STRATEGIC PLAN FOR MANAGING BIGHORN SHEEP IN THE TETON RANGE

By

THE TETON RANGE BIGHORN SHEEP WORKING GROUP

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BACKGROUND

The Teton Range supports a remnant population of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*). The population is scientifically valuable because it is among a small number of bighorn sheep populations that are endemic and have not been augmented with animals from other bighorn sheep populations. But the status of this population is currently very precarious and its survival is far from assured. The most pressing current threats include:

1. potential disease transmission from, and competition with, domestic sheep that graze on the Targhee and Bridger-Teton National Forests;

2. loss or abandonment of former low-elevation winter range due to human disturbances (e.g., developments, poaching, recreational activities) and vegetation succession resulting from alteration of the natural fire regime;

3. small populations size and likely genetic isolation, which greatly increases the population's vulnerability to extinction;

4. displacement from summer range due to human activities.

Prior to the arrival of Euro-Americans in western North America, bighorn sheep numbered approximately two million and were widely distributed (Seton 1925). However, 80 years after settlement, total bighorn numbers in the United States had dwindled to less than 20,000 because of competition from domestic livestock, diseases, excessive hunting, and loss of water ranges (Buechner 1960). One third of modern populations are reintroduced transplants, and over half are considered remnants; i.e., populations with reduced numbers and distribution (Trefethen 1975).

Bighorn sheep are highly evolved ungulates whose regimented social structure facilitated their successful long-term occupancy of virtually all suitable habitats---stable grasslands and alpine vegetation associated with rough terrain (Geist 1971a). These gregarious animals inherit traditional habitat use patterns from adults. Thus, populations that are eliminated from historic habitats, and that lose their social memory of an area, are limited I their ability to relearn to use habitats that may again become suitable.

Bighorn sheep in the Teton Range have lost much of their former habitat, particularly historic winter range, and are now restricted to high elevations during winter (Whitfield 1983). This population has also become isolated due to habitat fragmentation and extirpation of bighorn sheep populations in adjacent mountain ranges. The Teton Range bighorn sheep population consisted of approximately 125 animals in the 1970's and 1980's (Whitfield 1983). Continued research and monitoring since then indicates a declining population (Reid and Cain 1996, attached: Wyoming Game and Fish Department 1996). The population's currently occupied and domiciled historic habitat, as well as potential habitat (lands with physical and ecological characteristics that probably once supported bighorn sheep but where bighorn sheep use has not been documented), are shown in Figure 1 (attached).

Jurisdiction over the population's habitat is divided between Grand Teton National Park (hereafter, the Park) and a small portion of the Bridger-Teton National Forest on the east slope of the Teton Range and the Targhee National Forest (hereafter, Targhee) on the west slope. Management jurisdiction of the bighorn sheep population is shared by Wyoming Game and Fish Department (Wyoming Game and Fish) and the Park. Because of this multiple jurisdiction, ensuring the continued survival of the Teton Range bighorn sheep population will require coordination and cooperation among these agencies (Harvey 1992).

A wealth of evidence indicates that the single most important and ominous threat to the continued existence of bighorn sheep in the Teton Range is the potential for a major or complete herd die-off resulting from diseases or parasites acquired from domestic sheep (see the section on bighorn sheep/domestic sheep relationships). Of 38 recorded die-offs of bighorn sheep from 1905 to 1989, at least 23 were known to have been caused by contact with domestic sheep (U.S. Forest Service 1989). This well-documented relationship forms the basis for accepted and formalized management guidelines, recommendations, and practices at the domestic sheep/bighorn sheep interface.

The severely limited extent of available winter habitat and displacement from traditional ranges by human activities are also prominent concerns. The Teton Range bighorn sheep's currently occupied habitat, particularly winter habitat, may not be adequate to sustain a viable population.

Past management of the bighorn sheep population has been low intensity, undirected, and independent (Grand Teton National Park 1986, Harvey 1987). The managing agencies have cooperated, however, in funding a study of the population's distribution and ecology (Whitfield 1983) and in conducting annual aerial surveys to monitor the population's status.

Growing recognition of the tenuous status of the bighorn sheep population and the need for interagency cooperation in managing the population and its habitat led to the formation of the Teton Range Bighorn Sheep Working Group in 1990. the original Working Group was comprised of independent wildlife biologist who were experts in the ecology and management of this bighorn sheep population and its habitat, biologists from the Park and Wyoming Game and Fish, and range and wildlife staff from the Targhee. All members of the Working Group have been, and currently are, professionals with the single interest of helping to conserve this scientifically important bighorn sheep population that is unique to the Teton Range. The intent of the Working Group is to provide technical information to agency personnel responsible for managing the Teton Range bighorn sheep population and its habitat. The Working Group, which has met periodically since the summer of 1990 has:

1. assimilated pertinent information on the status, distribution and ecology of the population;

2. identified management issues that affect the population's long-term survival;

3. provided guidance and assistance in monitoring and research; and

4. developed a strategic plan for managing the population and its habitat.

The following Strategic Plan is based on the Working Group members' personal knowledge of the Teton Range bighorn sheep population and its habitat and is supported by our synthesis of other research and management findings.

OBJECTIVE

Maintain a population of at least 150 to 200 bighorn sheep in the Teton Range over the long-term through coordinated management by the U.S. Forest Service, Wyoming Game and Fish Department, and the National Park Service.

PROBLEMS AND STRATEGIES FOR RESOLVING THEM

1. The population has lost historic winter range due to human disturbances (e.g., developments, poaching, recreational activities) and vegetation succession resulting from alteration of the natural fire regime. The remaining winter range may be inadequate in availability, distribution, or condition to support either the historic or desired population.

    A. Identify historic, currently occupied, and potential winter range.

    B. Determine the ecological status of historic, currently occupied, and potential winter range.

    C. Identify factors that limit the availability or use of historic, currently occupied, and other potential winter range.

    D. Describe and prioritize actions needed to restore unoccupied historic and potential winter range.

    E. Describe and prioritize actions needed to restore bighorn sheep use of currently unoccupied historic and potential bighorn sheep winter range.

2. The distributions of bighorn sheep and domestic sheep overlap in some areas. This increases the probability of adverse impacts on the bighorn sheep population due to transmission of diseases and competition for forage.

    A. Identify seasonal overlap in domestic and bighorn sheep distributions on currently occupied, historic and potential bighorn sheep habitat.

B. Develop recommendations for removing domestic sheep grazing from currently occupied, historic, and potential bighorn sheep habitat in order to eliminate the chance for disease transmission to the bighorn sheep population and competition for forage.

C. Provide buffer zones at least 3 miles wide and, depending on local conditions and management options, up to 20 miles wide between currently occupied, historic, and potential bighorn sheep habitat and domestic sheep grazing and trailing areas.

3. Increasing recreational use may inhibit bighorn sheep from using some currently occupied, historic, or potential habitat.

    A. Synthesize information on the effects of human disturbance on bighorn sheep.

    B. Identify crucial occupied, historic, and potential bighorn sheep winter range and develop recommendations for closures to human use during winter and early spring.

    C. Develop recommendations for reducing the effects of human disturbance on other bighorn sheep seasonal ranges.

4. The viability of the bighorn sheep population may be compromised by a high inbreeding coefficient and low genetic variability because of the population's small size and isolation from other bighorn sheep populations.

    A. Determine the genetic status of the population.

    B. Develop recommendations for management of the population that will preserve or enhance genetic variability.

5. Accurate and current information on population dynamics, movements, seasonal distribution, habitat condition and use, and the effects of management practices is needed for appropriate coordinated management of this bighorn sheep population.

    A. Increase monitoring of the sex and age structure and trend of the population; its seasonal distribution; and the availability, condition, and use of its currently occupied, historic, and potential habitat.

    B. Determine the population's seasonal distribution, movements, and causes of mortality by means of coordinated ground and aerial surveys and radio-telemetry monitoring.

6. Non-native mountain goats are occasionally present, and may become established, in the Teton Range and may adversely impact the bighorn sheep population.

A. Monitor the status of mountain goats in the Teton Range.

B. Synthesize and evaluate information on the interrelationships between bighorn sheep and mountain goats as they pertain to ecological conditions in the Teton Range.

C. Based on this synthesis and evaluation, determine alternative actions and a preferred course of action for dealing with the possibility that mountain goats may disperse into, and become established in, the Teton Range.

7. Public awareness of the Teton Range bighorn sheep population, its status, and management concerns is limited.

    A. Develop a public information and education program that describes:

        i. The population's history, status, and uniqueness;

        ii. Conflicts between domestic and wild sheep;

        iii. The effects of human disturbance on bighorn sheep;

        iv. Bighorn sheep habitat requirements;

        v. Interrelationships between bighorn sheep, mountain goats, and other wildlife species;

        vi. Interagency guidelines for managing the bighorn sheep population.

STATUS OF THE TETON RANGE BIGHORN SHEEP POPULATION AND ITS HABITAT: A SUMMARY OF OUR CURRENT KNOWLEDGE

Status of Bighorn Sheep Winter Range

Bighorn sheep have probably occupied the Teton Range during at least some seasons since the retreat of the Pinedale Glaciation some 10,000 years ago (Whitfield 1983). Climatic variation in subsequent periods has probably caused shifts in bighorn occupation of high elevations n the region. Teton Range glaciers have retreated considerably since the later part of the 19th century (Love and Reed 1968), which suggests an amelioration of climate since settlement.

Natural Rocky Mountain bighorn sheep populations typically summered on high alpine ranges and descended to lowland areas to winter before human activities altered their seasonal movements, fragmented their habitat, and altered the natural fire regime (Honess and Frost 1942, Smith 1954, Buechner 1960, and others). Geist (1971a) notes that such natural populations typically crossed at least one deep, timbered gorge, and traveled up to 40 miles between seasonal ranges. Historical information collected by Whitfield (1983) from interviews of longtime residents and review of historic notes

suggests that Teton Range bighorn sheep made similar movements. Figure 1 identifies currently occupied, historic (since settlement in the late 1800s), and potential bighorn sheep winter range in the Teton Range. Date included in this map are based on Whitfield (1983), on more recent information obtained by Wyoming Game and Fish and the Park, and on interpretation of potential winter range by members of the working group who are familiar with the requirements of bighorn sheep and the physical and ecological characteristics of the Teton Range.

Bighorn sheep from the Teton Range probably wintered east of Jackson Hole, Wyoming, and on the Gros Ventre Buttes east of Wilson, Wyoming (Murie 1956, and A. Bowles, pers. comm., as cited in Whitfield 1983). Sheep wintered low in Fox Creek Canyon, Teton Canyon, Darby Canyon, and Bitch Creek Canyon and low on Rendezvous Mountain. Human encroachment upon winter ranges, including developments, poaching, and recreational activities, gradually eliminated bighorn sheep use of almost all the lowland areas originally available to Teton Range bighorn sheep.

A major portion of the bighorn sheep summering in the Teton Range probably wintered some distance from there. Bighorn sheep were reported historically in all mountain ranges adjacent to the Teton Range (Whitfield 1983), and they wintered in lowland areas at the bases of these ranges. Russell (1955:95) observed “immense numbers of Mountain Sheep” along the Snake River on the west edge of the Big Hole Mountain Range in January, 1839. Notably, the Big Holes provide considerable winter range opportunity, but little summer range, as has been learned from the introduction of mountain goats to the area (Hayden 1989). Teton Range bighorn sheep were likely among these wintering animals, or at least gained from genetic interchange with such adjacent populations which are now extinct.

Currently occupied bighorn sheep winter range in the Teton Range (Figure 1) is limited to small areas of windswept tundra, rock, or snowfree krumholz on ridges and slopes above 9,000 feet elevation (Whitfield 1983, Grand Teton National Park, unpublished data). Wintering conditions on these areas are extreme due to high winds, low temperatures, deep snow, and little available forage. Currently occupied winter ranges also predispose Teton Range Bighorn sheep to sources of mortality usually not associated with more typical, low elevation winter areas. Mortality due to avalanches and falls from cliffs is high, and starvation may also be important during some years (Reid and Cain 1996, attached). In addition, inspection of bighorn sheep teeth indicated that incisor wear may be abnormally high, possibly from winter foraging in rocky areas where little vegetation other than lichens exists. Such tooth wear could contribute to premature death.

Wildfire was a key element in the development and maintenance of plant communities in the lower elevations of the Teton Range, as noted in numerous references from the late 1800s immediately prior to settlement (Bradley 1873, Baillie-Grohman 1882, Fryxell 1943, Thompson and Thompson 1981). Journal notes of Richard “Beaver Dick” Leigh, the earliest white man to live in Teton Valley, Idaho, for extended periods, suggest that many of the wildfires during this period may not have been natural in origin or frequency (Thompson and Thompson 1981). For example, on September 19, 1875, Leigh saw a big fire burning from “north of Camas Creek to the North Ford (Snake River), a distance

of 24 miles," and he noted that the fire was set by the Bannocks, a regular event. On July 8, 1876, he reported a big smoke in Teton Creek, in the vicinity of a popular trapper campsite, and on August 8, 1878, he indicated that an escaped white man's campfire burned over 100 miles of country.

Bighorn sheep winter habitats in the Teton Range appear to have changed ecologically since settlement. The exclusion of fire in the Teton Range over the past 100 years has contributed to seral forb and grass communities becoming dominated by shrubs and conifers. Key areas thought to be affected by this ecological change include lower Fox Creek Canyon, Teton Canyon, and Bitch Creek. Forb and grass communities created by fire are important for bighorn sheep in Wyoming, Montana and Alberta (Crump 1971, Frisina 1974, Peek et al. 1979).

Factors that limit the availability or use of historic, currently occupied, and potential seasonal bighorn sheep habitat in the Teton Range include:

1. potential disease transmission from, and competition with, domestic sheep that graze on or trail through currently occupied, historic, and potential bighorn sheep habitat;

2. loss or abandonment of former low-elevation winter range due to human disturbances (e.g., developments, poaching, recreational activities) and habitat fragmentation;

3. vegetation changes from alteration of the natural fire regime;

4. likely genetic isolation and related consequences of inbreeding;

5. displacement fro summer range due to recreational activities

Bighorn Sheep/Domestic Sheep Relationships

The impact of domestic sheep diseases and parasites on bighorn sheep and other conflicts between the 2 species is well documented in the review by Suminski (1991) and in the following papers not reviewed by Suminski: Coggings (1988), Forety (1989, 1990, and 1992), Foreyt et al. (1993), Risenhoover (1988), Hunt (1980), Jessup (1980 and 1982), Kistner (1982), Onderka et al. (1988), Onderka and Wishart (1988), Armstrong (1989), Silflow et al. (1989 and 1993), Ward et al. (1990), Callan et al. (1991), and Schommer et al. (1991).

Overlap in the distribution of bighorn sheep and domestic sheep in the Teton Range can be accurately described from the map of currently occupied, historic, and potential habitat for bighorn sheep (Figure 1), from Map 29 in the Draft Forest Plan Revision for the Targhee (Targhee National Forest 1996), from a map by Steve Kilpatrick (Wyoming Game & Fish files), and from information in allotment management plans, grazing permits, and input from Targhee personnel and grazing permitees.

Current knowledge indicates that domestic sheep should be removed from currently occupied, historic, and potential bighorn sheep habitat in order to minimize adverse impacts on bighorn sheep populations. Essentially all the management strategies proposed by Suminski (1991) involve separation of domestic sheep and bighorn sheep, whether this is justified on the basis of disease transmission or on spatial competition.

The Park and Wyoming Game & Fish have repeatedly expressed concern about the threat domestic sheep grazing poses to the Teton Range bighorn sheep population, primarily because of the possibility of disease transmission and secondarily because of competition for forage. Both agencies have suggested that domestic sheep grazing should be terminated in bighorn sheep habitat (Wyoming Game & Fish Department 1985 and Job completion Reports for 1990-1995; National Park Service 1995).

That existing or potential conflict between bighorn sheep and domestic sheep can and should be eliminated by removing domestic sheep grazing from bighorn sheep habitat is supported by what has been done, or recommended to be done, on other U. S. Forest Service (USFS) and public lands. One such guideline, produced by and for the USFS (Suminski 1991), suggests establishing a buffer zone between domestic sheep and bighorn sheep use areas to prevent the transmission of fatal diseases and that no trailing of domestic sheep occur within at least 2 miles of occupied bighorn sheep ranges. Similar guidelines formulated by the Bureau of Land management (1992) in consensus with the American Sheep Industry Association, the Western Association of Fish and Wildlife Agencies, and several bighorn sheep specialists and organizations state that: 1) domestic sheep grazing and trailing should be discouraged in the vicinity of bighorn sheep range; 2) bighorn sheep and domestic sheep should be spatially separated to discourage the possibility of coming into physical contact wit each other; and 3) buffer strips (up to 9 miles wide depending on local conditions and management options) surrounding bighorn sheep habitat should be encouraged.

Goodson, et al. (1982, page 305) point out that:

> Some land and wildlife management agencies have responded to the available information on interactions between domestic sheep and bighorn sheep by developing direction or guidelines or by specific management decisions… The San Bernadino and Angeles National Forests…have a policy against domestic livestock on occupied bighorn range, which has been in force since 1967…The Inyo National Forest… completed an Environmental Analysis Report in 1979 in which the preferred Forest Service Alternative was not to convert an allotment partially on bighorn sheep range from cattle to domestic sheep…based largely on concern about the potential for disease transmission between domestic and bighorn sheep…The San Bernardino National Forest also recently documented a decision not to convert a cattle allotment to domestic sheep use because of its proximity to bighorn range and the potential for disease transmission…The Bureau of Land Management in Idaho has a policy against grazing domestic sheep within 3.3 kilometers…of occupied bighorn range in its land Management Plan for 1 resource area.

In addition, an April 1981 memo from Dale Jones, Director of Wildlife and Fisheries, USFS to Regions 1, 2, 4, 5, 6 and 10, after bighorn sheep die-offs at Lava Beds National Monument and the Methow Game Range stated (Goodson 1982, page 305):

> Although this is not conclusive evidence, it indicates that domestic sheep are a probable source of infection of bighorn and underscores the need to assess carefully the probability of disease transmission where domestic sheep are permitted to graze on bighorn sheep range or where domestic sheep may come into contact with bighorn held within enclosures, etc. Appropriate caution should be exercised to prevent contact between the species…(Our emphasis).

The preferred Alternative A in the DEIS for the Bureau of Land Management's Grass Creek Resource Area, which abuts the Shoshone National Forest, states that domestic sheep grazing would be restricted (i.e., prohibited unless adverse effects can be avoided or mitigated based on site-specific analysis) within 2 miles of bighorn sheep habitat. Alternative C, which placed greater emphasis than the Preferred Alternative A on wildlife habitat enhancement, called for restricting domestic sheep grazing within 20 miles of bighorn sheep habitat (Bureau of Land Management 1994:40).

Other guidelines for dealing with the conflict between bighorn sheep and domestic sheep include: U.S. Forest Service and Oregon Department of Fish and Wildlife (1988), Desert Bighorn Council Technical Staff (1990), Schommer, et al. (1991), and Bureau of Land Management (1992).

National Forests have imposed restrictions on domestic sheep and goat grazing to protect bighorn sheep populations. The Santa Fe and Carson National Forest prohibit the possession and transporting of domestic sheep and goats in the Pecos Wilderness Area, and all domestic sheep allotments where contact with bighorn sheep might occur have been changed from domestic sheep to cattle or retired. The Wenatchee National Forest has modified range allotments to protect bighorn sheep. And most recently, in 1995 the Wallowa-Whitman National Forest proposed to terminate domestic sheep grazing on portions of the Hells Canyon National Recreation Area where there is a high risk of bighorn sheep coming ito contact with domestic sheep. Domestic sheep grazing was to be allowed to continue in these high risk areas until October 1996, but domestic sheep grazing in allotments which were only partially within the Recreation Area in Idaho was to be retained (Wallowa-Whitman National Forest 1995). The rationale for the termination was to protect bighorn sheep fro contracting diseases from domestic sheep, since the susceptibility of bighorn sheep to such disease is well-documented. This action was taken after the Wallowa-Whitman National Forest tried, over an extended period of time, a variety of other unsuccessful management techniques to keep domestic sheep and goats separated from bighorn sheep, and after a die-off of bighorn sheep due to transmission of disease from a domestic animal. The delayed timing and limited scope of the proposal was challenged in court, but the Wallowa-Whitman National Forest's decision to eliminate domestic sheep grazing as proposed was upheld (Idaho Wildlife Federation vs. Richmond, No 94-1347-AS, April 16, 1996). The overriding factor in this case was the undisputed risk of disease transmission between bighorn sheep and domestic sheep in prime bighorn sheep habitat, not the USFS land classification as a National Recreation Area (M. Oechsner, pers. comm.).

Effects of Human Disturbance on Bighorn Sheep

The Working Group has not synthesized relevant literature regarding this topic. Whitfield (1983) reviewed the literature and other information prior to his study of the Teton Range bighorn sheep population. Barmore (personal files) has reviewed and abstracted relevant information from: Hamilton, et al. (1982), Geist (1971a and b), Hicks and Elder (1979), Irby, et al. (1989), MacArthur, et al. (1982), Miller and Smith (1985), and Whitfield (1983). Other relevant papers are: Harris (1992), Harris et al. (1995), King and Workman (1986), and Purdy and Shaw (1981).

Preliminary analysis of the above literature provides ambiguous conclusions—some studies conclude that human activity adversely impacts bighorn sheep distribution, others that it does not. None of the above studies demonstrate or speculate that human activities (other than mortality from hunting and poaching) have adverse impacts on bighorn sheep population dynamics, just their distribution and patterns of habitat use. But most of the studies dealt with human disturbance during summer or fall. That human disturbance during winter would have greater adverse impacts than disturbance during summer (when suitable habitat and forage is more widespread and available) is more clearly indicated, however. Human activities on the restricted occupied, historic, and potential bighorn sheep winter range in the Teton Range would adversely impact use of these areas by bighorn sheep. This would adversely affect their nutrition and metabolism during the critical winter-spring period and would likely have adverse population consequences (Geist 1971a:87-88, 311). With specific reference to bighorn sheep in the Teton Range, Whitfield (1983 concluded: (1) that bighorn sheep in the Teton Range significantly avoid high recreation use areas, (2) that rams avoid humans to a much greater degree after six years of hunting, and (3) that hunting had altered ram distribution and reaction to humans.

That human disturbance during winter may have adverse population consequences for bighorn sheep has been acknowledged by land management agencies. The Park has recognized the potential for human disturbance of critical bighorn sheep wintering areas in the Teton Range. Static Peak, a known bighorn sheep wintering area and once a popular ski mountaineering destination, was closed to human entry during winter for many years. This closure, while focused on a popular area, was inconsistent because it ignored other important bighorn sheep wintering areas. In conjunction with current research (Reid and Cain 1996, attached) as a part of a winter visitor use management analysis, the Park is in the process of delineating specific, critical bighorn sheep wintering sites throughout the Teton Range. Delineation of these sites will form the basis for closure recommendations that are applied consistently throughout the Park.

Travel restrictions are in place on bighorn sheep winter range in the Jackson and Whiskey Mountain bighorn sheep herd units. In the Jackson Unit, travel is restricted to designated routes and human presence is also restricted. On the Whiskey Basin Unit, vehicle travel is restricted but foot access is not. Travel is also restricted on deer, elk, and bighorn sheep winter range in the Eastfork Units north of Dubois, Wyoming Game & Fish Dept. (Doug Brimeyer, pers. Comm.).

National Forests also have imposed restrictions on human activity to protect bighorn sheep. The Wallowa-Whitman National Forest has closed roads to motorized travel to protect bighorn sheep. The current Wenatchee National Forest Plan includes winter activity restrictions on bighorn sheep winter habitat, limits timber sale activity in bighorn sheep lambing areas, and includes some road closures to favor bighorn sheep. The Medicine Bow National Forest Plan includes activity restrictions within one mile of known bighorn sheep lambing areas between May 1 and June 20. The White River National Forest has an area closure for all winter activity (dogs and people) from November 15 to March 15. And the Coronado National Forest has closures to protect bighorn sheep (M. Oechsner, pers. comm.).

Bighorn Sheep Population Viability

Shaffer (1981) differentiated factors which contribute to uncertainty for a population's future persistence into two general categories: systematic or deterministic pressures and stochastic or chance perturbations. As deterministic pressures whittle away at a habitat's capacity to support a population, the population becomes increasingly affected by chance events. Stochastic or chance forces that might lead to the extinction of a reduced population (Shaffer 1981, Gilpin and Soule 1986), include:

1. Demographic stochasticity—chance variation in individual reproduction and survivability.

2. Genetic stochasticity—random change in genetic composition due to genetic drift, the founder effect, or inbreeding.

3. Environmental stochasticity—chance temporal variation in habitat and ecological parameters and environments shocks experienced by the population.

4. Natural catastrophes—fires, floods, droughts, and similar events which occur randomly.

Habitat Loss. Whitfield (1983) documented a historical loss of habitat quantity and quality for bighorn sheep in the Teton Range, most notably loss of historic winter ranges at lower elevations, and lost opportunity for migration onto winter ranges in adjacent areas. Whitfield also documented the loss of historic, but now extinct, bighorn sheep populations in adjacent mountain ranges. Insularization of a habitat reserve often results from the loss of access to habitats outside the reserve which are required for survival of a population (Wilcox 1980). The Teton Range may have once supported a much larger summering bighorn population, components of which could winter in several areas outside the Teton Range, including areas within and across Jackson Hole to the east, and in the lower elevations of the Snake River and Big Hole Mountain Ranges to the south and west (Whitfield 1983).

Environmental Stochasticity. Environmental uncertainty ranges from extremely unpredictable catastrophes, such as floods or major storms, to mildly unpredictable

events such as annual changes in weather patterns (Brussard 1986). The Teton Range is an extreme example of the seasonal effects of environmental stochasticity for a bighorn population (Whitfield and Keller 1984). Winters are long and spring weather is unpredictable. Cold wet springs may be particularly difficult for this bighorn population that winters in extreme habitats and is thus in relatively poor condition in late winter and spring. Predictably, survival of yearling bighorn sheep through their first winter appears to be very low (Whitfield 1983).

Change in environmental quality, or environmental disturbance dynamics, becomes very important to a population's vulnerability to extirpation (Gilpin and Soule (1986). Environmental stochasticity strongly interacts with demographic and genetic parameters (Goodman 1987, Brussard 1986). Recent evidence of decline in the size of the bighorn sheep population of the Teton Range suggests that inclement weather may be a contributing cause (S. Cain, pers. comm.).

Demographic Stochasticity. Goodman (1979) considered the particular demographic features of long-lived animals to be: relatively high survival rate, low fecundity, and late reproductive maturity. Such animals are behaviorally advanced to the extent that they learn foraging, fighting, and courtship skills over several years. As they advance and survive, their potential value to the population increases. Survivability of breeding adults is expected to be a key factor in the determination of the population growth rate.

Population uncertainty includes random variation in sex ratio, age of first reproduction, number of offspring, distribution of offspring over an individual lifetime, and time of death (Brussard 1986). These factors affect two parameters of critical importance in determining minimum viable population, mean population growth rate, and variation in population growth rate (Goodman 1987). In the classic sense wherein chance demographic variation is assumed to be independent for each individual, demographic stochasticity is a significant extinction threat only at very low population levels (Brussard 1986). Simulation models suggest that a population should be relatively immune to extinction due to chance demographic events which act at the individual level when population numbers exceed 20-50 individuals (Goodman 1987, Shaffer 1981). However, these numbers are overly optimistic if one considers the effects of environmental change (Leigh 1981). Environmental variation in this context creates population-wide change in the probabilities of reproduction and death and variance in population growth rate. If this parameter is at all unfavorable, objectives for long persistence times become much more difficult to achieve (Goodman 1987). Management actions to minimize the effects of environmental variability are strongly supported in this case (Brussard 1986, Goodman 1987).

Genetic Concerns. A strategy for conservation of a particular species should be in part determined by knowledge or inference about the genetic structure of that species (Franklin 1980). Population bottleneck events may result in a severe loss of heterozygosity or polygenic balance in a reduced population (Carson 1983), but may have much less impact than does genetic drift in a perennially small population following such an event (Nei et al. 1975). Subdivided populations may rapidly lose variability within each subpopulation, but retain more diversity in the total population if limited mixing occurs, than does a panmictic population (Lacy 1987).

Franklin (1980) suggests that for short term fitness, a minimum effective breeding population for vagile species with random mating should approximate 50 individuals. Actually, a population of this size offers only short term protection because approximately 64% of this population's neutral genetic variation will be lost through genetic drift in 100 generations (Brussard 1986). For the long term, Franklin (1980) suggested a minimum viable population of 500 to ensure that genetic traits are not lost faster than they can be replaced by mutation. Typically, greater genetic heterozygosity infers greater ecological advantage, and achievement of greater age, among individuals in natural populations (Soule 1980).

Population Persistence in Wild Sheep. When habitat fragmentation isolates a population in poor habitat, numbers dwindle to the point that stochastic events can take control (Terborgh and Winter 1980). The Teton Range bighorn sheep population has persisted for over 50 years in a much reduced habitat (Whitfield 1983), but appears to be declining in size (S. Cain, pers.comm.). Our primary goal for this population must be to prevent any additional loss of habitat quantity and quality to avoid stochastic control of the population, and ultimate extinction.

In his review of outcomes for historical populations of desert bighorn sheep, Berger (1990) found that initial population size was a good indicator of population persistence. Populations of 50 or less had a 100% probability of going to extinction in less than 50 years, whereas those of more than 100 persisted for up to 70 years and longer. Small sample size for populations intermediate between these two categories prevented conclusive determination of trend. Berger discounted inclement weather, food shortages, predation, and interspecific competition as primary causes of extirpation in desert bighorn populations. Data suggest that genetic and etiological factors may be important determinants of persistence. There is evidence of widespread extinctions where native bighorn sheep are exposed to domestic sheep.

Available information suggests that the Teton Range bighorn sheep may be experiencing some genetic effects of small population size and lack of interchange with other populations. Teton Range bighorn sheep had the lowest heterozygosity of 12 herds in Wyoming which were analyzed for genetic variability (Fitzsimmons 1992). This is consistent with observations that suggest potential inbreeding problems in the population, such as poor lamb survival and small body size (Whitfield 1983, Grand Teton National Park, unpublished data). Fitzsimmons' analysis was based on only 4 individual bighorn sheep fro the Teton Range. Pending analyses of samples from 16 additional individuals collected during the Park's research should help clarify the heard's genetic status. Additional relevant information is in Bleich et al. (1990) and Schwartz, et al. (1986).

Status of the Teton Range Bighorn Sheep Population

A definitive enumeration of presettlement and early postsettlement bighorn sheep numbers in the Teton Range is not available. Settlement of the valleys around the Teton Range began in the 1880s, and human occupation of the range was very widespread then (Whitfield 1983). Immense numbers of domestic sheep were herded throughout

the Teton Range, prospectors scoured the mountains and developed claims in several areas, trappers and big game hunters were active in all seasons, and saw mills sprang up in the mouths of most canyons, where winter logging often occurred. During this era, bighorn sheep declined or became extinct in adjacent mountain ranges, and bighorn sheep numbers were reduced in the Teton Range. Use of lower elevations habitats was reduced or eliminated. By the 1930's bighorn sheep numbers in the Teton Range were greatly diminished (Fryxell 1938, Honess and Frost 1942, Murie 1956, Burnap et al. 1957 Buechner 1960, Whitfield 1983). Buechner (1960) attributes the decline of bighorn sheep throughout the west to several factors acting in concert. Among these factors in effect in the Teton Range were competition and disease from domestic sheep, excessive hunting (poaching), and restriction of winter ranges. Interviews with old timers who were familiar with the Teton Range suggest that the bighorn population may have declined to a low point in the 1930's and 1940's with some recovery in numbers during subsequent years (Whitfield 1983).

Current knowledge of the population is based on Whitfield (1983), annual winter counts conducted from 1988 to the present (Table 1), other summer ground counts and classifications (both organized and opportunistic, Tables 2 and 3), and on research conducted by the Park from 1994 until the present on the genetic status, movements, sources of mortality, and seasonal distribution of the population (Reid and Cain 1996, attached). Minimum counts of bighorn sheep (not necessarily based on full coverage of suitable habitat) have ranged from 39 to 97 since 1976 (Table 1). Whitfield (1983) believed that the total population approached 125 in 1981 and was static or declining. Annual winter counts and high winter mortality during the last 2 years indicate that the population may have declined substantially (Table 1, Reid and Cain 1996, attached). The current distribution of bighorn sheep in the Teton Range is indicated in Figure 1.

Table 1. Results from winter helicopter surveys of bighorn sheep in the Teton Range [a]

YEAR	MONTH	RAMS	EWES	LAMBS	YRLNG	UNCL	TOTAL	LAMBS: 100 EWES	RAMS: 100 ESES	OBS
76	DEC	17	23	13	0	18	71	57	74	WGFD
78	DEC/JAN	12	18	9	0	0	39	50	67	WGFD
79	JAN	13	28	10	3	9	63	36	46	WGFD
88	DEC	25	35	29	8	0	97	83	71	WGFD
89	NOV	19	27	8	3	0	57	30	70	WGFD
91	FEB	27	40	23	2	0	92	58	68	WGFD
91	NOV	21	28	17	0	0	66	61	75	WGFD
93	DEC	16	22	5	0	0	43	23	73	WGFD
94	MAR	27	33	11	3	1	75	33	82	NPS
										WGFD
95	MAR	16	17	5	1	0	39	29	94	NPS
										WGFD
96	MAR	9	20	11	5	0	45	55	45	NPS
										WGFD

[a] Data do not include duplicate observations, but may not represent full coverage of available habitat.

Table 2. Results of Grand Teton National Park summer ground classification surveys of bighorn sheep in the Teton Range.[a]

YEAR	RAMS	EWES	LAMBS	YRLING	UNCL	TOTAL	LAMBS: 100 EWES	YRLNGS: 100 EWES	RAMS: 100 EWES
90	5	12	9	1	15	42	75	8	42
91	6	14	12	1	0	33	86	7	43
92	14	9	6	3	14	46	67	33	156
93	6	34	12	6	0	58	35	17	18
94	7	12	8	3	0	30	67	25	58
95	2	14	5	3	0	24	36	21	14

[a]Data do not include duplicate observations and are not based on full coverage of available habitat.

Table 3, Miscellaneous bighorn sheep classification data from Grand Teton National Park files.[a]

YEAR	SEASON	LAMBS	YRLGS	EWES	RAMS	UNCL	TOTAL	LAMBS: 100 EWES	RAMS: 100 EWES
56	OCT	2	0	8	5	0	15	25	63
57	MAR	10	0	12	8	0	31	83	67
69		22	1	26	22	0	70	85	85
74	APR	7	0	15	14	6	45	47	93
75		6	3	11	9	0	26	55	82
76	JUL-AUG	12	0	27	38	0	86	44	141
77	AUG-SEP	13	9	38	52	0	114	34	137
77	SUMMER	9	11	31	35	0	75	29	113
78	JUL-AUG	25	0	65	21	6	121	38	32
78	SUMMER	16	4	30	14	0	64	53	47
79	SUMMER	10	1	20	14	0	45	50	70
1956-1979 TOTALS		132	33	283	232	12	692	47	82
80		9	0	13	14	6	42	69	108
81	MAR	11	3	25	12	0	51	44	48
82	SUMMER	15	0	28	8	16	67	54	29
83	SUMMER	0	0	4	4	23	31	0	100
84	SUMMER	2	2	9	25	17	55	22	278
85	SUMMER	18	5	27	18	24	92	67	67
86	SUMMER	4	3	7	1	0	15	57	14
87	SUMMER	11	2	12	22	43	90	92	183
90	AUG	12	0	15	6	18	51	80	40
91	JUL-SEP	37	0	54	18	8	117	69	33
1980-1991 TOTALS		119	15	194	128	155	611	61	66

[a]Data may include duplicate observations and are not based on full coverage of available habitat.

Bighorn Sheep / Mountain Goat Relationships

The Working Group has not synthesized relevant literature regarding this topic. Barmore (personal files) has reviewed the following publications and abstracted information relevant to the local situation: Adams, et al. (1982); Chadwick (1983); Coblentz (1990); Hobbs, et al. (1990); Hobbs et al. (n.d.); and Laundre, J.W. (1990). In addition Hayden (1989) studied mountain goat ecology in the Snake River Range.

Preliminary analysis of the above publications indicates that, if nonnative mountain goats became established in the Teton Range, they would compete with bighorn sheep for food, particularly on the limited winter habitat, and this would have adverse population consequences for the native bighorn sheep. Observations of mountain goats in the Teton Range have been few and incidental with no evidence that mountain goats have become permanently established there. The presence of non-native mountain goats in the Park would be incompatible with NPS management policies (National Park Service 1988, Chapter 5:5-6, 12-14).

Monitoring Needs

The Park and Wyoming Game and Fish monitored the population's status by sporadic ground and/or aerial surveys from 1956 to 1988 and annually from 1988 to the present. Annual winter counts were paid for by Wyoming Game and Fish from 1988 to 1993 and by the Park from 1994 to the present. The best population estimates are based on these counts, as they are conducted when sheep are confined to, and concentrated on, small, snow-free areas at high elevation. It has always been assumed that the majority of sheep in the herd are counted during these surveys. However, small numbers of additional sheep winter in other extremely rugged and difficult-to-survey locations (Grand Teton National Park, unpublished data), hence the ability to arrive at accurate population estimates is limited. Organized summer ground classification surveys have been conducted sporadically by the Park and other volunteer groups for several years (Table 2 and 3). These surveys are important for determining minimum numbers by area, and for determining age and sex composition of the herd, especially lamb/ewe and yearling/ewe ratios.

Regular monitoring of the herd should be continued, expanded, and better coordinated. Funding for the annual winter surveys, the most important of annual monitoring efforts, is not secure. Special project funds from the Park which have covered costs in recent years will not exist in the future, and Wyoming Game and Fish aerial survey budgets have been cut significantly. Furthermore, because of the high variance associated with these counts, funds for duplicate surveys should be sought. Summer ground counts, conducted sporadically in the past, should be done annually in both northern and southern parts of the Teton Range. The commitment of funds and other resources required to successfully implement these procedures should be coordinated among responsible agencies and interested volunteer groups. Otherwise, a consistent and sufficient level of monitoring will not be possible.

No formal program is in place for monitoring goats in the Teton Range; however, the Park and the Wyoming Game and Fish personnel record observations obtained during ground and aerial surveys of the Teton Range bighorn sheep population.

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