

Bienn. Symp. North. Wild Sheep
and Goat Counc. 8:97-110.

DECLINE AND HABITAT ABANDONMENT BY BIGHORN SHEEP ON BATTLEMENT MESA,
COLORADO, 1906-1990

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Abstract: Bighorn sheep (*Ovis canadensis*) on Battlement Mesa, Colorado, numbered up to 250 animals in the early 1900's and declined to about 50 animals by 1970. Minimum herd sizes during 1989 and 1990 were 23 and 26, respectively, including 4 lambs each year. Since 1961, the herd has abandoned about 56 km² of historic range. The decline corresponded with probable vegetation changes on Battlement Mesa, intensive livestock grazing through the 1950's, reports of poaching and an increasing elk (*Cervus elaphus*) herd. Bighorn sheep remained on the western portion of the range during winter and spring, 1989. During dry months (Jul 89, Aug 89, Jun 90), sheep concentrated in Anderson and Durant Gulches near a free-flowing spring and seep. Bighorns on Battlement Mesa appear limited by dense mountain shrub stands that separate productive meadows from escape terrain and cover historic migration routes. In 1989-90, sheep remained mostly on shale slopes. Without intensive and long-term habitat management this small unique herd will remain static or decline.

In 1915 Colorado supported about 7,320 Rocky Mountain bighorns but by 1970, only about 2,200 remained (Bear and Jones 1973). Today there are approximately 6,100 sheep in 67 herds, including about 2,400 in transplanted populations (Bailey 1990). Many of these sheep are in small remnant herds intermittent throughout historic range. Herds that were not extirpated persisted in isolated or highly productive portions of their range. The bighorns of Battlement Mesa are a classic example of a remnant, isolated population. The Battlement Mesa bighorn sheep are 1 of 4 indigenous, low-elevation, herds remaining in Colorado (J. A. Bailey, Colo. State Univ., pers. commun.). Battlement Mesa is within the geographic range of desert bighorn (*Ovis canadensis nelsoni*) as reported by Manville (1985). It is not clear if Battlement Mesa bighorns should be considered *O. c. canadensis* or *O. c. nelsoni*. In 1988, information on the herd was limited to scattered Colorado Division of Wildlife (CDOW) aerial counts and hunter surveys, scattered United States Forest Service (USFS) reports, local newspaper clippings and knowledge held by local residents. A Colorado State University (CSU) internship project in 1976 (McGowan and Van Sant 1976) and an Environmental Assessment developed for the herd in 1986 (White River Wildlife Team 1986) provided the most current herd data. CDOW classified the herd as declining or static. Seasonal ranges and factors limiting the herd were uncertain. We initiated a research-descriptive study to gather data necessary to effectively manage this unique herd. Pre-treatment data on numbers of sheep and areas of use

were needed to measure post-treatment effects for any herd or habitat management that might be implemented.

Study objectives were to (1) develop an historic perspective of bighorn sheep on Battlement Mesa, (2) determine herd size and sex-age composition, (3) determine seasonal distributions, including lambing area(s), water sources, migration corridors, timing of major activities and movements including rutting (1989) and lambing (1989, 1990), (4) evaluate potential limiting factors, and (5) suggest management options.

This study resulted from cooperation among the White River National Forest (WRNF), Grand Mesa National Forest (GMNF), CDOW and the Rocky Mountain Bighorn Society (RMBS). J. Ellenberger, J. Frothingham, J. Broderick and A. Trujillo from the CDOW are thanked for their assistance. J. Grode, WRNF, is acknowledged for coordinating the USFS support. Numerous volunteers assisted with field data collection.

STUDY AREA

Battlement Mesa is located in northwest Colorado, approximately 80 km east of Grand Junction, and encompasses 96 km² on National Forest, Bureau of Land Management (BLM) and private lands (Fig. 1). The range crests northeast to southwest, with lands of the GMNF and BLM on the south slopes and WRNF on the north slopes. Elevations range from 1830 m at the west to 3337 m on North Mamm Peak. Bighorn sheep remain within about 40 km² on the west end of Battlement Mesa at elevations of 2040-2700 m (lower Battlement Mesa). There are 2 private inholdings within the range. Topography is characterized by steep south-facing cliffs with scattered shrubs, forbs, and grasses and steep north-facing slopes with forest and shrub communities.

Arid to sub-arid conditions exist at low elevations, especially on south-facing slopes. The highest elevations on upper Battlement Mesa are more moist. Lower Battlement Mesa receives 38.1-63.5 cm annual precipitation while upper Battlement Mesa receives 50.8-76.2 cm.

Lower Battlement Mesa has 5 major habitats: 1) pinyon pine (*Pinus edulis*)-juniper (*Juniperus osteosperma*) at lower elevations, 2) Douglas-fir (*Pseudotsuga menziesii*) on north-facing slopes at higher elevations and in draws, 3) mountain shrub, predominantly gambel oak (*Quercus gambelii*) and serviceberry (*Amelanchier alnifolia*) at middle to higher elevations, in draws and on dry sidehills, 4) aspen (*Populus tremuloides*) on north-facing slopes at higher elevations, and 5) fescue meadow (*Festuca thurberi*-*Festuca idahoensis*) at higher elevations on north facing slopes (White River Wildlife Team 1986). Shale slopes were considered a sixth habitat for analysis during this study. Upper Battlement Mesa has 3 major habitats: (1) fescue meadow interspersed with (2) aspen and (3) Douglas-fir.

Historically, rangelands on Battlement Mesa were overgrazed by both domestic sheep and cattle based on historic Forest Service reports (U.S. For. Serv. 1914-1990). Lower Battlement Mesa is presently divided among 3 allotments of which 1 is utilized by cattle on a 3-pasture

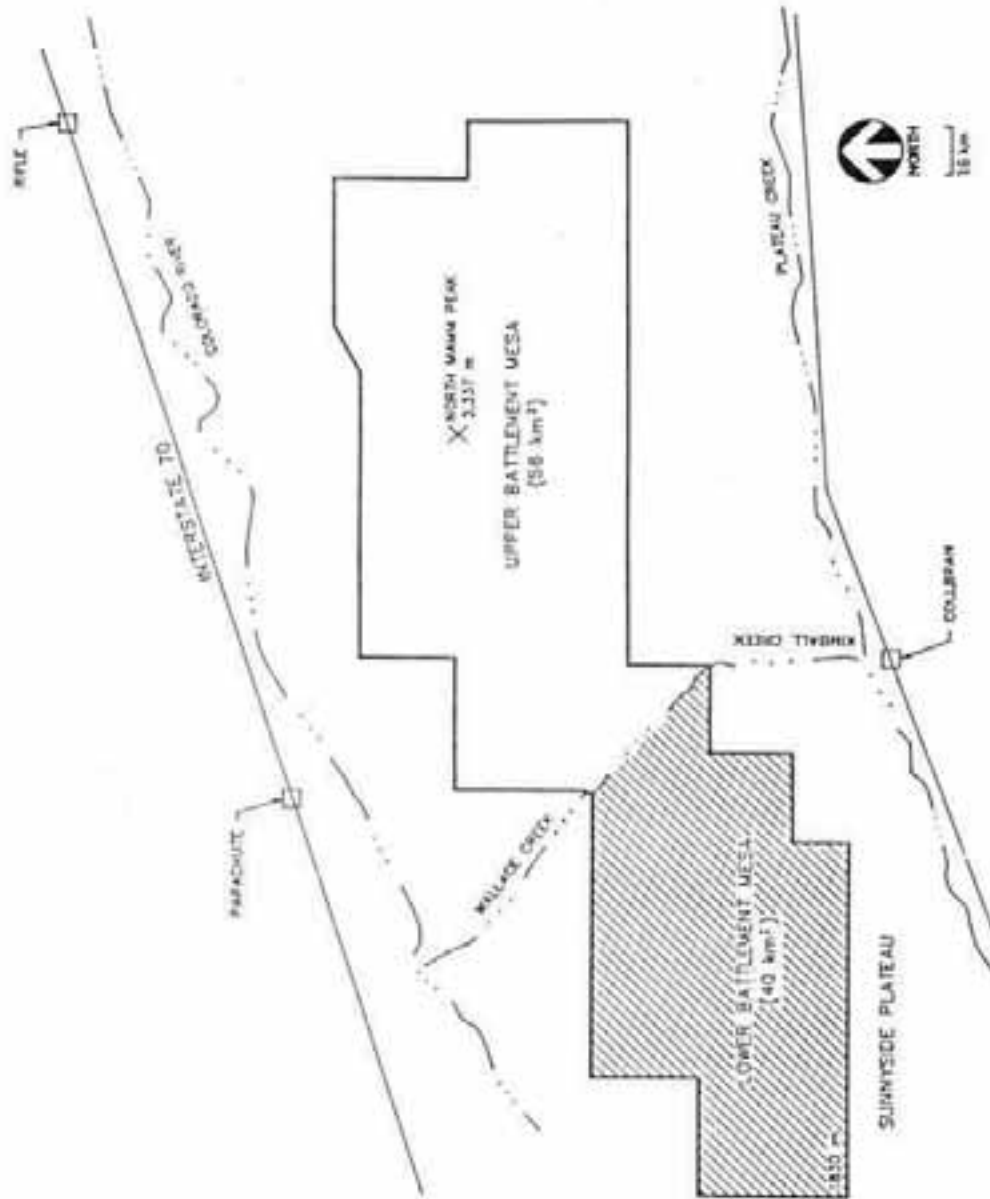


Fig. 1. Schematic diagram of Battlement Mesa, Colorado, depicting nearby towns, roads and important land features.

rotation system for 117 days from mid-June through mid-October. No livestock grazing occurs on the other allotments.

METHODS

Determining Current and Historic Bighorn Ranges

We determined present bighorn sheep range on Battlement Mesa from observations (1988-90) and by mapping reported sheep locations (1980-90). Seasonal range boundaries followed the lowest elevation contour recorded for locations during summer and winter, respectively. We searched CDOW, WRNF, GMNF files and local newspapers for information on historic bighorn sheep sightings and distribution to gain an historic perspective on the herd. We interviewed 13 local residents, including ranchers and outfitter-guides familiar with the area, for knowledge of past herd numbers and areas of use.

Historic migration routes were estimated from historic observations and the locations of potential sheep escape terrain. We estimated historic bighorn sheep summer range (upper Battlement Mesa) from past CDOW surveys, documents and from interviews. We searched these areas on 15 occasions in 1988-90, using fixed-wing aircraft and horses, to validate range abandonment.

Determining Herd Size and Sex-age Composition

We attempted to capture bighorn sheep for radio-collaring from 1988-90 (Cunningham 1991). Clover traps (Clover 1956) baited with alfalfa hay, apple pulp and salt were unsuccessful. One ewe, a 36 kg 2.5 year-old, was captured using a dart gun and fitted with a radio collar on 15 March 1989.

Intermittent observations of sheep began 5 December 1988, with intensive data collection occurring 3 January 1989 through 12 January 1990 and 5 June 1990 through 11 July 1990. We divided the suspected present range into 16 units to effectively search for sheep (Cochran 1977). We based unit boundaries on topographic features and the ability of field personnel to completely search a unit in 1-2 days. Sheep were located by (1) tracking 1 radio-collared ewe from the ground to obtain visual observations, (2) systematically searching the 16 units between 13 July 1989 and 27 October 1989 (4 complete searches) when all units were accessible, (3) fixed-wing and helicopter flights along predetermined routes, and (4) ground reconnaissance of the range. Located sheep were classified by sex and age (Geist 1971). When possible we determined percent slope with a clinometer. We tested the null hypothesis that there was no difference in use of slope categories between uncollared and radio-collared groups of sheep with the Chi-square test for association (Steel and Torrie 1980). Maximum unduplicated counts of sheep in each sex-age class determined a known minimum population for 1989 and for summer, 1990.

Seasonal Ranges

We determined seasonal ranges by locating sheep in the 4 seasons based on forage phenology: (1) spring (16 Feb-30 May), (2) summer (1 Jun-30 Sep), (3) fall (1 Oct-15 Nov), and (4) winter (16 Nov-15 Feb) (Dale

1987). We monitored movements by the radio-collared ewe and by other identifiable sheep and inferred migration corridors within the present sheep range. We located potential lambing areas based on the lambing-area requirements of desert bighorn sheep because of the similarities between the present sheep range and desert environments (Bear and Jones 1973, Hansen 1985). We located ewes with lambs <2 months old to define and map present lambing areas. We determined rutting periods and rutting range by observing sheep behavior, changes in group composition, and locations during the fall.

Determining Potential Limiting Factors

We investigated factors affecting the Battlement Mesa bighorn sheep for the past 75 years and analyzed data from 1988-90, to identify potential limiting factors. Literature revealed factors limiting or adversely affecting other Rocky Mountain and desert bighorn sheep herds: (1) habitat, (2) diseases and parasites, (3) predation, (4) conflicts with elk, deer and livestock, (5) hunting and poaching, (6) exotic free-ranging ungulates, and (7) limited summer water supply. "Potential" is the key work in this summary of limiting factors. Unless a factor postulated as limiting to a herd of sheep is manipulated and a treatment and control group of animals defined, we cannot demonstrate the factor is indeed limiting. Each of the above factors were evaluated for their potential in limiting the Battlement Mesa bighorns.

Habitat.--We measured the area available to sheep for each of the 6 habitat types within the present range from USFS Resource Information System maps (U.S. For. Serv. 1986). Randomly selected sites were ground-truthed to confirm habitat types. We tested the null hypothesis that bighorn sheep use the available habitat on Battlement Mesa in proportion to the availability of each habitat type with the Chi-square goodness-of-fit test (Neu et al. 1974, Steel and Torrie 1980). We developed a preference index for each habitat type by dividing the proportion of observations within a habitat type by the proportion of that habitat type within the available study area. Preference and avoidance refer to the likelihood that a habitat will be selected more or less frequently than predicted based on availability (Petrides 1975, Thomas and Taylor 1990).

Other potential limiting factors.--We collected 9 fresh bighorn sheep fecal samples between January 1989 and April 1989. Samples were analyzed for lungworm larvae (*Protostrongylus* sp.) at the CDOW Research Laboratory, Fort Collins. Nasal swabs and skin scrapings from the captured ewe were analyzed for incidence of the *Psoroptes* mite or other external parasites. We recorded any clinical signs of pneumonia in observed sheep and recorded observations and sign for predators, elk, mule deer (*Odocoileus hemionus*) and cattle on lower Battlement Mesa. We summarized CDOW bighorn sheep harvest records for the herd between 1960 and 1982, interviewed long-time residents of the area and investigated reports of poaching incidents. We documented all reports of exotic, free ranging ungulates in the area, all water developments, and permanent water sources for sheep on the present range.

RESULTS

Systematic Searching and Opportunistic Observations

Between 5 December 1989 and 28 June 1990, we observed uncollared groups of sheep on 84 occasions and groups of sheep with the radio-collared ewe on 21 occasions. We observed sheep 14 times during 4 systematic searches of study area units between 12 July and 16 November 1989 (included in 105 total).

Bighorn Range

Current range.--The current range of bighorn sheep on Battlement Mesa is approximately 40 km², including summer and winter ranges. Observations during 1988-90 revealed 2 overlapping seasonal ranges and 1 migration corridor (Fig. 2). Mature rams were scattered over a larger area than were ewe-juvenile groups, which remained concentrated during lambing seasons and for most of the summers in Anderson and Durant Gulches.

Sheep remained on the west end of the range from December 1988 to May 1989 at elevations of 2073-2400 m. From April to July 1989, sheep migrated to summer range at 2340-2700 m. Observations between January and July 1990 revealed seasonal ranges similar to those recorded in 1989. Migration to lambing and summer range during 1990 occurred from 15 May to 28 June.

Historic range and herd size.--We observed no sheep or sheep sign during 8 searches of historic summer range on upper Battlement Mesa. We estimated historic range (including present range) at 96 km². On the upper Mesa, talus slopes, rock piles and cliffs occur in many areas adjacent to open meadows (potential and perhaps historic areas of sheep use) and there are numerous permanent water sources. All evidence suggests that bighorn sheep have abandoned this summer range, with no sheep observed since a sighting on Mamm Peak in 1961. Snow depth on upper Battlement Mesa may eliminate the possibility of sheep using the area in winter.

According to records and recollections of local residents, the herd numbered up to 250 animals in the early 1900's and declined to an estimated 50 animals by 1970. CDOW aerial and ground counts of sheep on Battlement Mesa from 1969-88 fluctuated widely with a general downward trend beginning in 1970. Search effort was not consistent over years and methods varied between helicopter counts and more intensive, though less extensive, ground counts. Agency records, newspaper articles and interviews also documented (1) 4 historic low-elevation bighorn herds within 19-74 km of Battlement Mesa, (2) alleged poaching and predation incidents, and (3) changing vegetation on Battlement Mesa, from 1906-88 (Cunningham 1991).

Habitat Use

Sheep used 3 of the 6 habitat types on lower Battlement Mesa in 73 observations of uncollared sheep and 21 observations of the radio-collared ewe and her group (Tables 1, 2). They used shale slopes with scattered

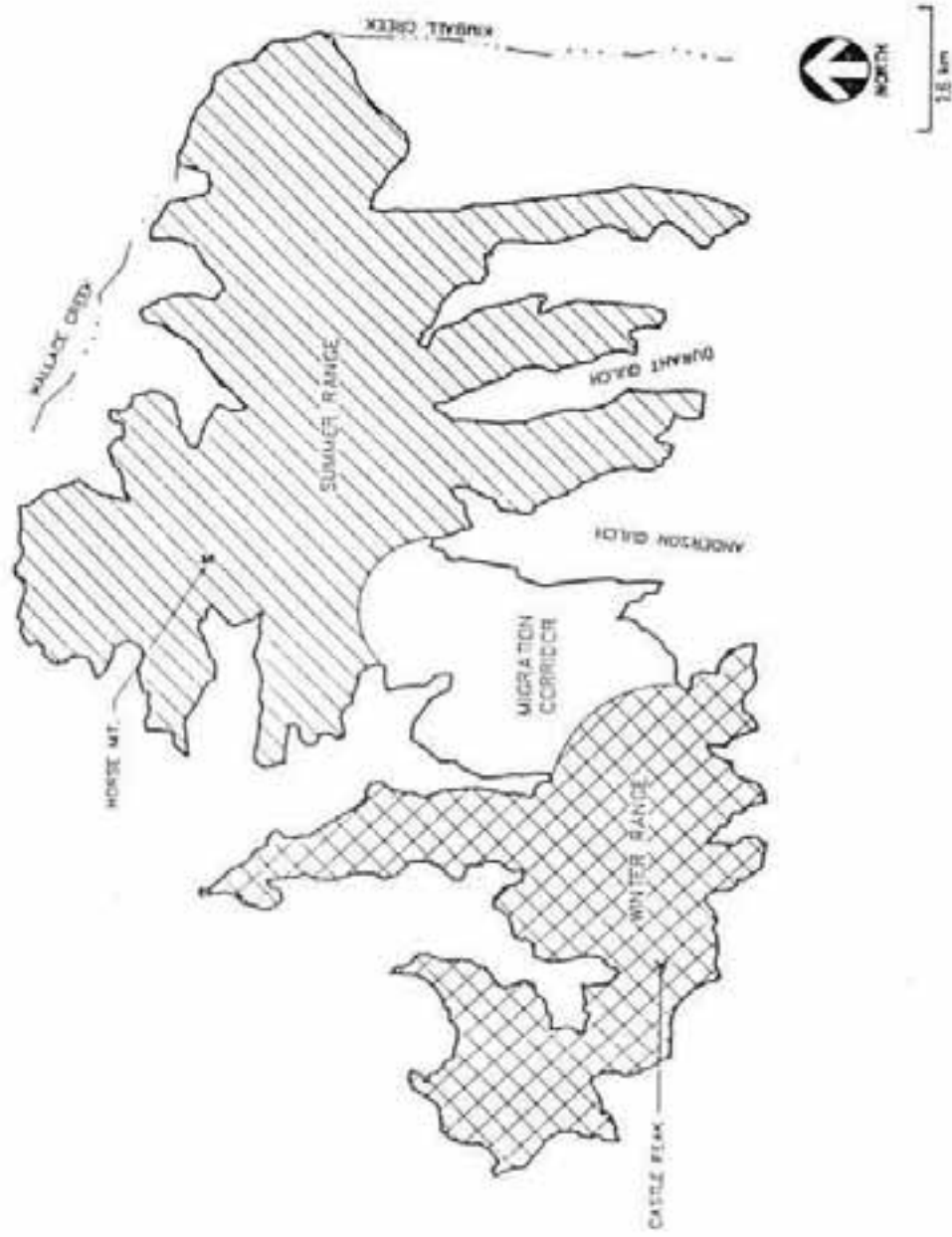


Fig. 2. Seasonal home ranges and migration corridor used by bighorn sheep on lower Battlement Mesa, Colorado, 1989-90.

grasses, forbs, and shrubs most of the time. We never observed sheep in nearby meadows that were separated from shale slopes by stands of mountain shrubs or aspen. Sheep were found in open Douglas-fir stands (<20% canopy cover) on south slopes on 2 occasions. These stands were adjacent to a shale slope and the sheep never ventured more than 30 m from escape terrain. Pinyon-juniper habitat was used by uncollared sheep during winter and spring when sheep were at lower elevations where this habitat was more available.

Table 1. Use of habitat types by uncollared bighorn sheep in 73 observations on Battlement Mesa, Colorado, 1989-90.

Habitat type	Hectares available		Bighorn observations* (% of 73)
	Hectares	(%)	
Pinyon-juniper	2320	38	12.3
Mountain shrub	1366	22	0.0
Douglas fir	1335	22	1.4
Shale slope	713	12	86.3
Aspen	303	5	0.0
Meadow	49	1	0.0

* $\chi^2 = 381.1$, $P \leq 0.001$; based on observed numbers of observations in each habitat type vs. expected numbers calculated from habitat composition.

Table 2. Use of habitat types by collared bighorn ewe in 21 observations on Battlement Mesa, Colorado, 1989-90.

Habitat type	Hectares available		Bighorn observations* (% of 21)
	Hectares	(%)	
Pinyon-juniper	2320	38	0.0
Mountain shrub	1366	22	14.3
Douglas fir	1335	22	4.8
Shale slope	713	12	81.0
Aspen	303	5	0.0
Meadow	49	1	0.0

* $\chi^2 = 96.6$, $P \leq 0.001$; based on observed numbers of observations in each habitat type vs. expected numbers calculated from habitat composition.

The observations (73) of uncollared sheep emphasized slopes >200% while observations of the radio-collared ewe (19 with slope category recorded) were more often on slopes 51-100% (Table 3). Use of slope categories was not significantly different between the 2 groups. When sheep were not observed on slopes >200%, distance to escape terrain averaged 6.1 m for uncollared sheep and 35.6 m for the radio-collared ewe.

Table 3. Steepness of terrain used by bighorn sheep in 73 observations of uncollared sheep and in 19 observations of a radio-collared ewe, Battlement Mesa, Colorado, 1989-90.

Slope category (%)	Observations (% of total)*	
	Uncollared (73)	Radio collared ewe (19)
0-50	4	5
51-100	23	37
101-150	21	32
151-200	4	5
>200	48	21

* $\chi^2 = 4.59$; $P \geq 0.05$

Rutting, Lambing, and Population Size

Rutting behavior was observed during November-January on both summer and winter ranges. Lambing occurred on summer range with estimated dates of birth from 15 April through 25 June during both 1989 and 1990 (Cunningham 1991).

The known minimum population of sheep during 1989 was 23 individuals including 4 1989 lambs, 3 yearlings, 7 adult ewes and 9 adult rams. Less search time and a restricted search area during 1990 leaves no doubt sheep were missed. The known minimum population of sheep during summer 1990 was 18, although 26 is a more likely number assuming no loss in any age classes between December 1989 and June 1990, except for 1 lamb not observed after August 1989. Four lambs were observed in 1990. Based on known minimum numbers of ewes, lamb:ewe ratios were 57:100 and 50:100 in 1989 and 1990, respectively.

Potential Limiting Factors

Habitat.--Bighorn sheep did not use habitats in proportion to their availabilities on Battlement Mesa and emphasized use of shale slope habitat (Tables 1, 2). This suggests they were selecting the most secure habitat on or near escape terrain, and avoiding less secure, but more productive, foraging areas. Preference-avoidance indices for both uncollared and radio-collared sheep support these results (Table 4).

Table 4. Preference indices for 6 habitat types available to bighorn sheep on Battlement Mesa, Colorado, 1989-90.

Habitat Type	Preference Index*	
	Uncollared sheep (N = 73)	Radio-collared (N = 21)
Pinyon-juniper	0.3	0.0
Mountain shrub	0.0	0.6
Douglas fir	0.1	0.2
Shale slope-cliff	7.2	6.8
Aspen	0.0	0.0
Meadow	0.0	0.0

* Proportion of observations within a habitat type divided by proportion of that habitat type within the available study area.

Other potential limiting factors.--Three of 9 bighorn sheep fecal samples had low incidences of Protostrongylus larvae (0.4-8.6/g). The remaining samples were negative. No die-offs or clinical signs of pneumonia were recorded. No parasites were recovered from swabs or scrapings from the radio-collared ewe. Contact between bighorn and domestic sheep probably occurred in the early 1900's when up to 40,000 domestic sheep grazed in the area. Chances for disease transmission were presumably high, but no records of die-offs were discovered.

Evidence of predation was limited to finding 3 decayed lamb skulls. One skull had punctures on the cranium, indicating mountain lion (Felis concolor) predation. Reports of alleged lion predation on the sheep have occurred since 1927.

On Battlement Mesa, elk, mule deer and bighorn ranges overlap throughout the year, but especially in winter on the western portion of the bighorn range. CDOW trend counts indicate elk numbers increased substantially on Battlement Mesa from 1973-89. There was no range overlap between bighorn and cattle during 1989-90. Exotic ungulates occurred in 3 areas, 3.2-19.3 km from the present bighorn range.

Hunting for bighorn sheep occurred from 1960-82 when 121 licenses were issued and 17 rams harvested. The area was closed in 1982 due to suspected low numbers of sheep and hunter complaints of seeing few or no sheep. Five of the 13 residents interviewed knew of sheep poaching incidents.

We found 12 springs and seeps on lower Battlement Mesa. One guzzler and 3 redwood tanks were installed on or near the sheep range in the early 1980's, but 3 sites were outside of the present range. The tanks were either destroyed, not holding water, or required maintenance. We observed

no sheep sign at 3 of the water development sites. The destroyed site, which contained a natural pool, had sheep sign.

DISCUSSION

Historic Perspective on the Herd

All evidence indicates that the Battlement Mesa bighorn sheep herd once was larger and occupied a larger range. The herd migrated farther to summer range and wintered at lower elevations adjacent to the present winter range. Local residents reported changing vegetation on Battlement Mesa, indicating that more oakbrush and heavy timber are present in the area today. Battlement Mesa bighorns abandoned historic summer range about 30 years ago and today occupy about 42% of the historic 96 km² yearlong range. The present summer and winter ranges have similar vegetation, but no water sources occur on present winter range.

Wallace Creek and Dry Kimball Creek, north and east, respectively, of present sheep range, are likely historic migration routes based on historic sheep observations and topography. These drainages are dominated by dense shrubs, a habitat avoided by Battlement Mesa sheep. Beyond these migration routes, historic summer range still has escape terrain adjacent to permanent water and productive foraging areas with little visual obstruction. Abandonment of this summer range was verified during 1989-90. Range abandonment, decline of sheep numbers and the general decline of herd quality on this isolated range, have coincided with habitat change. Expansion of dense shrub vegetation was presumably due to historic overgrazing by livestock and curtailment of wildfire for over 60 years. Other factors that may have contributed to herd decline are considered less important in limiting the herd today (Cunningham 1991).

Present Condition of Battlement Mesa Bighorn Sheep

Lamb:ewe ratios on Battlement Mesa (0.57 and 0.50 in 1989 and 1990, respectively) were not unusual for bighorn herds. Ratios vary greatly among and within herds (Goodson 1978, Turner and Hansen 1985). This variation has been attributed to population density, forage quality (Geist 1971) and possibly to degree of inbreeding (Skiba and Schmidt 1982). Goodson (1978) concluded that yearling:ewe ratios, not lamb:ewe ratios, have been correlated with herd trends. The yearling:ewe ratios at Battlement Mesa (0.41 and 0.38 in 1989 and 1990, respectively) were similar to those reported for "slowly increasing" herds (Goodson 1978). However, given the small number of sheep at Battlement Mesa, herd increase cannot be predicted as loss of one yearling (or ewe) would alter the ratio greatly.

The Battlement sheep exhibited 2 characteristics that Geist (1971) considered common in low quality bighorn herds with static or declining population size. These are (1) small body size, and (2) tightly curled horns. The 36 kg ewe captured on Battlement Mesa appeared similar in size to her associates. In contrast, Hansen (1985) estimated the average desert bighorn ewe at 47 kg. Risenhoover and Bailey (1988) reported an average weight of 66.4 kg for ewes at Waterton Canyon, Colorado and Blood et al. (1970) estimated the average Rocky Mountain bighorn ewe at 72 kg.

Rams harvested from the Battlement herd also exhibited small body size and small horns (John Ellenberger, Colo. Div. of Wildl., pers. commun.).

Geist's "dispersal theory" (1987) links herd quality to the duration of available green forage, which is enhanced when animals migrate altitudinally. On Battlement Mesa, loss of migration and consequent loss of summer ranges, has reduced the duration of access to green forage. On habitats preferred by Battlement sheep (shale slopes), green forage is scarce, sparsely distributed, and available only briefly each year. On present summer range, forage options are limited to true mountainmahogany (*Cercocarpus montanus*), bitterbrush (*Purshia tridentata*), Indian ricegrass (*Oryzopsis hymenoides*) and scarce forbs and other grasses near permanent water sources. A few small meadows occur on summer range but are separated from sheep escape terrain by barriers of dense shrubs. On historic summer range, shrub types are absent and meadows are dominated by Idaho and Thurber fescue, Kentucky bluegrass (*Poa pratensis*), other grasses, and several species of forbs.

Battlement sheep must have been primarily grazers during summer on historic summer range. Today their summer diet is dominated by shrubs. The loss of grasses from the diet may have caused natural selection to favor the smaller-bodied animals; or the current small size of Battlement sheep may be a phenotypic response to limited forage resources. Productivity of the herd may also be limited by quantity and quality of forage.

CONCLUSION

Currently, the Battlement Mesa bighorn herd is limited in distribution, herd size, and perhaps in animal quality. The strongest evidence indicates that habitat change, especially the expansion of dense shrub vegetation, has influenced the decline of Battlement Mesa bighorn, and that habitat conditions limit the herd today. This evidence includes coinciding changes in habitat and herd decline with range abandonment, the current non-use of excellent foraging areas surrounded by barriers of dense shrubs, and the use restricted primarily to secure habitats with good visibility. As a case study, the Battlement herd illustrates trends that Wakelyn (1987) concluded have been common in Colorado. Habitat improvement, including reduction of shrubs, will be necessary to restore this unique herd (Risenhoover and Bailey 1988, Cunningham 1991). A 4-phase management plan for the Battlement Mesa herd is proposed by Cunningham (1991).

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