ANNUAL ECOLOGICAL CYCLES OF ROCKY MOUNTAIN BIGHORN SHEEP POPULATIONS WITH HIGH ELEVATION WINTER RANGES IN THE EAST KOOTENAYS

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ABSTRACT

Classified carry-over counts of the Elk River Valley Bighorns resulted in a 10 year average of 55 lambs to 100 ewes. Sheep winter range is confined to windswept high-elevation slopes and ridges with significant selection for south and southeastern aspects. Overall habitat use was highest in Alpine Tundra and Subalpine Meadows and lowest in the Alluvial Complex and Riparian Meadows. Elevations above 2400 m received highest overall range use. Slopes between 26 and 40 degrees were significantly more used in winter than in other seasons. Mineral licks seemed to be critical habitat requisites from early spring to summer. Overall diet was significantly dominated by graminoids. Winter range fidelity was confirmed for the Ewin and Sheep Mountain populations. All populations are migratory and use established travel corridors for long distance movements.

INTRODUCTION

Periodic die-offs are associated with most Rocky Mountain Bighorn sheep populations (Stelfox 1971, Demarchi 1967, Bandy 1966). Factors believed to contribute to major die-offs are high population densities, inter- and intraspecific competition, range competition with livestock, winter range deterioration, absence of fires and predators, heavy infestations of parasites, and diseases (Stelfox 1971). Assessing the 1962 to 1967 major population crash of the East Kootenay sheep populations, Demarchi and Demarchi (1967) concluded that sheep wintering on ranges above 2400 meters were not affected. This has been attributed to the generally high productivity of alpine grasslands (Stelfox 1976), the high nutrient content of the dormant forage (Hebert 1972), the absence of interspecific competition, and forage availability of the usually snowfree upper slopes of southern exposures (Schuerholz 1982).

Currently, 8 high-elevation winter ranges supporting a total of 400 to 500 animals are known from the Southern Rocky Mountains of British Columbia; they are located east and west of the Upper Elk River Valley (Warkentin, pers. comm.).

This paper deals with the population ecology of sheep wintering on Ewin Ridge, Sheep Mountain and Todhunter/Imperial, east of the Elk River Valley (i.e. approximately 76% of all Elk Valley populations). Particular attention is given to winter ranges, habitat utilization, diet composition, and population movements.

METHODS

The study area covers approximately 200 km^2 of mountainous terrain with 400 ha of alpine and subalpine high quality sheep winter range.

Bighorn were classified from helicopter and from the ground on all winter ranges each year since 1981 (Schuerholz 1982). The data were supported by Government records dating back to 1971.

A 1:20,000 vegetation map was produced which served as a basis for the habitat assessment of the four sheep winter ranges. Seventeen cover types (Table 1) synonymously used with "habitat types" were differentiated, based on dominant vegetation, vegetation structure and degree of disturbance. The plant community types which form a vegetation cover type were investigated through 170 vegetation plots located by computer-assisted tabular analysis as described by Ceska and Roemer (1978).

Habitat use by season, elevation, and aspect was identified through 2444 browse pellet plots on 153 line transects proportionately representing the 17 cover types.

Table 1. Habitat types in East Elk River Valley Study Area.

Alpine Tundra
Subalpine Meadow
Alpine Larch
Engelmann Spruce Subalpine Fir
Englemann Spruce Lodgepole Pine
Lodgepole Pine
Douglas Fir
Riparian Meadow
Engelmann Spruce Riverbottom
Alluvial Complex
Slide Area
Burned
Logged
Disturbed
Talus
Non-vegetated
Rock

Daily and seasonal movements of sheep were monitored through weekly survey flights, and ground triangulations using 15 radiocollared animals instrumented between 1981 and 1983. Relocations were recorded on UTM grid co-ordinates and analysed through the computer "Home Range" model described by Harestad (1981).

Composite fecal samples collected in February, June, August and October, served to investigate seasonal diet composition and plant species preference as described by Davitt (1980).

RESULTS AND DISCUSSION

POPULATION STRUCTURE AND POPULATION CONDITION

Ewin Ridge supports approximately 47% of the Elk Valley Sheep population while Sheep Mountain supports 20%, and Todhunter and Imperial support combined 9%.

The helicopter census records from 1971 to present show large fluctuations in numbers of sheep on the 4 winter ranges (Table 2). These fluctuations are believed to reflect environmental conditions of each survey rather than changes in population sizes (Schuerholz 1983).

Comparing the 13 years record, the data suggest that the respective populations are stable. The mean lamb:ewe ratio of 55:100 for the record period indicates good recruitment and high lamb survival.

Fecal samples collected from the winter range in 1981 showed very low parasite loads which may suggest that the respective populations experience a low stress level (Schuerholz 1982).

RANGE USE

Of the 17 cover types, Engelmann Spruce-Subalpine Fir, Engelmann Spruce-Lodgepole Pine, and Subalpine Meadow are most abundant in the study area. The pellet group counts show the highest pellet group densities for Alpine and Subalpine Meadows (Table 3) on the winter range.

Sheep seem to select east-southeastern aspects throughout the year and avoid valley bottoms in the study area (Figure 1). Ridge tops seem to be preferred habitat independent of season. High elevation ridges (0 -5^{0}) are preferred bedding sites by sheep and are used for long-distance travel, which may explain the pellet group concentration. Slopes from 26 to 40 degrees were used more in winter than in any other season (Figure 2). Comparing elevations, habitats above 2400 m revealed highest pellet group densities (Figure 3).

The distinct seasonal use of elevational ranges seems to be controlled by snow. Sheep in the study area winter in high elevations utilizing the windblown southfacing upper slopes and ridge tops from December to May. As was evidenced through this study, even in years with low snowfall, Ewin Bighorns are unable to leave the high elevation winter ranges before May (Schuerholz 1982) due to high snowpack in elevations below 2400 m. In spring, sheep follow the receding snowline downslope and start to disperse to their respective summer ranges as soon as snowpacks in the valleys to be crossed permit. From spring to fall, sheep may be found in all elevational ranges.

Preliminary analysis of 3 years records of radiocollared sheep revealed that sheep from all 4 winter ranges are migratory. Range fidelity was substantiated for winter ranges, spring mineral-lick home ranges, and to a

Table 2. Results from the helicopter surveys of the four sheep winter populations.

DATE	LOCATION	# LAMBS : FEMALES	# OF RAMS	TOTAL NO. OF SHEEP	PRINCIPLE OBSERVER
Feb.20, 1971	Ewin	54 : 100	10	106	Warkentin
	Todhunter	78 : 100	3	28	"
	Imperial	-	-	-	"
	Sheep Mt.	not surveyed)			
Feb. 7, 1973	Ewin	29 : 100	22	147	Warkentin
	Todhunter	-	-	-	"
	Imperial	-	-	-	"
	(Sheep Mt.	not surveyed)			
Mar. 7, 1975	Ewin	52 : 100	16	103	Warkentin
	Todhunter	-	-	-	"
	Imperial	66 : 100	4	14	"
	(Sheep Mt.	not surveyed)			
Mar. 6, 1976	Ewin	37 : 100	15	88	Warkentin
	Todhunter	87 : 100	6	21	"
	Imperial	63 : 100	10	90*	"
	(Sheep Mt.	not surveyed)			
Mar.12, 1979	Ewin	48 : 100	22	95	Warkentin
	Todhunter	-	-	-	"
	Imperial	50 : 100	7	28	"
	(Sheep Mt.	not surveyed)			
Mar. 6, 1981	Ewin	50 : 100	27	179	Schuerholz
	Todhunter	57 : 100	12	23	"
	Imperial	25 : 100	1	11	"
	(Sheep Mt.	not surveyed)			
Feb. 4, 1982	Ewin	52 : 100	7	97	Schuerholz
	Todhunter	57 : 100	2	13	"
	Imperial	40 : 100	3	10	"
	(Sheep Mt.	not surveyed)			
Feb. 4, 1983	Ewin	51 : 100	24	147	Schuerholz
	Todhunter	43 : 100	3	26	"
	Imperial	50 : 100	-	1	"
	Sheep Mt.	46 : 100	31	50	"
Mar.10, 1984	Ewin	78 : 100	21	123	Crows Nest
	Todhunter	-	-	-	Resources
	Imperial	75 : 100	1	15	"
	Sheep Mt.	85 : 100	15	54	"

* questionable

Table 3. Sheep pellet group densities by cover type

HABITAT TYPE	NO. OF PLOTS	NO. OF PELLET GROUPS	*DENSITY
Engelmann Spruce-Subalpine Fir	193	26	.13
Engelmann Spruce-Lodgepole Pine	241	19	.08
Lodgepole Pine	132	1	.01
Alpine Larch	93	9	.09
Alluvial Complex	22	0	0
Riparian Meadow	37	0	0
Subalpine Meadow	897	560	.62
Disturbed	1	0	0
Slide Area	95	21	.22
Talus	62	23	.33
Logged	79	3	.04
Douglas Fir	34	1	.03
Engelmann Spruce Riverbottom	27	0	0
Alpine Tundra	74	100	1.35
Rock	13	4	.31
Burned	240	23	.10

* Density is expressed in pellet groups per plot.

Fig.1. Seasonal range use of Elk Valley Bighorn by aspect. Considered are exclusive winter and summer ranges and range areas used within both seasons.

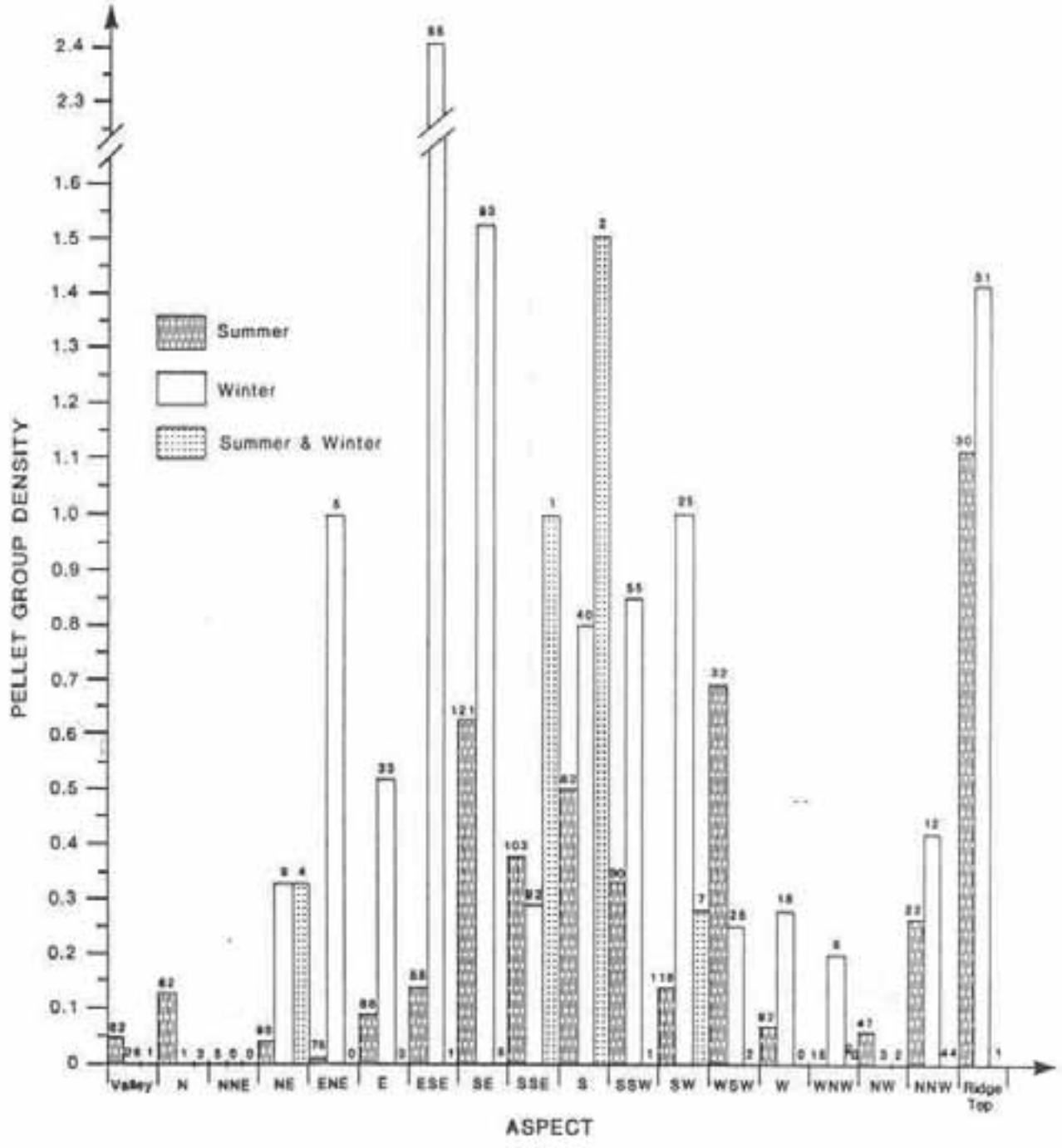


Fig.2. Seasonal distribution of Elk Valley Bighorns by slope. Considered are exclusive winter and summer ranges and range areas used within both seasons.

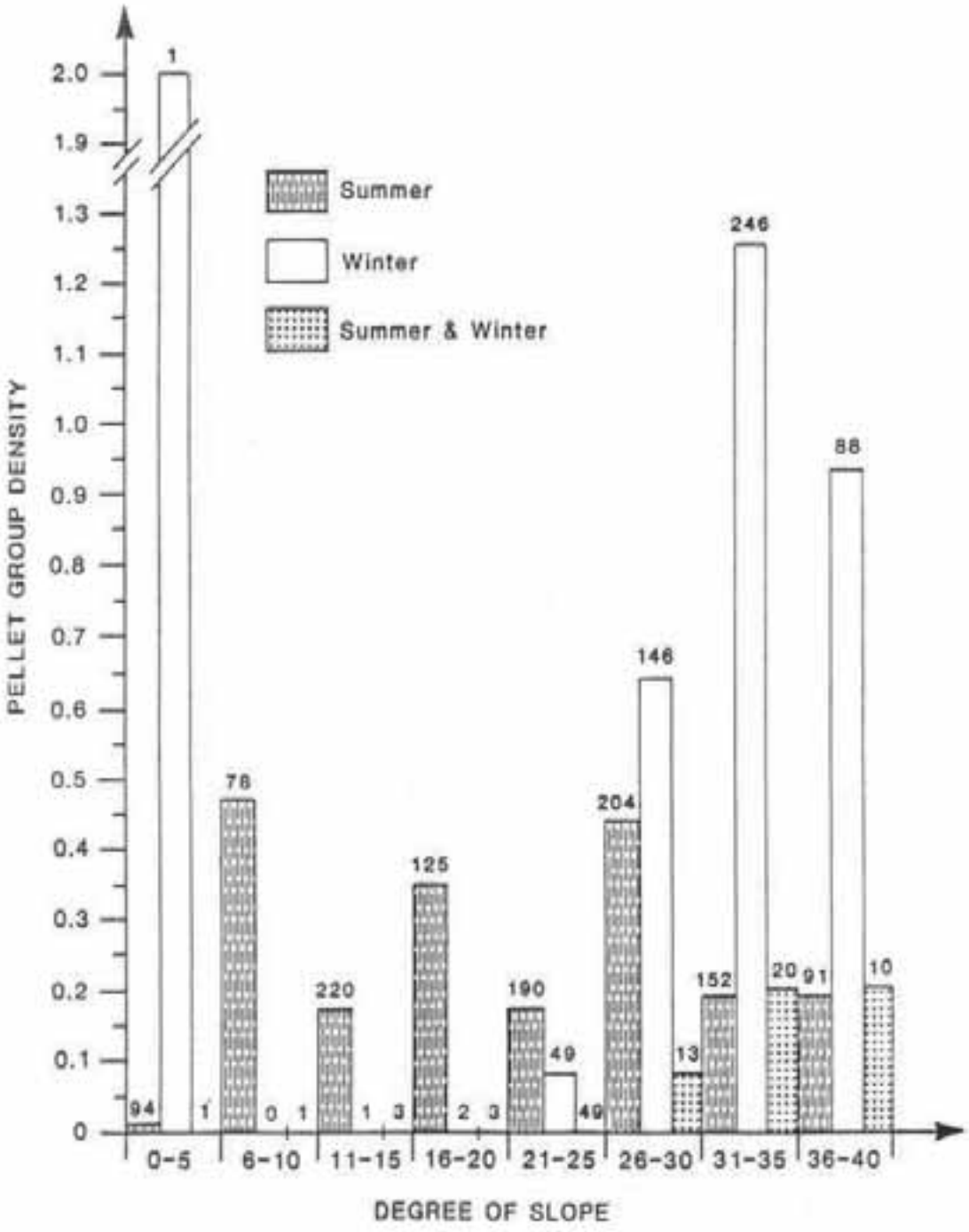
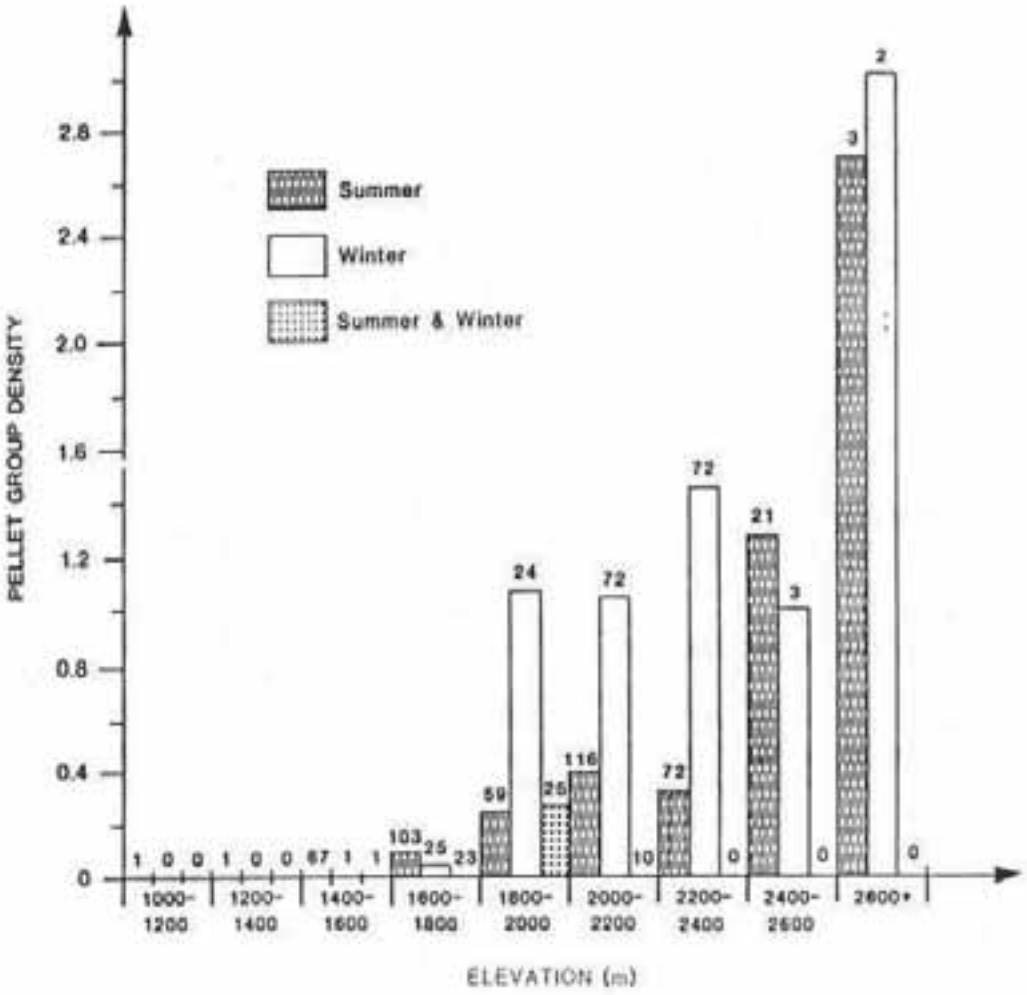


Fig.3. Seasonal distribution of Elk Valley Bighorn by elevation. Considered are exclusive winter and summer ranges and range areas used within both seasons.



lesser degree for summer ranges. Long-distance travel between seasonal and home ranges seemed to occur via well established routes which mostly followed mountain ridges. Some home ranges of sheep from Ewin and Sheep Mountain overlapped; however, little interaction between the two populations was observed except for rams during the rutting season. Rutting generally occurred close to the respective winter ranges with a peak in November. Rams and ewes were found on the same winter range.

From the radio telemetry data, it was deduced that sheep in the study area lamb in the Engelmann Spruce-Subalpine Fir forests, below and adjacent to the winter ranges. This applies in particular to the Ewin population. The ewes of the Sheep Mountain group seemed to lamb in rugged cliffs adjacent to the winter range. The Ewin population did not seem to form nursing bands as described by other researchers (Geist 1971, Stelfox 1978), except when found in open terrain.

FORAGE COMPOSITION

The fecal analysis for the four sheep populations revealed a diet pattern which seemed to reflect mostly the phenological plant development from spring to mid-summer. Sheep forced by deep snow to stay on high-elevation winter ranges until early summer (i.e. Ewin Ridge and Sheep Mountain populations), consumed proportionately more graminoids (59%) than sheep from lower montaine forests (28%). The diet of the latter at this time was dominated by forbs (57%) and shrubs (14%). In comparison, sheep from Subalpine-Alpine ranges used fewer shrubs (3%), but also utilized forbs (36%). Conifers constituted a low percentage of the diet for both range elevations, although more conifers were used on the higher ranges.

Forbs were second most important in the diet of Elk Valley Bighorns; they received a moderately higher use on the lower ranges. The comparison of diets on the two elevational ranges for the spring-early summer season by plant species indicates a distinct use of Festuca scabrella within graminoids (Table 4). On the higher elevation ranges Penstemon spp. receives highest use amongst forb species in contrast to Epilobium augustifolium on lower ranges. Again, this reflects mostly the availability of the plant species on the respective ranges in that season. It is interesting to note that sheep used both Sambucus spp. and Salix spp. in early spring and summer.

The summer-fall diet of sheep is dominated by graminoids on both elevational ranges (Table 5). Second most important are forbs which receive a moderately higher use on the lower elevation range. Shrubs and conifers are found in the diet on both ranges, but in negligible quantities. On a plant species level, it is interesting to note that fescues constitute 41% of the diet on the higher elevation range and 16% on the lower elevation range (Table 4). Further, there is a distinct shift in use of Penstemon spp. from spring to fall by elevation. In early summer, 21% is found in high-elevation samples versus 7% in late summer. The same species constitutes 9% of the sheep early-summer diet in lower elevation range and 14% in late summer on the same range.

The winter diet is dominated by graminoids. On Todhunter and Imperial ranges, more forbs are utilized than on the 500 m higher located Ewin Ridge and Sheep Mountain ranges (Table 6). A diet comparison by plant species shows

Table 4. Spring-early summer diet of Bighorn sheep by elevational range

	Subalpine-Alpine		Lower Montane Forests	
	Species	% Diet	Species	% Diet
GRAMINOIDS	Festuca scabrella	32.9%	Festuca scabrella	8.6%
	Poa spp.	8.3	Poa spp.	5.6
	Elymus spp.	4.3	Elymus spp.	3.2
	Phleum alpinum	5.7	Carex spp.	4.0
	Carex spp.	1.5	Phleum alpinum	5.1
	Other graminoids	6.4	Other graminoids	1.6
		59.1%		28.1%
FORBS	Penstemon spp.	20.8%	Epilobium angustifolium	15.9%
	Antennaria lanata	6.2	Anaphalis margaritacea	3.9
	Other forbs	8.7	Penstemon spp.	9.0
		35.7%	Antennaria lanata	2.1
			Dryas octapetala	2.3
			Unknown forb	2.0
			Other forbs	21.5
				56.7%
SHRUBS	Shrubs	2.5%	Sambucus spp.	6.0%
		2.5%	Salix spp.	4.5
			Other shrubs	3.9
				14.4%
CONIFERS	Conifers	2.7%	Conifers	0.8%
		2.7%		0.8%

Table 5. Summer-fall diet of Bighorn by elevational range

	Subalpine-Alpine		Lower Montane Forests	
	Species	% Diet	Species	% Diet
GRAMINOIDS	Poa spp.	11.1%	Festuca scabrella	16.4%
	Elymus spp.	4.8	Poa spp.	11.3
	Carex spp.	10.8	Festuca spp.	11.3
	Festuca spp.	41.1	Elymus spp.	8.1
	Other graminoids	5.7	Carex spp.	2.8
		73.5%	Agropyron spicatum	8.3
			Other graminoids	7.5
				65.7%
FORBS	Antennaria lanata	6.2%	Penstemon spp.	14.4%
	Penstemon spp.	7.0	Lupinus spp.	6.2
	Other forbs	8.4	Other forbs	6.5
		21.6%		27.1%
SHRUBS	Shrubs	3.5%	Shrubs	3.6%
		3.5%		3.6%
CONIFERS	Conifers	1.4%	Abies spp.	3.0%
		1.4%	Other conifers	0.6
				3.6%

Table 6. Winter diet of Bighorns by elevational range

	Ewin Ridge		Sheep Mountain		Todhunter-Imperial	
	Species	% Diet	Species	% Diet	Species	% Diet
GRAMINOIDS	Festuca scabrella	60.6%	Festuca scabrella	56.5%	Festuca scabrella	53.3%
	Poa spp.	11.7	Poa spp.	21.9	Poa spp.	14.7
	Carex spp.	5.1	Carex spp.	10.8	Carex spp.	2.0
	Agropyron spicatum	6.5	Other graminoids	6.7	Other graminoids	8.6
	Other graminoids	5.4		95.9%		78.6%
		89.3%				
FORBS	Antennaria lanata	2.3%	Forbs	4.1%	Antennaria lanata	8.7%
	Other forbs	6.3		4.1%	Penstemon spp.	2.0
		8.6%			Other forbs	9.1
						19.8%
SHRUBS	Shrubs	0.1%			Shrubs	1.6%
		0.1%				1.6%
MOSS	Moss	2.0%				
		2.0%				

highest use of Festuca scabrella for all winter ranges, reflecting the relative abundance of this species (Schuerholz, 1982).

Stelfox (1976) reports that for sheep wintering in high elevations in Banff, Jasper and Waterton Parks, fescues and wheatgrass are very important diet components, confirming the findings for the Elk Valley Study area.

A literature review of sheep diets suggests that sheep are opportunistic feeders and exhibit a varied diet, even over short distances, depending on the availability of forage species (Sudgen 1961, Schuerholz 1982). Of the approximately 100 plant species identified on the winter ranges in the study area, almost 50% have been used as food plants by Bighorns in other parts of British Columbia and the Western United States (Table 7).

Based on the fecal analysis relative values were assigned to plant species found in the fecal materials. The results show highest values for graminoids and forbs (Table 8). Shrubs and conifers have very low overall diet values. Fescues and bluegrasses have the highest overall values within graminoids. Penstemon spp. is the only forb with a moderately high overall value. Shrubs, conifers and bryophytes show low values for all seasons and ranges.

CONCLUSIONS

The relatively high quality of the winter range in the study area is attributed to the mostly fire-induced, herb-rich tall-grass meadows which predominate on south-facing slopes of all high altitude winter ranges in the Elk River Valley (Ogilvie 1978), the lack of competition with other ungulates and/or livestock, and most importantly, the favorable microclimatic conditions which keep the upper slopes free of snow through strong westerly winds (Schuerholz 1982).

The dietary fecal analysis suggests that the best year-long range is that which offers a wide variety of forbs, shrubs and grasses. The winter ranges in the study area offer a mixture of all three forage classes, and a large number of plant species known to be utilized by Bighorns in other areas. Given the high productivity of the Ewin Ridge alpine meadows (Schuerholz 1983) and the fact that alpine forage has been found to be more nutritious than that of conventional low elevation winter ranges (Hebert 1972), it may be concluded that the Elk Valley winter ranges can sustain healthy sheep populations as long as population densities can be controlled at current levels. Preliminary carrying capacity estimates for the sheep winter ranges indicate that the Ewin Ridge range is currently stocked below the level of carrying capacity (Schuerholz 1983). The survey data for the same population suggest that it has been stable for the past 10 years.

Assuming that winter range is the single most important factor controlling the sheep population, it can be concluded that the Elk Valley sheep herds from Ewin Ridge, Todhunter, Imperial and Sheep Mountain are not prone to a major die-off as long as densities are maintained at the current levels and no contagious diseases enter the population.

Table 7. Plant species found on the Elk Valley sheep winter ranges and used as food by Rocky Mountain and California Bighorn sheep[1] in other areas of British Columbia and the Western United States (from Schuerholz 1982)

Plant Species	Average Usage Rating*2	Range of Use*3	No. of times reported as food plants*4
GRASSES, SEDGES & RUSHES:			
Agropyron spicatum	high	-	11
Agropyron spp.	low	low-medium	8
Bromus spp.	low	-	2
Carex spp.	low	low-high	15
Elymus spp.	low	-	1
Festuca spp.	medium	low-high	17
Kobresia myosuroides	low	-	2
Koeleria cristata	low	low-medium	13
Luzula spicata	low	-	1
Poa spp.	low	low-high	17
FORBS:			
Achillea millefolium	low	-	9
(Allium cernuum)	low	-	2
(Anaphalis margaritacea)	low	-	1
Anemone spp.	low	-	2
(Antennaria microphylla)	low	-	1
Antennaria spp.	low	-	2
Antennaria umbrinella	low	-	1
Arenaria spp.	low	-	1
Artemesia spp.	medium	low-high	11
Aster spp.	low	-	2
Astragalus spp.	low	-	7
Bistorta vivipara	low	-	2
Cerastium spp.	low	-	1
Draba spp.	low	-	2
Epilobium angustifolium	low	-	1
Erigeron compositus	low	-	1
Erigeron spp.	low	-	6
Eriogonum spp.	low	-	6
Galium spp.	low	-	2
Hedysarum spp.	low	-	3
Heuchera cylindrica	low	-	2
Lithospernum ruderale	low	-	1
Lupinus spp.	low	-	11
Oxytropis spp.	low	-	5
Penstamon spp.	low	-	2
(Phacelia hastata)	low	-	2
Phacelia sericea	low	-	2
Polemonium spp.	low	-	1

(cont....)

Table 7 (cont.)

Plant Species	Average Usage Rating*2	Range of Use*3	No. of times reported as food plants*4
Potentilla spp.	low	-	1
Ranunculus spp.	low	-	1
Sedum spp.	low	-	1
Senecio spp.	low	-	4
Taraxacum spp.	low	-	3
TREES AND SHRUBS:			
Amelanchier alnifolia	low	low-medium	6
Arctostaphylos uva-ursi	low	-	10
Juniperus spp.	low	-	4
Picea engelmannii	low	-	2
Pinus contorta	low	-	5
Potentilla fruticosa	medium	low-high	3
Rosa spp.	low	-	9
Salix nivalis	medium	-	1
MOSSES AND LICHENS:			
mosses	low	-	2
lichens	low	-	2

*1 The four species in brackets were utilized only by California bighorn sheep.

*2 Plant species were ranked low, medium or high with regard to the level of use reported by each author. The overall average value is listed here.

*3 If a wide range of use was reported.

*4 Out of a total of 20 references: (Constan 1972), (Cowan and Guiget 1965), (Banfield 1974), (Berwick 1968), (Blood 1970), (Flook 1964), (Hebert 1973), (Honess and Frost 1942), (Keiss and Schoonveld 1974), (Morrison 1972), (Moser 1962), (Oldemeyer, et al. 1971), (Riggs 1977), (Schallenberger 1966), (Singleton 1976), (Smith 1954), (Stelfox 1976), (Sugden 1961), (Todd 1972), (Todd 1975).

Table 8. Relative values of plant species for Bighorn sheep

Species Name	Relative Forage Values*1										
	Winter				Spring-Early Summer			Summer-Fall			Overall
	E*2	S*3	T*4	$\bar{x}$*7	Sa*5	L*6	$\bar{x}$	Sa	L	$\bar{x}$	$\bar{x}$
GRAMINOIDS											
Festuca scabrella	+	+	+	+	+	0	+		+	0	+
Festuca spp.								+	+	+	0
Elymus spp.					-	-	-	-	0	0	-
Phleum alpinum					0	0	0				-
Carex spp.	0	+	-	0	-	-	-	+	-	0	0
Poa spp.	+	+	+	+	0	0	0	+	+	+	+
Agropyron spicatum	0			-					0	-	-
Other graminoids	0	0	0	0	0	-	-	0	0	0	0
FORBS											
Antennaria lanata	-		0	-	0	-	-	0		-	-
Penstemon spp.			-	-	+	+	+	0	+	+	0
Lupinus spp.									0	-	-
Epilobium angustifolium						+	0				-
Anaphalis margaritacea						-	-				-
Dryas octapetala						-	-				-
Unknown forb						-	-				-
Other forbs	0	-	0	0	0	+	+	0	0	0	0
SHRUBS											
Sambucus spp.						0	-				-
Salix spp.						-	-				-
Other shrubs	-		-	-	-	-	-	-	-	-	-
CONIFERS											
Abies spp.									-	-	-
Other conifers					-	-	-	-	-	-	-
MOSS	-			-							-

*1 Symbols used for relative forage values are:
+ highly valuable (over 10% of diet)
0 valuable (5-10% of diet)
- low value (less than 5% of diet)

*2 Ewin Ridge

*3 Sheep Mountain

*4 Todhunter - Imperial

*5 Subalpine - Alpine

*6 Lower Fording

*7 Statistical Mean

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