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SEASONAL MOVEMENTS AND HABITAT USE OF THE HIGHLAND/PIONEER MOUNTAINS BIGHORN SHEEP HERD OF SOUTHWEST MONTANA

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Abstract: A study of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) within the Highland and Pioneer Mountains was conducted on a seasonal basis during 1994. Data were collected related to sex and age structure, home ranges, population estimate, food habits, and possible competition with mule deer (*Odocoileus hemionus*) and/or cattle. Winter and summer home ranges for 3 subpopulations were assessed with telemetry data from 36 radio-collared ewes. Home ranges ranged from 6.40 to 32.97 km². Sex and age composition were determined from 5,985 observations of individual sheep (included multiple observations of the same animal), resulting in 1994 mean lamb:ewe and ram:ewe ratios of 43.6 lambs and 54.4 rams per 100 ewes. Feeding site, fecal, and rumen analysis showed that graminoids were the dominant vegetation class in the diet of bighorn sheep during all seasons. However, feeding site analysis showed that as palatable forbs became abundant during the spring and early summer, sheep increased intake of forbs. Mule deer and bighorn sheep diets during the winter showed dissimilarities, with bighorn sheep consuming more ($P < 0.05$) graminoids than mule deer. The summer diets of bighorn sheep and cattle were similar in forb and shrub content, but cattle consumed more ($P < 0.05$) graminoids than bighorn sheep. Cattle and sheep maintained spatial separation in summer. This study described seasonal movements and habitat use of the Highland/Pioneer mountains bighorn sheep herd immediately prior to a die-off attributed to a sheep pneumonia complex. Approximately 90% of the population died between December 1994 and March 1995.

The native herd of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis)* that originally inhabited the Highland Mountains area south of Butte, Montana, was extirpated in the early 1900s (Coucy and Schallenberger 1971). In the late 1960s, 51 bighorn sheep were relocated to the Camp Creek area within the Highland Mountains complex via 2 transplants from the Sun River bighorn sheep herd of north-central Montana. The transplants occurred in 1967 and 1969 with 21 and 30 sheep, respectively.

In the early 1970s, bighorn sheep began expanding their range, branching out from the Camp Creek area in both north and northwesterly directions. The sheep population continued to expand its range throughout the 1970s and 80s forming 3 subpopulations present today. One subpopulation remains in the Camp Creek area; the second subpopulation settled north of Camp Creek in the Moose Creek area; and the third subpopulation settled in the Maiden Rock area of the East Pioneer Mountains (Weigand 1994). The 3 subpopulations will be referred to as Camp Creek Subpopulation (CCS), Moose Creek Subpopulation (MCS), and East Pioneer Mountains Subpopulation (EPMS).

By the early 1970s the bighorn sheep population in the Highland/Pioneer mountains had grown to a size that allowed limited hunting opportunities (Janson 1974). In the mid-1980s, the Highlands bighorn sheep herd had become one of the premiere herds in the United States for trophy rams, with many rams reaching trophy status by 4 years of age. From 1983-1993, 24 rams taken by hunters in Hunting District 340 (HD 340) made the Boone and Crockett record book (minimum score = 180) (Karwaski 1994). Included in these trophy rams is a dead ram found by Jack Atcheson, Jr. in 1992 that scored 203 5/8 and ranked #2 in Montana and #5 in the world (Reneau and Reneau 1993).

This study was developed to document the status of the Highland/Pioneer Mountains bighorn sheep herd using the following objectives: (1) determine the sex and age structure of the herd; (2) document the seasonal ranges of the 3 primary segments of bighorn sheep; (3) estimate the population size; (4) document food habits of bighorn sheep by season; and (5) delineate the degree of overlap of range use among mule deer and bighorn sheep, and between livestock and bighorn sheep. This report covers monitoring efforts in 1994 and is a continuation of the study by Weigand (1994).

I wish to acknowledge the Bureau of Land Management, Montana Department of Fish, Wildlife and Parks (MDFWP), the Foundation for North American Wild Sheep, and Atcheson's Taxidermy of Butte, Montana, for funding this study.

STUDY AREA

The study area was located south of Butte, Montana in the Highland and Pioneer mountains. The boundaries of Hunting District (HD) 340 (MDFWP Legal Descriptions 1994), within MDFWP's Region 3, also served as the boundaries for the study unit. Bighorn sheep have been documented to occupy approximately 400 km^2 of the 2335 km^2 of land area that lies within HD 340.

The study area was divided into east and west sides by Interstate 15. The east side of the study area was made up of the Highland Mountain Range and adjacent southwestern foothills. The west side of the study area was comprised of the East Pioneer Mountains. Bluebunch wheatgrass (*Agropyron spicatum*), curlleaf mountain mahogany (*Cercocarpus ledifolius*), big sagebrush (*Artemisia tridentata*), and Douglas-fir (*Pseudotsuga menziesii*) were the dominant grass, shrubs, and tree of the study area, respectively. Elevations of the study area ranged from 1580 m to 3110 m. Land uses included mining and ranching.

Climate

The climate of the study area was semi-arid, characteristic of southwestern Montana. Figures 1 and 2

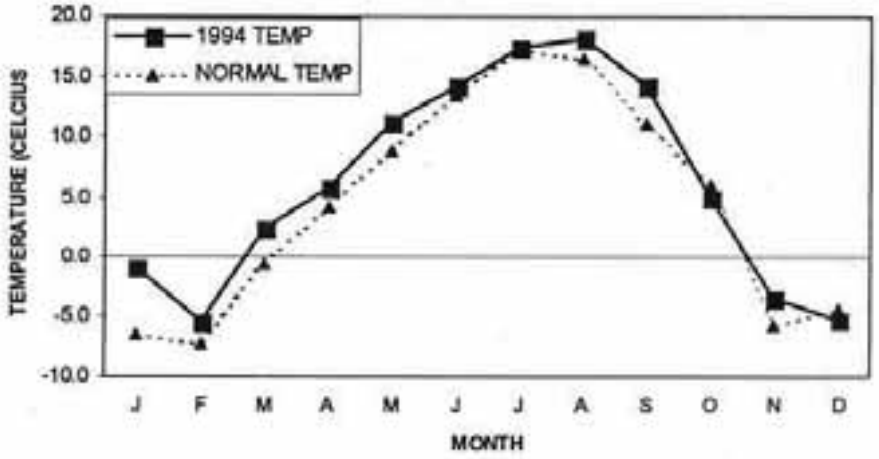

Figure 1. Comparisons of the 1994 mean monthly temperatures versus the 30-year mean monthly temperatures of the study area.

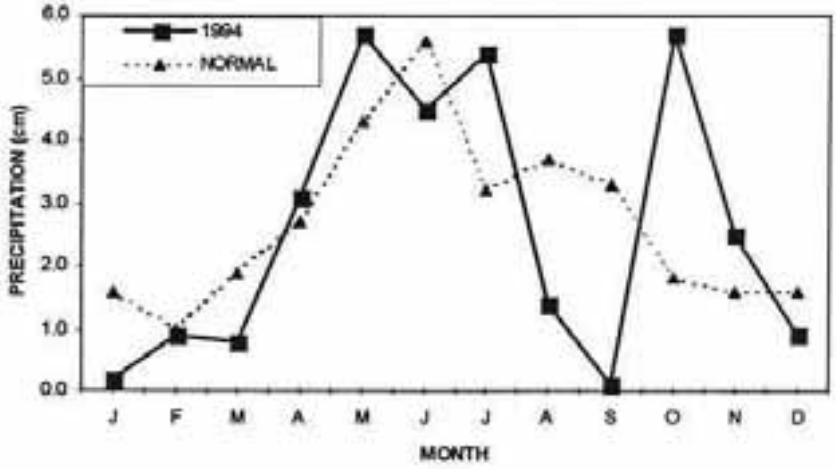

Figure 2. Comparisons of 1994 mean monthly precipitation levels versus the 30-year mean monthly precipitation levels of the study area.

represent the mean monthly 1994 temperature and precipitation compared to the 30-year mean normal temperature and precipitation (U.S. Department of Commerce 1995). Weather data were collected at the United States Weather Bureau Station at approximately 1,650 m in elevation near Divide, Montana, located on the northern boundary of the study area. The winter of 1994 was very mild throughout the study area. Drought conditions prevailed during the months of August-September. October and November had greater amounts of precipitation than normal, and severe weather continued into the winter of 1995.

METHODS

Relocations of 36 radio-collared ewes were obtained using radio telemetry from ground and air. No rams were radio-collared during the study. Some uncollared bighorn sheep were individually identifiable by peculiar markings, mainly physical abnormalities (i.e. scars, broken or deformed horns, etc.). Ground sightings and radio relocations were obtained using a Telonics receiver (frequency range 150.000-154.000), a handheld H-antenna, 10x50 binoculars, and a 20x spotting scope. Aerial relocations were made using a Piper Super Cub with a retractable bottom mounted, directional 3-element Yagi antenna.

Home ranges, sex and age structure, and population estimates were determined using the relocation data. Cut-off dates between summer and winter ranges were determined when at least 80% of the radio-collared ewes had relocated to the summer and winter core areas documented by Weigand (1994). Home ranges were determined using the program Calhome (Kie et al. 1994). Population estimates were made by analyzing the number of sheep observed during 19 flights in 1994.

Food Habits

Feeding site data were obtained by observing feeding bighorn sheep for a time period of no less than 10 minutes, then the feeding site was approached to collect data. Data were collected using the method described by Frisina (1974), where one bite was considered to designate an instance of use per plant. Instances of use were placed into one of four categories; graminoids, forbs, shrubs, or trees. Seasonal instances of use were totaled and analyzed to determine food habits on a seasonal basis.

Forty composite fecal samples (10 per season) from bighorn sheep were sent to the AAFAB Composition Analysis Laboratory in Fort Collins, Colorado to be classified by microhistological analysis. Whenever possible, fresh fecal samples from at least 10 different animals were combined to make up 1 composite sample. The samples were placed in paper bags and oven-dried at 51° C for a period of 24 hours. After drying, individual pellets were randomly selected from paper bags until approximately 10 grams of pellets were obtained. This sub-sample was sent to be analyzed.

A list of the 1994 bighorn sheep permit holders for HD 340 was obtained, and a letter was sent to each permit holder requesting that he or she save the rumen for analysis upon harvesting a bighorn sheep. A total of 70 letters were sent. Approximately 1 liter of rumen content from each sample was placed in a 1 liter jar and filled with 10% buffered formalin solution to preserve the specimen until the food habit analysis was performed. Rumen contents were examined at the MDFWP Wildlife Laboratory in Bozeman, Montana.

Determination of food habits by rumen analysis was accomplished using the point-frame method described by Chamrad and Box (1964). Plant fragments were identified to plant type or species with the aid of a 7x30 dissecting scope and the plant specimen library at the MDFWP Wildlife laboratory in Bozeman, Montana.

Interspecific Relationships

Locations were recorded for bighorn sheep and other wild and domestic ungulates to determine the extent of range overlap. Distance from observed elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), mountain goats (*Oreamnos americanus*), pronghorns (*Antilocarpra americana*), cattle, and domestic sheep to bighorn sheep were recorded during each season. Distances were placed in 1 of 5 categories (0-10, 11-50, 51-200, 201-500, and >500 m) for analysis. An observation was only recorded when another ungulate species, regardless of the number of individuals present, could be seen in the same field of view as bighorn sheep.

Comparisons of mule deer and bighorn sheep diets were made by fecal analysis during the winter. Five composite fecal samples were collected from mule deer using areas in close proximity to bighorn sheep. The mule deer composite fecal samples were prepared and analyzed in the same manner as the composite fecal samples of bighorn sheep.

Cattle and bighorn sheep diets were compared during summer by feeding site analysis. Four feeding site analyses were completed for cattle within grazing allotments on public lands located in areas of bighorn sheep use. Cattle feeding site analysis was executed in the same matter as bighorn sheep feeding site analysis.

Differences in deer-sheep and cattle-sheep diets were identified using multiple t-tests for forage class and season. Areas of use (i.e. ridge tops, open meadows, movement patterns) were also taken into consideration.

RESULTS

Sex and Age composition

Between 1 January and 31 December 1994, 8,285 observations of individual bighorn sheep (included multiple observations of the same animal) were made. Of these observations, 4,096 were made during 19 flights, and the remaining 4,189 observations were made during ground censuses. Attempts were made to classify bighorn sheep age and sex composition during each survey, but 2300 observations of sheep were not classified due to weather conditions, darkness, or distance.

The population age structure was estimated at 30, 35, 53, and 51 lambs per 100 ewes for winter (Jan-Mar), spring (Apr-Jun), summer (Jul-Sep), and fall (Oct-Dec), respectively. Sex structure was estimated at 53, 67, 49, and 50 rams per 100 ewes during winter, spring, summer, and fall, respectively.

Home Ranges

Home ranges were calculated only for ewe-lamb groups because these were the only groups that contained marked animals which could be consistently relocated. Mature ram groups were segregated from ewe-lamb groups during most of the year and sporadic observations of mature rams groups did not define a positive home range boundary for these animals.

Ewe-lamb groups in the CCS were migratory and, therefore, had distinct winter and summer home ranges. Summer home range dates were from 10 May to 6 October, while the winter home ranges were occupied from 7 October to 9 May. These dates were also arbitrarily applied to the EPMS and MCS, even though these subpopulations were not considered to be migratory. Home range sizes ranged from 6.4 km^2 to 32.9 km^2 (Table 1). Home range boundaries were determined using the 95% minimum convex polygon method (Figure 3).

Population Estimation

The population size was estimated from the 19 flights taken during 1994. A mark-recapture population estimation was not used because the assumption that all animals had an equal chance of being sighted was violated. Radio-collared ewes were used to locate bighorn sheep groups, thus biasing the number observed to the sheep within the marked groups and no unambiguously marked ram groups were available.

As an alternative, a population estimate was applied based on minimum number known alive to estimate the population. The highest number of sheep observed during a single flight was 321 on 8 April, 1994. Because rams and ewes remained segregated for most of the year this was not considered to be an accurate estimate of the minimum number of sheep known alive. A more accurate estimate of the minimum number known alive was obtained by summing the highest number of mature rams and the highest number in ewe-lamb groups, even though they occurred on different flights. The greatest number of mature rams (82) was observed on an 8 April flight, while the highest number of ewe and lambs (242) was observed on 22 July. This gives an minimum number known alive of 324.

Average sizes of ewe-lamb and ram groups were summarized to determine the time of year when maximum group size occurred (Figure 4). The maximum ewe-lamb group sizes occurred during the winter months, while spring to early summer observations showed that rams were congregated in larger groups.

Table 1. Number of relocations (n) and land area (km^2) of summer and winter home ranges for the East Pioneer Mountain (EPMS), Moose Creek (MCS), and Camp Creek (CCS) subpopulations.

	SUMMER		WINTER	
SUBPOPULATION	n	km^2	n	km^2
EPMS	252	31.3	239	32.9
MCS	52	6.4	45	28.5
CCS	91	25.5	146	20.6

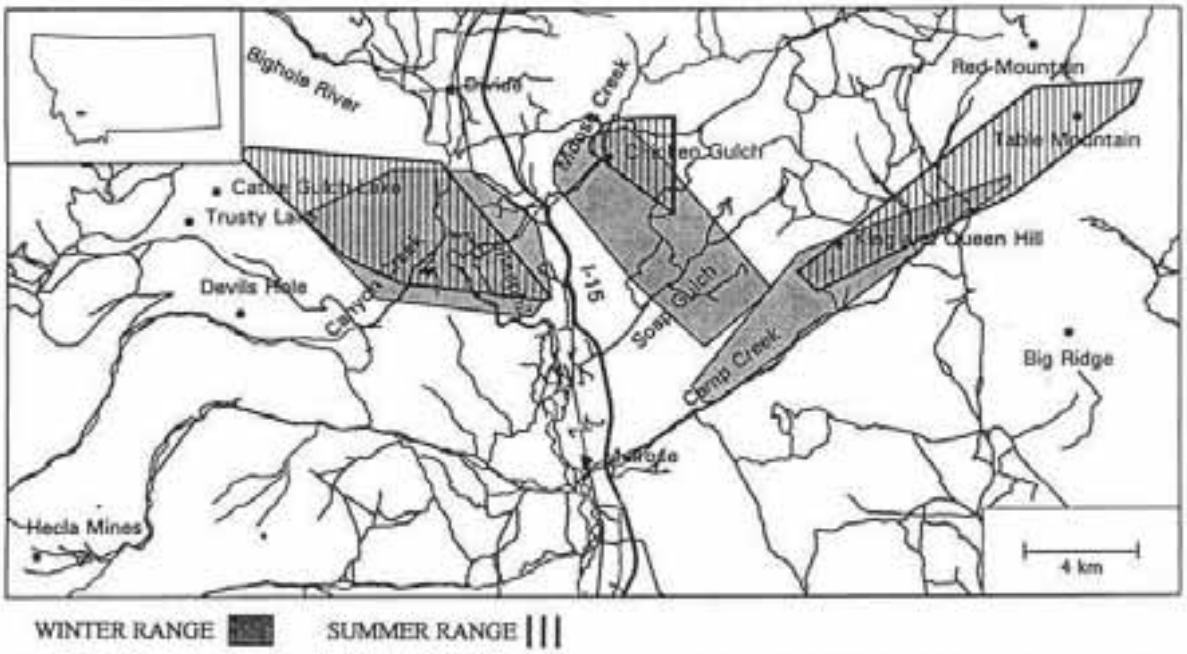

Figure 3. Winter and summer home ranges of the ewe-lamb groups within the East Pioneeer Mountain, Moose Creek, and Camp Creek subpopulations.

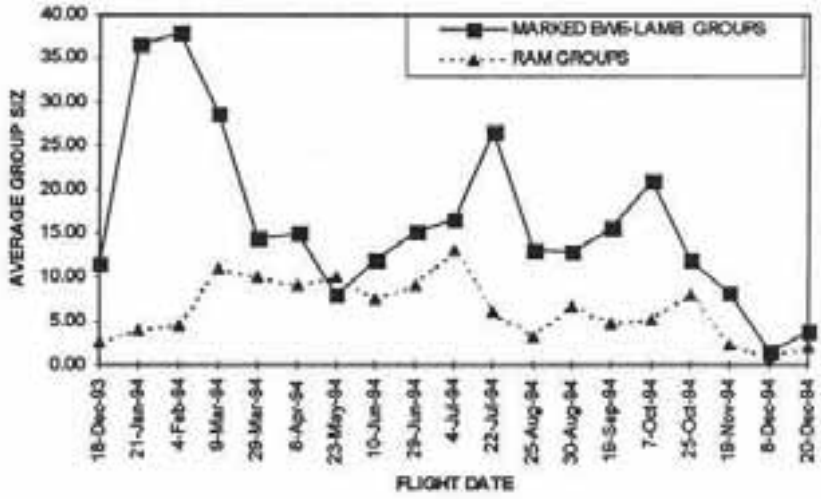

Figure 4. Average groups size for ewe-lamb and ram groups as determined from 19 flights taken during 1994.

Food Habits

Seasonal food habits of bighorn sheep were determined from 51 feeding sites, 40 composite fecal samples, and 32 rumen samples. Seasonal percentages of the diet based on the graminoids, forbs, shrubs, and trees are shown in Table 2.

Graminoids were the dominant forage class consumed during each season of the year, while trees were the least consumed. Intake of shrubs and forbs varied among seasons and with the type of analysis. Forbs were consumed more than shrubs during the spring and summer according to the feeding site analyses, but forbs were only dominant over shrubs during the summer months using the fecal analysis.

Table 2. Percentage of seasonal diets of bighorn sheep as determined by 3 methods of analysis.

	FEEDING SITE				FECAL				RUMEN
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Fall
GRAMINOIDS	78.2	65.2	53.5	63.2	51.0	60.5	66.1	52.6	82.0
FORBS	5.8	30.3	39.4	4.8	6.1	18.5	24.7	5.9	6.3
SHRUBS	14.4	4.6	7.1	31.9	42.2	19.6	7.8	41.3	11.4
TREES	0.0	0.0	0.0	0.0	0.6	1.3	1.1	0.2	0.3
UNKNOWN	1.5	0.0	0.0	0.1	0.1	.01	0.2	0.0	0.1

Interspecific Relationships

Observations indicated that mule deer, domestic sheep, and cattle had the greatest degree of spatial overlap with bighorn sheep. Mule deer range overlapped with bighorn sheep range most frequently during the winter. Bighorn sheep used agricultural areas that supported domestic sheep most often during the fall. Diet overlap of domestic sheep and bighorn sheep was not determined because domestic sheep were kept on private lands and fed in hay fields. Cattle use of bighorn sheep range occurred most often during summer on public land grazing allotments.

Diets based on fecal analyses of mule deer and bighorn sheep differed in winter ($P < 0.05$). Mule deer ingested fewer graminoids than sheep ($P < 0.05$), but no significant differences were identified for shrubs, forbs, or trees (Figure 5).

Data collected at feeding sites indicated that cattle ingested a higher proportion ($P < 0.05$) of graminoids than bighorn sheep during summer (Figure 6). No differences in use of forbs, shrubs, or trees were indicated. Cattle used areas of open grassland meadows near water, while bighorn sheep used the ridges during summer.

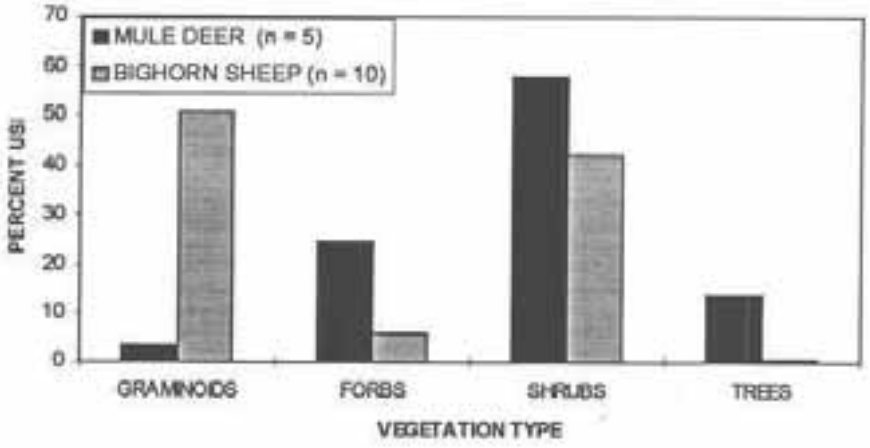

Figure 5. Diet similarities based on composite fecal analyses of bighorn sheep and mule deer during the winter of 1994.

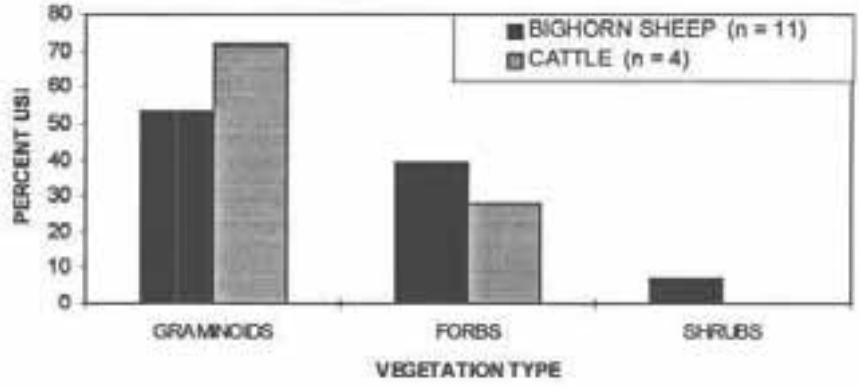

Figure 6. Comparison of diet similarities based on feeding site analyses of bighorn sheep and cattle during the summer of 1994.

DISCUSSION

The 1967 and 1969 transplants totaling 51 bighorn sheep from the Sun River herd into the Highland Mountains were highly successful. Since these 2 transplants, the Highland/Pioneer Mountain bighorn sheep herd has expanded its range from the introduction point in the Camp Creek area to a region covering approximately 400 km^2 while increasing in population size from 51 to almost 400 animals (Weigand 1994) in a 25 year span.

It has been shown that reproduction in ruminants, including bighorn sheep, decreases as the population density increases (Geist 1971). The sex and age structure of the Highland/Pioneer Mountain bighorn sheep herd indicate that this herd may have reached a population density high enough to reduce herd fecundity. Lamb:ewe ratios of 50 lambs per 100 ewes are considered adequate to support a population increase (Lawson and Johnson 1982, Geist 1971). The 1994 winter lamb:ewe ratio of 30 lambs per 100 ewes with the Highland/Pioneer herd does not indicate an increasing population. However, the relatively young ages of rams in the Highland/ Pioneer herd at maturity and death may indicate an expanding population. Geist (1971) suggested that in declining or stable populations most adults die in excess of 10 years. Horn annuli counts indicated harvested rams ranged from 3 ½ to 9 ½ years old in the Highland/Pioneer herd, with only 1 ram being harvested over 9 years of age in 1994.

Interactions between subpopulations occurred in all seasons except summer. No aggressive behavior was seen between sheep of different subpopulations during periods of mixing. Although individuals from different subpopulations did interact, they remained with their own subpopulations the majority of the time. As suggested by Festa-Bianchet (1986), the results of this study indicated that ewes are able to recognize other sheep belonging to their group and are not likely to join other groups permanently. It is advantageous for sheep to remain within their own groups because this is where movement patterns and habitat use were learned (Geist 1971 and Festa-Bianchet 1986). Additionally, social stress and risk of predation may be minimized.

The minimum number of sheep known alive within the Highland/Pioneer herd was determined to be 324 animals. Population estimates of animals during aerial surveys usually contain biases due to animals missed because of bad weather conditions, dense cover, light conditions, and observer fatigue (Caughley 1974 and 1977, Samuel and Pollock 1981, Pollock and Kendall 1987, Unsworth et al. 1990, Bodie et al. 1995). During aerial surveys more than one-third of the animals are often missed (Caughley 1977:35). This is supported with sightability of bighorn sheep. Bodie et al. (1995) and Neal et al. (1993) found that the mean sighting probability of bighorn ewes was 0.57 and 0.58, respectively. During the 8 April, 1994 flight, 321 individual bighorn sheep were sighted in the Highland/Pioneer herd. Assuming a conservative 25 percent of the herd missed, the approximate population size of the Highland/Pioneer herd was approximately 400 individuals.

Food Habits

Seasonal food habits of the Highland/Pioneer bighorn sheep herd were determined using feeding site, fecal, and rumen analyses. Biases have been shown to be associated with each of these types of analyses (An-

thony and Smith 1974, Dearden et al. 1975, Smith and Shandruk 1979, Sanders et al. 1980, Vavra and Holechek 1980, Holechek and Gross 1982).

The gregariousness of bighorn sheep minimized the difficulty of detecting light use of an area, a major bias of feeding site analysis (Smith and Shandruk 1979). Out of 51 feeding sites, only 11 contained less than 10 individuals. The problem of other ungulates using an area (Smith and Shandruk 1979) was accounted for by examining an area immediately after bighorn sheep use. This not only reduced the chance of prior use by other ungulates but made it easier to determine fresh bites from old ones. During this study, the major unresolved bias in feeding site analysis appeared to be within the shrub category. Each individual bite was difficult to locate on shrubs, and, therefore, shrub utilization may have been underestimated.

Misidentification of plant species in fecal analysis is a major problem in fecal analysis (Fitzgerald and Waddington 1979) and was a problem with the Highland/Pioneer study. The graminoid results were clearly incorrect and had to be returned to have the slides reread. The second set of results appeared to be more accurate, but one grass genus (*Schismus*) , which does not occur in Montana (Hitchcock 1971), was identified in 1 composite sample. The problem of fecal analysis representing a different location other than where it was collected (Sanders et al. 1980, Smith and Holechek 1979) was believed to be corrected during this study by combining individual fecal samples from multiple areas into 10 composite samples for each season, thus increasing the chance that fecal analysis represented the entire study area and not a restricted section.

Robel and Watt (1970) found no significant differences between the mean percentage of rumen content as determined by the standard volumetric technique and the point-frame method used in this study. Chamrad and Box (1964) revealed that 2 assumptions must be met for point-frame analysis to be unbiased; "(1) the sample is adequately mixed and (2) there are no unusually large items in the composition". Dirschl (1962) showed there were no significant differences in the mean compositions of forages using 5.66 mm, 4.00 mm, and 2.83 mm meshes for filtering rumen contents and concluded that mesh size does not affect results to any extent. Rumen analysis results from the Highland/Pioneer herd indicate that mesh size may have affected the correct analysis. The use of a 3-layered sieve system with a 8.00 mm sieve on the top to filter contents of uniform size into the 2.80 mm sieve may have excluded some of the larger shrub material caught by the 8.00 mm sieve from being analyzed.

Interspecific Relationships

Range overlap and diet similarities have been used to determine possible competition between bighorn sheep and other ungulates in past studies (Julander 1958, Schallenberger 1966, Constan 1967, Lonner and Mackie 1983). During this study, mule deer and cattle were found to be potential competitors with bighorn sheep based on range overlap and/or diet.

Other studies in Montana indicate mule deer utilize the same areas as bighorn sheep, especially during the winter (Schallenberger 1966, Constan 1967). However, Pallister (1974) found that mule deer and bighorn sheep ranges in the Beartooth mountains of Montana only overlapped during the summer. Schallenberger (1966) found that there was a possibility of competition among mule deer and bighorn sheep for forbs and shrubs. My study showed that mule deer and bighorn sheep used shrubs in similar amounts, but the quantity of shrubs available to both ungulate species appeared to be adequate to cancel any competition. Grasses were 10 times more abundant in bighorn diets than in mule deer diets during winter. Although, bighorn sheep and mule deer diets overlapped, competition was unlikely because mule deer did not utilize the grasses favored by bighorns during the winter months.

Use of the same areas by cattle and wild herbivores may result in competition for foraging areas and for forage (Julander 1958, McCollough 1980, Lonner and Mackie 1983). Spatial minimization of competition between cattle and bighorn sheep was noted in the San Luis Valley in south-central Colorado (McCollough 1980). My study showed that cattle and bighorn sheep used forage classes similarly, but used different areas to obtain these forages. The cattle remained on gentler slopes, in open grassland meadows, and near water, while the bighorn sheep used ridges further from water sources. Although the ridges used by bighorn sheep were accessible to cattle, cattle seemed reluctant to venture far from water. The potential for competition was low despite dietary overlap. The large overlap in diet probably did not indicate competition because none of the forages species were apparently limiting to either ungulate species (McCollough 1980).

Competition could also occur via displacement. If cattle displaced bighorn sheep, the sheep should utilize the gentler open grassland meadows favored by cattle when cattle were absent. This did not happen. The Upper Cattle Gulch grazing allotment was rested during 1994, and the bighorn sheep continued to use the ridges the majority of the time and did not advance into the areas favored by cattle. With little evidence of spatial overlap, displacement, or excessive forage utili

zation, I believe that no competition between cattle and bighorn sheep occurred during 1994 in the Highland and Pioneer mountains.

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