Ecology of the Rock Creek bighorn sheep herd, Beartooth Mountains, Montana
by Steve Alan Martin

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Movements, population characteristics, range use, and food habits of a Rocky Mountain bighorn sheep (Ovis canadensis canadensis) herd were examined in southcentral Montana and northwestern Wyoming during 1978 and 1979. From November to July this nearly 95 member herd occupies an 88 sq km area surrounding the headwaters of the Main Rock Creek and Line Creek drainages of the Beartooth Mountains. During both autumn and spring sheep ranged from lower subalpine canyon bottoms to alpine plateaus. Winter use was generally restricted to alpine plateaus southeast of Rock Creek. Ewes lambed on steep rocky northwest facing canyon walls from late May to mid-June. Winter range pooled standard diameter and polygon home range size of marked bighorns was 4.17 km and 17.9 sq km, respectively. Spring migration ran from May to mid-July. Rams and barren ewe-juvenile groups left the winter range before ewes with lambs. A migration route of 57 km was documented.

The mean distance between summer and winter centers of activity for marked rams and ewes was 45 km and 37 km, respectively. Early migrants required over a week to travel the route, while those leaving in late June and July required as little as 84 hours. The summer ranges were located in the Absaroka Mountains east of Yellowstone National Park. Rock Creek ewe-juvenile groups restricted summer movements to a 34 sq km area around Pilot and Index Peaks. Ram groups ranged widely in the Wyoming Absarokas from the Montana border south to the Crandall Creek drainage and in the Wolverine peak area of the Montana Absarokas. Ram summer ranges overlapped the ewe-juvenile and ram ranges of at least five other bighorn herds. The population of the entire Absaroka summer range was estimated at 375 bighorns. Marked ewes gave a summer range pooled standard diameter and polygon home range size of 2.1 km and 2.0 sq km, respectively, values for one adult ram were 13.6 km and 15.8 sq km. Early summer range use was primarily centered on alpine turf vegetation. During mid-summer and autumn use of timberline dirt-scree dominated habitats increased markedly. Autumn migration coincided with the arrival of permanent snow on the summer range in October or early November. Rock Creek herd lamb production and survival to yearling age averaged 54 per 100 mature ewes and 57 %, respectively, over a five year period. Use of graminoids, forbs, and browse was 74, 16, and 10 percent, respectively during late summer and 40, 50, and 10 percent, respectively during fall. Sedge and fescues were the most important items in the diet during late summer, while fringed sage, fescues, lupine, and sedge were important in the fall. The Rock Creek herd showed a light to moderate level of lungworm infection. Mean larval output was significantly higher on the winter range than on the Pilot-Index summer range (272 versus 128 larvae per gram, respectively).

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Movements, population characteristics, range use, and food habits of a Rocky Mountain bighorn sheep (Ovis canadensis canadensis) herd were examined in southcentral Montana and northwestern Wyoming during 1978 and 1979. From November to July this nearly 95 member herd occupies an 88 sq km area surrounding the headwaters of the Main Rock Creek and Line Creek drainages of the Beartooth Mountains. During both autumn and spring sheep ranged from lower subalpine canyon bottoms to alpine plateaus. Winter use was generally restricted to alpine plateaus southeast of Rock Creek. Ewes lambed on steep rocky northwest facing canyon walls from late May to mid-June. Winter range pooled standard diameter and polygon home range size of marked bighorns was 4.17 km and 17.9 sq km, respectively. Spring migration ran from May to mid-July. Rams and barren ewe-juvenile groups left the winter range before ewes with lambs. A migration route of 57 km was documented. The mean distance between summer and winter centers of activity for marked rams and ewes was 45 km and 37 km, respectively. Early migrants required over a week to travel the route, while those leaving in late June and July required as little as 84 hours. The summer ranges were located in the Absaroka Mountains east of Yellowstone National Park. Rock Creek ewe-juvenile groups restricted summer movements to a 34 sq km area around Pilot and Index Peaks. Ram groups ranged widely in the Wyoming Absarokas from the Montana border south to the Crandall Creek drainage and in the Wolverine Peak area of the Montana Absarokas. Ram summer ranges overlapped the ewe-juvenile and ram ranges of at least five other bighorn herds. The population of the entire Absaroka summer range was estimated at 375 bighorns. Marked ewes gave a summer range pooled standard diameter and polygon home range size of 2.1 km and 2.0 sq km, respectively. Values for one adult ram were 13.6 km and 15.8 sq km. Early summer range use was primarily centered on alpine turf vegetation. During mid-summer and autumn use of timberline dirt-scree dominated habitats increased markedly. Autumn migration coincided with the arrival of permanent snow on the summer range in October or early November. Rock Creek herd lamb production and survival to yearling age averaged 54 per 100 mature ewes and 57 %, respectively, over a five year period. Use of graminoids, forbs, and browse was 74, 16, and 10 percent, respectively during late summer and 40, 50, and 10 percent, respectively during fall. Sedge and fescues were the most important items in the diet during late summer, while fringed sage, fescues, lupine, and sedge were important in the fall. The Rock Creek herd showed a light to moderate level of lungworm infection. Mean larval output was significantly higher on the winter range than on the Pilot-Index summer range (272 versus 128 larvae per gram, respectively).

INTRODUCTION

Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) are indigenous to the Beartooth Mountains of southcentral Montana. Several distinct bighorn herds occupy this mountain range. The principal wintering areas are located along the Stillwater River, West Rosebud Creek, and the upper reaches of Rock Creek. Coordinated studies of the bighorns wintering in the Stillwater and West Rosebud drainages were initiated in 1971. Stoneberg (1973, 1974) studied bighorn reproduction and lungworm incidence as well as grass utilization on these winter ranges from 1971 to 1974. Pallister (1974) studied population composition, movements, range use and food habits of the West Rosebud and Stillwater herds during the summer and fall of 1973. Stewart (1975) extended the latter investigation through the summer of 1974 and the winter and spring of 1975, also studying total standing crop of forage and protein content of principal forage species on West Rosebud and Stillwater winter ranges.

Prior to 1977, knowledge of the bighorns wintering along the upper Rock Creek drainage was limited to occasional winter and spring counts. In 1977 a study dealing with the movements, population composition, range use and food habits of the Rock Creek herd was initiated by the Montana Department of Fish, Wildlife and Parks (MDFWP). I conducted field work between early June and mid-September of 1978, from May through mid-December of 1979 and in July of 1980.

STUDY AREA

The study area is located in the Beartooth and Absaroka mountain ranges of southcentral Montana and northwestern Wyoming approximately 120 km southwest of Billings, Montana (Figure 1). Two thirds of this approximately 1970 sq km area lies within the Absaroka-Beartooth Wilderness Area of the Gallatin and Custer National Forests, the North Absaroka Wilderness Area of the Shoshone National Forest, and Yellowstone National Park.

Intensive field work was conducted on the winter and summer ranges of the Rock Creek bighorn sheep herd (Figure 1). Late spring, early summer and late autumn field work was conducted in the Beartooth Mountains along the upper reaches of Rock and Line creeks at the border between Montana and Wyoming. Summer and early autumn work was distributed along the northern portion of the Wyoming Absaroka Mountains just east of Yellowstone Park and in a small portion of the Montana Absarokas bordering the northeast corner of the Park.

The differing geological history of the Beartooth and Absaroka ranges has resulted in distinctly contrasting landforms. The Beartooths, dominated by Precambrian Era granitics, are characterized by barren rocky peaks, deep glaciated canyons, and high alpine plateaus. Elevations vary from 3,901 m (12,799 ft) on Granite Peak to about 2012 m (6,600 ft) in the Rock Creek canyon. The Absarokas, on the other hand, are dominated by Tertiary volcanics of the Cenozoic Era and consist of steep scree mountains and ridges above broad glaciated

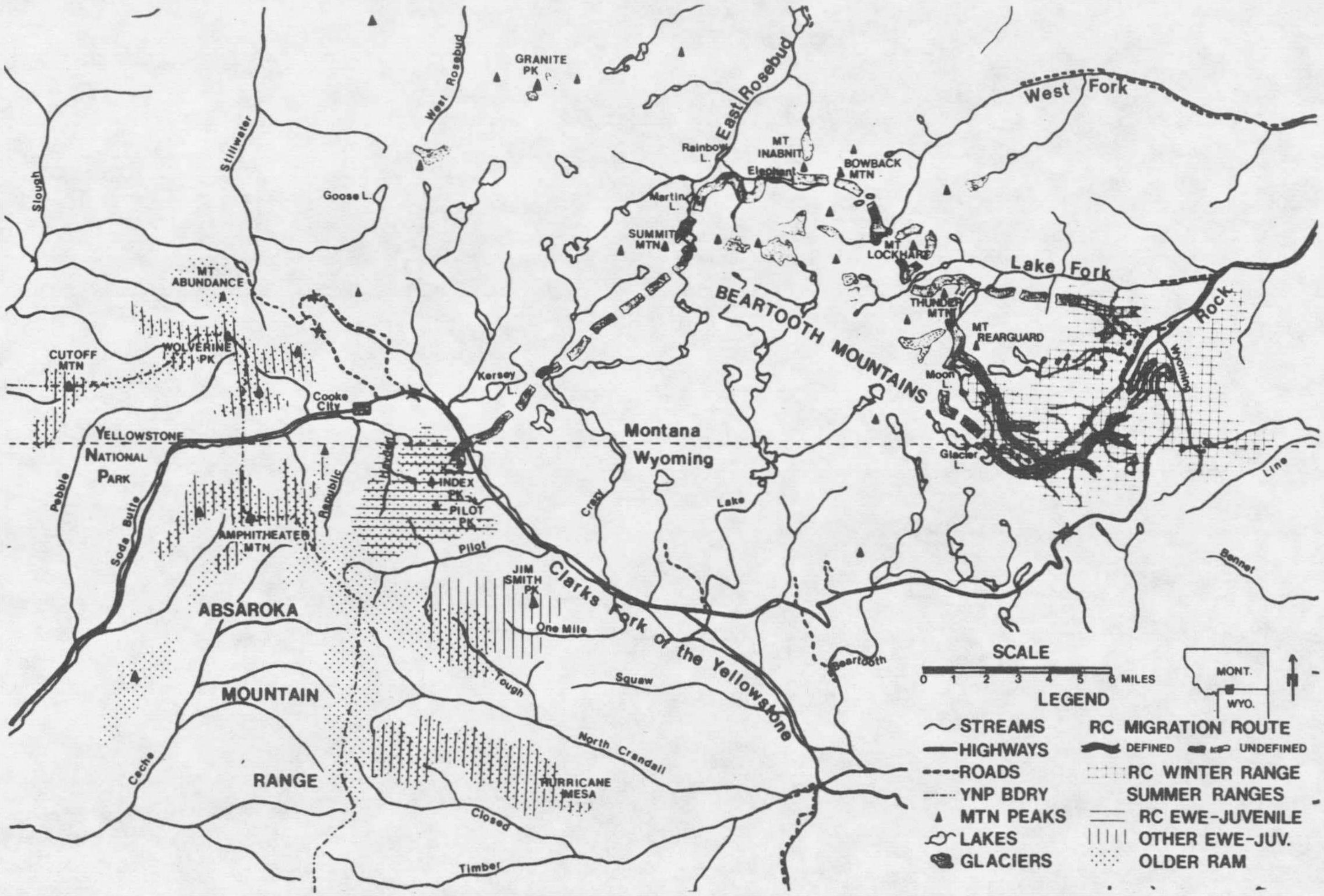

Figure 1. Map of study area showing seasonal ranges and migration route of the Beartooth-Rock Creek bighorn sheep herd.

valleys. Absaroka elevations on the study area range from 3,569 m (11,708 ft) on Pilot Peak to about 2,012 m (6600 ft) in the Clarks Fork River drainage. The geology of the Beartooth block is described in detail by the Billings Geological Society (1958).

The climate of the Absaroka and Beartooth Ranges is characteristic of the Rocky Mountain region and is locally controlled by altitude. An indication of weather conditions for the study area was provided by U.S. Weather Bureau Stations at Red Lodge, 15 km northeast of the Beartooth winter range, Cooke City, within the Absaroka summer study area, and at Mystic Lake, 25 km north of both ranges (USDC-NOAA 1977, 1978, 1979). Seasonal patterns in temperature and precipitation recorded at the three stations are presented in Tables 1 and 2.

Mean temperatures decline and precipitation normals increase from the Red Lodge to the Cooke City station, reflecting a 592 m increase in elevation. Mean January temperatures varied from -5.4C to -10.3C between the stations, while July means ranged from 17.9C to 13.3C. Annual precipitation normals varied from 58.9 cm to 67.6 cm between the three stations. Snowpack measured at Fisher Creek, at 2774 m (9100 ft) on the northeast end of the summer study area, averages 115 cm in late April and 102 cm by late May.

Both the winter and summer ranges lie for the most part at elevations between 2743 m (9000 ft) and 3353 m (11000 ft). Temperatures likely averaged about 10C cooler on the winter range than those recorded at Red Lodge and 5C cooler on the summer range than those recorded at Cooke City. The U.S. Dept. Agriculture, Soil Conservation Service estimates mountain precipitation totals on the

Table 1. Summary of temperature data from the Red Lodge (RL, 1699 m), Mystic Lake (ML, 1999 m), and Cooke City (CC, 2291 m) weather stations.

	Station	Temperature (C) Win	Spr	Sum	Aut	Year
Normals	RL	-3.5	8.9	15.7	1.5	5.6
	ML	-3.2	7.8	15.0	1.7	5.3
	CC	-8.0	4.8	11.2	-3.7	1.1
Deviations						
1977	RL	+0.7	+2.1	-0.6	-1.2	+0.3
	ML	+1.4	+2.1	-0.6	-0.6	+0.6
	CC	-0.1	+1.5	-0.4	+0.3	+0.3
1978	RL	-0.4	+0.4	-0.3	-3.4	-0.9
	ML	+1.1	+0.3	-0.1	-2.7	-0.3
	CC	+1.9	-0.1	-0.8	-2.9	-0.4
1979	RL	-2.3	+0.4	+1.3	+0.3	-0.1
	ML	-1.4	+0.2	+1.4	+0.1	+1.0
	CC	-1.6	-0.4	+0.8	-1.7m	-0.9m

Seasons: Win = Jan-Mar, Spr = Apr-Jun, Sum = Jul-Sep, Aut = Oct-Dec.
m = One or more months data missing. Normals substituted for missing months.

Absaroka summer range from 102 cm to 203 cm, and Beartooth winter range totals from 51 cm to 203 cm, depending on elevation and exposure.

Temperatures in 1977 were about average or slightly warmer than normal at the three weather stations (Table 1). Spring temperatures were warmer at all stations. Precipitation totals in 1977 were slightly below normal at Red Lodge, well below at Mystic Lake, but above normal at Cooke City (Table 2). All stations showed below normal winter and spring precipitation except Red Lodge which experienced heavy snowfall in March. Late April and late May snowpack readings at

Table 2. Summary of precipitation data from the Red Lodge (RL, 1699 m), Mystic Lake (ML, 1999 m), and Cooke City (CC, 2291 m) weather stations.

	Station	Precipitation (cm) Win	Spr	Sum	Aut	Year
Normals	RL	10.9	26.4	11.8	9.8	58.9
	ML	12.7	25.7	15.5	11.3	65.2
	CC	15.8	20.3	15.6	15.7	67.6
Deviations						
1977	RL	+5.5	-12.6	+3.3	+2.2	-1.6
	ML	-5.7	-11.4	-0.7	-0.8	-18.6
	CC	-4.3	-3.5	+4.1	+12.4	+8.7
1978	RL	-1.0	+2.2	+9.0	+8.1	+18.3
	ML	-4.7	+0.1	+2.2	+4.5	+2.1
	CC	+5.4	-7.2	+0.9	+2.6	+1.6
1979	RL	+0.9	-7.4	-4.2	+2.2	-8.5
	ML	-0.2	-6.0	-4.7	-0.7	-11.6
	CC	+9.6	-4.0m	-4.5	-6.1m	-5.1m

Seasons: Win = Jan-Mar, Spr = Apr-Jun, Sum = Jul-Sep, Aut = Oct-Dec.
m = One or more months data missing. Normals substituted for missing months.

Fisher Creek were only 51 and 57 % of normal, respectively. Autumn precipitation was well above normal at Cooke City due to heavy December snowfall.

In 1978 winter temperatures were slightly warmer than usual while autumn temperatures were cooler (Table 1). Precipitation was above normal at Cooke City in winter but below normal in spring (Table 2). Heavy precipitation occured at Red Lodge and Mystic Lake in May. Snowpack was 104 % of normal in late April and 117 % of normal by late May at Fisher Creek. All stations recorded above normal precipitation during summer and autumn, but the greatest deviations occurred at Red Lodge. Precipitation at Red Lodge was 131 % of normal in 1978.

In 1979 temperatures were below normal at all stations in winter, near normal during spring and autumn, and slightly above normal during summer (Table 1). Precipitation was above normal in winter at Cooke City due to heavy February and March snowfall, but below normal at all stations in spring (Table 2). Fisher Creek snowpack measured 90 and 83 % of normal during late April and late May readings, respectively. Below normal precipitation continued through the summer. Total precipitation at all stations was below normal in 1979.

Vegetation on the study area varies from alpine tundra above 2,930 m (9,600 ft) to montane forests below 2,260 m (7,400 ft). A detailed description of study area vegetation is given in Appendix A.

METHODS

Capture and Marking

Fourteen bighorn sheep were marked on the Rock Creek winter range during the spring months of 1977, 1978, and 1979 by MDFWP personnel (Table 3). Free ranging bighorns were immobilized with Rompun (xylazine) or succinylcholine chloride using a "capture" gun. Radio transmitter collars were placed on thirteen sheep. These collars consisted of a transmitter and antenna package of a frequency between 150.915 and 151.015 MHz inserted into a molded, color coded, PVC plastic pipe. One bighorn was fitted with a color coded neckband. Sheep were tagged in both ears with numbered, yellow Ritchey eartags.

Distribution and Movements

Distribution and movements of bighorn sheep were determined from aerial and ground based relocation of instrumented and marked bighorns, location of bighorns observed during aerial and ground based population and habitat use surveys, field searches for bighorn sign, and MDFWP observation records.

Aerial relocations were obtained during flights in a Piper Supercub airplane equiped with a three element Yagi antenna or in a Cessna 182 aircraft equipped with dual whip antennas. An attempt was made to obtain aerial relocations at biweekly intervals between May and October of 1978 and 1979 with daily flights during bighorn migration. Weather and logistics problems often interfered with this goal. Aerial

Table 3. Bighorn sheep captured and marked from the Beartooth-Rock Creek herd, 1977-1979.

ID	Sex	Age at Capture	Capture Date	Transmitter Brand	Comment
W:R01	F	3.5	4/7/77	AVM	Radio functional through 12/17/79.
B/Y04	M	2.5	4/7/77	AVM	Radio never functional, dropped spring 1979. Hunter kill Montana 11/10/79.
BS12	M	3.5	4/26/77	AVM	Hunter kill Wyoming 9/3/77.
YS03	F	6-7	4/29/77	AVM	Sheep died shortly after capture.
RS11	F	2.5	5/2/78	AVM	Radio functional until late 8/79.
R/Y09	M	1.5	5/2/78	AVM	Radio functional until dropped mid 7/78.
G/W15	F	3.5	5/10/78	AVM	Sheep died 6 to 7 days after capture.
YS14	F	6-7	5/10/78	AVM	Sheep died 1 to 2 days after capture.
W-B15	F	7.5	5/12/78	Neckband	Collar worn through 2/28/80.
G/W20	F	1.5	5/11/79	AVM	Radio functional through 12/17/79.
GS29	F	1.5	5/15/79	AVM	Radio functional until dropped mid 9/79.
R/W28	M	1.5	5/16/79	Telonics	Radio functional through 12/17/79.
BS	M	1.5	5/17/79	Telonics	Sheep died early 7/79.
YS22	F	8.5	5/21/79	Telonics	Sheep died 1 to 2 days after capture.

relocation information was obtained from 5, 9, and 17 flights during 1977, 1978, and 1979, respectively. During these flights an attempt was made to visually locate instrumented bighorns, but all locations thought to be within 0.5 km were used in data analysis.

Ground relocations of instrumented animals were made on foot with the use of AVM Model LA12 receivers and various handheld two, three, and four element Yagi antennas. Rugged topography on the study area did not permit triangulation. Relocations verified with a visual sighting and those judged to be accurate to within 0.5 km were used in data analysis.

Locations of all bighorn sheep observed during the study were plotted to within 100 m on 15 minute USGS topographic maps. Marked bighorn relocations were used to determine three indices of animal movement: polygon home range (Mohr 1947), standard diameter (Harrison 1958), and average activity radius (Hayne 1949).

Population Characteristics

Information on population characteristics was collected during aerial and ground surveys of bighorn sheep ranges. Aerial survey information was obtained from 8, 12 and 12 flights during 1977, 1978, and 1979, respectively. Bighorns were classified as 3/4 or greater (3/4+) horn curl rams, 3/4- curl rams, ewes, or lambs from the air.

Ground observations were made with the aid of a 32 X spotting scope and 7 X binoculars. Bighorns were classified as males, females or lambs. Rams were further classified as to degree of horn curl (less than 1/4, 1/4-1/2, 1/2-3/4, 3/4+), and those with less than 3/4 curl could often be aged by counting horn segments (Geist 1966). Females were further classified as yearlings or ewes. From a distance yearling rams were often difficult to distinguish from mature ewes during June and July. Likewise, yearling ewes were sometimes difficult to distinguish from older ewes during autumn.

Habitat Use

Habitat use information was recorded during ground based surveys of bighorn sheep ranges. Data was summarized by month and season. Seasons were defined as follows: winter = January - March, spring = April - June, summer = July - September, autumn = October - December. On the winter range July was also considered to be spring.

Slope

Degree of slope within a 15 m (50 ft) radius around each bighorn sheep sighting was estimated in the field visually and with the aid of a compass. For purposes of data analysis six slope categories were recognized:

1) Horizontal (H) = 0 to 3 degrees
2) Gentle (G) = 4 to 10 degrees
3) Moderate (M) = 11 to 25 degrees
4) Steep (S) = 26 to 45 degrees
5) Very Steep (VS) = 46 to 65 degrees
6) Cliff (C) = Greater than 65 degrees

Aspect

Aspect within a 15 m radius around each group of bighorn sheep observed was determined from 15 minute USGS topographic maps and recorded as one of nine exposures: N, NE, E, SE, S, SW, W, NW, and --- (none).

Distance to Escape Cover

Proximity of bighorn sheep to escape cover consisting of steep rocky terrain, dense timber, or combinations of timber and rock was estimated and recorded. For purposes of data analysis the following distance categories were used:

1) In (IN) = Within 1 m (3 ft)
2) Very Near (VN) = 1 to 5 m (4 to 16 ft)
3) Near (NR) = 6 to 25 m (17 to 82 ft)
4) Moderate (MD) = 26 to 50 m (83 to 164 ft)
5) Far (FR) = 51 to 100 m (165 to 328 ft)
6) Very Far (VF) = More than 100 m (328 ft)

Topographic Position

Three broad topographic positions were recognized on the winter range and four on the summer range areas. On the Beartooth winter range these were the plateau top/edge (PTE), canyon wall (CW), and canyon bottom (CB) positions. On the Absaroka summer range they included the ridgetop (RT), ridgeside (RS), basin bottom (BB), and valley bottom (VB) positions.

Elevational Zones

Elevation above mean sea level was recorded from USGS 15 minute topographic maps for all bighorn sightings. Six elevational zones were recognized on the study area. These zones were based on characteristics of forest vegetation as described by Pfister et al. (1977) and modified based on vegetation conditions particular to the study area. The vegetation structure and composition of each is a reflection of a climatic gradient of increasing amounts of precipitation and decreasing mean temperatures from the lowest to the highest elevational zone.

The six elevational zones, their approximate elevational limits and distinguishing characteristics are as follows in order of increasing climatic severity:

Montane (MN): Less than 2260 m (7400 ft). Forests are potentially dominated by Douglas Fir, lodgepole pine, or limber pine. Upper elevational boundary variable.

Lower Subalpine (LS): 2260 m to 2559 m (7400 to 8399 ft). Forests are potentially dominated by subalpine fir, yet are still warm enough to support Douglas Fir. Lower boundary variable.

Upper Subalpine (US): 2560 m to 2799 m (8400 to 9199 ft). Forests are potentially dominated by subalpine fir, whitebark pine is well represented. Above the climatic limits of Douglas Fir.

Lower Timberline (LT): 2800 m to 2929 m (9200 to 9599 ft). Forests are potentially dominated by stunted subalpine fir (generally less than 15 m in height) or whitebark pine. Spruce is often well represented. Timbered areas occur in patches or fingers interspersed with open areas. Herbaceous vegetation is similar to the subalpine zone.

Upper Timberline (UT): 2930 m to 3019 m (9600 to 9899 ft). Subalpine fir, whitebark pine, and spruce occur primarily as small patches of stunted deformed scrub-like individuals (generally less than 5 m tall) surrounded by open areas. Herbaceous vegetation similar to alpine zone.

Alpine (AL): 3020 m (9900 ft) or greater. Zone in which trees occur only as occasional, scattered, dwarf, scrub-like individuals. Vegetation dominated by alpine graminoids and forbs.

The elevational limits given for these zones were based on average conditions occuring over the entire study area. Elevational limits shifted depending primarily on exposure and also to some extent on location within the study area.

Vegetation Structural Components and Formations

Classification Scheme: Sheep vegetation type use was related to readily discernable structural vegetation characteristics. Physiognomic and structural criteria of vegetation (vertical stratification, life form dominance, and composition) and environmental components (altitude, water, soil, exposure) were used. Floristic criteria provided only supplemental information.

Fourteen basic vegetation structures (lifeform combinations) of four basic structure levels (vertical strata) were recognized as being important components of bighorn sheep habitat on the study area. Based on the relative coverage of these structural components, any given bighorn use site could be classified to a vegetation structure formation (structural vegetation type). A vegetation formation is defined as a readily distinquishable vegetation unit, easily recognized by a characteristic dominant life form or life form combination (Mueller-Dombois and Ellenberg 1974). The fourteen basic vegetation structure components and their related structural formations were as follows:

Tree Layer

Tree (tr): Upright conifers, generally over 5 m (16 ft) tall. Montane through upper timberline. Related formation - Coniferous Forest (CF): Habitat with over 30 % tree cover.

Scrub/Shrub Layer

Scrub (sc): Creeping or lodged conifers less than 5 m (16 ft) tall, often less than 2 m (6 ft). Lower timberline through alpine. Related formation - Coniferous Scrub (CS), also refered to as "Krummholz": Habitat with over 30 % scrub cover, but less than 30 % tree cover.

Shrub (sh): Deciduous and evergreen shrubs less than 5 m (16 ft) tall. Montane through alpine. Related formation - Evergreen/Deciduous Shrub (EDS): Habitat with over 30 % shrub cover, but less than 30 % tree cover.

Herb Layer

Turf (tf): Alpine "tundra", herbaceous vegetation comprising at least 50 % ground cover. Lower timberline through alpine. Related formation - Alpine Turf (AT): Habitat with over 30 % turf cover, but less than 30 % tree or scrub/shrub cover.

Mat (mt): Patchy alpine herbaceous vegetation in tufts or small mats, substrate exposure over 50 %. Lower timberline through alpine. Related formation - Alpine Mat (AM): Habitat with over 30 % mat cover, but less than 30 % tree or scrub/shrub cover.

Snowbed (sb): Alpine vegetation covered by snow for more than 9 months per year, watered by melting snowfield well into summer. Lower timberline through alpine. Related formation - Alpine Snowbed (AS): Habitat with over 30 % snowbed cover, but less than 30 % tree or scrub/shrub cover.

Meadow (md): Forb rich openings in forested elevation zones. Montane through lower timberline. Related formation - Subalpine Meadow (SM): Habitat with over 30 % meadow cover, but less than 30 % tree or scrub/shrub cover.

Grassland (gl): Graminoid dominated communities within and below lower forested zones. Montane through lower subalpine. Related formation - Montane/Subalpine Grassland (MSG): Habitat with over 30 % grassland cover, but less than 30 % tree or scrub/shrub cover.

Substrate Layer

Rock Cliff (rc): Massive solid rock face with an average slope over 65 degrees and at least 5 m (16 ft) high. Montane through alpine. Related formation - Sparsely Vegetated Cliff (SVC): Habitat with over 30 % cliff exposure, but less than 30 % tree, scrub/shrub or herb component cover.

Rock Outcrop (ro): Exposed broken mass of solid rock at least 5 m (16 ft) long and 2 m (6 ft) high. Montane through alpine. Related formation - Sparsely Vegetated Outcrop (SVO): Habitat with over 30 % rock outcrop exposure, but less than 30 % tree, scrub/shrub or herb component cover.

Rock Talus (rt): Large rocks, generally over 0.2 m (8 in) in diameter, unconsolidated in surface. Montane through alpine. Related formation - Sparsely Vegetated Talus (SVT): Habitat with over 30 % rock talus exposure, but less than 30 % tree, scrub/shrub or herb component cover. Montane to alpine.

Rock (rk): Large rocks, generally over 0.2 m (8 in) in diameter, consolidated into a stable soil surface. Related formation - Sparsely Vegetated Rockland (SVR): Habitat with over 30 % consolidated rock exposure, but less than 30 % tree, scrub/shrub or herb component cover.

Dirt-Scree (ds): Various mixtures of exposed soil and unconsolidated rock fragments less than 20 cm (8 in) in diameter. Montane to alpine. Related formation - Sparsely Vegetated Dirt-Scree (SVDS): Habitat with over 30 % dirt-scree exposure, but less than 30 % tree, scrub/shrub or herb cover.

Snowfield (sf): Summer persistent snowfield or bank. Upper timberline through alpine. Related formation - Snowfield (SF): Habitat with over 30 % snowfield cover, but less than 30 % tree, scrub/shrub or herb cover.

Field Methods: A circle with a radius approximating 15 m (50 ft) was visually centered on each observed bighorn. This radius was chosen because it appeared to represent a general zone of influence having the most effect on sheep habitat selection behavior. All vegetation structure components occurring within this circle, with over 10 % cover, were recorded and considered important in sheep habitat selection. Coverage was estimated for each component at one of two levels: 10 to 29 % cover (common), or 30 to 100 % cover (abundant).

Component cover was mutually exclusive within a habitat circle, i.e. any given point in a habitat circle could be classified as only one structural component. Points with more than one structural layer were classified by the overstory component. For example, herbaceous understory beneath a patch of conifers was considered part of the "tree" structural component.

Based on component coverage within the habitat circle, a vegetation structure code was derived for each bighorn observation. This code consisted of an abbreviated list of the component types in the following format:

Structure Code = Abundant Component(s) , (Common Component(s)).

Those of the same cover level were listed in order of life form dominance (structural layer) first, relative coverage second. The structure code accounted for a minimum of 90 % of the vegetation structure coverage within a habitat circle.

The structural formation of the habitat circle was determined by the dominant cover component (that of the highest structure level) with coverage over 30 %. Subtypes of the primary structural type were distinguished by the other abundant components present, if any.

For example, in a habitat circle where turf and rock structures were each abundant and rock outcrop was common, the structure code would be recorded as tf-rk,(ro). The structural formation would be Alpine Turf, while the structural subtype would be designated as Alpine Turf-Sparsely Vegetated Rock (AT-SVR) or "turf-rock" (tf-rk).

Data Analysis: General habitat use information was provided by comparing seasonal occurrence of sheep within the fourteen vegetation formations. Further definition of bighorn habitat use was obtained by noting differences in sheep occurrence among the subtypes of the vegetation formations.

In addition, the frequency at which a vegetation component was associated with bighorn sheep sightings provided information on the influence of the component in bighorn sheep habitat selection. This level of analysis was particularly useful in revealing the influence of components which, while rarely of sufficient coverage in the immediate vicinity of bighorns to warrant recognition as formations or subtypes, were nevertheless frequent associates of sheep and therefore might play a significant role in bighorn habitat selection behavior.

Vegetation Sampling

Field Methods

Vegetation associations within selected structural vegetation types were described floristically. Plant communities characteristic of the structural types most used by bighorn sheep received the most emphasis. Vegetation work was concentrated on the summer range as most of the summer growing season was spent in this area.

Structural vegetation component coverage was estimated and a structure code was derived from the vicinity of each floristically described plant community stand. Forest and shrub/grassland habitats below the upper timberline elevational zone were classified to habitat type using the methods of Pfister et al. (1977) and Mueggler and Stewart (1980). Stands not conforming to these habitat classification methods, including all those sampled in the upper timberline and alpine zones, were described as to dominant species composition. A complete species list was made, with unknowns being collected for later identification. Botanical nomenclature followed Hitchcock and Cronquist (1976). Cover of each tree and shrub species was visually estimated within the stand. Low lying vascular plant species and substrate cover were estimated using either the point intercept or canopy coverage methods.

The general theory of the point intercept method is given by Mueller-Dombois and Ellenberg (1974). Study area vegetation was quantitatively sampled by holding a walking stick, grooved along one side at 25 cm intervals, about 15 cm from the ground parallel with the fall line of the slope. A long writing pen was lowered along each of the four grooves in turn and the first "hit" made with a plant species or substrate component was recorded for each. The stick was placed at 1.5 m intervals along a transect running perpendicular with the slope.

A minimum of 100 points (25 stick placements) were read in each sampled stand. Cover of each plant species or substrate class was estimated based on percent of total "hits".

The canopy coverage method is described by Daubenmire (1959). Canopy coverage of plant species and exposure of substrate classes were obtained by examining twenty 2 X 5 dm plots located at 1.5 m intervals along a line transect. Eight coverage classes were recognized (0, 0-<1, 1-<5, 5-<25, 25-<50, 50-<75, 75-<95, and 95-100 % cover).

Data Analysis

Relevé tables were constructed listing the coverage of all vascular plant species and substrate classes in each sampled stand for both the winter and summer range areas. Similarities in stand structure, species/substrate dominance and species composition were then used to group stand information into community type descriptions.

Based on this descriptive work, dominant and characteristic plant communities within each structural formation were determined. While this information could not be directly related to sheep habitat use, it did provide information on the variety and composition of vegetation types available to bighorns on the study area and supplemented the vegetation structure use data.

Food Habits

Food habits of bighorn sheep were determined by examination of feeding sites (Cole 1956) and from microhistological analysis of fecal samples (Sparks and Malechek 1968). In feeding site examinations an estimation of one bite was considered to represent one instance of use.

Fecal samples were collected in 1979 between August 15 and September 28 on the summer range and from November 14 to December 14 on the winter range. Samples were analyzed at the Colorado State University Composition Analysis Laboratory, Fort Collins.

Lungworm Burden

Fecal samples collected between August 15 and December 14, 1979 were used to determine the incidence and intensity of lungworm (*Protostrongylus* spp.) infection in the Beartooth-Rock Creek herd. Analysis was conducted at the Montana State University Veterinary Laboratory, Bozeman using the technique described by Baermann (1917).

RESULTS

Distribution and Movements

The Beartooth-Rock Creek bighorn sheep herd occupied two widely separate seasonal range areas, connected by traditional migration routes. The two ranges were designated the Rock Creek Winter Range (RCWR) and the Absaroka Summer Range (ASR). Seasonally related movements and habitat shifts occurred within each of these two ranges, but further definition of seasonal ranges and traditional movement patterns, such as those reported by Geist (1971), could not be substantiated. The possibility remains however that segments of the herd showed more intricate movement patterns than those described below.

Beartooth-Rock Creek Winter Range

The winter range of the Beartooth-Rock Creek bighorn sheep herd is located in the upper Rock Creek and Line Creek drainages of the Beartooth Mountains. Figure 1 delineates the boundaries of the 88 sq km (40 sq mile) area from which bighorn observations have been obtained. During this study the area was used by about 95 bighorns for approximately eight to nine months of the year. Bighorns were observed at elevations between 2260 m (7400 ft) and 3230 m (10,600 ft), but sheep use was primarily restricted to alpine plateaus and timberline-subalpine canyon walls immediately surrounding the drainages.

Rock Creek bighorn sheep arrive on the winter range between mid-October and mid-November. From the time of their arrival to after the peak of the rutting season sheep ranged widely over the entire RCWR. Habitats from the lower canyon walls up to the edges of the plateaus were used, and there was frequent movement across the Rock Creek canyon floor.

Winter season bighorn observations on the RCWR were often limited to survey flights and therefore may be biased in favor of larger sheep groups located in open areas, such as on plateaus. Mid-winter observations were concentrated on the west and northwest ends of plateaus and upper canyon walls in four areas: between Mirror Lake and Chain Creek, between Chain Creek and the Beartooth Highway switchbacks, between Wyoming Creek and Tolman Mountain, and the plateau between the two upper branches of Line Creek. It appears that as the rut ended and winter conditions became more severe, sheep moved to areas blown free of snow in search of forage. On the RCWR these sites are limited to the windward edges of alpine plateaus. Mid-winter use of alpine plateaus was also reported by Stewart (1975) for the bighorns which winter in the West Rosebud Creek area of the Beartooths.

By late April bighorn sightings were again more dispersed on the RCWR. Observations shifted from plateaus to the lower canyon walls, with increased use of the subalpine elevational zone where vegetation green-up occurred earlier. Most sightings were from the canyon walls below winter concentration areas and on the south and east facing canyon walls northwest of Rock Creek.

From late May through June pregnant ewes isolated themselves and lambed on the steeper more rocky areas of the canyon walls south and east of Rock Creek. After about a week of isolation with their new lamb they then joined other ewes with lambs along with some barren ewes and juveniles, forming nursery bands which were usually observed on the upper canyon walls.

Table 4 presents movement statistics for marked bighorns based on all of their nonmigratory relocations from the winter range area. Further seasonal delineation of movement patterns on the winter range was not possible due to the scarcity of mid-winter relocations. The mean of the winter range standard diameters, average activity radii, and polygon home range sizes of the 10 marked sheep were 4.17 km (2.59 mi), 1.88 km (1.17 mi), and 17.9 sq km (6.91 sq mi), repectively. Marked ewes showed slightly larger movement patterns than rams, but this was likely an artifact of ram radio and collar loss, which resulted in few relocations for older rams. The pooled standard diameter is somewhat larger than the 3.70 km (2.30 mi) reported by Brown (1974) in northwestern Montana for sheep on the winter range.

All bighorn sheep marked on the winter range were accounted for during each subsequent winter of the study. Marked bighorns returned to Rock Creek each winter, with the exception of two rams which died. This high fidelity to the winter range is in agreement with the highly traditional nature of bighorn movement patterns (Geist 1971).

Spring Migration

Departure Dates: Based on departure dates of radio-collared bighorns and the decline in sheep sightings, movement off the winter range begins during the last half of May, peaks in early June and is

Table 4. Movement statistics from marked Beartooth-Rock Creek bighorn sheep, 1977-1980.

ID	Sex	Birth Year	ROCK CREEK WINTER RANGE n	CA	SD	AAR	PHR	ABSAROKA SUMMER RANGE n	CA	SD	AAR	PHR
W:R01	F	73	81	49870 6246	4.50	1.95	31.2	21	49809 5887	2.16	0.96	3.2
RS11	F	75	46	49882 6274	5.13	2.22	33.1	15	49814 5887	2.17	0.92	1.6
W-B15	F	70	33	49867 6242	3.62	1.57	9.9	8	49816 5883	1.38	0.58	1.1
G/W20	F	77	32	49870 6249	5.77	2.58	27.7	7	49819 5889	2.36	1.06	0.5
GS29	F	77	21	49857 6224	2.45	1.05	7.3	10	49807 5861	2.39	1.12	3.5
B/Y04	M	74	14	49869 6243	4.97	2.09	26.7	3	49881 5786	3.93	1.86	1.6
BS12	M	73	3	49873 6239	5.18	2.47	3.8	4	49795 5877	13.64	5.73	15.8
R/Y09	M	76	34	49889 6268	5.21	2.36	22.7	2	— —	—	—	—
R/W28	M	77	22	49856 6214	3.08	1.14	11.8	12	49805 5863	3.35	1.47	9.1
BS	M	77	21	49864 6238	1.75	1.36	4.7	0	— —	—	—	—
Ewes	Mean		5	— —	4.29	1.87	21.8	5	— —	2.09	0.93	2.0
	s.d.			— —	(1.30)	(0.59)	(12.3)		— —	(0.41)	(0.21)	(1.3)
Rams	Mean		5	— —	4.04	1.88	13.9	3	— —	6.97	3.02	8.8
	s.d.			— —	(1.56)	(0.60)	(10.4)		— —	(5.78)	(2.36)	(7.1)
All	Mean		10	— —	4.17	1.88	17.9	8	— —	3.92	1.71	4.6
	s.d.			— —	(1.36)	(0.56)	(11.5)		— —	(4.01)	(1.67)	(5.3)

Abbreviations: n = Number of relocations, CA = Center of activity (UTM x 10), SD = Standard diameter (km), AAR = Average activity radius (km), PHR = Polygon home range (sq km).

for the most part complete by early July. The entire herd eventually is absent from the winter range during most of summer and early autumn. Weather conditions did not appear to affect spring departure dates during the study.

Departure dates of individual sheep varied with sex and reproductive status. Rams and barren ewe-juvenile groups for the most part left the area by late June. However, ewes which lambed from late May to mid-June on the winter range spent two weeks to over a month in nursery bands grazing on canyon sides before migrating.

Marked ewes illustrated this trend. Ewe W:R01 lambed in 1977 and that year did not migrate until late July or early August. In 1978 she didn't lamb and left the winter range on June 20. In 1979 she lambed again and did not migrate until July 3. Ewe RS11 lambed in 1978 and waited until July 11 to migrate, while in 1979 she did not lamb and left the area in mid-June. Ewe W-B15 lambed on or about July 11, 1978, but had lost her lamb by June 20. She remained on the winter range in a nursery band until she migrated with them in early July.

The possibility remains that some pregnant ewes leave the winter range the last half of May or early June and lamb along the migration route, as has been reported by Smith (1954), but this could not be confirmed. Late departure dates of ewes lambing on the winter range was also reported by Blood (1963) for California bighorns in southern British Columbia.

<u>Migration Route</u>: Figure 1 charts the most probable path of migration based on relocations and observations of migrating marked and unmarked bighorns and on topographic features of the area. The route

travels through the heart of the Beartooth Mountains and traverses extremely rough terrain. Five major headwater canyons of the Beartooth Mountains are crossed, as well as four passes over 3,414 m (11,200 ft) in elevation.

Sheep leaving Rock Creek appear to do so in two areas. Many move from their spring activity centers on the canyon walls south of Rock Creek down to about 2,690 m (8,800 ft) to cross to the north canyon wall. They then move upstream, eventually entering the Lake Fork drainage, probably through a 3,410 m (11,200 ft) pass just west of Mount Rearguard. Other sheep, with spring activity centers east of Wyoming Creek, appear to move across Rock Creek canyon and thence along the south wall of the Lake Fork canyon to leave the winter range.

The two departure routes join on Thunder Mountain. From here the sheep traverse the canyon wall down to about 2,770 m (9,100 ft) to cross the upper Lake Fork drainage, then climb back up to 3,350 or 3,540 m (11,000 to 11,600 ft) in order to move into the West Fork drainage in the vicinity of Mount Lockhart. They then drop to about 2,930 m (9,600 ft) to cross the head of the West Fork, from which they must make their way back up at least to the 3560 m (11,680 ft) pass southwest of Bowback Mountain. From here the bighorns drop into the East Rosebud drainage, moving down to Elephant Lake at 2900 m (9500 ft), then continuing along the south wall of the East Rosebud canyon until they reach Martin Lake at 2,800 m (9,200 ft).

At this point most sheep appear to ascend Falls Creek out of the East Rosebud and into the Clarks Fork of the Yellowstone River drainage over the 3,510 m (11,520 ft) pass east of Summit Mountain. From this pass they travel in a southwesterly direction to the Pilot-Index Peaks area of the Absaroka Mountains. First crossing the Clarks Fork at about 2,290 m (7,500 ft), then moving into the summer range at points east of Ram Pasture Peak.

Some rams travel to the Wolverine Peak area instead of the Pilot-Index Peaks area of the Absaroka Mountains. The route these bighorns follow after entering the East Rosebud drainage was not determined.

Those bighorns which migrate along the route to the Pilot-Index Peaks area travel approximately 57 km (35 mi) between winter and summer ranges while those rams which move to the Wolverine Peak area travel at least 64 km (40 mi). The mean distance between summer and winter centers of activity for Rock Creek rams was 45.0 km (28.0 miles) compared to 37.1 km (23.1 miles) for ewes.

Migration Rate: The rate of bighorn movement during spring migration depended on departure date. Sheep leaving the winter range in May or early June appeared to spend more time migrating than those departing during mid-June to July. One marked young ram left the winter range in late May or early June and spent a minimum of seven days on the route to the Pilot-Index area. At least four of those days were spent in the East Rosebud drainage.

The travel rate of later spring migrants is best illustrated by the movements of two instrumented two year old ewes which were monitored over the entire route to the Pilot-Index area at an average of 16 hour intervals. These sheep traveled the approximately 57 km (35 mi) route in less than 104 hours for a rate of 13.2 km (8.2 mi) per day. Four radioed bighorns, all ewes leaving the winter range in late June to early July, are known to have migrated in about 4.5 days or less (84 to 104 hours). Two of these ewes were accompanied by lambs.

Movement of individual bighorn groups off the winter range was abrupt. Radio-collared sheep monitored as they began their migration generally left their spring home ranges during the morning hours and by late afternoon had traveled 8 to 11 airline km (5 to 7 mi). This rapid rate of travel continuing over the entire migration contrasts with the slow drifts observed during spring migration for other bighorn herds (Smith 1954, Blood 1963, Geist 1971).

Based on observation times and grouping of locations of sheep on the migration route, it appears that certain areas are used as stopover points where sheep spend variable amounts of time delaying their migration. Late migrants use these areas only to spend the night, while early migrants may delay for longer periods. Four such areas were found: Thunder Mountain, Elephant Lake-Mount Inabnit, Martin Lake, and Clarks Fork River-Highway 212.

Much of the route traveled in migration is over 3,050 m (10,000 ft) in elevation and the terrain is rocky and barren. Open timberline subalpine fir-whitebark pine stands reach up into some of the canyons to about 2,930 m (9,600 ft) but generally the vegetation cover is alpine or nonexistent. However, 11 km (7 mi) of the route to the Pilot-Index Peaks area lies across the forested Clarks Fork-Beartooth high lakes country. This area consists of a large plateau of broken rocky hills and ridges covered by a dense forest dominated by subalpine fir and/or lodgepole pine. Numerous lakes and wet meadows dot the area. All monitored radio-collared sheep moved through this area rapidly until reaching the Clarks Fork River and Highway 212. This hurried movement through a large timbered expanse is in line with the observations of McCann (1956) and Geist (1971) that bighorns possess an inborn fear of extensive heavily timbered areas but will cross such an area during migration.

Disturbance Factors: Approximately 90 % of the migration route to the Pilot-Index area lies within the Absaroka-Beartooth Wilderness Area. Here the potential for human disturbance of migration is very low. However, in two places the route crosses roads where considerable human activity takes place. Highway 212, which travels over Beartooth Pass and serves as access to the northeast entrance of Yellowstone National Park, switchbacks through the center of the winter range and passes along the eastern edge of the summer range of the Rock Creek bighorns. This highway is generally open for travel between late May and mid-October. In addition, a Forest Service road in Rock Creek canyon serves several campgrounds and provides access to backcountry trails. Bighorns migrating to the Pilot-Index area must cross both of these roads.

By the time peak migration is occuring in mid-June, recreational travel on the roads has started in earnest. There is some evidence indicating that the roads at this time can be disturbing to bighorns. A ewe-lamb group was observed attempting to cross the Rock Creek Forest Service road on two consecutive afternoons, a period of the day when recreational activity in the canyon is high. The sheep in both instances dropped about 150 m (500 ft) to the canyon bottom and made their way rapidly to the creek, which runs near the road. In the first instance, the sheep just began to ford the creek when a vehicle approaching on the road disturbed them and the sheep hurridly reversed their course back to their original position on the canyon wall. In the second instance, the sheep reversed their course even though no disturbing factor could be discerned. Radio-collared animals provided more evidence for the disturbing influence of roads on migration. Monitored sheep spent up to 24 hours in the Clarks Fork forest just east of Highway 212 before crossing into the summer range. Most bighorns appeared to cross the highway under cover of darkness during hours when traffic was light.

Absaroka Summer Range

The Absaroka Mountain summer study area extended along the northeastern boundary of Yellowstone National Park from Hurricane Mesa in the Crandall Creek drainage of Wyoming to the Cutoff Mountain-Wolverine Peak area of Montana (Figure 1). Bighorn sheep summer range within this area consisted of two continuous blocks of habitat, separated by the forested Soda Butte Creek valley near the Montana/Wyoming state line. At least five bighorn sheep herds, each using distinct and widely separate winter ranges, occupied the summer study area. Population surveys indicated that approximately 375 bighorn sheep occupied the Montana and Wyoming ASR during this study. Bighorns were observed on the ASR for four to five months of the year, though highest densities occurred during July, August and September.

Summer distribution, movements and mixture of sheep from the seperate herds varied between the ram and ewe-juvenile population segments. Older rams appeared to move freely within the two continuous summer range habitats on the study area. Older rams from several different wintering herds intermixed within these two ram ranges. No rams were observed to move between the Montana and Wyoming Absaroka ram ranges. Whether this is a traditional barrier to summer movement, due to the deep forested Soda Butte valley, or a more recent development caused by the high summer level of human activity in the Cooke City - Silver Gate - Highway 212 area, is unknown.

Older rams from the Beartooth-Rock Creek herd summered in both ram ranges. Some migrated to the Pilot-Index Peaks area, then ranged widely over the entire Wyoming summer range. Others summered in the Montana range, either moving there after migrating to the Pilot-Index area, or more likely, following a different path from the East Rosebud portion of the known migration route.

Rock Creek rams shared the Wyoming summer range with rams from a herd which winters along Soda Butte Creek in Yellowstone National Park (Woolf et al. 1970, Oldemeyer et al. 1971) and one or more other herds which likely winter somewhere in the upper Clarks Fork drainage of Wyoming. Mixture of older rams from these separate herds probably occurred. Rock Creek rams shared the Montana summer range with ram groups from the Druid Peak herd of Yellowstone National Park (Woolf et al. 1970, Oldemeyer et al. 1971) and the Beartooth-West Rosebud bighorn herd (Stewart 1975). Summer mixture of rams from the different herds was known to occur.

The two large ram summer ranges overlapped six distinct, and more restricted, ewe-juvenile summer ranges (Figure 1). It is likely, but was not proven, that each of these summer range subunits was occupied by a separate ewe-juvenile herd. Two such ewe-juvenile ranges occurred in the Montana Absarokas: the Cutoff Mountain and Wolverine Peak subunits, which corresponded to the Yellowstone National Park-Druid Peak and Beartooth-West Rosebud herds. Four occurred in the Wyoming Absarokas: the Amphitheater Mountain, Pilot-Index Peaks, Jim Smith Peak, and Hurricane Mesa subunits, corresponding to the Yellowstone Park-Theater Mountain, Beartooth-Rock Creek and Wyoming Clarks Fork herds. Summer ewe or juvenile movement beyond these restricted ewe-juvenile ranges appeared to be rare. No mixing of ewes and juveniles from different herds was known to occur on the summer study area.

Rock Creek ewes and juveniles appeared to summer exclusively in the Pilot-Index Peaks subunit of the Wyoming Absaroka summer range. This summer range consisted of an approximately 34 sq km (13 sq mile) area bounded by Highway 212 on the east and north, Republic Creek on the west, and Pilot Creek on the south.

Rock Creek rams less than three years old followed ewes to the Pilot-Index ewe-juvenile summer range subunit, while those three years and older generally followed older rams to either the Montana or the Wyoming ram summer ranges. One young ram switched from using the Pilot-Index Peaks area as a two year old in 1978, to using the Wolverine Peak-Mineral Mountain area as a three year old in 1979. In 1979, he was with a five year old marked ram when last sighted on the winter range and when he was next located they were together on the older ram's traditional summer range. This supports the hypothesis that young rams develop their movement patterns by following older rams (Geist 1971).

The differing summer distribution patterns of rams and ewe-juveniles is reflected in the movement statistics computed for instrumented bighorn sheep (Table 4). Ewes generally showed very restricted summer movements. Average distance five marked ewes were relocated away from their centers of activity was only 0.93 km (0.58 mi), their pooled standard diameter was 2.09 km (1.30 mi), and their average polygon home range size was 2.0 sq km (0.77 sq mi). Brown (1974) and Klaver (1978) reported much higher standard diameter figures of 10.1 and 9.3 km (6.3 and 5.8 miles), repectively, for ewes on the summer range.

Due to mortality and collar loss or failure, relatively few relocations of rams on the summer range were obtained. The pooled standard diameter, average activity radius, and polygon home range size of the three rams relocated three or more times was 6.97 km (4.33 mi), 3.02 km (1.88 mi), and 8.8 sq km (3.40 sq mi), repectively. The oldest ram monitored, a four year old, had a summer standard diameter of 13.64 km (8.48 mi) and a polygon size of 15.8 sq km (6.10 sq mi). This pattern of movement was believed to be closer to the average for mature rams on the summer range. Farthest distance between points of relocation was 14.2 km (8.8 mi) for this ram on the summer range. Brown (1974) and Klaver (1978) found standard diameters of 8.1 and 9.7 km (5.0 and 6.0 miles), respectively, for rams on the summer range.

A two year old radio-collared ram, RW28, showed erratic movements late in the summer of 1979. On August 15 and 16 he was on the

Pilot-Index ewe-juvenile summer range associated with another two year old male and a small group of ewes, lambs, and yearlings. When next relocated on August 30 he was 18.6 km (11.5 miles) away, traveling with a two year old ram in the upper East Rosebud drainage. This was about three miles northwest of the nearest point on the migration route. On September 29 he was in the Mount Inabnit area of the East Rosebud portion of the migration route where he remained until he moved into the winter range on October 14. Erratic movement by young rams has also been reported by Geist (1971).

Autumn Migration

Departure dates from the summer range varied with weather conditions, specifically with the severity and length of autumn snowstorms. In 1977, light snowstorms occurred in the mountains from mid-September on and permanent snow began to accumulate by early October. Although 1977 observations are limited, it appears that most bighorns left the summer range in early to mid-October. In contrast, 1978 was a year when permanent snow did not occur in the mountains until the last week in October and it appears that many sheep remained on the summer range until early November. The fall of 1979 was intermediate in snowstorm occurrence, snow did not accumulate until mid-October. That year peak autumn migration occurred from mid to late October, when snow depths were 15 to 20 cm (6 to 8 in) on the summer range.

The effect of fall snowstorms on sheep movements is illustrated by the reaction of bighorns to two early storms in 1978. In mid-August of that year a snowstorm dropped about 5 cm (2 in) on the summer range and the snow stayed for about a day. Sheep on the east side of Pilot and Index Peaks dropped into subalpine forests during this period. In mid-September a week of intermittent snowstorms deposited over 18 cm (7 in) of snow on the summer range. Hunters reported seeing several ewes and juveniles moving off the summer range into the Clarks Fork portion of the migration route during this period. Shortly after this the storm subsided and unseasonably warm dry weather returned to the area. An aerial survey conducted on October 6 showed a relatively high fall count of bighorns on the summer range while no bighorns were reported at this time on the winter range. This suggests that the sheep which moved into the migration route reversed their migration and returned to the summer range once weather conditions moderated. Similar responses to fall storms were described by Smith (1954).

There is some evidence to suggest that younger rams left the summer range and arrived on the winter range earlier than ewes. In 1977, three year old ram B/Y04 was located on the winter range on September 14, about one month before significant numbers of ewes and juveniles began showing up. In 1978 this ram and two other younger rams arrived on the winter range by October 22, two weeks before ewes and juveniles were seen. In 1979, two year old ram R/W28 reached the winter range on October 14, again about two weeks before ewes and juveniles arrived.

Bighorn sheep used traditional routes of departure in leaving the Pilot-Index summer range. Local residents, hunters and Forest Service employees have reported seeing sheep leave the summer range by crossing Highway 212 at points just north of the Montana-Wyoming border and east of Ram Pasture Peak. Sheep trails crossing the highway were frequent in this area in late October of 1979. Individual groups of bighorns were observed to gather in the forested areas just west of and above the highway near the state line as they began their migration. Sheep waited above the highway at least a few hours before crossing. Traffic is light at this time of the year and there is ample opportunity to cross during quiet periods.

After crossing the highway the sheep moved into the Clarks Fork forest. Trails made in the snow by migrating sheep indicate that travel through the forest is single file and rapid but that sheep may spread out and graze on raised hilltops with less forest canopy. Bighorns took advantage of rocky ridges and hilltops as much as possible while traveling through the forest. Instrumented animals indicate that bighorns spend up to 24 hours in the forested Clarks Fork drainage before moving rapidly northeast toward the East Rosebud drainage.

No instrumented bighorns were followed through an entire fall migration, but locations obtained from several sheep indicate that the route of migration back to the winter range is the same as that traveled in the spring. The rate of travel was similar to that seen with early spring migrants. Two radioed bighorns are known to have required about 9 to 10 days to reach the winter range.

Population Characteristics

Beartooth-Rock Creek Herd Population Trends

Population Size and Composition: Winter range minimum population estimates of the Beartooth-Rock Creek bighorn sheep herd have been made periodically since 1971 (Appendix B, Table 27). These estimates were based on maximum air and ground unduplicated counts. Aerial surveys, using both helicopters and fixed wing aircraft, have generally provided the bulk of the population estimate. Such surveys are subject to variations in efficiency due to weather conditions and pilot-observer experience. Fluctuations in population estimates based entirely on winter range counts are likely more a reflection of survey effort and winter severity than of actual changes in population numbers.

Aerial surveys of the Pilot-Index segment of the Absaroka summer range were conducted between 1977 and 1980. Intensive ground based surveys were conducted in 1978 and 1979 and one was conducted on the area in 1980. Table 28, Appendix B, presents the aerial and ground based maximum unduplicated counts and ground survey estimates for the Pilot-Index subunit from 1977 to 1980.

Best estimates of the autumn pre-hunting season population of the Beartooth-Rock Creek herd for the years 1977 through 1980 were derived using counts from both the winter and summer ranges (Table 5). The female, lamb, and less than three year old male population estimate was obtained primarily from Pilot-Index summer range ground based surveys. The population estimate of rams older than three years was derived from the winter range maximum unduplicated count and hunter kill records.

The Beartooth-Rock Creek bighorn sheep population appears to have

Table 5. Autumn population estimates of the Beartooth-Rock Creek bighorn sheep herd, 1977-1980.(a)

Year	Rams		Ewes	Nonlamb Subtotal	Lambs	Total	Number/100 Ewes	
	3/4+	3/4-					Rams	Lambs
1977	4	16	46	66	29	95	43	63
1978	8	12(b)	49	69	16	85	41	33
1979	8	18	52	78	19	97	50	37
1980	6(c)	13	52(d)	71	28	99	37	54

a) The 1977 estimate was derived from 77-78 winter range maximum unduplicated counts, MDFWP records. The 1978-1980 estimates of the female, lamb, and less than 3 year old ram population segments were derived from summer range ground surveys, while the estimates for rams 3 years and older were derived from winter range maximum unduplicated counts and hunter kill records.

b) Excludes July 1978 young ram count.

c) Assumes no mortality after 1979 hunt.

d) Summer 1980 ewe counts were likely overestimates, assume no decrease from 1979 to 1980.

remained relatively stationary between the years 1977 and 1980. Total numbers and numbers of nonlambs fluctuated around levels near 95 and 72 individuals, respectively (Table 5). The low 1978 estimate of 85 sheep likely represents a real population drop caused by poor lamb survival through, and low lamb production following a winter of above average snowpack and heavy spring snowfall. Similar winter conditions in 1975 resulted in extremely poor lamb survival and a severe drop in the Beartooth-West Rosebud bighorn population (Stewart 1975).

Over the four year period the lamb population segment averaged 23 individuals, or 24 % of the total population. The nonlamb segment was made up of an average of 50 ewes and 22 rams, for a nonlamb ram:ewe ratio of 44:100. Assuming 12 of the 23 lambs were males, the average overall sex ratio was 56:100. An average of 7 legal 3/4 + horn curl rams were counted in the population each year between 1977 and 1980.

The ram population segment decreased from an estimate of 26 in 1979 to 19 in 1980. This decline reflects the known loss of six rams during the Rock Creek hunt in 1979 and also the fact that winter range counts were not available for the autumn of 1980. Ram numbers are best estimated only during the rutting season on the winter range. Complete coverage of sheep habitat is difficult during this period so the ram population numbers given in Table 5 are conservative estimates.

<u>Lamb Production and Survival</u>: Monthly lamb:ewe and yearling:ewe ratios based on multiple and maximum unduplicated counts made during ground and aerial surveys are presented in Appendix B, Tables 29 and 30. Air and ground based observations resulted in significantly different population ratios. Ground based ratios were based on numbers

of ewes two years or older, while those from the air were based on numbers of nonlamb ewes, which likely also included some yearling rams. Analysis by multiple observation and maximum unduplicated counts also resulted in different ratios depending on survey intensity. Therefore, ground based survey population ratios were more reliable, but adjusted aerial ratios were also used for periods when coverage or intensity of ground surveys was low. Except during periods when large maximum unduplicated counts were obtained, multiple observations seemed to yield the most reliable information.

Based on these considerations and monthly survey data, Beartooth-Rock Creek herd lamb production and lamb survival to age two were estimated for the years 1976 through 1980 (Table 6). Yearly fluctuations in lamb production and survival were likely related to winter severity. However, using local weather station data to derive an index to the severity of winter conditions on the bighorn range was hampered due to incomplete weather records and difficulty in relating late winter and spring station data to the much more severe conditions existing on the alpine winter range. Lamb production did seem to be inversely correlated with late May snowpack at Fisher Creek for the same year, but the data were insufficient to test this hypothesis. The relationship seemed weaker for lamb survival.

Using 50 nonlamb ewes as a baseline stationary population figure and assuming that almost half the yearlings in the population were females, the five year mean yearling:adult ewe ratio of 31:100 suggests an average of 13 yearlings occurred in the population. The mean lamb:adult ewe ratio of 54:100 would result in an average of 23 lambs

Table 6. Yearly lamb production and survival for the Beartooth-Rock Creek bighorn sheep herd, estimated from monthly ground and aerial multiple observations and maximum unduplicated counts, 1976-1980.(a)

Year	Lamb:Ad.Ewe Summer	Lamb Survival	Yrl:Ad.Ewe Summer	Yrl Survival	Yrl/Ad.Ewe Spring
1976	71:100		10:100		----
		63 %		100 %	
1977	65:100		45:100		10:100
		57 %		96 %	
1978	35:100		37:100		43:100
		89 %		81 %	
1979	43:100		31:100		30:100
		72 %		--	
1980	55:100		31:100		----
Mean	54:100	57 %	31:100	90 %	28:100

a) 1976 and 1977 data from MDFWP records.

being produced yearly, the same number obtained by averaging lamb counts from direct population estimates between 1977 and 1980. A mean population estimate of 13 yearlings and 23 lambs strengthens the conclusion that average lamb survival to yearling age was near 57 % during this study.

Using a lamb survival rate of 57 %, a yearling survival rate of 90 % (Table 6), and assuming lamb and yearling sex ratios only slightly skewed to males, the nonlamb female population contained an average of 38 ewes three years or older. This suggests that about 61 % (23/38) of the potentially productive ewes bear viable lambs each spring. In other words, under normal conditions most mature ewes in the Beartooth-Rock Creek herd produce young only every other year.

Bighorns of the Jim Smith Wyoming Subunit

Aerial and ground based unduplicated counts and classifications of the bighorns summering in the Jim Smith subunit of the Wyoming Absaroka summer range are presented in Table 7. Ground and aerial survey multiple observation data are presented in Appendix B, Tables 31 and 32. Intensive air and ground surveys were conducted on the Jim Smith area only in 1978 and 1979.

Ground survey population estimates for the Jim Smith subunit were very similar in 1978 and 1979. However, because ewe-juvenile use areas east of the head of Tough Creek (Figure 1) were not adequately sampled on foot in 1978 the ewe-juvenile population of this subunit was underestimated that year. A more realistic picture of the 1978 population was obtained by combining the ground survey estimate of 43 rams with the aerial maximum count of 54 nonlamb females and 31 lambs for a total estimate of 128 bighorns. Survey intensity in 1980 was too low to provide a reliable population estimate.

Sex composition on the Jim Smith range varied markedly between 1978 and 1979. The corrected 1978 ram:ewe ratio was 80:100 compared to 39:100 in 1979. Older rams were frequently sighted west of Tough Creek in 1978, but were seldom seen in that area in 1979. The drop in sheep numbers between 1978 and 1979 was due either to a real drop in older ram use of the subunit or to a decrease in ram observability on the subunit.

During the July 1980 summer range foot survey rams were again prevalent on the west end of the Jim Smith subunit. However, because the ewe-juvenile use area on the east end of the subunit was not

Table 7. Unduplicated counts and classifications of bighorn sheep on the Jim Smith subunit of the Wyoming Absaroka summer range, 1977-1980.

Year	Method(a)	Rams (Horn Curl)(b)				Yearling Females	Ewes(c)	Lambs	Uncl	Total	Number/100 Ewes		
		3/4	1/2-3/4	1/4-1/2	0-1/4						Rams	Yrlg.	Lambs
1977	AMUC	0	-	5	-	-	20	14	0	39	25	-	70
1978	AMUC	12	-	10	-	-	54	31	0	107	41	-	57
	GMUC	21	13	5	8	2	24	19	0	92	181	42	79
	GSPE	19	11	5	8	2	26	21	25	117	154	38	81
1979	AMUC	5	-	7	-	-	40	20	0	72	30	-	50
	GMUC	10	2	5	6	5	56	31	0	115	39	20	55
	GSPE	10	2	5	6	5	56	31	0	115	39	20	55
1980	AMUC	3	-	2	-	-	41	14	0	60	12	-	34
	GMUC	5	7	4	1	0	14	10	3	44	121	7	71
	GSPE	5	7	4	1	0	14	10	3	44	121	7	71

a) AMUC = Aerial maximum unduplicated counts. Rams classified as those greater and those less than 3/4 horn curl, female yearlings classified with female adults. 1977 data from MDFWP records.
GMUC = Ground maximum unduplicated counts.
GSPE = Ground survey population estimate.

b) Rams less than 1/4 curl were yearlings, rams greater than 1/2 curl were generally three years or older.

c) In analyzing ground observations, adult females were counted in two catagories, those with and those without lambs.

adequately covered, the calculated ram:ewe ratio of 121:100 is not an accurate reflection of sex composition. Combining the conservative ground survey estimate of 17 rams with the aerial maximum count of 41 females results in a ram:ewe ratio of 41:100 for 1980.

Lamb production of Jim Smith ewes appeared to be very high during the study (Table 7). However, the 1978 and 1980 surveys oversampled a traditional ewe-juvenile use area at the head of Tough Creek, where large and highly visible ewe-lamb groups often occur. Thus the ewe:lamb ratio calculated for those years is skewed upward. Aerial maximum unduplicated count ratios provide a check on ground counts. Trends in aerial lamb:ewe ratios suggest a high lamb crop in 1978, followed by progressively lower production in 1979 and 1980. The 1979 ground survey estimated yearling:ewe ratio indicates low survival of the excellent lamb crop of 1978. Little is known about the location or condition of the Jim Smith ewe-juvenile herd's wintering area.

Bighorns of the Hurricane Mesa Wyoming Subunit

Aerial unduplicated counts and classifications on the Hurricane Mesa summer range for the years 1977 through 1980 are presented in Table 8. No ground based surveys were conducted on this subunit.

A maximum of 47 bighorns were counted on the Hurricane Mesa range in 1979. This subunit supports a small ewe-juvenile population. Aerial counts of females have increased steadily since 1977, while lamb:ewe ratios have fluctuated. As with the Jim Smith ewe-juvenile herd, little is known about this group's wintering area.

Ram use of the Hurricane Mesa subunit appears to fluctuate. At least 17 rams used the area in 1979, 12 of which were legal rams over

Table 8. Aerial maximum unduplicated counts and classifications on the Hurricane Mesa summer range, 1977 - 1980.(a)

Year	Rams		Females	Lambs	Total	Number/100 Ewes	
	3/4+	3/4-				Rams	Lambs
1977	4	5	0	0	9	—	—
1978	7	6	13	7	33	100	54
1979	12	5	18	12	47	94	67
1980	0	0	19	4	23	0	21

a) 1977 data from MDFWP records.

3/4 horn curl. Aerial counts of rams in 1977, 1978, and 1980 were 9, 13 and 0, respectively (Table 8).

Combined Wyoming Absaroka Summer Range

Table 9 presents maximum counts and classifications from observations on the entire Wyoming Absaroka Mountain summer range. Tables 31 and 32, Appendix B, provide a check on the relative intensity of ground and aerial surveys on the individual subunits.

Aerial maximum unduplicated counts indicate that at least 213 and 259 bighorn sheep occupied the entire Wyoming range in 1978 and 1979, respectively. However, ground surveys estimated at least 222 bighorns in 1978 and 208 in 1979 for the Pilot-Index and Jim Smith subunits alone. A population estimate of 300 bighorn sheep for the entire Wyoming summer range during the study period would probably be conservative.

An accurate estimate of sex composition for the entire Wyoming

Table 9. Unduplicated counts and classifications of bighorn sheep on all areas of the Wyoming Absaroka Mountains summer range, 1977-1980.(a)

Year	Method(b)	Rams (Horn Curl)(c)				Yearling Females	Ewes(d)	Lambs	Uncl	Total	Number/100 Ewes		
		3/4	1/2-3/4	1/4-1/2	0-1/4						Rams	Yrlg.	Lambs
1977	AMUC	4	-	20	-	-	80	51	0	155	30	-	64
1978	AMUC	14	-	26	-	-	124	49	0	213	32	-	40
	GMUC	21	13	13	20	10	63	36	0	176	92	48	57
	GSPE	19	14	18	22	11	66	37	35	222	95	50	56
1979	AMUC	19	-	29	-	-	146	63	2	259	33	-	43
	GMUC	8	7	11	14	9	91	43	0	183	41	25	47
	GSPE	13	6	12	14	9	104	50	0	208	41	22	48
1980	AMUC	4	3(e)	3	-	-	91	29	4	134	11	-	32
	GMUC	5	9	7	6	2	54	31	3	117	48	15	57
	GSPE	5	9	8	8	3	68	38	7	146	42	16	56

a) Includes Pilot-Index, Jim Smith, Hurricane Mesa, and Amphitheater-Yellowstone National Park subunits plus bighorn sheep range connecting the subunits. Ewes and juveniles were assumed to be restricted within their subunit, rams 3 years and older were assumed to potentially travel without restriction over the entire Wyoming summer range.

b) AMUC = Aerial maximum unduplicated counts. Rams classified as those greater and those less than 3/4 horn curl, female yearlings classified with female adults. 1977 data from MDFWP records.
GMUC = Ground maximum unduplicated counts, Pilot-Index and Jim Smith subunits only.
GSPE = Ground survey population estimate, Pilot-Index and Jim Smith subunits only.

c) Rams less than 1/4 curl were yearlings, rams greater than 1/2 curl were generally three years or older.

d) In analyzing ground observations, adult females were counted in two catagories, those with and those without lambs.

e) Unclassified rams.

range is difficult to obtain because numbers of older rams tended to be underestimated for three reasons. First, their wide ranging movements required that survey estimates of their numbers be made only for the entire Wyoming range and not for each subunit as with ewes and juveniles. Second, older rams were less observable than ewes during late summer and autumn, apparently because of differences in habitat selection. Third, the Hurricane Mesa and Amphitheater Mountain subunits were not surveyed on foot leading to a reliance on aerial counts of older rams in these areas. Aerial counts were more subject to observability biases than ground counts.

Ground surveys estimated the ram population of the Pilot-Index and Jim Smith area alone at 73, 45, and 30 in 1978, 1979, and 1980, respectively (Table 9). The estimate of legal 3/4+ curl rams was 19, 13, and 5 during these three years, respectively. Aerial survey counts for the entire Wyoming range in 1978, 1979, and 1980 were 14, 19, and 4 legal rams, respectively. Legal rams were most commonly observed in the Jim Smith and Hurricane Mesa subunits of the Wyoming range.

Bighorns of the Wolverine Peak Montana Subunit

Unduplicated counts and classifications made on the Wolverine Peak subunit of the Montana Absaroka summer range are presented in Table 10. Aerial and ground based multiple observations data are presented in Appendix B, Tables 31 and 32, respectively.

Aerial surveys in 1978 resulted in the highest unduplicated count of 41 bighorn sheep on the area, 20 of which were ewes. Aerial counts in 1977 found more females but fewer rams, while aerial counts in 1979 found lower numbers of all classes of sheep. The highest ground count

Table 10. Unduplicated counts and classifications of bighorn sheep on the Wolverine Peak subunit of the Montana Absaroka summer range, 1977-1980.

Year	Method(a)	Rams (Horn Curl)(b) 3/4	1/2-3/4	1/4-1/2	0-1/4	Yearling Females	Ewes(c)	Lambs	Total	Number/100 Ewes Rams	Yrlg.	Lambs
1977	AMUC	1	-	2	-	-	22	11	36	14	-	50
1978	AMUC	2	-	13	-	-	20	6	41	75	-	30
	GMUC	1	0	4	2	1	8	3	19	78	38	38
1979	AMUC	0	-	3	-	-	13	5	21	23	-	38
	GMUC	1	3	3	4	0	13	8	32	85	31	62

a) AMUC = Aerial maximum unduplicated counts. Rams classified as those greater and those less than 3/4 horn curl, female yearlings classified with female adults. 1977 data from MDFWP records.
GMUC = Ground maximum unduplicated counts.

b) Rams less than 1/4 curl were yearlings, rams greater than 1/2 curl were generally three years or older.

c) In analyzing ground observations, adult females were counted in two cohorts, those with and those without lambs.

of 32 bighorns was obtained in 1979, due primarily to a more intensive foot survey effort on the area in that year.

Absaroka Summer Range Summary

The Absaroka summer range study area supported an estimated population of 375 bighorn sheep during the study period. At least 300 bighorns occupied the Wyoming portion, roughly distributed among the subunits as follows: Amphitheater Mountain (YNP) - 40, Pilot-Index - 100, Jim Smith - 120, and Hurricane Mesa - 40. The Montana portion likely supported near 75 sheep between the Cutoff Mountain and Wolverine Peak subunits.

Group Characteristics

Group Composition

Bighorn sheep groups were classified into eight types based on sex and age composition. A summary of monthly bighorn sheep group composition, based on ground based surveys of both the winter and summer ranges in 1978 and 1979, is presented in Table 11, along with an explanation of the make up of the group types. These data, when supplemented by aerial observations for periods when ground effort was minimal, illustrate seasonal bighorn group composition changes.

During the spring season on the winter range the ewe group type peaked in frequency, while the ewes-lamb type declined. This was due to the increased tendency for ewes and lambs to separate prior to the lambing season and the change in classification of older lambs to yearlings during and after the lambing season, resulting in an increase in ewe-juvenile group observations. Single ewes with lambs were

Table 11. Monthly bighorn sheep group composition from ground based observations on the winter and summer ranges, 1978-1979.

Month	No. Grps.	Group Type (a) (percent groups observed) Ewe	Ewe Lmb	Ews Lmb	Ewe Juv	Ewe Ram	Yng Ram	Old Ram	Uncl
May	10	30	--	20	--	--	10	--	40
Jun	73	14	16	19	29	--	14	--	8
Jul	104	9	2	16	26	--	14	10	23
Aug	77	10	1	22	22	--	12	4	29
Sep	42	7	12	19	36	--	7	2	17
Oct	6	17	--	--	33	--	--	--	50
Nov	30	3	3	13	50	10	3	10	7
Dec	23	17	--	9	39	17	13	--	4
Year	365	11	6	18	29	2	12	5	19

a) Group Types: Ewe = Female nonlambs only; Ewe-Lmb = Single ewe & lamb; Ewes-Lmb = Ewes with lamb(s); Ewe-juv = Ewe(s) and lamb(s) with yearling to 3/4 horn curl ram(s); Ewe-Ram = Ewe(s) and juvenile(s) with 3/4 or greater horn curl rams; Yng Ram = Ram(s) with less than 3/4 horn curl; Old Ram = Ram(s) with 3/4 or more horn curl; Uncl = Groups with one or more unclassified bighorn.

frequently observed during June on lambing areas. Young and old ram groups each made up less than 10 % of the group type observations. No ewe-ram groups were observed from the ground during spring, but a small percentage were recorded in aerial surveys.

On the summer range ewe-juvenile and ewes-lamb groups made up at least 40 % of the group types observed. Ewe groups were still common and ewe-lamb groups rare, except in September. Young and old ram groups were most frequently observed in July and then declined in frequency somewhat throughout the rest of the summer.

When bighorns returned to the winter range in the autumn the frequency of ewe and ewes-lamb groups declined, while that of young ram, old ram, mixed ewe-ram, and ewe-juvenile groups increased. Rams of all ages frequently joined and traveled between ewe groups as rutting season approached and progressed.

Aerial data suggest that during mid-winter the frequency of young and old ram groups, and mixed ewe-ram groups, declined from a high in January to lows following the rut. Ewe-juvenile and ewe groups increased in frequency slightly, while the percentage of ewes-lamb groups grew to a yearly high.

Group Size

Monthly fluctuations in bighorn sheep group size are presented in Table 12. The average group size calculated from ground based observations between June 1978 and December 1979 was slightly less than that calculated from aerial observations made between January 1977 and May 1980.

Two peaks in bighorn group size occur during the year, one in

Table 12. Mean monthly bighorn sheep group size based on ground (1978-79) and aerial (1977-80) observations on the Beartooth winter range and Absaroka summer ranges.

Month	Ground						Air					
	All Ranges		Pilot-Index		Jim Smith		All Ranges		Pilot-Index		Jim Smith	
	n	Mean(a)	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
Jan	---	---	---	---	---	---	12	5.8	---	---	---	---
Feb	---	---	---	---	---	---	13	9.0	---	---	---	---
Mar	---	---	---	---	---	---	17	7.4	---	---	---	---
Apr	---	---	---	---	---	---	14	5.9	---	---	---	---
May	10	6.0	---	---	---	---	23	5.3	---	---	---	---
Jun	73	4.1	1	6.0	---	---	72	5.9	16	6.1	17	7.0
Jul	104	7.8	62	7.4	23	11.8	71	8.8	26	9.0	19	11.2
Aug	77	8.7	56	6.6	17	16.2	58	8.3	30	6.4	14	12.6
Sep	42	7.1	35	6.9	5	7.2	11	9.5	7	8.6	3	11.7
Oct	6	5.2	4	4.5	---	---	10	7.5	5	6.2	5	8.8
Nov	30	4.8	---	---	---	---	1	4.0	1	4.0	---	---
Dec	23	3.7	---	---	---	---	---	---	---	---	---	---
Year	365	6.6	158	6.9	45	12.9	302	7.5	85	7.7	58	10.1

N = Number of bighorn groups observed. Mean = Mean group size.

midwinter and one in midsummer. Group size tends to be lowest in midspring and late autumn. These fluctuations can be related to habitat use patterns. Groups averaged the largest when sheep were primarily using open alpine areas, plateau tops on the winter range and open ridgesides on the summer range. Use of open alpine areas require sheep to stray farther from escape terrain. Oldemeyer et al. (1971) and Stewart (1975) reported that as habitat security levels decreased, bighorn group size tended to increase.

In addition, the increase in group size noted in the summer could be partially explained by the high forage quality on open alpine turf slopes in July. This would allow larger aggregations of bighorns on a given area. During August forage quality declines on alpine slopes and sheep tend to use lower elevation scree areas where security levels are higher and forage is more dispersed, resulting in smaller group sizes. The continued overall increase in group size noted in August was due entirely to data from the Jim Smith subunit. Large aggregations of ewes and juveniles were common on this subunit until late summer, especially at the head of Tough Creek. Pilot-Index group size decreased from July to August.

Group size averaged much larger on the Jim Smith subunit than other summer range areas, based on both aerial and ground observations (Table 12). This difference was especially prominent in August when Jim Smith mean group size was more than twice that of the Pilot-Index subunit.

Aerial data shows an increase in September mean group size (Table 12). This is partly due to a low sample size and partly because of a shift in bighorn habitat use to areas where aerial observability decreases, resulting in the tendency to record only the larger groups in more visible open areas.

Lowest mean group size was observed in November and December on the winter range. At this time sheep ranged widely over the winter range in small groups. High security, low forage density canyon wall habitats received heavy use contributing to low group sizes.

The spring low in mean group size corresponds to the period when bighorns drop down onto canyon walls to search for early greenup among the rock outcrops. In this type of habitat security is relatively high while forage density is relatively low, resulting in lower group sizes.

The broad majority of all bighorn groups observed were in the 2 to 10 size range (71 %). This held true for all areas and seasons. Single sheep made up 13 % of all bighorn observed on all areas. On the Rock Creek and Pilot-Index ranges single sheep made up 19 and 12 %, respectively of the groups observed. No lone bighorns were sighted on the Jim Smith range during ground based surveys. Ewes and two year old males were the most likely classes of sheep to be observed alone, 40 and 33 % of all lone bighorns were of these two classes, respectively.

Bighorn sheep groups made up of more than 30 individuals comprised 2 % of all groups sighted during the entire study. No such groups were observed on the Rock Creek area during the spring or autumn seasons. During the summer 1 % of groups consisted of more than 30 individuals on the Pilot-Index range, while these groups made up 11 % of the groups observed on the Jim Smith Range. The largest group recorded, 41 individuals, was observed on this latter area during July of 1979.

Physical Habitat Use

Distance To Escape Terrain

Beartooth-Rock Creek Winter Range: Bighorn sheep exhibited a strong affinity for escape terrain during both the late spring and autumn study periods on the winter range (Table 13). This tendency was especially pronounced during late spring 1978, when 41 % of the bighorns observed were in or within 5 m of escape terrain and only one individual was observed at a distance greater than 100 m. This affinity was somewhat less pronounced during the spring of 1979, when 32 % of observations were within 5 m and 23 % were at distances greater than 50 m from escape terrain. Most sheep observed during both spring seasons were between 6 and 25 m from such terrain.

In autumn, observed use of sites in or very near escape terrain was less than during spring, while use of sites 6 to 50 m from such terrain was much greater. Ten percent of use occurred on sites over 100 m from escape terrain, but this was not particularly related to increased use of plateaus as most plateau use was within 50 m of steep broken canyon walls.

Pilot-Index Summer Range Subunit: The strong affinity of bighorns for escape terrain decreased markedly during early summer on the Pilot-Index subunit, then increased again as the summer progressed (Table 13). In July of 1978, most sheep were observed at distances greater than 50 m from such terrain, only 35 % were within 25 m. However, by August 62 % were observed within 25 m and only 16 % at distances greater than 50 m. Survey effort in September of 1978 was low, but it appears that there was less association with escape terrain

Table 13. Monthly and seasonal bighorn sheep association with escape terrain based on ground survey observations on the Rock Creek winter and Absaroka summer ranges, 1978-1979.

Area and Time Period		Percent Observations in Distance Class(a) IN	VN	NR	MD	FR	VF	Sample Size
RCWR								
1978	June-July	24	17	46	12	—	1	168
1979	May-July	24	8	35	10	17	6	233
	Nov.-Dec.	14	3	56	12	4	10	231
Pilot-Index Subunit ASR								
1978	July	6	9	20	11	30	25	257
	August	11	7	44	22	10	6	221
	September	—	—	43	8	38	13	40
1979	July	12	13	31	5	26	12	189
	August	27	3	27	28	14	—	150
	September	8	8	66	9	8	3	200
	October	33	—	67	—	—	—	18
Jim Smith Subunit ASR								
1978	July	—	—	1	5	38	55	148
	August	—	—	47	—	—	53	62
1979	July	24	—	29	9	17	22	121
	August	9	17	8	4	—	63	213
	September	11	—	89	—	—	—	36
Wolverine Peak Subunit ASR								
1978	August	11	20	20	37	—	11	27
1979	July	31	15	54	—	—	—	13
	September	—	—	—	8	—	92	24
	October	100	—	—	—	—	—	7

a) Distance Classes (m): IN (0-1), VN=Very Near (2-5), NR=Near (6-25), MD=Moderate (26-50), FR=Far (51-100), VF=Very Far (>100).

than in August. Almost half of the observed bighorns were at distances greater than 50 m from such terrain during this month.

In 1979 there was less use of sites greater than 50 m from escape terrain. In July 38 % were at these distances, but 25 % of use was within 5 m of escape terrain. August use showed a shift from sites over 50 m from escape terrain to those within 25 to 50 m and increased use of escape terrain itself. September observations found 82 % of bighorns on sites less than 25 m from escape terrain. October observations were few but indicate that this high affinity for escape terrain continued until autumn migration.

Jim Smith Summer Range Subunit: Affinity of bighorns for escape terrain was much less pronounced on the Jim Smith subunit than on the Pilot-Index area, especially in 1978 (Table 13). During July and August of that year 55 and 53 %, respectively, of the sheep observed were at distances greater than 100 m from such terrain. Only 1 % of July observations were within 25 m of escape terrain. In 1978 no sheep on this subunit were observed in or within 5 m of escape terrain prior to being disturbed by the observer.

In 1979 a greater affinity for escape terrain was noted on the Jim Smith area. In July most sheep were observed within 25 m of such terrain, while 39 % were at distances greater than 50 m. August observations in contrast showed 63 % of use on sites more than 100 m from escape terrain. September 1979 observations are few but appear to indicate a sharp shift to use of sites near escape terrain.

Wolverine Peak Summer Range Subunit: Ground based surveys of the Wolverine Peak subunit were infrequent so generalizations are difficult. In 1978, most sheep were observed within 25 m and few were at distances over 100 m from escape terrain, while in 1979, half were observed at distances over 100 m (Table 13).

<u>Slope</u>

<u>Beartooth-Rock Creek Winter Range</u>: A slight decrease was observed in the mean degree of slope used by bighorns on the Rock Creek range in late spring between 1978 and 1979 (Table 14). This reflects a higher use of very steep slopes and cliffs (46-90 degrees) in 1978. Observed use was restricted to slopes of less than 45 degrees in 1979. Most use during both years was on slopes designated as steep (26-45 degrees). The general slope of canyon wall use areas were within the upper part of this range. Very little observed spring use was on slopes of 10 degrees or less.

The mean slope used in the autumn of 1979 was much less than the spring mean due primarily to heavy use of moderate, gentle, and horizontal slopes of less than 25 degrees on plateau tops and edges in November. In December, when plateaus were undersurveyed, bigorns were generally observed on steep canyon wall slopes.

<u>Pilot-Index Summer Range Subunit</u>: The mean slope at which bighorns were observed on the Pilot-Index range did not vary much over the summer and averaged 25 degrees both years of the study (Table 14). The observed decrease in mean slope compared to the winter range reflects the gentler nature of slopes on the summer range. Moderate and steep slopes were most used both years. Somewhat greater use of gentle and horizontal sites was observed in 1978. This was related to more sheep being observed on ridgetops during that summer.

Table 14. Monthly and seasonal bighorn sheep use of slope and aspect based on ground survey observations on the Rock Creek winter and Absaroka summer ranges, 1978-1979.

Area and Time Period		Percent in Slope Class(a) HZ	GN	MD	ST	VS	CL	Mean Slope(b)	Percent in Aspect Class N	NW	W	SW	S	SE	E	NE	Sample Size
RCWR																	
1978	June-July	7	4	5	64	10	10	42	38	29	24	2	3	—	—	3	168
1979	May-July	6	—	8	87	—	—	35	41	26	29	3	1	—	—	—	233
	Nov.-Dec.	12	15	26	39	9	—	24	2	16	30	6	16	28	—	2	231
Pilot-Index Subunit ASR																	
1978	July	1	13	39	44	2	2	27	3	2	45	18	20	9	3	—	257
	August	5	19	47	27	2	—	27	2	5	29	2	37	1	15	9	221
	September	—	75	18	8	—	—	11	—	—	—	—	68	20	13	—	40
1979	July	—	3	61	37	—	—	24	9	6	21	22	29	7	5	2	189
	August	—	4	47	47	2	—	26	—	—	3	2	19	38	35	3	150
	September	—	5	43	50	4	—	26	4	—	11	23	24	9	30	—	200
	October	—	28	67	6	—	—	18	—	—	—	—	28	6	67	—	18
Jim Smith Subunit ASR																	
1978	July	8	7	18	67	—	—	25	5	—	41	49	—	—	—	5	148
	August	—	—	10	90	—	—	30	10	11	—	79	—	—	—	—	62
1979	July	—	—	13	87	—	—	29	—	—	14	64	11	12	—	—	121
	August	—	16	45	35	4	—	24	4	11	—	46	16	21	—	3	213
	September	—	31	—	69	—	—	23	—	33	—	—	25	31	11	—	36
Wolverine Peak Subunit ASR																	
1978	August	—	30	59	11	—	—	15	11	—	41	—	—	19	30	—	27
1979	July	—	—	27	73	—	—	35	—	—	58	27	—	—	15	—	13
	September	—	92	8	—	—	—	6	—	—	—	—	—	—	92	8	24
	October	—	—	—	100	—	—	40	—	—	100	—	—	—	—	—	7

a) Slope Classes (degrees): HZ=Horizontal (0-3), GN=Gentle (4-10), MD=Moderate (11-25), ST=Steep (26-45), VS=Very Steep (46-65), CL=Cliff (66-90).
b) Mean Slope in degrees.

Jim Smith Summer Range Subunit: The mean slope used by bighorns on the Jim Smith range was similar to that of the Pilot-Index area (Table 14). Again steep and moderate slopes were the major categories used. The 1978 decrease in use of gentle and horizontal slopes between July and August was due to less observed use of ridgetops. In 1979 use of gentle slopes increased over the summer due to increased use of basin bottom sites.

Wolverine Peak Summer Range Subunit: Mean slope used by bighorns on the Wolverine Peak area varied erratically due to low monthly and seasonal sample sizes. In 1978, 89 % of use was on moderate and gentle slopes. In 1979 most use was on gentle and steep slopes (Table 14).

Exposure

Beartooth-Rock Creek Winter Range: During late spring on the winter range bighorns were observed almost exclusively on north, northwest, and west exposures (Table 14). This reflected heavy use of canyon wall slopes on the southeast side of Rock Creek. May 1979 data show high use of west exposures, which had less snow than north exposures. Only one young ram group was observed from the ground on southerly exposures northwest of the creek in late spring. Aerial data show use of southerly and westerly exposures during the early spring period when sheep were more dispersed throughout the winter range.

In the autumn bighorns were much less restricted in their choice of exposures (Table 14). This reflected use of both sides of the canyon during this season. West and south slopes were used most in November, while southeast and west slopes were most used in December. Compared to late spring, north and northwest exposures were used much less in the autumn.

Pilot-Index Summer Range Subunit: On the Pilot-Index subunit use of exposures varied during and between the summers of 1978 and 1979 (Table 14). In 1978 west exposures were most important in July and along with south and southwest slopes made up 83 % of observed use. In August the primary exposure used was south, use of west slopes decreased and use of east exposures increased. Eighty one percent of the sheep observed in August of that year were seen on those three exposures. September sample size was low, but use of southern and easterly exposures remained important.

In July 1979, south, southwest, and west exposures were used most with 72 % of observations. In August use shifted dramatically to southeast and east exposures with 73 % of observations. Heavy use of east exposures continued in September and use on south and southwest exposures picked up again, these three containing 77 % of the observations. Use of southeast exposures showed a sharp decline. Northerly exposures were little used at any time during the summer. High elevation north exposures on the summer range generally consisted of steep broken cliffs, outcrops, scree, and snowfields of use only as escape terrain.

Jim Smith Summer Range Subunit: The southwest aspect received most observed bighorn use on the Jim Smith area during all periods of the summer (Table 14). This is primarily due to the northwest - southeast tending ridgelines in the vicinity of Tough Creek, where large highly visible sheep groups were frequently observed. High use of west exposures in July of 1978 reflects ram use of ridges west of Tough

Creek. This was not observed in 1979. Southeast slopes were important late in the summer of 1979. East and northerly slopes were generally of little importance on this subunit.

Wolverine Peak Summer Range Subunit: East, west, and southwest exposures were used most by sheep in this area. Little use was observed on northerly or south slopes (Table 14).

Elevation

Beartooth-Rock Creek Winter Range: During June and July of 1978 most bighorns were observed in the upper timberline elevational zone, while from May through July of 1979 they were spread more evenly through the timberline and upper subalpine zones (Table 15). Relatively little late spring use was observed in the alpine or lower subalpine zones during either year.

During both years almost 90 % of late spring observations occurred on the canyon sides. Use of the canyon bottom was only observed when a group of sheep was attempting to cross the canyon on a migratory movement. Use of plateaus was restricted to edges overlooking the canyon below, no sheep were observed more than 25 m from the steep canyon walls.

The mean elevation of bighorns on the RCWR during autumn was somewhat lower than that observed in late spring. Heaviest use was in the alpine and upper subalpine elevational zones. This reflects use which was concentrated either on the plateau tops or middle and lower canyon sides. Bighorns on plateaus were observed over 100 m (328 ft) from the canyon walls during this period. Canyon bottoms were little used for anything other than a means to cross from one side to another.

Table 15. Monthly and seasonal elevational distribution of bighorn sheep based on ground survey observations on the Rock Creek winter and Absaroka summer ranges, 1978-1979.

Area and Time Period		Percent in Elevation Zone (a) AL	UT	LT	US	LS	Elevation Mean (m)	Range (m)	Sample Size
RCWR									
1978	June-July	4	52	20	23	1	2888	2646 - 3048	168
1979	May-July	10	27	32	24	7	2846	2524 - 3085	233
	Nov.-Dec.	36	9	7	35	13	2822	2402 - 3232	231
Pilot-Index Subunit ASR									
1978	July	84	13	2	1	—	3139	2683 - 3268	257
	August	85	12	3	tr(b)	—	3131	2756 - 3280	221
	September	40	43	18	—	—	3017	2805 - 3207	40
1979	July	82	11	4	3	—	3116	2683 - 3366	189
	August	42	25	5	29	—	2940	2634 - 3232	150
	September	58	14	15	14	—	2979	2646 - 3158	200
	October	—	—	33	39	28	2664	2439 - 2951	18
Jim Smith Subunit ASR									
1978	July	89	11	—	—	—	3098	2927 - 3280	148
	August	42	58	—	—	—	3051	2927 - 3146	62
1979	July	83	12	5	—	—	3070	2890 - 3232	121
	August	75	23	—	2	—	3045	2780 - 3171	213
	September	8	56	11	25	—	2895	2683 - 3171	36
Wolverine Peak Subunit ASR									
1978	August	63	—	37	—	—	3004	2866 - 3122	27
1979	July	100	—	—	—	—	3103	3064 - 3125	13
	September	8	92	—	—	—	2944	2927 - 3140	24
	October	—	100	—	—	—	2981	2982	7

a) Elevation Zones (m): AL=Alpine (> 3020), UT=Upper Timberline (2930-3019), LT=Lower Timberline (2800-2929), US=Upper Subalpine (2560-2799), LS=Lower Subalpine (2260-2559).
b) Tr=Less than 0.5 %.

Winter ground data collected by Shawn Stewart (MDFWP) between 1976 and 1979 shows 94 % of the groups observed were in the alpine and upper timberline zones. Eighty five percent of the groups were on plateau tops or edges, only 13 % were on canyon walls. Aerial data collected during these winters shows a mean elevation for bighorn groups at 3035 m (9958 ft) and a range between 2896 m and 3322 m (9500 and 10900 ft). Heavy use of alpine zone plateau tops generally decreased rapidly during the month of April.

Pilot-Index Summer Range Subunit: During the summer, elevational distribution of bighorns on the Pilot-Index subunit shifted downward from almost exclusive use of the alpine zone to increased use of the timberline and upper subalpine zones (Table 15). The timing of this shift varied between the summers of 1978 and 1979. In 1978, elevational use during July and August was quite similar, with both monthly means being near 3139 m (10300 ft) and use restricted primarily to the alpine zone. Although the September sample size was low in 1978, a distinct shift from alpine to timberline zones was indicated. This shift actually began in mid-August of 1978. In 1979 it was observed two to three weeks earlier. The August 1979 mean elevation was 176 m (577 ft) lower than the July mean. Use of the alpine zone declined while use of timberline and upper subalpine zones increased sharply. In September 1979, bighorns showed a slight drift back up to higher elevations. The October sample size is small and represents elevation selection during the last half of the month after snow began to accumulate on the summer range.

Use of mountainside and ridgeside slopes steadily decreased throughout the summer while use of ridgetops and basin floors generally increased. Much of the increase in use of ridgetops was in the timberline and subalpine zones. Practically all the increased use of basins was in the broken dirt-scree type at the headwaters of many south and east flowing drainages.

Early summer Beartooth-Rock Creek herd elevational use was comparable to that of the winter with heavy use of the alpine zone. Late summer use was somewhat comparable to autumn and perhaps early spring on the winter range except that there was less of a tendency to use subalpine sites. Summer range subalpine areas were generally heavily forested while burns have opened up much of this zone on the winter range.

Jim Smith Summer Range Subunit: A similar trend of decreasing use of the alpine zone over the summer was observed on the Jim Smith summer range subunit (Table 15). However, the shift did not appear to be as pronounced as on the Pilot-Index area. July and August elevational means for both 1978 and 1979 were near or above 3048 m (10000 ft). Although sample size in September of 1979 was only 36 individuals, it appears there was a distinct shift away from alpine to timberline and upper subalpine areas during this month.

Use of mountain and ridgeside slopes did not decrease over the summer of 1978 on the Jim Smith subunit, however use of broken basin floors did show an increase. In 1979, use of slopes showed a decrease over the summer and was correlated with an increase in use of broken basins.

Wolverine Peak Summer Range Subunit: Not enough work was done in the Wolverine Peak area to determine a clear trend in elevational use. However, 1979 data indicate that the summer shift from alpine to timberline probably occurs here as on the rest of the Absaroka summer range.

Vegetation Habitat Use

Table 16 presents monthly and seasonal percent use by bighorn sheep of the structural vegetation formations on the RCWR and Pilot-Index, Jim Smith, and Wolverine Peak subunits of the ASR. Table 17 shows the frequency at which bighorns occurred in habitats with common and abundant coverage of each of the components of vegetation structure. Tables 18 through 21 present monthly and seasonal sheep use of the structural vegetation subtypes on each of the four areas. Floristic descriptions of plant communtities within the more commonly utilized structures are given in Appendix A.

Rock Creek Winter Range

Spring: During late spring of 1978 and 1979 on the Rock Creek winter range almost half of the bighorn sheep observed were in the Alpine Turf vegetation structure (Table 16). Alpine Mat was the second most used formation both years. The level and type of herbaceous formation use was very similar in both 1978 and 1979. About 70 % of sheep were observed in herbaceous types, with the dominant subtypes used being Turf, Turf-Rock and Mat-Rock Outcrop (Table 18). Compared to 1978, 1979 spring season occurrence declined in the Coniferous Forest, Coniferous Scrub and Sparsely Vegetated Cliff formations, while it increased in the Sparsely Vegetated Talus, Sparsely Vegetated

Table 16. Monthly and seasonal bighorn sheep use of structural vegetation formations based on ground survey observations on the Rock Creek winter and Absaroka summer ranges, 1978-1979.

Area and Time Period		CF	CS	EDS	AS	AT	AM	SM	SVC	SVO	SVT	SVDS	SF	Sample Size
		Percent Observations in Formation(a)												
RCWR														
1978	June-July	10	5	—	—	48	20	4	6	2	5	—	—	168
1979	May-July	3	—	6	—	49	18	3	—	10	12	—	—	233
	Nov.-Dec.	8	1	13	—	39	5	17	—	2	16	—	—	231
Pilot-Index Subunit ASR														
1978	July	—	tr(b)	—	—	66	9	2	—	2	5	17	—	257
	August	6	4	—	—	26	27	—	—	tr	1	36	—	221
	September	—	—	—	—	51	20	—	—	—	—	29	—	40
1979	July	3	—	—	2	58	5	—	—	2	1	30	—	189
	August	—	15	—	7	29	—	15	—	1	—	33	—	150
	September	—	3	—	9	39	—	12	—	3	—	35	—	200
	October	33	—	—	—	—	—	—	—	—	—	67	—	18
Jim Smith Subunit ASR														
1978	July	—	3	—	—	91	—	—	—	—	—	4	1	148
	August	19	—	—	10	54	—	—	—	—	—	18	—	62
1979	July	—	11	—	—	67	5	—	—	2	—	15	—	121
	August	—	—	—	—	71	—	1	—	4	—	25	—	213
	September	25	—	—	—	42	—	—	—	—	—	33	—	36
Wolverine Peak Subunit ASR														
1978	August	—	—	—	—	11	—	19	—	—	—	52	19	27
1979	July	—	—	—	—	27	—	—	—	—	—	73	—	13
	September	—	—	—	—	100	—	—	—	—	—	—	—	24
	October	—	—	—	—	—	—	—	—	—	50	50	—	7

a) Structural Vegetation Formations: CF=Coniferous Forest, CS=Coniferous Scrub, EDS=Evergreen/Deciduous Shrub, AS=Alpine Snowbed, AT=Alpine Turf, AM=Alpine Mat, SM=Subalpine Meadow, SVC=Sparsely Vegetated Cliff, SVO=Sparsely Vegetated Outcrop, SVT=Sparsely Vegetated Talus, SVDS=Sparsely Vegetated Dirt-Scree, SF=Snowfield.

b) tr = Less than 0.5 %.

Table 17. Monthly and seasonal bighorn sheep association with the components of vegetation structure based on ground survey observations on the Rock Creek winter and Absaroka summer ranges, 1978-1979.

Area and Time Period		Tr	Sc	Sh	Sb	Tf	Mt	Md	Rc	Ro	Rt	Rk	Ds	Sf	Sample Size
						Percent Observations (a) Associated with Component (b)									
RCWR															
1978	June-July	21/10	7/ 5	—	—	58/58	23/20	8/ 8	9/ 9	55/38	7/ 7	32/21	—	—	168
1979	May-July	9/ 3	—	6/ 6	—	49/49	18/18	11/11	11/ 0	54/37	19/13	24/19	—	—	233
	Nov.-Dec.	36/ 8	9/ 1	17/13	—	42/42	10/ 5	41/35	4/ 4	22/17	17/17	32/27	9/ 9	—	231
Pilot-Index Subunit ASR															
1978	July	3/ 0	2/tr(c)	—	—	66/66	14/ 9	2/ 2	tr/tr	44/19	5/ 5	7/ 3	61/56	—	257
	August	8/ 6	11/ 4	—	—	28/28	56/27	—	—	24/14	1/ 1	3/ 0	86/81	4/ 0	221
	September	18/ 0	38/ 0	—	—	51/51	49/20	—	—	—	—	—	49/49	—	40
1979	July	4/ 3	21/ 0	—	2/ 2	58/58	19/ 5	—	—	29/18	1/ 1	8/ 0	71/69	—	189
	August	21/ 0	25/15	—	7/ 7	44/44	13/ 0	16/15	—	26/21	—	7/ 6	81/56	—	150
	September	7/ 0	21/3	—	9/ 9	42/42	32/ 0	15/12	—	14/ 7	—	7/ 0	79/64	—	200
	October	33/33	28/ 0	—	—	—	28/ 0	39/ 0	—	44/ 0	—	—	72/72	—	18
Jim Smith Subunit ASR															
1978	July	—	3/ 3	—	—	95/95	—	—	—	7/ 0	—	5/ 5	13/ 4	1/ 1	148
	August	19/19	48/ 0	—	10/10	54/54	19/ 0	—	—	—	10/10	—	65/36	—	62
1979	July	11/ 0	33/11	—	—	67/67	10/ 5	—	—	12/12	—	7/ 0	44/39	—	121
	August	—	32/ 0	—	—	71/71	—	1/ 1	—	19/ 7	—	4/ 0	68/67	—	213
	September	25/25	44/ 0	—	—	42/42	—	—	—	—	—	8/ 8	100/58	—	36
Wolverine Peak Subunit ASR															
1978	August	—	—	—	—	11/11	41/0	19/19	—	11/11	—	20/20	70/70	39/19	27
1979	July	—	—	—	—	27/27	42/0	—	—	15/ 0	—	—	73/73	—	13
	September	—	—	—	—	100/100	—	—	—	—	—	92/ 0	8/ 0	—	24
	October	—	50/ 0	—	—	—	50/ 0	—	—	50/50	50/50	—	100/100	—	7

a) Percent of bighorns in habitats where component: exceeds 10 % cover / exceeds 30 % cover.
b) Vegetation Structure Components: Tr=Tree, Sc=Scrub, Sh=Shrub, Sb=Snowbed, Tf=Turf, Mt=Mat, Md=Meadow, Rc=Rock Cliff, Ro=Rock Outcrop, Rt=Rock Talus, Rk=Rock, Ds=Dirt-Scree, Sf=Snowfield.
c) tr = Less than 0.5 %.

Table 18. Bighorn sheep use of structural vegetation subtypes on the Rock Creek winter range, based on ground survey observations, 1978-1979.

Structural Subtype (a)	Percent of Observations During Period(b) Spr 1978	Spr 1979	Aut 1979	All Obs.
Sample Size	168	233	231	632
Coniferous Forest				
Tr-Tf	4	--	--	1
Tr-Mt	--	tr(c)	--	tr
Tr-Md	4	2	7	5
Tr-Ro	1	--	tr	tr
Tr-Rt	2	--	--	tr
Coniferous Scrub				
Sc-Tf	2	--	1	1
Sc-Ro	3	--	--	1
Evergreen/Deciduous Shrub				
Sh-Tf	--	--	1	4
Sh-Md	--	6	11	3
Alpine Turf				
Tf	23	25	16	21
Tf-Ro	7	6	--	4
Tf-Rk	18	18	24	20
Alpine Mat				
Mt-Rc	3	--	2	2
Mt-Ro	17	18	3	12
Subalpine Meadow				
Md	1	1	8	3
Md-Ro	3	2	5	3
Md-Rk	--	--	3	1
S. V. Cliff				
Rc	5	--	--	1
Rc-Ro	2	--	--	1
S. V. Outcrop				
Ro	2	8	--	4
Ro-Rt	--	2	2	1
S. V. Talus				
Rt	2	10	--	4
Rt-Rc	--	--	2	1
Rt-Ro	3	2	5	3
Rt-Ds	--	--	9	3

a) Structural subtype abbreviations are based on vegetation structure component abbreviations (see Table 17).
b) Spr 1978 = June - July 1978, Spr 1979 = May - July 1979, Aut 1979 = November - December 1979.
c) tr = Less than 0.5 %.

Table 19. Bighorn sheep use of structural vegetation subtypes on the Pilot-Index subunit of the Absaroka summer range, based on ground survey observations, 1978-1979.

Structural Subtype (a)	Percent of Observations During Period									
	Jul	Aug	Sep	1978	Jul	Aug	Sep	Oct	1979	All Obs.
Sample Size	257	221	40	524	189	150	200	18	557	1081
Coniferous Forest										
Tr	—	—	—	—	—	—	—	28	1	tr(b)
Tr-Ds	—	6	—	2	3	—	—	6	1	2
Coniferous Scrub										
Sc-Tf	—	2	—	1	—	15	3	—	5	3
Sc-Ds	tr	2	—	1	—	—	—	—	—	tr
Alpine Snowbed										
Sb	—	—	—	—	2	7	10	—	6	3
Alpine Turf										
Tf	35	15	51	28	29	12	19	—	20	24
Tf-Ro	—	1	—	tr	—	—	—	—	—	tr
Tf-Rk	—	—	—	—	—	6	—	—	2	1
Tf-Ds	31	10	—	19	29	11	20	—	20	20
Alpine Mat										
Mt-Rk	3	—	—	2	—	—	—	—	—	1
Mt-Ds	6	27	20	16	5	—	—	—	2	9
Subalpine Meadow										
Md	1	—	—	tr	—	3	6	—	3	1
Md-Rc	tr	—	—	tr	—	—	—	—	—	tr
Md-Ro	tr	—	—	tr	—	1	—	—	tr	tr
Md-Ds	—	—	—	—	—	11	7	—	4	2
S. V. Outcrop										
Ro-Ds	2	tr	—	1	2	1	3	—	2	2
S. V. Talus										
Rt	1	1	—	1	1	—	—	—	tr	tr
Rt-Ro	4	—	—	2	—	—	—	—	—	1
S. V. Dirt-Scree										
Ds	4	28	29	17	17	15	30	67	23	20
Ds-Ro	12	8	—	9	13	18	5	—	11	10

a) Structural subtype abbreviations are based on vegetation component abbreviations (see Table 17).
b) tr = Less than 0.5 %.

Table 20. Bighorn sheep use of structural vegetation subtypes on the Jim Smith subunit of the Absaroka summer range, based on ground survey observations, 1978-1979.

Structural Subtype (a)	Percent of Observations During Period Jul	Aug	1978	Jul	Aug	Sep	1979	All Obs.
Sample Size	148	62	210	121	213	36	370	580
Coniferous Forest								
Tr	--	19	5	--	--	--	--	2
Tr-Ds	--	--	--	--	--	25	2	2
Coniferous Scrub								
Sc-Tf	3	--	2	--	--	--	--	1
Sc-Ds	--	--	--	11	--	--	4	2
Alpine Snowbed								
Sb-Rt	--	10	3	--	--	--	--	1
Alpine Turf								
Tf	86	35	71	61	33	33	42	53
Tf-Rk	5	--	4	--	--	8	1	2
Tf-Ds	--	19	5	6	38	--	24	17
Alpine Mat								
Mt-Ds	--	--	--	5	--	--	2	1
Subalpine Meadow								
Md-Ds	--	--	--	--	1	--	tr(b)	tr
S. V. Outcrop								
Ro-Ds	--	--	--	2	4	--	3	2
S. V. Dirt-Scree								
Ds	4	18	8	5	22	33	17	14
Ds-Ro	--	--	--	10	4	--	5	3
Snowfield								
Sf	1	--	1	--	--	--	--	tr

a) Structural subtype abbreviations are based on vegetation component abbreviations (see Table 17).

b) tr = Less than 0.5 %.

Table 21. Bighorn sheep use of structural vegetation subtypes on the Wolverine Peak subunit of the Absaroka summer range, based on ground survey observations, 1978-1979.

Structural Subtype (a)	Percent of Observations During Period 1978	Jul	Sep	Oct	1979	All Obs.
Sample Size	27	13	24	7	44	71
Alpine Turf						
Tf	11	27	100	--	63	43
Alpine Mat						
Mt-Ds	19	--	--	--	--	7
S. V. Talus						
Rt-Ds	--	--	--	50	8	5
S. V. Dirt-Scree						
Ds	20	73	--	--	22	21
Ds-Ro	11	--	--	50	8	9
Ds-Rk	20	--	--	--	--	8
Snowfield						
Sf	19	--	--	--	--	7

a) Structural subtype abbreviations are based on vegetation component abbreviations (see Table 17).

Outcrop and Evergreen/Deciduous Shrub formations.

During late spring of both 1978 and 1979 bighorns were most often observed in association with the turf and rock outcrop structural components (Table 17). While more sheep were observed in or near turf in 1978, sheep tended to use habitats where turf had greater coverage in 1979. Rock, mat and trees were additional frequent components of bighorn habitat in 1978. Association with these structures declined somewhat in 1979, while that with talus and shrubs increased. Tree cover was rarely abundant in the vicinity of bighorn sheep during late spring.

In late spring bighorn sheep were distributed mainly in the timberline zones on steep, northerly or west facing canyon walls where turf is often rocky and interspersed with rock outcrops dominated by patchy mat vegetation. In 1979 more sheep were observed just prior to migration off the winter range traveling over talus fields and in shrub-meadow canyon bottom habitat.

Autumn: The Alpine Turf formation was of somewhat less importance during autumn than during late spring of 1979, but still received the most use (Table 16). Fewer observations were made in the Alpine Mat type also, but sightings in the Subalpine Meadow, Evergreen/Deciduous Shrub and Sparsely Vegetated Talus formations increased in autumn. Sixty one percent of bighorns were observed in herbaceous types, with most use being in the Turf-Rock and Turf subtypes. The Shrub-Meadow, Meadow and Tree-Meadow subtypes were also frequently used (Table 18).

Turf, meadow, trees, and rock were the most commonly recorded structural components in bighorn habitat during autumn (Table 17). Respectively, 42, 41, 36, and 32 % of observed bighorns were associated with these structures. Compared to late spring, there was more use of habitats with meadows, trees and shrubs. Trees were associated with 36 % of the bighorns observed, but only 8 % were in habitats where tree cover was abundant.

When sheep returned to the winter range in autumn they did not resume late spring use of steep northerly exposed timberline canyon walls. Instead they distributed themselves to a greater extent on more moderately sloped southerly facing subalpine lower canyon sides where shrub and meadow habitats were interspersed with scattered conifers. More use was also observed on westerly facing alpine plateau edges dominated by rocky turf.

Pilot-Index Summer Range Subunit

Bighorn sheep structural habitat use on the Pilot-Index summer range subunit varied between and over the course of both the summers of 1978 and 1979.

1978: In July 1978, 66 % of all bighorns were observed in the Alpine Turf formation, with use spread fairly evenly between the Turf and Turf-Dirt Scree subtypes (Tables 16 and 19). The only other formations with much use were Sparsely Vegetated Dirt Scree and Alpine Mat. Most Dirt Scree use was in the Dirt Scree-Rock Outcrop subtype. Turf, dirt scree, and rock outcrop habitat components were at least common in the vicinity of 66, 61, and 44 % of all bighorns observed at this time (Table 17). Most sheep association with rock outcrops was in habitats where this component had less than 30 % coverage.

During August, Alpine Turf use dropped sharply, while use of Sparsely Vegetated Dirt Scree doubled and that of Alpine Mat tripled (Table 16). Sightings in herbaceous vegetation types dropped from 77 to 53 %. Subtypes most used were Dirt Scree, Mat-Dirt Scree, Turf, and Turf-Dirt Scree (Table 19). The Dirt Scree component was at least abundant in over 80 % of the habitats used. Mat vegetation was at least common in the vicinity of 56 % of the bighorns observed (Table 17).

Survey effort in September 1978 was low and restricted to the first half of the month, but some shift back to Alpine Turf from Dirt Scree and Alpine Mat was suggested. Sheep were observed in the Turf, Dirt Scree and Mat-Dirt Scree structural subtypes. Turf was of predominant or exclusive coverage near 51 % of the sheep observed, while mat and dirt scree were at least common near 49 % of the bighorns observed. In September scrub and trees were frequently recorded in association with sheep, but never at cover levels over 30 %.

In 1978 the shift from habitats with continuous herbaceous vegetation cover to those with discontinuous or sparse herb cover occurred during mid-August. Around this time sheep use of westerly exposed moderate to steep alpine turf slopes declined and use of south and easterly exposed moderate slopes and ridgetops increased. On these areas turf is largely supplanted by mat vegetation intermixed with dirt and scree. This habitat shift was accomplished without an accompanying shift in elevation use. In early September sheep were observed at lower elevations on turf and dirt scree basin bottoms and slopes. No use of the Alpine Snowbed formation was observed in 1978, probably because snowfields persisted well into the summer of that year and field surveys ceased in early September.

<u>1979</u>: Alpine Turf was again the dominant formation used by bighorns in July of 1979, but at a somewhat lower level than that observed the previous year (Table 16). Use of the Sparsely Vegetated Dirt Scree formation was much higher than that observed the previous July. Turf, Turf-Dirt Scree, Dirt Scree and Dirt Scree-Rock Outcrop were the primary structural subtypes used (Table 19). Dirt scree and turf were at least abundant in the habitats of 69 and 58 % of all sheep observed, respectively (Table 17). Rock outcrop occurred near 29 % of bighorns and scrub near 21 %. All association with scrub was in habitats where it had less than 30 % cover, however.

As in the previous year, a sharp August shift away from the Alpine

Turf formation was observed. However, in 1979 the shift was primarily to the Coniferous Scrub, Subalpine Meadow, and Alpine Snowbed formations rather than to the Alpine Mat and Dirt Scree types selected in 1978 (Table 16). Use of Sparsely Vegetated Dirt Scree showed only a minor increase, but was used at a level only slightly below that observed the previous August. Bighorns were spread widely through the Dirt Scree-Rock Outcrop, Dirt Scree, Scrub-Turf, Turf, Turf-Dirt Scree, Meadow-Dirt Scree, and Snowbed subtypes (Table 19). Eighty one percent were observed near dirt scree. Forty four percent were still associated with turf, but much of this was in habitats with over 30 % scrub cover. Association with trees rose sharply in August, but tree cover near sheep never exceeded 30 % (Table 17).

In September there was some return to the Alpine Turf formation. Occurrence in Coniferous Scrub declined sharply, while the Subalpine Meadow type showed a slight decrease. Use of Sparsely Vegetated Dirt Scree and Alpine Snowbed increased somewhat (Table 16). Dirt Scree, Turf-Dirt Scree and Turf were the most used subtypes (Table 19). Association with the dirt scree and turf components remained at levels similar to those observed in August. Association with mat vegetation increased, at low coverage levels, while that with trees declined (Table 17).

October observations were few and limited to the latter half of the month when snow was accumulating on the study area. Bighorns were observed in the Dirt Scree, Tree, and Tree-Dirt Scree subtypes. Dirt scree, rock outcrop, meadow, tree, mat, and scrub were recorded in sheep habitat. No sightings were near the turf structure. These data reflect habitat selection just prior to autumn migration.

The shift in habitat use observed in 1979 began in late July, two to three weeks earlier than that observed in 1978. There was a trend away from alpine west, southwest, and south exposed turf and dirt scree slopes toward timberline and upper subalpine east and south facing dirt scree and meadow slopes. Most of the turf use observed in August was on upper timberline east slopes. Use of scrub, rock outcrop, and turf types in timberline broken basins increased. In contrast to 1978, occurrence on ridgetops declined in August of 1979 and those used were more sparsely vegetated than in 1978. Consequently, no use of the Alpine Mat formation was recorded in August of 1979. Use of the Alpine Snowbed formation occurred exclusively on a few alpine east slopes beneath persistent ridgetop snowbanks. The increased scrub use occurred primarily in timberline basins, but also was seen on slopes.

In September scrub-turf use in basins and on slopes was largely replaced by use of turf slopes again. Ridgetop use increased, especially on those with continuous herbaceous vegetation cover in the upper timberline to upper subalpine elevational zones. These sites were classed in either the Alpine Turf or Subalpine Meadow category depending on elevation. Most September meadow use was on these ridgetops rather than on the discontinuous meadow slopes used in August. September dirt scree use occurred mostly on east and southerly slopes primarily in timberline and alpine zones. Snowbed use continued in the same areas used in August.

Late summer and early autumn snowstorms caused definite shifts in vegetation use. In 1979, when snow began to accumulate during the last half of October, only one bighorn group was sighted in areas sheep were traditionally observed during August and September ground based surveys. All sheep observed during the last half of October were at comparatively low elevations. All were in or fairly close to dense timber stands. In 1978 a similar abandonment of open alpine and timberline areas was observed for a short time after a mid-August snowstorm deposited about 6 cm (2 in) of snow on the summer range. Heavy rain, or hail storms, which were quite common during late summer and autumn, did not appear to cause a noticable response in bighorn range or elevational use.

Jim Smith Summer Range Subunit

Throughout the summers of both 1978 and 1979, bighorns on the Jim Smith subunit were more likely to be observed in the Alpine Turf formation and less less likely to be seen in the Sparsely Vegetated Dirt Scree formation than sheep on the Pilot-Index range. The mid-summer shift away from continous herbaceous vegetation was less pronounced on the Jim Smith range (Table 16).

1978: The dominant vegetation formation used on the Jim Smith range between July 13 and August 15, 1978 was Alpine Turf, with 80 % of bighorn observations. In July, 91 % of bighorns were observed in this formation, but by August its use dropped to 54 % due to increased use of the Coniferous Forest, Dirt-Scree, and Alpine Snowbed formations (Table 16). The major subtype used in both July and August was Turf, but in August Turf-Dirt Scree, Tree, and Dirt Scree also were important (Table 20).

Ninety five percent of the Jim Smith sheep observed in July were in habitats where turf was at least abundant, 80 % in habitats where turf had exclusive coverage. Sheep were seldom associated with other habitat components during July (Table 17). In August there was a marked increase in association with dirt scree, scrub, mat, tree, snowbed, and talus, while association with turf declined. Still, over half were observed in habitats where turf was abundant. Almost half were associated with scrub, but scrub cover never exceeded 30 % near sheep.

Use of turf vegetation was exclusively in the alpine zone in July with most occurring on steep southwest or west slopes. Alpine turf ridgetops were used by older ram groups in the western part of the Jim Smith area. August sample size is rather low, but indicates some shift down to upper timberline turf slopes. Use of the Alpine Snowbed formation was of the discontinous snowbed community associated with abundant talus, the type found below steep walls of northerly facing timberline basins. No use was observed in south facing broken timberline basins, but no late summer surveys were conducted on the Jim Smith range in 1978.

One ewe-juvenile group was observed in the Coniferous Forest formation on a southwest facing upper timberline slope in August, but in general this formation was relatively unimportant to bighorns in their normal daily activities. It was frequently used as escape cover however, especially by mature rams. When disturbed by the observer, ram groups often chose to run several hundred meters down to a closed stand of trees rather than use steep broken rock outcrop and dirt scree slopes close at hand. At times rams chose to escape to timbered cover even when this required them to initially travel toward me, though they could easily have quickly been out of sight on steep broken ridgesides. Ewe-juvenile bighorn groups rarely dropped into thick forests when disturbed, preferring instead to run away from the disturbance to the nearest steep outcrop or scree slope.

1979: The dominant vegetation formation used through the period of July 14 to September 19, 1979 on the Jim Smith range was Alpine Turf, with 67 % of observed use. During both July and August the use of Alpine Turf greatly exceeded that of other formations (Table 16), but in August there was a shift from the Turf to the Turf-Dirt Scree subtype (Table 20). Use of the Alpine Turf formation actually increased slightly in August as did use of the Dirt-Scree formation. Use of the Scrubland and Alpine Mat types decreased. The September Jim Smith sample size was quite low, however a shift away from Alpine Turf appears evident.

In July of 1979 bighorn association with turf was much less, and that with dirt scree and scrub much greater than during the previous July (Table 17). During August habitats where turf had less cover and dirt scree more exposure were used. The small September sample indicates that this trend continued.

Alpine Turf use occurred primarily on alpine slopes in July and August. Some use of timberline basin bottom turf was observed in August. Dirt-scree use shifted from slope, ridgetop, and basin sites throughout the alpine and timberline zones to broken basins almost exclusively. Sheep also used the Rock Outcrop formation on headwalls of northfacing basins in August. Use of traditional alpine areas appeared to decline sharply in September, when sheep tended to be found on lower slope and broken basin areas.

Wolverine Peak Summer Range

1978: Ground based surveys were conducted on August 3 and August 20 on the Wolverine Peak summer range, but relatively few bighorn observations were recorded. Sparsely Vegetated Dirt-Scree was the vegetation formation with the most observed use (Table 16). The earlier survey found sheep exclusively in the alpine zone on Dirt Scree ridgetops and slopes and on the Alpine Turf plateau habitat on the top of Mineral Mountain. The later survey only detected one large bighorn group in the timberline zone on Subalpine Meadow and Snowfield slopes in the upper Sheep Creek drainage.

1979: The area was surveyed on July 24, Sept 2, and October 9 in 1979, but the sample size of observed bighorns on the Wolverine Peak range was still low. Alpine Turf was the most used formation (Table 16). In late July sheep were observed in the alpine zone on Turf slopes and on Dirt Scree slopes and ridgetops. In early September a large group was observed on Turf in the upper timberline zone, slightly above where the large late August group of 1978 was observed. Another small group was observed on Turf on the Mineral Mountain plateau. In October one group was observed on upper timberline Dirt Scree and Talus slopes on Miller Mountain (Table 21).

Food Habits

Microhistological analysis of fecal samples collected between August 15 and September 28, 1979 shows that late summer foraging on the Pilot-Index area was concentrated primarily on graminoids (Table 22). Twenty two plant taxa were reported from late summer samples. Sedges comprised the bulk of the graminoids used, but fescues and tufted hairgrass also were significant. Sample distribution indicates that sedges were heavily used in all areas, but were replaced somewhat by sheep and Idaho fescue on lower elevation timberline and subalpine ridges and basins. Hairgrass showed up mostly in September samples near moist east slope snowbed vegetation where it was a dominant species. Other species of some importance were willows and lupine. Silvery lupine was common on drier alpine to subalpine slopes. Heavy willow use corresponded fairly closely with samples from alpine areas where dwarf alpine species were present.

Analysis of fecal samples collected between November 14 and December 14, 1979 showed that during late autumn on the Rock Creek winter range, forbs received more use than graminoids (Table 22). Thirty one taxa were reported in autumn samples. Dwarf sages and lupine made up most of the forb use, while fescue, sedges and tufted hairgrass made up the bulk of the graminoid use. Sage showed up primarily in samples collected from the highway switchback area of the winter range where fringed sage was a common species. Fescue was found in samples from all areas but was most common in plateau samples where sheep fescue occurs. Lupine, sedge and hairgrass were also more common in plateau samples. Sedge is ubiquitous in the alpine zone and silvery

Table 22. Late summer and autumn bighorn sheep food habits based on microhistological analysis of fecal samples from the Pilot-Index summer range subunit and the Rock Creek winter range, 1979.(a)

Food Item	Percent of Diet (Constancy in Samples) Pilot-Index n=17	Rock Creek n=16
Graminoids		
Agropyron spp.	——	0.21 (1)
Agrostis scabra	——	0.43 (1)
Bromus spp.	0.39 (2)	——
Calamagrostis spp.	——	0.08 (1)
Carex spp.	51.55 (17)	14.63 (13)
Deschampsia caespitosa	6.15 (14)	3.58 (9)
Equisetum spp.	——	0.21 (1)
Festuca spp.	10.75 (15)	17.66 (15)
Juncus spp.	2.32 (6)	——
Luzula spp.	0.25 (1)	0.20 (1)
Oryzopsis spp.	0.81 (3)	1.05 (3)
Phleum spp.	——	0.21 (1)
Poa spp.	1.84 (8)	0.77 (4)
Sitanion spp.	——	0.08 (1)
Stipa spp.	——	0.28 (2)
Total Graminoids	74.06 (17)	39.51 (15)
Forbs		
Antennaria-Cirsium spp.	——	0.74 (3)
Artemisia spp.	1.07 (2)	24.78 (6)
Astragalus spp.	2.27 (3)	2.90 (7)
Composite spp.	0.78 (4)	1.54 (7)
Descurainia spp.	2.34 (4)	0.98 (2)
Draba spp.	——	0.22 (1)
Lesquerella spp.	——	1.48 (5)
Lupinus spp.	4.78 (4)	16.17 (9)
Phacelia spp.	——	0.18 (1)
Phlox spp.	——	1.02 (3)
Plantago spp.	0.20 (1)	——
Potentilla-Geum spp.	0.37 (2)	0.21 (1)
Sibbaldia procumbens	3.70 (7)	0.07 (1)
Unknown Forb	0.63 (3)	——
Total Forbs	16.14 (15)	50.28 (16)
Browse		
Berberis spp.	——	0.18 (1)
Pinus spp.	0.86 (2)	2.42 (10)
Pseudotsuga spp.	——	1.22 (3)
Rosa spp.	1.46 (4)	2.34 (6)
Rubus spp	0.43 (2)	2.60 (6)
Salix spp.	5.33 (8)	1.44 (5)
Shepherdia canadensis	1.71 (2)	——
Total Browse	9.79 (10)	10.20 (14)

a) Pilot-Index samples collected between August 15 and September 28. Rock Creek samples collected between November 14 and December 14.

lupine is a common species on westerly facing plateau slopes and edges. Hairgrass is dominant on gentle easterly plateau aspects.

Thirteen bighorn sheep feeding sites were examined on the Pilot-Index subunit in 1978 and 1979. Plant species with observed use were recorded and estimates were made of the number of bites on each plant (Table 23). Fewer total bites were recorded on graminoids, but graminoid species were used in a wider variety of habitats. Forb use was often heavily concentrated on a specific species at a particular site. Bluegrasses were the most frequently used and heavily grazed species. Other species of importance in a variety of habitats were sedges, sheep fescue, and diverse-leaved cinquefoil. On one basin site, bighorns grazed the tops and upper leaves off of an entire stand of seep-spring arnica, a forb often found in patches on scree or talus slopes below basin headwalls and cliffs. On one gentle snowbed and dirt-scree slope, alpine lewisia was heavily selected for.

Population Quality

Lungworm Larvae

Results of the analysis of 72 fecal samples collected during the summer and autumn of 1979 are summarized in Table 24. Mean larval output for all samples was 186.4 per gram dry feces. Eighty eight percent of the samples were positive for the presence of lungworm larvae, 33 % having more than 100 larvae per gram. This level of output is much higher than levels of lungworm infestation reported in recent studies of Montana bighorns (Brown 1974, Stewart 1975, Klaver 1978), but is much lower than levels reported for many Montana herds in

Table 23. Plant species with recorded use in feeding site examinations on the Absaroka summer range, August 7 to August 20, 1978 and July 24 to September 9, 1979.

Food Item	No. Sites Used n=13	Percent of Bites n=1473
Graminoids		
Agropyron scribneri	1	0.3
Carex spp.	8	8.4
Deschampsia caespitosa	3	++(a)
Festuca ovina	5	9.5
Juncus drummondii	1	++
Poa spp.	9	21.9
Trisetum spicatum	2	2.2
Total Graminoids	13	42.3
Forbs		
Achillea millefolium	2	0.1
Arnica longifolia	1	23.8
Artemisia scopulorum	2	1.4
Astragalus alpinus	1	0.1
Erigeron simplex	1	0.1
Geum rossii	2	4.5
Hedysarum sulphurescens	1	0.1
Lewisia pygmaea	2	11.8
Lloydia serotina	1	2.8
Lupinus argenteus	1	0.3
Mertensia alpina	2	0.1
Polygonum bistortoides	1	0.1
Potentilla diversifolia	4	7.2
Ranunculus eschscholtzii	2	2.5
Saxifraga oregana	1	0.1
Senecio spp.	2	0.8
Smelowskia calycina	1	0.7
Stellaria americana	1	0.1
Taraxacum lyratum	3	1.0
Viola adunca	1	0.1
Total Forbs	12	57.7
Browse		
Pinus albicaulis	1	+(b)

a) ++ = Heavy use recorded on some sites but not quantified.
b) + = Use recorded on a site but not quantified.

Table 24. Protostrongylid larval output (larvae/gram dry feces) of the Beartooth-Rock Creek bighorn sheep herd as determined from fecal samples collected between July and December 1979.

Area(a)	Sample Size	Percent in Infection Class(b) I	II	III	IV	V	VI	Mean Output	Range	Percent Positive
PI-ASR	38	13	16	18	29	21	3	127.5	0 - 1729	87
RCWR	25	16	0	12	20	44	8	271.8	0 - 1466	84
All	72	13	11	21	22	29	4	186.4	0 - 1729	88

a) Areas: PI-ASR = Pilot-Index subunit of the Absaroka summer range, RCWR = Rock Creek winter range, All = Samples from all areas Beartooth and Absaroka ranges.

b) Infection Classes (larvae/g dry feces): I = 0, II = 0.1 - 0.9, III = 1.0 - 9.9, IV = 10.0 - 99.9, V = 100.0 - 999.9, VI = More than 1000.0.

the late 1950's and 1960's (Forrester and Senger 1964). Canadian populations of bighorn sheep also showed higher levels of larval output than was found in this study (Uhazy et al. 1973, Stelfox 1976). Uhazy et al. (1973) concluded that counts of over 1400 larvae/g dry feces probably represented heavy infections, while sample groups averaging 157 and 496 larvae/g were considered light and moderate intensities of infection, respectively. On this basis, the sample collected during this study indicate a light to moderate level of infection. Only two samples (2.8 %) had levels higher than 1400 larvae/g.

Mean larval output on the Rock Creek winter range was significantly higher (t-test, $p < 0.001$) than that found on the Pilot-Index area of the summer range, 271.8 versus 127.5 larvae/g, respectively (Table 24). Fifty two percent of the samples collected on the winter range had a larval output greater than 100/g, while 24 % of those collected on the Pilot-Index summer range had that level of output. Uhazy et al. (1973) also reported an increase in larval output on the winter range.

Duration of Suckling Periods

Fourteen suckling bouts were observed on Rock Creek winter range lambing and nursery areas during late June and early July prior to spring migration. The average duration was 19.4 seconds. The longest lasted 40 seconds, but 79 % lasted 25 seconds or less. Shackleton (1973) reported a mean suckling duration of 28.0 seconds with half the bouts over 25 seconds in length for a population known to be of high quality. Mean suckling time for a low quality population was 14.1 seconds and only 5 % exceeded 25 seconds. The frequency distribution of suckling times from the RCWR resembled that of Shackleton's low quality population.

Horn Growth

Horn growth has been suggested as a measure of bighorn population quality, and ultimately of the quality of bighorn range (Geist 1971, Shackleton 1973). Rams from high quality populations exhibit faster growth and mature socially earlier than those from lower quality populations, therefore horn growth during the first four years of life should reflect population quality (Shackleton 1973). Stewart (Simmons and Stewart 1979) used horn growth indices from hunter killed rams to compare population quality of herds throughout the state of Montana. He reported that in general the highest quality rams were found in the western part of the state, while those of the lowest quality were in south central Montana. The Rock Creek and West Rosebud ram populations of the Beartooth Mountains ranked 18th and 21st, respectively, out of the 22 populations compared. Both of these herds winter on relatively poor alpine ranges. Stewart speculated that rams in these populations show a shortened period of reduced horn growth because they are exposed to succulent vegetation for less time and their response to spring green up is slower than for populations existing under less severe western Montana conditions.

Lamb Survival and Production

Geist (1971) suggested that winter survival of lambs to yearling age, while varying greatly between and within populations, was ultimately a function of population quality. Lamb mortality was inversely related to population quality and directly related to winter severity. Data collected over a five year period from the Beartooth-Rock Creek herd indicates fairly low lamb production, with most ewes successfully bearing young only every other year, coupled with fair lamb survival (57 %). This conforms to the parameters expected of a stable, poor quality, cold climate sheep population as hypothesized by Geist (1971).

DISCUSSION

Geist (1971) reported that bighorn rams may have as many as six seasonal home ranges and ewes as many as four. Only two seasonal ranges were detected for rams and ewes in the Beartooth-Rock Creek bighorn sheep herd. This does not preclude the possibility that some of the herd may use more than two, however. The restricted mid-winter ranges of some rams and ewes are likely distinct from their fall and spring ranges, but the lack of marked sheep observations during the winter prevented delineation of separate ranges in the Rock Creek area. There is a possibility that some rams gather in an early autumn prerut range, perhaps in the Mount Inabnit area of the migration route, and some pregnant ewes may have lambing ranges in the Lake Fork to East Rosebud segment of the migration route, but neither of these possibilities could be confirmed. No evidence of movement to salt licks was detected for the Beartooth-Rock Creek herd.

The placement of roads across bighorn sheep migration routes has been a subject of concern to wildlife managers because the interruption of seasonal movement patterns could very likely lead to the elimination of the sheep population dependent upon them (Wishart 1975). The Rock Creek bighorns have clearly adapted to the presence of a heavily traveled highway and Forest Service road across their migration route. Migratory behavior was modified, primarily in timing and duration, but the roads were not barriers to migration. The major problem caused by roads at the time of the study was in their allowing winter snowmobile access into key winter range areas (Stewart, personal communication). Further recreational development, such as campgrounds and resorts, should be avoided in upper Rock Creek and in the Clarks Fork drainage along Highway 212 near the state line, to ensure that disturbance to migrating sheep is not increased.

The migration route used by the Rock Creek bighorns does not follow a staight line between the Beartooth and Absaroka ranges. The arc shaped route requires migrations of 57 to 64 km compared to 37 to 45 km if a direct route were used. The longer route avoids the Clarks Fork-Beartooth high lakes plateau as much as possible. A straight line route would involve travel through approximately 19 km of this broken forested habitat and the crossing of several indistinct drainages. The route to the Pilot-Index Peaks area involves travel through 11 km of this country and follows a distinct ridgeline over much of this distance. By following the main crest of the Beartooths, the sheep travel through open rocky terrain offering excellent security and good visibility, characteristics which are likely advantageous and preferred by migrating bighorns. Navigation and orientation along a route which follows the crest of the mountain range and crosses distinct drainages is likely easier than on a route across the broken high lakes plateau (Baker 1980). This terrain also has superior snowshedding characteristics to that of the high lakes plateau.

Although these characteristics of the migration route make it advantageous at the present time, the route in all likelihood evolved under conditions of snow and vegetative cover dissimilar to those found in the area today. The sequence of events which led to the establishment of this route and the use of these two widely separated ranges under conditions which existed in the past is an interesting, but probably unanswerable question.

Baker (1980) states that "migration is an advantage when the realization of potential reproductive success achieved on the way to and in the spatial unit to which an individual migrates is greater than the realization of potential reproductive success that would have been achieved during the same period if the amimal had remained in the spatial unit vacated". What selective advantage does the Rock Creek herd gain in migrating 57 to 64 km to the Absaroka summer ranges in the spring and then reversing this movement and returning to the Beartooths in the autumn? The differing geological origins and resulting contrasting landforms of the Beartooth and Absaroka mountain ranges has resulted in each being advantageous for use during a particular season.

The Absaroka Mountains provide a longer summer period during which green succulent vegetation is available. In late summer, after alpine vegetation has dried up, timberline scree basins and other protected sparsely vegetated landforms continue to provide green forage in the Absarokas, while in the Beartooths such vegetation is confined to small scattered sites watered by perpetual snowbanks. Vegetation cover is significantly less on dirt-scree sites than on the alpine slopes, but plants remain green and continue to grow for longer periods. The extended growing season appeared to be due to the presence of snowbanks on the steep basin rims or rigetops above, which kept the dirt-scree subsurface damp through the summer; the broken nature of the terrain, which resulted in a variety of microsites protected from dessication caused by wind and sun; and the sparse coverage of the vegetation, which resulted in less competition for water and nutrients between individual plants. Broken timberline scree basins cover large areas in the Wyoming Absarokas. Such basins not only provide succulent vegetation but also are interspersed with escape terrain and have forest canopies sparse enough to make them ideal for bighorn sheep use.

The Beartooths, on the other hand, offer the advantage once snow begins to accumulate because of their better snowshedding qualities. High winds sweep snow from large continuous areas of the alpine plateaus surrounding Rock Creek. During winter sheep graze on this exposed turf and mat vegetation and use rock outcrops and scrub patches on the upper canyon walls for thermal and escape cover. In the Absarokas snowfree areas are confined to narrow bands along rocky ridgetops.

The differing parent material making up the Beartooths and Absarokas likely results in differing levels of available minerals and nutrients between the winter and summer ranges. The Beartooths are derived primarily from granitic materials while the Absarokas are volcanic in origin. Johnson (1962) reported that the least productive soils in the high altitude sheep ranges of Wyoming were those derived from granite, while soils on volcanic materials were deeper and more productive. Packard (1946) suggested that a long term bighorn population decline in Rocky Mountain National Park was ultimately due to mineral difficiencies caused by poor granitic mountain soils. He found that sheep frequented localized sites of exposed volcanic soil, ingesting large quantities apparently for the mineral salts. This suggests that the Absaroka Range may be advantageous nutritionally during the summer not only because of the longer growing season there but also because both the soil and the vegetation may be higher in minerals than in the Beartooth Mountains. The volcanic nature of the Absarokas may also explain why no salt lick has been found to be used by the Rock Creek herd since exposed volcanic soils are plentiful on the summer range.

Several authors have reported on the preference of bighorn sheep for succulent, new growth herbaceous vegetation (Davis 1938, Geist 1971, Todd 1972, Riggs 1977, Johnson 1980). The preference for new growth is expected among herbivores as growing plants and plant parts are higher in moisture, nitrogen, and essential nutrients (Matson 1980). Oldemeyer et al (1971) discussed the importance of escape terrain to bighorns. Todd (1972) suggested that bighorn sheep habitat is to a large extent determined by the presence of adequate escape terrain and the availability of green, nutrient rich vegetation. Shannon et al (1975) found that escape terrain was an important component of bighorn sheep habitat, but that forage variables such as biomass and nitrogen content may lessen this dependence.

The yearly movements of the Beartooth-Rock Creek bighorn sheep herd to a large extent are explained by the availability of succulent vegetation in the vicinity of escape terrain. After returning in autumn bighorns range widely over the Rock Creek range, searching for sparse late season forage, but rarely stray far from escape terrain on canyon walls. With increasing snow depths as winter approaches sheep are forced onto restricted sites on windswept alpine plateaus, the only areas in the mountains with available vegetation. Reliance on escape terrain is at a low point in mid-winter, sheep often graze far out onto the open plateau. All available forage on the restricted exposed sites must be utilized whether near escape terrain or not in order to extract sufficient nutrients from the cured vegetation to survive the winter.

As the snow melts off the lower elevation canyon walls in the spring, bighorns move down to take advantage of the more advanced vegetation greenup, and resume their close association with escape terrain. They follow the greenup elevationally back up the canyon wall as the season advances, but by June many leave the winter range entirely to travel great distances to the Absaroka summer ranges. Even ewes with new lambs are gone by mid-July. Thus at just the point when vegetation on the plateaus is at peak production and nutrient levels, all bighorns have departed. This behavior allows them to utilize timberline and alpine vegetation in the Absarokas, which may be higher in nutrient levels due to the volcanic soils, and obviously preserves the alpine plateau vegetation on the Rock Creek range for use in winter.

During the period when bighorns are arriving on the Absaroka Range, greenup is progressing from the timberline to the alpine elevational zone. Sheep follow this line to the alpine ridgetops and remain until mid-summer when most alpine vegetation dessicates. Dependence on escape terrain is low during early summer when sheep form large bands to graze on lush turf covered alpine slopes. After alpine vegetation dessicates sheep drop down into timberline scree basins or other protected dirt-scree dominated habitats where green vegetation is available, if not in as great an abundance as on the early summer turf slopes. Escape terrain is never far from the relatively small groups utilizing these basins. Foraging in the alpine zone at this time is mainly restricted to scattered sites watered by snowbanks on the east side of ridgetops. Heavy rains from thunder storms may cause some secondary greenup on open timberline and alpine slopes during moist autumns and bighorns appear to utilize this new growth when it occurs.

When snow begins to accumulate in the timberline and alpine zones it becomes advantageous for bighorns to migrate back to the Beartooth winter range before the route is blocked by snow. But most of the sheep appear to put off the long return migration until it is clear that winter has indeed finally arrived. Bighorns wait out snow storms in the timbered subalpine elevations for as long as a week before committing themselves to the migration. Such behavior would seem to be disadvantageous as it increases the energy required to make the trip and the likelyhood of injury or death along the rugged migration route. Apparently, the high frequency of ephemeral autumn snowstorms followed by mild weather has selected for this delayed return migration behavior. The advantages accrued through waiting out on the summer range what often turn out to be ephemeral snow storms must outweigh those of migrating along a route with less snow and arriving on the winter range earlier (Baker 1980).

Isolated, small populations are subject to losses in genetic diversity, and consequently population fitness, due to the effects of genetic drift and inbreeding depression (Soule 1982, Beardmore 1982). Franklin (1980) proposed that effective population sizes of 50 individuals are required to preserve genetic diversity in the short term, while 500 would maintain sufficient genetic variance for long term adaptation. Due to polygyny, effective population sizes of bighorn herds are at best likely no more than one third their census number. At an effective population size of 25 individuals, genetic variance would be reduced by one half in about 35 generations. It is clear that the several small bighorn sheep demes in the Beartooths and Absarokas of Montana and northern Wyoming, if completely isolated, would be subject to rapid losses in fitness.

The mixing of rams from the Beartooth-Rock Creek herd with those from other herds on the Absaroka summer range suggests a potential for genetic interchange between widely separate wintering populations. A young ram, at an age when he is shifting his movement patterns from those of ewe-juvenile bands to mature rams, might very well follow an older ram to a winter range other than the one in which he was born if he is in a group which includes rams from different wintering herds when fall migration begins. After spending the rutting season and wintering with rams from the new herd, this young ram would likely incorporate the new winter range into his traditional movement pattern. Thereafter he would continue to return, eventually participate in the rut and sire offspring in that herd. No marked rams were observed to switch winter ranges during this study, but the sample size was far too low to detect such a switch. It seems likely that occasionally such interchanges occur.

Chesser (1982) suggested that the most effective model for maintenance of genetic variation involving isolation by distance is that of interbreeding demes within a series of "neighborhoods". This model is similar to the scenerio proposed for the Beartooth-Absaroka bighorn herds. Using computer simulations of an "island model" of migration, Allendorf (1982) found that exchange rates as low as one reproductively successful migrant individual per generation among demes would ensure that genetic variation is maintained in local populations, but would still allow genetic differentiation among demes in response to local selective pressures. Frankel and Soule (1981) suggest that for large mammals transfer rates of one to five individuals per generation would have the required result. These low exchange rates are probably realistic for the bighorn herds in question.

It is suggested then that the Beartooth-Rock Creek bighorn sheep population is a genetic part of a major zone of sheep populations, extending at least from the eastern Beartooths to the northeast corner of Yellowstone Park, and possibly as far as 180 km across Yellowstone Park to the Madison Range. The exchange rates between these populations are completely unknown and likely quite variable. Therefore the actual effects this exchange has on effective population size and population fitness can not be predicted. However, it can be inferred that exchange between these local wintering populations is extremely important in maintaining their viability. Loss of individual populations or their isolation due to barriers across migration corridors would be detrimental to the entire regional bighorn population.

Sound management of bighorn sheep herds is complicated when several different wintering populations use the same summer ranges as occurs on this study area. Because rams intermix over entire ranges, harvest quotas or regulations on the summer range cannot be adjusted to meet the needs of an individual herd. The manager might assume that the harvest quota is spread between the various herds in the proportions in which the various legal ram populations occur. However, due to: a) incomplete census knowledge of all the populations involved, b) the fact that the wintering areas are spread widely between different administrative districts, regions, states, and agencies, and c) chance deviations from expected harvest proportions, it is impossible to predict in such a situation what percent of a given ram population will be harvested. This obviously can result in unexpected overharvest of ram population segments.

Management of individual bighorn herds by restricting harvest to separate winter ranges is not a sound alternative. Hunting is a disturbance factor that causes rams to seek escape terrain or cover. On the summer range older rams were rarely observed once hunting season began. Because the one legal ram instrumented during the study was harvested on the third day of the 1977 season in Wyoming, no data was collected on changes in ram habitat use during the hunting season. Sheep hunters were of the general opinion that on the summer range legal rams dropped into timber, but it was also suggested that many move into Yellowstone Park to escape harassment. In either case hunting results in increased energy expenditures and the abandonment of accustomed use areas by rams (Geist 1971).

This disturbance is particularly serious on the winter range. By the time sheep return to these ranges snow has already begun to accumulate and the rut is about to begin. Increased energy expenditures by rams at this time will not be made up until late in the following spring. Hunting during the rut not only increases already elevated energy expenditures for older rams, but in the short term disrupts the social system at a time which is critical to the continued maintenance of population size, and in the long term selects against breeding by dominant high quality older rams and for that by opportunistic young rams. A population with most breeding by younger rams increases energy expenditures of females and results in less efficient use of sheep habitat (Geist and Petocz 1977).

Geist (1975) suggested that until an adequate system of reserves were established for relict natural populations of bighorn sheep we could not afford the luxury of managing natural populations for either consumptive or nonconsumptive purposes. However, discontinuing hunting of the Beartooth and Absaroka herds altogether is clearly an unacceptable alternative. They are substantial regional recreational and economic resources. The total elimination of bighorn sheep hunting would tend to reduce public interest and support for further study, management, and impact control, over the long term.

The study area is presently managed under three hunting districts in two states. Montana District 502, encompassing the Montana portion of the winter range and migration route, is on a quota/unlimited permit system with a season running from mid-September to mid-December. It is extended into December to allow local hunting of rams returning from the Absarokas. The quota of 3/4+ curl rams was 4 in 1979. Montana District 501, also on a quota/unlimited permit system, includes the

Wolverine Peak summer range subunit and has a season running from mid-September to late November. The quota was 5 rams in 1979. Wyoming Region 1, on a limited permit system, consists of the north Absaroka Mountains of Wyoming including the Wyoming subunits of the summer range and part of the winter range. The bighorn season here runs from the beginning of September to late November. Bordering Region 1 and District 502 is Yellowstone National Park where hunting is prohibited.

All rams of 3/4 or greater horn curl in the Beartooth-Rock Creek herd are therefore subject to hunting in at least two hunting districts for a period about one month longer than rams from surrounding herds. Hunting the ram population segment under more than one set of regulations over an extended season could potentially result in detrimental consequences for the Rock Creek herd.

Hunting the same ram population under multiple seasons and quotas increases the likelihood that a chance harvest aberation will result in serious and unforseen losses to that ram population. The percent of Rock Creek rams in the harvests in Region 1 and District 501 is unknown and probably low, but may fluctuate greatly between years due to random chance in hunter kill. In 1979 a total quota of about 25 rams were allowed in the three districts. The Rock Creek herd supported about eight legal rams during the study period so there is a definite possibility that all the legal rams from Rock Creek herd could be harvested during one season. The probability of this happening is likely low, but it demonstrates the fact that there is no way of predicting the harvest of Rock Creek rams under multiple seasons.

There is a further complication resulting from Rock Creek ram use of two summer ranges under different hunting seasons and regulations. Differing harvest rates between districts could eventually lead to the cessation of use of the district with the higher harvest rate. Differential loss of older rams summering in one district over a long period would result in ever fewer young rams learning of this summer range and eventually could result in the loss of that range to the ram population segment altogether. This in turn would lead to fewer rams supported by a more restricted range and just as important would result in increased isolation of the herd from neighboring herds, therefore decreasing the effective population size of bighorns in the entire region.

There is little data on the proportion of Rock Creek rams harvested in the three districts. If the harvest rate is highest in Wyoming's Region 1, the Wolverine Peak Montana range may be increasing in use and importance to Rock Creek rams. The Wolverine Peak subunit is more restricted in area and provides lower quality habitat than the Wyoming summer range. A trend from use of the Wyoming range to the Montana range would therefore likely be accompanied by a decrease in the quantity and quality of the ram segment of the herd.

No evidence was collected during the study that suggested the present hunting system is endangering the ram population of the Rock Creek herd or any other herd in the area in the short term. However, knowledge of all the individual herds involved is crude at best. More information is needed on the population size and composition, location and quality of winter ranges, and the degree of intermixing and interchange for all the herds using the Absaroka summer range before management plans can be proposed. Such management must take into consideration not only the individual herds within individual districts or states, but must be based on the needs of the entire regional assemblage of bighorn sheep populations if present population levels are to be maintained in the long run.

Based on the considerations given above, the following recommendation is offered for the short term management of the Beartooth-Rock Creek bighorn sheep population. Rock Creek rams provide hunting opportunities during September, October, and November in both Montana and Wyoming. The current practice of extending the hunting season into the rut on the winter range does not seem justifiable in the light of the possible long term harm it could be doing. Shortening or discontinuing the bighorn hunting season in District 502 would also decrease the possibility of chance overharvest of Rock Creek rams.

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APPENDICES

APPENDIX A

STUDY AREA VEGETATION DESCRIPTION

VEGETATION DESCRIPTION

The distribution of the 14 vegetation structure components and formations and plant species occurrence and coverage in selected vegetation communities within the structural types on the Beartooth winter range and Absaroka summer ranges are described below. Table 25 summarizes the vegetation stand data. A list of the scientific and common names of all plant species identified during the study is given in Table 26.

Rock Creek Winter Range

Coniferous Forest

Coniferous forests covered much of the canyon bottom and lower canyon wall terrain on the winter range. They extended from montane to lower timberline elevations, but were most prevalent in and below the lower subalpine zone. The tree structure often bordered grassland in the montane zone and bordered or surrounded meadows or shrub stands in the lower subalpine zone. Various rock components (cliff, outcrop, and talus) were intermixed with forests at all elevations on the canyon walls. At its upper elevational limits, the tree component graded into the scrub structure, and was commonly bordered above by the turf or mat structures.

Little quantitative vegetation work was performed in winter range forests, but several sites were habitat typed using the methods of Pfister et al (1977). Most forests fell into the Subalpine Fir (ABLA)

Table 25. A summary of sample stand data from plant communities in selected vegetation structures on the Beartooth-Rock Creek winter and Absaroka summer ranges, 1978 and 1979. (a)

Taxa	Winter Range		Summer Range									
	Turf	Mat	Turf					Mat		Snowbed	Meadow	
			Open		Closed	Scrubland		Rtp &	Bkn	Open &	Closed	Misc
			Slp	Bsn	Slp	Slp	Bsn	Slp	Bsn	Closed	Rtp	Slp
Sample Size (b)	19/19	8/7	14/10	9/9	18/16	9/5	4/3	15/7	6/1	2/2	3/3	9/2
Plant	100/85	100/49(c)	100/74	100/80	100/96	100/90	100/73	100/28	100/44	100/70	100/79	100/83
Graminoids	100/15	100/8	100/15	100/19	100/22	100/30	100/14	100/8	100/24	100/35	100/29	100/23
Forbs	100/67	100/36	100/55	100/58	100/61	100/55	100/55	100/21	100/20	100/23	100/49	100/62
Shrubs and Dwarf Shrubs	10/tr	13/tr	14/1	11/3	22/4	56/3	50/1	—	—	50/8	—	22/tr
Trees and Scrub	—	—	—	11/P	6/P	100/P	100/P	7/P	—	—	—	100/P
Substrate	100/15	100/51	100/26	100/20	94/4	78/10	100/27	100/73	100/56	100/31	100/21	100/18
Litter	58/1	50/4	29/1	—	17/tr	—	—	—	—	—	—	—
Rock	84/10	100/20	86/5	100/15	61/2	44/2	100/5	93/14	100/14	50/11	100/4	100/6
Scree	11/1	38/25	50/10	89/tr	22/tr	22/2	75/5	100/36	100/24	50/14	100/4	100/2
Soil	79/3	75/2	100/10	100/4	88/2	67/6	100/17	100/18	100/19	100/6	100/14	100/8
Graminoids												
Agropyron caninum	—	25/tr	—	—	17/tr	33/2	—	—	—	—	—	22/1
A. scribneri	32/1	75/1	36/1	44/+	39/tr	33/1	50/tr	100/4	100/6	—	33/tr	11/tr
Agrostis humilis	—	—	14/+	22/1	—	—	25/tr	—	—	—	—	—
Bromus spp.	—	13/1	—	—	6/tr	11/tr	—	—	—	—	—	—
Calamagrostis scopulorum	—	—	—	—	—	11/+	—	7/+	—	—	67/6	44/1
Carex spp.	100/9	75/4	86/8	67/11	100/12	78/10	100/5	27/tr	50/1	100/12	100/6	44/9
Deschampsia atropurpurea	16/tr	—	—	—	—	—	—	—	—	—	—	—
D. caespitosa	37/2	25/tr	14/+	44/tr	17/1	11/tr	—	7/+	67/13	100/17	—	11/2
Festuca idahoensis	—	—	7/+	67/+	17/tr	78/9	25/+	—	17/+	—	67/8	22/+
F. ovina	68/1	38/tr	79/1	44/2	78/1	44/2	25/tr	67/1	33/3	50/2	100/1	11/tr
Juncus drummondii	—	—	14/tr	33/+	22/1	22/2	50/2	—	—	—	—	—
Luzula hitchcockii	—	—	—	—	—	—	—	—	—	—	—	11/1
L. spicata	—	—	21/tr	33/1	33/2	22/tr	25/tr	—	17/1	—	—	—
Phleum alpinum	—	—	—	11/+	6/tr	22/tr	25/tr	—	—	—	—	22/1
Poa spp.	63/1	75/1	79/2	100/2	100/3	89/4	75/3	67/1	67/tr	100/4	67/3	78/2

Table 25. (continued)

Taxa	Winter Range Turf	Winter Range Mat	Summer Range: Turf, Open, Slp	Turf, Open, Bsn	Turf, Closed, Slp	Turf, Scrubland, Slp	Turf, Scrubland, Bsn	Mat, Rtp & Slp	Mat, Bkn Bsn	Snowbed, Open & Closed	Meadow, Closed, Rtp	Meadow, Misc, Slp
Stipa lettermanii	—	—	—	—	—	—	—	—	—	--	—	44/4
Tristetum spicatum	53/1	60/1	79/2	100/2	78/1	44/1	100/3	73/1	83/tr	50/tr	100/4	44/1
Unknown Graminoids	—	—	7/tr	—	11/tr	11/+	—	7/+	—	—	—	11/2
Forbs												
Achillea millefolium	68/1	50/2	57/3	100/7	44/2	89/5	100/10	60/2	83/2	—	100/7	89/1
Androsace septentrionalis	16/tr	—	29/1	56/1	17/tr	11/+	25/tr	13/tr	17/1	—	33/tr	—
Anemone multifida	5/tr	—	7/tr	—	11/tr	—	—	20/tr	—	—	—	—
Antennaria alpina	5/tr	38/1	50/1	44/+	39/1	44/tr	—	20/+	33/1	50/tr	67/tr	11/+
A. corymbosa	—	—	—	33/5	—	—	100/9	13/+	33/+	—	33/1	56/1
Antennaria spp.	—	—	—	22/+	—	—	—	—	—	—	—	11/tr
Aquilegia flavescens	—	—	—	—	—	—	—	—	—	—	—	11/2
Arabis lyalli	—	—	—	—	—	11/+	25/tr	13/tr	50/3	—	—	—
Arenaria congesta	—	—	—	78/tr	—	11/tr	75/3	—	17/+	—	33/2	22/+
A. nuttallii	21/tr	—	14/1	—	6/tr	11/1	—	—	—	—	—	—
A. obtusiloba	58/1	63/3	71/3	78/3	89/2	44/1	25/tr	67/1	50/4	50/tr	67/tr	11/+
A. rossii	—	—	—	—	—	—	—	—	17/+	—	—	—
Arnica longifolia	—	—	7/+	11/+	—	11/+	—	—	33/+	—	—	11/25
A. parryi	—	—	—	—	—	—	—	—	—	—	—	11/+
A. rydbergii	5/tr	—	—	—	—	11/tr	—	7/tr	—	—	—	11/1
Artemisia frigida	—	—	—	—	—	—	—	—	—	—	33/3	—
A. michauxiana	5/tr	38/2	7/tr	11/+	—	11/tr	50/3	13/+	17/+	—	33/1	44/6
A. scopulorum	37/1	25/tr	36/3	—	67/2	11/2	—	27/1	—	100/6	—	—
Aster alpigenus	11/tr	—	21/tr	33/4	11/tr	22/tr	50/3	7/+	50/1	—	—	—
Aster spp.	—	—	—	11/5	—	11/tr	—	—	—	—	—	11/9
Astragalus alpinus	—	—	50/2	56/1	78/3	56/2	50/8	33/tr	—	50/tr	33/2	11/+
A. kentrophyta	—	—	57/2	100/6	17/tr	22/+	25/1	67/2	50/+	—	33/4	22/+
Balsamorhiza sagittata	—	—	—	—	—	—	—	—	—	—	—	22/+
Bupleurum americanum	42/tr	38/tr	14/tr	—	28/tr	33/tr	—	7/+	17/+	—	33/1	—
Campanula parryi	5/tr	—	—	—	6/tr	—	—	—	—	—	33/tr	22/+
Castilleja cusickii	11/tr	—	21/tr	—	44/tr	22/tr	—	—	—	—	—	—
Cerastium berringianum	74/2	88/1	79/2	11/4	72/2	56/2	25/tr	40/1	—	—	100/6	—

Table 25. (continued)

Taxa	Winter Range Turf	Winter Range Mat	Summer Range Turf Open Slp	Turf Open Bsn	Turf Closed Slp	Turf Scrubland Slp	Turf Scrubland Bsn	Mat Rtp & Slp	Mat Bkn Bsn	Snowbed Open & Closed	Meadow Closed Rtp	Meadow Misc Slp
Chaenactis alpina	—	—	—	—	—	—	—	13/+	17/+	—	—	—
Cirsium scariosum	11/tr	50/tr	29/tr	33/+	—	11/+	50/2	53/1	83/+	—	33/tr	33/tr
Claytonia lanceolata	—	—	7/tr	—	—	—	—	—	—	—	—	—
C. megarhiza	—	13/tr	—	—	—	—	—	13/tr	—	—	—	—
Cymopterus hendersonii	5/tr	50/1	—	—	—	—	—	—	—	—	—	—
Dodecatheon conjugens	5/tr	13/+	7/tr	—	6/tr	—	—	—	—	50/tr	—	—
Draba crassifolia	5/tr	—	—	—	—	—	—	13/tr	—	—	—	—
D. densifolia	—	38/tr	—	—	—	—	—	13/tr	17/+	—	33/tr	—
D. lonchocarpa	—	13/tr	—	—	—	—	—	—	—	—	—	—
Draba spp.	—	—	—	—	11/tr	—	—	—	—	—	—	—
Epilobium angustifolium	—	—	—	—	—	11/+	—	—	—	—	—	11/4
E. glaberrimum	—	—	—	—	—	11/tr	—	—	—	—	—	—
Erigeron compositus	16/tr	63/1	14/tr	22/+	6/tr	11/+	—	47/1	33/+	—	33/1	11/+
E. rydbergii	58/1	38/tr	36/1	56/+	28/tr	—	75/3	7/+	—	—	—	—
E. simplex	74/1	13/+	36/1	—	56/2	22/tr	25/+	27/tr	—	50/tr	—	11/+
Eriogonum ovalifolium	11/tr	25/tr	—	11/+	—	—	—	20/tr	—	—	67/1	—
E. umbellatum	—	—	—	—	—	—	—	—	—	—	—	—
Eritrichium nanum	32/tr	13/tr	—	—	—	—	—	—	—	—	—	—
Erysimum asperum	5/tr	13/tr	—	—	—	—	—	—	—	—	—	—
Fragaria vesca	—	—	—	—	—	—	—	—	—	—	—	11/tr
F. virginiana	—	—	—	—	—	—	—	—	—	—	—	11/+
Geum rossii	100/24	88/4	64/7	67/1	89/17	44/7	—	47/3	33/tr	100/3	33/tr	—
Hedysarum sulphurescens	—	—	—	—	28/tr	—	—	—	—	—	—	22/+
Lewisia pygmaea	—	—	14/1	—	—	—	—	—	—	—	—	—
Linum perenne	—	—	—	—	—	—	—	7/+	—	—	33/1	—
Lloydia serotina	16/tr	—	21/1	—	33/tr	—	—	—	—	—	—	—
Lomatium cous	—	—	21/tr	—	22/1	—	—	13/2	—	—	—	—
Lupinus argenteus	5/1	—	29/4	11/+	56/5	100/8	—	7/tr	17/+	50/tr	—	56/4
Lupinus spp.	—	—	—	—	—	—	—	—	—	—	—	11/+
Mertensia alpina	74/2	38/tr	29/2	—	39/1	11/tr	—	—	—	—	—	—
M. ciliata	—	—	—	—	—	11/+	—	—	—	—	—	—
Myosotis sylvatica	53/1	25/tr	36/1	—	72/1	33/tr	—	20/tr	—	—	—	—
Oxyria digyna	5/tr	—	—	11/+	—	—	—	13/+	17/+	50/tr	—	—

Table 25. (continued)

Taxa	Winter Range		Summer Range									
	Turf	Mat	Turf					Mat		Snowbed	Meadow	
			Open		Closed	Scrubland		Rtp &	Bkn	Open &	Closed	Misc
			Slp	Bsn	Slp	Slp	Bsn	Slp	Bsn	Closed	Rtp	Slp
Oxytropis sericea	—	—	21/3	—	22/1	11/1	—	13/tr	—	—	67/8	—
Pedicularis groenlandica	—	—	—	—	6/tr	—	—	—	17/+	—	—	—
Pensteron fruticosus	—	—	—	—	—	—	—	—	17/+	—	—	—
P. procerus	—	—	21/tr	44/+	17/tr	11/tr	25/1	20/+	17/tr	—	33/tr	11/+
Pensteron spp.	—	—	7/tr	—	—	—	—	—	17/+	—	—	11/1
Phacelia hastata	—	25/1	—	33/+	—	22/tr	25/tr	13/tr	67/+	—	—	11/+
P. sericia	16/tr	13/tr	—	22/+	—	—	—	7/tr	50/+	—	33/tr	—
Phlox pulvinata	100/3	63/2	43/2	56/3	50/2	56/3	25/tr	33/1	50/1	—	33/2	—
Polemonium viscosum	16/tr	88/2	—	—	6/tr	—	—	13/tr	—	—	—	—
Polygonum bistortoides	26/1	25/tr	36/tr	—	56/1	44/tr	—	—	—	—	—	—
P. viviparum	21/tr	—	—	—	28/1	11/tr	—	—	—	50/3	—	—
Potentilla diversifolia	84/4	38/tr	71/3	22/3	83/4	67/8	75/tr	7/+	17/tr	100/5	—	11/+
P. quinquefolia	—	—	—	—	—	—	—	—	—	—	33/1	—
Potentilla spp.	—	13/tr	—	—	6/tr	—	—	—	—	—	—	44/1
Ranunculus eschscholtzii	—	—	21/tr	33/1	17/tr	—	—	7/+	17/1	100/4	—	—
Saxifraga bronchialis	47/1	50/tr	—	11/+	6/tr	11/+	25/tr	20/+	—	—	—	11/tr
S. flagellaris	—	—	14/tr	—	6/tr	—	—	—	—	—	—	—
S. oppositifolia	—	—	—	—	—	—	—	7/+	—	—	—	—
S. oregana	5/tr	13/+	—	—	6/tr	—	—	—	—	—	—	—
S. rhomboidea	5/tr	13/tr	7/tr	—	28/tr	—	—	27/1	—	50/tr	—	—
Saxifraga spp.	5/tr	—	—	—	—	11/tr	—	—	—	—	—	—
Sedum lanceolatum	37/tr	50/tr	50/1	33/1	50/1	56/1	50/tr	4/tr	17/tr	—	100/1	22/+
S. roseum	16/tr	38/tr	7/tr	—	17/tr	—	—	—	—	50/1	—	—
Senecio canus	—	13/tr	29/1	22/+	22/tr	22/tr	—	33/tr	33/+	—	100/3	—
S. crassulus	—	—	—	—	—	11/+	—	13/tr	—	—	—	—
S. fremontii	—	—	—	—	—	11/+	—	47/tr	50/3	—	—	—
S. fuscatus	16/tr	—	—	—	—	—	—	—	—	—	—	—
S. serra	—	—	—	11/+	—	33/3	—	—	—	—	—	33/1
S. triangularis	—	—	—	—	—	—	—	—	—	—	—	11/3
S. werneriaefolius	21/1	38/tr	—	—	6/tr	11/1	—	20/tr	—	50/tr	—	—
Senecio spp.	5/tr	13/tr	—	—	6/tr	—	—	—	—	—	—	—

Table 25. (continued)

Taxa	Winter Range Turf	Winter Range Mat	Summer Range: Turf, Open Slp	Turf, Open Bsn	Turf, Closed Slp	Turf, Scrubland Slp	Turf, Scrubland Bsn	Mat, Rtp & Slp	Mat, Bkn Bsn	Snowbed Open & Closed	Meadow, Closed Rtp	Meadow, Misc Slp
Sibbaldia procumbens	—	—	21/1	56/7	6/tr	11/tr	75/2	—	—	50/1	—	22/tr
Silene acaulis	74/2	38/1	43/2	44/2	61/2	22/tr	75/1	33/1	17/2	50/tr	—	—
Smelowskia calycina	42/2	13/tr	21/tr	—	33/1	11/tr	—	33/tr	—	—	33/tr	—
Solidago multiradiata	—	—	29/1	100/4	61/2	33/1	100/10	27/+	83/1	50/tr	33/3	33/tr
Stellaria americana	5/tr	25/tr	—	—	—	—	—	7/tr	—	—	—	—
Taraxacum lyratum	11/1	—	36/1	11/4	44/1	67/3	—	13/1	17/4	—	—	—
Trifolium dasyphyllum	11/1	25/tr	—	—	—	—	—	—	—	—	—	—
T. haydenii	68/6	75/7	—	—	—	—	—	—	—	—	—	—
T. nanum	74/5	13/tr	—	—	—	—	—	—	—	—	—	—
Trifolium spp.	5/1	13/2	—	—	—	—	—	—	—	—	—	—
Veronica wormskjoldii	—	—	—	—	—	—	—	—	—	50/tr	—	—
Viola adunca	—	—	7/tr	—	—	—	—	—	—	—	—	—
Unknown Forbs	16/tr	25/tr	43/1	11/tr	44/1	44/1	—	33/tr	—	—	67/tr	56/3
Shrubs and Dwarf Shrubs												
Berberis repens	—	—	—	—	—	—	—	—	—	—	—	22/tr
Dryas octopetala	—	—	7/+	—	17/1	11/tr	—	—	—	—	—	—
Juniperus communis	—	13/tr	—	—	—	—	—	—	—	—	—	—
Phyllodoce empetriformis	—	—	7/+	11/3	—	—	25/4	—	—	—	—	—
Ribes spp.	5/tr	—	—	—	—	22/+	—	—	—	—	—	—
Salix spp.	—	—	14/1	—	22/3	11/3	25/4	—	—	50/8	—	—
Vaccinium scoparium	—	—	7/+	—	—	33/tr	50/1	—	—	—	—	11/tr
Trees and Scrub												
Abies lasiocarpa	—	—	—	—	—	100/P	100/P	—	—	—	—	100/P
Picea engelmannii	—	—	—	—	6/P	67/P	100/P	—	—	—	—	56/P
Pinus albicaulis	—	—	—	11/P	—	89/P	100/P	7/P	—	—	—	56/P
P. contorta	—	—	—	—	—	—	—	—	—	—	—	33/P
Pseudotsuga menziesii	—	—	—	—	—	—	—	—	—	—	—	33/P

Table 25. (continued)

Taxa	Winter Range		Summer Range									
	Turf	Mat	Turf					Mat		Snowbed	Meadow	
			Open		Closed	Scrubland		Rtp &	Bkn	Open &	Closed	Misc
			Slp	Bsn	Slp	Slp	Bsn	Slp	Bsn	Closed	Rtp	Slp
Other												
Fern	10/tr	—	—	—	—	11/+	—	—	—	—	—	11/tr
Lichen (Soil Borne)	53/1	38/1	14/tr	—	22/tr	—	—	—	—	—	—	—
Selaginella densa	68/2	63/2	36/4	33/tr	67/1	—	50/1	20/tr	—	—	33/tr	—
Unknown Mosses	47/1	38/tr	21/tr	—	56/2	22/tr	—	13/+	—	100/4	33/tr	—

a) Abbreviations: Slp = Slope, Bsn = Basin, Rtp = Ridgetop, Bkn Bsn = Broken Scree Basin. tr = Less than 0.5%, P = Present but cover not quantified, + = Present but not detected by quantitative sampling method.
b) Total number of stands examined / Number quantitatively sampled for taxa coverage.
c) Data presented as: Constancy / Mean % Cover, where
Constancy = the percent of stands examined in which taxa was present, and
Mean % Cover = Mean coverage of taxa in those stands sampled quantitatively.

Table 26. Vascular plant species identified from the Beartooth winter and Absaroka summer bighorn sheep ranges, 1978-1979.

Graminoids	
Agropyron caninum	Slender Wheatgrass
A. scribneri	Scribner Wheatgrass
A. spicatum	Bluebunch Wheatgrass
Agrostis humilis	Alpine Bentgrass
Bromus ciliatus	Fringed Brome
B. inermis	Smooth Brome
Calamagrostis canadensis	Bluejoint Reedgrass
C. scopulorum	Cliff Reedgrass
Carex geyeri	Elk Sedge
Carex spp.	Sedge
Deschampsia atropurpurea	Mountain Hairgrass
D. caespitosa	Tufted Hairgrass
Festuca idahoensis	Idaho Fescue
F. ovina	Sheep Fescue
Festuca spp.	Fescue
Juncus drummondii	Drummond's Rush
Luzula hitchcockii	Smooth Woodrush
L. spicata	Spiked Woodrush
Phleum alpinum	Alpine Timothy
Poa alpina	Alpine Bluegrass
P. nevadensis	Nevada Bluegrass
P. rupicola	Timberline Bluegrass
Poa spp.	Bluegrass
Stipa lettermanii	Letterman's Needle-grass
S. occidentalis	Western Needle-grass
Trisetum spicatum	Spike Trisetum
Forbs	
Achillea millefolium	Yarrow
Androsace septentrionalis	Fairy Candelabra
Anemone multifida	Cliff Anemone
Antennaria alpina	Alpine Pussytoes
A. corymbosa	Flat-topped Pussytoes
Antennaria spp.	Pussytoes
Aquilegia flavenscens	Yellow Columbine
Arabis lyalli	Lyall's Rockcress
Arenaria congesta	Ballhead Sandwort
A. nuttallii	Nuttall's Sandwort
A. obtusiloba	Arctic Sandwort
A. rossii	Ross Sandwort
Arnica cordifolia	Heart-leaf Arnica
A. latifolia	Mountain Arnica

Table 26. (continued)

Forbs (continued)	
A. longifolia	Seep-spring Arnica
A. parry	Nodding Arnica
A. rydbergii	Rydberg's Arnica
Artemisia frigida	Fringed Sagebrush
A. michauxiana	Michaux Sagebrush
A. scopulorum	Alpine Sagebrush
Aster alpigenus	Alpine Aster
Aster spp.	Aster
Astragalus alpinus	Alpine Milkvetch
Astragalus kentrophyta	Kentrophyta
Balsamorhiza sagittata	Arrowleaf Balsamroot
Bupleurum americanum	American Thorway
Caltha leptosepala	Elkslip
Campanula parryi	Parry's Harebell
Castilleja cusickii	Hairy Indian Paintbrush
Castilleja spp.	Indian Paintbrush
Cerastium berringianum	Alpine Chickweed
Chaenactis alpina	Alpine Dusty Maiden
Cirsium scariosum	Elk Thistle
Claytonia lanceolata	Western Springbeauty
C. megarhiza	Alpine Springbeauty
Cymnopterus hendersonii	Henderson's Cymnopterus
Dodecathèon conjugens	Shooting Star
Draba crassifolia	Thickleaved Draba
D. densifolia	Whitlowgrass
D. lonchocarpa	Lancefruit Draba
D. oligosperma	Few-seeded Draba
Draba spp.	Draba
Epilobium angustifolium	Fireweed
E. glaberrimum	Smooth Willow-weed
Erigeron compositus	Cutleaved Daisy
E. rydbergii	Rydberg's Daisy
E. simplex	Alpine Daisy
Eriogonum ovalifolium	Oval-leaf Eriogonum
E. umbellatum	Sulfur Buckwheat
Eritrichium nanum	Pale Alpine Forget-me-not
Erysimum asperum	Rough Wallflower
Fragaria vesca	Woods Strawberry
F. virginiana	Broadpetal Strawberry
Galium trifidum	Sweet Scented Bedstraw
Gentiana algida	Whitish Gentian
Geum rossii	Ross' Avens
Hedysarum sulphurescens	Yellow Hedysarum
Lewisia pygmaea	Alpine Lewisia
Linnaea borealis	Twin Flower

Table 26. (continued)

Forbs (continued)

Linum perenne	Blue Flax
Lloydia serotina	Alpine Lily
Lomatium cous	Cous Biscuit-root
Lupinus argenteus	Silvery Lupine
Lupinus spp.	Lupine
Mertensia alpina	Alpine Bluebell
M. ciliata	Broad-leaf Bluebell
Myosotis sylvatica	Alpine Forget-me-not
Oenothera caespitosa	Tufted Evening Primrose
Oxyria digyna	Mountain Sorrel
Oxytropis sericea	Silky Crazyweed
Parnassia fimbriata	Fringed Parnasia
Pedicularis bracteosa	Bracted Pedicularis
P. groenlandica	Elephantshead
Penstemon fruticosus	Shrubby Penstemon
P. procerus	Small-flowered Penstemon
Penstemon spp.	Penstemon
Phacelia hastata	Silverleaf Phacelia
P. sericia	Silky Phacelia
Phlox pulvinata	Cushion Phlox
Polemonium viscosum	Sky Pilot
Polygonum bistortoides	Western Bistort
P. viviparum	Alpine Bistort
Potentilla diversifolia	Diverse-leaved Cinquefoil
P. gracilis	Soft Cinquefoil
P. quinquefolia	Five-leaved Cinquefoil
P. recta	Erect Cinquefoil
Potentilla spp.	Cinquefoil
Ranunculus eschscholtzii	Subalpine Butterweed
Saxifraga arguta	Brook Saxifrage
S. bronchialis	Yellowdot Saxifrage
S. flagellaris	Stoloniferous Saxifrage
S. oppositifolia	Purple Saxifrage
S. oregana	Bog Saxifrage
S. rhomboidea	Diamond-leaf Saxifrage
Saxifraga spp.	Saxifrage
Sedum lancolatum	Lance-leaf Stonecrop
S. roseum	Roseroot
Senecio canus	Wooly Groundsel
S. crassulus	Thick-leaved Groundsel
S. fremontii	Dwarf Mountain Butterweed
S. fuscatus	Twice Hairy Butterweed
S. serra	Tall Butterweed
S. triangularis	Arrow-leaf Groundsel

Table 26. (continued)

Forbs (continued)	
S. werneriaefolius	Rock Butterweed
Senecio spp.	Butterweed
Sibbaldia procumbens	Creeping Sibbaldia
Silene acaulis	Moss Champion
Smelowskia calycina	Alpine Smelowskia
Solidago multiradiata	Northern Goldenrod
Stellaria americana	American Starwort
Taraxacum lyratum	Alpine Dandelion
Thalictrum occidentale	Western Meadowrue
Townsendia parryi	Parry Townsendia
Trifolium dasyphyllum	Whiproot Clover
T. haydenii	Hayden's Clover
T. nanum	Dwarf Clover
Trifolium spp.	Clover
Veronica wormskjoldii	American Alpine Speedwell
Viola adunca	Early Blue Violet
Zygadenus elegans	Alpine Death Camas
Shrubs and Trees	
Abies lasiocarpa	Subalpine Fir
Alnus incana	Thinleaf Alder
A. sinuata	Sitka Alder
Arctostaphylos uva-ursi	Kinnikinnick
Artemisia arbuscula	Dwarf Sage
A. tridentata	Big Sage
Berberis repens	Creeping Oregongrape
Betula occidentalis	Water Birch
Ceanothus velutinus	Snowbrush Ceanothus
Cornus stolonifera	Red Dogwood
Dryas octopetala	White Dryas
Juniperus communis	Common Juniper
Phyllodoce empetriformis	Pink Mountain Heath
P. glanduliflora	Yellow Mountain Heath
Physocarpus malvaceus	Ninebark
Picea engelmannii	Engelman's Spruce
Pinus albicaulis	Whitebark Pine
P. contorta	Lodgepole Pine
P. tremuloides	Quaking Aspen
Potentilla fruticosa	Shrubby Cinquefoil
Pseudotsuga menziesii	Douglas Fir
Ribes spp.	Gooseberry
Rosa acicularis	Prickly Rose
Salix spp.	Willow

Table 26. (continued)

Shrubs and Trees (continued)	
Symphoricarpos spp.	Snowberry
Vaccinium globulare	Blue Huckleberry
V. scoparium	Grouse Whortleberry
Vaccinium spp.	Blueberry

habitat series. Only in the lower canyon areas on the fringes of the winter range were Douglas Fir (PSME) series habitats present. Douglas fir nevertheless dominated many stands, especially on canyon walls below 2440 m (8000 ft). Dense lodgepole pine stands covered large areas of the canyon bottom up to 2380 m (7800 ft). Much of the canyon bottom and lower walls above 2320 m (7600 ft) were devoid of trees due to extensive burns during the late 1940's.

Subalpine fir dominated many stands on north and east facing canyon walls above 2440 m (8000 ft) with Subalpine Fir/Grouse Whortleberry (ABLA/VASC ht.) and Subalpine Fir-Whitebark Pine/Grouse Whortleberry (ABLA-PIAL/VASC ht.) being the most common habitat types present. Spruce was an important species of wetter sites on these slopes. South facing slopes above 2440 m (8000 ft) were dominated primarily by whitebark pine stands with scree or talus dominating in the understory. The Whitebark Pine (PIAL ht.) and Forested Scree habitats were common on south exposures.

Coniferous Scrub

This structural type, also known as krummholtz, was common on upper canyon walls and some plateau areas from the lower timberline into the alpine elevational zones but was most prevalent in the upper timberline zone. Scrub was generally closely associated with turf or mat vegetation and various rock structures.

The scrub overstory consisted of patches or fingers of dwarfed and deformed subalpine fir, whitebark pine, and spruce. Understory composition was quite variable and generally dominated by litter or exposed substrate (bare soil, rock or rock outcrop). Understory species coverage was estimated on one Coniferous Scrub site on the winter range. Graminoids and forbs comprised 4 and 27 % of understory cover, respectively. Substrate exposure averaged 69 %, with bare soil and litter predominant. Hayden's clover was the only plant species with significant coverage. Other species which were commonly observed in the understory of scrub sites were bluegrasses, sedges, yellowdot saxifrage, and clubmoss.

Evergreen/Deciduous Shrubland

The shrubland formation was not extensive in coverage, but was found throughout the winter range at all elevations. It included several floristically distinct vegetation communities which occupied diverse habitats from montane canyon bottoms to alpine plateaus. At lower elevations the shrub component was commonly associated with the tree, grassland, or meadow structures, and often occurred at the base of talus fields or cliffs. At upper elevations it was generally surrounded by turf. Little floristic work was done in this structural type.

In nonforested areas of the lower Rock Creek canyon bottom and on lower south facing canyon walls between approximately 2160 m and 2320 m (7100 and 7600 ft) bunchgrass-sage stands occurred which conformed to the Big Sage/Idaho Fescue shrubland habitat type (ARTR/FEID ht.) of Meuggler and Stewart (1980) at lower elevations and to the Dwarf Sage/Idaho Fescue habitat type (ARAR/FEID ht.) at upper elevations.

Small quaking aspen stands occurred in burn areas on lower canyon walls near or intermixed with coniferous forest stands. These communities were included in the shrub structural category because of their patchy nature and height generally less than 5 m.

Low deciduous and evergreen shrubs were found as scattered individuals and in patches on lower canyon walls between 2320 m and 2680 m (7600 to 8800 ft). Shrub cover on some old burn sites was sufficient to warrant classification as the Evergreen/Deciduous Shrub formation. The more common species were snowberry, prickly rose, snowbrush ceanothus, ninebark, grouse whortleberry, common juniper, and kinnikinnick.

Riparian shrub communities occurred along streams in canyon bottoms to 2560 m (8400 ft). Characteristic shrubs included thinleaf alder, water birch, red dogwood, quaking aspen, and willow.

Dwarf alpine willow communities were found in gentle drainage basins on alpine plateaus. These communities were briefly described by Johnson and Billings (1962) under the designation "Salix Thicket". A species list and cover estimate was obtained from one site characterized by an overstory of willow mostly less than 1 m in height with an understory dominated by sedge. Graminoids, forbs and shrubs made up 33, 38, and 23 % cover, respectively. Important forbs included alpine bluebell, sivery lupine, western bistort, and diverse-leaved cinquefoil.

Montane/Subalpine Grassland

This structural type had little coverage on the winter range, occuring only in the lower Rock Creek canyon. No floristic work was done here. Some stands appeared to conform to the Idaho Fescue/Bluebunch Wheatgrass grassland habitat type of Mueggler and Stewart (1980).

Subalpine Meadow

Due to an overall dominance of forb species all herbaceous plant communities located in the subalpine and lower timberline elevation zones were classified as the meadow vegetation structure. Meadows occurred in burned areas in the canyon bottom, as well as on open canyon walls. This structure included many floristically diverse plant communities, but little vegetation work was completed in this type. One canyon wall meadow with significant spring bighorn use appeared to conform to the Western Needlegrass phase of the Idaho Fescue/Bluebunch Wheatgrass grassland habitat type of Mueggler and Stewart (1980), however most meadow sites could not be habitat typed using their descriptions.

Alpine Turf

Sites located in the upper timberline and alpine elevational zones with continuous herbaceous vegetation coverage were classified as the turf structure. On the winter range, the turf structure occurred in extensive uninterrupted stands on plateaus and as smaller patches surrounded by rock, rock outcrop and scrub components on canyon walls. It was most prevalent in the upper timberline and alpine elevational zones, but on north and east exposures turf vegetation associations were observed in the lower timberline zone down to 2800 m (9200 ft).

Winter range floristic work was concentrated on the turf structural type. Nineteen sites were described and sampled quantitatively (Table 25). Ross' avens and sedges were dominant species on almost all turf sites. Graminoids averaged 15 % coverage. Aside from sedges the most frequently recorded graminoid species were sheep fescue and bluegrasses. Tufted hairgrass was of significant coverage on gentle north and east plateau exposures. Spike trisetum was commonly observed on rockier sites, especially on the canyon walls.

Forb species dominated the turf structure, averaging 67 % cover. After Ross' avens, the most common species were diverse-leaved cinquefoil, dwarf clover, and Hayden's clover. Cushion phlox was a constant species on plateaus and rocky sites on canyon walls. Alpine bluebell was another constant species on plateau sites. Clubmoss was commonly present, especially on canyon wall sites.

Substrate averaged 15 % exposure on turf sites with rock being the most important component except on some plateau sites where bare soil supplanted rocks in exposure.

Johnson and Billings (1962) floristically described the vegetation of the Beartooth Plateau. Their "Geum Turf" and "Deschampsia Meadow" communities were included in the Alpine Turf structural formation recognized in this study.

Alpine Mat

The alpine mat structural formation was distinguished from the turf structure primarily on the basis of plant coverage. Restricted discontinuous patches of upper timberline and alpine herbaceous vegetation interspersed with exposed substrate structures were classified as the mat structure. The mat structure graded into turf as vegetation cover increased and exposure of substrate components declined. In transition zones a general rule of 50 % substrate exposure was used to distinguish the two structures.

On the winter range mat vegetation occurred widely in the timberline and alpine zones. It was primarily associated with rock outcrops and cliffs on canyon walls, although it also appeared on exposed windswept plateau sites. As substrate structures often dominated locations with mat vegetation, the Alpine Mat formation was much less common than the mat component itself.

Eight alpine mat sites were described on the winter range, seven quantitatively (Table 25). Mat vegetation associations were generally dominated by exposed rock, although in a few scree was predominant. As in the turf structure, Ross' avens and sedges were often the dominant plant species, but occurred at greatly reduced coverage levels. Graminoid and forb cover averaged only 8 and 36 %, respectively, while substrate exposure averaged 51 %. Vegetation coverage was overestimated on mat sites due to a bias against quantitatively sampling areas of exposed rock. Bluegrasses and Scribner's wheatgrass were common grasses, as was spike trisetum to a lesser extent. Hayden's clover, arctic sandwort, and yarrow were common forbs on rocky sites, while Michaux sagebrush and silverleaf phacelia frequently occurred on dirt-scree dominated slopes. Clubmoss was a constant species on rocky sites.

Alpine Snowbed

Timberline or alpine herbaceous plant communities influenced by the melting of perpetual or summer persistent snowbanks were classified as snowbed vegetation. It was structurally similar to both turf and mat vegetation. The snowbed structure occurred below snow accumulation sites on the plateaus, sometimes over large areas, and occupied restricted sites under snowbanks on canyon walls.

No winter range snowbed sites were sampled floristically. The snowbed structure on plateaus included the "*Carex scopulorum* Bog" and "early snowbed" vegetation types described by Johnson and Billings (1962).

Sparsely Vegetated Cliff

Cliffs were prominent features of winter range canyon walls in all elevational zones and on all exposures. The mat and scrub or tree and meadow structures were often associated with cliffs on ledges. Because vegetation coverage on most cliffs was insignificant, these sites were generally classified as the Sparsely Vegetated Cliff formation.

Sparsely Vegetated Outcrop

Rock outcrops were a characteristic feature of canyon walls and were common in some plateau areas on the winter range. Mat was the most common vegetation structure associated with this substrate type. Turf often surrounded individual rock outcrops in less broken areas. In the subalpine zones the meadow component replaced mat and turf. Trees, scrub, and shrubs also were common associates with rock outcrop. The more extensive areas of broken rock outcrop with little associated vegetation were classified as the Sparsely Vegetated Outcrop formation.

Sparsely Vegetated Talus

Talus fields were common on canyon walls in all elevational zones. Extensive talus fields occurred below cliffs and intermixed with rock outcrops. Plant cover was generally quite sparse or entirely absent. Scattered trees or small patches of mat vegetation occasionally were found at the base of talus fields, while turf, meadow, and tree components sometimes bordered them. Extensive talus fields were classifed as the Sparsely Vegetated Talus formation.

Sparsely Vegetated Rockland

Sites with exposed consolidated rock fields were found on and near the edges of plateaus, often associated with the turf or mat structures, and under receeding snowfields on plateaus in association with snowbed vegetation. These sites were in general not very extensive in coverage and were dominated by surrounding vegetation components. Therefore the Sparsely Vegetated Rockland formation was rare on the winter range.

Sparsely Vegetated Dirt-Scree

The dirt-scree structure occurred as scree dominated canyon wall slopes and as restricted bare soil sites on plateaus. Depending on the elevational zone, the mat or meadow structure was often found interspersed with this type. Scrub and tree patches were also common associates on canyon walls. Due to the granitic parent material of the winter range, dirt-scree sites were uncommon and often overshadowed by surrounding substrate or vegetation components. Therefore the Sparsely Vegetated Dirt-Scree formation was rare on the winter range.

Snowfield

Persistent snowfields covered significant areas on alpine plateaus and extended down the canyon walls as far as the upper subalpine zone. Canyon wall snowfields were often surrounded by rock outcrops with or without mat vegetation. Below were talus or dirt-scree slopes or occasionally snowbed vegetation. Snowfields on the plateaus were less persistent than those on canyon walls but in some cases supported areas of green snowbed vegetation throughout the summer, surrounded by dessicated turf communities. Sites exposed by melting snowfields prior to about mid-July generally conformed to the snowbed vegetation component, those exposed later were dominated by dirt-scree or rock substrate components.

Absaroka Summer Range

Coniferous Forest

Coniferous forests covered almost all of the summer range study area below the timberline elevational zones. Openings in the forest canopy were usually restricted in size and occupied by the dirt-scree, rock and meadow structures. Forest cover in the lower timberline zone was less extensive. Occasionally, especially on south exposures, restricted fingers of the forest structural type extended into the upper timberline and even a short distance into what was generally considered the alpine zone. Tree cover was generally restricted to scattered stands surrounded by extensive areas of alpine turf or dirt-scree and rock types.

Several forested sites on the summer range were keyed to forest habitat type using the Pfister et al (1977) classification scheme. Douglas fir series habitat types occurred at elevations below 2260 m (7400 ft). The most common type appeared to be the Douglas Fir/Elk Sedge habitat type (PSME/CAGE ht) which occurred along the eastern fringes of the summer range in the valleys of the major drainages.

The subalpine zones supported a variety of Subalpine Fir series habitat types. The Subalpine Fir/Bluejoint habitat type, Bluejoint phase (ABLA/CACA-CACA ht.), was widely distributed, but restricted to moist sites on valley floors near stream courses and on some lower ridgeside positions near seeps. Subalpine fir was generally the dominant overstory species. On lower subalpine sites spruce was a major overstory species. Lodgepole pine was often a major species of seral stands. On upper subalpine sites subalpine fir was generally dominant with substantial coverage of spruce. Lodgepole and whitebark pine were often present but of low coverage. The understory generally conformed to the habitat description given by Pfister et al (1977), bluejoint and arrowleaf groundsel being the most common species.

The Subalpine Fir/Grouse Whortleberry type (ABLA/VASC ht.) was the forest habitat with the most coverage on the summer range. This lower subalpine type covered extensive areas on valley floors and ridgesides. Two phases were found on the study area. The Western Meadow Rue (THOC) phase occupied moist areas often bordering the ABLA/CACA ht. Lodgepole pine was generally a dominant species on all sites examined except one lower elevation site dominated by Douglas fir. Spruce was generally a major species and occasionally whitebark pine was important. On most sites subalpine fir was restricted to young trees growing in the understory. Understory in this phase was dominated by western meadow rue. The VACA phase was the most abundant on the study area, occupying drier sites. Lodgepole pine generally dominated with spruce and subalpine fir being less important. Undergrowth was dominated by extensive grouse whortleberry coverage.

Restricted areas of the Subalpine Fir/Blue Huckleberry habitat type (ABLA/VAGL ht.) were found on some north and east slopes in the lower subalpine zone. Subalpine fir or lodgepole pine dominated the few stands examined, with spruce being generally present. Blue huckleberry and grouse whortleberry were the dominant understory species.

One creek side site in the lower subalpine zone was keyed to the Subalpine Fir/Sweet Scented Bedstraw habitat type (ABLA/GATR ht.). This site was dominated by lodgepole pine with scattered spruce and young subalpine fir.

Additional habitat types believed to be present in the lower subalpine zone on the summer range study area were: Subalpine Fir/Twinflower (ABLA/LIBO ht.) at lower elevations on north facing ridge slopes; Subalpine Fir/Sitka Alder (ABLA/ALSI ht.) in restricted sites on north facing slopes; and Subalpine Fir/Elk Sedge (ABLA/CAGE ht.) at lower elevations on dry south facing slopes.

In the upper subalpine zone the most common forest habitat was the Subalpine Fir-Whitebark Pine/Grouse Whortleberry type (ABLA-PIAL/VACA ht.). These sites were generally dominated by subalpine fir with whitebark pine usually being a codominant or at least an important species. Spruce was occasionally an important species as was lodgepole pine. Grouse whortleberry was the dominant understory species on all sites.

In the timberline zones, forested habitats generally conformed to the Whitebark Pine-Subalpine Fir habitat types (PIAL-ABLA hts.) of Pfister et al (1977). On these sites whitebark pine, subalpine fir, and spruce occurred together in varying amounts, subalpine fir was stunted. In the upper timberline zone all tree species were generally stunted and deformed and the formation was classified as coniferous scrubland. Understory species composition was extremely variable. Grouse whortleberry and mountain heath were important species on moist sites while sedges, Idaho fescue, ballhead sandwort, and silvery lupine were common species on dry sites. On a few dry south slopes and ridges the timberline forest conformed to the Whitebark Pine habitat type (PIAL ht.). Timber stands on these types were composed almost exclusively of whitebark pine with understory similar to other timberline forest types.

On some of the steep slopes on the summer range, in all elevational zones and on all exposures, timber formed a significant coverage over a dirt-scree base and conformed to the Forested Scree habitat type of Pfister et al (1977).

Coniferous Scrubland

The scrubland structural formation was found from upper subalpine to alpine elevations, but was only common in the upper timberline zone on the summer range. Scrub generally occurred either as scattered islands or as long fingers on slopes and was often surrounded by turf or dirt-scree and rock components. Scrub species included whitebark pine, subalpine fir, and spruce in varying amounts. Understory cover was often replaced by dirt-scree. Species composition was generally dependent on that of surrounding open areas.

Four scrub sites were examined, three quantitatively, in hanging alpine and upper timberline basins dominated by broken outcrops and dirt-scree (Table 25). Understory coverage of graminoids, forbs, shrubs, and clubmoss averaged 14, 55, 1, and 1 %, respectively. Yarrow and northern goldenrod were the most constant species with significant understory coverage. Other common forbs were ballhead sandwort and alpine milkvetch. Important graminoids were sedges, spike trisetum and bluegrasses. Grouse whortleberry occurred in the understory of some sites. Bare soil, litter, rock, and scree cover averaged 27 % understory exposure on the sites sampled.

Nine scrub sites were examined, five quantitatively, on alpine and upper timberline slopes (Table 25). Understory cover was sparse in these stands so herbaceous vegetation immediately surrounding the scrub patches were sampled. Mean coverage of graminoids, forbs and shrubs was recorded at 30, 55, and 3 % respectively. These sites were generally dominated by sedges, mixtures of Idaho and sheep fescue, and silvery lupine. On east and north slopes bluegrass replaced fescues and sedges as the dominant graminoids and alpine milkvetch became a dominant forb species. On south and west exposures diverse-leaved cinquefoil and yarrow were often important forbs. Bare areas of rock, scree and soil averaged 10 % coverage.

Evergreen/Deciduous Shrubland

This structural type was rare on the summer range. Shrubs were scattered throughout many subalpine areas but generally occurred as understory species within the forest structural type. Dwarf alpine shrubs less than 0.3 m in height, such as some alpine willow species, white dryas, and mountain heath, were not classifed as shrubs in the structural classification scheme used during this study. Lower elevation stream courses on valley floors occasionally supported riparian shrub stands, but these were not examined.

Montane/Subalpine Grassland

Scattered openings in subalpine and lower timberline forests were classified as the grassland structural type on the summer range. Large openings dominated by tufted hairgrass and sedges occurred on upper subalpine and timberline valley floors. These sites conformed to the Tufted Hairgrass/Sedge grassland habitat type (DECA/CAREX ht.) of Mueggler and Stewart (1980). In north and east facing hanging basins, this type sometimes graded into the Idaho Fescue/Tufted Hairgrass grassland habitat (FEID/DECA ht.) on lower ridgesides and thence into alpine vegetation. Some forest openings in subalpine valleys keyed to the Idaho Fescue/Slender Wheatgrass grassland habitat (FEID/AGCA ht.).

Subalpine Meadow

Herbaceous vegetation structures in the subalpine and lower timberline zones which did not conform to the grassland habitat types listed above were classified as the meadow structural component. This structure encompassed many floristically diverse vegetation communities. Discontinuous (patchy and/or open) herbaceous vegetation was classified as the meadow component if it occurred in the subalpine zones, while that in and above the timberline zones was considered to be the mat structure. Dirt-scree, rock, and tree were the most common structural components associated with the meadow type on the summer range.

Meadow sites with a continuous herb layer often occurred on ridgetops which dropped gradually south or west from the timberline into the subalpine zone. These meadows were bordered below by forests, rock outcrops and dirt-scree. Three such sites were sampled quantitatively (Table 25). Graminoids, forbs, and moss averaged 29, 49, and 1 % cover, respectively. Yarrow and sedges were the most constant species at significant cover levels. Grasses of importance were Idaho fescue and spike trisetum. Alpine chickweed, silky crazy weed, and wooly groundsel were important forbs. Bare soil, scree, and rock averaged 21 % exposure with soil being the most important component.

Nine other meadow sites were examined, two quantitatively, in a variety of vegetation associations (Table 25). Discontinuous meadow vegetation on subalpine dirt-scree slopes and in broken basins was often dominated by lupine, with Michaux sagebrush also being a common species. Forb rich meadow vegetation often occurred on restricted moist seep areas at the base of talus slopes and cliffs. One such site in the upper subalpine zone was dominated by a dense stand of seep spring arnica, with sedges, fireweed and arrowleaf groundsel as secondary species. An open stand of cliff reedgrass, kentrophyta, and elk thistle was found on a rocky slope at the base of one lower timberline cliff examined. Openings in the subalpine forest on steep south exposures were often dominated by Michaux sagebrush, pussytoes and yarrow. Letterman's needlegrass was sometimes an important grass as were various bluegrasses. Arrowleaf balsamroot was occasionally an important forb on these sites. Several other floristic associations were included in the meadow structural type but these were not examined.

Alpine Turf

On the summer range the alpine turf structural type occurred over extensive areas of the upper timberline and alpine elevational zones. Turf commonly bordered patches or extensive areas of the dirt-scree and mat structures and often surrounded islands of coniferous scrub. Rock was an important associate on ridgetop areas as were rock outcrops on some slopes.

Two basic subsets of turf vegetation were recognized: turf which had little substrate exposed (Closed Turf), and that in which substrate had between 10 and 30 (50) % exposure (Open Turf). Closed turf vegetation commonly covered west facing ridgesides, the gentler slopes on other exposures, and the broader ridge and mountain tops. Open turf was common in broken outcrop and dirt-scree dominated basins and on the steeper ridgesides, often in transition areas between closed turf and mat or dirt-scree vegetation.

Closed turf was examined at 18 sites, 16 quantitatively (Table 25). Graminoid, forb, and shrub species cover averaged 22, 61, and 4 %, respectively. Substrate exposure averaged 4 %, with bare soil being the dominant component. As on the winter range, closed turf vegetation was generally dominated by Ross´ avens and sedges, however distinct floristic types were recognized.

In some south and west slope closed turf stands, Ross´ avens and sedges shared dominance with silvery lupine. Important grasses were bluegrasses and spike trisetum while diverse-leaved cinquefoil and alpine chickweed were common forbs. On other closed turf sites silvery lupine was unimportant. Here sheep fescue and bluegrasses were comon grasses while alpine milkvetch, arctic sandwort, and diverse-leaved cinquefoil were important forbs. Dwarf willow had significant coverage on one such site. Substrate exposure, primarily rock and dirt, averaged 5 % in both of these dry site closed turf communities.

Closed turf on east slopes was more restricted in coverage than west and south slope turf as this aspect tended to be dominated by dirt-scree and rock formations on the summer range. East slope closed turf occupied mesic habitats, often bordering snowbed vegetation. Diversed-leaved cinquefoil was often codominant with Ross′ avens and sedges. Tufted hairgrass was usually an important graminoid as was Drummond′s rush on some sites. Bluegrasses were always present. Western bistort and alpine sagebrush were important forbs. Alpine willow was a common dwarf shrub. Substrate exposure averaged only 2 %.

Open turf in broken dirt-scree basins occurred in restricted stands on flat basin floor sites and on the lower ridgesides surrounding the basin. Nine such sites were quantitatively sampled (Table 25). Graminoids, forbs, and shrubs averaged 19, 58, and 3 % coverage, respectively. Species composition was quite diverse between sites but yarrow, kentrophyta, northern goldenrod, spike trisetum, and bluegrasses were constant species with significant cover. Sedges dominated many sites, while Ross′ avens was important only on a few. Creeping sibbaldia was a species of occasional importance. Substrate exposure averaged 20 % with rock being the most important component.

Fourteen ridgeside open turf sites were sampled, ten quantitatively (Table 25). Graminoid, forb, clubmoss, and shrub cover averaged 15, 55, 4, and 1 %, respectively. Substrate exposure averaged 26 %. Ridgeside open turf was floristically quite variable depending on site and exposure.

West and south slope open turf often occurred in transition zones between sparcely vegetated dirt-scree and closed turf vegetation. Two basic floristic types were observed. One was dominated by Ross′ Avens and sedges while the other was characterized by silvery lupine, cushion phlox, and yarrow. Important grasses of the former type were bluegrasses and spike trisetum while important forbs were arctic sandwort, alpine sagebrush and silky crazyweed. Dwarf willow was a major species on one site. Substrate exposure averaged 26 % with bare soil being dominant. In the lupine association important graminoids were bluegrasses, spike trisetum and sheep fescue while alpine daisy was an important forb. Substrate was dominated by dirt and averaged 19 % exposure.

East slope open turf occurred between moist closed turf and dirt-scree vegetation, and as scattered pockets within dirt-scree and rock mat vegetation. It was quite variable floristically. One alpine site was dominated by Rydberg′s daisy, yarrow, cushion phlox and sedges, with fairy candelabra, alpine chickweed, and spike trisetum also being important species. The substrate was dominated by scree and had 20 % exposure. Three upper timberline sites were dominated by sedges and creeping sibbaldia. Other important plants were bluegrasses, alpine pussytoes, western bistort and clubmoss. Important species in other stands were alpine lewisia, tufted hairgrass, alpine timothy, and grouse whortleberry.

Alpine Mat

The mat vegetation structure was common on exposed alpine and upper timberline ridgetops, dirt-scree slopes, rock outcrops, cliff ledges and in broken scree basins on the summer range. Dirt-scree and rock components were constant associates with the mat structure on the summer range. Although the structure itself was common at higher elevations, it usually occurred as restricted patches interrupted or surrounded by substrate components. Consequently the Alpine Mat formation was not as prevalent as the mat component.

Fifteen ridgetop and slope mat sites were examined, 7 quantitatively (Table 25). Graminoid and forb cover averaged 8 and 21 %, respectively, on the sites sampled. Substrate exposure averaged 73 %.

Ridgetop mat vegetation in the upper timberline and alpine zones was of two types, very sparse (less than 15 %) vegetation cover on broken rock outcrop and dirt-scree sites and more substantial vegetation coverage (15 to 50 %) on consolidated dirt and rock ridgetops. On both sites Scribner wheatgrass, sheep fescue and spike trisetum were constant species and kentrophyta was often a dominant forb. On the sparsely vegetated ridgetops common forbs were alpine pussytoes, alpine dusty maiden, elk thistle, cutleaved daisy, mountain sorrel, dwarf mountain butterweed, and alpine smelowskia. On consolidated ridgetops Ross' avens generally exceeded kentrophyta in dominance and arctic sandwort was another important forb. Yarrow, cliff anemone, northern goldenrod, and moss champion were also common species on these sites.

Mat vegetation on alpine slopes was dominated by Scribner wheatgrass with bluegrass and yarrow also being important. Spike trisetum was often present as was Ross' avens, alpine chickweed, and arctic sandwort. On the sites examined vegetation coverage averaged 26 %. Scree was the dominant substrate component in the habitat.

Two timberline mat vegetation sites were examined on a steep dirt-scree rock outcrop slope. Dominant species were sheep fescue, yarrow, alpine milkvetch and northern goldenrod.

Six broken scree basin mat sites were examined, only one quantitatively (Table 25). Graminoid and forb cover averaged 24 and 20 %, respectively, on the site sampled. Scribner wheatgrass and yarrow were the dominant plant species. Other common plants were spike trisetum, elk thistle, northern goldenrod, and silverleaf phacelia. Tufted hairgrass dominated on rock and talus seeps. Substrate exposure varied from 50 to over 90 % on the sites examined.

Alpine Snowbed

On the summer range the snowbed vegetation structure occurred in the upper timberline and alpine elevational zones on north and east exposures (Table 25). Two general types of snowbed vegetation were observed. Snowbed sites with continuous vegetative cover occurred as restricted pockets beneath snowbanks on otherwise turf dominated slopes. This type generally occurred on east slopes just below ridgetop snow accumulation sites. The second snowbed vegetation type was characterized by discontinuous herbacious plant cover on a dirt-scree and talus base. This type was prominent on lower slopes at the head of north facing basins. It was bordered by steep talus slopes, cliffs, and perpetual snowfields above; and the Tufted Hairgrass/Sedge grassland habitat on the basin floor below.

Continuous snowbed vegetation was characterized by the dominance of sedges, dwarf willow, and tufted hairgrass. Bluegrasses and sheep fescue were common grasses. Alpine sage, diversed-leaf cinquefoil, and alpine bistort were common forbs. Graminoid coverage exceeded that of forbs. As this type graded into turf on the fringe of the melt water influence, graminoid and dwarf shrub coverage decreased and was replaced by increases in forbs, especially Ross' avens.

Discontinuous snowbed vegetation was dominated by tufted hairgrass. Sedges and bluegrasses were common graminoids. Subalpine butterweed was an important forb. This vegetation graded upward into alpine mat slope vegetation on sites between snowfields. Downward, vegetation coverage increased with sedges, diversed-leaf cinquefoil and elkslip becoming important before finally grading into the moist grassland on the basin floor.

Sparsely Vegetated Cliff

Cliffs were common on north and east exposures on the summer range. They were a characteristic feature at the head of north flowing drainages and occasionally occurred on the walls of south facing basins as well. Most were broken by dirt-scree or talus ledges. Unbroken rock faces were uncharacteristic of the volcanic parent material underlying the summer study area. However, in the lower subalpine zone an almost unbroken belt of limestone and sandstone cliffs occurred along the north and east border of the Wyoming portions of the summer range.

Sparsely Vegetated Outcrop

Rock outcrops were common features on all slope exposures and on ridgetops in the summer range area. The rock outcrop structural formation was common at the headwaters of many drainages, especially on north and east slopes and in the area south and west of Pilot and Index Peaks.

Sparsely Vegetated Talus

Talus slopes were less common on the summer than on the winter range, but did occur under extensive cliff and rock outcrop slopes, especially at the head of basins and in the Pilot Peak vicinity.

Sparsely Vegetated Rockland

Consolidated rock was common only on some gently sloping wide ridgetops and on the floors of some south facing headwater drainage basins. The Rockland formation was uncommon on the summer range.

Sparsely Vegetated Dirt-Scree

Dirt and scree were characteristic substrate components in all areas of the summer range, being the common end product of the weathering of volcanic parent material. Bare dirt and scree occurred in varying mixtures, with scree often dominating on ridgesides and dirt dominating more gently sloping sites. The Sparsely Vegetated Dirt-Scree formation was common at higher elevations on all exposures of the summer range.

Snowfield

On the summer range perpetual snowfields were common on steep north and east facing exposures in the upper timberline and alpine zones. In the alpine zone temporary snowbanks lasted well into the summer in snow accumulation sites on all exposures.

APPENDIX B

SUPPLEMENTAL POPULATION CHARACTERISTICS TABLES

Table 27. Maximum unduplicated counts and classifications of bighorn sheep on the Beartooth-Rock Creek winter range, 1971-1980.(a)

Year	Rams		Females	Lambs	Uncl	Total	Number/100 Ewes	
	3/4+	3/4-					Rams	Lambs
1970-71	3(b)		36	14	-	53	8	39
1974-75	3	8	31	6	3	51	35	19
1976-77	4	10	25	17	2	58	56	68
1977-78	4	16	46	29	-	95	43	63
1978-79	7	11	33	11	-	62	55	33
1979-80	3	11	45	9	-	68	31	20

a) Combines repeated ground and aerial maximum counts, late autumn through spring. 1970-1977 data from MDFWP records.
b) Unclassified rams.

Table 28. Unduplicated counts and classifications of bighorn sheep on the Pilot-Index subunit of the Wyoming Absaroka summer range, 1977-1980.

Year	Method(a)	Rams (Horn Curl)(b)				Yearling Females	Ewes(c)	Lambs	Uncl	Total	Number/100 Ewes		
		3/4	1/2-3/4	1/4-1/2	0-1/4						Rams	Yrlg.	Lambs
1977	AMUC	0	-	7	-	-	41	23	0	71	17	-	56
1978(d)	AMUC	2	-	10	-	-	56	10	0	78	21	-	18
	GMUC	0	3	8	12	8	39	17	0	87	49	51	44
	GSPE	0	3	13	14	9	40	16	0	95	61	58	40
1979	AMUC	2	-	10	-	-	58	17	0	87	21	-	30
	GMUC	2	7	6	8	4	35	12	0	74	59	34	34
	GSPE	5	4	7	8	4	48	19	0	95	46	25	40
1980(e)	AMUC	1	3(f)	1	-	-	31	11	4	51	16	-	35
	GMUC	0	2	3	5	2	40	21	0	73	24	18	53
	GSPE	0	2	4	7	3	54	28	4	102	23	19	52

a) AMUC = Aerial maximum unduplicated counts. Rams classified as those greater and those less than 3/4 horn curl, female yearlings classified with female adults. 1977 data from MDFWP records.
GMUC = Ground maximum unduplicated counts.
GSPE = Ground survey population estimate.
b) Rams less than 1/4 curl were yearlings, rams greater than 1/2 curl were generally three years or older.
c) In analyzing ground observations, adult females were counted in two catagories, those with and those without lambs.
d) July 1978 ground surveys overcounted yearling males and undercounted adult ewes, population ratios are skewed upward.
e) July 1980 ground data overcounted adult females and undercounted yearling males, population ratios are skewed downward.
f) Unclassified rams.

Table 29. Monthly sex and age composition of bighorn sheep on the Rock Creek winter and Pilot-Index summer ranges, as determined from ground based multiple and maximum unduplicated observations, 1976-1980.(a)

Year Month	Sample Size	Rams (Horn Curl) 3/4	1/2-3/4	1/4-1/2	0-1/4	All	Females Adult(b)	Yrlg.	Lambs	Uncl	Number/100 Ewes Rams	Yrlg.(c)	Lambs
1976-77													
Dec.	64/30(d)	7/3	4/2	4/1	1/1	16/7	28/13	-	20/10	-	57/54	7/17	71/77
Apr.	111/39	5/4	2/2	4/3	3/2	14/11	61/17	-	36/11	-	23/65	10/27	59/65
1977-78													
Nov.	41/37	-	2/2	1/1	3/3	6/6	21/19	-	14/12	-	29/32	33/38	67/63
Apr.	57/48	-	3/2	3/3	7/7	13/12	30/25	-	10/8	4/3	43/48	61/78	33/32
May	191/51	3/3	9/5	15/3	8/2	35/13	107/28	-	40/10	9/-	33/46	16/15	37/36
1978-79													
Jun-Jul.	162/27	-	3/1	16/4	20/3	39/8	69/12	10/1	44/6	-	57/67	43/33	64/50
Aug.(e)	126/60	-	3/3	7/4	7/6	17/13	66/32	17/5	26/10	-	20/35	36/34	39/31
May	227/33	3/2	3/2	10/2	17/4	33/10	132/19	-	28/4	34/-	25/53	30/53	21/21
1979-80													
Jun-Jul.	173/32	1/1	4/2	19/5	3/1	27/9	78/14	5/1	50/8	13/-	33/64	10/14	64/57
Jul.(e)	110/71	2/2	8/7	6/6	4/2	20/17	58/35	8/7	24/12	-	30/40	12/26	41/34
Aug.(e)	117/58	-	1/1	12/5	10/8	23/14	65/29	3/4	26/11	-	34/42	20/41	40/38
Sep.(e)	159/49	2/2	1/1	1/2	16/3	20/8	96/29	-	43/12	-	21/28	40/23	45/41
Nov-Dec.	231/43	11/4	12/3	24/5	26/3	73/15	105/18	2/1	46/9	5/-	68/79	64/38	44/50
1980													
Jul.(e)	103/73	-	0/2	4/3	8/5	12/10	53/40	3/2	35/21	-	21/24	21/18	66/53

a) 1976 and 1977 data from MDFWP records.
b) From June through September, when compiling the maximum count, females were counted in two catagories, those with and those without lambs.
c) From September through May, numbers of yearling females and males were assumed to be equal.
d) Total number of animals observed / maximum unduplicated count.
e) Counts made on Pilot-Index summer range, multiple observations include only those sheep seen in groups completely classified.

Table 30. Monthly sex and age composition of bighorn sheep on the Rock Creek winter range and Pilot-Index summer range, as determined from aerial surveys, 1977-1980.(a)

Year Month	Sample Size	Rams (Horn Curl) 3/4+	Rams (Horn Curl) 3/4-	Females	Lambs	Number/100 Ewes Rams	Number/100 Ewes Lambs
1976-77							
Jan	31	1	5	15	10	40	67
Feb	50	1	8	24	17	38	71
1977-78							
Jun-Sep(b)	166/71(c)	0	14/7	100/41	52/23	14/17	52/56
Mar-May	154/84	9/4	14/5	80/46	51/29	29/20	64/63
1978-79							
Jul-Oct(b)	176/77	2/2	19/10	125/55	30/10	17/22	24/18
Jan	38	7	7	17	7	82	41
May	35	1	9	19	6	53	32
1979-80							
Jun	116/52	3/3	19/9	75/32	19/8	29/38	25/25
Jul(b)	87	2	10	58	17	21	29
Aug(b)	80/45	1/1	4/4	60/32	15/8	8/16	25/25
Feb	42	1	5	30	6	20	20
May	49	2	9	33	5	33	15
1980							
Aug(b)	42	2	3	26	11	19	42

a) Counts include only bighorns observed in groups completely classified. 1977 data from MDFWP records.
b) Surveys of Pilot-Index summer range.
c) When more than one aerial survey was made during the time period, data are presented as multiple observations/maximum unduplicated count.

Table 31. Multiple ground based counts and classifications of bighorn sheep on the Absaroka summer range, 1978-1980.

Year	Area(a)	Rams (Horn Curl)(b)				Yearlings		Ewes	Lambs	Uncl	Total	Number/100 Ewes		
		3/4	1/2-3/4	1/4-1/2	0-1/4	Females	Unkn					Rams	Yrlg.	Lambs
1978	PI	0	3	30	59	43	0	192	95	112	534	39	53	49
	JS	27	21	9	8	3	0	52	43	47	210	118	21	83
	WYO+	27	24	39	67	46	0	244	138	159	744	54	46	57
	WP	0	0	6	2	2	0	10	4	3	27	67	40	40
	ASR+	27	24	45	69	48	0	254	142	162	771	55	46	56
1979	PI	4	10	24	32	8	11	265	115	94	563	26	19	43
	JS	11	8	11	18	5	6	183	102	26	370	26	16	56
	WYO+	15	18	35	50	13	17	448	217	120	933	26	18	48
	WP	0	2	5	8	0	0	18	11	0	44	83	44	61
	ASR+	15	20	40	58	13	17	466	228	120	977	28	19	49
1980	PI	0	2	4	11	3	0	72	47	19	158	23	19	65
	JS	5	7	4	1	0	0	14	10	3	44	121	7	71
	WYO+	5	9	8	12	3	0	86	57	22	202	38	17	66

a) Areas: PI = Pilot-Index, JS = Jim Smith, WYO+ = Wyoming subtotal, WP = Wolverine Peak, ASR+ = Absaroka Summer Range total.

b) Rams less than 1/4 horn curl were yearlings.

Table 32. Multiple aerial counts and classifications of bighorn sheep on all areas of the Absaroka summer range.

Year	Area(a)	Rams (Horn Curl) 3/4+	Rams (Horn Curl) 3/4-	Rams (Horn Curl) Uncl	Females	Lambs	Uncl	Total	Number/100 Females Rams	Number/100 Females Lambs
1977(b)	PI	0	13	1	103	55	21	193	14	53
	JS	0	6	-	20	14	0	40	30	70
	HM	4	5	-	0	0	0	9	--	--
	YNP	0	3	-	24	18	0	45	13	75
	WYO	4	27	1	147	87	21	287	22	59
	WP	1	2	-	30	19	0	52	10	63
	SR	5	29	1	177	106	21	339	22	59
1978	PI	2	19	-	128	30	42	221	16	23
	JS	23	23	-	108	63	25	242	43	58
	HM	12	6	-	26	8	0	52	69	31
	YNP	0	0	-	1	1	0	2	0	100
	WYO	37	48	-	263	102	67	517	32	39
	WP	3	35	-	44	11	18	111	86	25
	ASR	40	83	-	307	113	85	628	40	37
1979	PI	5	23	-	161	34	18	241	17	21
	JS	22	30	1	129	54	68	304	41	42
	HM	12	5	-	34	21	0	72	50	62
	YNP	2	2	-	7	1	0	12	57	14
	WYO	41	60	1	331	110	86	629	31	33
	WP	0	3	-	18	6	0	27	17	33
	ASR	41	63	1	349	116	86	656	30	33
1980	PI	1	1	3	31	11	4	51	16	35
	JS	3	2	-	41	14	0	60	12	34
	HM	0	0	-	19	4	0	23	0	21
	WYO	4	3	3	91	29	4	134	11	32

a) Areas: PI = Pilot-Index, JS = Jim Smith, HM = Hurricane Mesa, YNP = Amphitheater-Yellowstone National Park, WYO = Wyoming Subtotal, WP = Wolverine Peak, ASR = Absaroka Summer Range Total.

b) 1977 data from MDFWP records.