Bienn. Symp. North. Wild Sheep
and Goat Counc. 9:131-138.

SUMMER-FALL HABITAT USE AND FALL DIETS OF MOUNTAIN GOATS AND BIGHORN SHEEP IN THE ABSAROKA RANGE, MONTANA

NATHAN C. VARLEY, Department of Biology, Montana State University, Bozeman, MT 59717

Abstract: A three year study (1991 to 1993) of mountain goat (*Oreamnos americanus*) ecology was conducted in the Absaroka Range of Montana, Wyoming, and Yellowstone National Park. Data on habitat-use and food habits of goats and bighorn sheep (*Ovis canadensis canadensis*) are presented here. Summer and early fall habitat use by mountain goats and bighorn sheep were dissimilar. Feeding sites for goats tended to be rocky, steep, and sparsely vegetated while sheep feeding sites tended to be open, moderately sloping, and continuously vegetated. Behavioral feeding strategies for the two species also differed. Six observations of interspecific interactions were made during the study. Diets of mountain goats and bighorn sheep were similar and consisted primarily of grasses and sedges. Forage taxa contributed to fall food habits in approximate proportion to their abundance as estimated from taxa frequency and canopy coverage data collected at representative habitat-types.

Mountain goats have been introduced successfully into several mountain ranges in western North America (Johnson 1977). In the Absaroka range of southwest Montana, mountain goats were successfully introduced in 1956 (Swenson 1985). Emigrants from this expanding population have been sighted recently in the Absarokas of northeastern Yellowstone N. P. and Wyoming. Evidence for goats being a member of Yellowstone's Holocene faunal community is lacking; therefore, they are considered exotic by the National Park Service. Determining the ecological effects of mountain goats in Yellowstone is important to their management.

Exotic species may cause impact to native communities (Berger 1991). For instance, mountain goats in Olympic National Park had a detrimental affect on vegetation communities and endemic plants (Pike 1981, Pfitsch and Bliss 1985). Despite being sympatric during their evolution, the introduction of goats to native sheep habitats in western states has evoked questions about potential competition between the two species (Adams et al. 1982).

This study describes summer/fall ecological relationships of mountain goats and bighorn sheep in the Absaroka Range. The data presented include: (1) terrain and vegetation characteristics of goat and sheep feeding sites, (2) fall goat diet for comparison with sheep diet, (3) feeding behavioral strategies of both species, and (4) interspecific interactions observed.

STUDY AREA

The 260 km^2 study area is located in the northern Absaroka Range of southwest Montana and northwest Wyoming. Elevations range from timberline at 2,550 m to 3,313 m, the highest point, on Amphitheater Mountain. Lacking large plateaus, the range is characterized by narrow, abrupt ridges separated by forested drainages. Parent material is primarily the Eocene Absaroka Volcanic Supergroup (Decker 1990). Bedrock is of two primary types: volcanic breccia and lava flows. Steep cliffs and scree slopes are common on northern and eastern exposures. Gradually-sloping northern and western aspects accumulate more soil and support alpine turf communities. Dry, southern slopes have shallow soils and are sparsely vegetated.

METHODS

Ground surveys of the study area were conducted during five 30-day periods from May 15 through October 15, 1991-1993 to document habitat-use by goats and sheep. Prospective goat feeding sites were searched by research teams and observations were made with the aid of 7 x binoculars and a 20x-60x spotting scope.

Habitat-type occupied, time spent in each type, and distance traveled were recorded for feeding goats and sheep. Habitat-types were classified

based on terrain, vegetation, and soil characteristics within a 10-meter radius of the subject animal. Four physical characteristics of feeding site selection also were recorded from 7.5" U.S.G.S. topographic maps: slope, aspect, elevation, and distance to escape terrain. Vegetation in three habitat-types used frequently by feeding mountain goats was examined. Percent canopy coverage and frequency were estimated visually for plant species in 2 X 5 decimeter plot frames spaced at one meter intervals along a 20-40 meter line transect (Daubenmire 1959).

In 1992, 22 goat hunters successful in drawing permits in the study area were asked to provide one-quart rumen samples from their harvested animal. Rumen sample analysis (Korschgen 1980) was used to determine fall food habits. No adjustments for differential digestibility were made. Mean percent occurrence of forage taxa in rumen samples and mean percent canopy coverage of forage taxa from plot transects were compared using Spearman's rank-correlation.

Four distinct bighorn sheep herds migrate to summer ranges in the Absarokas from winter ranges in the Beartooth Range and Yellowstone Park. Sheep arrived on the Absaroka summer range in mid-June having already lambed in transitional ranges (Stewart 1975, Martin 1985). Data for groups of ewes, lambs, and juveniles were collected (few adult rams were encountered).

Interspecific interactions were recorded when sheep and goats were observed within 20 m of each other. Each interaction fit into one of four descriptive categories based on whether or not interference competition (Miller 1967) was observed: sheep-dominated, goat-dominated, mutual tolerance, or ambiguous outcome.

RESULTS

Mountain Goats

Goats primarily fed on young plant tissue which grew throughout the summer following receding snow. Goats were observed using various habitats on all aspects depending on snow-melt and plant growth stages (Tables 1 and 2). In the spring, goats fed in snow-free habitats on south aspects. As the summer progressed, goats pursued receding snow lines and the emergence of young, succulent vegetation to habitats on west aspects. By late summer and early fall goats used north and east aspects where steep, shaded ledges harbored melting snow.

Goats fed individually or in small groups ($\bar{x}$ = 5.6±8, 1-47) within or nearby steep, rocky escape cover during all periods (Figure 1). Forty-six percent of all observations of feeding mountain goats were within escape terrain (Figure 2). Mean slope and mean elevation of feeding habitats was 33 degrees (19-63) and 3562 (2925-3836) m, respectively.

While feeding, goats often traveled substantial distances before arriving at bedding sites. They typically traversed a variety of habitats pausing no more than a few minutes to graze any particular site. A mean of 2.9±1.9 habitat-types were used per hour of uninterrupted feeding.

Seven of 15 successful hunters returned rumen samples. Analysis of rumen samples collected from 9-15-92 to 10-6-92 indicated predominant use of graminoid species (76%) in the fall (Table 3). Forbs were second in importance (20%), while a combination of browse and lichens made up the remaining portion of the diet. Spearman's rank-correlation between mean canopy coverage of forage taxa in the three habitat types examined and mean percent occurrence in rumen samples was 0.45 (P< 0.05) suggesting forage selection is proportional to abundance. Spearman's rank-correlation between graminoid species canopy coverage and mean percent occurrence of those species in rumen samples was 0.83 (P<0.01) suggesting graminoid use in the fall diet is proportional to abundance. No discernible association between use of forb taxa and their availability was detected using the rank-correlation test statistic (-0.09 (p < 0.80)).

Bighorn Sheep

From mid-June through September, sheep fed in large groups ($\bar{x}$ = 11.5 ±9, 2-42) in open alpine and timberline meadows. By late September, smaller groups fed in timberline meadows and patches of sparsely vegetated dirt-scree and talus. Bighorn sheep and mountain goats were observed using different aspects (P<0.0001) and habitats (P<0.001) during all five periods (Tables 1 and 2).

Distance to escape terrain was greater for feeding sheep than goats (P<0.001). The average slope of sheep feeding sites was 24 degrees (12-39). The mean elevation of sheep feeding sites was 3429 meters (2960-3868), 133 meters less than goats (t=4.34, P<0.001).

In contrast to goats, sheep tended to concentrate feeding on one site per feeding period.

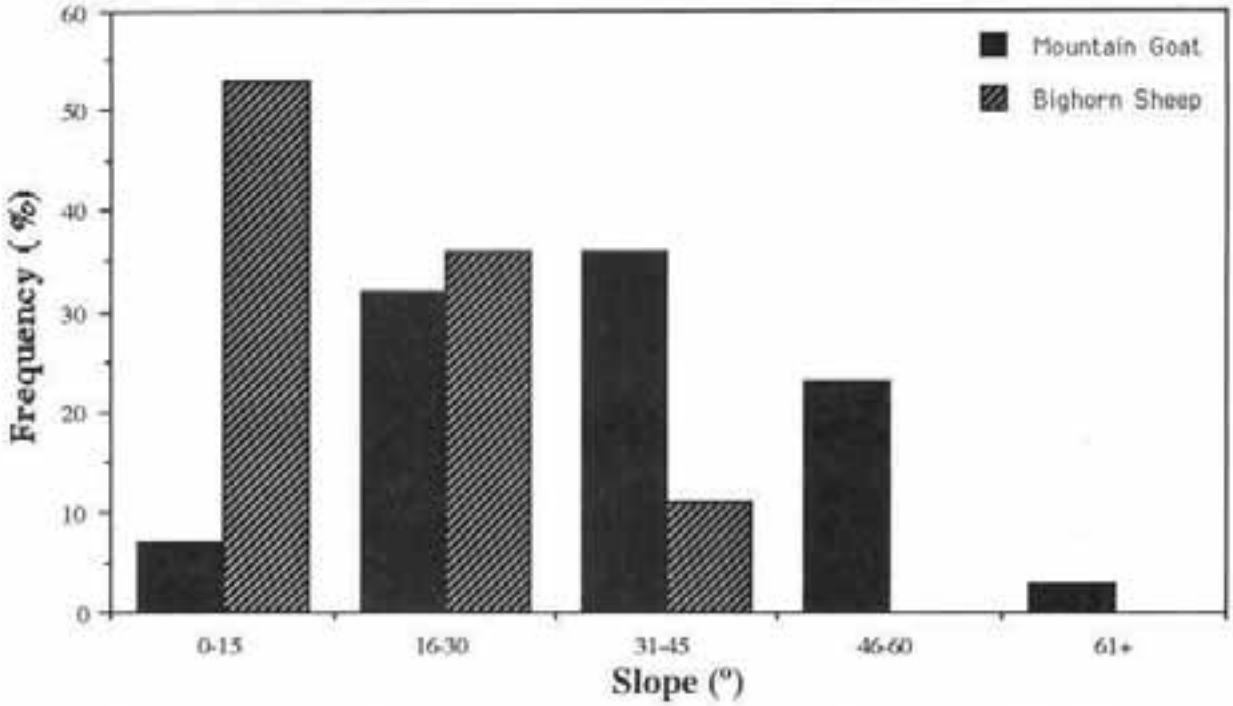

Figure 1. Use of slope by feeding mountain goats and sheep in the Absarokas, 1991-1993.

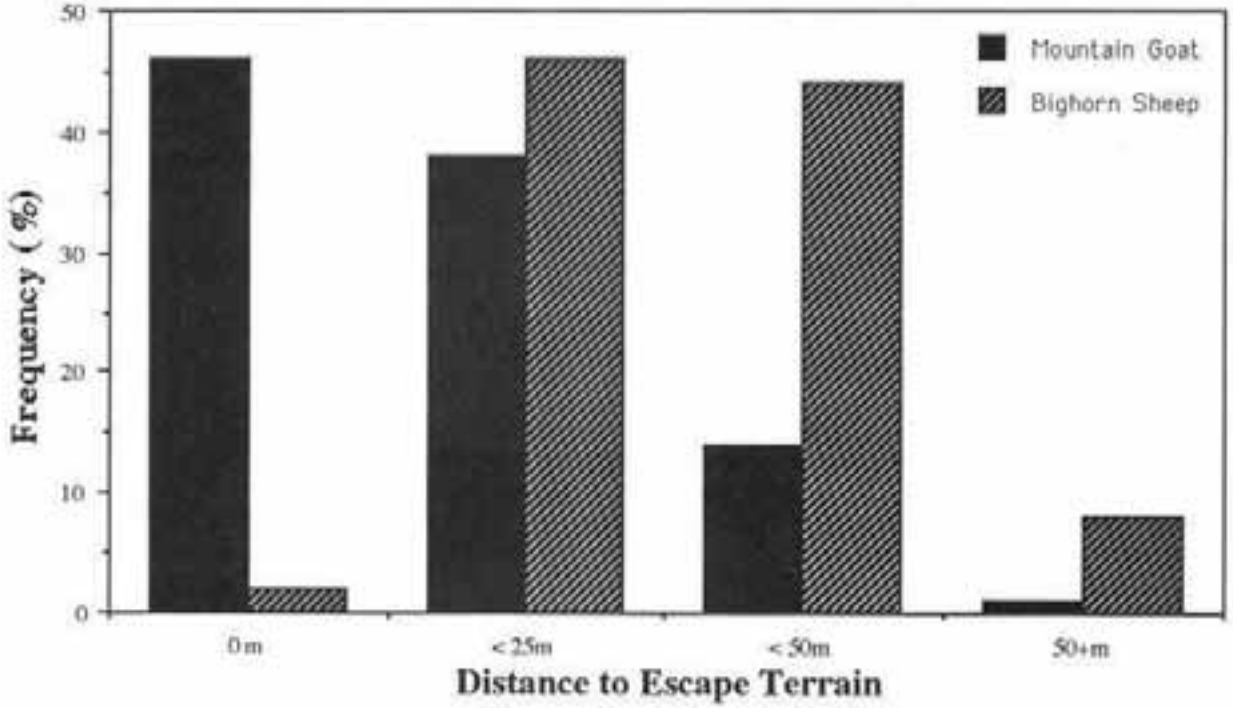

Figure 2. Association with escape terrain by feeding mountain goats and sheep in the Absarokas, 1991-1993.

Table 1. Habitat use[a] by feeding mountain goats and sheep in the Absarokas, 1991-1993.

	n	Ledge	R. scree	S. scree	T. scree	Turf	S.alpine	Talus
May-June								
Goats	48	12 (20)[b]	9 (19)	7 (15)	4 (8)	7 (15)	7 (15)	1 (2)
June-July								
Goats	40	10 (25)	10 (25)	7 (18)	5 (12)	5 (12)	2 (6)	1 (2)
Sheep	36	0 (0)	3 (8)	5 (14)	6 (17)	15 (42)	7 (19)	0 (0)
July-Aug.								
Goats	74	23 (32)	20 (27)	6 (8)	9 (12)	9 (12)	6 (8)	1 (1)
Sheep	34	0 (0)	2 (6)	2 (6)	5 (22)	14 (40)	8 (22)	0 (0)
Aug.-Sept.								
Goats	68	25 (37)	17 (25)	6 (9)	8 (12)	6 (9)	5 (7)	1 (1)
Sheep	28	1 (3)	2 (7)	3 (10)	5 (18)	10 (36)	7 (26)	0 (0)
Sept.-Oct.								
Goats	62	19 (31)	14 (22)	7 (12)	5 (8)	6 (10)	9 (14)	2 (3)
Sheep	29	0 (0)	1 (4)	4 (14)	7 (24)	10 (34)	7 (24)	0 (0)

[a] Types include ledge, rocky scree, sandy scree, turf scree, turf, subalpine, and talus.
[b] Number of observations (percent of total).

Table 2. Aspect use by feeding mountain goats and sheep in the Absarokas, 1991-1993.

	n	N	NE	E	NW	W	SW	SE	S
May-June									
Goats	48	5(10)[a]	2 (4)	2 (4)	5 (10)	6 (13)	8 (16)	9 (18)	11(23)
June-July									
Goats	40	8 (21)	3 (7)	3 (7)	6 (15)	5 (13)	5 (13)	4 (11)	6 (15)
Sheep	36	2 (7)	0 (0)	0 (0)	1 (2)	8 (27)	9 (32)	2 (7)	7 (25)
July-Aug.									
Goats	73	19(26)	10(14)	15(20)	9 (13)	8(11)	5(7)	4(5)	3(4)
Sheep	36	1 (2)	1(2)	0(0)	2 (5)	8 (22)	7 (19)	3 (10)	14(40)
Aug.-Sept.									
Goats	68	23(34)	11(16)	16(23)	11(16)	4 (6)	1 (2)	0 (0)	2 (4)
Sheep	28	3 (12)	1 (3)	1 (3)	4 (13)	10(35)	3 (12)	1 (3)	5 (19)
Sept.-Oct.									
Goats	62	15(24)	11(18)	12(20)	15(24)	7 (12)	0 (0)	1 (2)	0 (0)
Sheep	29	2 (5)	0 (0)	0 (0)	1 (2)	8 (27)	9 (32)	2 (7)	7 (25)

[a] Number of observations (percent of total).

Mean number of habitat-types per hour of feeding was 1.5 ± 0.7 and less than for goats (t=3.29, P<0.01). Sheep herds intensively grazed one site per feeding bout and directional movements were not observed to the same extent as goats.

Interspecific Interactions

Only six observations of goat-sheep interactions were made, and of these five were neutral. The sixth concerned a group of 11 sheep feeding within 20 m of 7 bedded goats. When the author appeared, ten sheep fled leaving one adult ewe and the goats who appeared unconcerned. Attempting to escape to ledge areas, the ewe was blocked by the bedded goats. The ewe approached to within 10 meters of the author in order to access an alternate escape route. Although goats seemed to prevent use of the escape route, this observation was influenced by the observer and was ambiguous.

DISCUSSION

Feeding site selection and behavioral strategies for the two species were dissimilar. Mountain goats fed on steep, sparsely vegetated sites during all observation periods. Feeding sites were often rocky and closely associated with melting snow. Generally, goats fed individually or in small groups and traveled substantial distances before stopping. Chadwick (1974) described this behavior as "trail feeding" and noted it was greatest in the summer and did not vary until winter when snow prevented long movements and thus, restricted feeding to particular sites.

Bighorn sheep generally fed in large groups in open, moderately sloping, alpine or timberline meadows. While sheep were observed in ledge habitats, they rarely fed at these sites. Sheep seemed to be attracted by the relatively high biomass of turf communities, where they relied on large group size and the visual radius of their feeding sites to detect predators (Shannon et al. 1975, Adams et al. 1982). In contrast to goats, sheep tended to concentrate their feeding on one site.

Seasonal changes in aspect, elevation, and habitat use in response to early growth has been reported in other mountain goat studies (Hjeljord 1973, Smith 1976). In this study, goats consistently used sites with early-growth vegetation. By closely following receding snows and foraging on the subsequent "green-up", goats used all habitat types on all aspects during the five observation periods. Phenologically similar sites were available throughout the growing season because snow melted more slowly on steep, northern and eastern aspects. In contrast, sheep used drier sites where vegetation was more abundant and mature relative to that selected by goats. By using wet sites predominantly, goats avoided temporal overlap with sheep that, in some instances, used the same sites later in the season.

Martin (1985) determined fall diet for sheep on Absaroka summer range by microhistological analysis of fecal droppings (Table 3). Sheep used grasses predominantly (74%) while forbs were second in importance (16%). Sheep also used browse (10%), mainly willow (*Salix* spp). Sheep diets were similar to those found for mountain goats in this study. Both species' diet primarily consisted of common graminoids, particularly sedges (*Carex* spp.). The 5 forage taxa with the highest mean canopy-coverage composed greater than half of both species' fall diets suggesting both species are generalists and feed on the most abundant forage available during the fall. The use of uncommon forage taxa was not detected in either species' diet.

With few exceptions, sheep and goats foraged on different forbs. Sheep used more browse and less lichen than goats. Dissimilarities in the two diets may reflect feeding site selection differences. For instance, goats fed on rushes (*Juncus* spp.) which were abundant in wet, shaded areas like ledges and steep avalanche chutes. Also, sheep browsed willow which primarily grew along drainages in gently-sloping meadows.

Neither species was observed using mineral licks. Martin (1985) did not observe sheep using mineral licks on the Absarokas summer range as well. The alkaline rock types of the Absarokas are characterized by relatively high potassium and/or sodium content (Decker 1990); therefore, mineral sources may be abundantly dispersed throughout the range, rather than concentrated in particular sites. Forage growing in the volcanic soils may also provide minerals.

Competition would occur if the two species were utilizing some environmental resource in short supply; however, feeding behavioral strategies and site selection differences minimized this possibility during the growing season. The contrasting patterns described here are indicative of niche divergence that would be expected given the two species' extensively overlapping distribution and evolutionary history in North America.

The potential for competition between sympatric

sheep and goats is likely greater during winter when resources are more limited (Adams et al. 1982). Mountain goats do not occupy sheep winter ranges in Yellowstone Park at present. However, wintering areas for the Beartooth Mountains' goat population overlap with those for some sheep herds that migrate from the Absaroka summer range. Investigating the relationship between the two species on this winter range would be valuable in further addressing the question of competition between native bighorn sheep and introduced mountain goats.

LITERATURE CITED

ADAMS, L. G., K. L. RISENHOOVER., AND J. A. BAILEY. 1982. Ecological relationships of mountain goats and Rocky Mountain bighorn sheep. Bienn. Symp. North. Wild Sheep and Goat Counc. 3:9-22.

BERGER, J. 1991. Greater Yellowstone's native ungulates: myths and realities. Conser. Biol. 5:353-363.

CHADWICK, D. H. 1974. Mountain goat ecology-logging relationships in the Bunker Creek Drainage of Western Montana. M.S. Thesis. Univ. Montana, Missoula. 262pp.

DAUBENMIRE, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-61.

DECKER, P. L. 1990. Style and mechanics of liquefaction-related deformation: lower Absaroka volcanic supergroup (Eocene), Wyoming. Special Paper/Geological Society of America. Boulder, Colorado. 213 pp.

HJELJORD, O. G. 1973. Mountain goat forage and habitat preference in Alaska. J. Wildl. Manage. 37:353-362.

JOHNSON, R. L. 1977. Distribution, abundance, and management status of mountain goats in North America. Pages 1-7. *in* W. Samuel and W.G. Macgregor (eds.), Proc. First Internat. Mountain Goat Symp., Kalispell, MT. 243pp.

KORSCHGEN, L. J. 1980. Procedures for food habits analysis. Pages 113-127 *in* S. D. Schemnitz (ed.), Wildlife Management Techniques Manual. The Wildlife Society, Washington, D.C.

MARTIN, S. A. 1985. Ecology of the Rock Creek bighorn sheep herd, Beartooth Mountains, Montana. M.S. Thesis, Montana State Univ., Bozeman. 152pp.

MILLER, R. S. 1967. Pattern and process in competition. Pages 1-74 *in* J. B. Cragg (ed.), Advances in Ecological Research. Academic Press. Vol. 4.

PFITSCH, W. A., AND L. C. BLISS. 1985. Seasonal forage availability and potential vegetation limitations to a mountain goat population, Olympic National Park. Am. Midl. Nat. 113:109-121.

PIKE, D. K. 1981. Effects of mountain goats on three plant species unique to the Olympic Mountains, Washington. M.S. thesis, Univ. of Washington, Seattle.

SHANNON, N. H., R.J. HUDSON, V.C. BRINK, AND W.D. KITTS. 1975. Determinants of spatial distribution of Rocky Mountain bighorn sheep. J. Wildl. Manage. 39:387-401.

SMITH, B. L. 1976. Ecology of Rocky Mountain goats in the Bitterroot Mountains, Montana. M. S. Thesis, Univ. of Montana, Missoula. 203 pp.

STEWART, S. T. 1975. Ecology of the West Rosebud and Stillwater bighorn sheep herds, Beartooth Mountains, Montana. M.S. Thesis, Montana State Univ., Bozeman. 129pp.

SWENSON, J. E. 1985. Compensatory reproduction in an introduced mountain goat population in the Absaroka Mountains, Montana. J. Wildl. Manage. 49:837-843.

Table 3. Canopy coverage and frequency in threee habitat types and fall diets of mountain goats and bighorn sheep.

Taxa	Habitat types						Fall diets			
	Ledge n = 6		Rocky scree n = 12		Turf n = 11		Mountain goat n = 7		Bighorn sheep[a] n = 17	
GRAMINOIDS	30.0	94[b]	26.0	88	26.0	98	75.6	75.5[c]	74	17[d]
Agropyron spp.	0.1	2	2.2	68	0.2	4	5.3	7	-	-
Agrostis scabra	-	-	-	-	0.3	4	tr.[e]	Tr.	-	-
Alopecurus alpinus	-	-	-	-	0.2	4	-	-	-	-
Bromus spp.	-	-	-	-	-	-	-	-	1	2
Carex spp.	9.9	94	8.5	54	4.0	24	20.1	19	51	17
Deschampsia caespitosa	2.1	43	0.4	24	7.3	82	6.1	6	6	14
Elymus spp.	-	-	0.1	4	0.4	5	1.6	1.5	-	-
Festuca ovina	2.1	36	2.4	48	2.5	33	8.4	7	11	15
Juncus spp.	7.3	62	7.0	85	1.9	18	15.2	15	2	6
Koeleria cristata	0.1	2	0.4	8	1.4	16	1.0	1	-	-
Luzula spp.	1.5	60	1.0	13	1.1	5	6.5	6	1	1
Oryzopsis spp.	-	-	-	-	-	-	-	-	1	3
Phleum alpinum	-	-	0.7	8	0.8	10	-	-	-	-
Poa spp.	6.6	97	2.9	81	5.3	85	10.4	11	2	8
Trisetum spicatum	0.7	22	1.1	32	1.1	7	2.5	2	-	-
FORBS	22.0	91	37.0	90	59	100	19.6	22	16	15
Achillea millefolium	0.5	12	0.9	16	2.2	26	tr.	tr.	-	-
Androsace spp.	-	-	-	-	0.8	32	-	-	-	-
Antennaria spp.	0.8	36	1.3	7	0.3	4	1.7	1.3	-	-
Areneria obtusiloba	0.8	30	1.5	55	6.4	53	1.7	1.6	-	-
Arnica spp.	0.3	14	3.1	17	1.1	13	1.1	1.7	-	-
Artemisia spp.	1.4	18	0.8	12	0.5	8	tr.	tr.	1	2
Astragalus spp.	1.2	40	3.5	51	5.4	37	tr.	tr.	2	3
Castilleja spp.	-	-	-	-	1.5	12	-	-	-	-
Cerastium arvense	0.7	21	1.4	28	3.2	41	1.5	1.6	-	-
Cirsium foliosum	1.5	48	1.5	40	0.4	5	tr.	tr.	-	-
Draba spp.	-	-	0.1	2	-	-	-	-	-	-
Descurainia spp.	-	-	-	-	-	-	-	-	2	4
Epilobium angustifolium	-	-	-	-	0.5	12	-	-	-	-
Erigeron spp.	2.5	62	1.7	38	3.2	43	tr.	tr.	1	4
Lupinus argenteus	0.1	4	0.8	8	2.6	16	3.1	4	5	4
Mertensia alpina	0.1	4	0.4	6	4.3	20	1.8	1.7	-	-
Phlox multiflora	0.2	8	0.2	4	7.8	58	tr.	tr.	-	-
Plantago spp.	-	-	-	-	0.4	19	-	-	1	1

Taxa	Ledge n = 6		Rocky scree n = 12		Turf n = 11		Mountain goat n = 7		Bighorn sheep[a] n = 17	
Polemolium pulcherum	0.4	20	0.2	12	0.8	6	-	-	-	-
P. viscosum	1.4	32	3.2	41	-	-	-	-	-	-
Polygonum bistortoides	0.1	2	0.1	1	1.9	31	tr.	tr.	-	-
Potentilla spp.	1.2	19	1.1	39	8.2	57	tr.	tr.	1	2
Ranunculus spp.	0.1	14	0.5	14	0.1	1	-	-	-	-
Rumex spp.	0.1	2	0.1	1	-	-	tr.	tr.	-	-
Saxifraga spp.	5.4	76	4.5	32	0.9	26	tr.	tr.	-	-
Sedum lanceolata	2.1	42	4.4	62	3.8	37	4.3	5.4	-	-
Senecio spp.	0.6	18	1.3	20	-	-	1.3	1.3	-	-
Sibbaldia procumbens	-	-	-	-	-	-	-	-	4	7
Silene acaulis	-	-	2.2	38	2.2	17	tr.	tr.	-	-
Smelowskia calcyna	0.5	38	0.7	13	0.2	2	-	-	-	-
Taraxacum spp.	-	-	0.2	4	0.4	6	-	-	-	-
Trifolium haydenii	1.2	20	1.4	40	1.5	16	1.1	1.5	-	-
BROWSE	0.3	5	1.1	15	1.0	5	0.4	0.5	10	10
Pinus spp.	0.3	5	0.8	8	0.2	1	tr.	tr.	1	2
Rosa spp.	-	-	0.2	5	-	-	-	-	1	4
Rubus spp.	-	-	-	-	-	-	-	-	1	2
Salix spp.	-	-	0.1	2	0.8	4	0.1	0.5	5	8
Shepherdia canadensis	-	-	-	-	-	-	-	-	2	2
Vaccinium scoparium	-	-	-	-	-	-	0.1	0.5	-	-
MOSS	16.0	92	5.0	87	3.0	44	tr.	tr.	-	-
LICHEN	5.0	88	3.0	73	1.0	10	2.3	2.5	-	-
ROCK AND SOIL	22.0	100	29.0	100	11.0	85	-	-	-	-

[a] From Martin (1985).
[b] Percent canopy coverage, followed by frequency of occurrence.
[c] Percent of diet, followed by mean percent volume.
[d] Percent of diet, followed by constancy of samples.
[e] Trace amount (<1 ml or 1%).