Seasonal movements and habitat use of the Highland/Pioneer Mountains bighorn sheep herd of southwest Montana
by William J. Semmens

A thesis submitted to Graduate Faculty 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 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 home ranges, sex and age composition, population estimation, site preference, food habits, vegetational cover of feeding sites versus food habits, mineral use, 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 km^2. Sex and age composition were determined from 5,985 observations of individual sheep (includes 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. Site preferences for ewe-lamb, ram, and mixed groups were determined by 4 parameters: — distance to escape cover, slope, aspect, and ground cover. Winter site preferences in a winter with mild weather conditions indicated bighorn sheep selected not only southfacing aspects, but also east and west aspects. In Spring, ewes and their young selected steeper slopes and sites nearer to escape cover. Summer preferences were influenced by drought conditions in 1994. Ewes evidently selected sites providing access to escape terrain as an anti-predator response. All groups responded to the harsh weather conditions in the fall by using south facing slopes where snow did not cover forage. Feeding site, fecal, and rumen analysis showed that graminoids were the dominant vegetation class in the diet of bighorn sheep during all seasons. Feeding site analysis revealed that grasses were selected in all seasons, but as palatable forbs became abundant during the spring and early summer, sheep increased intake of forbs. Soil mineral content analysis revealed that there were no differences ($P > 0.05$) in calcium, magnesium, potassium, or sodium levels among the 5 areas where bighorn sheep were observed ingesting soil. Hair mineral content revealed that female sodium levels were higher ($P < 0.05$) than males. 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. At least 75% of the population died between December 1994 and March 1995.

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APPROVAL

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William Joseph Semmens

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.

april 19, 1996
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Head, Major Department

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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 home ranges, sex and age composition, population estimation, site preference, food habits, vegetational cover of feeding sites versus food habits, mineral use, 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 km^2. Sex and age composition were determined from 5,985 observations of individual sheep (includes 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. Site preferences for ewe-lamb, ram, and mixed groups were determined by 4 parameters: distance to escape cover, slope, aspect, and ground cover. Winter site preferences in a winter with mild weather conditions indicated bighorn sheep selected not only south-facing aspects, but also east and west aspects. In Spring, ewes and their young selected steeper slopes and sites nearer to escape cover. Summer preferences were influenced by drought conditions in 1994. Ewes evidently selected sites providing access to escape terrain as an anti-predator response. All groups responded to the harsh weather conditions in the fall by using south facing slopes where snow did not cover forage. Feeding site, fecal, and rumen analysis showed that graminoids were the dominant vegetation class in the diet of bighorn sheep during all seasons. Feeding site analysis revealed that grasses were selected in all seasons, but as palatable forbs became abundant during the spring and early summer, sheep increased intake of forbs. Soil mineral content analysis revealed that there were no differences ($P > 0.05$) in calcium, magnesium, potassium, or sodium levels among the 5 areas where bighorn sheep were observed ingesting soil. Hair mineral content revealed that female sodium levels were higher ($P < 0.05$) than males. 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. At least 75% of the population died between December 1994 and March 1995.

INTRODUCTION

The native herd of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis)* that originally inhabited the Highland Mountains area south of Butte, MT, was extirpated in the early 1900's (Couey and Schallenberger 1971). In the late 1960's, 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. The first transplant occurred in 1967 with 21 sheep, and the second transplant occurred in 1969 with an additional 30 sheep.

In the early 1970's, bighorn sheep began expanding their range, branching out from the Camp Creek area in both northerly and northwesterly directions. The sheep population continued to expand its range throughout the 1970's and 80's forming the 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 1970's the bighorn sheep population in the Highland/Pioneer mountains had grown to a size that allowed limited hunting opportunities (Janson 1974). By the mid-1980's, 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 1983-93, 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 is currently ranked #2 in Montana and #5 in the world (Reneau and Reneau 1993).

In 1994, 70 bighorn sheep hunting permits were issued for this sheep herd, the most bighorn sheep permits issued in a single hunting district in Montana that year, excluding the unlimited areas. Twenty-five either-sex permits were issued on the west side of Interstate 15 (HD 340-01), 10 either-sex permits on the east side of Interstate 15 (HD 340-02) and 35 ewe permits (HD 340-03) were issued for anywhere in HD 340.

The Highland/Pioneer Mountains bighorn sheep herd lived in close proximity to domestic sheep for over 20 years and remained healthy. Research has shown that domestic sheep may carry a bacterium, *Pasteurella haemolytica* , which causes a pneumonia fatal to Rocky Mountain bighorn sheep (Foreyt and Jessup 1982, Coggins 1988, Foreyt 1989 and 1990). Disease attributed to *Pasteurella haemolytica* is often so acute in bighorn sheep that no clinical signs are observed before death (Thorne et al. 1982).

Due to the enormous success and value of this herd, the Bureau of Land Management (BLM) and the Montana Department of Fish, Wildlife and Parks (MDFWP) wanted to obtain more information about this bighorn sheep herd to help with future management decisions. This study was developed to document the status of the Highland/Pioneer Mountains bighorn sheep herd by monitoring range use, movements,

and possible competition between other wild ungulates or livestock. This report covers monitoring efforts in 1994 and is a continuation of the study by Weigand (1994).

In early December of 1994, a die-off began within this herd. The die-off has been attributed to a sheep pneumonia complex. Only the initial report of this die-off will be included in this thesis because field work ended prior to the final analysis of data from the die-off.

OBJECTIVES

1. To document the seasonal ranges of the 3 primary wintering segments of bighorn sheep.
2. To document any seasonal interaction of various herd segments, especially in winter.
3. To delineate the degree of overlap of range use among mule deer, elk, and bighorn sheep, and between livestock and bighorn sheep, and to develop a program for monitoring interaction among these ungulates in HD 340.
4. To document habitat use by bighorn sheep and livestock by season.
5. To document minerals utilized by bighorn sheep.

STUDY AREA

Boundaries

The study area was located south of the town of Butte in southwestern Montana. The boundaries of 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 (Figure 1). The study area was divided into east and west sides by Interstate 15.

Geology and Topography

The east side of the study area was made up of the Highland Mountain Range and adjacent southwestern foothills. The northern section of the Highland Mountains Range comprises the area around Red Mountain (3,071 m), East Peak (3,013 m), and Table Mountain (3,118 m). Formed by the 70 million year old granite of the southern end of the Boulder batholith (Alt and Hyndman 1990), these were the highest peaks in the study area that have been documented to support bighorn sheep. The Boulder batholith is a large granitic intrusion running from north of Helena, Montana to the Hells Canyon area within the Highland Mountain complex (Sahinen 1950). The Moose Creek area constitutes a separate mass of granite, composed of a satellite of the Boulder batholith, that forms the Humbug Spires. The southern section of the Highland Range, Hells Canyon to McCartney Mountain, consists of a sedimentary formation, deposited 350

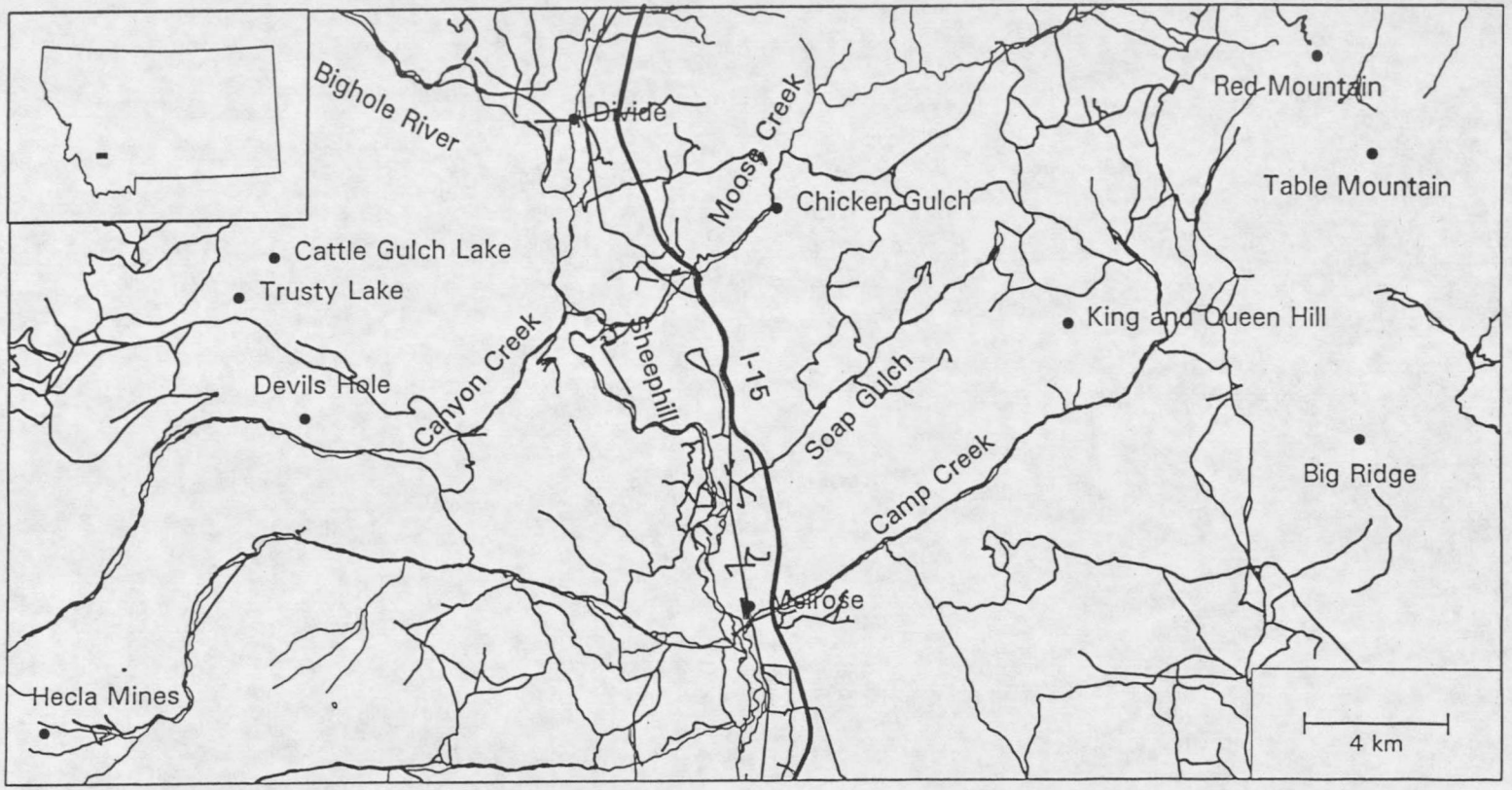

Figure 1. Map of study area.

million years ago, made up of pale gray Madison limestone layered in tight folds.

The west side of the study area was composed of the East Pioneer Mountains. The lower elevations around the Bighole River consist of tightly folded sedimentary formations sectioned into flat slabs along faults full of granite intrusions (Alt and Hyndman 1990). The area west of Melrose was formed approximately 70 million years ago when large amounts of granite magma flowed into the limestone formations, producing zones of rocks called "skarns". Skarns are filled with crystals of garnets and other minerals. The high peaks (2921-3177 m) just outside the western boundary of the study area were formed by the Pioneer batholith, the 70 million year old granite that makes up the core of the Pioneer Mountain Range (Alt and Hyndman 1990).

The topography of the east side of the study area was characterized by 3 drainages; Camp Creek, Soap Gulch, and Moose Creek. These drainages flow southwest from the highest peaks in the Highland Mountain Range. The Camp Creek and Soap Gulch drainages consisted of steep shrub and grass covered hills with patches of timber on the north facing slopes. In the Camp Creek area, the dominant shrub and grass were curlleaf mountain mahogany (*Cercocarpus ledifolius*) and bluebunch wheatgrass (*Agropyron spicatum*), respectively. In the Soap Gulch area, the dominant shrubs were curlleaf mountain mahogany and big sagebrush (*Artemisia tridentata*), while the dominant grasses were bluebunch wheatgrass at the lower elevations and Idaho fescue (*Festuca idahoensis*) at the higher elevations. The Moose Creek drainage consisted of steep grass covered hills at the lower elevations, the dominant grass was bluebunch wheatgrass. Timbered areas interspersed with rock outcroppings were common at the

higher elevations. Douglas-fir (*Pseudotsuga menziesii*) was the dominant tree of all 3 drainages.

The topography of the west side of the study area was characterized by moderate to steep shrub and grass covered hills along the Bighole River with grass covered southeast slopes and timbered north slopes at higher elevations. Curlleaf mountain mahogany and bluebunch wheatgrass were the dominant shrub and grass along the Bighole River, while big sagebrush and Idaho fescue were the dominants at the higher elevations. Douglas-fir was the dominant timber type on the west side of the study area. Cliffs were sporadically distributed throughout the west side of the study area.

Climate

The climate of the study area was semi-arid and characteristic of southwestern Montana. Figures 2 and 3 represent the mean monthly 1994 temperature and precipitation compared to the 30-year mean normal temperature and precipitation (U.S. Department of Commerce). Weather data were collected at the United States Weather Bureau Station at approximately 1,650 m in elevation near Divide, Montana. This station is located on the northern boundary, between the east and west sides of the study area .

The winter of 1994 was very mild throughout the study area. During the winter months of January-March, the mean monthly temperatures were near or above normal, while the precipitation was below normal. During spring, temperatures were above normal, and the precipitation was above normal 2 out of the 3 months. Drought conditions prevailed during the months of August and September. October and

November were more severe than normal, and severe weather continued into the winter of 1995.

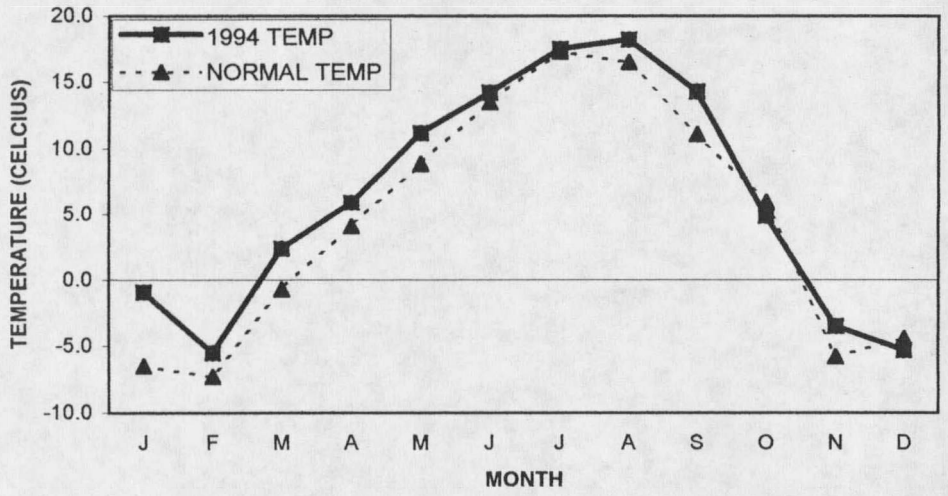

Figure 2. Comparisons of the 1994 mean monthly temperatures versus the 30 year mean monthly temperatures collected at the United States Weather Bureau Station at Divide, MT.

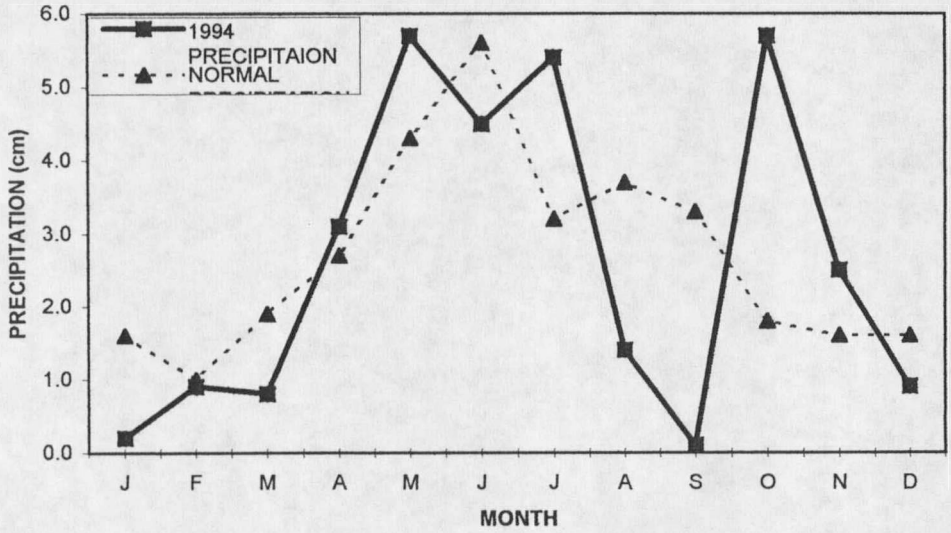

Figure 3. Comparisons of 1994 mean monthly precipitation levels versus long term (30 year) mean monthly precipitation levels of the study area collected at the United States Weather Bureau Station at Divide, MT.

METHODS

Capture and Marking

The bighorn sheep population in the study area was estimated to be 382 ± 75 in 1993 (Weigand 1994). Twelve marked ewes remained at the end of 1993, well below the proposed goal of 10 percent of the population being marked. To meet the desired goal, an additional 24 ewes were radio-collared on March 10, 1994. Personnel from Helicopter Wildlife Management Inc. of Salt Lake City, Utah and MDFWP used a helicopter and net-gun to capture the ewes. Each captured ewe was aged (estimated by incisors), fitted with a radio-collar, and marked with numbered ear tags placed in each ear. A blood sample and pharyngeal culture were also taken from each ewe. Serological tests were conducted on the blood. The cultures were tested for antibodies to pathogens. The blood samples and pharyngeal cultures were analyzed by the Montana State Diagnostic Laboratory at Montana State University. Cultures that tested positive for *Pasteurella spp.* were sent to the U.S. Department of Agriculture, National Animal Disease Center in Ames, Iowa, for bio- and sero-typing.

Movements and Relocations

Relocations of radio-collared ewes were obtained using radio telemetry from ground and air. Some uncollared bighorn sheep were individually identifiable by peculiar markings, mainly physical abnormalities (eg. 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.

Geographical location, date, time of day, Universal Transverse Mercator (UTM) coordinates, weather conditions, total number of sheep present, slope, aspect, distance to escape cover, distance to other wildlife or livestock, and observed ground cover type were recorded upon relocation of a group of bighorn sheep. Sheep groups were classified into number of rams, ewes, or lambs present. Rams were classified into 1 of 4 categories by degree of horn curl; 3/4+, 1/2-3/4, 1/4-1/2, and <1/4 (Frisina 1974). Ewes and lambs were distinguished from one another by body size, horn development, and facial characteristics. Slope was determined with the use of a clinometer or by personal judgment. UTM coordinates and aspect were recorded from 1: 24,000 USGS quadrangle maps. Vegetative cover at each sheep observation site was classified by the dominant plants growth form or species in the immediate area a group of sheep was using. Six cover types were used by bighorn sheep; timber, rock/cliff, big sage/grass, curlleaf mountain mahogany, grass, and agriculture.

Home ranges, sex and age compositions, population estimates, and site preferences were determined using the relocation data. The cut-off dates between summer and winter ranges were determined to be when at least 80% of the radio-collared ewes had relocated to the areas documented by Weigand (1994) as summer or wintering areas. 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 taken in 1994.

Site Preference

Site preferences were determined for ewe-lamb, mixed, and ram groups for each season of the year. Ewe-lamb groups were defined as any groups that contained ewes and lambs or < 2 year old rams. Ram groups were defined as groups containing only rams. Mixed groups were defined as groups containing a mixture of ewes, lambs, immature rams, and mature rams. Site preference was determined seasonally by the number of groups present at observation sites using the following factors; distance to escape cover, slope, aspect, and cover.

A chi-square test was used to test the hypothesis that ewe-lamb, mixed, and ram groups used the same habitats during each season of the year. If this hypothesis was rejected ($p < 0.05$) then the possible reasons for the discrepancy were discussed (i.e. weather, predators, nutrition, etc). All statistical analyses were performed using the SAS statistical software (SAS 1991).

Vegetation Cover Analysis

Six sites per season were chosen for vegetation typing. Each site represented an area of high bighorn sheep use during 1 or more seasons. Canopy coverage for grasses, forbs, and shrubs (< 0.5 m) were determined using the method developed by Daubenmire (1959). Canopy coverage for shrubs greater than 0.5 m in height was determined by

stretching a 30.5 m tape measure over the representative area, dropping a plumb-bob at 3.05 cm intervals, and recording whether the plumb-bob hit or missed a living part of the shrub. The number of hits was then divided into the total number of points collected (N=1000) to determine the percent of shrub (> 0.5 m) canopy cover.

Food Habits

Feeding Site Analysis

Food habits 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. Plant species were identified with the aid of Morris et al. (1962), Hitchcock (1971), Porsild (1979), Dorn (1984), Stubbendieck et al. (1992), and the reference plant library at the BLM office in Butte. A plant species list was compiled for the study area and is shown in Appendix A, Table 14. Instances of use were placed into one of four categories; graminoids, forbs, shrubs, and trees. Seasonal instances of use were totalled and analyzed to determine food habits on a seasonal basis.

Comparisons were made to determine if the canopy cover of graminoids, forbs, and shrubs on feeding sites were matched, overmatched, or undermatched (Senft et al. 1987) by the proportion of vegetation classes in the diet. A chi-square test followed by a Bonferroni z-test (Marcum and Loftsgaarden 1980) was used to test the hypothesis that

the vegetation classes in bighorn sheep diets matched the availability (significance level = 0.05) by season.

Fecal Sample Analysis

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 picked out from the paper bags until approximately 10 grams of pellets were obtained. This sub-sample was analyzed.

From the remainder of the contents of the 40 dried fecal samples, approximately 10 grams from each sample were ground and sifted using a Regal (160 watt) electric coffee grinder and a 0.85 mm sieve. The ground and sifted fecal samples were analyzed at the Agricultural Experiment Station Analytical Laboratory at Montana State University for fecal nitrogen levels using the Kjeldahl technique (Williams 1984) on a dry weight basis. A Kruskal-Wallis test was used to identify differences levels ($p < 0.05$) in fecal nitrogen among seasons.

Rumen Analysis

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 upon

harvesting a bighorn sheep for analysis. A total of 70 letters were sent. Approximately 1 liter of rumen contents from each sample was placed in a 1.057 liter jar and filled with a 10% buffered formalin solution to preserve the specimen until the food habit analysis was performed. The rumens were examined at the MDFWP Wildlife Laboratory in Bozeman, Montana.

Determination of food habits by rumen analysis was accomplished using a modified version of the point frame method described by Chamrad and Box (1964). The rumen contents were washed through a 3-layered sieve system; an 8.00 mm sieve on the top, a 2.80 mm sieve in the middle, and a 2.36 mm sieve on the bottom. Washing the contents through the layered sieve system removed unusually large and small items and achieved a mixture of roughly consistent size in the middle (2.80 mm) sieve. This sample was placed in a 22x31 cm lab tray for analysis. The bottom of the lab tray was filled with water and the contents were stirred to obtain a uniform distribution in the tray. The 31 cm edge of the lab tray was divided into 10 equal segments placed 3 cm apart and a frame holding pins placed at 10 equal intervals, 1 cm apart, was set in the vegetation to be examined. Each plant fragment hit by the tip of a pin was recorded. After each of the 10 vegetational fragments hit by a pin was recorded, the frame was moved to the next mark along the 31 cm edge of the tray until a total of 100 vegetational fragments were recorded for each sample. Vegetational 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, MT.

Mineral Use

Mineral use by bighorn sheep was determined from both soil and hair samples. The soil and hair samples were analyzed for mineral content at the Chemistry Station Analytical Laboratory at Montana State University.

Five soil samples were collected from areas where sheep were observed ingesting soil. The 5 soil samples were air dried and then prepared for analysis by sifting them through a 0.85 mm sieve. The sifted soil samples were analyzed for parts per million (ppm) of calcium, potassium, magnesium, and sodium.

Hunters were also asked to collect hair samples from each bighorn sheep harvested. Hair samples were air dried, washed with a detergent (Alconox), rinsed with distilled water, and then placed in a alcohol bath to remove any surface particulate matter (Flynn et al. 1975). The hair samples were analyzed for the same minerals as the soil samples plus selenium.

Multiple Student's t-tests were use to identify differences in soil mineral composition among locations and between mineral content of male and female hair samples.

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

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

Hunter Harvest and Age Determination

Seventy bighorn sheep permits were allocated for HD 340; 25 rams permits for HD 340-01, 10 ram permits for HD 340-02, and 35 ewe permits for HD 340-03. The 1994 MDFWP hunter survey records were used to determine the bighorn sheep hunter success for the study area.

Twenty-four incisors from harvested bighorn sheep were sent to Matson's Laboratory in Milltown, Montana for age determination based on cementum analysis. Each hunter that harvested a ram was required by the MDFWP to have the horns plugged within 10 days of harvest, these rams were given an estimated age by horn annuli.

RESULTS

Capture and Marking

The capture and marking operation resulted in a total of 36 radio-collared ewes in the study area during 1 or more months in 1994; 21 within the EPMS, 11 within the CCS, and 4 within the MCS (Table 1). Only 2 radio-collared ewes were captured in MCS, but 2 ewes, I.D. numbers 41 and 44, from the CCS moved north and joined the MCS within one week of being collared.

Table 1. Radio-collared ewe information and status as of 20 December, 1994.

SUBPOPULATION	I.D. #	CAPTURE LOCATION	FREQUENCY	COLLAR SYMBOL	STATUS[a] DECEMBER 20, 1994
East Pioneer Mountains	1	Sheephill	151.373	Stars	Alive
	15	Sheephill	151.661	Gates	Alive
	18	Goat Mtn	151.237	3's	Alive
	21	Sheephill	151.702	Dashes	Alive
	23	Letter Gulch	150.708	Slashes	Alive[b]
	24	Letter Gulch	151.150	Checkerboard	Dead:Hunter Kill
	25	Letter Gulch	151.844	DP	Alive
	26	Letter Gulch	151.565	Open Circles	Alive
	27	Letter Gulch	151.772	2's	Alive
	28	Letter Gulch	150.575	Arrows	Alive
	29	Letter Gulch	151.260	Percent Signs	Alive
	30	Letter Gulch	151.040	Squiggles	Alive
	31	Letter Gulch	151.309	Squares	Alive
	32	Sheephill	150.146	Dbl. Stripe	Alive
	33	Sheephill	151.135	Star-Bar	Alive
	34	Sheephill	150.764	Bars	Alive
	35	Sheephill	151.482	Lg. Dot-Bar	Dead:Hunter Kill
	36	Sheephill	150.292	Hearts	Alive
	37	Sheephill	151.429	Open Triangles	Alive
	45	Goat Mtn	152.858	Diamonds	Alive
	46	Goat Mtn	152.897	Short Stripes	Alive
Moose Creek	2	Chicken Gulch	151.411	Crosses	Alive
	4	Soap Gulch	151.905	Daggers	Alive
	41	Camp Creek	151.257	Lazy H's	Alive
	44	Camp Creek	152.794	Blk. Squares	Alive
Camp Creek	5	Camp Creek	151.581	Chevrons	Alive
	6	Camp Creek	151.618	No Symbol	Dead:Hunter Kill
	7	Camp Creek	151.516	Bar-Dash	Alive[b]
	8	Camp Creek	151.464	Lg. Red Dots	Unknown
	9	Camp Creek	151.339	Solid Triangles	Alive
	22	Camp Creek	150.191	Long Stripe	Unknown
	38	Camp Creek	151.967	Y's	Alive
	39	Camp Creek	151.358	Off-Set Dots	Alive
	40	Camp Creek	151.815	Open Rectangles	Alive
	42	Camp Creek	151.252	Half Moons	Alive
	43	Camp Creek	152.879	Solid Triangles	Alive

[a] STATUS: refers to whether the ewe was alive or dead on December 20, the last observation flight taken

[b] ewes were observed alive visually even though the transmitter in their collars had quit

The analyses of the blood taken during the capture operation included tests for 16 diseases and parasites (Table 2). Antibodies for bovine viral diarrhea, *para-influenza,* and *Leptospira tarassovi* were present, with 45.8, 91.7, and 12.5% testing positive, respectively.

Table 2. Serologic evidence of various diseases from 24 captured bighorn sheep within the Highland/Pioneer Mountains.

SEROLOGIC TEST	# POSITIVE / # NEGATIVE	% POSITIVE
Brucella abortus	0/24	0.0
Blue Tongue	0/24	0.0
Anaplasmosis	0/24 (5 suspect)	0.0
Brucella ovis	0/24	0.0
Infectious Bovine Rhinotracheitis	0/24	0.0
Bovine Viral Diarrhea	11/24	45.8
Para-Influenza	22/24	91.7
Ovine Progressive Pneumonia	0/24	0.0
Leptospira pomona	0/24	0.0
Leptospira hardjo	0/24	0.0
Leptospira grippotyphosa	0/24	0.0
Leptospira autumnalis	0/24	0.0
Leptospira icterohemorrhagia	0/24	0.0
Leptospira canicola	0/24	0.0
Leptospira bratislava	0/24	0.0
Leptospira tarassovi	3/24	12.5

(courtesy of MDFWP)

Mixed colonies of non-pathogenic bacteria were identified in 15 of the 25 (60%) pharyngeal culture samples. Pharyngeal cultures from 10 sheep (40%) tested positive for *Pasteurella spp.*. The results from the bio- and sero-typing (Table 3) revealed that 4 were not *P. haemolytica* and the remaining 6 were *P. haemolytica* of bio-type T. Serotypes 3, 4, 10, and 15 were equally common.

Table 3. *Pasteurella haemolytica* BIO- and SERO-TYPING results.

CULTURE #	CATALASE	HEMOLYSIS	BIOTYPE	SEROTYPE
33427	0	0	T	3
33430	0	0	T	4, 10
33432	0	0	T	3, 15
33442	+	0	NOT *P. haemolytica*	
33445	+	0	NOT *P. haemolytica*	
33465	+	+	NOT *P. haemolytica*	
33466	+	0	NOT *P. haemolytica*	
33478	0	0	T	3, 15
33483	0	0	T	4, 10
33493	0	0	T	4, 10, 15

(courtesy of the National Animal Disease Center of Ames, Iowa)

Movements and Relocations

Between 1 January and 31 December 1994, 8,285 observations of individual bighorn sheep (includes 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 the bighorn sheep as to age and sex composition during each survey, but 2300 observations of sheep were not classified due to weather conditions, darkness, or distance. The remaining 5,985 observations were classified for each season and are reported in Appendix B, Table 15.

Winter (January - March)

Five flights were made during the winter of 1994. Classifications of sheep were unobtainable on 4 of the flights due to weather conditions. These flights plus ground observations yielded 2,038 observations of bighorn sheep within the study area. Of these observations, 70.3% occurred within the EPMS, 3.5% occurred within the MCS, and

26.2% occurred within the CCS. The cumulative sex and age classification for winter within the study area was 652 ewes, 197 lambs, 345 rams, and 844 unclassified sheep. These data indicate a lamb:ewe ratio of 30.2 lambs per 100 ewes and a ram:ewe-ratio of 52.9 rams per 100 ewes. Rams observed during the winter in the study area with degrees of horn curl of 3/4+, 1/2-3/4, 1/4-1/2, or < 1/4 were 47.5, 20.3, 22.3, and 9.9%, respectively.

The largest portion of the bighorn sheep within the EPMS wintered in the lower elevations along the Bighole River. Ewe-lamb groups were commonly seen in the Letter Gulch, Goat Mountain, Maiden Rock, and Sheephill areas. The ewe-lamb groups ranged from 1 to 114 bighorn sheep per sighting during winter. Mature ram groups were located in the areas of lower Cattle Gulch, Trusty Ridge, Devil's Hole, and lower Canyon Creek. Mature ram group numbers ranged from 3 to 24 animals per sighting.

The ewe-lamb groups of the MCS wintered in the areas of Moose Creek, Upper Chicken Gulch, and the foothills north of Soap Gulch. Group size ranged from 12 to 23 animals per sighting. The ewe-lamb groups of the CCS wintered in the lower elevations along the north side of Camp Creek. These groups were observed to use the areas ranging from Camp Creek Reservoir to King and Queen Hill. Group size ranged from 9 to 58 bighorn sheep.

The mature ram groups on the east side of Interstate 15 associated with ewe-lamb groups from the MCS and CCS during winter and fall. During the winter, only 2 different mature ram groups were located on the east side, 12 in one group on King and Queen Hill and 17 in the other group on Negro Mountain, in upper Soap Gulch.

Interaction among subpopulations was documented on 3 occasions during the winter of 1994. The first documentation occurred during a flight on 21 January. A collared ewe (I.D. # 4) from the MCS (Weigand 1994) was located in Letter Gulch among a group of 114 sheep from the EPMS. This ewe had returned to the MCS by 4 February and remained with this subpopulation for the remainder of the year. The second documentation occurred during a flight on 4 February. A collared ewe (I.D. # 6) from the CCS was located within 0.5 km of sheep belonging to the MCS. The third documentation occurred on 17 February. Four ewes and one ram (1/4-1/2 curl) were observed crossing from the west to east side of Interstate 15 in the Moose Creek area. I did not determined if these sheep were from the EPMS and crossing to the MCS, or if they were from the MCS and returning from the EPMS.

Spring (April - June)

Four flights were made in the spring of 1994. These flights and ground observations resulted in 1,789 observations within the total study area. Of the total observations made during the spring; 70.1% occurred within the EPMS, 5.0% occurred within the MCS, and 24.9% occurred within the CCS. The season totals for ewes, lambs, rams, and unclassified sheep within the study area were 687, 242, 461, and 399, respectively. Observations indicated a lamb:ewe ratio of 35.2 lambs per 100 ewes and a ram:ewe ratio of 67.1 rams per 100 ewes for the study area. The distribution of rams observed during the spring in the study area among horn curl classes of 3/4+, 1/2-3/4, 1/4-1/2, or < 1/4 was 60.9, 23.9, 13.5, and 1.7 %,

respectively.

Within the EPMS, the ewes began to move to the lambing areas during the first week in May. Four lambing areas, all along cliffs, were documented for this subpopulation: 1) the north side of Canyon Creek approximately 2.4 km west of the point where Canyon Creek meets the Bighole River; 2) the west side of the Bighole River approximately 2.2 km north of the Maiden Rock Bridge; 3) the west side of Sheep Hill approximately 2.0 km south of the Maiden Rock Bridge; and 4) cliffs west of Nez Perce Ridge approximately 1.6 km north of Cattle Gulch Lake. The ewes that lambed in the Canyon Creek and Nez Perce Ridge areas returned to join the group of ewes on the west side of the Bighole River within 3 weeks of lambing. Ewe-lamb groups consisting of 70 individuals or more were commonly seen in the area adjacent to the Bighole River. The mature rams within the EPMS were segregated from the ewe-lamb groups during the spring. Groups of mature rams ranging from 13 to 31 individuals were located in areas from Trapper Creek to Cattle Gulch Ridge during this time of year.

During 1994, the ewes of the MCS lambed approximately 1.6 km north of upper Chicken Gulch in the rocky areas to the north of and in the upper Moose Creek area. After lambing was complete, the ewe-lamb groups relocated to the Chicken Gulch area.

The ewes of the CCS moved off their winter range at the beginning of May and relocated to cliffs in Sawmill Gulch, a distance of approximately 7.5 km by air and an increase in elevation of approximately 760 m. This is the furthest any of the 3 subpopulations traveled between their winter range and lambing areas. By early June,

ewe-lamb groups had moved to the sub-alpine and alpine areas surrounding Table Mountain (3,118 m).

The mature ram groups on the east side of Interstate 15 were located in the areas of Old Glory Mountain (between Moose Creek and Soap Gulch) and Big Ridge. Individual mature ram groups ranged in size from 5 to 13 animals.

Interaction among subpopulations was again documented during the spring during a flight made by Mike Frisina, MDFWP Region 3 biologist, on 4 April. A collared ewe (I.D. # 41) from the MCS was located in the LarMarche Gulch area with ewes from the EPMS. Collared ewes (I.D. #27) from the EPMS and (I.D. #4) from the MCS were located in Soap Gulch with ewes from the CCS. A collared ewe (I.D. # 40) from the CCS was located in the Sheephill area of the EPMS.

Summer (July - September)

Five flights were made during the summer of 1994. These flights plus ground observations resulted in 2,360 observations within the study area. Of the total observations made during the summer, 74.2% occurred within the EPMS, 7.5% occurred within the MCS, and 18.3% occurred within the CCS. The season totals for ewes, lambs, rams, and unclassified sheep for the study area were 877, 465, 432, and 586, respectively. Analysis of the observations resulted in a lamb:ewe ratio of 53.0 lambs per 100 ewes and a ram:ewe ratio of 49.3 rams per 100 ewes. The distribution of rams observed during the summer in the study area among horn curl classes of 3/4+, 1/2-3/4, 1/4-1/2, or < 1/4 was 60.2, 19.7, 11.8, and 8.3 %, respectively.

Most ewe-lamb groups in the EPMS remained at the lower elevations along the Bighole River, with sporadic observations at higher elevations within Cattle Gulch and Sawmill Gulch (north of Cattle Gulch). Ewe-lamb groups of 70-120 animals were commonly seen feeding in the irrigated fields on private land adjacent to the Bighole River. During the heat of midday, the ewe-lamb groups in the Goat Mountain and Letter Gulch areas would move to timbered areas, while the ewe-lamb groups on Sheephill used old mining dredge cuts and mine shafts to bed in the shade. During July, most mature rams groups within the EPMS joined to form 1 large group that was seen on several occasions. This group was classified on July 15th and consisted of 77 animals; 53 were 3/4+ curl, 22 were 1/2-3/4 curl, and 2 were 1/4-1/2 curl. As summer continued and the drought severely increased, the mature rams split up into smaller groups of 5 to 18 animals and used timbered areas during the day.

The ewe-lamb groups within the MCS continued to use the area in and around Chicken Gulch. The use of timbered areas became more frequent as summer progressed making observations difficult. The ewe-lamb groups were observed bedded in rocky areas at the edge of the timber and fed on green vegetation near the creek.

The ewe-lamb groups in the CCS remained in sub-alpine and alpine areas around Table Mountain during most of the summer. The majority of the groups were located in the area between Table and Red Mountains in July, with 65 sheep making up the largest single group observed during a flight on 22 July. During August and the beginning of September, the ewe-lamb groups consisted of 2 to 8 animals, distributed from Red Mountain to East Peak. The first sheep to return to the winter range were 3 ewes, 5

lambs, and 2 rams (< 1/4 curl) that were observed in the King and Queen Hill area during a 19 September flight.

The mature ram groups on the east side of Interstate 15 used the area on and around Big Ridge during July and moved into the timbered area north of Big Ridge during August and September. No interaction between subpopulations was documented during the summer months.

Fall (October - December)

Five flights were made during the fall of 1994. These flights plus ground observations resulted in 2,098 observations within the total study area. Of the total observations made during the fall; 82.0% occurred within the EPMS, 5.0% occurred within the MCS, and 13.0% occurred within the CCS. The season totals for ewes, lambs, rams, and unclassified sheep for the study area were 807, 414, 406, and 471, respectively. Summation of the observations resulted in a lamb:ewe ratio of 51.3 lambs per 100 ewes and a ram:ewe ratio of 50.3 rams per 100 ewes for the study area. The distribution of rams observed during the spring in the study area among horn curl classes of 3/4+, 1/2-3/4, 1/4-1/2, or < 1/4 were 51.5, 25.1, 17.0, and 6.4%, respectively.

The ewe-lamb groups in the EPMS continued to use the same areas along the Bighole River that they had used in other seasons. Most ewe-lamb groups were seen feeding in agricultural areas on private land during daylight hours and ascending into the foothills in the evening. On 11 October, 8 mature rams were seen interacting with a group of 5 ewes in the lower Canyon Creek area, marking the first observations of

rutting activity. After this date, mature rams were seen throughout the winter range area interacting with ewe-lamb groups. The largest of these mixed groups consisted of 83 bighorn sheep, including 45 ewes, 22 lambs, and 16 rams. Out of the 16 rams; 6 were 3/4+ curl, 4 were 1/2-3/4 curl, 5 were 1/4-1/2 curl, and 1 was < 1/4 curl.

The ewe-lamb groups of the MCS remained in the Chicken Gulch and Moose Creek area during the month of October and then were located throughout November and December ranging between Chicken Gulch and the foothills on the north side of lower Soap Gulch. The first indication of the rut within this subpopulation came on 25 October, when a 3/4+ curl ram was seen chasing a ewe-lamb group of 9 sheep in the Moose Creek area.

During a flight on 7 October, it was evident that the major segment of the ewe-lamb groups within the CCS had returned to the winter range in the Camp Creek area. Six ewes and 1 lamb that remained in the Willow Creek area southwest of Table Mountain had moved down to the winter range by 4 November. The earliest documentation of rutting activity within the CCS was on 25 October, when mature rams were observed among the ewe-lamb groups on the winter range. The maximum number of individual bighorn sheep observed within a single group on the winter range during the fall was much smaller than that observed in the previous winter in the same area (19 vs. 58).

Interaction among subpopulations occurred most frequently during the fall, with 6 individual instances documented. On 8, 17, 19, and 24 October unmarked groups of bighorn sheep, 2 to 4 ewes and 3 rams (1/2-3/4 and 1/4-1/2 curl), were observed crossing

Interstate 15 in both directions in the Moose Creek area. During a flight on 19 November, 2 collared ewes (I.D. #'s 41 and 44) from the MCS were recorded north of Camp Creek Reservoir among sheep from the CCS.

Home Ranges

Home ranges were calculated only for the ewe-lamb groups because these were the only groups that contained marked animals which could be consistently relocated (Table 4). 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. Ewes spent from 1 to 3 weeks lambing in the Sawmill Gulch area (approximately 3 km southwest of the summit of Table Mountain) and then continued to the core summer range in the Red and Table mountains area. 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. Home range boundaries were determined using the 95% minimum convex polygon method (Figure 4).

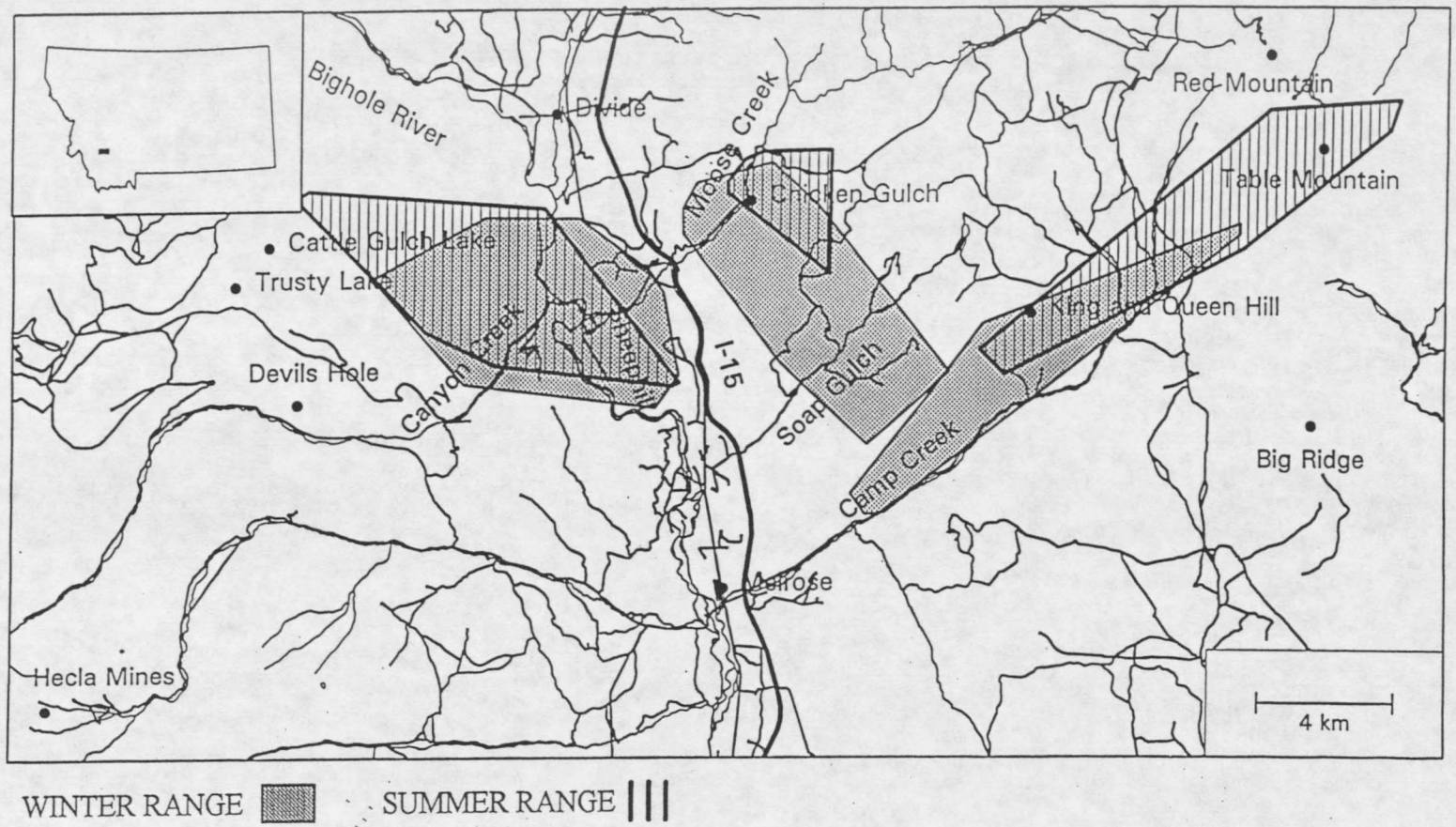

Figure 4. Winter and summer home ranges of the ewe-lamb groups within the East Pioneer Mountain, Moose Creek, and Camp Creek subpopulations.

Table 4. Number of relocations (n) and the land area (km^2) of the summer and winter home ranges for the East Pioneer Mountains (EPMS), Moose Creek (MCS), and the 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

Site Preference

Winter (January - March)

Based on observations of 83 groups of bighorn sheep in which ewe-lamb, mixed and ram groups constituted 40.9, 37.3, and 21.6% of sightings (Table 5), respectively. All group types used distances to escape cover, slopes, and ground covers similarly during the winter ($P > 0.05$). Aspect use differed between mixed and ewe-lamb groups and between mixed and ram groups ($P < 0.05$). During winter, the majority of all the group types observed used areas $\leq$ 50 m to escape terrain, slopes $\leq$ 40 degrees, and ground covers of curlleaf mountain mahogany or grass. Mixed groups favored east and west facing slopes, while ewe-lamb and ram groups used southerly facing slopes.

Spring (April - June)

Ewe-lamb, mixed, and ram groups constituted 50.4, 17.4, and 32.1%, respectively, of the 109 bighorn sheep groups observed during the spring. There was no