Ecology of bighorn sheep in relation to oil and gas development along the east slope of the Rocky Mountains, northcentral Montana
by Timothy Alan Andryk

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:
A bighorn sheep study was conducted on the east slope of the Rocky Mountains in northcentral Montana from June 1981 to April 1983. Objectives were to provide quantitative baseline information on bighorn sheep seasonal distribution, habitat use, population status and trend, and response to oil and gas exploration and development in an area that supported a transplanted population. Three population units and their seasonal ranges, rutting, lambing, and mineral lick areas were delineated based on the distribution and movements of 9 radio-collared and 9 neckbanded sheep and their associated groups. Lincoln index population estimates for the entire study area were 253 sheep in winter 1982-1983 and 258 in summer 1982. The January 1983 lamb:ewe ratio was 45:100 and ram:ewe ratio was 48:100. Population data indicated the sheep herd in the study area was healthy and evidently -expanding both in range and numbers. Important winter-spring habitat components were: open grassland and old burn cover types, elevations of 1526 m - 1678 m, distances less than 91 m from rocky terrain (escape cover), distances greater than 400 m from dense shrub and timber stands, south-facing slopes on a foothill winter range, and north-facing windswept slopes on a subalpine winter range. Important summer and fall habitat components were open rocky bluff and cliff sites, and elevations of 2,013 m - 2440 m. Timbered sites were used during fall. Grass-forb communities seemed less important on summer ranges than on winter-spring ranges. Grasses were the dominant food item in fecal samples during fall, winter, and spring, while forbs were dominant in summer. Sheep displacement from a lambing area was associated with seismographic activity in the area. A mean helicopter flushing distance of 364 m was recorded in 1982-1983 helicopter surveys. Mitigation guidelines for intense exploration and development activities are presented.

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

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Bozeman, Montana

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Date 24 August 1983

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ABSTRACT

A bighorn sheep study was conducted on the east slope of the Rocky Mountains in northcentral Montana from June 1981 to April 1983. Objectives were to provide quantitative baseline information on bighorn sheep seasonal distribution, habitat use, population status and trend, and response to oil and gas exploration and development in an area that supported a transplanted population. Three population units and their seasonal ranges, rutting, lambing, and mineral lick areas were delineated based on the distribution and movements of 9 radio-collared and 9 neckbanded sheep and their associated groups. Lincoln index population estimates for the entire study area were 253 sheep in winter 1982-1983 and 258 in summer 1982. The January 1983 lamb:ewe ratio was 45:100 and ram:ewe ratio was 48:100. Population data indicated the sheep herd in the study area was healthy and evidently expanding both in range and numbers. Important winter-spring habitat components were: open grassland and old burn cover types, elevations of 1526 m - 1678 m, distances less than 91 m from rocky terrain (escape cover), distances greater than 400 m from dense shrub and timber stands, south-facing slopes on a foothill winter range, and north-facing windswept slopes on a subalpine winter range. Important summer and fall habitat components were open rocky bluff and cliff sites, and elevations of 2,013 m - 2440 m. Timbered sites were used during fall. Grass-forb communities seemed less important on summer ranges than on winter-spring ranges. Grasses were the dominant food item in fecal samples during fall, winter, and spring, while forbs were dominant in summer. Sheep displacement from a lambing area was associated with seismographic activity in the area. A mean helicopter flushing distance of 364 m was recorded in 1982-1983 helicopter surveys. Mitigation guidelines for intense exploration and development activities are presented.

INTRODUCTION

The east slope of the Rocky Mountains in northcentral Montana has a high potential for oil and gas production (Mudge et al. 1978), and commercial quantities of gas have already been discovered. In response to a recent surge in oil and gas exploration, a study of Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) was initiated in 1981 on the East Front. Information available on bighorn sheep along the East Front prior to this study consisted largely of population ecology and range use studies in the Sun River area (Schallenberger 1966, Erickson 1972, Frisina 1974). Knowledge of mountain sheep population dynamics and habitat use along other segments of the mountain front is essential if impacts of oil and gas exploration and development are to be mitigated. This study, conducted from June 1981 through April 1983, was designed to provide information on sheep populations north of the Sun River drainage with emphasis on a population transplanted in 1976 from the Sun River area to the Walling Reef area approximately 45 kilometers (km) north of Sun River. The specific objectives were:

1) to provide quantitative baseline information on bighorn sheep seasonal distribution, habitat use, and population status and trend.
2) to investigate responses to human disturbance, particularily oil and gas exploration.

3) to develop management and mitigation guidelines for bighorn sheep populations in the study area.

Background information on the East Front was available from studies on mule deer (Odocoileus hemionus) (Kasworm 1981, Ihsle 1982), Rocky Mountain elk (Cervus elaphus nelsoni) (Picton 1960, Knight 1970, Picton and Picton 1975, Olson 1983), Rocky Mountain goats (Oreamos americanus) (Thompson 1981, Joslin 1983), and grizzly bears (Ursus arctos) (Sumner and Craighead 1973, Hamlin and Frisina 1975, Schallenberger 1974, 1976, Jonkel 1977, Schallenberger and Jonkel 1980, Aune and Stivers 1983).

The East Front Rocky Mountain Front Bighorn Sheep Study and Investigation was supported by the U.S. Forest Service through a contract with the Montana Department of Fish, Wildlife and Parks.

STUDY AREA

The study area included a 777 square kilometer (km^2) portion of the Sawtooth Range along the east slope of the Rocky Mountans in western Teton and Pondera counties (Fig. 1). It was bordered on the north by the Birch Creek drainage, on the south by the South Fork of the Teton River drainage, on the west by the Continental Divide, and on the east by the foothill/prairie ecotone of the East Front.

Approximately 90% of the area consisted of public lands administered by the Lewis and Clark National Forest. Remaining lands were administered or owned by the State of Montana, Bureau of Land Management (BLM), Nature Conservancy, or private individuals. The northern half of the study area was part of the Bob Marshall Wilderness complex.

Geology

Geological features of the study area have been described in detail by Gieseker (1937), Diess (1943), and Holdorf (1981). The East Rocky Mountain Front is composed of a series of parallel north-south extending ridges and peaks, characterized by moderate west facing slopes and abruptly sloped east faces, separated by narrow stream bottoms and canyons. Sheer limestone reefs ranging up to 250 m in height separate the foothills from the mountains. Elevations range from 1,556 meters (m) along the Teton River to 2,863 m at the summit

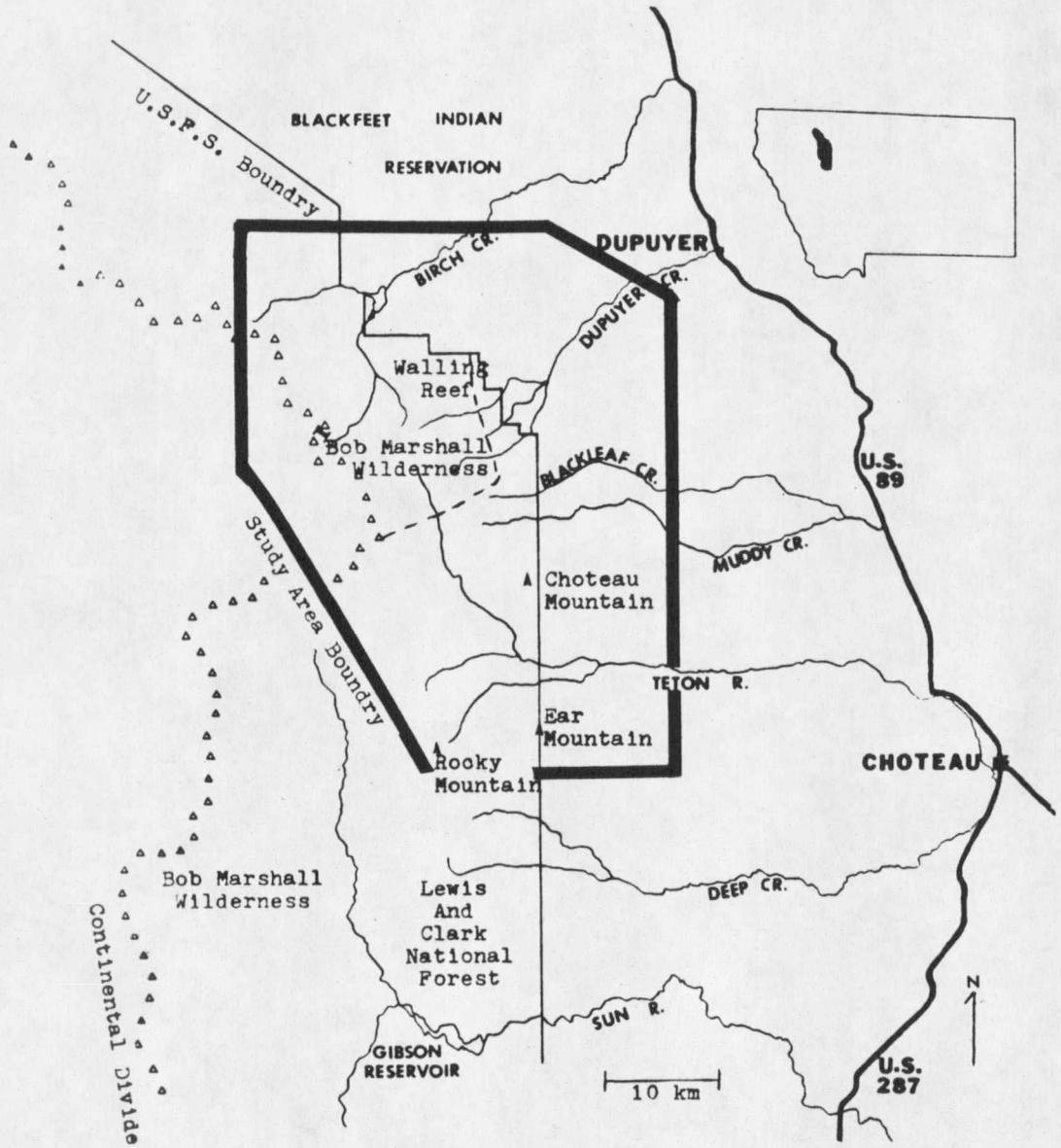


Fig. 1. Map of the East Front study area showing major features.

of Rocky Mountain. The mountains were created during the early Cenozoic when the Lewis overthrust pushed Paleozoic limestones and shales over more recent Mesozoic sediments, creating a situation condusive to petroleum deposition and accumulation.

Climate

Climatological data for the Blackleaf weather station (8 km east of the study area) and Gibson Dam weather station (24 km south of the study area) are presented in Appendix A Table 11. The average annual temperature in the area is approximately 5C., and precipitation ranges from 38 centimeters (cm) on the eastern prairie border to over 200 cm in the alpine zone, where 60-80% falls as snow (Joslin 1983). Precipitation from December through March 1981 was about average, while precipitation during the second winter of the study was much lower than average.

Land Use

Oil and gas exploration in the study area first began in 1947. Several wells were drilled, but discoveries were not profitable at the time and most exploration activity ceased by 1958 (U.S. Forest Service unpubl.). Higher prices for oil and gas stimulated renewed interest in the area, resulting in a surge of exploration activity beginning in 1978. Oil and gas development since 1978 has led to substantial increases in road building, seismic line blasting, drilling, helicopter traffic, and human disturbance along the East Front(Ihsle 1982).

Livestock grazing, primarily cattle, is the dominant land use on private land along the Mountain Front, and cattle and horse grazing allotments exist on public land. Timber harvest occurs on a small scale, but recreation is probably the single greatest use of public lands in the study area. The area supports huntable populations of mule deer, elk, mountain goats, bighorn sheep, black bears (Ursus americanus) and grizzly bears. It is also used by backpackers and horsepackers in summer and provides sites for skiing and snowmobiling in winter.

Vegetation

Detailed descriptions of the vegetation, habitat types, and landtypes of the area are given by Harvey (1980), Thompson (1981), Holdorf (1981) and Kasworm (1981). The vegetation of the eastern foothills is characterized by mountain grasslands and limber pine (Pinus flexilis) savannahs and forests. Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta), and sub-alpine fir (Abies lasiocarpa) habitat types dominate the forests at higher elevations. Shrubby cinquefoil (Potentilla fruticosa) and grassland habitat types were also common at higher elevations. Seral grass-shrublands were common on the burned areas that covered approximately 25% of the study area. Major fires occurred in the area in 1910, 1919, and 1940 (U.S. Forest Service, unpubl.).

History of Bighorn Sheep Herds

The Walling Reef area supported a resident sheep population until about 1920. No documentation of the extirpation of this population is available. However, local ranchers feel that this population was eliminated by poaching and competition with domestic sheep (Morris pers. comm.). Between 1920 and 1976 bighorns were occasionally observed passing through the area, and a small ram band was observed during late winter and spring in the South Fork of Dupuyer Creek in 1974-1976. These rams were most likely associated with the Ear Mountain sheep population at the south end of the study area (Erickson et al. 1977).

In March 1976, 37 bighorn sheep (23 ewes, 7 rams, 5 female lambs, 1 male ram, and 1 lamb of unidentified sex) were transplanted from the Sun River drainage to the Walling Reef area in March, 1976 (Erickson et al. 1977). Although the transplant was successful, the population was not monitored intensively until this study was initiated.

The Ear Mountain sheep population apparently resulted from a northward range expansion by a bighorn herd in the Sun River drainage, located approximately 20 km south of my study area. The first evidence of a resident population in the Ear Mountain vicinity was recorded in the winter of 1960-1961 when 30 sheep were counted. Subsequent counts fluctuated from a low of 8 in 1966 to a high of 74 in 1973 (Montana Department of Fish, Wildlife, and Parks, unpubl.).

METHODS

Seasonal Distribution and Population Dynamics

Eight bighorn sheep in the Walling Reef area were captured and equipped with radio transmitters during March and April 1982. Four were captured by helicopter darting using a M-99 (etorphine) and Rompun (xylazine hydrochloride) mixture and four were captured by helicopter net-gunning (Barrett et al. 1982, Andryk et al. 1983). A jet-converted Bell 47G 3 B-2 helicopter was used in all Walling Reef capture operations. Thirty of the 37 sheep in the 1976 transplant were equipped with individually recognizable neckbands of which at least 5 were present in the study area during 1981-1983.

Five bighorn sheep were captured in the Ear Mountain area during April 1982 using a Clover Trap (Clover 1956). One adult ewe was equipped with a radio transmitter, the others with neckbands. Information on age, sex, and capture and release sites for all marked sheep known to be present in the study area during this study are presented in Appendix A, Table 12.

Twenty radio relocation flights were made from April 1982 through April 1983 using a Piper Super Cub equipped with a 3-element Yagi antenna. Flights were flown twice a month during April-August 1982 and January-March 1983 (the periods of intensive field work) and once a month, weather permitting, during other periods.

Movements of radio marked sheep were analyzed using the TELDAY computer program (Lonner 1981) for calculation of seasonal home range sizes.

Seasonal distributions, sex and age ratios, and population estimates were determined by helicopter (Bell B-2) surveys conducted in July 1981, January, February, and August 1982, and January 1983 and were considered minimum population estimates. Lincoln indices derived from observations of marked and unmarked animals (Overton and Davis 1969) were used as maximum population estimates. Marked animals and their associates known to be in the area but missed during surveys were added to helicopter counts to obtain a subjective estimate within the lower and upper limits.

Ground surveys were conducted on all seasonal ranges within the study area at least once each field season. The largest sex and age cohorts observed (excluding all possible resightings) each season provided additional population and age and sex ratio estimates.

Habitat Characteristics and Use

Quantitative vegetation measurements were made during July and August 1982 on Walling Reef and Ear Mountain winter and summer concentration areas. Vegetation sample plots were placed at random sites (at a rate of 10/2.59 km^2) within concentration areas and at radio and

neckband relocation sites. At each site, 3 randomly placed 2 by 5 decimeter (dm) plots were used to estimate canopy coverage (Daubenmier 1959) of the ground stratum (all grasses, forbs, and shrubs less than 30 cm in height). Canopy coverage of plants in the mid-stratum (woody plants greater than 30 cm in height but less than 180 cm) and upper stratum (woody plants greater than 180 cm in height) was estimated in a 375 square meter (m^2) plot at each site (Pfister et al. 1977).

Habitat components recorded at each site included: terrain type, cover type, elevation, aspect, slope, habitat type, and distances to timber and escape cover. Slope was obtained from a U.S. Geological Survey slope grid used on 1:24,000 topographic maps. Habitat types followed Pfister et al. (1977) and Mueggler and Stewart (1980). Distances were estimated on the ground and verified using topographic maps. Escape cover was defined as cliffs or broken rock areas that provided security from predators.

A binomial probability test (Snedecor and Cochran 1980) was used to test the difference in percentages of habitat components on random plots versus sheep relocation plots. Spearman's Rank Correlation (Snedecor and Cochran 1980) was employed to test for differences in canopy coverage of ground stratum classes on random plots versus relocation plots. The Student's t test (Steel and Torrie 1960) was used to test for differences in canopy coverage of ground stratum classes in random plots on Walling Reef versus Ear Mountain concentration areas.

Habitat components recorded for all sheep observations (marked and unmarked) followed those recorded at each vegetation sample plot with two exceptions. Landtype was substituted for habitat type, since the latter was not available from U.S. Forest Service (U.S.F.S.) maps, and distance to the nearest road was included. Landtypes, defined as associations of habitat type, landform, and soil family occurrence by Holdorf (1981), were identified from U.S.F.S. overlays on 1:24,000 topographic maps. No attempt was made to compare use with availability due to time constraints.

Food Habits

Fecal samples (10 pellet groups per sample period) were collected from the Walling Reef and Ear Mountain areas during July and August 1982, October 1982, January 1983, and April 1983. Samples were dried, ground in a Wiley Mill, and submitted for microscopic analysis of diet composition using techniques described by Sparks and Malechek (1968). The Student's t test (Steel and Torrie 1960) was used to test the difference in diet composition of vegetation classes between the Walling Reef and Ear Mountain sheep.

Oil and Gas Impacts

The date, location, and duration of seismic exploration on the study area were noted and mapped. Distributions of radio-marked sheep before, during, and after seismic activity were compared. During the August 1982 and January 1983 helicopter surveys, flushing distances of

sheep were recorded. Helicopter height and ground distance to the sheep were used to calculate the diagonal distance from the helicopter to the sheep group.

RESULTS

Seasonal Distribution

Helicopter surveys (Appendix A Tables 13-17) and relocations of marked animals (Appendix B Figs. 4-7) indicated that 3 bighorn sheep population units (Walling Reef, Ear Mountain, and Choteau Mountain) were present in the study area (Fig. 2). Seasonal ranges, rutting sites, lambing areas, and mineral licks associated with these units are delineated on topographic maps in Appendix C. The seasonal distributions were based on 1981-1983 observations. The following distribution descriptions are of 1982-1983 observations (the period when radio-marked sheep were available for study).

Ewe bands in the Walling Reef unit wintered on plateaus associated with Walling Reef (Fig. 2). Lambing areas were located on Walling Reef and in the Birch Creek drainage, 8 km northwest of Walling Reef. Most of the ewe bands spent summer and early fall on the Walling Reef plateaus. In November, all radioed ewes moved into the Birch Creek drainage.

Walling Reef ram bands rutted and wintered in the vacinity of Walling Reef. About half of the rams wintered on the Walling Reef plateaus, and half on the South Fork of Dupuyer Creek, 4 km south of

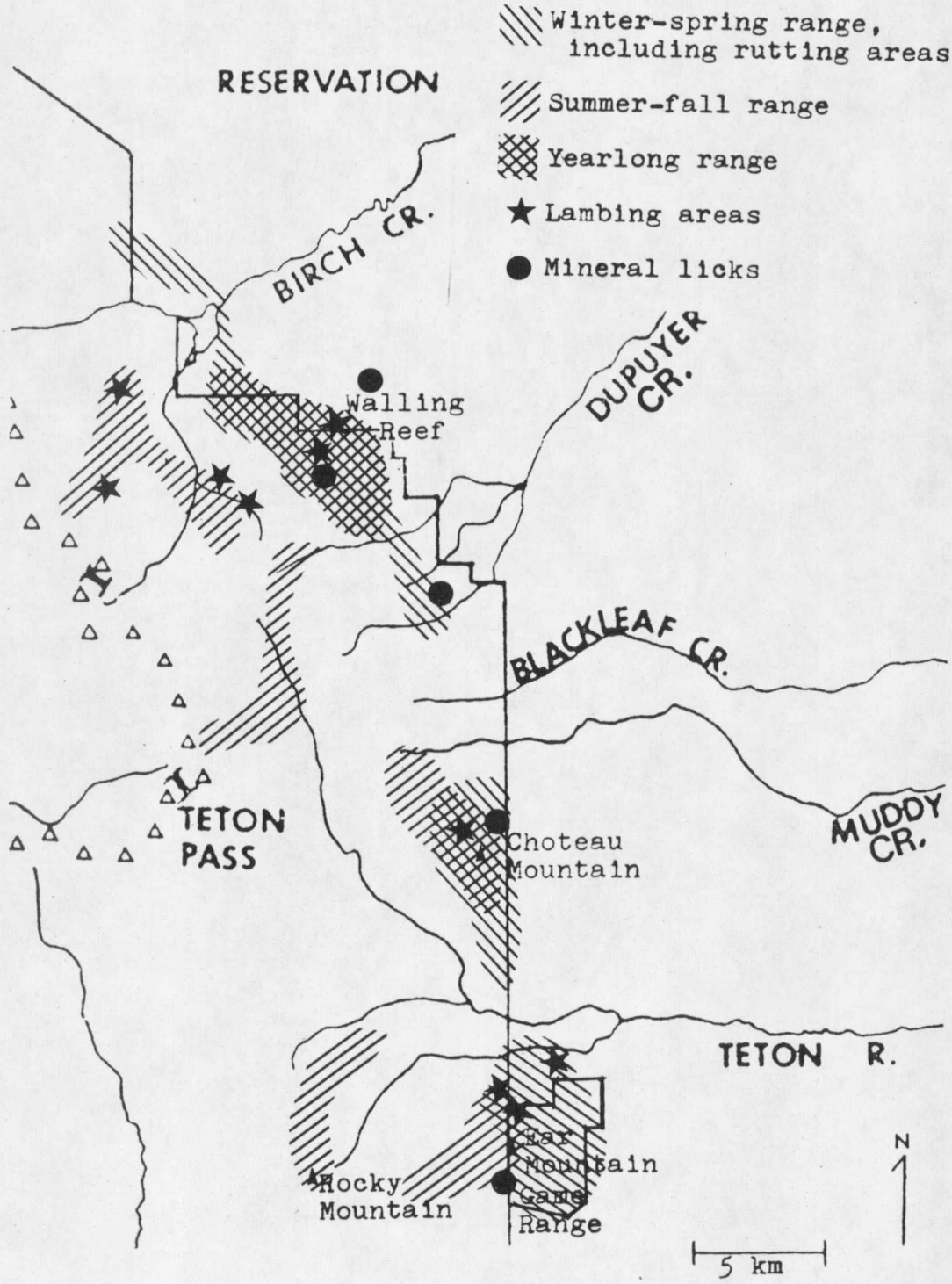


Fig. 2. Bighorn sheep seasonal use areas in the East Front study area as observed during 1981-1983.

Walling Reef. They spent summer at the head of the North Fork of the Teton River (6 km southwest of Walling Reef) and fall in the Birch Creek drainage (Fig. 2).

Ewe bands in the Ear Mountain area wintered in the foothills on the east side of Ear Mountain. Some of these lambed in the foothills, but the majority moved back to the headwall and upper cliffs of Ear Mountain to lamb. They spent summer and fall in the vicinity of this peak and at the heads of Bear, Rierdon, and Green Gulches, 3 to 5 km west of Ear Mountain. Ram bands, consistently sighted at the head of the South Fork Teton River drainage (Ear Mountain area) during summer, probably wintered south of the study area (Fig. 2).

The Choteau Mountain area contained neckbanded sheep originally marked in both the Walling Reef and Ear Mountain areas and seemed to be a range expansion of about 10 km for both populations. Choteau Mountain ewe bands appeared to spend the entire year on Choteau Mountain. However, there were no radio-marked sheep in this population unit, and these sheep were observed infrequently. Ram groups, present in the Choteau Mountain vicinity during summer and fall, rutted there and on the Ear Mountain winter range (Fig. 2). Most apparently wintered south of the study area in the Deep Creek drainage.

Home Ranges

The Walling Reef radio-marked ewes had the largest seasonal home ranges (mean = 10.9 km^2) of radioed sheep in the study area due to their movements to and from the Birch Creek drainage (Table 1).

Table 1. Seasonal and annual home range sizes (km^2), number of relocations (N), and home range means (km^2) for radioed bighorn sheep in the East Front study area during 1982-1983.

Animal I.D.	Spring 1982 Size	Spring 1982 N	Summer 1982 Size	Summer 1982 N	Fall 1982 Size	Fall 1982 N	Winter 1982-83 Size	Winter 1982-83 N	Annual 1982-83 Size	Annual 1982-83 N
WR Ewes[a]										
2-3[b]	4.5	8	2.3	5	7.6	4	1.6	6	14.6	23
2-6	12.3	7	0.3	4	27.4	4	3.5	8	40.5	23
2-7	33.6	6	0.6	6	5.6	3	7.0	7	61.1	22
3-2	30.8	8	1.3	7	20.2	3	2.9	8	88.4	26
4-2	15.1	7	12.4	4	19.1	4	8.8	8	40.2	23
	$\bar{X}$ = 19.3		$\bar{X}$ = 3.4		$\bar{X}$ = 16.0		$\bar{X}$ = 4.7		$\bar{X}$ = 49.0	
	SD = 12.5		SD = 5.1		SD = 9.2		SD = 3.0		SD = 27.5	
EM Ewes										
2-2	11.2	12	2.8	6	2.8	3	1.0	8	24.1	29
WR Rams										
3-4	13.8	8	1.3	3	0.0	2	11.7	6	76.8	19
4-10	27.9	8	2.2	4	2.4	3	4.7	5	77.3	20
4-12	9.5	3	0.0	1	5.3	3	8.1	6	92.0	12
	$\bar{X}$ = 17.1		$\bar{X}$ = 1.2		$\bar{X}$ = 2.6		$\bar{X}$ = 8.2		$\bar{X}$ = 82.0	
	SD = 9.6		SD = 1.1		SD = 2.7		SD = 3.5		SD = 7.6	
CM Ewe									1.1	5

[a] Groupings are based on relatively small mean association distances, and represent population units, WR = Walling Reef, EM = Ear Mountain, CM = Choteau Mountain.

[b] Band-channel radio frequency, Appendix A Table 12.

Radioed Walling Reef rams had the largest annual home ranges (mean = 82.0 km^2), as their seasonal ranges were more widely separated.

The radio-marked ewe in the Ear Mountain vicinity had much smaller annual and seasonal home ranges (means of 5.2 and 24.1 km^2 respectively) than Walling Reef ewes, since she spent the entire year in the vicinity of Ear Mountain.

Population Dynamics

Lincoln index population estimates were 258 (80% confidence interval = 188-409) for August 1982 and 253 (80% confidence interval = 180-426) for January 1983 (Table 2). Population estimates based on helicopter counts with missed marked animals and their associated groups added for the entire study area were 225 in August 1982 and 185 in January 1983 and for individual population units were: 70 in both August and January for Walling Reef; 110 in August and 90 in January for Ear Mountain; and 45 in August and 25 in January for Choteau Mountain. Although the latter estimation technique was subjective, I feel its estimates were more accurate. Cohort based estimates, from ground and airplane observations, produced highly variable but lower population estimates (Table 3).

The mean lamb:ewe ratio (with yearling ewes included) of 30:100 was lower and the mean ram:ewe ratio of 191:100 was higher in the July 1981 and January-February 1982 helicopter surveys than in the August 1982 and January 1983 (lamb:ewe = 47:100, ram:ewe = 75:100) surveys (Table 4). Differences were probably due to the small sample size of

Table 2. Total numbers observed and Lincoln index estimates for bighorn sheep helicopter surveys of the East Front study area.

Seasonal Range	August 1982 Actual Count	August 1982 Marked Animals Obs.	August 1982 Marked Animals Present	January 1983 Actual Count	January 1983 Marked Animals Obs.	January 1983 Marked Animals Present
Walling Reef	56	8	11	54	9	11
Ear Mtn.	79	2	4	77	1	5
Choteau Mtn.	37	2	3	18	0	1
TOTAL	172	12	18	149	10	17
Proportion of marked animals seen		0.66				0.58
Lincoln Index		258				253

Table 3. Total numbers observed and Lincoln index estimates for the largest sex and age cohorts of bighorn sheep observed seasonally in the East Front study area, excluding helicopter surveys.

Seasonal Ranges	Total	Rams (> 1 yr.)	Ewes (> 1 yr.)	Lambs	Uncl.	Marked Animals Obs.	Marked Animals Present	Lambs:100 Ewes	Rams:100 Ewes
April-June 1982									
Walling Reef	57	28	16	9	4[a]	5	11	56	175
Ear Mountain	64	28	10	8	18[b]	3	5	80	280
Choteau Mountain	22	2	4	2	14	1	1	50	50
TOTAL	143	58	30	19	36	9	18	63	193
Proportion of marked animals seen	0.50								
Lincoln Index	286								
July-Aug. 1982									
Walling Reef	38	7	18	11	3	8	11	61	39
Ear Mountain	36	22	7	4	3	2	4	57	314
Choteau Mountain	30	18	7	3	2	2	3	43	257
TOTAL	104	47	32	17	8	12	18	53	146
Proportion of marked animals seen	0.66								
Lincoln Index	156								

Table 3. Concluded.

Seasonal Ranges	Total	Rams (> 1 yr.)	Ewes (> 1 yr.)	Lambs	Uncl.	Marked Animals Obs.	Marked Animals Present	Lambs:100 Ewes	Rams:100 Ewes
Oct. 1982									
Walling Reef	41	8	12	6	15	7	11	50	67
Ear Mountain									
Choteau Mountain	5	5	—	—	—	1	3		
TOTAL	46	13	12	6	15	8	14	50	108
Proportion of marked animals seen	0.571								
Lincoln Index	81								
Dec. - March 1982-83									
Walling Reef	47	12	20	9	6	7	11	45	60
Ear Mountain	39	8	23	8		2	5	35	35
Choteau Mountain	4	4	—	—	—	0	1		
TOTAL	90	24	43	17	6	9	17	40	56
Proporton of marked animals seen	0.529								
Lincoln Index	170								

[a] All 4 sheep were unsexed yearlings.

[b] Included 13 unsexed yearlings.

Table 4. Numbers and age and sex ratios of bighorn sheep observed on helicopter surveys of the East Front study area, 1981-1983.

Seasonal Range	Total	Rams (> 1 yr.)	Ewes (> 1 yr.)	Lambs	Uncl.	Lambs:100 Ewes[a]	Rams:100 Ewes[a]
July 1981							
Walling Reef	46	29	11	4	2		
Ear Mtn.	30				30		
Choteau Mtn.	9	9					
TOTAL	85	38	11	4	32	36	345
Jan. 1982							
Walling Reef	49	19	23	7			
Ear Mtn.							
Choteau Mtn.	5	5					
TOTAL	54	24	23	7	0	30	104
Feb. 1982							
Walling Reef	46	21	20	5			
Ear Mtn.							
Choteau Mtn.	6	5	1			24	124
	52	26	21	5	0		
Aug. 1982							
Walling Reef	56	23	21	10	2	48	110
Ear Mtn.	79	20	39	20		51	51
Choteau Mtn.	37	26	8	3		38	325
	172	69	68	33	2	49	101
Jan. 1983							
Walling Reef	54	21	23	10		43	91
Ear Mtn.	77	13	43	21		49	39
Choteau Mtn.	18	3	11	4		36	27
TOTAL	149	37	77	35	0	45	48

[a] Age and sex ratios are not given for individual heard segments for the first 3 surveys because these sample sizes are too small.

ewes in the 1981 survey and the lower intensity of survey effort in the Ear Mountain area during the first 3 surveys.

Ground and aerial observations during June showed a lamb:adult ewe ratio of 63:100 promptly after lambing (Table 3). Most lambing occurred in the study area between mid-May and mid-June, with the peak of activity during the first week in June. Both helicopter and ground observations consistently showed higher lamb:ewe ratios in the Ear Mountain population unit than in the Walling Reef unit.

Habitat Charcteristics and Use

Winter Range Habitat Sampling

The Walling Reef winter range consisted mostly of a subalpine plateau at elevations of 1,647 m to 2,196 m. The Ear winter range was a foothill area ranging in elevation from 1,586 m to 1,830 m.

Too few relocations of marked animals were available for intensive habitat selection analysis. However, binomial probability analysis of the difference in habitat component occurrence in random plots versus radio and neckband relocation plots is included to help illustrate selectivity patterns (Table 5, Appendix A Tables 18, 19).

Bighorn sheep on the Walling Reef and Ear Mountain winter ranges appeared to select for cliff and broken rock terrain types, against timber and shrub cover types, for lower elevations (1526-1678 m), against distances to timber under 9 m, for escape cover distances under 9 m, and for rock scree habitat types (Table 5).

Table 5. Binomial probability analysis of the difference between percent occurrence of sheep habitat components in random habitat sample plots and sheep relocation sample plots ($p < 0.10$). Numbers of radio and neckband relocation sites are in parenthesis.

Habitat[b] Component	WR Winter (17)	EM Winter (19)	WR Summer (19)	EM Summer (7)
Terrain type				
Bluffs	NS	+	NS	+
Cliffs	+	+	+	
Cirque basin	NS			
Talus slope	NS			NS
Broken	+		+	
Ridge	NS	NS	NS	NS
Park	NS	-		NS
Creek Bottom	NS	-	NS	NS
Sidehill	NS	NS	-	NS
Cover type				
Timber	-	-	-	-
Shrub	-	NS		NS
Grass-forb	+	+	NS	NS
Rock-bareground	NS	+	NS	+
Old burn	+			NS
Elevation (m)				
1402-1525		NS		
1526-1678	+	+		
1679-1830	NS	-	NS	
1831-1983	NS		+	
1984-2135	NS		NS	NS
2136-2288	NS		NS	NS
2289-2440				NS
2441-2593				NS
Aspect				
N	+	-	+	NS
NE	NS	NS	+	NS
E	NS	NS	+	NS
SE	NS	+		NS
S	NS	+		NS
SW				NS
W	NS	-	NS	NS
NW	NS	NS	-	

Table 5. Continued.

Habitat[b] Component	WR Winter (17)	EM Winter (19)	WR Summer (19)	EM Summer (7)
Slope				
Under 20%	NS	NS	-	
20-29%	NS	+	NS	NS
30-39%	NS	+	+	-
40-49%	+	-	-	NS
50-59%	NS	-	NS	NS
60-79%	NS		NS	NS
80-100%		-	+	NS
Dist. to timber				
Under 9 m	-	-	-	NS
9-46 m	NS	+		NS
47-91 m	NS	NS		-
92-230 m	-	NS	-	
231-400 m	NS		NS	
Over 400 m			+	+
Dist to escape				
Under 9 m	+	+	+	+
9-46 m	NS	+	+	NS
47-91 m	NS	+	-	NS
92-230 m	NS	-	-	NS
231-400 m	-	-	-	NS
Over 400 m	NS	-		NS
Habitat type[c]				
Abla-Arco			-	NS
Abla-Cage				NS
Abla-Caru	NS			
Abla-Clps	+			
Abla-Gatr			NS	NS
Artr-Agsp		NS		
Artr-Fied		+		
Artr-Fesc		NS		
Fied-Agsp		+		
Fesc-Agsp		-		
Fesc-Feid	NS	NS		
Pien-Gatr	NS			NS
Pifl-Feid				NS
Pifl-Fesc	NS	+		
Pofr-Agsp		NS		
Pofr-Feid		NS	NS	NS
Pofr-Fesc		NS	-	NS

Table 5. Continued.

Habitat[b] Component	WR Winter (17)	EM Winter (19)	WR Summer (19)	EM Summer (7)
Psme-Arco	NS			
Psme-Aruv	-			
Psme-Cage	NS	NS		
Psme-Caru		NS		
Psme-Syal		NS		
Psme-Spbe			NS	
Rock-Scree	+	+	+	+
Timber Canopy				
0	NS	+	+	NS
0-1%	NS	NS	NS	NS
1-5%	NS	-		NS
5-25%			-	NS
25-50%	NS	NS	NS	NS
50-75%	NS	-		NS
75-95%	NS	NS		
95-100%				
Shrub Canopy				
0	NS	+	+	NS
0-1%	-	-	+	NS
1-5%	+	NS	-	NS
5-25%	+	NS	NS	NS
25-50%	NS	NS	NS	NS
50-75%	NS			
75-95%				
95-100%				
Ground cover				
0				
0-1%				
1-5%	NS		+	NS
5-25%	NS	NS	+	+
25-50%	NS	NS	-	NS

Table 5. Concluded.

Habitat[b] Component	WR Winter (17)	EM Winter (19)	WR Summer (19)	EM Summer (7)
50-75%	NS	NS	-	NS
75-95%	+	NS	-	NS
95-100%				

[a] NS = No significant difference.
+ = Significant higher occurrence in sheep relocation habitat sample plots.
- = Significant lower occurrence in sheep relocation habitat sample plots.

[b] WR = Walling Reef
EM = Ear Mountain

[c] See Appendix Table 22, for key to 4-letter plant species abbreviations.

Within the Walling Reef winter range, sheep seemed to select for the subalpine fir-clematis (Clematis pseudoalpina) habitat type on old burn sites with shrub canopy coverages of 1 - 25% and north-facing aspects of 40 - 49% slope at the north end of the plateau. In contrast, sheep on the Ear Mountain winter range appeared to select for fescue (Festuca spp.) habitat types on open south-facing benches (Table 5).

There was a positive rank correlation between ground coverage characteristics in random and relocation plots (Spearman's rank correlation, $r_s = 0.85\text{-}0.89$, $p < 0.05$) on both winter ranges (Table 6). Sixty-four percent (including 7 of the top 10 taxa ranked by canopy coverage) and 57% (including 6 of the top 10) of plant taxa identified in plots on the Walling Reef and Ear Mountain winter ranges, respectively, were in both random and sheep relocation plots (Appendix A, Table 20). Canopy coverage of Walling Reef random plots when compared to Ear Mountain random plots was greater for shrub, rock, and bareground and less for grass, forbs and herbaceous litter (Student's t test, $p < 0.005$).

Summer Range Habitat Sampling

The Walling Reef and Ear Mountain summer ranges were in alpine ridge and peak areas at elevations ranging from 2,013 m to 2,440 m. Sheep on both ranges appeared to select against timbered cover types, for distances to timber over 400 m, for escape cover distances under 9 m, for rock scree habitat types, and for ground canopy coverages of 5 - 25% (Table 5).

Table 6. Percent frequency of occurrence and mean percent canopy coverage of ground stratum classes found on the Walling Reef (WR) and Ear Mountain (EM) sheep winter and summer ranges. Numbers of frames sampled are in parentheses.

Classes	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Grass	85.1/11.1	90.2/7.7	94.4/18.3	100.0/22.6	86.7/15.0	86.0/4.7	81.6/14.7	76.2/5.3
Forbs	95.4/22.5	94.1/27.4	95.6/27.9	100.0/32.6	96.7/35.6	94.7/19.8	96.7/23.6	95.2/23.3
Shrubs	73.6/18.1	78.4/21.8	56.7/9.7	47.4/6.8	63.3/9.9	50.9/3.4	33.3/4.3	52.4/8.4
Selaginella densa	9.2/Tr[c]	25.5/3.5	16.7/1.9	29.8/3.8	11.7/1.5	5.3/Tr	3.3/Tr	4.8/Tr
Lichen	39.1/1.2	54.9/2.9	37.8/1.4	43.9/2.2	36.7/1.6	87.7/4.8	48.3/1.5	71.4/2.2
Moss	11.5/Tr	27.5/2.7	15.6/2.8	5.3/Tr	20.0/Tr	1.8/Tr	25.0/1.5	23.8/1.2
Herbaceous Litter	93.1/23.6	100.0/17.1	97.8/39.0	98.2/26.6	95.0/24.5	77.2/6.0	92.6/26.5	95.2/9.1
Woody Litter	56.3/3.6	64.8/6.9	55.6/3.0	24.6/1.0	26.3/2.2	15.8/Tr	50.0/3.7	33.3/Tr
Rock	56.3/19.8	64.7/17.3	46.7/3.6	59.7/9.4	46.7/17.4	96.5/45.9	85.0/33.3	100.0/53.4
Bare ground	56.3/2.7	70.6/4.6	66.7/7.3	84.2/6.0	65.0/5.0	75.4/3.5	51.7/6.4	23.8/1.2

[a] Random sample plots.

[b] Radio or neckband relocation sample plots.

[c] Percent frequency of occurrence/mean percent canopy coverage; Tr=trace, a value less than 1.0%.

Sheep on the Walling Reef summer range seemed to select for cliffs and broken rocky terrain types at the south end of the plateau; north, northeast, and east-facing aspects; slopes of 80 - 100%; and shrub canopy coverages of 0 and 0 - 1%. The number of sheep relocation plots available on the Ear Mountain summer range was small (7), and analysis showed no significant difference between most habitat occurrences on random versus relocation plots (Table 5).

There was a positive rank correlation between ground coverage characteristics in random and relocation plots (Spearman's rank correlation, r_s = 0.81-0.82, $p < 0.05$) on both summer ranges (Table 6). Similarity between random and relocation plots was less on summer ranges than on winter ranges. Forty-five percent and 42% (including 4 of the top 10 taxa ranked by canopy coverage) of plant taxa found on the Walling Reef and Ear Mountain summer ranges, respectively, were identified in both random and relocation plots (Appendix A, Table 20). Canopy coverage of Walling Reef random plots when compared to Ear Mountain random plots was greater for forbs and shrubs but less for rock ground stratum classes (Student's t test, $p < 0.005$).

Seasonal Habitat Use by All Observed Sheep

Percent use of habitat components by all sheep, marked and unmarked, observed during fixed-wing flights, helicopter surveys, and ground observations (Tables 7, 8) was generally consistent with results presented in the previous section. Approximately 70% of observations were within 91 m of escape cover and 93% were within 230 m of escape

Table 7. Percent use of habitat components by bighorn sheep observed in the East Front study area during helicopter surveys.

Habitat Component	July 1981 & Aug. 1982	Jan.-Feb. 1982 & Jan. 1983
Terrain Type		
Bluffs	14.3	13.0
Cliffs	14.3	8.7
Cirque Basin	14.3	4.3
Talus Slope	4.8	
Broken	9.5	4.3
Ridge	14.3	21.7
Park		4.3
Creek Bottom	4.8	4.3
Sidehill	23.8	39.1
Total obs.[a]	21	23
Cover Type		
Timber	12.9	9.1
Shrub	3.2	3.0
Grass-Forb	41.9	57.6
Rock-Bareground	41.9	24.2
Old Burn		6.1
Total obs.[b]	31	33
Elevation (m)		
1402-1525		
1526-1678		
1679-1830		26.1
1831-1983	19.0	30.4
1984-2135	9.5	34.8
2136-2288	28.6	4.3
2289-2440	38.1	
2441-2593	4.8	4.3
Total obs.	21	23
Aspect		
N	9.5	13.0
NE		8.7
E	57.1	26.1
SE	4.8	4.3
S	14.3	26.1
SW		8.7
W	14.3	8.7
NW		8.7
Total obs.	21	23

Table 7. Continued.

Habitat Component	July 1981 & Aug. 1982	Jan.-Feb. 1982 & Jan. 1983
Slope		
Under 20%		8.7
20-29%	14.3	13.0
30-39%	4.8	30.4
40-49%	9.5	13.0
50-59%	23.8	8.7
60-79%	33.3	17.4
80-100%	14.3	8.7
Total obs.	21	23
Dist. to Timber		
Under 9 m	9.5	13.0
9-46 m	4.8	13.0
47-91 m	19.0	34.8
92-230 m	38.1	12.7
231-400 m	28.6	17.4
over 400 m		
Total obs.	21	23
Dist. to Escape		
Under 9 m	14.3	21.7
9-46 m	28.6	21.7
47-91 m	23.8	30.4
92-230 m	23.8	26.1
231-400 m	9.5	
over 400 m		
Total obs.	21	23
Dist. to Timber		
Less than 0.40 km		
0.25-0.5 mi. 0.41-0.80 km		
0.51-1.0 mi. 0.81-1.61 km		8.7
1.1-2.0 mi. 1.62-3.22 km	23.8	21.7
Over 3.22 km	76.2	69.6
Total obs.	21	23

Table 7. Concluded.

Habitat Component		July 1981 & Aug. 1982	Jan.-Feb. 1982 & Jan. 1983
Landtypes			
14D	Landslides	5.0	
16	Ridgetops		7.7
17	Ridges & valley slopes		7.7
71	Steep, glacial troughs	5.0	
182	Steep, glacial breaks	25.0	7.7
202	Limestone scree	25.0	46.2
Vd	Low relief forest & grassland slopes	5.0	23.1
VI	Peaks, cirques	35.0	7.7
Total obs.[c]		20	14

[a] Total obs. = the total number of bighorn sheep groups observed.

[b] Totals are greater than the number of observations because cover type categories often overlapped; thus a single observation may have several cover types.

[c] Totals are less than the number of observations because non-National Forest lands were not included in landtype maps available.

Table 8. Percent use of habitat components by bighorn sheep observed in the East Front study area, April 1982-April 1983, excluding helicopter surveys.

Habitat Component	April-June	July-Aug.	Sept.-Nov.	Dec.-March
Terrain Type				
Bluffs	10.1	18.4	17.4	7.4
Cliffs	12.8	7.9	8.7	16.7
Cirque Basin	1.8	10.5	4.3	1.9
Talus Slope		15.8	17.4	1.9
Broken	3.7	13.2		7.4
Ridge	11.9	13.2	17.4	20.4
Park	5.5		4.3	
Creek Bottom	5.5	2.6		
Sidehill	48.6	18.4	30.4	44.4
Total obs.[a]	108	37	23	55
Cover Type				
Timber	3.4	8.7	34.3	5.0
Shrub	6.8	7.2	14.3	5.0
Grass-Forb	66.2	42.0	31.4	50.0
Rock-Bareground	18.3	29.0	14.3	25.3
Old Burn	5.4	13.0	5.7	14.8
Total obs.[b]	148	69	35	80
Elevation (m)				
1402-1525	5.8	2.7		
1526-1678	33.7			12.7
1679-1830	29.8		4.2	30.9
1831-1983	13.5	13.5	16.6	5.5
1984-2135	8.6	16.2	45.8	27.3
2136-2288	5.8	32.4	20.8	12.7
2289-2440	1.9	29.7	12.5	10.9
2441-2593	1.0	5.4		
Total obs.	108	37	23	55
Aspect				
N	5.6	2.6	4.3	5.5
NE	9.3	5.1	4.3	7.3
E	6.5	38.5	21.7	18.2
SE	13.0	2.6		
S	50.9	23.1	26.1	29.1
SW	6.5	10.3	4.3	18.2
W	3.7	17.9	30.4	16.4
NW	4.6		8.7	5.5
Total obs.	108	37	23	55

Table 8. Continued.

Habitat Component	April-June	July-Aug.	Sept.-Nov.	Dec.-March
Slope				
Under 20%	3.1	8.6	4.3	7.7
20-29%	26.2	2.9		19.2
30-39%	15.4	8.6	4.3	15.4
40-49%	10.8	11.4	17.4	9.6
50-59%	12.3	11.4	4.3	17.3
60-79%	12.3	40.0	56.5	11.5
80-100%	20.0	17.1	13.0	19.2
Total obs.	108	37	23	55
Dist. to Timber				
Under 9 m	14.0	15.8	30.4	16.7
9-46 m	41.1	13.2	4.3	18.5
47-91 m	26.2	36.8	26.1	20.4
92-230 m	8.4	15.8	13.0	33.3
231-400 m	5.6	18.4	26.1	5.6
Over 400 m	4.7			5.6
Total obs.	108	37	23	55
Dist. to Escape				
Under 9 m	24.3	29.7	4.3	29.1
9-46 m	25.2	10.9	13.0	18.2
47-91 m	33.3	37.8	47.8	30.9
92-230 m	3.6	21.6	17.4	21.8
231-400 m	9.9		13.0	
Over 400 m	3.6		4.3	
Total obs.	108	37	23	55
Dist. to Road				
Less than 0.40 km	6.3	2.7		5.6
0.41 km - 0.80 km	11.7			1.9
0.81 km - 1.61 km	23.4			1.9
1.62 km - 3.22 km	27.9	8.1	8.7	38.9
Over 3.22 km	30.6	89.2	91.3	51.9
Total obs.	108	37	23	55

Table 8. Continued.

Habitat Component		April-June	July-Aug.	Sept.-Nov.	Dec.-March
Landtypes					
14D	Landslides		5.7		
16	Ridgetops			5.0	2.6
18	Steep W. facing slopes	2.8	5.7		2.6
71	Steep, glacial troughs			10.0	
161	Low relief ridges & slopes	8.3	2.9		10.5
171	High relief ridges & slopes	8.3	2.9		
182	Steep, glacial breaks	2.8	11.4	5.0	5.3
202	Limestone scree	5.6	25.7	5.0	7.9
Vd	Low relief forest & grassland slopes	27.8	5.7	5.0	34.2
Ve	High relief forest & grassland slopes	22.2	2.9		13.2
VI	Peaks, criques[c]	22.2	37.1	70.0	23.7
Total obs.[a]		36	35	20	38

[a] Total obs. = the total number of bighorn sheep groups observed.

[b] Totals are greater than the number of observations because cover type categories often overlapped; thus a single observaton may have several cover types.

[c] Totals are less than the number of observations because non-National Forest lands were not included in landtype maps available.

cover. Bighorns in all 3 population units used grass-forb cover types, slopes with southern exposures, and low relief landtypes more on winter and spring ranges than on summer and fall ranges. Bighorns on summer and fall ranges were observed using higher elevations, steeper and more rugged terrain (bluffs, cliffs), more slopes with east exposures, closer distances to escape cover, and more peak, cirque, and scree landtypes than bighorns on winter and spring ranges (Tables 7, 8).

Helicopter surveys showed no use of old burn areas in summer and a majority of summer and winter sightings at distances greater than 3.2 km from roads. Sheep observed from the ground and airplanes were seen in old burn areas during all seasons, used areas greater than 3.2 km from roads more during summer and fall than during winter and spring, and used timbered sites during fall.

Known mineral licks were most heavily used by sheep during May and June. One lick was located on Walling Reef and another 3 km northeast of Walling Reef. One lick was identified on the south side of Ear Mtn., one on the east side of Choteau Mtn., and one on the South Fork of Dupuyer Creek (Fig. 2).

Food Habits

Grasses were the dominant food item in fecal samples during fall, winter, and spring, while forbs were dominant during summer (Table 9). Availability information from vegetation sample plots (Appendix A, Table 20) suggested that sheep selected for grasses during all seasons.

Table 9. Mean percentages of grass, forbs, and shrubs in seasonal diets, and mean percent canopy coverages in random vegetational sample frames (for winter and summer ranges only).

Area	Grass	Forbs	Shrubs
Summer 1982			
Walling Reef	42.5/15.0[a]	48.1/35.6	9.4/ 9.9
Ear Mtn.	29.8/14.7	36.3/23.6	33.9/ 4.3
Fall 1982			
Walling Reef	48.8	26.4	24.7
Ear Mtn.	64.0	14.2	21.8
Winter 1982-83			
Walling Reef	57.7/11.1	38.7/22.5	3.6/18.1
Ear Mtn.	66.7/18.3	15.1/27.9	18.2/ 9.7
Spring 1983			
Walling Reef	67.6	16.3	16.0
Ear Mtn.	75.2	11.8	13.1

[a] Mean percentage of the diet/mean percent canopy coverage.

Table 10. Ranking of top ten items in seasonal bighorn sheep fecal samples.

Plant Species	July 1982 Walling R.	Aug. 1982 Ear Mtn.	Oct. 1982 Walling R.	Oct. 1982 Ear Mtn.	Jan. 1983 Walling R.	Jan. 1983 Ear Mtn.	Ap. 1983 Walling R.	Ap. 1983 Ear Mtn.
Agropyron spp.	5	7	2	2	6	3	2	2
Astragalus spp.	2	2					8	9
Arctostasphylos uva-ursi			10	3				
Artemisia frigida								3
Artemisia tridentata						2	10	
Berberis repens			7					
Bromus spp.	9				8		9	10
Cruciferae	4		8					
Cyperaceae	6	10	4	7	4	8	4	4
Erigonum spp.						6		
Festuca spp.	1	1	1	1	1	1	1	1
Frasera speciosa					2			
Helictotrichon hookeri						10		
Koeleria cristata					9		7	6
Lupinus sericeus		8		10				
Pinus spp.		9				9	6	
Phlox spp.	7							7
Poa spp.			9	4	10			
Populus spp.	10	5						
Root					3	7		
Shepherdia canadensis		3	5	8				
Unknown browse	3	6		9				
Unknown forbs	8	4	3	5	7	5	5	8
Unknown grass			6	6	5	4	3	5

Walling Reef fecal samples, when compared to Ear Mountain samples (Appendix A, Table 21), contained more grass in summer but less in fall and winter; more forbs during summer, fall, and winter; and less shrubs during summer and winter (Student's t test, $p < 0.1$). There was no significant difference between spring samples in the two areas.

Festuca spp. were the most important plants in fecal samples during all seasons (Table 10). Astragalus spp. were the second most common on both the Walling Reef and Ear Mountain summer ranges. Agropyron spp. were the second most common plants in the fall and spring fecal samples for both the Walling Reef and Ear Mountain ranges. Frasera speciosa was the second most common plant in Walling Reef winter range samples, and Artemisia tridentata was the second most common plant in samples from the Ear Mountain winter range.

Oil and Gas Impacts

No wells were drilled on sheep seasonal ranges within the study area during June 1981 through August 1983. One nonproducing well, drilled in the 1950's was located on private land within the Ear Mountain winter range.

Three seismic exploration lines were conducted in the study area during summer 1982 (Fig. 6). Work on the two lines in the Walling Reef area was done during 16-24 June, while sheep were lambing in this area. All four radio-marked bighorns present in the Walling Reef vicinity in early June moved into the Birch Creek drainage (a 4 to 6 km movement) by 17 June. Intensive ground surveys of the Walling Reef

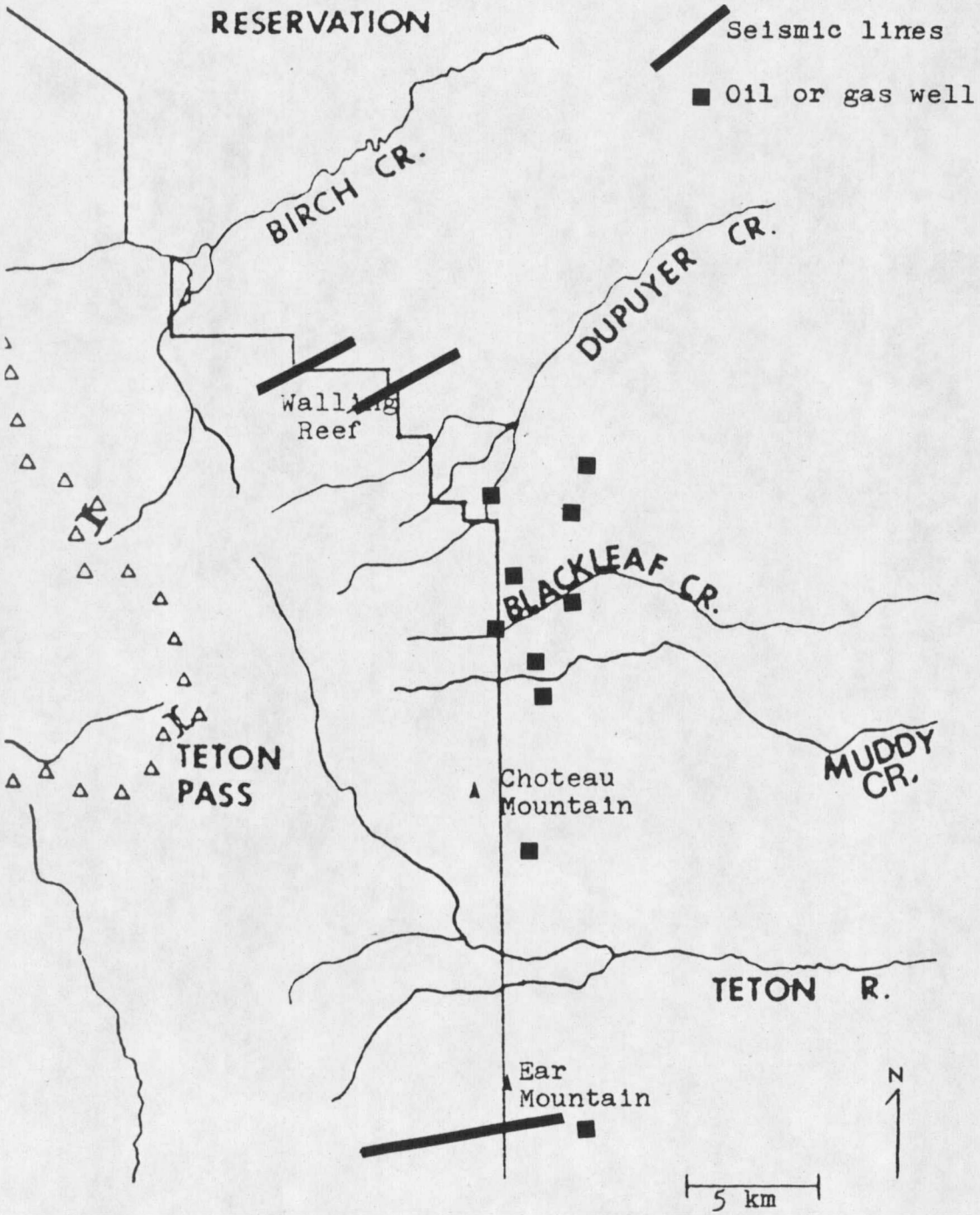


Fig. 3. Oil and gas well locations and seismic exploration lines run in the East Front study area during 1982.

vicinity were conducted 20-22 June and no sheep were observed. This was the only time during the entire study when bighorn sheep were not observed in this area during ground surveys.

The majority of work on the seismic exploration line in the Ear Mountain area was done during 17-25 June, at the end of the lambing period. These sheep did not leave the area during or after the seismic operation. I observed a ewe band of 34 animals 1.6 km north of this seismic line on 24 June. The sheep were using a salt lick directly in the flight corridor used for transporting men and material to the line.

Fourteen helicopter passes directly over the sheep group were observed with roughly 5-minute intervals between passes. The helicopters flew at heights of about 297 to 366 m above the ground. No behavioral response was observed to the sound of the helicopters, but upon seeing the machine, the sheep formed a tight group and usually ran a short distance (27 to 46 m). However, on 3 of the last 5 passes they ran to escape cover (91 to 183 m). Total behavioral reaction time (time from initial response to resumption of foraging) was short (3 to 5 min.) as they only saw each helicopter for a few seconds.

The sheep also showed little behavioral response to the explosive charges being detonated 2 km to the south. Four charges were detonated during the observation period and the sheep only looked up once.

Reaction and flushing distance data collection during helicopter population surveys also indicated high levels of response to helicopters. The mean helicopter flushing distance for the Aug. 1982 and Jan. 1983 helicopter surveys was 363.8 m (S.D. = 232.7 m) for 21

observations. All sheep ran as the helicopter approached and continued running until the helicopter left.

DISCUSSION AND CONCLUSIONS

Seasonal Distributions, Movements, and Home Ranges

Available seasonal observations of bighorn sheep in the study area from 1976-1981 (Montana Department of Fish, Wildlife, and Parks unpubl.) fell within ranges delineated during 1982-1983. Sheep were widely dispersed during summer and fall, and range overlap occurred between the three population units during these seasons. Largest individual home ranges occurred in April-June when individuals moved from winter ranges to summer ranges and lambing areas.

Migration distances between winter-spring ranges and summer-fall ranges (mean = 6.5 km) were comparable to those found in the Sun River herd (Erickson 1972, Frisina 1974). Some ram bands (specifically the group that probably wintered in the Deep Creek drainage and spent summer and fall north of the Teton River) migrated across hunting boundaries. The 4 hunting permits issued for north of the Teton River (hunting district 441) in 1982 were filled with full-curl rams (7½ to 8½ years old), of which only one was part of the 1976 transplant (Olson unpubl.). 1982 was the first year in which permits were issued for district 441.

The Walling Reef population unit appeared to be expanding its range to the north, south, and west. The Ear Mountain unit seemed to

be expanding north and west. Not enough information was available to determine if range expansion by the Choteau Mountain unit (itself a product of expansion by the Walling Reef and Ear Mountain units) was occurring.

Population Dynamics

The 1976 transplant that initiated the Walling Reef unit was one of the most successful, single introduction, bighorn sheep transplants in Montana's history (Rognrud 1983). The success of the transplant may be attributed to: transplanting bighorns into historic but unoccupied bighorn habitat, 4 mild winters in 7 years since the transplant, closing of Walling Reef to livestock grazing, and the migration of rams into the area from south of the Teton River before and after the transplant. Geist (1971) hypothesized that mountain sheep would not remain in an unknown area if other sheep were not present.

The range expansion that occurred in the study area is indicative of a healthy population (Geist 1971, Keating 1982). The lamb:adult ewe ratio in June 1982 of 63:100 compared favorably with post-lambing ratios for increasing herds (Woodgerd 1964, Shackleton 1973). The lamb:ewe ratio (including yearling ewes) of 45:100 and ram:ewe ratio of 48:100 for the January 1983 helicopter survey were slightly lower but comparable to the December 1982 ratios (lamb:ewe = 49:100, ram:ewe = 60:100) of the Sun River herd, a herd that has been maintained at relatively constant numbers by hunting and livetrapping (McCarthy unpubl.).

Horn sizes of rams harvested in the study area during 1982 were consistent with those harvested in the Sun River area (McCarthy unpubl.). Growth rate and size of horns of the Sun River herd rank among the highest in Montana (Stewart and Butts, 1982).

Blood samples taken during live capture operations indicated that sheep were under no unusual stress and in good health (Jessup unpubl.).

Habitat Characteristics and Use

The most important winter-spring habitat configurations used by sheep were open grassland and old burn cover types at elevations of 1526-1678 m, less than 91 m from cliffs and broken areas, more than 400 m from dense shrub and timber stands, and with terrain characteristics that inhibited snow accumulation. Walling Reef sheep mostly used steep north-facing slopes that were blown free of snow by strong northerly winds characteristic of this winter range. Ear Mountain sheep mostly used south-facing benches, typically the most snowfree areas in this foothill winter range.

Important summer-fall habitat configurations were open rocky bluff and cliff sites at elevations of 2,013-2440 m. Grass-forb communities seemed less important on the summer ranges than on the winter-spring ranges. Bighorns appeared to prefer distances greater than 400 m from timber in summer, but used timbered sites in early fall. Bighorn use of timber in early fall was most likely a response to greater availability of succulent forage at these sites relative to open sites. Sheep use of timbered sites during fall has also been

recorded by bighorn sheep in the Gallatin Range of southwestern Montana (Irby unpubl.) and by Dall sheep (Ovis dalli) in Canada (Newcomb unpubl.).

Use of habitat components was consistent with that found in the Sun River herd. Erickson (1972) and Frisina (1974) also documented a dependence on rocky escape cover during all seasons, heavy use of old burn and bunchgrass types during winter and spring, and heavy use of rocky reef types during summer and fall.

Within these seasonal ranges, differences in canopy coverage of ground stratum classes did not seem to influence sheep distribution. Sample sizes were too small to determine if species composition had an effect on distribution. The subalpine Walling Reef winter range appeared to have less grass and forb forage available than the foothill Ear Mountain winter range, assuming canopy coverage was an adequate index of standing crop. The consistently lower lamb:ewe ratios of the Walling Reef unit may be related to this difference in forage availability.

Food Habits

Food habits of bighorns in the study area were consistent with those found in the Sun River herd (Schallenberger 1965, Erickson 1972, Frisina 1974, Kaseworm et al. 1984). Sheep ate less grass and more forbs on the Walling Reef winter range than on the Ear Mountain winter range, even though sheep on both ranges appeared to be selecting for grasses. This diet difference was apparently related to differences in the plant communities on the two winter ranges.

Schallenberger (1965) and Kasworm et al. (1984) noted high levels of dietary overlap between bighorn sheep, elk, and cattle on Sun River winter ranges. Elk were not present on winter ranges in the study area in numbers large enough for competition to exist (Olson pers. comm.). The potential for competition with cattle was minimal during the study because more than 90% of the Walling Reef and Ear Mountain winter ranges were closed to livestock grazing, and terrain on Choteau Mountain was too precipitous for cattle.

Dietary overlap between bighorn sheep and mountain goats did occur during late winter and early spring (Joslin 1983). Fecal analysis indicated Festuca spp. was the most important item in the diet of both species during this period. However, information was inadequate to assess the extent of competition, if it existed.

Oil and Gas Impacts

Not enough information was available to assess the impact of seismic activity on reproduction. However, sheep displacement from Walling Reef lambing sites did indicate increased stress associated with seismic exploration during the critical lambing period. In contrast the Ear Mountain ewe band observed on the helicopter flight path did not leave the seismic area. Their tenacity may have been due to visual screening of the seismic line by a high ridge and/or to their salt hunger exceeding their desire to flee the disturbed area.

The mean helicopter flushing distance of 364 m was consistent with that found by McArthur et al. (1982). They recorded no behavioral

or physiological response to helicopters observed at distances exceeding 400 m from bighorn sheep.

The increased number of roads associated with development, whether oil and gas, timber, or other uses, may also cause poaching and other problems. Road use can impede movement into a previously heavily used site (Stevens 1982) and has been associated with decreased reproduction and health of bighorn herds (Simmons et al. unpubl., Youmans et al. 1982).

MITIGATION GUIDELINES

General Guidelines

There was not enough hydrocarbon exploration during the study to fully assess its impact on bighorn sheep. However, potential conflicts can be avoided by adhering to the following guidelines.

The cumulative effects of all disturbance activities, oil and gas exploration and development, timber harvesting, grazing and recreation must be considered when evaluating proposed activities. Avoid delineated bighorn sheep seasonal use areas when occupied, particularily:

1. Winter-spring ranges and rutting areas during 1 November - 30 April.
2. Lambing areas and mineral licks during 1 May - 1 July.

A 1.6 km (1 mile) buffer zone of no activity should separate each disturbance activity from an occupied seasonal use area.

Specific Guidelines

The following guidelines roughly adhere to the general management guidelines of the Interagency Rocky Mountain Front Wildlife Monitoring/ Evaluation Program (1983). Further study of bighorns in the area will be necessary to verify and/or modify these guidelines.

Seismic Exploration

1. Restrict seismic activities to the period 1 July - 1 November.

2. Limit seismic operations to methods that can be performed in the least amount of time and with minimal disturbance. Helicopters should be used instead of constructing new roads.
3. Require helicopters to maintain heights not less than 400 m from all ground surfaces, except in designated landing zones.
4. Restrict helicopter flight paths to designated corridors of not more than 0.8 km (0.5 miles) in width along seismic exploration lines.
5. Space concurrently active seismic lines at least 14.5 km (9 miles) apart to provide at least one undisturbed drainage between lines.
6. Minimize the number of helicopter trips necessary to complete each line by coordination and consolidation of activities.
7. Ensure adequate visual barriers between helicopter landing zones and occupied seasonal use areas.

Oil and Gas Wells

1. Avoid constructing wells or pipelines within 1.6 km (1 mile) of bighorn winter-spring ranges and rutting, lambing, and mineral lick areas. Efforts should be made to minimize the acoustic disturbance zone.
2. Schedule well drilling and construction activities to avoid seasonal use periods of bighorn sheep in the surrounding area.
3. Do not allow firearms during work periods or in vehicles traveling to and from work sites.
4. Personnel should not be housed in camps at the work site.

Roads

1. Do not construct roads within 1.6 km (1 mile) of winter-spring ranges and rutting, lambing, and mineral lick areas, unless access is not allowed during bighorn seasonal use periods.
2. Impose seasonal closures on all roads when they are not being used for their intended purpose.
3. Permanently close and reclaim all roads which are no longer needed for their intended purpose.
4. Keep roads which are used for oil and gas activity and other specified uses closed to the public.
5. Bus crews to and from work sites to reduce activity levels on roads.

Livestock Grazing

1. Restrict cattle grazing to the period 1 July - 15 October.
2. Continue to protect bighorn winter-spring ranges from domestic sheep and cattle grazing.

Timber Harvest

1. Allow no timber or firewood cutting on winter-spring ranges and rutting, lambing, and mineral lick areas during bighorn seasonal use periods.
2. Do not replant burn sites with low timber production potential (less than 50 board feet/acre/year) on existing or potential sheep range.

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APPENDICES

APPENDIX A

Table 11. Average temperature (C), total precipitation (cm), total snowfall (cm), and deviation from the long term average for 2 weather stations along the East Front from June 1981 through April 1983 (U.S. Dept. of Commerce 1981-1983).

		Temperature		Precipitation		
Month	Station[a]	Mean	Deviation from the long term average	Amount	Deviation from the long term average	Snowfall
June 1981	GD	11.7	-0.5	4.1	-6.5	
	BL	12.1		3.3		
July 1981	GD	16.6	0.1	4.8	+1.3	
	BL	17.4	+0.4	3.1	-0.5	
August 1981	GD	17.4	+1.5	4.0	+0.4	
	BL	18.9	+2.6	5.6	-1.9	
September 1981	GD	12.8	+1.5	1.2	-2.7	
	BL	13.2		0.5		
October 1981	GD	5.9	-1.2	2.8	-0.3	17.8
	BL	7.1		0.5		
November 1981	GD	3.4	+2.7	0.5	-2.5	2.5
	BL			0.3		2.5
December 1981	GD	-3.8	-1.0	2.4	0.1	19.1
	BL	-5.2		0.7		
January 1982	GD	-8.7	-3.2	3.6	1.0	58.0
	BL	-15.1		2.5		43.2
February 1982	GD	-5.0	-2.1	4.8	3.0	34.3
	BL	-6.1		1.7		11.4

Table 11. Continued.

Month	Station[a]	Temperature: Mean	Temperature: Deviation from the long term average	Precipitation: Amount	Precipitation: Deviation from the long term average	Precipitation: Snowfall
March 1982	GD	-1.0	0.6	4.1	1.5	59.7
	BL	-2.9		2.3		45.8
April 1982	GD	2.1	-2.0	2.3	-1.5	27.9
	BL	2.5		0.9		11.4
May 1982	GD	7.8	-0.8	3.7	-4.5	7.6
	BL	8.1		8.1		20.3
June 1982	GD	14.4	1.1	5.8	-4.6	
	BL	14.1		8.9		
July 1982	GD	16.3	-0.3	2.2	-1.3	
	BL	17.2		1.8		
August 1982	GD	16.9	1.0	2.2	-1.4	
	BL	17.9		2.3		
September 1982	GD	11.2	-0.2	6.7	2.8	
	BL	11.6		4.6		5.1
October 1982	GD	7.1	-0.1	0.5	-2.4	1.3
	BL					
November 1982	GD	-1.4	-2.1	1.4	-1.7	27.9
	BL	-3.3		0.9		10.2
December 1982	GD	-2.3	-0.5	1.4	-1.0	20.3
	BL	-3.8		0.7		10.2

Table 11. Concluded.

Month	Station[a]	Temperature		Precipitation		
		Mean	Deviation from the long term average	Amount	Deviation from the long term average	Snowfall
January 1983	GD	0.6	+2.3	1.3	-1.7	0.5
	BL					
February 1983	GD	1.6	+4.1	0.3	-1.7	1.3
	BL	1.3		0.5	-1.3	2.5
March 1983	GD	1.1	2.3	5.1	2.8	54.6
	BL	0.8		2.5	0.8	
April 1983	GD	3.6	-0.3	1.5	-2.8	7.6
	BL	3.6		0.5	-3.0	

[a] GD = Gibson Dam, BL = Blackleaf.

Table 12. Bighorn sheep radiocollars and neckbands in the East Front study area, April 1982-April 1983.

Date Captured	Sheep	Collar	Ear Tags	Capture & Release Data
3/76	Ewe-4 yrs.+ Walling R.	White Neckband Black H's	A0464 A0465	27N,9W,S3NW Sheep Cr., Transplanted from Sun River
"	Ewe-4 yrs.+ Walling R.	White Neckband Black O's	A0241 A0242	" "
"	Ewe-1½ yrs. Choteau Mtn.	White Neckband Black Z's	A0229 A0230	" "
"	Ewe-1½ yrs. Walling Reef	White Neckband Black T's	A0216 A0217	" "
"	Ram-2½ yrs.[b] Choteau Mtn.	White Neckband Black C's	A0218 A0219	" "
3/30/82	Ewe-4 yrs.+	2-7.3 & 151.159 Red Stripe on White	A10520 A10521	28N,9W,S31SE Ear Mountain/M-99
"	Ram-2 yrs. 1/2 Curl	3-4.3 & 151.389 Red O's on White	A9611 A9612	28N,10W,S35SE Ear Mountain/M-99
4/20/82	Ewe-4 yrs.+	2-6.4 & 151.134 Red Crossbars on WHT	A2389 A2390	27N,9W,S6SE Ear Mountain/M-99
"	Ewe-2 yrs.	4-2.4 & 151.639 Blue Stripe on White	A9609 A9610	" "
"	Ram-6 yrs. 3/4 Curl	4-12.3 & 151.891 Black Squares on BRN	A9613 A9614	27N,9W,S8SE Walling Reef/Net-Gun
"	Ewe-4 yrs.+ 1976 Trans.	3-2.2 & 151.334 All White	A0239 A0240	" "
"	Ewe-1 yr.	2-3.5 & 151.069 Black O's on hite	A10524 A10525	" "
"	Ram-4 yrs.+ 3/4 Curl	4-10.3 & 151.837 Orange	A10518 A10519	" "
4/23/82	Ewe-4 yrs.+	2-2.2 & 151.031 Black M's on White	A10756 A10757	24N,8W,S8NE Ear Mountain Clover Trap
4/22/82	Ram-2 yrs. 1/4 Curl	Red Neckband White T's	A10752 A10753	" "
"	Ram-1 yr.	Red Neckband White Horiz. Bars	A10770 A10771	" "
4/25/82	Ram-1 yr.	Red Neckband Two White Stripes	A10754 A10755	" "
"	Ram-1 yr.	Black Neckband Yellow Dashed Line	A10758 A10759	" "

[a] Age determined by incisor replacement, and horn rings of males.

[b] This ram was killed by a hunter on Choteau Mountain, 11/10/82.

Table 13. Bighorn sheep helicopter survey of the East Front study area, 11-12 July 1981.

Total	Rams	Ewes	Lambs	Uncl.	Location
6	2 (1/4 curl) 2 (1/2 curl) 2 (3/4 curl)				26N,9W,S17NE N.Fk.Teton R.
3	2 (1/2-3/4 curl) 1 (3/4 curl)				26N,9W,S15SW Blackleaf Creek
26[a]	20 (1/4-3/4 curl) 6 (3/4-full curl)				26N,10W,S22NW Bruce Creek
16[b]	2 (1/4 curl)	8	4	2	27N,9W,S20NE Walling Reef
1[c]		1			27N,9W,S17NE Walling Reef
1	1 (1/4 curl)				28N,10W,S18NE Hungry Man Cr.
1[d]		1			28N,10W,S16SE Major Steele Backbone
1[e]		1			29N,10W,S31 Feather Woman Mtn.
30				30	24N,8W,S19NE Ear Mtn.

[a] Included 1 neckbanded ram

[b] Included 2 neckbanded ewes

[c] Included 1 neckbanded ewe

[d] Included 1 neckbanded ewe

[e] Included 1 neckbanded ewe

Table 14. Bighorn sheep helicopter survey of the East Front study area, 19-20 January 1982.

Total	Rams	Ewes	Lambs	Location
37	1 (¼ curl) 4 (½ curl) 1 (3/4 curl) 1 (full curl)	23	7	Swift Resevoir (West Slope) 28N,10W,S26SE
6	5 (½-3/4 curl) 1 (¼ curl)			Walling Reef 27N,9W,S5SW
6	1 (½ curl) 4 (3/4 curl) 1 (unclassified)			South Fork Dupuyer Creek 26N,9W,S2NW
5	4 (3/4 curl) 1 (½ curl)			Head of Clary Coulee 25N,9W,S13SW

Table 15. Bighorn sheep helicopter survey of the East Front study area, 25 February 1982.

Total	Rams	Ewes	Lambs	Location
37	8 (¼-3/4 curl) 4 (¼ curl)	20	5	Walling Reef 27N,9W,S8SE
9	1 (¼ curl) 4 (½ curl) 4 (3/4 curl)			South Fork Dupuyer Creek 26N,9W,S2NW
5	5 (3/4 curl)			Volcano Reef 26N,9W,S11SW
1		1		Choteau Mountain 25N,9W,S12SE

Table 16. Bighorn sheep helicopter survey of the East Front study area, August 1982.

Date	Total	Rams	Ewes	Lambs	Uncl.	Location
8/5/82	12		8	4		24N,9W,S13SW Ear Mtn.
"	9		6	3		24N,8W,S19NW Ear Mtn.
"	39[a]	1 (yrlg.)	25	13		24N,9W,S27NW Green Gulch
"	19	8 (3/4-full curl) 6 (1/2 curl) 3 (1/4 curl) 2 (full curl)				24N,9W,S18SW Our Lake
8/6/82	13	1 (1/4 curl)	8	4		28N,10W,S31SE Mt. Richmond
8/7/82	22	11 (3/4-full curl) 5 (1/2 curl) 4 (full curl) 2 (1/4 curl)				27N,10W,S36SW N. FK. Dupuyer Cr.
8/8/82	21[b]		13	6	2 (yrlgs.)	27N,9W,S17NE Walling Reef
8/18/82	5		4	1		26N,9W,S1NW Choteau Mtn.
"	7	1 (1/4 curl)	4	2		26N,9W,S12NW Choteau Mtn.
"	1	1 (3/4 curl)				26N,9W,S35SW Jones Creek
"	24[c]	11 (3/4-full curl) 6 (1/2 curl) 4 (full curl) 3 (1/4 curl)				25N,9W,S3NW Jones Creek

[a] Included neckbanded yearling ram from N. Fk. Willow Creek.

[b] Included neckbanded ewe from 1976 transplant.

[c] Included neckbanded ram from N. Fk. Willow Creek and neckbanded ram from 1976 transplant.

Table 17. Bighorn sheep helicopter survey of the East Front study area, 14 January 1983.

Total	Rams	Ewes	Lambs	Location
46[a]	6 (3/4 curl) 4 (1/4 curl) 2 (full curl) 2 (1/2 curl)	22	10	27N,9W,S8SE Walling Reef
1		1		27N,10W,S13SE Phone Creek
17	2 (1/4 curl) 1 (1/2 curl)	10	4	25N,9W,S12NW Choteau Mtn.
1		1		26N,9W,S35SW Jones Creek
7	7 (1/2-3/4 curl)			26N,9W,S11NE Volcano Reef
14		11	3	24N,8W,S8NE Ear Mtn.
2	1 (3/4 curl)	1		24N,8W,S8SE Ear Mtn.
13	1 (3/4 curl) 1 (1/2 curl)	7	4	24N,8W,S18SE Ear Mtn.
1	1 (1/4 curl)			24N,8W,19NE Ear Mtn.
3		2	1	24N,8W,S17SW Ear Mtn.
6	1 (3/4 curl)	3	2	24N,8W,S20NW Ear Mtn.
10	1 (1/4 curl) 1 (1/2 curl)	3	5	24N,8W,S29NW Ear Mtn.
22	5 (1/4 curl) 1 (1/2 curl)	12	4	24N,8W,S28NW Ear Mtn.
6		4	2	24N,9W,S13NE Ear Mtn.

[a] Included two neckbanded ewes from 1976 transplant.

Table 18. Percent occurrence of habitat components in vegetation sample plots within the Walling Reef area.

Habitat Component	Winter Range Plots		Summer Range Plots	
	Random	Radio & Neckband	Random	Radio & Neckband
Terrain Type				
Bluffs	6.7	11.8	15.0	15.8
Cliffs	6.7	17.6	10.0	63.2
Cirque Basin	6.7			
Talus Slope	6.7			
Broken	3.3	11.8	10.0	21.1
Ridge	10.0	23.5	5.0	
Park	6.7			
Creek Bottom	6.7		5.0	
Sidehill	46.7	35.3	55.5	
Total Plots	30	17	20	19
Cover Type				
Timber	11.1		20.8	
Shrub	27.8	19.0		
Grass-Forb	25.9	33.3	54.2	48.4
Rock-Bareground	13.0	11.9	25.0	51.7
Old Burn	22.2	35.7		
Total Plots[a]	54	42	24	31
Elevation (m)				
1402-1525				
1526-1678	3.3	11.8		
1679-1830	36.7	47.1	10.0	
1831-1983	43.3	35.3	5.0	21.1
1984-2135	13.3	5.9	40.0	31.6
2136-2288	3.3		45.0	47.4
2289-2440				
2441-2593				
Total Plots	30	17	20	19
Aspect				
N	23.3	47.1	35.0	
NE	13.3	5.9	5.0	31.6
E	6.7		40.0	68.4
SE	13.3	11.8		
S	30.0	29.4		
SW				
W	3.3	5.9	5.0	
NW	10.0		15.0	
Total Plots	30	17	20	19

Table 18. Continued.

Habitat Component	Winter Range Plots Random	Winter Range Plots Radio & Neckband	Summer Range Plots Random	Summer Range Plots Radio & Neckband
Slope				
Under 20%	10.0		20.0	
20%-29%	10.0	5.9	15.0	15.8
30%-39%	13.3	5.9	40.0	
40%-49%	10.0	35.3		21.1
50%-59%	20.7	11.1	10.0	
60%-79%	26.7	17.6	5.0	
80%-100%	10.0	23.5	10.0	63.2
Total Plots	30	17	20	19
Dist. to Timber				
Under 9m	30.0	5.9	25.0	
9-46 m	16.7	11.8		
47-91 m	30.0	29.4	25.0	
92-230 m	10.0	41.2	20.0	15.8
231-400 m	13.8	11.8	30.0	84.2
Over 400 m				
Total Plots	30	17	20	19
Dist. to Escape				
Under 9 m	10.0	41.2	20.0	73.7
9-46 m	13.3	5.9		15.8
47-91 m	16.7	17.6	15.0	
92-230 m	23.3	23.5	30.0	
231-400 m	30.0	11.8	35.0	
Over 400 m	6.9			
Total Plots	30	17	20	19
Habitat Type[b]				
Abla-Arco			15.0	
Abla-Caru	6.7	5.9		
Abla-Clps	23.3	58.8		
Abla-Gatr			5.0	
Fesc-Feid	3.3			
Pifl-Fesc	3.3			
Pien-Gatr	10.0			
Psme-Arco	3.3			
Psme-Aruv	13.3			
Psme-Cage	3.3			
Psme-Spbe			5.0	
Pofr-Fesc	20.0	5.9	35.0	
Pofr-Feid			10.0	15.8
Rock-Scree	13.3	29.4	30.0	84.2
Total Plots	30	17	20	19

Table 18. Concluded.

Habitat Component	Winter Range Plots Random	Winter Range Plots Radio & Neckband	Summer Range Plots Random	Summer Range Plots Radio & Neckband
Timber Canopy Coverage				
0	46.7	58.8	70.0	100
0-1%	30.0	41.2	5.0	
1-5%	10.0			
5-25%			20.0	
25-50%	6.7		5.0	
50-75%	3.3			
75-95%	3.3			
95-100%				
Total Plots	30	17	20	19
Shrub Canopy Coverage				
0	10.0		25.0	36.8
0-1%	26.7	5.9	40.0	63.2
1-5%	20.0	47.1	15.0	
5-25%	30.0	47.1	10.0	
25-50%	10.0			
50-75%	3.3			
75-95%				
95-100%				
Total Plots	30	17	20	19
Ground Canopy Coverage				
0				
0-1%				
1-5%	6.7		5.0	21.1
5-25%	13.3	11.8	10.0	63.2
25-50%	13.3	11.8	35.0	15.8
50-75%	43.3	29.4	35.0	
75-95%	23.3	47.1	15.0	
95-100%				
Total Plots	30	17	20	19

[a] Totals are greater than the number of sample plots conducted because cover type categories often overlapped; therefore a single plot may have had more than one cover type.

[b] See Appendix Table 22 for key to 4-letter plant species abbreviations.

Table 19. Percent occurrence of habitat components in vegetation sample plots within the Ear Mountain area.

Habitat Component	Winter Range Plots		Summer Range Plots	
	Random	Radio & Neckband	Random	Radio & Neckband
Terrain Type				
Bluffs	6.7	21.1		28.6
Cliffs		10.5		
Cirque Basin				
Talus Slope			20.0	28.6
Broken				
Ridge	13.3	10.5	15.0	
Park	13.3		15.0	
Creek Bottom	20.0	5.3	5.0	
Sidehill	46.7	52.6	45.0	42.9
Total Plots	30	19	20	7
Cover Type				
Timber	34.3		50.0	20.0
Shrub	8.6		8.3	
Grass-Forb	57.1	76.2	16.7	30.0
Rock-Baregrouńd		23.8	16.7	50.0
Old Burn			8.3	
Total Plots[a]	35	21	24	10
Elevation (m)				
1402-1525	3.3			
1526-1678	33.3	68.4		
1679-1830	63.3	31.6		
1831-1983				
1984-2135			40.0	28.6
2136-2288			40.0	42.9
2289-2440			15.0	14.3
2441-2593			5.0	14.3
Total Plots	30	19	20	7
Aspect				
N	33.3	10.5	10.0	
NE	13.3	21.1	15.0	14.3
E	10.0		10.0	14.3
SE	3.0	10.5	15.0	
S	20.0	52.6	15.0	14.3
SW			25.0	28.6
W	13.3		25.0	28.6
NW	6.7	5.3		
Total Plots	30	19	20	7

Table 19. Continued.

Habitat Component	Winter Range Plots		Summer Range Plots	
	Random	Radio & Neckband	Random	Radio & Neckband
Slope				
Under 20%	13.3	5.3		
20%-29%	30.0	42.1	10.0	
30%-39%	23.3	42.1	20.0	
40%-49%	20.0		15.0	14.3
50%-59%	13.3		20.0	42.9
60%-79%			25.0	42.9
80%-100%		10.5	10.0	28.6
Total Plots	30	19	20	7
Dist. to Timber				
Under 9 m	43.3	21.1	60.0	42.9
9-46 m	33.3	68.4	15.0	28.6
47-91 m	16.7	5.3	20.0	
91-230 m	6.7	5.3		
231-400 m				
Over 400 m			5.0	28.6
Total Plots	30	19	20	7
Dist. to Escape				
Under 9 m	6.7	31.6		28.6
9-46 m	13.3	31.6	5.0	14.3
47-91 m	6.7	36.8	25.0	28.6
92-230 m	20.0	5.3	40.0	14.3
231-400 m	26.7		20.0	14.3
Over 400 m	26.7		10.0	
Total Plots	30	19	20	7
Habitat Type[b]				
Abla-Arco			25.0	14.3
Abla-Cage			10.0	
Abla-Gatr			5.0	
Artr-Agsp	3.3			
Artr-Feid		21.1		
Artr-Fesc	6.7	5.3		
Feid-Agsp	3.3	26.3		
Fesc-Agsp	13.3			
Fesc-Feid	6.7			
Pien-Gatr			10.0	28.6
Pifl-Feid			5.0	
Pifl-Fesc		10.5		
Pofr-Agsp	3.3			
Pofr-Feid	6.7	5.3	10.0	
Pofr-Fesc	30.0	21.1	15.0	
Psme-Syal	10.0			
Psme-Caru	10.0			
Psme-Cage	6.7			
Rock-Scree		10.5	20.0	57.1
Total Plots	30	19	20	7

Table 19. Concluded.

Habitat Component	Winter Range Plots		Summer Range Plots	
	Random	Radio & Neckband	Random	Radio & Neckband
Timber Canopy Coverage				
0	40.0	84.2	30.0	42.9
0-1%	16.6	15.8	10.0	28.6
1-5%	20.0		10.0	
5-25%			25.0	28.6
25-50%	6.7		15.0	
50-75%	13.3			
75-95%	3.3			
95-100%				
Total plots	30	19	20	7
Shrub Canopy Coverage				
0	20.0	63.2	15.0	28.6
0-1%	43.3	10.5	5.0	
1-5%	23.3	15.8	25.0	14.3
5-25%	10.0	10.5	40.0	57.1
25-50%	3.3		15.0	
50-75%				
75-95%				
95-100%				
Total Plots	30	19	20	7
Ground Canopy Coverage				
0				
0-1%				
1-5%			25.0	14.3
5-25%	3.3			42.9
25-50%	10.0	10.5	40.0	42.9
50-75%	26.7	21.1	25.0	
75-95%	60.0	68.4	10.0	
95-100%				
Total Plots	30	19	20	7

[a] Totals are greater than the number of sample plots conducted because cover type categories often overlapped; therefore a single plot may have had more than one cover type.

[b] See Appendix Table 22 for key to 4-letter plant species abbreviations.

Table 20. Percent frequency of occurrence and mean percent canopy coverage of plants found on the Walling Reef (WR) and Ear Mountain (EM) sheep winter and summer ranges. Numbers of frames sampled are in parentheses.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Grasses and Grasslikes:								
Agropyron spp.	1.1/Tr[c]	3.9/Tr	18.9/Tr	17.5/Tr	5.0/Tr	3.5/Tr	18.3/Tr	
Agropyron caninum				1.8/Tr			6.6/Tr	
Agropyron dasystachyum	4.6/Tr	2.0/Tr						
Agropyron smithii	5.7/Tr	7.8/Tr		1.7/Tr		5.0/Tr		
Agropyron spicatum	14.9/Tr	7.8/Tr	42.2/2.2	64.9/4.0	10.0/Tr	12.3/Tr	20.0/2.0	9.5/Tr
Bromus carinatus	16.1/Tr	7.8/Tr	3.3/Tr	1.8/Tr	28.3/Tr	12.3/1.0	1.6/Tr	
Bromus inermis	18.3/Tr	17.6/Tr	4.4/Tr	5.3/Tr		1.8/Tr		
Calamagrostis montanensis	1.1/Tr	2.0/Tr				3.5/Tr		
Calamagrostis rubescens	3.4/Tr	2.0/Tr			1.7/Tr			
Carex spp.	34.5/1.1	31.3/2.8	38.9/1.1	36.8/1.4	43.3/1.5	22.8/Tr	25.0/1.2	4.8/Tr
Carex filifolia	9.2/Tr	7.8/Tr	23.3/Tr	26.3/Tr	6.7/Tr	10.5/Tr	11.6/Tr	
Carex geyeri	3.4/Tr		5.6/Tr		1.7/Tr		5.0/Tr	
Carex rupestris	10.3/Tr		3.3/Tr	12.3/Tr	15.0/Tr	57.9/1.3		23.8/Tr
Carex stenophylla	8.0/Tr	7.8/Tr			5.0/Tr	1.8/Tr		
Danthonia spp.			6.7/Tr					
Danthonia intermedia	12.6/Tr	11.8/Tr	6.7/Tr	15.8/Tr	38.3/2.3	1.8/Tr	8.3/Tr	
Danthonia parryi		3.9/Tr						
Danthonia unispicata			2.2/Tr					
Eleocharis acicularis	3.4/Tr	5.9/Tr						
Festuca idahoensis	31.0/2.1	19.6/1.9	55.6/3.0	56.1/4.3	43.9/4.3	12.3/1.0	30.0/2.8	23.8/1.9
Festuca scabrella	20.7/Tr	41.2/2.6	53.3/4.3	43.9/2.4	23.3/3.5	1.8/Tr	18.3/3.1	9.5/Tr
Helictotrichon hookeri	1.1/Tr		3.3/Tr	1.8/Tr				
Juncus spp.					3.3/Tr			
Koeleria cristata	6.9/Tr	9.8/Tr	17.8/Tr	14.0/Tr	5.0/Tr	19.3/Tr	10.0/Tr	23.8/1.3
Luzula hitchcockii					6.7/Tr			
Phleum alpinum	3.4/Tr	5.9/Tr			5.0/Tr			
Poa spp.	2.3/Tr	3.9/Tr	5.6/Tr	7.0/Tr			1.6/Tr	
Poa alpina	4.6/Tr	7.8/Tr			5.0/Tr	1.8/Tr	25.0/Tr	28.6/Tr
Poa compressa			3.3/Tr	7.0/Tr				
Poa cusickii	2.3/Tr	13.7/Tr			3.3/Tr		10.0/Tr	

Table 20. Continued.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Poa pratensis	14.9/Tr	9.8/Tr	7.8/Tr	8.7/Tr				
Poa sandbergii	17.3/Tr	5.9/Tr		1.8/Tr	1.7/Tr			
Stipa sp.	2.3/Tr	2.0/Tr						
Stipa comata	5.7/Tr	3.9/Tr	6.7/Tr				1.6/Tr	
Stipa viridula			4.4/Tr	10.5/Tr		1.8/Tr	5.0/Tr	
Unknown grasses	3.4/Tr	23.5/Tr	2.2/Tr					
Forbs:								
Achillia millefolium	42.5/1.5	42.1/1.1	32.2/1.8	31.2/1.4	40.4/2.2		38.3/1.1	9.5/Tr
Actae rubra		2.0/Tr						
Agoseris glauca	17.3/Tr	19.6/Tr	7.8/Tr	3.5/Tr	15.0/1.45	1.8/Tr	5.0/Tr	
Allium textile	4.6/Tr		1.1/Tr	5.3/Tr	1.7/Tr		1.6/Tr	4.8/Tr
Anaphalis margaritacae	2.3/Tr	3.9/Tr	7.8/Tr		8.3/Tr	1.8/Tr	1.6/Tr	
Androsace spp.					1.7/Tr			
Androsace lehmanniana	3.4/Tr				30.0/1.5	38.6/1.1	5.0/Tr	38.1/Tr
Angelica spp.		9.8/Tr						
Angelica multifida	6.9/Tr	17.6/Tr			8.3/Tr	1.8/Tr	5.0/Tr	9.5/Tr
Anemone spp.	1.1/Tr				3.3/Tr	1.8/Tr		
Anemone nuttalliana	5.7/Tr	3.9/Tr	13.3/Tr	15.8/Tr				
Anemone parviflora	1.1/Tr				6.7/Tr		15.0/Tr	
Antennaria anaphaloides		3.9/Tr						
Antennaria microphylla	5.7/Tr	11.8/Tr	20.0/1.5	19.3/1.7	15.0/Tr	19.3/Tr	6.7/Tr	14.3/Tr
Antennaria racemosa			1.1/Tr	1.8/Tr				
Arenaria spp.		3.9/Tr						
Arenaria capillaris	3.4/Tr	19.6/Tr			10.0/Tr	10.5/Tr	16.6/Tr	9.5/Tr
Arenaria congesta	5.7/Tr	3.9/Tr			1.7/Tr		3.3/Tr	
Arenaria obtusiloba	1.1/Tr	2.0/Tr	15.6/Tr	17.5/Tr	6.7/Tr		8.3/Tr	4.8/Tr
Arnica cordifolia	9.2/Tr	7.8/Tr	6.7/Tr				1.6/Tr	
Arnica fulgens			3.3/Tr	1.8/Tr				
Arnica latifolia			1.1/Tr	3.5/Tr				
Arnica longifolia			4.4/Tr					
Arnica sororia			6.1/Tr	3.5/Tr				

Table 20. Continued.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Artemesia campestris					1.7/Tr	5.3/Tr		
Artemesia ludoviciana	2.3/Tr			5.3/Tr				
Artemesia michauxiana	2.3/Tr					7.0/Tr	1.6/Tr	
Aster spp.		2.0/Tr			11.7/Tr			
Aster conspicuous	4.6/Tr	5.7/Tr			5.0/Tr			
Astragalus spp.	3.4/Tr	13.7/Tr	1.1/Tr		11.7/Tr		11.6/Tr	9.5/Tr
Astragalus adsurgens	2.3/Tr	2.0/Tr	2.2/Tr		5.0/Tr			
Astragalus drummondii			2.2/Tr					
Astragalus vexilliflexus	3.4/Tr							
Balsamorhiza sagittata			1.1/Tr	38.6/8.2				
Besseya wyomingensis	5.7/Tr		10.0/Tr	10.6/Tr		12.3/Tr		14.3/Tr
Bupleurum americanum	24.1/Tr	21.0/Tr	2.2/Tr	5.3/Tr	26.7/1.8	5.3/Tr	11.6/Tr	14.3/Tr
Calochortus apiculatus	2.3/Tr				1.7/Tr			
Campanula rotundifolia	13.8/Tr	6.9/Tr			11.7/Tr	7.0/Tr	11.6/Tr	33.3/Tr
Castilleja spp.	1.1/Tr	2.0/Tr						
Castilleja minata	1.1/Tr	5.9/Tr	1.1/Tr				3.3/Tr	
Cerastium arvense	27.6/Tr	31.4/1.5	47.8/1.4	42.1/1.0	15.0/Tr	14.0/Tr	25.0/Tr	14.3/Tr
Chrysopsos villosa	3.4/Tr		3.3/Tr		3.3/Tr	1.8/Tr	1.6/Tr	
Cirsium spp.					1.7/Tr	7.0/Tr	6.6/Tr	9.5/Tr
Claytonia megarhiza							5.0/Tr	
Clematis hirsutissima				5.3/Tr				
Clematis pseudoalpina	11.1/Tr	11.8/Tr	1.1/Tr		5.0/Tr			
Collomia linearis				7.0/Tr				
Comandra umbellata	2.3/Tr		4.4/Tr	7.0/Tr	1.7/Tr			
Crepis occidentalis			5.6/Tr	1.8/Tr				
Crepis acuminata			2.2/Tr					
Cruciferae			1.1/Tr	3.5/Tr				
Delphinium bicolor	4.6/Tr	3.9/Tr	6.7/Tr	12.3/Tr				
Dodecatheon conjugans			2.2/Tr					
Douglasia montana	3.4/Tr		3.3/Tr	14.0/Tr	6.7/Tr	8.8/Tr	6.6/Tr	33.3/5.6
Dryas octopetala	5.7/Tr				25.0/8.9	56.1/13.6		23.8/5.6
Epilobium angustifolium		2.0/Tr					10.0/Tr	
Erigeron spp.	6.9/Tr	2.0/Tr	15.6/Tr	15.8/Tr	11.7/Tr			
Erigeron compositus	1.1/Tr	3.9/Tr	4.4/Tr		8.3/Tr	8.8/Tr	10.0/Tr	9.5/Tr

Table 20. Continued.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Erigeron ochroleucus	2.3/Tr	13.7/Tr	6.7/Tr		11.7/Tr	8.7/1.0	3.3/Tr	9.5/Tr
Erigeron speciosus	4.6/Tr	2.0/Tr	1.1/Tr				3.3/Tr	9.5/Tr
Eriogonum spp.							1.6/Tr	
Eriogonum flavum	1.1/Tr	9.8/Tr						
Eriogonum ovalifolium							3.3/Tr	
Eriophyllum lantum			1.1/Tr	3.5/Tr				
Eritrichium howardii			2.2/Tr	5.3/Tr				
Erythronium grandiflorum	3.4/Tr		5.6/Tr					
Fragaria virginiana	28.7/1.9	35.3/3.7	13.3/Tr		6.7/Tr		18.3/Tr	
Frasera speciosa	2.3/Tr	5.9/Tr			16.7/1.1	7.0/Tr	3.3/Tr	
Gaillardia aristata	16.1/Tr	3.9/Tr	3.3/Tr	5.3/Tr	6.7/Tr	1.8/Tr	15.0/Tr	14.3/Tr
Galium boreale	57.5/3.2	64.7/2.2	38.9/1.7	38.6/1.4	28.3/Tr	3.5/Tr	21.6/Tr	23.8/Tr
Galium triflorum	5.7/Tr		3.3/Tr		1.7/Tr		25.0/1.3	28.6/Tr
Gaura coccinea	1.1/Tr							
Gentiana amarella							11.6/Tr	
Gentiana calycosa		3.9/Tr			6.7/Tr		13.3/Tr	
Geranium richardsonii	2.3/Tr							
Geranium viscosissimum	2.3/Tr	3.9/Tr	5.6/Tr	7.0/Tr				
Geum triflorum	6.9/Tr	3.9/Tr	4.4/Tr	3.5/Tr				
Hedysarum spp.	33.3/2.8	43.1/3.8			50.0/3.6	29.8/1.1	35.0/2.9	23.8/1.3
Hedysarum sulphurescens			4.4/Tr	5.3/Tr				
Helianthus anuus				3.5/Tr				
Heuchera cylindrica	4.6/Tr	2.0/Tr						
Hymenoxys acaulis			6.7/Tr	10.6/Tr				
Hymenoxys richardsonii						1.8/Tr		
Lathyrus ochroleucus	4.6/Tr	9.8/Tr	2.2/Tr					
Liliaceae	2.3/Tr		1.8/Tr					
Linum perenne	3.4/Tr	9.8/Tr	5.6/Tr	1.8/Tr			3.3/Tr	
Lithospermum ruderale			2.2/Tr	3.5/Tr				
Lomatium spp.	1.1/Tr							
Lomatium macrocarpum			3.3/Tr	5.3/Tr				
Lomatium dissectum		2.0/Tr						
Lomatium triternatum				1.8/Tr				

Table 20. Continued.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Lupinus sericeus	10.3/Tr	2.0/Tr	28.9/3.3	17.5/1.1	10.0/Tr	1.8/Tr		
Mertensia ciliata	4.6/Tr				5.0/Tr			
Monarda fistulosa	5.7/Tr	3.9/Tr			1.7/Tr			
Orthocarpus luteus			1.1/Tr					
Osmorhiza occidentalis	2.3/Tr		3.3/Tr		1.7/Tr			
Oxytropis spp.	4.6/Tr		2.2/Tr	3.5/Tr				
Oxytropis bessevi			2.2/Tr					
Oxytropis sericea	5.7/Tr	3.9/Tr	10.0/Tr	12.3/Tr	20.0/Tr	35.1/1.2	3.3/Tr	33.3/2.7
Oxytropis lagopus	3.4/Tr							
Oxytropis splendens			13.3/Tr	3.5/Tr				
Oxytropis viscida	6.9/Tr	11.8/Tr			1.7/Tr		5.0/Tr	
Paronychia sessiliflora			2.2/Tr					
Pedicularis groenlandica	12.6/Tr	17.6/Tr	1.1/Tr	1.8/Tr	5.0/Tr	1.8/Tr	6.6/Tr	14.3/Tr
Penstemon spp.	2.3/Tr	2.0/Tr					3.3/Tr	
Penstemon albertinus			3.3/Tr	3.5/Tr				
Pnestemon confertus	24.1/1.6	12.3/Tr	1.1/Tr		10.0/Tr		13.3/Tr	9.5/Tr
Phacelia hastata	1.1/Tr	5.9/Tr				3.5/Tr	8.3/Tr	
Phlox alyssifolia	2.3/Tr				1.7/Tr	8.8/Tr		
Phlox hoodii	1.1/Tr		18.9/2.2	28.1/2.9	6.7/Tr	3.5/Tr		4.8/Tr
Plantago major	4.6/Tr	5.9/Tr	6.7/Tr	3.5/Tr	3.3/Tr	8.7/Tr	6.6/Tr	4.8/Tr
Polygonum bistortoides	2.3/Tr	2.0/Tr	10.0/Tr		5.0/Tr			
Potentilla spp.	8.0/Tr	2.0/Tr			1.7/Tr	1.8/Tr	1.6/Tr	
Potentilla anserina	2.3/Tr							
Potentilla diversifolia			2.2/Tr	1.8/Tr				
Potentilla gracilis	13.8/Tr	3.9/Tr	5.6/Tr		15.0/Tr		16.6/Tr	4.8/Tr
Ranunculus eschscholtzii							1.6/Tr	
Ranunculus glaberrimus			1.1/Tr					
Rumex crispus				3.5/Tr				
Sedum lanceolatum	26.4/Tr	29.4/Tr			13.3/Tr		21.6/Tr	9.5/Tr
Sedum stenopetalum	2.3/Tr		1.1/Tr	5.3/Tr				9.5/Tr
Senecio spp.	3.4/Tr	5.9/Tr					5.0/Tr	4.8/Tr
Senecio canus	10.3/Tr	15.7/Tr		1.8/Tr	3.3/Tr	7.0/Tr	21.6/Tr	33.3/1.6
Senecio fremonti					1.7/Tr	1.8/Tr		
Senecio serra		3.9/Tr						
Senecio streptanthifolius							1.6/Tr	

Table 20. Continued.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Senecio triangularis					6.7/Tr			
Senecio pseudaureus	10.3/Tr	23.5/Tr					5.0/Tr	
Smilacena racemosa			4.4/Tr			3.5/Tr		
Solidago spp.	33.3/1.4	29.4/2.1	17.8/1.3	12.3/Tr	40.4/7.6		58.3/3.4	42.8/2.9
Stellaria americana						5.3/Tr	5.0/Tr	19.0/Tr
Streptopus amplexifolius	1.1/Tr	2.0/Tr					1.6/Tr	
Taraxacum officinale			30.0/2.2	28.1/1.3	8.3/Tr		10.0/Tr	
Thalictrum occidentale	8.0/Tr	5.9/Tr	1.1/Tr		8.3/Tr		8.3/Tr	
Townsendia montana								9.5/Tr
Tragopogon dubius				3.5/Tr				
Valeriana diocia	4.6/Tr	2.0/Tr			6.7/Tr	1.8/Tr		
Valeriana sitchensis					13.3/Tr		1.6/Tr	
Vicia americana	8.0/Tr	3.9/Tr	16.5/Tr	24.6/1.0				
Viola spp.							5.0/Tr	
Viola adunca		4.4/Tr						
Viola canadensis		7.8/Tr						
Viola orbiculata	4.6/Tr				1.7/Tr			
Zygadenus elegans	4.6/Tr	3.9/Tr	7.8/Tr	5.3/Tr	5.0/Tr	12.3/Tr	3.3/Tr	
Zygadenus venenosus		2.0/Tr	7.8/Tr	12.3/Tr				
Unknown forbs	24.1/Tr	15.7/Tr	30.0/1.0	14.0/Tr	35.0/Tr	3.5/Tr	18.3/Tr	38.1/Tr
Shrubs and Trees:								
Abies lasiocarpa							3.3/Tr	
Acer glabrum	1.1/Tr	2.0/Tr					1.6/Tr	
Amelanchier alnifolia	1.1/Tr		5.6/Tr	3.5/Tr				
Arctostaphylos uva-ursi	20.7/8.3	27.5/7.5	4.4/Tr		8.3/Tr	10.5/1.5	5.0/1.4	9.5/3.7
Artemisia frigida		23.2/1.7	35.1/3.8					
Artemisia tridentata		5.6/Tr	5.3/Tr					
Berberis repens	1.1/Tr	3.9/Tr	3.3/Tr	1.8/Tr			1.6/Tr	
Cornus stolonifera		2.0/Tr						
Juniperus communis	5.7/Tr	3.9/Tr			1.7/Tr		3.3/Tr	4.8/Tr
Juniperus horizontalis	1.1/Tr		4.4/Tr	3.5/Tr				4.8/Tr
Penstemon fruticosus	4.6/Tr				1.7/Tr	21.1/Tr	6.6/Tr	4.8/Tr

Table 20. Concluded.

Taxa	WR Winter Random[a] (90)	WR Winter Reloc.[b] (51)	EM Winter Random (90)	EM Winter Reloc. (57)	WR Summer Random (60)	WR Summer Reloc. (57)	EM Summer Random (60)	EM Summer Reloc. (21)
Picea engelmannii	1.1/Tr	2.0/Tr					3.3/Tr	
Pinus albicaulis					1.7/Tr			
Pinus flexilus	1.1/Tr	2.0/Tr					3.3/Tr	
Populus tremuloides	3.4/Tr		3.3/Tr					
Potentilla fruticosa	35.6/5.9	15.7/4.2	21.1/2.7	3.5/Tr	45.0/6.6	45.6/2.4	11.6/Tr	4.8/Tr
Prunus virginiana	1.1/Tr	2.0/Tr	1.1/Tr	3.5/Tr				
Pseudotsuga menziesii		1.1/Tr		1.7/Tr				
Ribes spp.						1.8/Tr	1.6/Tr	
Rosa spp.	28.7/2.0	23.5/2.0	17.8/1.0	24.6/3.2	3.3/Tr		1.6/Tr	
Rubus idaeus	1.1/Tr							
Rubus parviflorus	2.3/Tr	2.0/Tr			3.3/Tr			
Salix spp.					1.7/Tr			
Shepherdia canadensis	11.5/Tr	2.0/Tr			3.3/Tr		5.0/Tr	
Spiraea betulifolia	24.1/1.0	37.3/2.6	4.4/Tr		5.0/Tr		8.3/Tr	
Symphoricarpos albus	9.2/Tr	3.9/Tr	6.7/Tr					
Symphoricarpos occidentalis			7.8/Tr	17.5/1.1				

[a] Random sample plots.

[b] Radio or neckband relocation sample plots.

[c] Percent frequency of occurrence/mean percent canopy coverage; Tr=trace, a value less than 1.0%.

Table 21. Mean percentages of the diet for plants found in seasonal fecal samples of the Walling Reef and Ear Mtn. bighorn sheep populations (N = 10 and standard deviations are in parentheses).

Plant Species	July 1982 Walling R.	Aug. 1982 Ear Mtn.	Oct. 1982 Walling R.	Oct. 1982 Ear Mtn.	Jan. 1983 Walling R.	Jan. 1983 Ear Mtn.	Ap. 1983 Walling R.	Ap. 1983 Ear Mtn.
Douglasia montana	0.2 (0.7)	1.3 (2.2)		0.3 (0.7)	0.2 (0.5)			0.2 (0.5)
Erigonum spp.	0.6 (1.3)		1.2 (1.8)	0.2 (0.6)	0.2 (0.5)	4.3 (3.3)	0.2 (0.6)	0.2 (0.7)
Fragaria virginiana	0.8 (1.5)	0.4 (0.9)	0.2 (0.6)				0.2 (0.6)	
Frasera speciosa				0.2 (0.7)	21.1 (9.0)		0.2 (0.6)	
Gallium spp.	1.2 (1.5)	1.3 (2.4)	1.1 (1.8)					
Geum spp.	0.4 (0.8)	0.2 (0.7)	0.2 (0.7)					
Hedysarum spp.		1.4 (1.7)	0.4 (0.8)	0.2 (0.6)				
Heuchera spp.			0.2 (0.6)					
Other Liliaceae	1.0 (1.7)	0.2 (0.7)	0.2 (0.6)	0.2 (0.5)			0.2 (0.6)	
Lomatium spp.		0.2 (0.5)			0.2 (0.5)			
Lupinus sericeus	5.5 (3.2)	3.9 (3.2)	2.4 (2.2)	2.7 (1.7)	0.3 (0.7)	1.3 (1.3)	2.4 (2.3)	0.3 (0.7)
Oxytropis spp.	0.6 (1.4)		0.7 (1.1)					0.7 (2.1)
Phlox spp.	1.7 (1.4)	0.9 (1.5)	0.4 (0.8)	0.4 (0.8)		0.5 (0.8)	1.2 (1.4)	3.8 (1.6)
Potentilla spp.	0.4 (0.9)	0.6 (1.5)		0.2 (0.5)				
Root				0.2 (0.6)	12.2 (6.7)	0.5 (1.3)	0.6 (1.4)	
Sedum spp.		0.2 (0.7)	0.2 (0.6)					
Smilacina spp.			0.2 (0.6)					
Vicia americana	9.2 (2.3)	8.5 (1.7)	8.0 (1.9)	5.3 (1.8)	3.3 (2.0)	4.5 (0.9)	5.3 (1.7)	3.3 (1.6)
Total forbs	48.1(14.1)	36.3 (9.3)	26.4(11.5)	14.2 (6.3)	38.7(12.8)	15.1 (4.7)	16.3 (4.8)	11.8 (8.1)

Table 21. Continued.

Plant Species	July 1982 Walling R.	Aug. 1982 Ear Mtn.	Oct. 1982 Walling R.	Oct. 1982 Ear Mtn.	Jan. 1983 Walling R.	Jan. 1983 Ear Mtn.	Ap. 1983 Walling R.	Ap. 1983 Ear Mtn.
Agropyron spp.	7.0 (5.1)	4.0 (2.6)	9.4 (2.7)	10.7 (3.9)	4.9 (1.6)	12.3 (2.7)	19.7 (6.0)	16.3 (3.7)
Bromus spp.	4.3 (2.4)	2.4 (2.4)	1.4 (1.9)	1.8 (1.2)	3.1 (2.3)	0.5 (0.8)	2.8 (1.1)	2.2 (1.4)
Cyperaceae	6.7 (2.5)	2.5 (7.3)	5.0 (1.8)	4.4 (1.2)	9.4 (3.9)	3.5 (1.9)	5.9 (1.4)	5.6 (2.7)
Danthonia spp.				0.2 (0.6)	0.3 (0.7)	0.4 (0.8)	0.7 (0.9)	
Festuca spp.	17.2 (7.1)	15.6 (4.6)	25.1(11.8)	32.2 (3.3)	31.5 (6.8)	39.1 (6.3)	28.9 (3.5)	39.8(12.5)
Helictotrichon hookeri						2.2 (0.8)		0.2 (0.6)
Koeleria cristata		0.2 (0.5)	0.4 (0.8)	1.9 (2.7)	2.6 (2.0)	3.9 (2.9)	3.6 (2.5)	4.5 (1.5)
Poa spp.	3.2 (1.9)	2.0 (0.2)	3.4 (3.9)	6.9 (2.9)	1.9 (1.2)	0.3 (0.6)	0.6 (1.0)	1.1 (1.9)
Stipa spp.	1.9 (0.1)	0.2 (0.7)	0.4 (0.8)	0.2 (0.6)	0.5 (1.1)	0.5 (1.1)	0.6 (1.0)	0.3 (0.9)
Trisetum spp.		0.2 (0.7)		0.5 (1.2)		0.2 (0.5)	0.2 (0.6)	
Unknown grass	5.3 (1.2)	3.3 (1.2)	4.5 (1.9)	5.0 (1.0)	5.8 (1.1)	4.9 (1.5)	6.4 (1.4)	4.8 (1.4)
Total grass	42.5(12.8)	29.8 (6.3)	48.8(17.7)	64.0 (8.2)	57.7(12.5)	66.7 (8.4)	67.6 (8.1)	75.2(13.3)
Achillea millefolium	1.3 (2.0)	1.3 (1.5)	0.2 (0.6)			0.2 (0.5)		
Androsace spp.	0.5 (0.9)	0.2 (0.7)	0.6 (1.3)	0.2 (0.5)	0.2 (0.5)	0.2 (0.6)	0.4 (1.3)	
Antennaria spp.	0.2 (0.6)	0.2 (0.6)	0.4 (0.8)	0.4 (1.2)				0.4 (1.3)
Arenaria spp.	0.6 (0.9)		0.2 (0.7)			0.2 (0.6)	0.2 (0.6)	0.2 (0.5)
Astragalus spp.	11.5 (5.5)	12.6 (4.4)	5.2 (3.7)	2.1 (1.9)	0.4 (1.1)	1.4 (1.2)	3.2 (3.4)	2.4 (2.6)
Boraginaceae				0.2 (0.5)				
Cerastium spp.	0.2 (0.6)	0.2 (0.7)					0.2 (0.6)	
Cirsium spp.	0.2 (0.7)							
Other Compositae	1.3 (1.5)	2.0 (2.5)	0.8 (1.4)	0.8 (1.3)	0.2 (0.5)	1.0 (1.1)	1.0 (1.5)	0.9 (2.3)
Cruciferae	9.8 (4.0)	1.1 (1.5)	3.4 (3.2)	0.5 (0.8)			0.4 (0.8)	0.6 (1.4)

Table 21. Concluded.

Plant Species	July 1982 Walling R.	Aug. 1982 Ear Mtn.	Oct. 1982 Walling R.	Oct. 1982 Ear Mtn.	Jan. 1983 Walling R.	Jan. 1983 Ear Mtn.	Ap. 1983 Walling R.	Ap. 1983 Ear Mtn.
Abies lasiocarpa				0.2 (0.5)			2.0 (1.8)	
Amelanchier alnifolia	0.2 (0.6)	0.2 (0.6)		0.4 (1.2)			0.2 (0.6)	
Artemisia frigida	0.4 (1.2)	0.7 (2.2)	2.5 (3.0)	0.6 (1.3)	1.4 (1.6)		1.1 (1.8)	9.8 (4.6)
Artemisia tridentata	0.4 (0.9)		0.6 (2.0)		0.9 (2.3)	14.5 (5.7)	2.5 (1.0)	1.4 (2.2)
Arctostaphylos uva-ursi			2.8 (3.0)	0.2 (0.6)				
Berberis repens	0.4 (0.8)	0.4 (0.9)	3.9 (4.9)	10.2 (6.3)			2.8 (3.6)	
Dryas octopetala							0.2 (0.6)	
Juniperus spp.		0.4 (0.8)					0.9 (1.5)	
Pinus spp.		2.7 (2.7)	2.6 (3.8)	1.3 (2.3)	0.7 (1.2)	2.4 (2.3)	4.7 (2.5)	1.0 (1.4)
Potentilla fruticosa	0.4 (1.2)	0.4 (1.4)					0.2 (0.7)	
Populus spp.	3.7 (3.5)	8.4 (2.5)	2.5 (3.0)	0.2 (0.6)	0.2 (0.5)		2.9 (2.3)	
Prunus virginiana			0.2 (0.6)				0.2 (0.7)	
Pseudotsuga menziesii		0.2 (0.6)	0.8 (1.7)	1.1 (1.8)				
Ribes spp.		0.4 (0.9)		0.2 (0.7)				
Rosa spp.			0.2 (0.6)	0.3 (0.7)				
Salix spp.			0.4 (0.8)					
Shepurdia canadensis	1.4 (2.3)	12.1 (6.3)	4.8(14.6)	4.0 (3.1)				
Symphoricarpos spp.		0.8 (1.3)		0.2 (0.5)	0.2 (0.5)			
Unknown browse	1.4 (1.7)	7.2 (2.0)	2.6 (1.7)	2.9 (2.0)	1.2 (1.2)	1.5 (0.9)	2.4 (1.9)	1.0 (1.4)
Total browse	9.4 (3.5)	33.9 (8.0)	24.7(19.7)	21.8 (7.9)	3.6 (1.8)	18.2 (7.0)	16.0 (7.9)	13.1 (6.4)
Selaginella densa					0.2 (0.5)	0.1 (0.4)		

Table 22. Key to 4-letter plant species abbreviations.

Abbreviation	Scientific name	Common name
Abla	Abies lasiocarpa	alpine fir
Agsp	Agropyron spicatum	bluebunch wheatgrass
Arco	Arnica cordifolia	heartleaf arnica
Artr	Artemesia tridentata	big sagebrush
Aruv	Arctostaphylos uva-ursi	kinnikinnick
Cage	Carex geyeri	elk sedge
Caru	Calamagrostis rubescens	pinegrass
Clps	Clematis pseudoalpina	alpine clematis
Feid	Festuca idahoensis	Idaho fescue
Fesc	Festuca scabrella	rough fescue
Gatr	Gallium triflorum	fragrant bedstraw
Pien	Picea engelmanii	Engelmann spruce
Pifl	Pinus flexilis	limber pine
Pofr	Potentilla fruticosa	shrubby cinquefoil
Psme	Pseudotsuga menziesii	Douglas fir
Spbe	Spirea betulifolia	white spiraea
Syal	Symphoricarpos albus	common snowberry

APPENDIX B

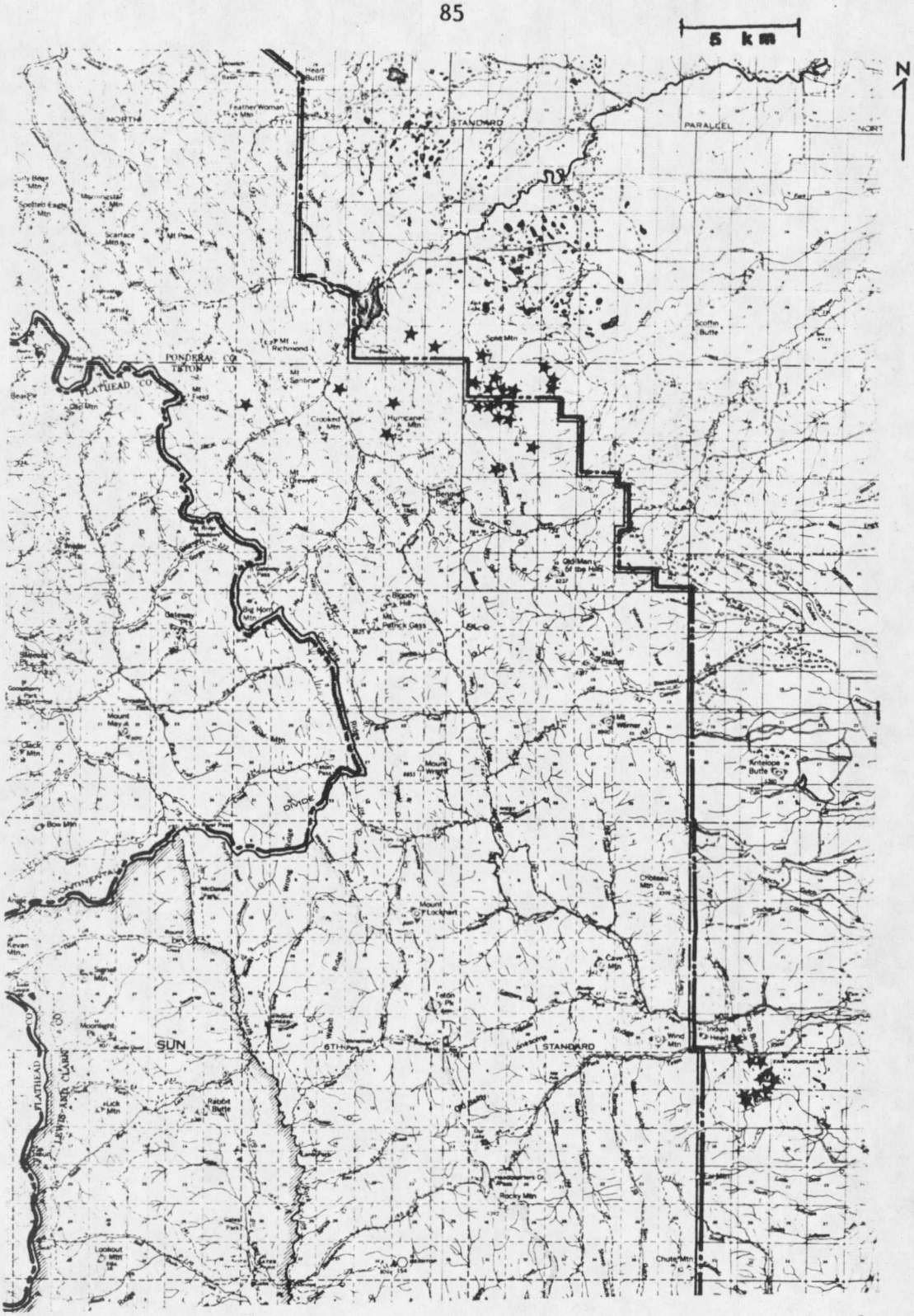


Fig. 4. Bighorn sheep radio and neckband relocations during April-June, 1982 and April, 1983.

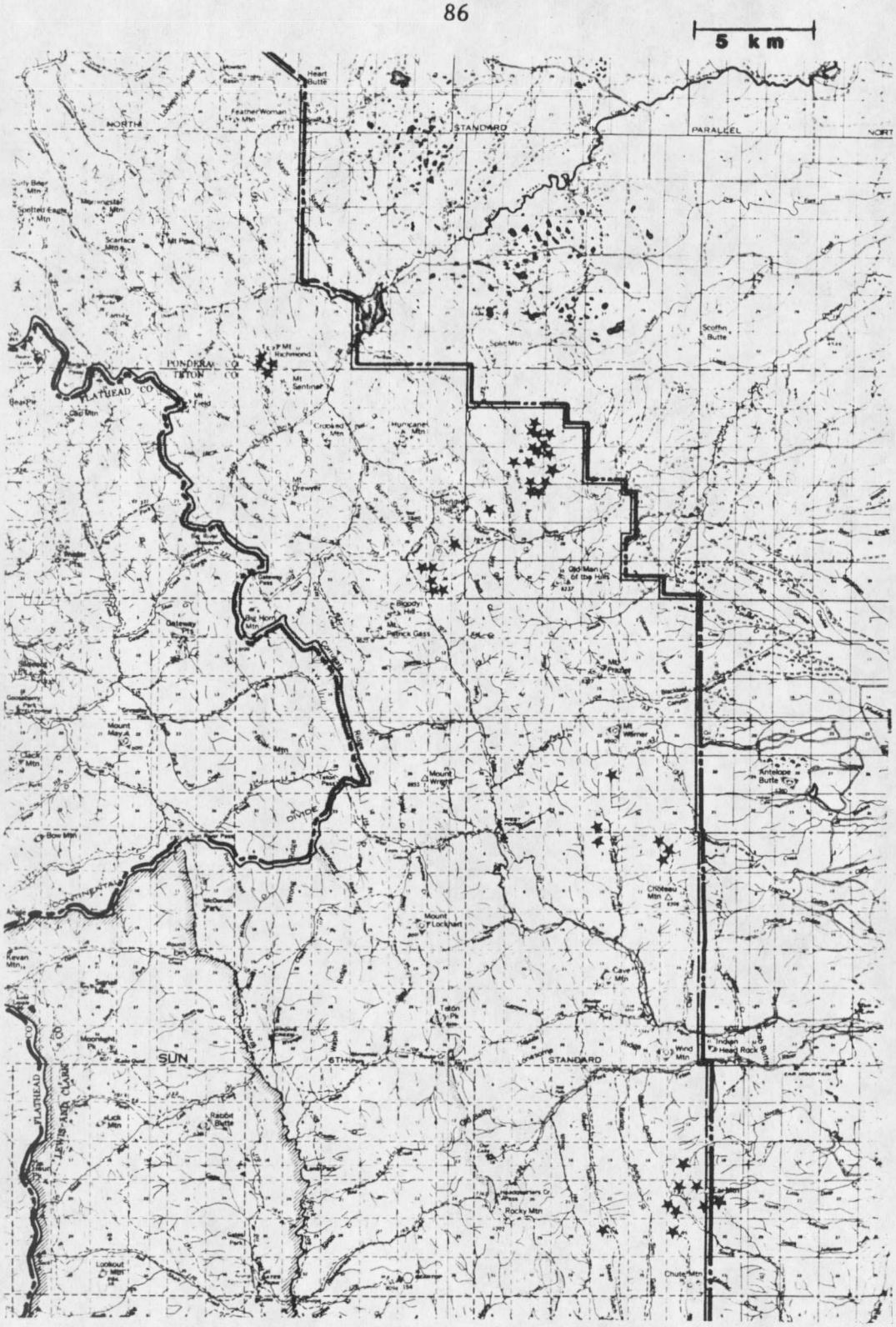


Fig. 5. Bighorn sheep radio and neckband relocations during July-August, 1982.

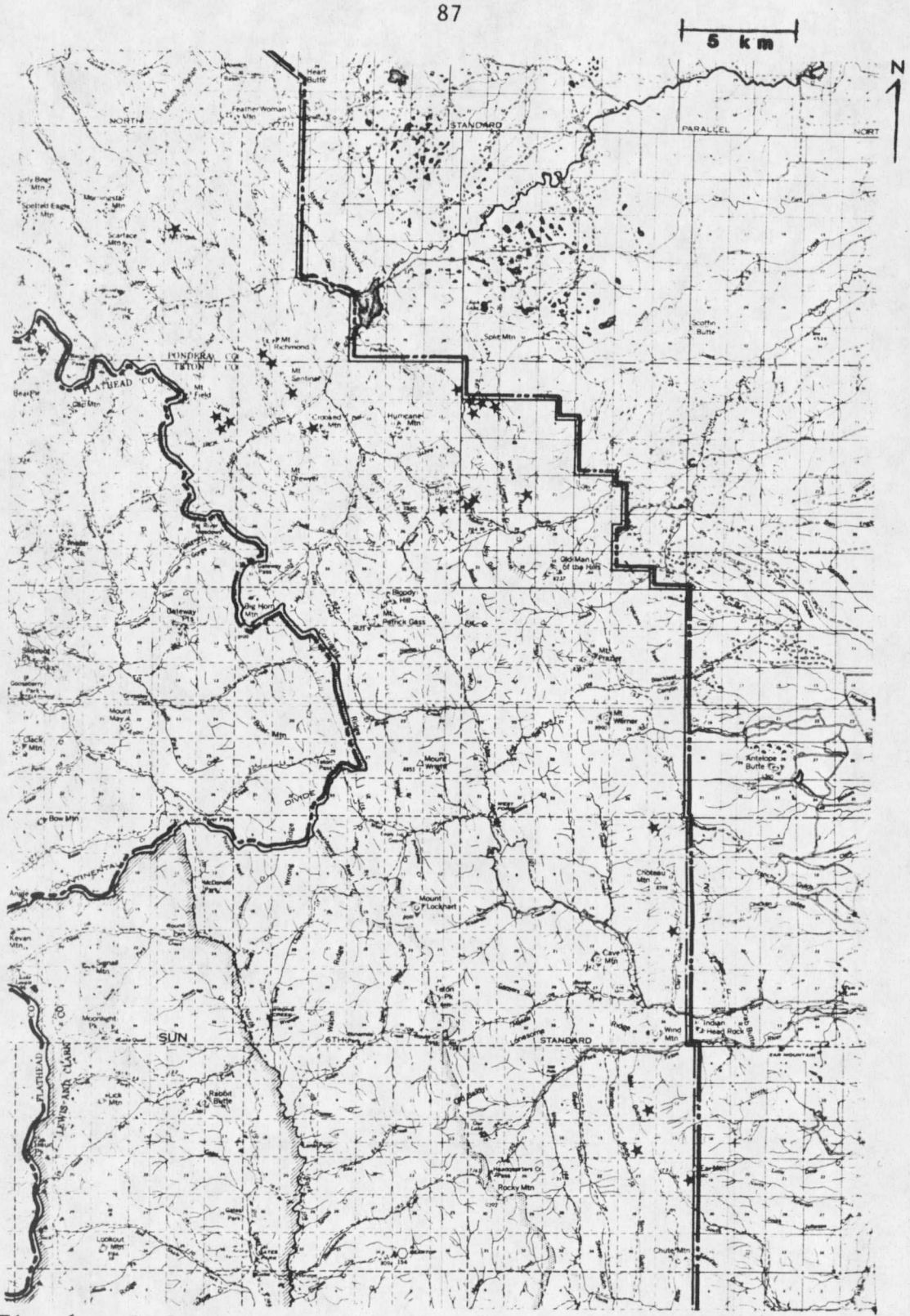


Fig. 6. Bighorn sheep radio and neckband relocations during September-November, 1982.

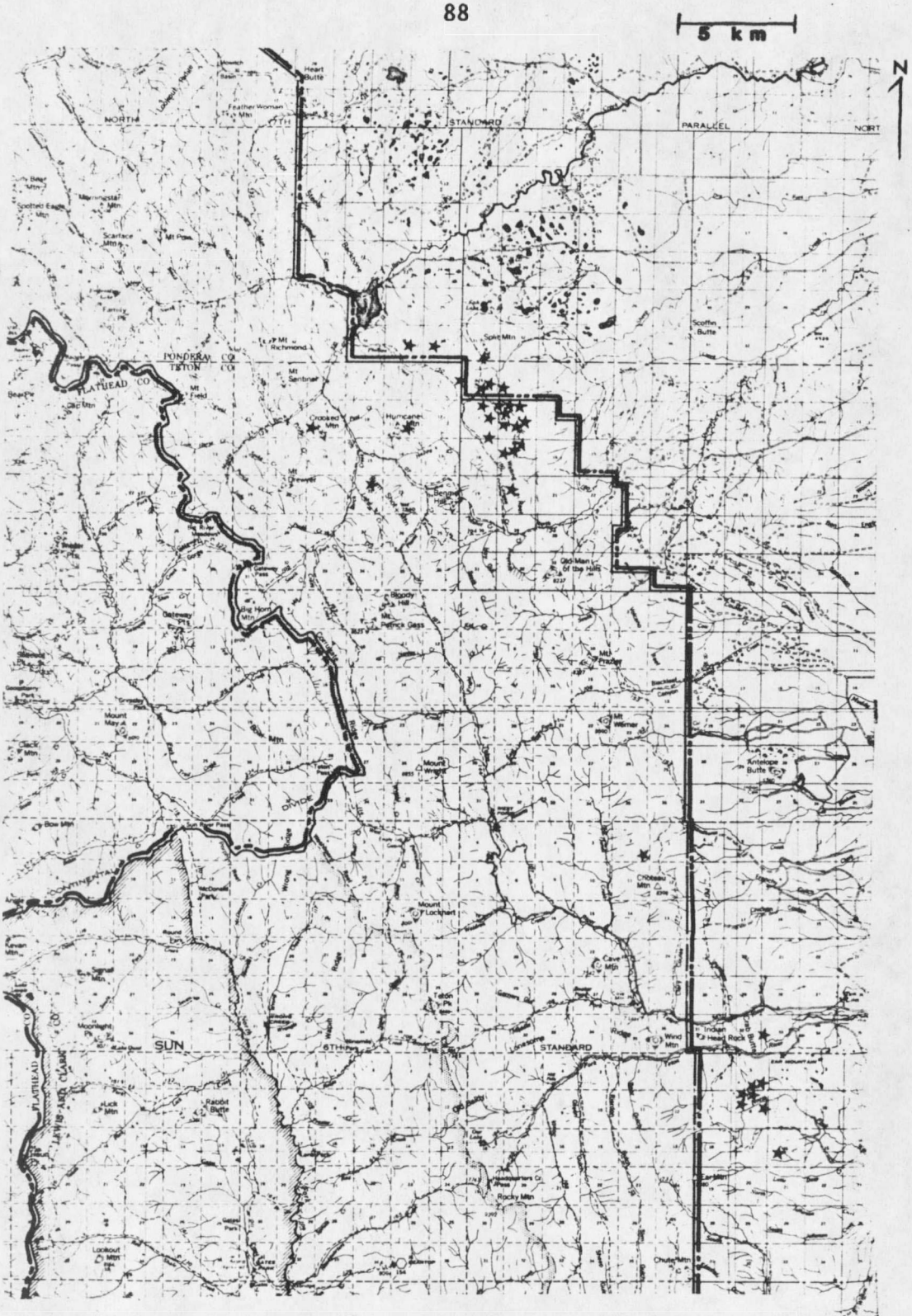


Fig. 7. Bighorn sheep radio and neckband relocations during December, 1982-March 1983.

APPENDIX C

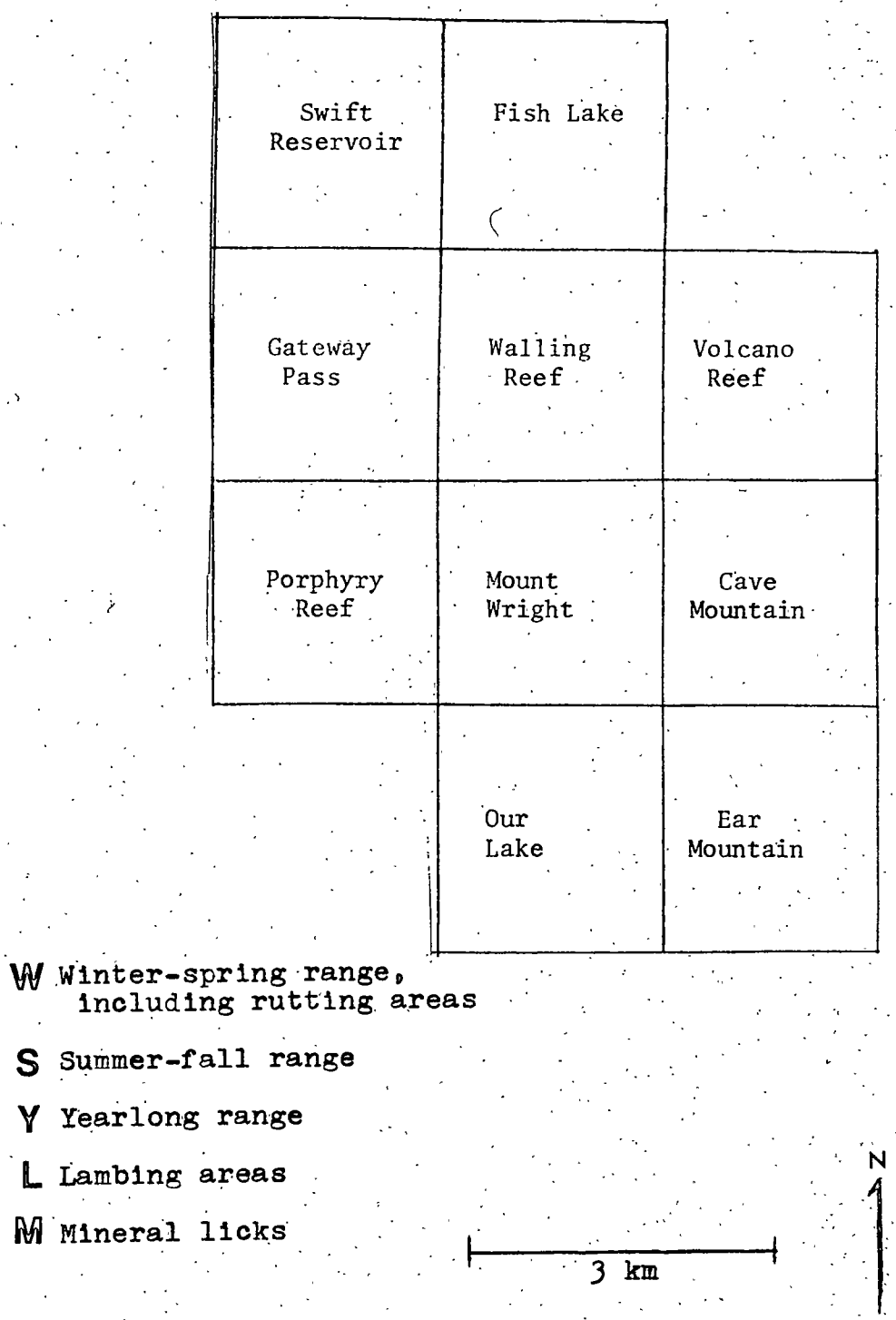


Fig. 8. Key to topographic maps of bighorn sheep seasonal use areas in the East Front study area during 1981-1983.

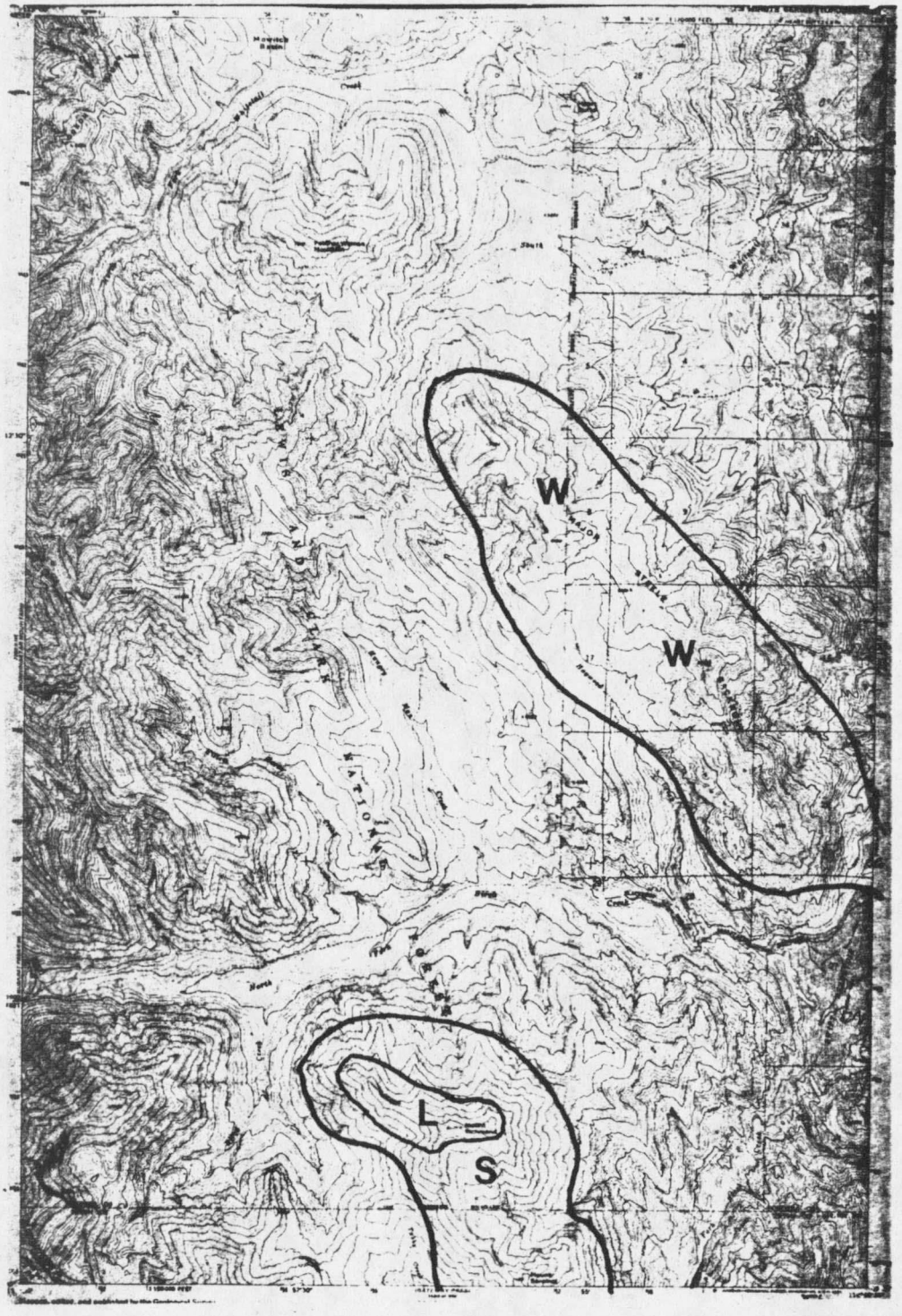


Fig. 9. Bighorn sheep seasonal use areas on the East Front-Swift Reservoir during 1981-1983.

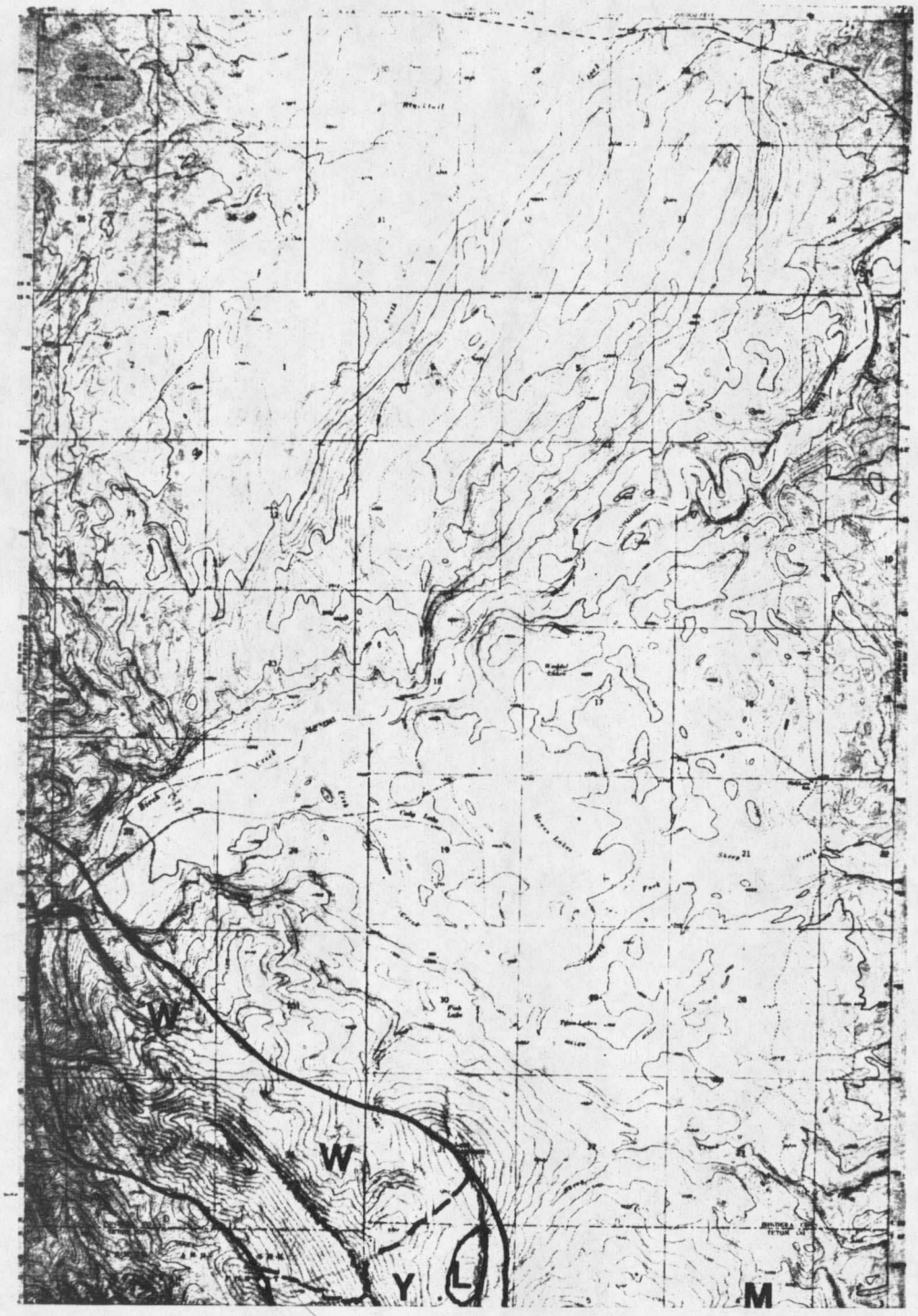


Fig. 10. Bighorn sheep seasonal use areas on the East Front-Fish Lake during 1981-1983.



Fig. 11. Bighorn sheep seasonal use areas on the East Front-Gateway pass during 1981-1983.

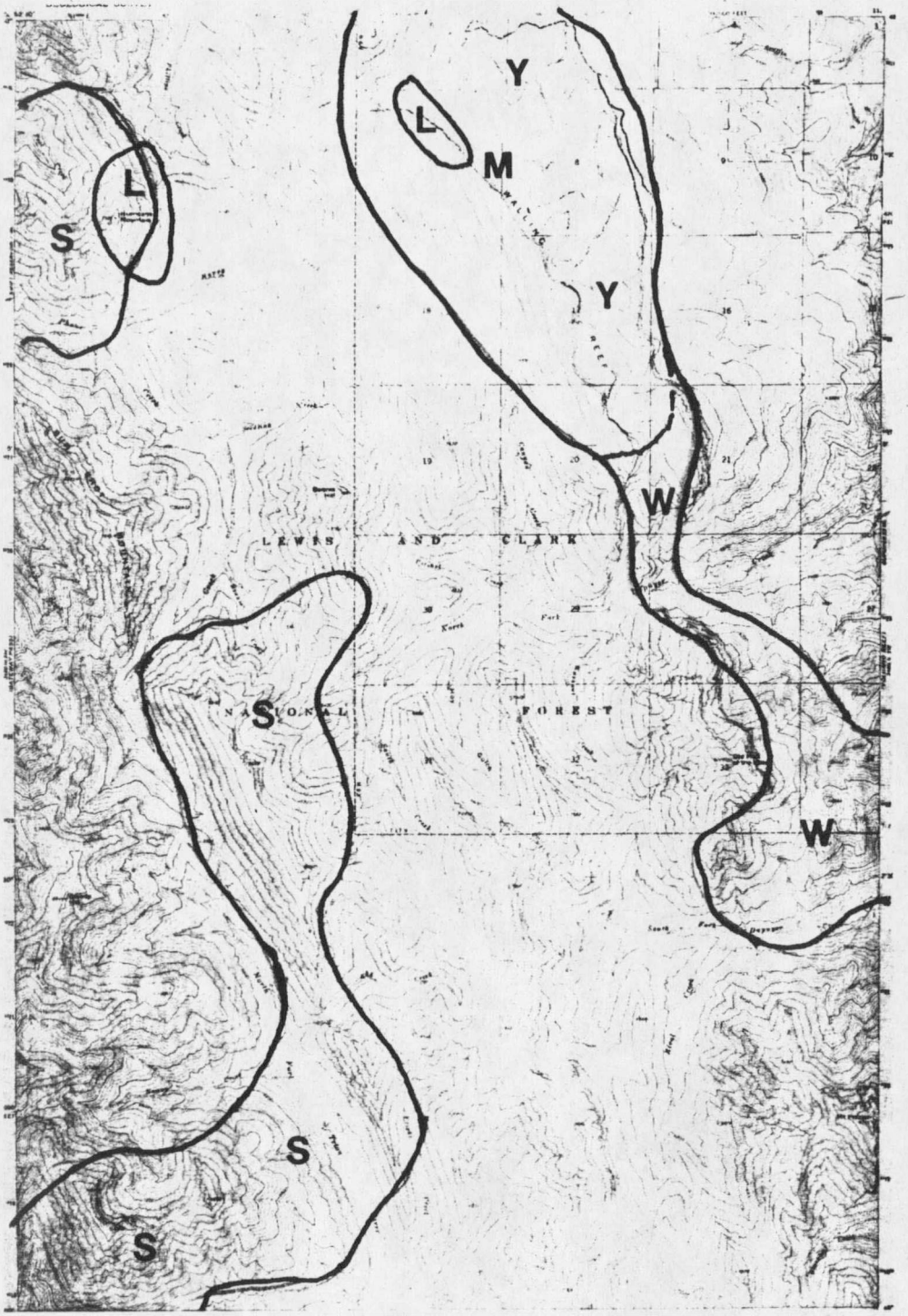


Fig. 12. Bighorn sheep seasonal use areas on the East Front-Walling Reef during 1982-1983.

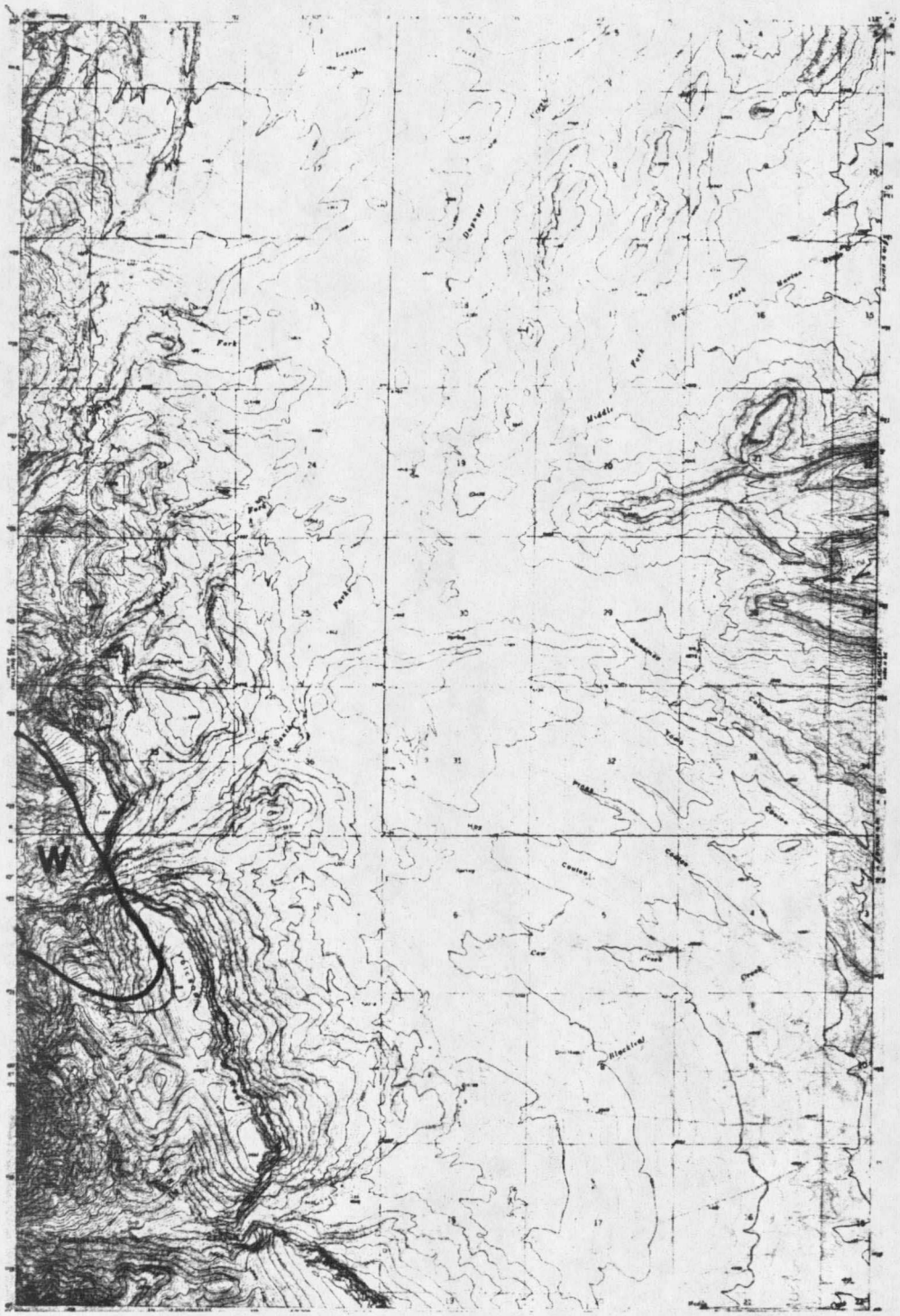


Fig. 13. Bighorn sheep seasonal use areas on the East Front-Volcano Reef during 1981-1983.

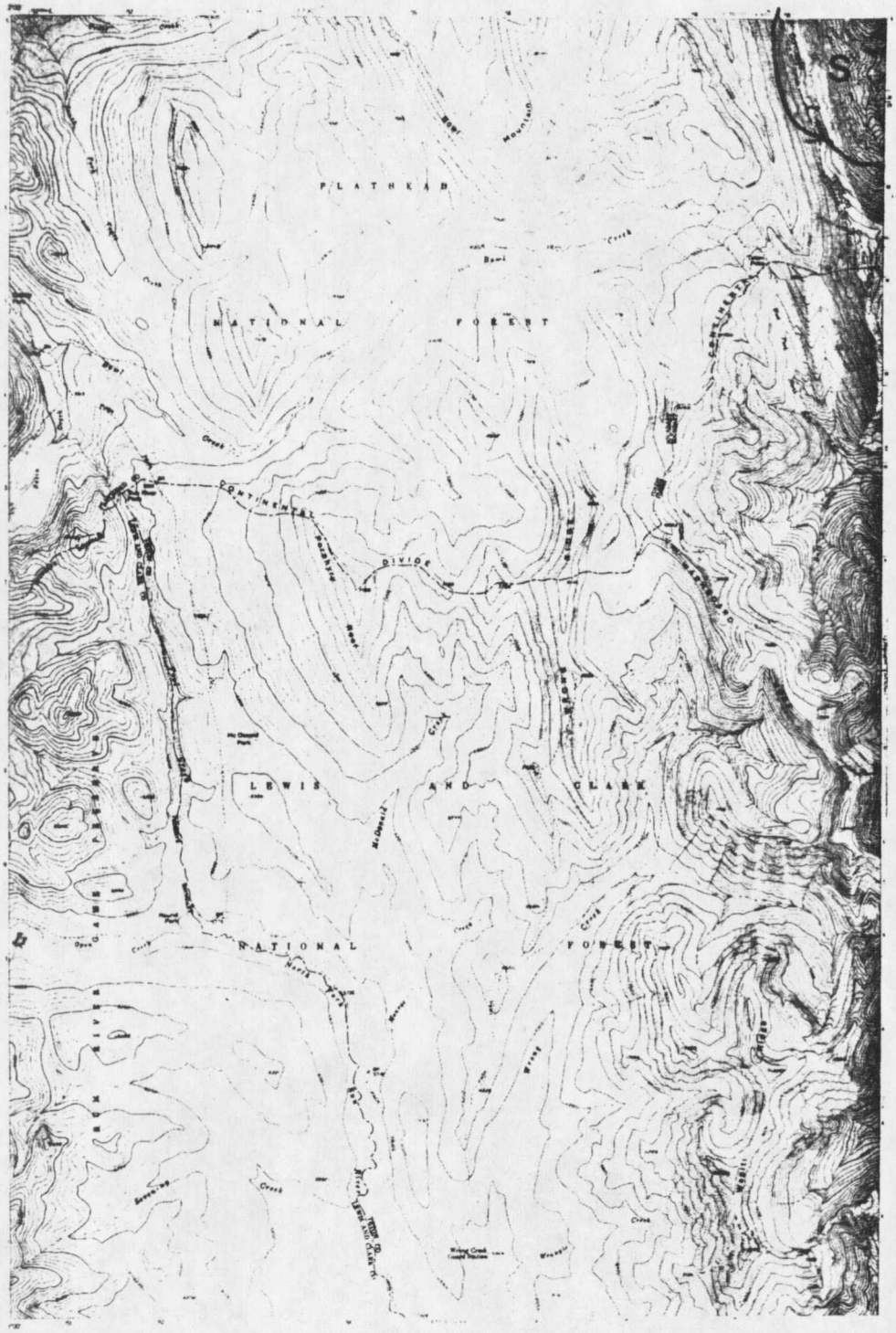


Fig. 14. Bighorn sheep seasonal use areas on the East Front-Porphyry Reef during 1981-1983.

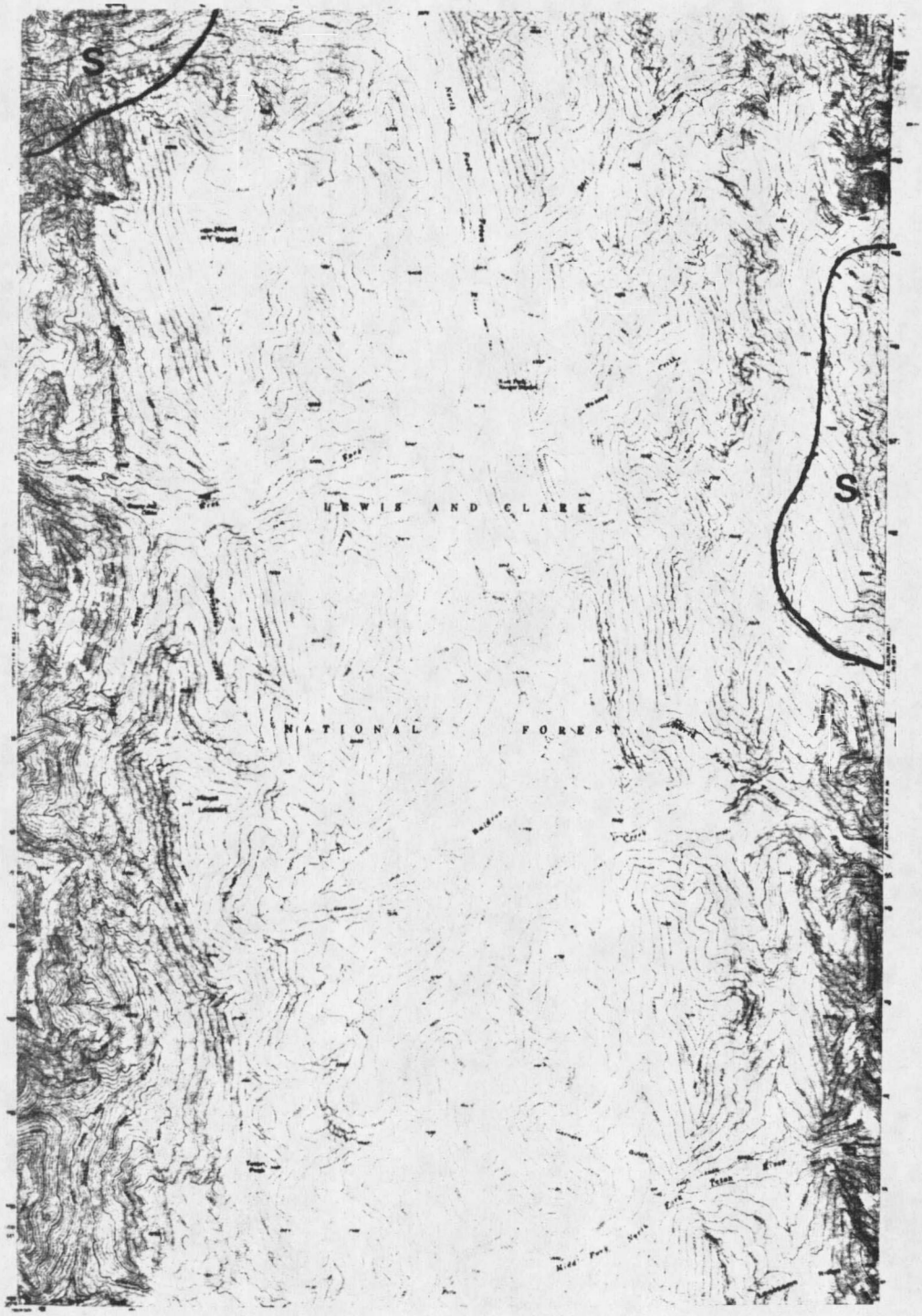


Fig. 15. Bighorn sheep seasonal use areas on the East Front-Mount Wright during 1981-1983.

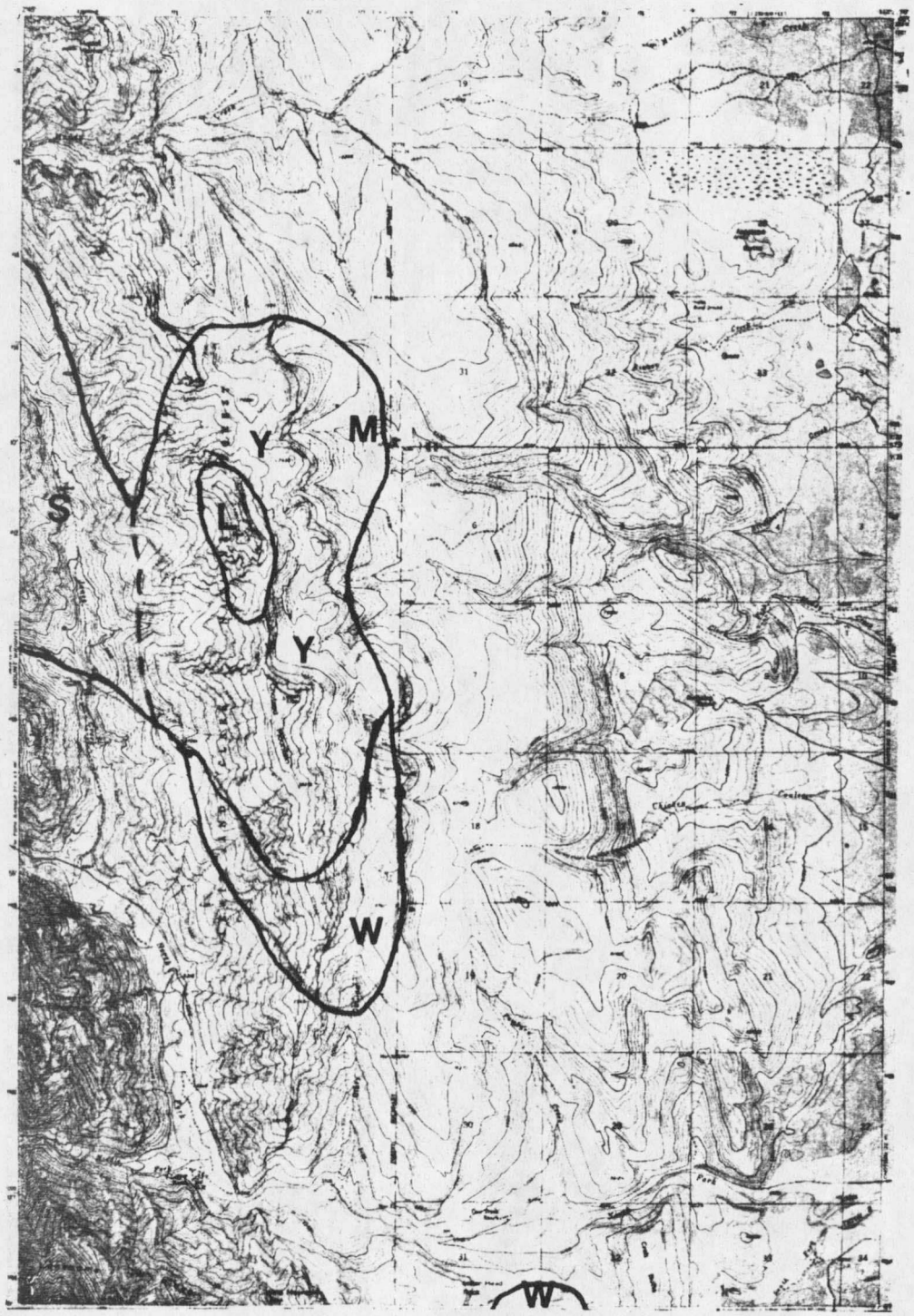


Fig. 16. Bighorn sheep seasonal use areas on the East Front-Cave Mountain during 1981-1983.



Fig. 17. Bighorn sheep seasonal use areas on the East Front-Our Lake during 1981-1983.

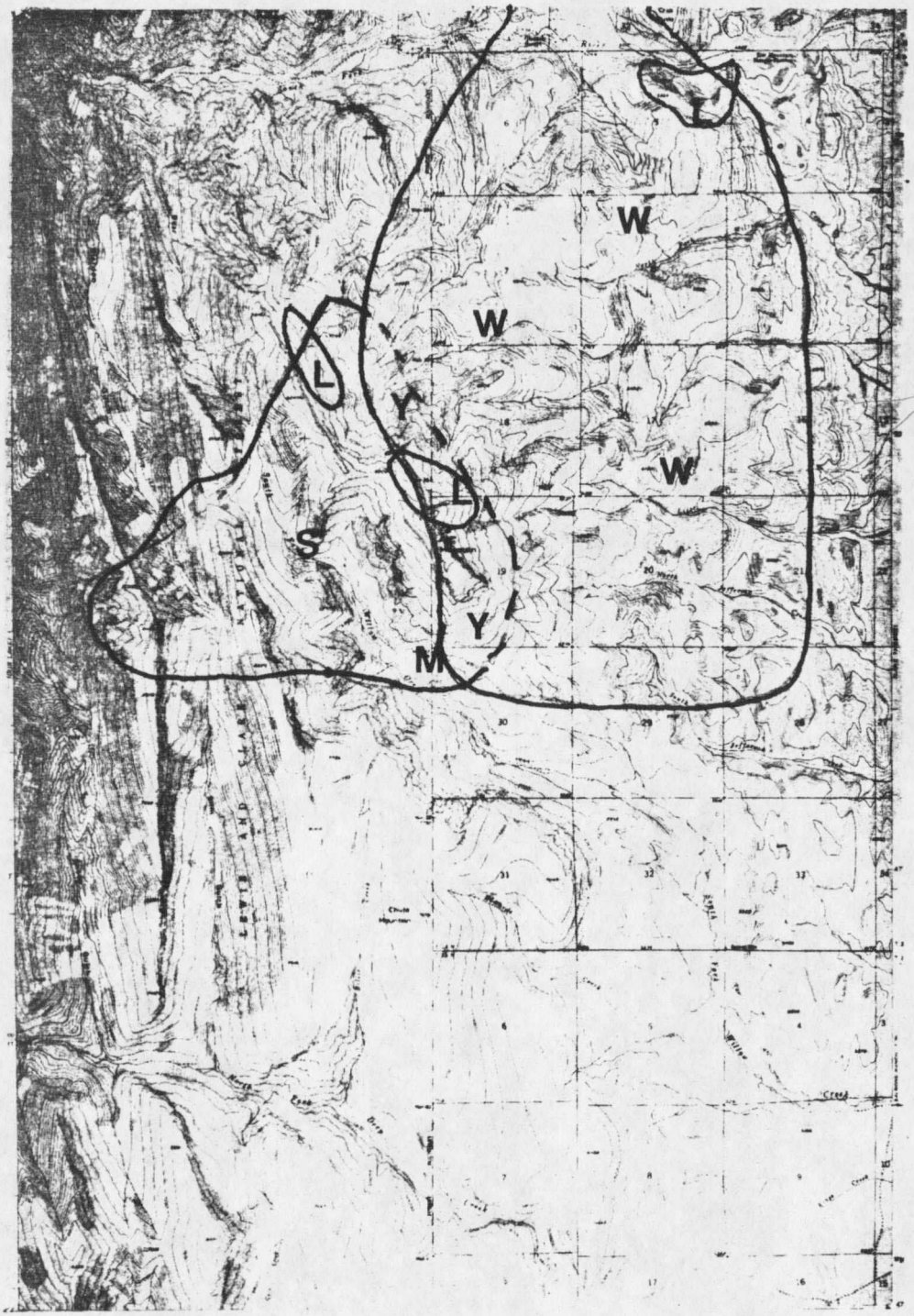


Fig. 18. Bighorn sheep seasonal use areas on the East Front-Ear Mountain during 1981-1983.

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