BIGHORN SHEEP AND FIRE: SEVEN CASE HISTORIES

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ABSTRACT: Responses of seven bighorn sheep populations and habitats to prescribed fire and wildfire in southern British Columbia, Idaho, and Glacier National Park ranged from no influence to increase; interacting factors such as lungworm infection, livestock grazing, and reduction in forage overrode potential benefits of subsequent increases in production and nutritive content of forages. A list of factors to be considered before prescribed fire is used in bighorn habitats is provided.

INTRODUCTION

The purpose of this paper is to summarize investigations of responses of vegetation and bighorn sheep (*Ovis canadensis nelsoni, O. C. californiana*) to wildfire and prescribed burns in British Columbia, Idaho, and Montana. Historical records compiled by Stelfox (1971) and Smith (1954) suggest that, in addition to other habitats, bighorn originally occurred in areas where fires were frequent. Perhaps because of the sensitivity of this species to human influences, direct or indirect (as through livestock grazing), and their frequent association with climax bunchgrass winter range, the prevailing management for bighorn habitat has been to exclude livestock and minimize human activity. In the last decade, a few investigations into fire-bighorn-habitat relationships have occurred, motivated primarily by the low population levels which continued to persist in some areas even after adequate protection of habitat and populations was achieved. Additionally, habitat manipulation to improve forage sources using prescribed fire was becoming more widely recognized as an acceptable practice. Finally, areas of prime bighorn habitat where wildfire was common were being incorporated into wilderness, and a knowledge of bighorn response to fire was needed if fire was to be restored to the ecosystem.

Seven areas have been investigated in the British Columbia-Idaho-Montana region and are reviewed here: Wigwam Flats and the Bull, Chilcotin, and Ashnola River areas in British Columbia; East Fork and Middle Fork Salmon River areas in Idaho; and Glacier National Park, Mont. Each represents a case study comprising different habitats, responses, and implications for management and further research.

ASHNOLA RIVER-EWART CREEK, BRITISH COLUMBIA

Description of Area

The prime California bighorn (*Ovis canadensis californiana*) winter range habitat in the Similkameen River valley has been preempted by orchards, alfalfa fields, livestock grazing, and human settlement. The bighorn winter ranges in the Ashnola River valley can be considered as refuges for a historically much larger population. Two populations exist in the Ashnola: one on the grasslands above Ewart Creek and one on the grasslands of Crater Mountain.

The Ashnola valley is dominated by steep relief, with deeply entrenched valleys. The grasslands are topographically controlled, and few potential grassland sites exist. The existing winter ranges above Ewart Creek are a mixture of bunchgrass communities dominated by *Agropyron spicatum, Festuca idahoensis, Koeleria micrantha, Poa pratensis, or Festuca scabrella*. This area would be considered a high mountain winter range area.

Areas adjacent to the grasslands are dense forests of *Pseudotsuga menziesii, Pinus contorta, or Picea engelmanii*, depending on elevation. Six major fires have occurred in the valley in the past 140 years. The most recent, in the late 1920's, occurred during a period of extreme drought (Harcombe and Kowall 1983).

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There is only minor encroachment of forests onto grassland soils; the boundary between grassland soils and those associated with forests is distinct, following almost exactly the present tree margins. Present grasslands have remained stable for several centuries (Harcombe and Kowall 1983).

Burning Management Program

The bunchgrass communities have been heavily grazed by domestic livestock (cattle, sheep, and horses) in the past and by bighorn sheep and mule deer (*Odocoileus hemionus*) (Blood 1961; Demarchi 1965). Any effects of fires on the grasslands have been greatly masked because of heavy grazing.

The British Columbia Fish and Wildlife Branch regional office at Penticton suggests that the Ewart Creek herd of bighorn sheep would benefit if nine designated areas were burned (Hankins 1962); however, it is doubtful that burning any of those nine areas would increase forage productivity on winter ranges or that burning would create new winter ranges or enlarge existing ones. In addition, burning existing grasslands would cause a net nutrient loss due to the poor cation exchange capacities of these soils (Harcombe and Kowall 1983).

Burning the immature forests and scrublands adjacent to the winter ranges could provide migration avenues from winter ranges to summer ranges, with some potential spring and fall use ranges being created. Several sparsely forested sites are now used as migration corridors, and it is doubtful that additional corridors are necessary.

Bighorn Response

A closed bighorn hunting season from 1909 to 1955 (except for 1947), a predator control program from 1952 to 1955, and the removal of domestic sheep from the summer ranges produced no immediate observable increase in the bighorn numbers (Blood 1961). Bighorn numbers did increase, however, by two to two and one-half times in the mid-1960's. Cattle were removed from the main Ewart Creek bighorn winter ranges in 1968; as yet the bighorn numbers have not increased over those of the mid-1960's.

Few plant species changed so as to affect grasslands composition in the period 1960 to 1972, although almost all sites visited were in a better condition class in 1972 than in 1960 or 1963. Bighorn sheep distribution and use patterns had changed after the cattle were removed, and one consequence was that some sites had a lower condition class after the cattle were removed than under heavy cattle grazing. In total, though, the winter ranges were in better condition 4 years after the cattle were removed than while they were still grazing this area.

BULL RIVER, BRITISH COLUMBIA

Description of Area

The Bull River Rocky Mountain bighorn (*Ovis canadensis canadensis*) winter range is located on the glacier terraces and cutbanks of the north side of the Bull River in the Rocky Mountain Trench. This winter range was logged in the 1920's; in July 1931, two large fires burned the logging debris and remaining forests. Once the tree canopy was removed, the high evapotranspiration rate and calcareousness of the limestone-derived soils were able to retard any tree encroachment on to the newly established shrub-grasslands.

Subsequent to the removal of the forest canopy, feral horse numbers increased until an active program by the British Columbia Forest Service was initiated to remove them from all public lands in the East Kootenay. Domestic sheep were permitted on crown range in the 1940's and 1950's but were replaced by cattle. Mule deer, white-tailed deer (*Odocoileus virginianus*), and bighorn sheep numbers increased subsequent to the forest canopy removal and then declined rapidly in the early 1960's during a period of deep snow winters, probably as a result of forage shortages due to too many ungulates on the range.

Burning Management Program

The Bull River winter range was subjected to several decades of overgrazing by domestic and wild ungulates; this caused severe livestock-wildlife interest conflicts. In 1974 this winter range was included in a coordinated wildlife-livestock management plan that allowed for the buildup of forage carryover, control of livestock distribution by herding and drift fences, and the implementation of a controlled burning program.

On April 15 and 16, 1975, the British Columbia Fish and Wildlife Branch and the B.C. Forest Service burned approximately 600 ac (243 ha) of shrub/grass vegetation on moraine, alluvial fans, and lower mountain slopes. On April 5 and 6, 1976, they burned approximately 540 ac (218 ha) of shrub/grass vegetation on glacial terraces and escarpments. The primary vegetation community before these burns was seral shrub-grassland dominated by *Purshia tridentata, Amelanchier alnifolia, Rosa woodsii, Arctostaphylos uva-ursi, Poa pratensis, Poa compressa, Bromus tectorum, Stipa occidentalis, and Antennaria rosea.*

The burning reduced the *P. tridentata* canopy and increased the grass and forb component of the stand. The control of cattle grazing allowed reestablishment of *A. spicatum, F. scabrella,* and *F. idahoensis.*

Population Response

Rocky Mountain bighorn response to the 1931 fires was not documented. An adjacent bighorn population, on the Wildhorse River bighorn winter

range that exists on a series of rocky outcrops and escarpments in a dense *P. menziesii/Pinus ponderosa* forest, has about 50 animals. The Bull River area would probably have had the same stand structure before logging in the 1920's as the Wildhorse River has now and was approximately the same size, so there would have been habitat for 40 to 60 animals. By 1964, in spite of the heavy livestock, elk (*Cervus elaphus*), mule deer, and white-tailed deer grazing, there were 250 to 300 bighorn on this winter range. A severe die-off occurred in the winter of 1964-65, affecting all age classes of bighorn; only about 10 animals survived. By 1981 the bighorn population had recovered to about 50 animals.

The bighorn responded to the original logging and forest fire that eliminated the forest canopy by increasing fivefold to sixfold. Animals that had survived a severe die-off caused by overgrazing and deep snows in 1964-65 were able to rebuild the population to 50 from less than 10 once the range condition had been improved by proper livestock distribution and a prescribed burning program. The Bull River bighorn herd appears to have resisted the pneumonia-lungworm epidemic which decimated adjacent herds in the 1981-82 and 1982-83 winters.

CHILCOTIN RIVER-JUNCTION WILDLIFE MANAGEMENT AREA, BRITISH COLUMBIA

Description of Area

The California bighorn (*Ovis canadensis californiana*) that occur along the river breaks of the lower Chilcotin River and breaks off the lower Chilcotin River and adjacent Fraser River (designated as the Junction Wildlife Management Area) are nonmigratory. They exist year-round on dry, low-elevation grasslands, which are composed of few plant species. The climax communities are dominated by *A. spicatum, K. micrantha,* and *Artemisia frigida,* whereas seral stands reflecting intense grazing pressure are dominated by *Stipa comata, K. micrantha, A. frigida, and A. rosea* (Demarchi and Mitchell 1973). Some stands of *A. tridentata and A. spicatum* exist at low elevations above the Fraser and Chilcotin Rivers. Some *P. menziesii* forests occur on strong east- and northward-facing slopes, although on the bighorn range few such sites exist.

This area is composed of deep lacustrine silts over deeper fluvial deposits; the rivers are deeply incised and have long grassland slopes interspersed with exposed silt or rock. The Fraser River flows around this land unit, and the Chilcotin, which takes the full force of southerly winds, flows southeasterly into the Fraser River valley.

The grasslands do not show any evidence of being burned; such sign probably has been obliterated by the intense livestock grazing that occurred on this range from the late 1800's to 1973. Adjacent forests are often immature, and the large matriarchal *P. menziesii* show evidence of multiple fire scars--on an adjacent range, Strang and Parminter (1980) suggest that the last large forest fire in the region was before 1926, and that the lack of subsequent fires was due to the removal of litter by grazing.

Burning Management Program

The British Columbia Fish and Wildlife Branch regional office at Williams Lake developed a management plan for the Junction Wildlife Management Area. They recommended prescribed burning as a tool to reduce or retard encroachment of brush or coniferous species. Prescribed burning was also to be used to rejuvenate the soil and increase grass production (Mitchell and Prediger 1974). Several sites were burned before spring green-up in the period 1975-81. Each area was completely burned.

In 1970 a drift fence was constructed to restrict livestock movement on the main bighorn range, and in 1973 cattle were removed from this area. For several decades before 1973, this area was used to winter-over several hundred steers.

Burning of the *A. tridentata* stands killed off all the *A. tridentata* and most of the *A. frigida. Agropyron spicatum* was not affected, and *S. comata* increased on some sites.

Burning of previously overgrazed sites that had been dominated by *S. comata, A. frigida, and C. album* resulted in stands that became dominated by dense swards of *S. comata.*

Bighorn Population Response

Bighorn populations in this range have fluctuated; however, most of that information has been lost with time. The area was closed to bighorn hunting from 1918 to 1975. In the 1930's a local rancher complained that placer miners were decimating the bighorns. In 1954, 250 bighorn were counted, and in 1961, the year of the first helicopter survey, 401 animals were observed. Deep snow and extreme cold in the months of December 1968 and January 1969 triggered a decline and in March 1969 only 231 animals were counted (Demarchi and Mitchell 1973). By February 1981 there were over 600 bighorn on this range (Mitchell 1981).

The reduction of cattle grazing from 1969 to 1973 and the full removal of cattle from this range since 1973 have undoubtedly been the major reasons for the improved forage carryover and species composition changes that have been observed in the period 1968 to 1983. The spring burning program, however, may have hampered the recovery of the overgrazed grasslands. These grassland soils have low cation exchange capacities, so it is doubtful burning will help achieve the management objective of releasing soil nutrients for further plant growth (Dick 1980). Any increase in bighorn numbers can be attributed to the termination of abusive livestock grazing, which has subsequently increased forage carryover and improved range conditions.

The burning program does not seem to have had any negative impacts on the bighorn. In fact, they are probably less likely to be discouraged from traversing the narrow bands of forests where the canopy has been opened. There is, however, no forest encroachment onto areas that are considered potential winter range habitat or that are critical habitats because these sites are essentially permanent grasslands. The burning of the *A. tridentata* stands may have removed some cover that could be used as hiding cover, thermal cover (from intense summer heat), a snow interceptor, and a possible forage source.

WIGWAM FLATS, BRITISH COLUMBIA

Description of Area

The Wigwam Flats Rocky Mountain bighorn (*Ovis canadensis canadensis*) winter range is located on a large glacial terrace, steep rocky outcrops, and fluvial deposits north of the Wigwam River and east of the Elk River in the Rocky Mountain Trench. This unit was not logged before the large fire that burned across it in July 1931. Once the tree canopy was removed, the high evapotranspiration rate combined with the calcareousness of the limestone-derived soils was able to retard any tree encroachment onto the newly established shrub-grasslands.

Several attempts were made to homestead this range unit, and it was grazed with domestic sheep, horses, and cattle until the mid-1950's. From 1954 to the early 1970's only a few domestic horses grazed this unit. In 1929 the area was designated as a Hunting Closed Area, and a hunting ban was placed on all members of the deer family (but not on bighorn sheep). The numbers of elk and mule deer increased to form large herds until the fall of 1965, when the hunting restrictions were removed. Bighorn sheep numbers had increased until the early 1960's, when a die-off reduced their numbers to about 200 or 250, or one-half the former population.

Burning Management Program

This winter range has not been grazed by cattle for several decades; the primary use of the forage resource is for elk, bighorn sheep, and mule deer. The British Columbia Fish and Wildlife Branch has burned some of the seral shrub-grass communities in order to stimulate resprouting of shrubs to benefit the elk and mule deer. Bighorn habitat has been burned in the process. This burning, conducted before spring green-up, has produced positive responses in the vegetation. In most sites only the standing litter was removed; at other sites, the shrub growth has been retarded, allowing *A. spicatum* and *F. scabrella* to dominate.

Population Response

Rocky Mountain bighorn response to the 1931 fire is not documented. Judging from the small bighorn populations that occur in adjacent forested habitats and other similar areas, the Wigwam Flats bighorn herd before 1931 was probably less than 200. By 1964, in spite of the homesteading attempts and the heavy elk and mule deer grazing, bighorns numbered about 450 to 500.

An all-age die-off occurred in the winter of 1963-64 and was followed by low lamb production. The population declined to about 200 or 250. With the opening of the range to the hunting of elk and deer, their numbers were severely reduced and the condition of the range improved. By 1970 there were 300 to 350 bighorn on this range, and by 1977 the number had reached 450 to 500. In the winter of 1981-82, however, another die-off and subsequent lamb crop failure occurred, and the bighorn numbers were reduced to 125.

Elimination of the forest canopy through burning has improved the conditions for bighorn sheep on this range. As there is very little forest encroachment on the bighorn winter range at present, fire is not needed to increase winter range habitat for bighorns. There is sufficient bighorn, elk, and mule deer grazing to prevent the forage species from becoming rank. Burning of the seral shrub-grasslands at this time will not further enhance this range for bighorn; however, burning of adjacent areas would be desirable to expand mule deer and elk winter ranges in order to reduce competition with bighorns.

EAST FORK SALMON RIVER, IDAHO

Description of Area

The bighorn winter range on the East Fork of the Salmon River is about 21,200 ac (8 582 ha) of sagebrush-grassland communities and is dominated by *A. tridentata wyomingensis, A. spicatum, F. idahensis, and Poa sandbergi* (Lauer and Peek 1976). This area receives approximately 7 in (18 cm) annual rainfall and is thus among the drier winter ranges occupied by bighorn in this region. The area is high, ranging from about 5,700 to about 8,000 ft (1 744 to 2 438 m) elevation, and is representative of bighorn winter ranges along the Salmon River south of Salmon, Idaho.

Vegetation Response and Utilization

Seven study sites 0.12 to 1.1 acres (0.05 to 0.45 ha) were burned in September 1974 using hand-held propane torches and flares (Peek and others 1979). Each area was completely burned, with unburned stubble height on bluebunch wheatgrass being less than 0.1 in (0.25 cm), and all Wyoming big sagebrush plants burned to ground level. No fall regrowth occurred after burning. Bluebunch wheatgrass declined in production the first year after the fire, then increased the following 2 years. No change in basal diameters of this species after burning were noted. Other grasses were not affected.

Perennial forbs were not affected, except for an increase in production the second year following burning. This was likely related to precipitation patterns. *Lupinus spp.*, and *Crepus acuminata* were the major forbs. Big sagebrush seedlings appeared two growing seasons after the fire.

Heavy utilization by bighorn sheep using these burned areas occurred the following two winters after the fire, with over 66 percent of the plants grazed. Utilization was consistently higher on burned sites than on adjacent unburned sites for 4 years after the fire.

The Bureau of Land Management (BLM) developed a habitat improvement plan for this winter range after these experimental burns suggested that vegetation could be made more palatable to bighorn sheep by using prescribed fire. Drainage heads on this winter range, which are preferred bighorn sheep sites, have received most attention. To date, an estimated 15 to 20 percent or 346 acres (140 ha) of these drainage heads have been treated (Smith 1983). BLM is continuing this program of burning.

Bighorn Sheep Population Response

The bighorn sheep population was estimated at less than 50 animals by Idaho Department of Fish and Game from 1960 to 1970. After this date, the population started to increase, until in 1983, 132 individuals were present (Hickey 1983).

Bighorn sheep populations have thus gone through three fluctuations, ranging from fewer than 50 individuals to over 100 individuals in the 1920 to 1983 period in this area. Causes of these fluctuations are unknown, but the lungworm-pneumonia infection is implicated in the two early crashes (Lauer and Peek 1976). The impetus for the current population increase is not clear. Cattle were removed from critical winter range, and trespass livestock were blocked from access by fencing in 1975, but the degree to which domestic livestock competed for forage with bighorn sheep appeared low, especially on the higher, more rugged areas preferred by bighorn sheep. Human exploitation was consistently low over the period and again would not have been a likely factor influencing sheep population. The burning project conducted by BLM may have been substantial enough to affect bighorn sheep populations, along with the series of milder winters experienced in the region since 1976. At least the burning program must be considered to either have had no effect or a positive effect on this population--certainly not a negative effect. The ultimate test will be if no major die-off occurs again or, if one does, the population crashes to a low which is higher than the previous two lows.

MIDDLE FORK SALMON RIVER, IDAHO

Description of Area

The Middle Fork Salmon River bighorn sheep populations occupy extremely rugged and steep winter ranges dominated by bunchgrass and shrub communities. Sparse stands of *P. ponderosa and P. menziesii* occur in some areas. *A. spicatum and F. idahoensis* are common grasses, and *Balsamorhiza hookeri* is a common forb. Stands of *Cercocarpus ledifolius* occur on the more exposed and rocky sites. The winter ranges extend from 3,280 to 4,920 ft (1 000 to 1 500 m) elevation, whereas summer ranges extend to 9,840 ft (3 000 m) (Smith 1954). Average precipitation is about 12 in (30 cm) annually, with temperatures over 86° F (30° C) in July and August, and less than -2° F (-30° C) in winter having been recorded.

The Ship Island Fire of August 1979 burned 11,000 acres (1 635 ha) from the riverbank to the heads of drainages, encompassing the entire range occupied by one band of bighorn sheep. The area represents typical bighorn sheep habitat for the drainage. The fire was extremely hot.

Vegetation Response

Grasses, including *A. spicatum, Calamagrostis rubescens, and Poa spp.*, were depressed in production, clump diameter, and canopy coverage the year following the burn. *Poa spp. and Bromus tectorum* increased in production the second growing season after the fire.

C. ledifolius was completely burned, with no resprouting or seedling establishment evident for three growing seasons following the fire. *Salix scouleriana and Ceanothus velutinus* seedlings were abundant at higher elevations in *P. menziesii* habitat types the second growing season after the fire. *Glossopetalon nevadense* was determined to be a resprouter and was browsed at approximately twice the level on burned sites as on unburned sites.

The major effects of this fire were a dramatic reduction in forage the winter following the fire and elimination of *C. ledifolius*, an important forage species for these bighorn sheep (Smith 1954).

Bighorn Sheep Population Response

The bighorn sheep population on the Ship Island Burn and immediately adjacent drainages was estimated at approximately 90 animals before the fire (Hickey 1983). Variation in the number following the fire was attributable to weather conditions during the count and differences in winter severity, rather than actual changes in population size. Population parameters of bighorn sheep occupying the Ship Island Burn are similar to those of bighorn sheep immediately across the river and unaffected by the burn.

Bighorn sheep did prefer to graze on areas which had been burned after vegetation had regrown; however, no major shifts in distribution were apparent, and thus the only discernible response by bighorn sheep was local shifts in habitat use, initially a shift away from burned areas, and then a shift onto the new vegetation.

GLACIER NATIONAL PARK, MONTANA

Description of Area

The bighorn sheep winter range of 420 acres (170 ha) in the Swiftcurrent Valley, the major winter range for bighorn sheep in Glacier National Park, was almost completely burned in 1936 (Riggs 1977). This area is a mixture of climax bunchgrass communities dominated by *A. spicatum, F. idahoensis, F. scabrella, and Amelanchier alnifolia,* and seral vegetation of subalpine fir habitat types (Pfister and others 1977). The seral communities important to bighorn occurred on microsites of concave relief which would retain windblown snow in winter; these comprised 26 percent of the winter range. *Carex geyeri, Spiraea betulifolia, and Calamagrostis rubescens* were common species in these seral stands. Succession toward conifers after the 1936 fire was very slow on this area because of the severe climate of high winds and rapid freezing-thawing conditions in winter. Very little conifer regeneration was apparent 40 years after the fire, illustrating the severity of the climate on these sites. This area would be considered a high mountain winter range with vegetation representative of the eastern Rocky Mountain slopes at 4,600 to 6,900 ft. (1 400 to 2 100 m) elevation in this region.

Vegetation Response and Habitat Use Patterns

Climax bunchgrass communities occupied 74 percent of the winter range that Riggs (1977) described. His investigations of composition and characteristics of these communities revealed little, if any, effect attributable to the burning 40 years afterward. Nevertheless the seral communities previously described did persist over that period of time and likely will continue to be recognizable in the near future. These seral communities were preferred foraging areas for bighorn sheep when they were snow free in winter. Since succession to conifer vegetation would likely reduce the forage on these sites, and bighorn sheep generally favor nonconiferous vegetation, the tentative conclusion is that the fire added winter range to this area for bighorn sheep.

Population Response

Bighorn sheep population response to the 1936 fire was not well documented, but available records were summarized by Riggs (1977). Population estimates in the 1925-83 period ranged from 40 to 134, with a history of artificial winter feeding, horse grazing on the winter range, and periodic die-offs due to pneumonia among the bighorn sheep. Following the 1936 fire, the population suffered substantial mortality due to lungworm (*Protostrongylus stilesi*)-pneumonia interactive infection and disease. The winter feeding program, which concentrated the bighorn sheep and may have aggravated the die-off, was discontinued after that winter, and the population increased from 30 in 1939, to 40 in 1951, 82 in 1967, and 115 in 1975. Whereas the earlier estimates occurred in winter, the 1975 estimate was taken in May and may reflect better observing conditions and/or a spring influx of bighorn sheep onto this winter range coincident with spring green-up.

Responses of bighorn sheep populations to this burn were obscured by the artificial feeding, grazing, and disease-parasite interactions; however, population estimates before the burn ranged from 40 to 134 and, after the burn, 30 to 115. On this basis, the conclusion is that no appreciable response to vegetation change attributable to this fire occurred.

It is noteworthy that no die-offs due to the lungworm-pneumonia complex have been observed in this area since the winter following the burn. This does not mean that die-offs have not occurred or will not in the future or that the additional range provided by the fire is related. It does however, bring up the possibility that the population, which appears to have been at the same level before and after the fire, may not be as concentrated on habitats now as before. If so, this postulated broader dispersal pattern of sheep across this winter range may be related to the absence of a die-off since the fire and thus is a relationship worthy of further investigation.

DISCUSSION

The areas considered here encompass the broad range of habitats occupied by bighorn sheep in this region. Some were forested sites that were changed to shrub/grass ranges by wildfires in the early part of the century. Other sites were native grasslands or shrub-steppe that may have burned periodically. Plant succession following burning varied extensively, from rapid restoration of preburn conditions to extremely slow changes where conifer cover was removed. A variety of responses in vegetation and bighorn sheep were evident. The British Columbia experience illustrated that once the initial bighorn sheep range is created, additional burning may not benefit bighorn sheep if subsequent livestock grazing is intensive enough to affect forage species used by bighorn sheep. The lungworm-pneumonia complex, if prevalent, may limit capabilities of bighorn sheep to respond to increases in forage quantity and/or quality resulting from burning. In areas of high fire frequency where plant responses are short-lived, the bighorn sheep response may also be short-lived or nonexistent.

Positive results from burning these areas range from changes in bighorn sheep distribution (which may have reduced the effects of lungworm infection), to stabilization of populations, to increases. In all cases, however, definite proof that burning was responsible is lacking because we are unable to isolate the effect of the fire from other potential limiting factors. The increase of bighorn sheep in the East Fork Salmon River area may be the exception, since the only factor that appeared to have changed over the period that was considered to be affecting the sheep population was the prescribed burning program.

At least four important factors can be considered to potentially limit these populations, including lungworm; poor range conditions due to past livestock use; low range productivity (due to drought, lack of grazing, or poor soils); and competition with other big game. All of these may be predisposed by severe weather. Additionally, predation is a possible limiting mechanism.

These case histories illustrate that prescribed fire will not necessarily increase bighorn sheep populations and may have a negative effect. The benefits of increasing forage production may be outweighed by other limiting factors. Nevertheless, there is evidence that use of prescribed fire reduces incidence of lungworm infections, and this should be evaluated further in populations with a history of chronic lungworm problems. There is also evidence that prescribed fire, used in conjunction with controlled grazing plans, may benefit bighorn sheep. In areas of high fire frequency where fire management policies will allow fires to burn, the effect on bighorn sheep should be minimal.

Prescribed fire is a useful tool in managing bighorn sheep habitat if a proper plan which identifies objectives and considers the limiting factors is developed, and the burning follows the prescription.

Fire can negatively affect bighorn sheep habitat when range condition is poor and forage species cannot respond, when nonresprouting species which provide important forage for bighorn sheep are eliminated, or when too much area is burned and inadequate forage remains until the next growing season. Another potential negative response is observed when other species, especially elk, are attracted to prescribed fires intended to benefit bighorn sheep. When fires produce these negative results, bighorn sheep then become more vulnerable to the other limiting factors. Therefore, a well-thought-out plan must be developed before fire is considered for use on bighorn sheep range. Plans must consider the following:

1. Condition of plants. Plants to be favored should be in robust condition to respond most satisfactorily to burning. This also means that timing of the burn and intensity of the burn must be considered.

2. Plant response. Are species that burn intended to resprout, reseed, or increase in productivity from unburned residual growth? Areas where nonresprouting species occur and which serve as forage at critical times should be given special attention. If objectives are to rejuvenate deteriorated stands, fire may still be considered a part of the treatment. If nonresprouting stands are productive, then efforts to restrict fire from these areas may be needed.

3. Adjacent conifers. The possibility of creating more open range that is favored by bighorn sheep exists if conifer stands, or tall shrub fields, occur next to currently used range. Bighorn sheep may colonize adjacent habitats as rapidly as commonly associated big game species like elk or mule deer.

4. Limiting factors. Factors that may limit bighorn sheep populations should be identified, and the effect of burning habitats on these limiting factors should be evaluated. Care should be taken since limiting factors are interactive.

a. Lungworm. Lungworm infections can possibly be altered by reducing bighorn sheep concentrations; however, if burns are small and concentrate bighorn sheep, results could be negative. If burns disperse populations, the effects could be positive.

b. Competitive. Burns may attract elk or deer to the ranges used by bighorn sheep, which may result in competition for forage.

5. Bighorn sheep response. Changes in distribution patterns may be a sufficient goal if the objective is to reduce lungworm infection. If population maintenance or increase is the goal, then larger burns will be needed. Provision for adequate forage remaining after the fire needs to be considered.

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