (northernmost zone), hunting occurs from August 1 to September 15, and a non-resident auction permit hunt in Zone 6 extends from July 21 to October 31. On average, 4% of the adult thinhorn population becomes a full-curl ram each year, and the current harvest strategy of no more than 4% of the adult population is considered sustainable. For populations that are not surveyed, the ages of harvested rams (i.e., the proportion of harvested rams over age 8) is also used as an indicator of the sustainability of the harvest and is based on the British Columbia system described below. All licensed hunters who harvest a sheep are required to submit the skull to an Environment Yukon office for a plug to be inserted into the horns and to allow horns to be measured.

Dall's sheep populations of the Northwest Territories occur in the Mackenzie Mountains that border Yukon. The vast majority of the harvest is by non-residents or non-resident aliens. Resident, and general (subsistence) hunters take <20 animals per year. All non-residents and non-resident aliens must use the services of an outfitter and must be accompanied by a licensed guide in order to hunt sheep. Use of an outfitter or guide is optional for resident hunters. Eight licensed outfitting zones occur in the Mackenzie Mountains. No harvest quotas exist and each outfitter has the exclusive rights to harvest within a zone. The bag limit for all sheep hunters is one adult male (at least one horn $\frac{3}{4}$ curl or longer). Harvest by non-residents or non-resident aliens is strictly monitored. The hunting season extends from July 15 to October 31 and from 1972 to 2014, an average of 174 Dall's sheep were harvested annually. Harvest pressure is low, with a maximum total annual harvest prior to 2000 of 1.6% of the total population. Since 2000, Dall's sheep harvested by hunters have averaged 11 years-of-age on an annual basis.

Licensed harvest for Dall's sheep and Stone's sheep (includes Fannin sheep) in British Columbia is restricted to full-curl rams (i.e., a ram whose horn tip when viewed squarely from the side at right angles to the sagittal plane of the skull, extends dorsally beyond the forehead-nose bridge plane), or rams that have attained the age of at least 8 years as evidenced by horn annuli. Harvest opportunities are generally provided between August 1 and October 15 through general open seasons (GOS) or by limited-entry hunting permit (LEH) authorization (i.e., a draw system). Resident hunters are managed through GOS and LEH seasons and bag limits, and non-resident harvest is managed through guide-outfitter quotas that align with GOS season dates and bag limits.



Photo courtesy of Kevin Hurley, Wild Sheep Foundation

Successful hunters must, within 30 days of their date of kill, present the complete upper portion of the ram's skull (with horns naturally attached) for inspection, whereby compliance with the harvest provisions can be assessed. A genetic sample is collected, horn morphology (i.e., measurements and annuli) are recorded, and a unique alphanumeric sequenced pin is inserted. The province publishes a written hunting and trapping synopsis every two years that details harvest opportunities and any changes.

In British Columbia, two approaches are used for determining annual allocations of harvest and guide quotas. These include: (1) the Population Inventory Model that requires the determination of an annual allowable harvest (AAH) based upon inventory and demographic information for the population management unit and assumes a harvest rate of 3%; or (2) the Harvest Age Structure Model that is applied where insufficient information exists to estimate a population and considers adjustments to allowable harvests in the context of a 5-year allocation period. Based on the proportion of mature rams in the harvest that are ≥ 8 years-of-age, the available harvest can be reduced or increased for the next allocation period. Compulsory inspection and hunter harvest survey data are utilized in both models. Further, the Big Game Harvest Management Policy directs that harvest will generally be more conservative in provincial parks and will reflect management direction provided by park plans, a consideration when setting harvest targets, AAHs, or licensed harvest allocations.

WAFWA:

- Recognizes hunting of thinhorn sheep as a highly desired opportunity and that harvest of thinhorn sheep has important cultural, conservation, and management implications among First Nations or Tribal organizations.
- Supports appropriate and sustainable harvests of thinhorn sheep, including harvest of various age classes of males and females to achieve cultural objectives or management goals.

- Recognizes the importance of basing thinhorn sheep harvest recommendations and other management decisions on defensible data.
- Supports law enforcement efforts to minimize illegal harvest or illegal possession of thinhorn sheep.
- Promotes viewing and other non-consumptive opportunities consistent with the sustainable management of thinhorn sheep populations.



Photo courtesy of Jeff Burwell

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Maintain sustainable hunting opportunity through flexible management systems, monitoring, habitat protection, and disease prevention.

Objectives and Strategies:

1. Monitor thinhorn populations through the collection of appropriate information to ensure proper harvest management.
 - A. Perform periodic population surveys, conducted in a consistent manner using established standards, to determine population structure, status, trend, and appropriate harvest levels.
 - B. Conduct mandatory registration and marking of harvested thinhorn sheep to collect age data and other biological samples, and to lessen the likelihood of harvest or sale of illegally obtained individuals.
 - C. Collect and evaluate information gleaned from hunters, guides, and outfitters that provide insight into thinhorn sheep population status and condition, and the overall hunting experience.
 - D. Coordinate monitoring efforts and harvest recommendations among jurisdictions and management agencies to ensure sustainable harvest levels, especially where management of inter-jurisdictional populations is required.

2. Develop and implement regulations that provide for maximum public use opportunities.
 - A. Ensure that aboriginal rights and cultural needs are considered through harvest allocation processes and when calculating sustainable harvest opportunities.
 - B. Maintain flexibility when developing hunting seasons to provide high-quality experiences while ensuring the biological needs of the animal.
 - C. Consider “alternative weapon” regulations to facilitate thinhorn sheep hunting as necessary to regulate hunter effort, manage harvest success or timing, and to generate added hunter opportunity, while considering factors such as wounding loss and potential impacts to non-target individuals.
 - D. Provide non-consumptive opportunities such as viewing or photography of thinhorn sheep.

ORGANIZATIONAL CHALLENGES

Thinhorn sheep suffer, or potentially suffer, from the same things from which they benefit: remote and rugged landscapes, harsh climates, high degrees of landscape connectivity, and wild spaces that remain predominantly untouched by human impacts. It is these aspects of wild sheep and their habitats that draw people to them. Nevertheless, these attributes obscure wild sheep and the perils they face from the world of wildlife managers charged with conserving and promoting an understanding of wild sheep. Government and other public agency budgets remain challenged in a time of global economic realignment and a concomitant and ever-increasing demand for natural resources. The realities of these situations elevate the importance of wild sheep advocates and conservation groups and their financial contributions. Thinhorn sheep are now benefitting from private support, and the increased awareness and cooperative stewardship that this government-stakeholder bond promotes.

FUNDING AND PERSONNEL RESOURCES

Because thinhorn herds and populations are distributed widely across much of their range, obtaining accurate inventory and population estimates is challenging. The added costs of undertaking work in the remote mountain ranges inhabited by these wild sheep poses additional obstacles that typically don't exist in more readily accessible areas. While it is currently estimated that there may be as many as 100,000 Dall's sheep inhabiting North America and approximately 13,000 Stone's sheep in British Columbia, the confidence of managers in those estimates is less than desirable. Additionally, as government and agency staffing and discretionary budgets shift, the ability of wildlife managers to respond to or gather necessary data becomes increasingly difficult.



WAFWA:

- Recognizes the importance and need for adequate funding and staff dedicated to achieving thinhorn sheep management goals and objectives.
- Supports efficient use of available resources.
- Encourages pursuit of additional funding sources and creative strategies for addressing budget and staffing shortfalls.
- Encourages cooperation with wild sheep advocacy groups, First Nations or Tribal organizations, conservation organizations, and independent stakeholders to identify and synergistically enhance revenues for thinhorn sheep conservation and management programs.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Stable source of long-term financial and human resources dedicated to the conservation and management of thinhorn sheep and their habitats.

Objectives and Strategies:

1. Ensure efficient use of existing staff and the financial resources necessary to support staff activities.
2. Identify existing knowledge gaps, current risks, and future needs required for successful management of thinhorn sheep, and plan staffing accordingly.
3. Develop collaborative approaches and partnerships among agencies, First Nations or Tribal organizations, conservation organizations, and individual stakeholders to address shortfalls.
4. Identify and secure alternative funding sources.
 - A. Explore opportunities for sharing personnel or cost-sharing of resources among other agencies or organizations that are dedicated to the conservation of thinhorn sheep.
 - B. Investigate opportunities for creating endowment funds through private donations or other means to support thinhorn sheep conservation and management initiatives.



Photo courtesy of Tim Shinabarger

- C. Obtain support from major foundations with interests in the conservation of wildlife in general, or in thinhorn sheep specifically.
- D. Work directly with private industry to create opportunities for cooperation that will ensure the best possible stewardship of thinhorn sheep and their habitat. Such opportunities include positions funded by industry but directed by agencies to carry out monitoring to ensure that impacts to thinhorn sheep resources are mitigated to the extent possible.

MANAGEMENT RESTRICTIONS AND SHARED MANAGEMENT RESPONSIBILITIES

The delivery of societal priorities when managing wildlife and their habitats has become an important component of how wildlife managers and other resource specialists make decisions across the landscape. Each jurisdiction is faced with pressures that define how individual species are managed, whether for consumptive use, recreation, conservation, or other purposes. These demands are intensified and further confounded by the diverse ownership and management of the lands that are occupied by thinhorn sheep and the complexity of differing mandates and philosophies among those responsible. The impacts of various activities and land management strategies on private lands, public lands, land-use tenures, First Nations or Tribal aboriginal lands, other stakeholder values, and past policy or legislative challenges all must be carefully evaluated. A better understanding of the impacts of management on neighboring jurisdictions, land management agencies, or private landowners is critically important in sustaining long-term viability of shared populations of thinhorn sheep and the opportunities they provide.



Photo courtesy of Mike Taras, ADF&G

WAFWA:

- Recognizes state, provincial, aboriginal, and territorial rights and responsibilities for managing wildlife within jurisdictional boundaries.
- Acknowledges the challenges associated with shared decision-making and management as they relate to the conservation and management of thinhorn sheep and their habitats.
- Recognizes and respects the diversity of mandates affecting land management policies and programs carried out by government agencies, First Nations or Tribal organizations, and private landowners in thinhorn sheep range, while simultaneously advocating that conservation and management of thinhorn sheep be considered among the highest of priorities.

- 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 care and priority as other purposes for which wilderness areas were established.
- Acknowledges and emphasizes the importance of First Nations and other Tribal traditional territories, local government administered areas, and private lands, and the value of building cohesive and positive relationships and partnerships with stakeholders to the long-range conservation of thinhorn sheep.
- Supports proactive efforts to promote protection, conservation, and management of thinhorn sheep habitats and populations that occupy public or private lands.
- Encourages cooperation, respectful dialogue, and outreach initiatives among stakeholders to promote cultural or organizational understanding that furthers conservation of thinhorn sheep.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Work collaboratively with multiple jurisdictions and local, state, federal, and crown governmental agencies, First Nations or Tribal organizations, private landowners, non-governmental organizations, and other stakeholders to further thinhorn sheep conservation while minimizing, and eventually eliminating, political and sociological impediments that could jeopardize the persistence of viable and healthy populations of thinhorn sheep.

Objectives and Strategies:

1. Distinguish populations that are subject to shared decision-making challenges and work cooperatively with stakeholders to develop goals, objectives and strategies, outline responsibilities, clarify communications, and identify potential solutions that further the conservation of thinhorn sheep.
2. Collaborate with federal, state and provincial agencies, wilderness advocacy groups, and conservation organizations to elevate conservation of thinhorn sheep and other wildlife to the same level of importance accorded the other purposes for which wilderness was designated.
 - A. Ensure that management constraints imposed by wilderness or other political designations are interpreted consistently by personnel and leadership within and among public land management agencies.
 - B. Engage in land management planning to ensure that thinhorn sheep and their habitats are considered in that process.
 - C. Develop or assist other agencies in developing appropriate training projects and publications that are intended to foster understanding and collaboration among stakeholders.

3. Develop and implement standardized thinhorn sheep management goals, objectives, and strategies that are applied across jurisdictional boundaries.
4. Work cooperatively with First Nations or Tribal organizations and private landowners to develop management strategies that benefit conservation of thinhorn sheep on non-public lands.

CLIMATE CHANGE

The higher latitudes of North America have experienced changes to climate over the past number of decades. The effects of climate change in northern environments are evidenced in the modification of vegetation communities (e.g., increased abundance of shrubs), changes to the amount and type of precipitation or variability of weather patterns (including icing that limits access to forage), and the timing of spring green-up.

Changes in forage distribution or availability, or both, have the potential to alter thinhorn sheep behavior, migration and movement patterns, and the seasonal distribution across the landscape and between jurisdictions. In addition to impacts to thinhorn sheep, these changes are likely to affect the behavior, distributions, and densities of predators, the prevalence of pathogens and parasites, and human use of the environment.

The effects of climate change are important to disease dynamics in wild sheep and cannot be ignored. Shifts in climate have been implicated in changes to host-parasite systems and the increasingly wider geographic distributions of those systems, including some involving thinhorn sheep. Climate change likely will make northern regions more suitable for intermediate hosts of parasites, ultimately facilitating a higher intensity and variety of parasitism among ungulates in those regions.

Landscape-level changes in northern areas will most likely be more substantial than those observed in more southerly climes. Human activities generally promote range expansion of other ungulates that ultimately could overlap habitats currently occupied almost exclusively by thinhorn sheep. In addition to resource competition, interference competition, or apparent competition, the pathogens, parasites, or predators associated with those colonizing ungulates are expected to affect the viability of thinhorn populations in some areas. Perhaps one of the greatest challenges is the uncertainty regarding the level and nature of the changes that are forecast to occur to habitat and its suitability for thinhorn sheep.



Photo courtesy of Darren Bruning, ADF&G

WAFWA:

- Acknowledges the importance of climate to the dynamics of wild sheep populations.
- Recognizes the potentially adverse and unpredictable effects that a changing climate may have on the severity and geographic distribution of pathogens, diseases, or parasites of wild sheep, and further acknowledges the management challenges that these will pose.
- Acknowledges the importance of proactive advocacy for maintaining effective temporal and spatial separation, as well as education concerning the risks associated with exposure of thinhorn sheep to domestic sheep or goats in the event that climate change results in improved conditions for domestic livestock production.
- Acknowledges that many conservation have been initiated, but also recognizes that those efforts must be expanded and focused more on thinhorn sheep.
- Opposes actions that are based on speculative or otherwise unsubstantiated climate-related impacts over extended (i.e., centuries-long) timeframes.
- Encourages identification of knowledge gaps through research and monitoring, and implementation of adaptive management to meet the increasing challenges associated with climate change, and supports collaboration among diverse partners to address the resulting complexities and their impacts to thinhorn sheep.
- Promotes development of outreach programs to educate a diverse public about the conservation challenges associated with climate change, and to build support for ongoing thinhorn sheep management efforts.

MANAGEMENT GOAL, OBJECTIVES AND STRATEGIES

Management Goal: Improve understanding of existing and potential impacts of a changing climate including shifts in severity of winter or spring weather, changes in recruitment rates, habitat responses, distributional shifts of pathogens or parasites and resulting diseases, changes in human impacts and animal husbandry practices, and shifts in the distribution or abundance of predators.

Objectives and Strategies:

Assess the potential impacts of climate change and associated management factors that could limit thinhorn sheep populations.

1. Develop down-scaled climate models for each eco-region in which thinhorn sheep occur.

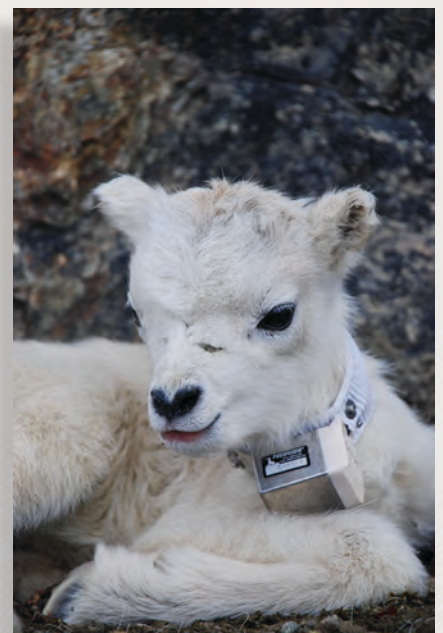


Photo courtesy of Tom Lohuis, ADF&G

2. Conduct vulnerability assessments for thornhorn sheep and the ecosystems they occupy.
3. Engage partners in collaborative efforts to conserve thornhorn sheep.
 - A. Incorporate conservation of thornhorn sheep into agency wildlife action plans.
 - B. Ensure that thornhorn sheep are identified as a conservation priority in appropriate landscape conservation cooperatives or planning efforts.
 - C. Provide technical guidance or other incentives to landowners and managers in cooperative efforts to conserve thornhorn sheep habitat on private lands.
4. Develop regional habitat conservation plans to facilitate latitudinal or elevational movements of thornhorn sheep.
 - A. Identify habitat linkages and movement corridors used by thornhorn sheep and, where appropriate, encourage conservation easements on private lands and establish governmental protected areas.
 - B. Seek and implement opportunities to acquire essential habitats.
5. Adjust hunting regulations to accommodate demographic changes that occur as a result of climate change.
6. Advocate for additional funding to ensure the persistence of populations of thornhorn sheep that may be impacted by shifts in climate.
7. Conduct baseline health assessments and implement regular monitoring of thornhorn sheep populations.
8. Partner with stakeholder organizations, First Nations or Tribal organizations, or other community members to promote a broader understanding of the impacts of climate change and solicit participation in monitoring or sampling where opportunities arise.
9. Identify and support collaborative research, standardization and harmonization of methods, and development of training opportunities focused on assisting wildlife managers in identifying and understanding changes in the environmental conditions that could affect thornhorn sheep populations.

SUMMARY

Many consider the existence of wilderness in the "North" as simply implied; the romanticized perception that the '*wild frontier*' could be anything but that is counterintuitive to most individuals. Still, within that world, thornhorn sheep inhabit the most rugged and inhospitable of terrains and are presented with the most challenging of conditions. As a result, they are well-adapted mountain ungulates and truly are an iconic species.

In contrast to bighorn sheep, populations of thinhorn sheep are nearly contiguous across the northern landscape. There may be as many as 100,000 Dall's sheep in Alaska, the Yukon, Northwest Territories, and British Columbia, and about 13,000 Stone's sheep are thought to occupy British Columbia. The overall population of thinhorn sheep is considered stable, but the remote nature and relative lack of knowledge of thinhorn sheep habitat yields many unanswered questions. Among these is a fuller understanding of each of the many challenges outlined above. The purpose of this document is to help wildlife agency administrators, the public, and other public or private officials respond to those challenges with the interests of thinhorn sheep in mind.

The WAFWA Wild Sheep Working Group is committed to promoting and leading the conservation and management of thinhorn sheep in Canada and the United States. Addressing conservation challenges and implementing effective and measurable management goals, objectives, and strategies is essential to ensuring viable and healthy populations of Dall's sheep and Stone's sheep across their distributions. This document was developed by experienced wildlife professionals charged with the management and conservation of thinhorn sheep, and with ensuring the sound stewardship of that resource for future generations.

Our purpose in preparing this document was to encourage collaboration among agencies and stakeholders, thereby fostering the steps necessary to ensure healthy, wild thinhorn sheep populations. A 2014 summit sponsored by the Wild Sheep Foundation and attended by parties charged with or interested in the conservation and management of thinhorn sheep was a pivotal initial step toward that purpose. Indeed, the summit facilitated much discussion and culminated in jurisdictionally relevant risk matrices that were sourced and constructed by a wide range of stakeholders. An especially important outcome was the identification of those responsible for, dependent upon, or interested in thinhorn sheep, and who are committed to advancing the level of communication, cooperation and commitment to benefit the conservation of those iconic ungulates. Publication of this document is, in part, a tribute to the success of that summit.



Photo courtesy of Tom Lohuis, ADF&G



Photo courtesy of Kevin Hurley, Wild Sheep Foundation

Appendix 1.

Jurisdictional Importance Levels – Thinhorn Sheep Conservation Challenges

CHALLENGE	AK	YT	NWT	BC
Habitat				
Quality-Quantity	L	L	L	H
Human Encroachment	L	H	L	H
Competition	L	L	L	L-M
Disease	M	L	M	H
Predation	M	L	L	M
Population Management				
Translocations	L	L	L	L
Viability and Connectivity	L	M	L	M
Harvest Strategies	H	H	L	M
Organizational Challenges				
Funding-Personnel Shortfalls	M	M	M	H
Management Restrictions	L	L	L	M
Shared Management	H	L	M	L
Responsibilities				
Climate Change	M	M	L	H

Appendix 2.
Thinhorn Sheep Distribution by State, Province, or Territory

Alaska (Dall's sheep)

- Wrangell Mountains (also in Yukon)
- Chugach Mountains
- Kenai Mountains
- Talkeetna Mountains
- Chulitna-Watana Hills
- Alaska Range
- Tanana Hills
- White Mountains
- Ogilvie Mountains (Dall's and Fannin Sheep¹)
- Brooks Range (also in Yukon)

Yukon (Dall's sheep and Fannin sheep²)

- British/Richardson Mountains (Dall's sheep)
- Cassiar Mountains (Fannin sheep and possibly Stone's sheep³)
- Mackenzie Mountains (Yukon and Northwest Territories; Dall's sheep)
- Kotaneelee and La Biche Ranges (Yukon and Northwest Territories; Dall's sheep)
- Selwyn Mountains (Fannin sheep and Dall's sheep)
- Hess Mountains (Dall's sheep and Fannin sheep)
 - Nadaleen Range
 - Bonnet Plume Range
 - Wernecke Mountains
 - Knorr Range

- Pacific Coast Ranges (Dall's sheep)
 - St. Elias Mountains (also Wrangell St. Elias Mountains in Alaska)
 - Kluane Range
 - Alsek Range (Yukon and British Columbia)
- Yukon Ranges
 - Dawson Range (Dall's sheep)
 - Miners Range (Dall's sheep)
 - Nisling Range (Dall's sheep)
 - Ogilvie Mountains (Dall's sheep and Fannin sheep)
 - Nahoni Range
 - Pelly Mountains (Dall's and Fannin sheep)
 - Big Salmon Range
 - Glenlyon Range
 - Saint Cyr Range
 - Anvil Range
 - Ruby Range (Dall's sheep)

Northwest Territories (Dall's sheep)

- Mackenzie Mountains (also in Yukon)

British Columbia (Dall's sheep, Fannin sheep and Stone's sheep)

- St. Elias Mountains (also in Yukon; Dall's sheep)
 - Fairweather Range
- Coast Mountains (Fannin and Stone's sheep)
- Kaska Mountains (Stone's sheep)
- North and Central Canadian Rocky Mountains (Stone's sheep)
- Interior Plateau / Mountains
 - Cassiar Mountains (also in Yukon; Fannin and Stone's sheep)
 - Omineca Mountains (Stone's sheep)
 - Stikine Plateau (Stone's sheep)
 - Skeena Mountains (Stone's sheep)

¹A minimal presence and occurrence of Fannin sheep has been reported to ADF&G by the hunting public. These reports are based on visual examination of a low number of harvested rams taken from mountain range areas that extend into AK from the Yukon.

²Based on recent genetic analyses, Fannin sheep are hybrids between Dall's sheep and Stone's sheep, and are not considered a unique subspecies.

³Stone's sheep may occur in some areas of the southern Cassiar Mountains, and efforts to confirm presence or absence through genetic analysis is currently in progress.

