Range use and interspecific competition of Rocky Mountain bighorn sheep in the Highland Mountains, Montana

by Joseph Paul Weigand

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:
A study of bighorn sheep was conducted in the Highland area south of Butte, in southwestern Montana during summer and fall of 1992 and 1993. Quantitative data were obtained on range use, seasonal mixing of herd segments, degree of overlap of range use among mule deer, elk, and bighorn sheep, and current types and levels of habitat use by livestock by season. During March of 1992 and 1993, 15 and 7 ewes were radio-collared, respectively. Sex and age composition were determined from 5935 ground and aerial observations of bighorn sheep. Numbers per 100 ewes for rams were 30.6 in 1992 and 42.6 in 1993. Numbers of lambs per 100 ewes were 41.3 and 34.5 for 1992 and 1993, respectively. Total estimated population for the study period was 382 ± 75 bighorn sheep. During summer 84% of the bighorn sheep observations were made on the bunchgrass vegetation type. During fall 48.5% of observations occurred on the agricultural type and 40.7% on the bunchgrass type. Mean slopes of 34% and 12% were used during summer and fall, respectively.

Telemetry data yielded home ranges for 19 bighorn ewes and aided in the delineation of 3 population-habitat units. Home ranges covered . 5.3, 3.7, and 2.3 km^2 for each of the 3 population-habitat units, respectively.

Autumn food habits were determined through the examination of 41 rumen contents collected from hinter harvested bighorns during fall 1992 and 1993. Summer food habits were determined from microhistological analyses of 20 fecal samples collected during summer, 1993. Rumen contents revealed 84.8% use of graminoids, 6.3% use of forbs, and 8.9% use of woody plants. Fecal analyses showed 31.3, 53.1, and 15.6% use of graminoids, forbs, and woody plants, respectively. Forage use overlap of bighorn sheep with domestic livestock was determined through feeding site analyses. No significant difference existed in the use of graminoids, forbs, or woody plants between bighorns and domestic Sheepi Significant differences were found in the use graminoid and forb forage classes between bighorn sheep and cattle.

Forage quality was determined through fecal nitrogen contents derived by the Kjeldahl technique. A mean nitrogen content of 2.6% was found which is well within reported ranges for bighorn sheep growth and maintenance requirements. Fecal nitrogen did not differ significantly between the population-habitat units or between bighorn sheep groups of. different sexual composition.

Range use overlap of bighorn sheep with other wild ungulates during summer and fall were determined from the observation of 80 mule deer, 48 elk, 23 mountain goats, 23 pronghorns, and 4 moose. Interspecific competition was considered not likely. The potential competition with domestic livestock is high. Food habits overlapped enough, between bighorns and domestic livestock, to represent threat of competition if stocking rates were increased, however, resources did not seem to be in limited supply for competition to have occurred during the study.

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APPROVAL

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Joseph Paul Weigand

This thesis has been read by each member of the graduate 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

A study of bighorn sheep was conducted in the Highland area south of Butte, in southwestern Montana during summer and fall of 1992 and 1993. Quantitative data were obtained on range use, seasonal mixing of herd segments, degree of overlap of range use among mule deer, elk, and bighorn sheep, and current types and levels of habitat use by livestock by season. During March of 1992 and 1993, 15 and 7 ewes were radio-collared, respectively. Sex and age composition were determined from 5935 ground and aerial observations of bighorn sheep. Numbers per 100 ewes for rams were 30.6 in 1992 and 42.6 in 1993. Numbers of lambs per 100 ewes were 41.3 and 34.5 for 1992 and 1993, respectively. Total estimated population for the study period was 382 ± 75 bighorn sheep. During summer 84% of the bighorn sheep observations were made on the bunchgrass vegetation type. During fall 48.5% of observations occurred on the agricultural type and 40.7% on the bunchgrass type. Mean slopes of 34% and 12% were used during summer and fall, respectively.

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Forage quality was determined through fecal nitrogen contents derived by the Kjeldahl technique. A mean nitrogen content of 2.6% was found which is well within reported ranges for bighorn sheep growth and maintenance requirements. Fecal nitrogen did not differ significantly between the population-habitat units or between bighorn sheep groups of different sexual composition.

Range use overlap of bighorn sheep with other wild ungulates during summer and fall were determined from the observation of 80 mule deer, 48 elk, 23 mountain goats, 23 pronghorns, and 4 moose. Interspecific competition was considered not likely. The potential competition with domestic livestock is high. Food habits overlapped enough, between bighorns and domestic livestock, to represent threat of competition if stocking rates were increased, however, resources did not seem to be in limited supply for competition to have occurred during the study.

INTRODUCTION

Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) are indigenous to the Highland Mountains of southwest Montana. Native populations were extirpated from this area during the early 1900's through overhunting and heavy grazing by domestic livestock. Bighorn sheep were reintroduced from the Sun River in 1967 (27 sheep) and 1969 (31 sheep). The bighorn population slowly expanded through the 1970's across the Bighole River and into the foothills of the Pioneer mountains (J. Eichorn pers. comm.). The number of bighorns grew steadily through the 1980's and was estimated at 350 to 400 sheep in 1993.

Bighorn Sheep Hunting District (HD) 340, which encompasses the study area, has been open to hunting since the 1970's and has produced record class rams on a yearly basis since the 1980's. Holders of the Governor's permit have taken 4 rams in the area, 2 of which have exceeded 190 Boone and Crockett points. Bidding prices of these auctioned permits have ranged from $79,000 to $310,000 in 1988 and 1994, respectively. Currently, there are 35 ewe permits and 35 either sex permits allotted for the area in 1994. Production of trophy rams and providing viewing and hunting opportunity for bighorn sheep have been maintained as high priorities by the Bureau of Land Management (BLM) and Montana Department of Fish, Wildlife, and Parks (MDFWP) in this area.

The current population includes 3 distinct subpopulations that summer in different parts of the area. Groups from each of these subpopulations exist in close proximity to domestic livestock for at least part of the year. Recent evidence suggests that disease transmission from livestock, domestic sheep in particular, can result in death to bighorn sheep (Foreyt 1990, 1992). In 1991, an application was submitted to the BLM, Butte District, for grazing domestic sheep on the area which makes up most of the bighorn herd's primary winter range. This action prompted the BLM and MDFWP to investigate the potential impacts of domestic livestock on the bighorn population.

This project was initiated to determine potential impacts of livestock and to determine current status of the bighorn herd. It was divided into summer/fall and winter/spring aspects. The objectives were to (1) document summer and early fall ranges of the 3 primary wintering segments of the bighorns, (2) document any seasonal mixing of various herd segments, especially in winter, (3) delineate the degree of overlap of range use among mule deer, elk, and bighorn sheep and develop a procedure for continued monitoring of interaction (eg. competition) among these ungulates in HD 340, and (4) document the current types and levels of habitat use by livestock by season. This thesis covers the summer/fall portion of the study, with field work conducted June - December, 1992, and June - August, 1993.

STUDY AREA

The study area lies in the Highland and Pioneer Mountain Ranges in Beaverhead, Silverbow, Madison, and Jefferson counties in southwest Montana. The northern portion of the area borders Butte, Montana, with the remainder continuing to the south and southwest. The study area boundary is defined by FWP's legal description of the hunting district and includes approximately 235 km^2, however, only a portion of this is occupied by bighorns (Figure 1). The area includes ownership by BLM, USDA Forest Service (FS), State Lands, and private landowners.

Physical Characteristics

Lowest elevations (1,593 m) occur along the Bighole River. Table Mountain (3,108 m) on the crest of the Highland Range is the highest point. According to Alt and Hyndman (1986), the topography of the area is formed by Madison limestone and the Boulder batholith in the Highlands and the Pioneer batholith and by limestones, sandstones, and shale in the Pioneer range.

The climate is semi-arid, with an average annual precipitation of 31.5 cm (Table 1). The greatest amount of monthly precipitation received at the Divide Weather Station during the field seasons occurred in June, 1992 (8.3 cm) and June, 1993 (8.0 cm). Mean temperatures ranged from -9.0 °C in December, 1992 to 16.4 °C in August ,1992 for the study period. The normal mean annual temperature is 7.3 °C.

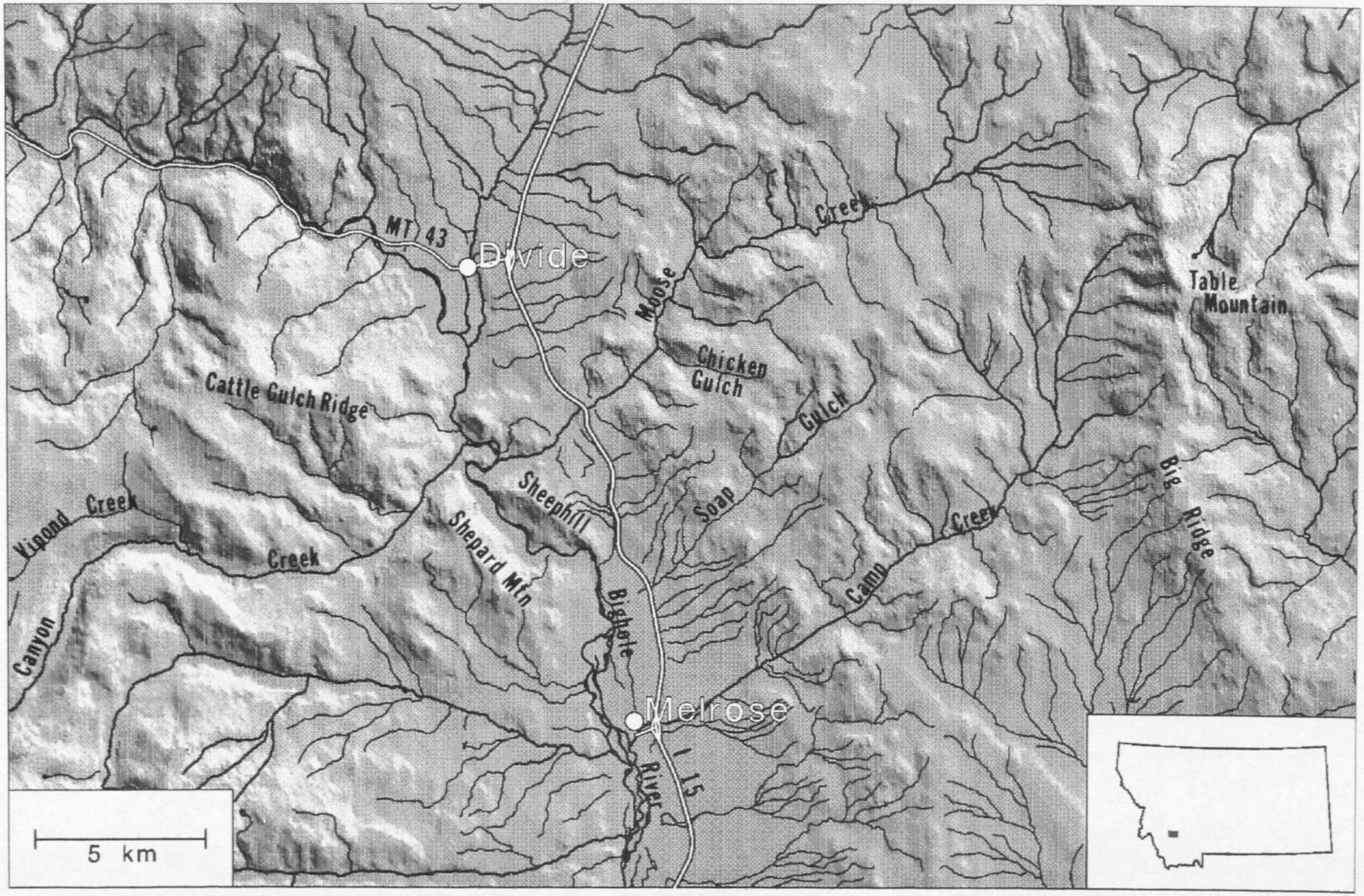

Figure 1. Map of portion of the study area south of Butte, Montana in the Highland and Pioneer Ranges.

Table 1. Mean temperatures, total precipitation, and departures from normal at Divide weather station (NOAA).

Month	Temperature °C	Departure °C	Precipitation cm	Departure cm
1992				
June	15.0	1.8	8.3	2.1
July	15.3	-2.1	5.0	2.1
August	16.4	0.1	1.9	-1.2
September	12.0	0.6	1.4	-1.5
October	7.4	1.2	2.2	0.2
November	-2.1	-1.0	1.2	-0.1
December	-9.0	-3.7	0.9	-0.7
1993				
June	11.9	-1.6	8.0	2.4
July	12.4	-4.9	7.3	4.1
August	13.8	-2.6	8.5	4.9
September	11.2	0.1	0.8	-2.5
October	6.6	0.6	3.4	1.6
November	-3.5	-2.3	0.8	-0.8
December	-3.8	2.4	0.4	-1.1

Wildlife

Bighorn sheep were the most commonly observed wild ungulate. Mule Deer (Odocoileus hemionus), were common and were seen during summer and fall in the rough lowland habitats, riparian areas, and adjacent to or within timber stands at the upper elevations. Rocky Mountain Elk (Cervus elaphus nelsoni) were observed feeding in the subalpine meadows which were frequented by bighorn rams during summer but were not abundant in the study area in summer. Mountain goats (Oreamnos americana) were often observed in the alpine areas of the Highlands, but were not abundant. Pronghorn antelope (Antilocapra americana) were occasionally observed feeding or bedded in the Sheephill and Shepard

Mountain areas but were not abundant. Moose (Alces alces), were the least frequently observed and were the least abundant ungulate in the area during 1992 and 1993. I observed 2 moose in the low elevation shrub-grassland adjacent to Camp Creek and 2 others in heavily timbered Moose Creek.

Coyotes (Canis latrans) were observed commonly in all habitat types except alpine and dense timber. A bobcat (Felis rufus) was observed briefly in the rough lowlands of Camp Creek in August, 1992. Other carnivores known to inhabit the area are black bear (Ursus americana) and mountain lion (Felis concolor). The harvest quota for mountain lions is filled yearly, indicating a healthy population. Additionally, golden eagle (Aquila chrysaetos) and other birds of prey are commonly observed.

Land Uses

Livestock grazing was the dominant use of private and public lands during summer and fall. Forest Service and BLM allotments maintained the largest number of cattle during the summer, but private lands also supported sustained grazing. Domestic sheep grazing occurred only on the private lands near the Bighole River and the lower Moose Creek drainage.

Recreational use of the land was the next most common activity in the area during summer and fall. Numerous private parties and clients of outfitters visited the study area to fish. Several hundred float trips were made on a daily basis during peak times during the summer.

Opportunities for wildlife viewing and photography during summer and fall and hunting during fall attract many visitors.

Surface mining of phosphorus occurred at Maiden Rock. While only a small portion of land is mined, the mine visually dominates the area. Past mining for gold is evident throughout Soap Gulch and Camp Creek. Small mine shafts and piles of tailings litter these drainages.

Logging is a major land use in the northern portion of the Highland range. Large expanses have been clearcut. Small tracts of land have been logged in the upper limits of Soap Gulch and Camp Creek. No timber harvest occurred in the Cattle Gulch area during my study.

METHODS

Sheep Capture and Marking

Twenty-two adult ewes were fitted with radio-transmitters (Figure 2) during March 1992 (15) and 1993 (7). Ewes were captured in 1992 with a helicopter and tranquilizer gun. Sheep were immobilized with Carfentanil and revived with Naloxone. Ewes collared in 1993 were captured by a net gun fired from a helicopter. Netted ewes were blindfolded while being handled to decrease stress and increase ease of handling. All captured ewes were fitted with a transmitter collar marked with individual symbols to aid in identification (Appendix, Table 15). Numbered metal eartags were also affixed to each ewe. Blood samples were taken and analyzed at the Montana State University (MSU) Veterinary Research Laboratory for blood chemistry and serum antibody titers.

I attempted to identify uncollared animals with unique characteristics to increase my sample size of known animals. To aid recognition of unmarked animals, unique characteristics were recorded. I noted rams with distinctive scars and horn damage but they proved to be of little use because most rams with unique characteristics were only observed on 3 or less occasions.

Figure 2. Ewe bighorn fitted with a transmittered collar.

Seasonal Distribution, Movements, Habitat Use, and Range Overlap

Distribution, movements and seasonal habitat use were determined through aerial and ground relocations of radio-collared ewes and observations of unmarked bighorns. A Piper Super Cub with a belly-mounted, directional 3-element Yagi antenna was used for aerial relocations and surveys. Aerial surveys were made each month, weather permitting, to relocate all collared ewes and to locate and classify as many bighorns as possible. All wild ungulates seen were recorded, as were location, habitat type, age, and sex. For bighorns the following were also recorded: distance to escape terrain, proximity to livestock, activity, presence of collared ewes, and degree of curl for rams. I tried to make 2 flights per month but weather frequently limited me to 1 flight per month. Most relocations were confirmed visually, those not confirmed, were assumed to be accurate to within a 5.5 ha circle (Denton 1973).

Ground searches were made daily by motorized vehicle and on foot to locate bighorn sheep. A Telonics (Telonics Inc., Mesa AZ) receiver with a hand-held 3-element Yagi antenna aided relocation of collared ewes. Sex and age class of all individuals in a group were recorded when possible. Rams were classified by degree of curl as described in Frisina (1974). Location, aspect, elevation, slope, habitat type, activity, and proximity to escape terrain and livestock were also recorded. Observations of other ungulates were similarly recorded. All locations were noted using Universal Transverse Mercator (UTM) coordinates with 1:24,000 USGS quadrangle maps. Ewe home ranges were plotted, and size was determined using program Home Range (Ackerman et al. 1990). A population estimate was made using the Lincoln Index (Davis and Winstead 1980) along with an aerial survey which was considered to most closely approximate a census.

Vegetational Characteristics

Quadrats (Daubenmire 1954) and point transects were used to define major vegetation types of the area. Plants were collected throughout the study area to aid identification. The BLM, Butte District, herbarium was used to verify specimens. Nomenclature follows that of Scott and Wasser (1980).

Feeding Site Analysis

I used feeding site analysis to determine similarity in forage use between bighorn sheep and cattle and bighorn sheep and domestic sheep. This involved observing a group of feeding animals, waiting until the animals moved from the site, and then walking a transect along which every other step resulted in a plant point. Specific point location was aided by a thin line drawn vertically on the toe of my boot.

The plant nearest to the point was recorded to species and a visual estimate of the percent of the plant that had been eaten. Nearby plants which were intact were used for reference when estimating the percentage of use when possible. To preclude any bias on which plant the point fell the observer did not watch the step being taken. A minimum of 1000 points was recorded for each transect; however, 3 transects fell short of this mark due to the onset of adverse weather.

One assumption was required for this analysis; that the plants observed were used by the intended study animal. To increase confidence that use was limited to the specific animal, no other species could have been observed on the transect area for at least 1 week. The purpose of this was to allow time for plants previously used to be visually identifiable as such and omitted from the transect. This was found not to be a problem because no other ungulate species were observed on transect sites other than the species for which the transect was being done.

Differences in forage utilization among ungulates were tested using analysis of covariance. Plants identified on transects were classified as graminoid, forb, or browse. The percentages of plants that were observed to be grazed in each forage category were totalled and divided by the number of animals that had foraged at the site to produce an index of utilization per animal. Analyses of covariance were completed to ascertain if food habits were similar for each forage class. Analyses of variance of the least squares means were made to detect specific differences in forage use between ungulates. The covariates used were 1 over the numbers of animals (1/n) that had utilized each transect site and dependent variables included percent utilization of each forage class per animal (%use/n).

To determine if the intensity of grazing on individual plants differed among livestock and bighorn sheep, additional analyses of variance were run on transect data. Analyses were similar to those given above except that the mean percent of mass of individual plants grazed for each forage category was used as an index of intensity of feeding.

Indices of similarity were used to produce a measure of the overall similarity of diets of bighorn sheep, cattle, and domestic sheep based on use of the 3 forage classes. The calculations for indices of similarity were from Horn (1966). A Ro value of 1 implies identical composition and 0 indicates no similarity. These indices were used only as relative measures of similarity and should not be interpreted as estimates of statistical tests (Horn 1966).

An additional index of similarity was used to determine plant community similarity among transects for bighorn sheep, cattle, and domestic sheep, based on the 3 forage classes. The formula used was adapted from Cole (1949). The index value is similar to Ro in that 1 indicates similarity and 0 dissimilarity.

Fecal Sample Collection and Analysis

Fecal samples from adult bighorn sheep were collected during summer and early fall 1993 for fecal nitrogen and forage composition analysis. Fecal samples were collected only from observed bighorn sheep to assure that they were from bighorns versus other wild ungulates or domestic sheep. Pellet groups from lambs were excluded because their pellets may not accurately reflect forage quality due to nursing. Overall forage quality and forage composition was desired so a "sample" was a composite of pellet groups from 5-7 bighorns within a band. As soon after collection as possible, fecal pellets were frozen and stored until drying. Pellet groups were oven dried at 46 °C for 24 hours and cleaned of debris prior to analysis.

Jenks et al. (1989) found that nitrogen values between pellet groups analyzed separately and taking a mean value were no different from those obtained by combining equal amounts of each pellet group and making a single measurement. Therefore, pellets were combined and 10 gm were ground with mortar and pestel. Fecal nitrogen was determined by the Kjeldahl technique (Williams 1984) at the MSU Chemistry Station Analytical Laboratory. Percent moisture was also determined to correct for dry weight nitrogen content.

Comparisons of nitrogen level were made to determine if differences existed in forage quality between areas where fecal samples were collected and between sheep groups of different sex composition (ie. all males vs all females). Analysis of variance was conducted to determine if mean nitrogen levels differed between the 3 population-habitat units I studied.

Composite samples were also used for forage composition analysis. Microhistological analysis for fecal forage composition was completed at the College of Agriculture, School of Renewable Natural Resources, in Tucson, Arizona. At their request, pellet groups for microhistological analysis were ground and combined by their laboratory. A list of plants common to the area was supplied to the college to aid identification and increase the accuracy of results obtained (Appendix, Table 19).

Rumen Collection and Analysis

With the cooperation of graduate student Kerry Hoar and Dr. David Worley of the MSU Veterinary Research Laboratory, permit holders for bighorn sheep in HD 340 were contacted prior to the 1992 and 1993 hunting seasons and given supplies to voluntarily collect and turn in the gastro-intestinal tracts from harvested bighorns. Rumen content samples of approximately 1 liter were rinsed in pan with a 1/8 inch wire mess bottom and preserved in a labelled container of 10% formalin solution. Rumen contents were sorted and identified as described by Cole (1956). Following identification, volummetric measurement was made. Contents of a container were drained and blotted then placed into a graduated cylinder. The volume of each container was recorded and the aggregate percentage method was used to determine forage composition for each rumen sample (Martin et al. 1946). Mean percent composition of species from each year were used in a paired t-test to compare diets in 1992 with 1993.

RESULTS

Vegetation Types

While the Highland-Pioneer Mountains contain a large array of vegetation and terrain types only those important to bighorn sheep are described. These include 7 major vegetation types and 7 subtypes.

Bunchgrass Type

Grass Subtype. This subtype is found throughout the bunchgrass type. It consists of primarily bunchgrasses with few forbs or shrubs. Bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) are the dominant species with some slender wheatgrass (*Agropyron trachycaulum*). Kentucky bluegrass (*Poa pratensis*) and sandberg bluegrass (*Poa secunda*) are also common throughout this subtype.

Forb Subtype. This subtype is mostly found at subalpine elevations along Big Ridge, Cattle Gulch, and Trusty Gulch (Figure 3). Bluebunch wheatgrass, Idaho fescue, slender wheatgrass, and *Poa* species are common. Dominant forbs include prairie smoke (*Geum triflorum*), silky lupine (*Lupinus sericeus*), and sticky geranium (*Geranium viscossissimum*).

Shrub subtype. This subtype occurs extensively along the Bighole River and along the lower elevation ridges and drainages such as Sheephill, Canyon Creek, and Camp Creek (Figure 3). Dominant shrubs are curlleaf mountain mahogany (*Cercocarpus ledifolius*) and big sagebrush (*Artemisia tridentata*).

Figure 3. Grass-forb subtype with Douglas-fir type in the background.

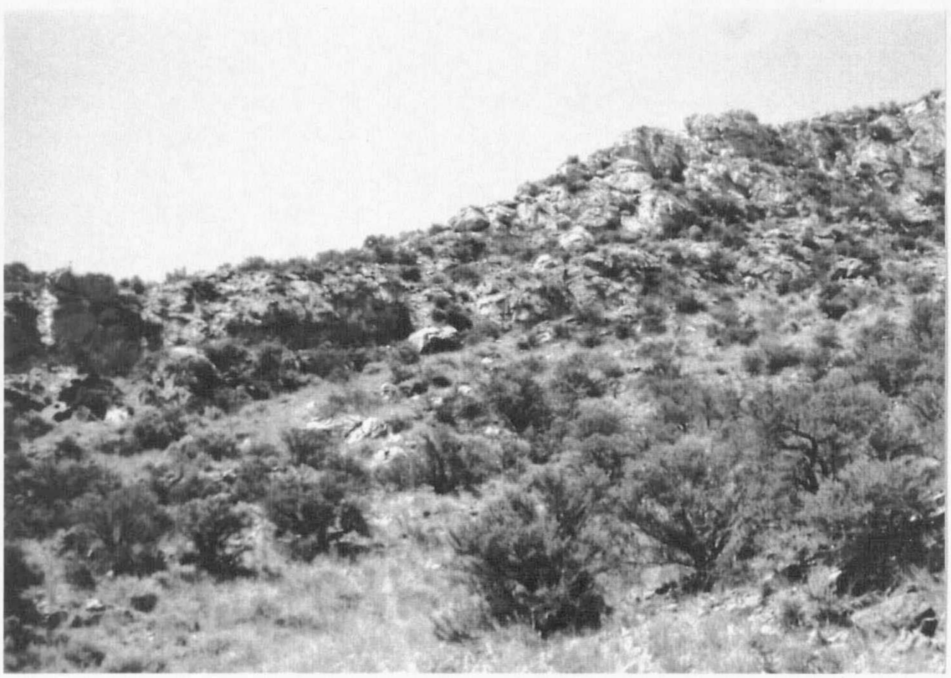

Figure 4. Shrub subtype within the bunchgrass type.

Fringed sage (Artemisia frigida), green rabbitbrush (Chrysothamnus viscidiflorus) and rubber rabbitbrush (Chrysothamnus nauseosus) can also be found in this subtype. Dominant bunchgrasses are similar to those mentioned previously.

Douglas-Fir Type

Rock Outcrop Subtype. This type and subtype are most common at moderate elevations and sometimes include other vegetation such as bunchgrasses and shrubs (ie. bluebunch wheatgrass and curlleaf mountain mahogany). Rock outcrops and talus slopes are characteristic of the Humbug Spires area (Figure 5) and occur sporadically along Cattle Gulch, Sawmill Gulch, and Bighole River. The understory often includes grouse whortleberry (Vaccinium scoparium).

Figure 5. Rock-outcrop subtype within the Douglas-fir vegetation type.

Lodgepole Pine Type

No bighorn sheep were observed in this type, but it is considered important as escape cover. It consists primarily of lodgepole pine (*Pinus contorta*) and it often makes up pure stands both within the Cattle Gulch area and along the Highland range north to Butte. Large stands are heavily logged within the Highland area but remain uncut in Cattle Gulch. The understory is similar to that of the Douglas-fir type.

Subalpine Fir Type

While some pure stands exist, this type is often interspersed with the Douglas-Fir type at subalpine elevations. Subalpine fir (*Abies lasiocarpa*) occurs primarily in Trusty Gulch and Cattle Gulch and at higher elevations in the Pioneer range (Figure 6). Understory and topography are similar to that of the Douglas-fir type.

Whitebark Pine Type

This type can be found with Douglas-fir in the Highland and Big Ridge areas at moderate elevations (2500 m). Whitebark pine (*Pinus albicaulis*) occurs extensively from Big Ridge up to timberline in the Highland peaks. It is found in krummholz form in the alpine. Understory is often sparse or non-existent at higher elevations.

Alpine Type

Talus Subtype. This subtype consists of shale and limestone ridgetops, cliff bases, and cirques. It occurs extensively along the crest of the Highland range. Little vegetation is found in this subtype.

Figure 6. Subalpine fir vegetation type with bunchgrass vegetation type in foreground.

Scree Subtype. This subtype is similar to the talus type but maintains more vegetation. Krummholz whitebark pine is found scattered in clumps or small pockets and alpine grasses and forbs are found in limited abundance in this subtype.

Grass/Forb Subtype. This subtype occurs along some of the saddles and within cirques in the Highland range (Figure 7). Common grass and grass-like plants are alpine bluegrass (Poa alpina), alpine fescue (Festuca alpina), alpine timothy (Phleum alpinum), and sedges (Carex spp.). Dominant forbs include alpine cinquefoil (Potentilla ledebouriana), alpine chickweed (Cerastium beeringianum), alpine collomia (Collomia debilis), American bistort (Polygonum bistortoides), and moss campion (Silene acaulis).

Figure 7. Portion of Highland range showing alpine vegetation type.

Riparian Type

Vegetation varies according to specific drainages. Cottonwood (Populus sp.) and quaking aspen (Populus tremuloides) are found in the Bighole River drainage. The Camp Creek drainage contains some large stands of quaking aspen and willow (Salix sp.). Big sagebrush and rose (Rosa sp.) are also frequent in some of the drainages. Douglas-fir is a dominant riparian species in the Moose Creek drainage.

Agricultural Type

This type is located primarily on the floodplain of the Bighole River and the lower Moose Creek and Camp Creek drainages (Figure 8). It consists of grass hay, alfalfa (Medicago sativa), and barley (Hordeum sp.) fields adjacent to bighorn escape terrain. Grasses generally include bromes (Bromus spp.), bluegrasses (Poa spp.), and some giant wildrye (Elymus cinereus) and needle-and-thread (Stipa comata). Due to heavy grazing, few forbs other than alfalfa or yellow sweetclover (Melilotus officinalis) are found. The few shrubs that persist are fringed sage, big sage, and green rabbitbrush, and these are usually heavily hedged from grazing.

Figure 8. Agricultural vegetation type along the Bighole river.

Population Characteristics

Composition and Productivity

The summer-fall population during 1992 and 1993 was 382 ± 75 sheep as estimated from the Lincoln Index (Davis and Winstead 1980) and flight data. Ground observation and flight data yielded mean annual lamb:ewe ratios of 41.3:100 and 34.5:100 for 1992 and 1993, respectively. Mean annual ram:ewe ratios for 1992 and 1993 were 30.6:100 and 42.6:100, respectively. Ratios based on individual flight data varied from 20 to 133 rams and 34 to 58 lambs per 100 ewes. The best aerial count obtained was conducted on August 30, 1992 and produced ratios of 46.5 lambs and 107.1 rams per 100 ewes, respectively. I counted 336 sheep on this flight (87% of the presumed population).

Early season ground observations and flights often resulted in lower lamb ratios than later observations due to the difficulty of viewing young lambs (Table 3). Observed lamb:ewe ratios gradually increased until all ewes had lambed. Observations of rams varied within and among months. Rams were most likely to be viewed on mild, clear days and just prior to and during the rut.

Survival and Mortality

Survival of lambs and yearlings from fall 1992 to spring 1993 appeared to be good. A spring 1993 survey flight yielded a 53.8:100 lamb:ewe ratio and a count of 20 yearling rams out of 177 sheep (M. Frisina, pers comm.). Assuming a sex ratio of 50:50 this would indicate 22% of the survey number were yearlings. The number of ewes in the survey was 91, approximately 20 of which were yearling ewes, this along with the number of yearling rams gives a ratio of 56 yearlings per 100 ewes beginning spring, 1993.

Mortality as indicated by ground searches also seemed to be low. Bodies of 6 ewes, 1 lamb, and 4 rams were found or reported in 1992.

Table 2. Percentage of observed sheep classified as ewes, lambs, and rams by month, 1992 and 1993.*

Season	Ewes	Lambs	Rams 0-1/4	1/4-1/2	1/2-3/4	3/4+	Total Rams	Unclass Sheep
Summer								
June	62.2	22.6	3.1	1.7	4.1	2.5	13.8	1.5
July	75.1	27.8	3.9	9.3	18.6	13	44.8	3
August	42.1	14.3	5.3	1.4	0.7	7.7	21.1	18
Fall								
September	45.7	23.4	5.3	2.6	1.1	0.2	9.2	12.8
October	53.6	30.8	4	2.3	3.3	6	15.6	0
November	35.3	17.6	0	9.8	17.6	19.6	47.8	0
December	56.2	23.8	0	3.8	10.8	5.4	20	0
Study Period	50.3	20.7	3.6	3.3	5.5	5.1	20.8	8.3

*Samples sizes for each time period are identical to those given in Table 3.

Table 3. Lamb:ewe and ram:ewe ratios of observed bighorns by month, 1992 & 1993.

Season	Lamb:Ewe Ratios	Ram:Ewe Ratios	Sample Size
Summer			
June	36.3:100	22.2:100	1372
July	37.0:100	70.7:100	1774
August	34.0:100	50.1:100	940
Fall			
September	51.2:100	20.1:100	1099
October	57.5:100	29.1:100	569
November	49.9:100	133.1:100	51
December	42.3:100	35.6:100	130
Study Period	41.2:100	41.4:100	5935

Only 3 rams and 1 ewe were found dead during 1993. Several of these mortalities had occurred several years prior to their discovery so actual mortalities per year could not be determined.

The 1992 and 1993 hunting seasons resulted in the harvest of 39 and 40 sheep, respectively (Table 4). This includes the ram taken by the holder of the Governor's Permit in 1992. Thirty-five additional sheep were removed for transplant in December, 1992. They included 16 ewes, 13 lambs, and 6 rams. These sheep were transplanted to augment an existing herd in the Sleeping Giant area north of Helena, Montana.

Table 4. Hunting and sheep harvest data for Hunting District 340, 1992 & 1993(MDFWP 1992 & 1993).

Permit Type	Number Issued	Number of Hunters	Hunter Days	Sheep Harvested	Percent Success
1992					
340-01	6	6	48	5	83
340-02	6	6	44	6	100
340-03	30	27	54	26	96
1993					
340-01	10	10	77	10	100
340-02	6	6	138	6	100
340-03	30	26	80	24	92

Seasonal Distribution, Home Ranges, and Movement

The Highland-Pioneer population was divided into 3 segments termed population-habitat units (PHU's). Pac et al. (1991) defines a PHU as a definable yearlong habitat which a population occupies and uses, with individuals bonded together by traditional use of individual home ranges. Telemetry data indicated that each subpopulation occupied distinct areas with little or no mixing during summer and fall and traditionally used each area yearlong. PHU boundaries were delineated using home range data and past observations of bighorns by Jim Eichorn (landowner) and Jack Atcheson Jr. (outfitter). Although no mixing of transmittered ewes was documented during these seasons, rams have been known to move between PHU's during the rut and occasionally to remain in another PHU for some time (J. Atcheson pers. comm.).

Each of the PHU's ranged in size from 2.3 km^2 to 5.3 km^2 (Figure 9). PHU 1 covered the largest area and PHU 3 the smallest. PHU 3 spanned the greatest elevational gradient (1672-3108 m).

PHU 1. The major wintering range is encompassed by PHU 1 and included Sheephill, Goat Mountain, and Letter Gulch as major use areas during all seasons. While rams generally summered above 2,400 m, ewes were found dispersed throughout suitable habitat during summer and fall. Areas used by ewes during summer included Canyon Creek, Cattle Gulch Ridge, Goat Mountain, and Sheephill. Rams summered almost exclusively in the upper Cattle Gulch and Trusty Gulch areas. I believe that many may have summered outside the study area to the south of this PHU.

PHU 1 supported the largest number of sheep. Groups of ewes, lambs, and young rams numbering over 100 animals were often seen, but smaller groups of 10 to 35 animals were more common. Ram groups included 15 to 45 animals, with all horn classes usually represented. The largest ram group included 103 rams, over half of which were 3/4 curl or greater. This PHU apparently sustains over 200 bighorn sheep.

PHU 2. This unit supports the smallest band of sheep in the population. This group included approximately 40 individuals except during the rut. This PHU was occupied almost entirely by ewes and lambs; rams were only observed during the rut. Except during the lambing season, this ewe band spent the entire summer in the Moose Creek

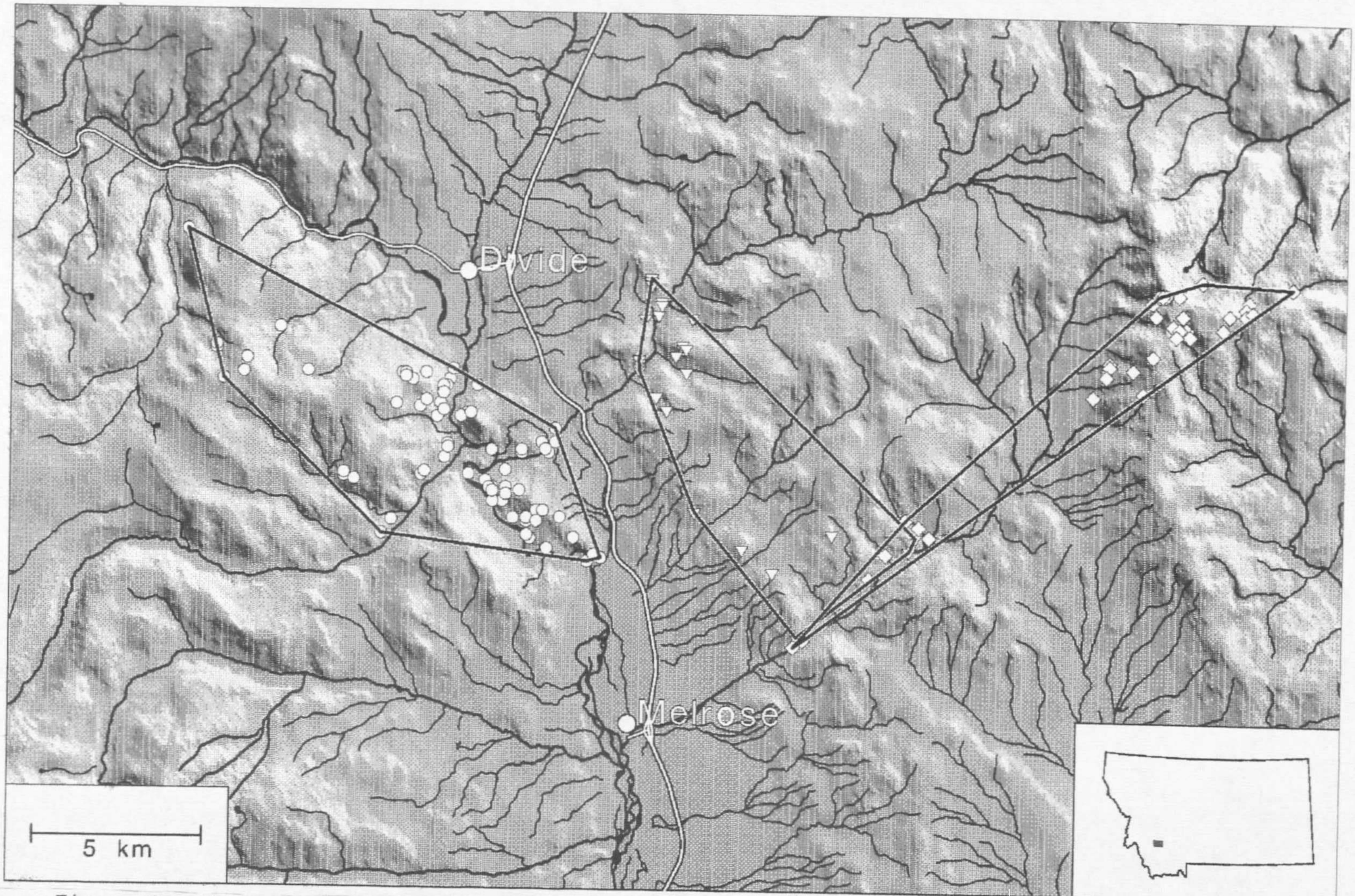

Figure 9. Map with plots of 100 percent convex polygon home ranges and relocations within them.

and Chicken Gulch areas. During lambing, sheep moved to the rocks and cliffs which span the lower elevations between Soap Gulch and Camp Creek (Figure 10).

PHU 3. This PHU was small but covered a large elevational gradient from the Highland crest to the lower elevations of Camp Creek. During summer, most of the ewes, lambs, and rams were found above 2,300m. Observations indicate that at least 80 sheep lived in this PHU.

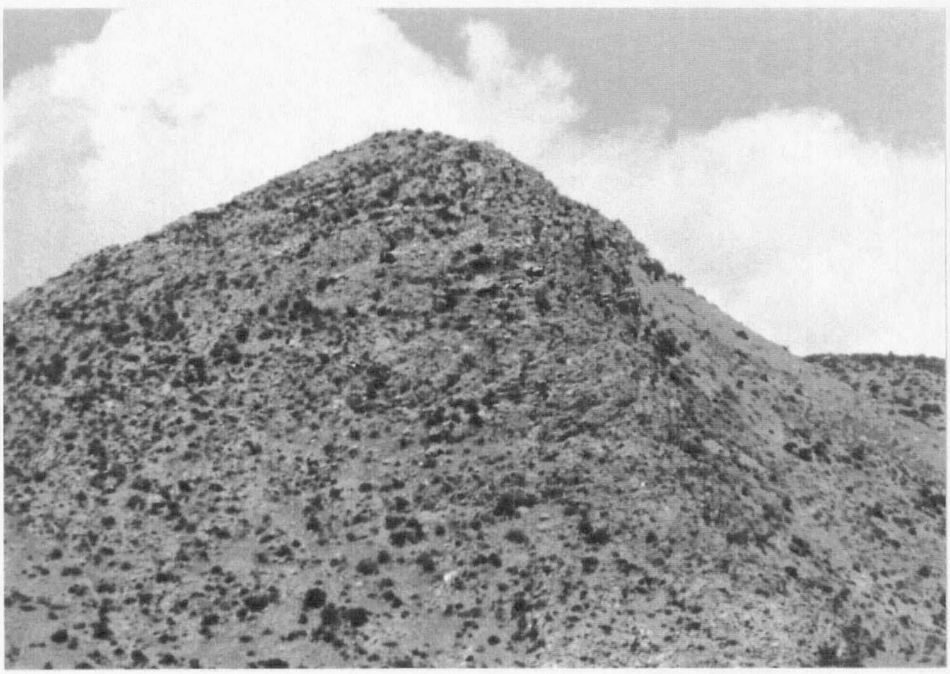

Figure 10. Lambing area among cliffs between Soap Gulch and Camp Creek.

The actual number of sheep in this PHU was difficult to estimate due to the diverse topography and poor visibility. Weather conditions at the upper elevations also made counts and classifications of these sheep difficult. Reports of rams by landowners with land adjacent to and within this area indicated that the number observed during this study may underestimate the population by 20 animals or more. Hamilton Ranch personnel had seen and photographed at least 20 more rams than I observed (R. Engle pers. comm.).

Summer-fall home ranges for transmittered sheep were calculated using program HOME RANGE (HR). Home ranges were calculated from 4 to 25 locations. Home ranges generally increased with the number of observations up to 12 observations where size began to stabilize (Table 5).

Mean home range size for transmittered ewes was 2.1 km^2, with a mean 50 percent convex polygon home range (CPHR) or core area of 0.2 km^2. The mean distance travelled between consecutive relocations and the mean distance from the arithmetic center to each location were 172 m^2 and 195 m^2, respectively.

Relocations for all transmittered sheep within a PHU were combined and used to estimate the total size of home ranges for each subpopulation and the total area occupied by the entire population. The 50 percent convex polygon home range was used to determine the size of the core area or central area of use. Subpopulation home ranges were also used to delineate each PHU.

<u>Study area</u>. When all relocations for estimated PHU home ranges were combined, a total area of 24.1 km^2 is covered by the 100% convex polygon. Not all of this area was suitable habitat (ie. sage flats) for sheep but includes the entire area they are known to have occupied and traversed each year.

Table 5. Enclosed areas (sq. km) of convex polygon home ranges, and mean distances travelled between consecutive relocations (m) and mean distance from arithmetic center to each location (m).

ID #	Total Number of Observations	Mean distance between consecutive locations	Mean distance from arithmetic center to each location	100% Convex Polygon Home Range		50% Convex Polygon Home Range	
				Enclosed Area	Number of Defining Points	Enclosed Area*	Number of Defining Points
1	22	205.5	273.1	3.8	8	0.2	6
2	14	147.6	197.2	3.5	7	0.6	6
3	16	105.3	178.6	3.4	6	0.3	6
4	19	108.6	165.8	7.0	7	0.3	5
5	12	267.2	496.8	1.6	7	0.3	5
6	8	168.4	162.0	0.5	5	0.1	4
7	12	216.3	192.9	1.3	8	0.2	6
8	12	283.2	423.7	1.8	6	0.1	6
9	11	146.9	110.4	0.5	6	0.1	5
12	15	201.8	144.4	3.0	7	0.4	5
13	24	151.9	174.0	2.9	8	0.2	6
14	24	190.0	187.7	3.6	6	0.3	7
15	25	102.4	128.1	3.1	7	0.1	5
16	6	76.4	79.7	0.3	4	0.1	4
17	8	187.7	131.9	0.3	6	0.1	5
18	4	190.1	132.1	0.3	5	0.1	3
19	9	222.7	267.8	1.6	8	0.1	4
21	7	48.8	74.7	0.4	7	0.1	4
22	4	246.8	186.9	0.2	4	0.1	3
PHU 1	114	---	208.9	5.3	8	0.9	10
PHU 2	70	---	155.6	3.7	8	0.5	6
PHU 3	60	---	258.3	2.3	7	0.3	7
Population	244	---	691.7	24.1	8	5.0	12

* All 50% CPHR areas less than 0.1sq km were rounded up to 0.1.

PHU 1. The 100% CPHR was estimated at 5.3 km² based on 114 relocations. The core area (50% CPHR) which the sheep occupied covered 0.9 km².

PHU 2. The CPHR for this herd included 3.7 km² based on 70 relocations. The core area which covered 0.5 km².

PHU 3. The estimate of this CPHR was 2.3 km² based on 60 relocations. The core area covers .3 km². This home range was very elongate and narrow.

Habitat Use

Summer (June-August)

Eighty-four percent of 4,197 summer observations of individual bighorn sheep occurred on the bunchgrass type during June-August (Table 6). This was the most extensively used type during June-August. The shrub subtype received the greatest use (60%) within this type. Attempts to observe sheep in the alpine type were relatively infrequent compared to other types and accounts for the indicated non-use of this type during summer. Observations in the timbered types are most likely underepresented due to the poor visibility and the difficulty of finding sheep in them. The shrub and grass subtypes were used most during summer. Use of the grass subtype increased through summer, and use of the shrub subtype decreased. Use of the grass subtype exceeded use of the shrub subtype by 13.2% during August. More observations were made in the alpine type during August than previous months. Better flight conditions and observability of sheep during this month accounted

Table 6. Percent of observations of bighorn sheep on various vegetation types and subtypes by month and season for summer and fall 1992 and 1993.

Vegetation Type	Summer				Fall				
or Subtype	June	July	Aug.	Season	Sept.	Oct.	Nov.	Dec.	Season
Bunchgrass Type	86.5	85.9	77.2	83.9	47.4	38.1	17.5	8.7	40.7
Grass Subtype	3.7	18.8	45.2	20.3	19.1	3	----	----	11.7
Forb Subtype	5.9	3	----	3.2	----	----	---	----	----
Shrub Subtype	76.9	64	32	60.4	28.3	35.2	17.5	8.7	29
Douglas-Fir Type	4.9	6.9	4.1	5.6	0.6	----	7.5	----	0.5
Rock Outcrop Subty|	2	3.7	Tr	2.3	----	----	----	----	----
Subalpine Fir Type	----	2.9	----	1.2	----	----	----	----	----
Whitebark Type	----	0.9	3.7	1.3	----	6.1	----	----	2.1
Riparian Type	3.9	1.3	3.8	2.8	8.8	7.5	10	----	7.7
Alpine Type	2.4	2.1	10.6	4.3	0.6	----	----	----	Tr
Talus Subtype	2.4	2.1	4	2.7	----	----	----	----	Tr
Scree Subtype	----	----	3	0.7	----	----	----	----	----
Grass/Forb Subtype	----	----	3.5	0.9	----	----	----	----	----
Agricultural Type	2.3	----	0.6	0.9	42.5	48.3	65	91.3	48.5
Total Number of Sheep Observations	1370	1805	1022	4197	974	603	40	126	1743
Percent of Total Sheep Observed	32.6	43	24.4	100	55.9	34.6	2.3	7.2	100

for this increase. Use of subtypes showed little difference in use between months.

During summer, all observations occurred within 200 m of escape terrain, and 60% of these occurred within 100 m (Table 7). During June, ewes were associated with rocky terrain while lambing; and continued using rocky areas after joining other ewes and lambs. Use of habitat beyond 100 m during summer increased during July and August.

Overall, 70% of observed sheep were greater than 1000 m from domestic livestock (Table 8); 17% were 400-1000 m and 12% were 100-400 m from them. Fewer than 1% of the observations were within 100m from livestock during summer.

A mean slope of 34% was used by bighorns in 3,613 observations (Table 9). Mean slope varied little during summer due to the consistent use of similar vegetation and terrain types during these months. The mean and extreme elevations also changed little during the summer. Sheep exhibited high fidelity to specific areas: and, therefore, mean elevations were unlikely to change during the summer.

South, southwest, west, and east exposures received 40.9, 13.2, 14.0, and 22.5% of the summer use, respectively, in 4,181 observations of individual bighorns (Table 10). There was an increase in use of southwest and southeast exposures through the summer and a decrease in use of west exposure. This may be due to the amount of cover available

Table 7. Percent of observations of bighorns at distances from escape terrain, 1992 and 1993.

Period	Within 100 meters	100 To 200 meters	Greater Than 200 meters	Sample Size
Summer				
June	65.9	34.1	0	1371
July	56.3	43.7	0	1863
August	58.3	41.7	0	992
Fall				
September	18.6	77	4.4	1017
October	27.7	44.2	28.1	563
November	7.5	85	7.5	40
December	0	42.9	57.1	130

Table 8. Percent of observations of bighorns at distances from domestic livestock, 1992 and 1993.

Period	Within 100 meters	100 To 400 meters	400m To 1 km	Greater Than 1 km	Sample Size
Summer					
June	0	0.9	12.9	86.2	1370
July	0	22	21.8	56.2	1709
August	3.9	9.7	13.8	72.6	999
Fall					
September	0	8.3	23.9	67.8	1018
October	0	36.4	13.9	49.7	563
November	0	10	82.5	7.5	40
December	30	0	70	0	130

on these exposures to escape frequent severe thunderstorms and intense afternoon heat during these months.

Fall (September-December)

Use of vegetation types by bighorns changed considerably in fall. Use shifted from the bunchgrass to agricultural type as fall progressed.

Table 9. Percent of observations of bighorn sheep on physical terrain features.

	% Slope		Elev. (m)		
Period	Mean	n	Mean	Extremes	n
Summer					
June	33	1078	1810	3005-1646	1370
July	37	1583	2079	2890-1646	1864
August	31	952	2071	2914-1597	952
Fall					
September	13	964	1794	2926-1609	1120
October	12	562	1729	2524-1622	566
November	12	40	1617	1695-1600	37
December	0	130	1621	1646-1609	130

Table 10. Percent of observations of bighorn sheep that took place on various aspects.

Period	N	S	E	W	SE
Summer					
June	0	35.1	23.4	28.1	2.1
July	6	51.7	19.3	8.8	2.7
August	0.5	27.8	27.2	6.3	6.4
Fall					
September	0.7	18.6	24.1	5.3	2.5
October	3.5	26.1	1.6	17	2.3
November	29.1	1.8	7.3	9.1	5.5
December	0	0	0	0	0

	SW	NE	NW	Level	Sample Size
Summer					
June	8.2	1.7	0.6	0.8	1267
July	10.1	1.1	0	0.3	1900
August	25	2	0.3	4.4	1014
Fall					
September	0	0	1.9	46.7	1081
October	0.9	0	0	48.6	570
November	0	0	0	47.3	55
December	0	0	0	100	130

Use of the agricultural type was 43% in September with 48% for the bunchgrass type. These figures shifted in December to 91% and 9% of the agricultural and bunchgrass types, respectively. It could be argued that November and December sample sizes were insufficient to conclude that these percent usages are representative of use but the significant change in October supports the trend.

Bighorns moved to lower elevations in autumn and use of the alpine type was minimal in the fall. This was due to the movement of the sheep out of the alpine areas onto the fall rutting areas and winter range immediately following the first snowfall.

In September, bighorns began venturing further from escape cover or terrain. A larger percentage of bighorns used habitat 100-200 m from escape terrain. A few bighorns were further than 200 m away from escape terrain.

Distances to livestock decreased during fall as sheep moved onto lower elevation lands which are privately owned. While a majority of bighorns (55.3%) still remained greater than 1000 m from livestock, more bighorns were found within 400 m than summer (Table 8). On one occasion bighorns were observed feeding within 15 m of domestic sheep.

Bighorn use of aspect also changed in fall. Fifty-one percent of 1,836 observations were on level ground (<5% slope). These level areas were generally cultivated fields which provided alfalfa and grass-hay stubble. The mean slope for 1696 observations in fall was approximately 12%, considerably lower than that for summer, as sheep moved to lower elevation wintering areas. The first significant change in mean slope usage occurred in September, dropping from 31% in August to 13% in

September. In December all of 130 observations were made on terrain with 0 percent slope. Elevations used also decreased as sheep moved onto rutting and wintering grounds. Mean elevation dropped sharply in September but the extremes changed very little until November, when all sheep were observed on rutting and wintering ranges.

Habitat Overlap

Observations of wild ungulates other than bighorn sheep during summer and fall indicated that at least a minimal degree of habitat use overlap existed (Figure 11). The number of observations was not large enough to have a substantial impact on forage availability for bighorn sheep during summer or fall (Table 11).

Mule deer were the most commonly observed wild ungulate other than bighorns. A total of 80 mule deer were observed during the study. While many of these were located within the normal ranges of bighorns most were not within habitats often used by bighorns. Although 48 elk were observed, only 8 of were within areas of bighorn use.

Mountain goat numbers along the Highland crest seemed to be low. Over the course of the study only 23 were observed. Single goats were most often seen. The largest group I observed consisted of 5 individuals. Nannies with kids were also infrequently observed.

Several groups of pronghorns inhabited the area but were infrequently observed due to their non-use of bighorn habitats. A total of 23 pronghorns were observed.

Moose were not recorded in great enough numbers to consider possible competition even if forage use overlap with bighorns was present. Observations generally took place outside normal bighorn sheep use areas either in dense timber or riparian sites.

Table 11. Monthly numbers of mountain goats, mule deer, elk, pronghorn, and moose observed, 1992 & 1993.

Month	mtn. goat	mule deer	elk	pronghorn	moose
Summer					
June	0	31	0	0	3
July	8	30	44*	0	0
August	13	4	4	2	0
Fall					
September	2	3	0	0	0
October	0	12	0	21	1
November	0	0	0	0	0
December	0	0	0	0	0

* 40 of these observation were outside known areas of bighorn use.

Domestic livestock were frequently observed utilizing vegetation types used by bighorns and had the greatest potential impact on bighorn sheep. Cattle were present, often in large numbers, on most of the areas occupied by bighorns. The FS 1992 grazing allotment schedule showed that as many as 276 cow/calf pairs and 20 yearling bulls were allowed to graze the Upper Cattle Gulch and Trusty pastures which included a large part of the ram summer range. The grazing plan called for cattle in Upper Cattle Gulch June 27, moved to Upper Trusty August 6, and moved off August 8 to Vipond Creek which had minimal documented bighorn use. Maximum usage was to be 45 percent on these pastures. In 1993, 400 or more head of cattle were observed in these pastures. Use

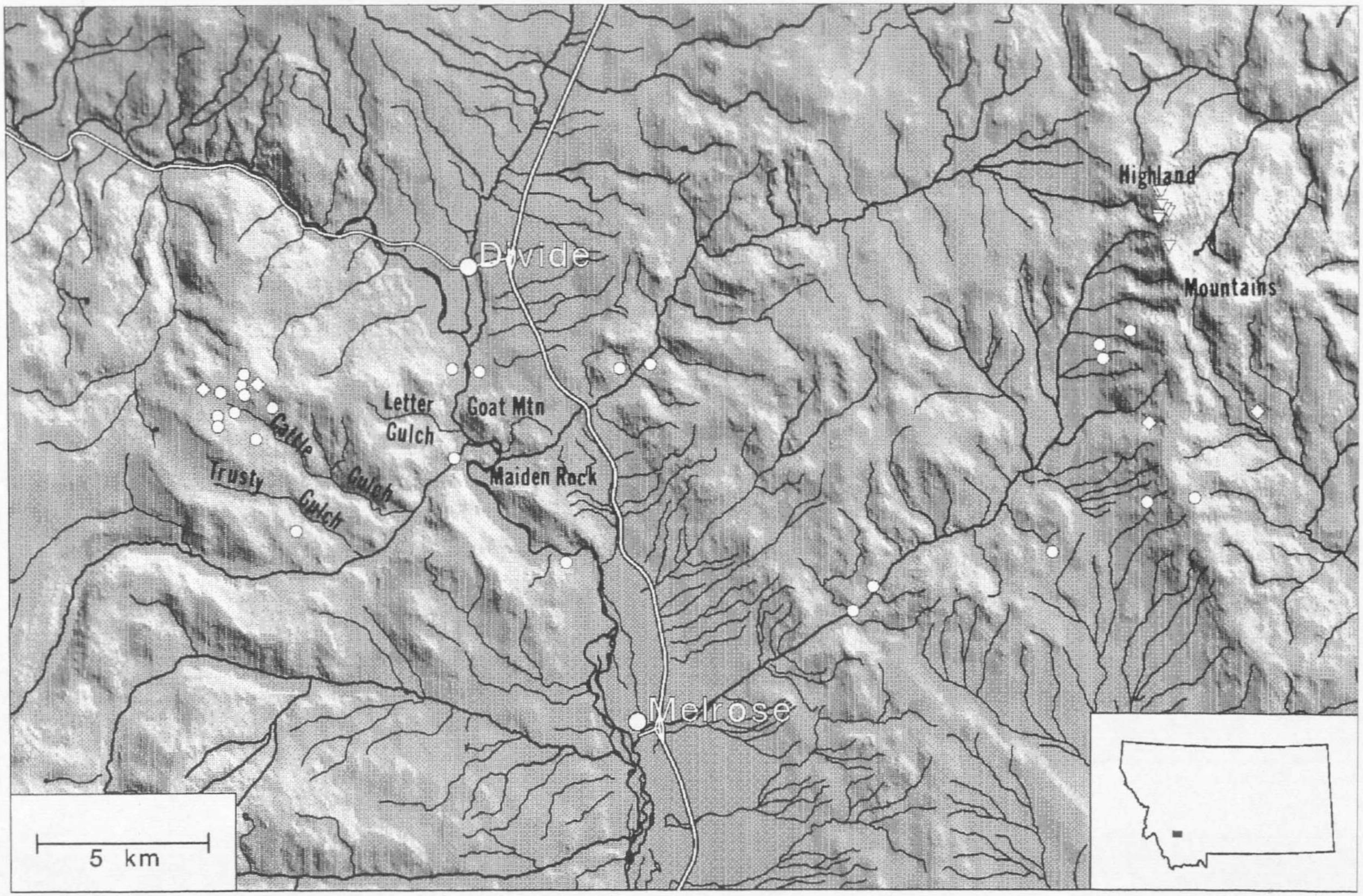

Figure 11. Map with locations of mountain goats(▽), mule deer(○), and elk(◇).

occurred from early July through August. Maximum usage seemed to exceed the 45 percent maximum for the pastures although I did not measure use. This level of use, range overlap and similarity of food habits support the possibility of severe interspecific competition with bighorn sheep.

Cattle density was lower on Moose Creek, Soap Gulch, Camp Creek, and Big Ridge than in the Cattle Gulch area. Moose Creek and Soap Gulch received light to moderate grazing depending on terrain, with few areas of major bighorn use being utilized. Cattle in the lower Camp Creek area were intensely grazed for a short part of the summer then removed. Riparian areas received the heaviest grazing pressure, and few cattle wandered out of the creek bottom into the rugged ridges lining the drainage where bighorn usually fed. Cattle on the upper Camp Creek and Big Ridge areas on Hamilton Ranch property were very widespread, but density and grazing pressure seemed very light. Cattle were grazed near primary ram summer range on Big Ridge, but grazing was not heavy. Forage competition in this area is unlikely.

Direct competition between bighorns and domestic sheep for forage was unlikely in 1992 and 1993. Domestic sheep were confined to fenced lowland pastures on low elevation private lands. Approximately 350 domestic sheep and goats were reared on two ranches near Maiden Rock in the Moose Creek drainage. I believe that grazing pressure by domestic sheep on these private lands was very heavy. Grazing occurred through summer and fall and forage use seemed very high. Although these lands are within bighorn summer-fall range, forage available outside the fenced pastures was abundant.

Food Habits

Rumen Analysis

Graminoids comprised the bulk of the contents of bighorn sheep rumens (Table 12). Because species identification was difficult, grasses and grass-like plants were combined into one forage class. They made up over 59% of the diet and most exceeded 75% of contents in individual rumens (Appendix). No significant difference (p=0.99) in diet composition existed between rumen contents in 1992 and 1993 (Figure 12).

Forbs were found in individual rumens and ranged from 10-24%. Most were lower than 10%. Eriogonum spp. were the most commonly found forbs and made up as much as 15% of the diet in some individuals.

The most commonly and heavily used browse species was curlleaf mountain mahogany. This species comprised greater than 20% of contents in some rumens. Shrubby cinquefoil (Potentilla fruticosa) were also commonly found.

Despite the differences in composition of individual rumen contents, each contained at least one species of a grass, a forb, and a woody species. This suggests that all 3 plant groups are required to maintain balanced fall diets.

Fecal Analysis

Fecal analysis suggested that forbs and mostly herbaceous species were highly used during summer (Table 13). Forbs made up over 50% of the overall diet in the 20 samples and exceeded 70% in some. The most

Table 12. Food habits of bighorn sheep by year as determined from the examination of 41 rumen samples collected from sheep during fall, 1992 and 1993.

	1992 (23) Sept.-Nov.		1993 (18) Sept.-Nov.		Mean (41) Sept.-Nov.	
Plant Taxa	Volume(%)	Frequency(%)	Volume(%)	Frequency(%)	Volume(%)	Frequency(%)
Graminoids	87.6	100.0	81.3	100.0	84.8	100.0
Forbs:						
Agoseris spp.	----	0.0	Tr	5.6	Tr	2.4
Allium spp.	----	0.0	0.7	22.2	Tr	9.7
Centaurea maculosa	Tr	4.3	----	0.0	Tr	2.4
Equisetum spp.	----	0.0	Tr	16.7	Tr	7.3
Eriogonum spp.	1.4	34.8	1.5	16.7	1.4	26.8
Lithospermum luderale	----	0.0	Tr	0.0	Tr	0.0
Medicago sativa	Tr	8.7	----	0.0	Tr	4.9
Melilotus officinalis	Tr	4.3	1.0	11.1	0.5	7.3
Unknown forbs	2.2	100.0	6.0	100.0	3.8	100.0
Total forbs	3.9		9.4		6.3	
Browse:						
Arctostaphylos uva-ursi	----	0.0	Tr	22.2	Tr	9.8
Artemisia frigida	Tr	4.3	0.9	5.6	Tr	2.4
Artemisia tridentata	----	0.0	Tr	5.6	Tr	2.4
Cercocarpus ledifolius	4.5	82.6	4.8	72.2	4.6	78.0
Potentilla spp.	1.3	56.5	1.6	66.7	1.4	58.8
Psuedotsuga menziesii	Tr	52.2	Tr	72.2	Tr	61.0
Purshia tridentata	Tr	4.3	Tr	5.6	Tr	4.9
Salix spp.	Tr	0.0	----	5.6	Tr	2.4
Unknown browse	2.8	100.0	1.8	100.0	2.3	100.0
Total browse	8.5		9.4		8.9	

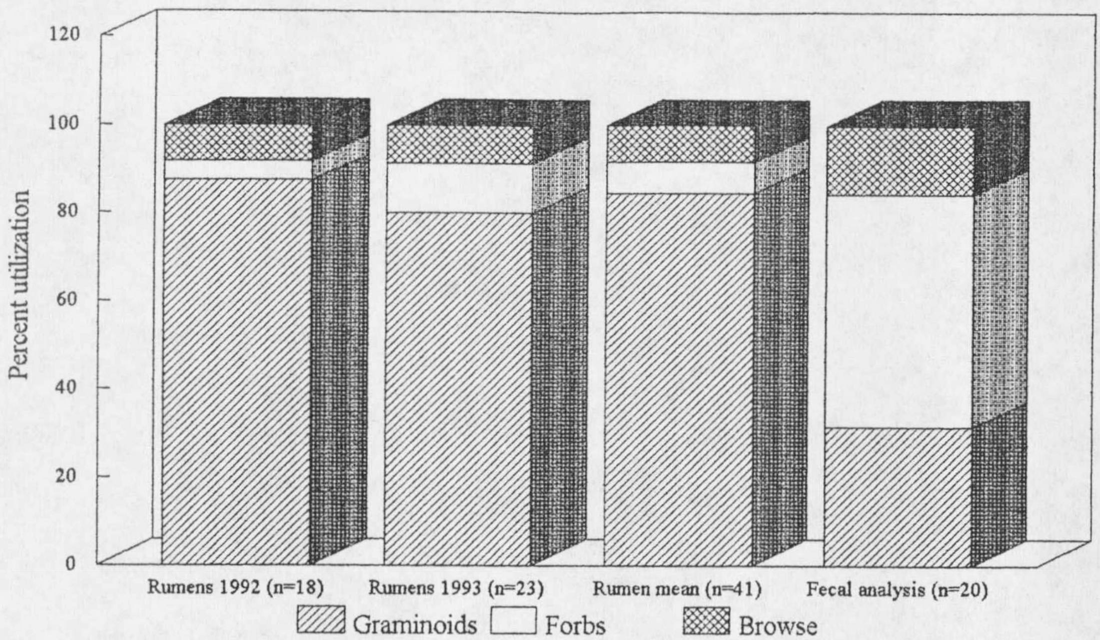

Figure 12. Percent composition of bighorn diets as determined from the analyses of 41 rumens and 20 fecal samples.

commonly used forb, eriogonum, was identified in all samples. Individual samples contained as much as 30.8% eriogonum. Prairie smoke (Geum trifolium), cinquefoil (Potentilla spp.), and western yarrow (Achillea lanulosa) were also present in a large portion of the samples with 95% containing prairie smoke and cinquefoil and 80% western yarrow. Cinquefoil was the only 1 of these 3 taxa that was utilized in quantity, up to 19%. Neither the prairie smoke nor yarrow were present in quantity exceeding 8%.

Graminoids comprised slightly over 31% of the overall summer diet. A maximum of 73% grass or grass-like plants were found in an individual sample. Fescues made up the bulk of the grass and were present in all of the samples. The greatest fescue content in a single sample was 30%.

Table 13. Percent composition of 20 bighorn fecal samples collected during summer, 1993.

Plant Taxa	Mean (%)	Frequency (%)	Extremes
Graminoids			
Agropyron spp.	8.1	85.0	3.4-14.9
Bromus spp.	3.0	80.0	0.8-5.7
Bromus tectorum	3.2	55.0	1.0-6.0
Carex spp.	2.6	10.0	*
Danthonia intermedia	2.3	20.0	0.7-6.4
Festuca spp	13.9	100.0	5.6-29.8
Juncus spp.	0.9	10.0	0.8-1.0
Koelaria spp.	2.3	60.0	1.5-3.9
Oryzopsis hymenoides	1.9	10.0	1.0-2.7
Phleum alpinum	1.0	5.0	*
Poa pratensis	1.9	15.0	1.0-3.7
Poa spp.	2.5	60.0	0.8-4.6
Stipa spp.	3.8	55.0	1.9-8.8
Overall mean	31.3		16.7-50.5
Forbs			
Achillea lanulosa	4.3	80.0	1.8-8.0
Allium spp.	1.7	5.0	*
Arenaria nutalli	1.6	15.0	1.0-2.6
Arnica spp.	1.0	5.0	*
Aster spp.	5.5	55.0	1.2-10.7
Astragalus spp.	4.6	45.0	1.8-8.9
Cerastium spp.	3.0	15.0	1.7-5.1
Delphinium scaposum	0.8	5.0	*
Delphinium spp.	2.5	5.0	*
Erigeron spp.	2.6	35.0	0.8-4.8
Eriogonum spp	17.9	100.0	5.0-30.8
Fragaria spp.	1.1	25.0	0.7-2.0
Geranium richardsonii	3.6	35.0	0.9-5.9
Geum spp.	4.5	95.0	1.8-7.7
Lupinus spp.	4.4	35.0	0.8-11.0

Table 13. Continued

Plant Taxa	Mean (%)	Frequency (%)	Extremes
Penstemon spp.	2.1	45.0	0.7-4.0
Phlox spp.	2.6	20.0	1.1-5.2
Potentilla spp.	9.2	95.0	3.6-19.0
Sphaeralcea spp.	8.6	50.0	0.8-31.3
Taraxicum spp.	5.7	50.0	0.8-16.5
Overall mean	53.1		30.5-73.4
<u>Woody/partly woody</u>			
Abies lasiocarpa	1.0	10.0	1.0-1.1
Artemisia spp.	4.4	45.0	1.5-7.7
Cercocarpus ledifolius	3.9	25.0	2.9-4.8
Chrysothamnus spp.	0.8	5.0	*
Gutierrezia sarothrae	0.9	10.0	0.8-1.0
Pinus spp.	1.1	5.0	*
Pseudotsuga menziesii	7.1	80.0	1.9-10.3
Purshia spp.	7.1	70.0	3.5-12.8
Salix spp.	2.7	65.0	0.8-5.2
Overall mean	15.6		0.0-36.0

* Only one value present or all values are equal.

Wheatgrasses and bromes were present in 80% or more of the samples but did not comprise as large a portion of individual samples as fescue. Wheatgrasses were found as high as 14.9% and bromes 5.7%. Cheatgrass brome (<u>Bromus tectorum</u>), bluegrass, Junegrass, and needlegrass were present in over 50% of the samples but all comprised less than 10 percent each of individual samples.

Woody plants accounted for over 15 percent of the overall diet. Individual samples contained up to 36% browse species. No individual species was found in every sample, but some were present in a large portion of them. Douglas-fir, bitterbrush and, willow were present in

80%, 70%, and 65% of the samples, respectively. Bitterbrush was present in the largest quantity, up to 12.8%. Douglas-fir was found to comprise as much as 10% of individual samples. Other conifers found included subalpine fir and various pines.

Feeding Site Analysis

Summer bighorn diets determined by feeding site analysis showed that the diet was comprised of almost equal proportions of graminoids (48%) and forbs (52%) (Figure 13). Total browse use was < 0.05%.

The diets of cattle as determined by feeding site analysis revealed more use of graminoids (65%) and less of forbs (34%) than bighorns. Browse use by cattle (1%) was similar to bighorns. Domestic sheep diets were found to include the largest proportions of graminoids (89.5%) and almost equal amounts of forbs (5%) and browse (5.5%).

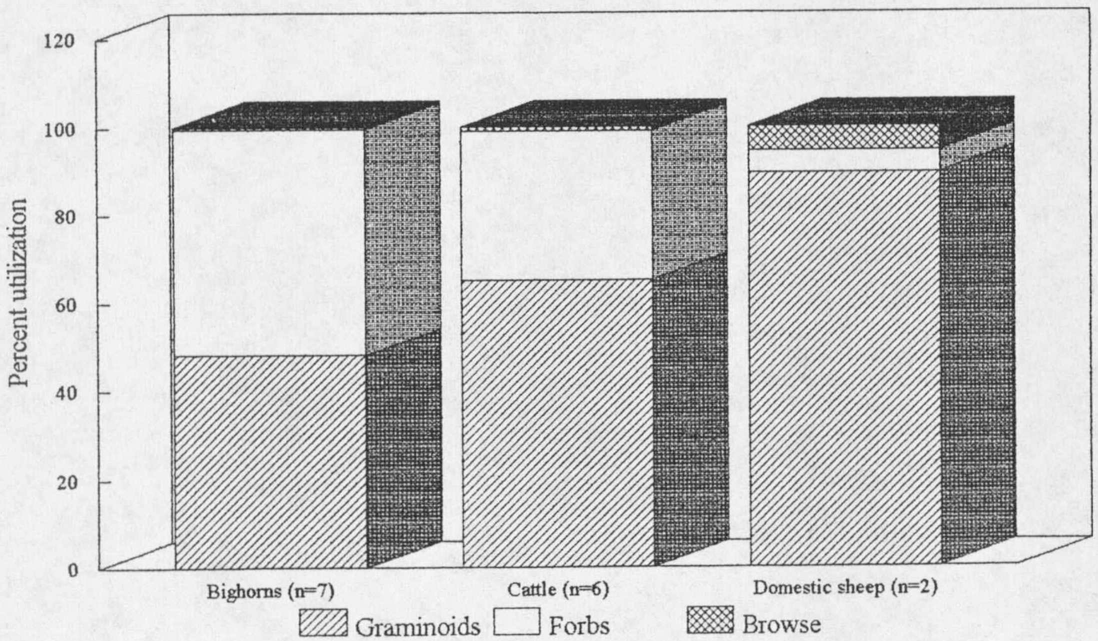

Figure 13. Comparison of percent composition of forage classes in the diets of bighorn sheep, cattle, and domestic sheep as determined from feeding site analysis.

Food Habit Similarity

Graminoid Use. Bighorns and domestic sheep used graminoids at a significantly different level ($P<0.05$) than cattle. However, bighorns and domestic sheep did not show a significant difference ($P=0.83$) in graminoid use.

Forb Use. Results for forb use are similar to that for graminoid use. Bighorns and domestic sheep used forbs at significantly different levels ($P<0.05$) than cattle. Bighorns and domestic sheep did not show a significant difference in forb use ($P=0.25$).

Browse Use. No difference was found among the three ungulates for browse use. Cattle and bighorn sheep did not show a significant difference ($P=0.27$) in browse use. Domestic sheep did not show a significant difference in browse use with bighorn sheep ($P=0.46$) or cattle ($P=0.86$).

Horn's Ro index of similarity showed that the overall diets of bighorn sheep, cattle, and domestic sheep were quite similar. The Ro index suggested that the diets of bighorn sheep and cattle (Ro=1.0) were more similar than the diets of bighorns and domestic sheep (Ro=0.92) or the diets of cattle and domestic sheep (Ro=0.93). The index strongly suggests that overall, the ungulates share very similar diets, without regard to forage category.

The mass of individual plants grazed or bitten off was found to vary among the three ungulates (Figure 14). Graminoids and forbs were grazed at significantly different levels ($P<0.05$), and browse not significantly different (P=0.13) among bighorns. cattle, and domestic sheep.

Graminoid Use. It was found that a significant difference in graminoid use only occurred between bighorns and cattle (P<0.05). No such difference was found between bighorns and domestic sheep (P=0.23) or domestic sheep and cattle (P=0.53).

Forb Use. Results for the amount of individual forbs grazed were very similar to that of graminoids. Bighorns and cattle showed a significant difference in plant use (P<0.05) while bighorns and domestic sheep (p=.54) and domestic sheep and cattle (P=0.27) did not.

Browse Use. It was found that the differences among the ungulates for the amount of browse bitten off was similar to the results of the percentage of observed plants used. No differences were found between bighorn sheep and cattle (P=0.053), bighorns and domestic sheep (P=0.17), or domestic sheep and cattle (P=0.96).

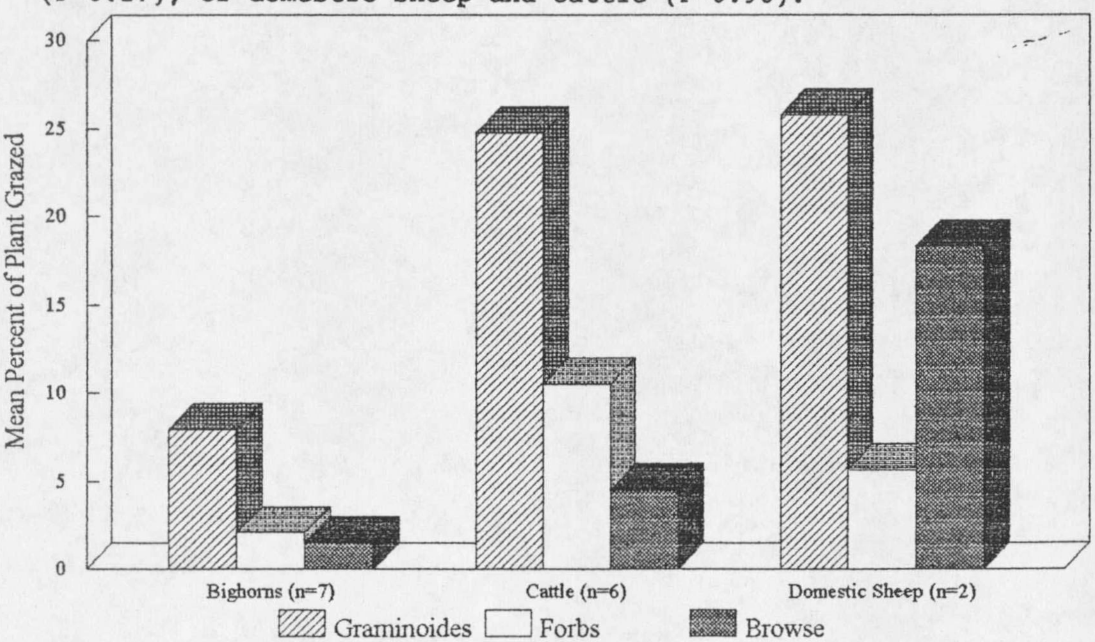

Figure 14. Mean percent of individual plants in each forage category bitten off, as determined from feeding site analyses.

Forage Quality

Fecal nitrogen during the summer ranged from 1.9% to 3.8% with a mean value of 2.6% (Table 14). Fecal nitrogen values were not significantly different (p=0.146) between PHU's. There was no significant difference (p=0.39) in fecal nitrogen among pellets from groups of sheep of different sexual composition.

Table 14. Total moisture, total Kjeldahl nitrogen as received, and total Kjeldahl nitrogen corrected for dry weight for 20 bighorn sheep fecal samples collected during summer, 1993.

Location	Date*	Total Moisture %	TKN % as received	TKN % dry weight basis
Upper PHU 1	159	3.6	3.6	3.8
	159	3.8	3.1	3.2
	173	3.7	2.3	2.4
	207	3.7	2.6	2.7
	208	4.0	2.7	2.8
	209	3.9	2.6	2.7
	213	3.9	2.5	2.6
	221	3.4	2.1	2.2
			Mean =	2.8
Lower PHU 1	160	3.9	2.6	2.7
	160	3.6	2.5	2.6
	179	3.6	2.5	2.6
	216	2.7	2.2	2.3
	244	3.1	1.8	1.9
			Mean =	2.4
PHU 2	154	3.1	2.1	2.2
	158	3.2	2.3	2.4
	182	3.6	2.3	2.4
			Mean =	2.3
PHU 3	165	3.0	2.7	2.8
	227	3.6	2.6	2.7
	228	4.0	2.9	3.0
	229	3.9	2.7	2.8
			Mean =	2.8

*Julian Date

Plant Community Similarity

The index of similarity for plant community composition suggested that the transect for bighorn sheep, cattle, and domestic sheep varied in similarity. Transects for bighorn sheep and cattle were the closest with an S value of .68. Values for bighorn sheep and domestic sheep transects and cattle and domestic sheep transects showed a moderate degree of dissimilarity with S values of .40 and .37, respectively.

DISCUSSION

Population Dynamics

The Highland population has been one of the most successful transplants of bighorn sheep in Montana (Janson 1974, Butts 1980, Kopec 1982, Rognrud 1983). Since the 1967 and 1969 transplants (51 sheep total), the herd has expanded to almost 400 sheep in a 240 km^2 range. This represents a population increase of 14.6% per year over 25 years and expansion from a single drainage into 2 mountain ranges.

Overall, lamb production in 1992 and 1993 was similar to that reported for other Montana bighorn herds (Schallenberger 1966, Erickson 1972, Frisina 1974, Roy 1992). Lamb:ewe ratios varied from 57:100 to 21:100 depending on the number of observations and month of observation. Spring trend counts indicated excellent over-winter survival of lambs and yearlings.

Horn and body growth in rams suggested an abundance of high quality forage was available. Stewart and Butts (1982) reported mean volumes of horns for 3 1/2 year old rams for many bighorn herds in Montana. The mean volume of horns from the Highlands area was well above average.

Geist (1971, 1983) and others (Caughley 1969, Johnson 1980, Cook 1990) have described this type of rapidly increasing, high quality population as exhibiting "r" selected characteristics. This classification is also supported by the lack of old rams harvested in the area. Rams in other populations frequently exceed 10 years of age.

The majority of the harvest in the Highland area includes 5 to 6 year old rams while relatively few over 8 years of age are ever taken.

Movements and Habitat Use

Movements were generally associated with seasonal changes. Little movement occurred in maternal bands until lambs were able to move rapidly. Early summer movements were short and never far from escape terrain. As summer progressed, maternal bands dispersed more widely. During dry summer months, sheep generally moved less and maternal bands were more often found near the Bighole River than in wet months.

In non-migrating sheep lambing generally occurred on or near winter range, and movements following lambing were minor. In migrating sheep groups, all lambing occurred during or after migration onto summer ranges. Martin (1985) and others (Smith 1954, Blood 1963) have reported that ewes which lambed on winter ranges on their study area tended to migrate later than barren ewes and ewes which lambed enroute to summer range. Lambing which occurred enroute to summer range was within 0.5 km of summer range, which suggests that these areas were preferred for lambing over the summer range, possibly due to an abundance of rock outcrops in these areas.

I was unable to obtain detailed information on rams in summer due to the lack of marked animals and their use of timbered habitat types. Attempts to find sheep within the timbered types were rare due to the nonproductivity and time involved with doing so. Because so many rams were not accounted for during the majority of the season I believe they remain in the timber during much of this time. The first noticeable aggregation of rams occurred in late August. After this, rams dispersed and were found in small bands at ever decreasing elevations until they reached the bands of ewes for the rut in late October.

Some movements were noticed when cattle were moved onto pastures on which rams resided. These movements generally consisted of a small move over a ridge or through timber to a pasture without cattle.

Home Ranges

Although the minimum convex polygon home range has been criticized by many (Hayne 1949, Stickel 1954, Mohr and Stumpf 1966, Jenrich and Turner 1969, Smith et al. 1973, Dixon and Chapman 1980, Spencer and Barrett 1984), it was more appropriate to my sample size and distribution than the harmonic mean and the bivariate home range estimators included in the HOMERANGE package (Ackerman et al. 1990). My results fell within ranges reported for individual sheep in other areas of Montana (Erickson 1973, Frisina 1974, Martin 1985). PHU ranges were discrete, this confirmed reports by Dixon and Chapman (1980) and Spencer and Barrett (1884). Because no rams were marked, definitive boundaries cannot be given for areas which they occupied.

Food Habits

Although fecal analysis has its limitations (Slater and Jones 1971, Pulliam and Nelson 1979, Sanders et al 1980, Vavra and Holechek 1980, Holechek et al. 1982, Gill et al. 1983) it was the most feasible method for determining summer diet in this study. Plant species mentioned as susceptible to over and under-estimation did occur in my fecal analysis, but these species occurred in small proportions. Species occurring in very high proportion in analysis, fescues and eriogonum, were unlikely to be poorly estimated. Bluegrass and needlegrass species did not comprise nearly as much of the diet. Forbs which were consistently underestimated by Gill et al. such as milkvetches and fringed sagewort were found to occur only in moderate quantities in my rumen and feeding site analyses. The importance of graminoids and forbs in the diets of bighorn sheep has been well documented (Schallenberger 1966, Constan 1972, Erickson 1973, Frisina 1974, Kasworm 1984, Keating 1985). Forbs which were important in summer diets were common, widely distributed species such as eriogonum, prairie smoke, cinquefoil, and western Yarrow. A few browse species were also found to be of importance and include Douglas-fir, bitterbrush, and curlleaf mountain mahogany.

Interspecific Competition

The bighorn herd population characteristics in this area give little evidence that they are competing for limited resources. Feeding site analysis supported this position. Cattle, domestic sheep, and bighorns used graminoids heavily during summer, but species composition differed. Competition with other wild ungulates was low because of low spatial overlap.

Constan (1972) studied the overlap of forage use in bighorn sheep, mule deer and elk. He found that at least some competition with mule deer was occurring and that significant numbers of elk could cause severe competition due to their similarity in food habits with bighorns.

Similar conclusions were made by Kasworm et al. (1984) where it was found that the majority of the diets of bighorns and elk during the winter consisted of graminoids. However, Constan (1972) also found that sheep utilized areas which the elk used infrequently and therefore could rely on forage in those areas being available. Schallenberger (1966) also noted interspecifc relationships of these animals but his findings were much more extreme. He found that serious interspecific competition occurred when these species were found using the same winter range.

Overlap in forage use during summer has been found with mountain goats and bighorn sheep. Dailey et al. (1984) documented similar forage use in the mountains of Colorado. Mountain goats and bighorn sheep using the same areas were found to chose similar diets during summer but not during winter. Diets were dominated by forbs in early summer and use of graminoids increased as summer advanced. They noted that this summer diet similarity could lead to interspecific competition during that season if numbers of animals became sufficient.

No studies were found that compared diet similarity of pronghorns or moose with bighorn sheep. The literature (Mason 1952, Dirschl 1963, Bayless 1969, Beale and Smith 1970, and Schwartz and Nagy 1976) suggests that at least some overlap in forage use could occur between pronghorn and bighorn sheep. Numerous plants are similarly used by the animals. Range use rarely overlaps in the Highland area. While pronghorn were documented in the area, they were most often found further away from bighorn escape terrain than the bighorns generally ventured. However, areas used by pronghorn could very well be used as winter range by bighorn sheep and could therefore be utilizing forage important to bighorn sheep and could therefore be utilizing forage important to bighorn in winter. Pronghorns are currently not abundant enough to cause serious loss of winter forage for bighorns.

The potential for the occurrence of interspecific competition of bighorn sheep with cattle or domestic sheep are present as indicated by feeding site analysis and range use overlap. Kasworm et al. (1984) also examined the diets of bighorn sheep and cattle. The results of both studies indicate dietary overlap between the two ungulates.

Current grazing rotation methods used by the FS on pastures in which both cattle and bighorn sheep are grazing seem to be preventing serious impacts on the bighorns. Bighorn groups which utilize the same areas as cattle, freely move onto areas which are inaccessible to cattle or that cattle are not using. Because some pastures are rested, substantial high quality forage was available to bighorns in those areas.

Spatial segregation occurred between bighorns and cattle. Few bighorns were observed feeding in the vicinity of cattle and most moved to another pasture when cattle entered a pasture where they were. This avoidance of cattle by bighorn sheep was related directly to the number of cattle present. Groups of cattle which included 10 to 30 animals caused very little disturbance of bighorns, but bighorns were rarely observed in pastures with greater than 50 head of cattle present regardless of size of pasture.

I could not determine the extent of competition that could occur between bighorns and domestic sheep. The only domestic sheep on the study area were in small pastures on 500 he private lands near sheep pastures were vastly different from those in areas of major bighorn sheep use. My feeding site analyses would be unlikely to apply to domestic sheep grazed on FS or BLM lands used by bighorns.

Several additional caveats should be mentioned. Categorization of plants, during feeding site data statistical analyses, eliminated any effects of preferred forage species on forage selection by bighorns or domestic livestock. Because plants were combined into forage categories the effect of individual species was lost. Plants were also weighted equally despite the number of incidences of use and availability. Species which only occurred a few times in a transect may have received 100 percent utilization and are given equal weight as species which occurred frequently and received high use. Percent utilization of species with few observations may not be accurately estimated. Lastly, each species of ungulate was given equal weighting even though rate and quantity of forage consumption varies between species. Group size was accounted for and used as a covariate during analysis to reduce some of the differential forage use.

Forage Quality

Fecal nitrogen values obtained in this study were within ranges for bighorn sheep reported from other studies (Hebert 1973, Herbert et al. 1984, Irwin et al. 1993). Some values for nitrogen and moisture may be influenced by the area and time when collected, eg. samples 17, 18, and 19 were collected in late summer at high elevation. Those areas experienced snowmelt throughout the summer and could maintain forage higher quality longer than the drier low elevations. Generally, an initial increase was followed by a gradual decrease through summer in PHU 1. No such trend was seen in PHU 2 or PHU 3. Timing of sample collection and too few samples could have masked this effect in PHU 2 and PHU 3.

Ingested plants with soluble tannins increase fecal nitrogen (Mcleod 1974, Mould and Robbins 1981, Robbins 1983, Leslie and Starkey 1985). Tannin bearing plants on the current study area include curlleaf mountain mahogany, bearberry, and fireweed found during rumen and feeding site analysis (Grainge and Ahmed 1988). Mould and Robbins (1981) mention that for Rocky Mountain elk, nitrogen levels were only slightly elevated when forages with tannins were reduced to 33% or less in a ration. Based on occurrence of these plants in analyses, it is unlikely that tannins have significantly influenced fecal nitrogen levels in this study.

Figure 15. A bighorn sheep ewe feeding on curlleaf mountain mahogany, a source of tannins.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The bighorn population in Hunting District 340 seems to be growing numerically and spatially. The total limit of growth for this population will likely be set by landowner tolerance rather than by range or forage. Quality habitat lies outside the population's current range and will most likely be colonized by bighorns for years to come; however, bighorn numbers in the center of their range seem to be approaching if not exceeding landowner tolerance.

Hunting and transplanting of sheep in the area will continue to be very significant tools for bighorn management in this area. To maintain the trophy ram production for hunting and viewing opportunities, rams will need to be carefully monitored to prevent overharvest of immature rams. Harvest of ewes and transplants should be the main tools for keeping population numbers within landowner tolerance limits. Transplants taken from specific herd segments which impact private lands would be helpful.

Because fewer rams and smaller ewe bands reside on the Highland portion of the area and the herd segments are generally more remote outside the rut than the Pioneer subpopulation, separate management of the 2 areas may be required. If additional study verifies the lack of interchange between areas, separate quotas for each subpopulation could insure that the productivity of the smaller groups is not lost.

Due to the accessibility of rams in this area during the rut, I recommend that ram harvest be closely monitored to assure that overharvest of prime rams does not occur. Though season closure prior to the rut is not assumed necessary, the ease with which hunters may harvest a ram during this time period is of concern. I believe the current harvest of ewes should be sufficient to stop any further population increase in the vicinity of private lands. If not a limited harvest of immature rams may be necessary.

The productivity of the population (ie. lamb production and survival) indicates that forage production and quality is high. Results of fecal nitrogen analysis further support that the bighorns are consuming quality forage during summer and fall.

Figure 16. Trophy rams accessed less than 100 m from the Bighole river and access road during October.

At present, interspecific competition with other wild ungulates does not seem to be occurring during the summer and fall seasons, thus no management changes are needed with regard to these animals. Domestic livestock, however, do represent a potential impact on the bighorns. While forage is not currently a limited resource for bighorns, higher stocking rates of cattle and the addition of domestic sheep grazing on public lands could create competition for forage and displace bighorns.

I recommend that stocking rates of cattle be maintained at no more than the current level to prevent negative impacts on bighorns and range. Additionally, given the uncertainty relative to disease and forage use overlap, caution should be used if domestic sheep are allowed to graze on public lands inhabited by bighorns and attempts made to keep the 2 species spatially segregated.

The possibility for disease transmission from domestic livestock to bighorns is definitely present. However, as Foreyt (1990, 1992) suggested, it is not likely because bighorns were not observed to have nose to nose contact with livestock, particularly domestic sheep. Bighorns were observed in close proximity to domestic sheep on few occasions suggesting that transmission is unlikely. Further research is required to determine disease transmission potential. Although nose to nose contact was not documented it is felt that it could occur especially during rutting activity and winter months when bighorns are concentrated near domestic livestock.

The bighorns have thus far coexisted with domestic sheep for more than 20 years with no outbreak of <u>Pasteurella haemolytica</u>, but the potential exists. It is in the best interest of both domestic and wild sheep managers to ensure that this does not occur. Future management should be geared towards preservation of the sheep population in cooperation with landowners so that each may benefit.

There is also need for an accurate census of the population. This would preferably be done by a systematic grid flight by helicopter. A census would aid researchers in detecting health problems in the herd and also give baseline data for causes in the event of a die-off.

The public should also be made aware of disease potential and be asked to report any suspicious or odd behaviors in bighorns, such as coughing and excess mucous, and sick or dead sheep. This would allow researchers to investigate problems during initial phases of health deterioration.

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APPENDIX

Table 15. Identification numbers, frequencies, ear tag numbers, sex, age (years), and status of bighorn sheep captured during March, 1992 and 1993.

				Ear tag number		Collar code	
ID #	Sex	Age	Frequency	Left	Right	(Color/Symbols)	Status
1	F	6-7	151.373	30623	30622	RED/stars	Alive
2	F	ad.	151.411	30607	30606	RED/crosses	Alive
3	F	ad.	151.358	30605	30604	RED/Xs	Hunter kill, 1993
4	F	3-4	151.905	30603	30602	RED/daggers	Alive
5	F	2	151.581	30629	30628	RED/chevrons	Alive
6	F	ad.	151.618	30627	30626	No symbol	Alive
7	F	4-5	151.516	30640	30639	RED/bar dash	Alive
8	F	2-3	151.464	30617	30616	RED/large dots	Alive
9	F	ad.	151.339	30615	30614	RED/triangles	Alive
10*	F	1 1/2		30621	30620		Found dead, 6/92
11*	F	ad.		30609	30608		Found dead, 6/92
12	F	ad.	151.772	30611	30610	RED/slashes	Hunter kill, 1993
13	F	8-10	151.322	30613	30612	RED/solid stripe	Alive
14	F	6-7	151.815	30619	30618	RED/lazy 2	Hunter kill, 1993
15	F	6-7	151.661	30625	30624	RED/gates	Alive
16	F	3	151.252	33475	-----	ORANGE/half moon	Hunter kill, 1993
17	F	ad.	151.262	33433	33438	ORANGE/arrows	Hunter kill, 1993
18	F	ad.	151.237	33425	-----	ORANGE/threes	Alive
19	F	ad.	151.257	33471	33439	ORANGE/lazy H's	Hunter kill, 1993
20	F	1/2	151.309	33447	33474	RED/squares	Found dead, 7/93
21	F	3	151.702	33449	-----	RED/dashes	Alive
22	F	5	150.191	33448	-----	ORANGE/long stripe	Alive

* Sheep had died before beginning of study so no collar data is given, collars were put on sheep during March, 1993 capture.

Table 16. The number of animals present at each feeding site transect.

Transect number	Cattle	Bighorns	Dom. Sheep
1	150	13	120
2	250	21	200
3	100	51	----
4	15	67	----
5	400	21	----
6	150	25	----
7	----	70	----

Table 17. Mean percent utilization per animal of total available plants determined by feeding site analysis.

Transect number	Cattle	Bighorns	Dom. Sheep
Graminoids			
1	0.005	0.008	0.006
2	0.003	0.001	0.005
3	0.009	0.001	----
4	0.027	0.001	----
5	0.002	0.017	----
6	0.003	0.004	----
7	----	0.007	----
Std. Dev.	0.010	0.006	0.001
Forbs			
1	0.002	0.014	0.003
2	0.003	0.005	0.001
3	0.004	0.002	----
4	0.017	0.007	----
5	0.001	0.007	----
6	0.003	0.002	----
7	----	0.003	----
Std. Dev.	0.006	0.004	0.001
Browse			
1	0.001	0.000	0.007
2	0.002	0.000	0.000
3	0.004	0.004	----
4	0.006	0.001	----
5	0.000	0.003	----
6	0.001	0.001	----
7	----	0.000	----
Std. Dev.	0.002	0.002	0.005

Table 18. Mean percent of individual plants bitten off per animal as determined by feeding site analysis.

Transect number	Cattle	Bighorns	Dom. Sheep
Graminoids			
1	0.125	0.362	0.203
2	0.107	0.008	0.169
3	0.235	0.010	----
4	1.462	0.009	----
5	0.052	0.769	----
6	0.098	0.086	----
7	----	0.113	----
Std. Dev.	0.550	0.283	0.024
Forbs			
1	0.032	0.312	0.065
2	0.071	0.110	0.024
3	0.148	0.032	----
4	0.339	0.080	----
5	0.029	0.032	----
6	0.057	0.016	----
7	----	0.040	----
Std. Dev.	0.119	0.104	0.029
Browse			
1	0.026	0.0	0.122
2	0.042	0.0	0.0
3	0.082	0.055	-----
4	0.280	0.056	----
5	0.028	0.032	----
6	0.023	0.008	----
7	----	0.012	----
Std. Dev.	0.100	0.024	0.086

Table 19. List of plants that were observed on the study area.

Taxonomy	Common Name
Graminoids	
Agropyron smithii	Western wheatgrass
A. spicatum	Bluebunch wheatgrass
A. subsecundum	Bearded wheatgrass
A. trachycaulum	Slender wheatgrass
A. trichophorum	Pubescent wheatgrass
A. intermedium	Intermediate wheatgrass
Bouteloua gracilis	Blue grama
Bromus inermis	Smooth brome
B. marginatus	Mountain brome
B. tectorum	Cheatgrass brome
Carex spp.	Sedges
Dactylis glomerata	Orchardgrass
Danthonia intermedia	Timber oatgrass
Deschampsia caespitosa	Tufted hairgrass
Elymus condensatus	Giant wildrye
Festuca idahoensis	Idaho fescue
F. ovina	Sheep fescue
F. scabrella	Rough fescue
Hordeum jubatum	Foxtail barley
Koelaria cristata	Prairie junegrass
Juncus spp.	Rushes
Oryzopsis hymenoides	Indian ricegrass
Phleum alpinum	Alpine timothy
P. pratense	Timothy
Poa alpina	Alpine bluegrass
P. ampla	Big bluegrass
P. fendleriana	Muttongrass
P. pratensis	Kentucky bluegrass
P. secunda	Sanberg bluegrass
Stipa Comata	Needle-and-thread
S. viridula	Green needlegrass
Forbs and Shrubs	
Achillea lanulosa	Western yarrow
Agoseris glauca	Pale agoseris
Allium cernuum	Nodding onion
Antennaria spp.	Pussytoes
Arctostaphylos uva-ursi	Bearberry
Arenaria nutallii	Nutall's sandwort
Arnica spp.	Arnica
Artemisia cana	Silver sagebrush
A. frigida	Fringed sagewort
A. tridentata	Big sagebrush
Aster spp.	Asters
Astragalus spp.	Milkvetch

Table 19. Continued

Taxonomy	Common Name
Balsamorhiza sagittata	Arrowleaf balsamroot
Calochortus nutalli	Sego lily
Castilleja miniata	Indian paintbrush
C. thompsonii	Thompson's paintbrush
Centaurea maculosa	Spotted knapweed
Cerastium arvense	Field chickweed
C. beergianum	Alpine chickweed
Chrysothamnus nauseosus	Rubber rabbitbrush
C. viscidiflorus	Green rabbitbrush
Convolvuvus arvensis	Bindweed
Delphinium bicolor	Low larkspur
Descurania spp.	Tansy mustard
Dodecatheon pauciflorum	Shooting star
Epilobium angustifolium	Fireweed
Erigeron spp.	Fleabane
Eriogonum spp.	Eriogonum
Erythronium grandiflorum	Glacier lily
Fragaria ovalis	Wild strawberry
Frasera speciosa	Green gentian
Fritillaria pudica	Yellow fritillary
Gentiana prostrata	Moss gentian
Geranium viscossissimum	Sticky geranium
Geum triflorum	Prairie smoke
Gutierrezia sarothrae	Broom snakeweed
Hedysarum spp.	Sweetvetch
Iris missouriensis	Western iris
Lappula spp.	Stickseed
Lithospermum ruderale	Wayside gromwell
Linnum perrene	Blue flax
Lupinus sericeus	Silky lupine
Medicago sativa	Alfalfa
Melilotus officinalis	Yellow sweetclover
Mimulus guttatus	Common monkeyflower
Oenothera spp.	Eveningprimrose
Oxytropsis lagopus	Rabbit-foot crazyweed
O. sericea	White pointloco
Pedicularis spp.	Lousewort
Penstemon spp.	Penstemon
Phlox spp.	Phlox
Polygonum bistortoides	American bistort
Potentilla diversifolia	Varileaf cinquefoil
P. fruticosa	Shrubby cinquefoil
P. ledebouriana	Alpine cinquefoil
P. nutallii	Nutall cinquefoil
Purshia tridentata	Antelope bitterbrush
Rumex acetosella	Sheep sorrel

Table 19. Continued.

Taxonomy	Common Name
R. pauciflorus	Mountain sorrel
Sarcobatus vermiculatus	Greasewood
Sedum lanceolatum	Lanceleaved stonecrop
Senecio spp.	Groundsel
Silene acaulis	Moss campion
Solidago spp.	Goldenrod
Sphaeralcea spp.	Globemallow
Taraxacum officinale	Common dandelion
Thlaspi spp.	Pennycress
Townsendia parryi	Parry's townsendia
Trifolium spp.	Clover
Vaccinium scoparium	Grouse whortleberry
Verbascum thapsus	Flannel mullein
Zigadenus elegans	Death camas
Trees	
Abies lasiocarpa	Subalpine fir
Cercocarpus ledifolius	Curlleaf mountain mahogany
Juniperus communis	Common juniper
J. horizontalis	Creeping juniper
J. scopulorum	Rocky mountain juniper
Pinus albicaulus	Whitebark pine
P. contorta	Lodgepole pine
Populus spp.	Cottonwood
P. tremuloides	Quaking aspen
Prunus virginiana	Common chokecherry
Pseudotsuga menziesii	Douglas-fir
Salix spp.	Willow