A DESCRIPTION OF SOUTHERN INTERIOR AND COASTAL MOUNTAIN GOAT ECOTYPES IN BRITISH COLUMBIA

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Abstract: Recently, the three subspecies of mountain goat found in British Columbia have been consolidated into a single species. Ecological data suggest that coastal and interior ecotypes exist within the present classification. The development of management systems for mountain goats must depend upon population, social and habitat characteristics within each ecotype. A comparison of productivity and recruitment data for mountain goats of the interior and coastal mountains reveals major differences in the vulnerability of these populations to harvest. Information on group size, frequency distribution of groups and family group status suggests the separation of ecotypes. Determination of animal density revealed clines in mountain goat populations in the outer coast mountains and that actual winter habitat utilized was limiting to the population. A preliminary determination of summer food habits indicates a browsing habit by coastal goats and a grazing habit by interior goats. A comparison of natural salt lick characteristics suggests a physical control of the physiological maintenance of sodium levels.

The drastic declines in Rocky Mountain goat populations described for southeastern and south central British Columbia (Phelps et al. 1976, Foster 1976, Fish and Wildlife Branch 1976) were characterized by: traditional reasoning in biology which did not allow biologists to recognize important differences in species biology; the lack of inventory data describing relative population size and trends, distribution, productivity and recruitment level; the lack of age structure information; the difficulties associated with sexing mountain goat during aerial surveys; the inability of hunters to differentiate sexes in a population; the hesitancy with which biologists accepted queries from hunters and guides regarding population levels and, the inability of resource management systems to control access and resource users. Further, past management prescriptions were based almost solely on harvest information (primarily sex class data and age data mainly limited to the yearling class) with little regard to population productivity and recruitment, spatial and temporal distribution of the harvest, or to biophysical factors which may have been limiting to one ecotype more than another.

Recently, Cowan and McCrory (1970) consolidated the three subspecies found in British Columbia into a single species. However, they did not mention that ecotypes exist within the classification. Population, density and habitat related information collected in south coastal and southeastern British Columbia and presented in this paper, exemplified specific differences between coastal and interior populations and possibly within coastal populations. It is suggested that present and future management presecriptions should attempt to incorporate as many of the ecological points discussed here as possible during the development of regional management plans.

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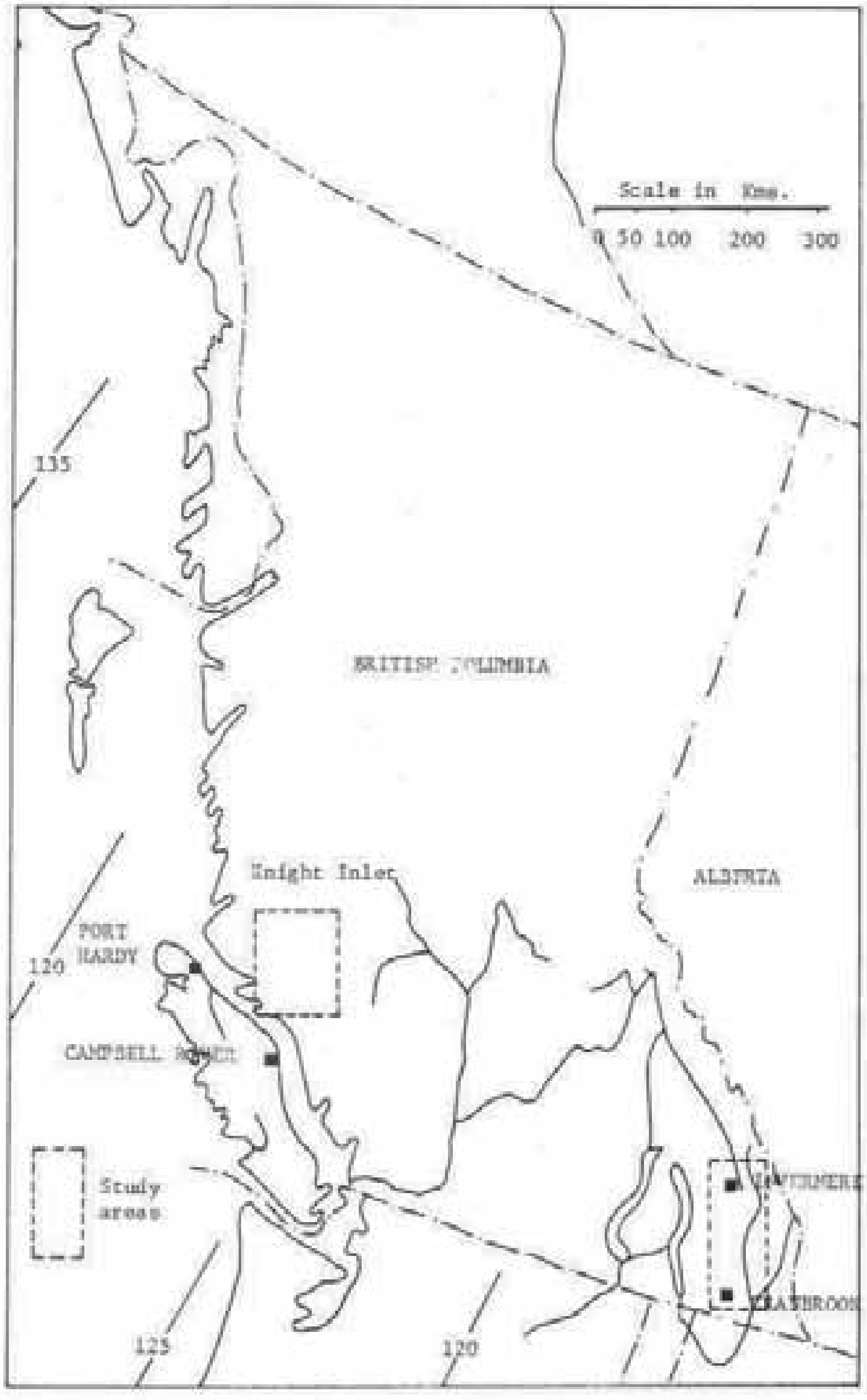

Figure 1. Outline map of British Columbia showing the location of the study areas, in the East Kootenays and Coast mainland.

STUDY AREA

The East Kootenay study area is centered in the Rocky Mountain Trench between Cranbrook and Radium Junction (49° 30' to 50° 45' north latitude). Information was collected in the Purcell Range on the west side of the Trench and in the Rocky Mountains on the east (Fig. 1). The coastal study area centers in the coast mountains of Region I, encompassing the main drainages entering Knight Inlet (Fig. 1). Associated information was collected in Wakeman Sound. Coastal watersheds fall into three categories (mountain block A, B and C) according to the total area of the elevational class of winter and summer range, the general physiography of the watershed and the actual amount of winter habitat within the elevational class 305 m (1,000 f) above the river bed to 1,525 m (5,000 f).

The majority of the coastal study area is composed of the Coast Crystalline Complex containing granitic, metamorphic and volcanic rocks (Souther 1967). Within it are large portions of granodiorite, quartz diorite, diorite and gabbro and diorite. Much of the aerial survey information was collected on areas composed of dacitic and basaltic flows (Silverthrone formation), migmatite and schists, gneisses, quartzite and crystalline limestone. In contrast, the majority of the East Kootenay study area is composed of sedimentary formations.

METHODS

Information collected in the East Kootenays came from ground surveys using binoculars and spotting scopes. The coastal data were collected from a Jet Ranger helicopter using two observers. Transects were flown at 152.5 m (500 f) intervals beginning at about 1,200 - 1,372.5 m (4,000 - 4,500 f) in mountain block C drainages and at 762.5 m (2,500 f) to 915 m (3,000 f) in mountain block A and B drainages (Table 1). They were flown in proportion to the amount of each aspect present in each watershed. The sex ratio established for the Stanton Creek population was determined by observing goats at close range (12.2 - 22.9 m) (40 - 75 f) from a helicopter for up to 30 seconds with a 200 mm. telephoto lens or a pair of binoculars. It was possible to establish sex in approximately 70 percent of the goats observed because they had not previously been disturbed by man.

Food habits were determined by rumen analysis according to standard procedures. Coastal goats were collected as biological samples while East Kootenay goats were harvested by hunters.

Analysis for ruminal and fecal nitrogen was done according to AOAC methods for macro-Kjeldahl and for fecal and soil sodium using an atomic-absorption spectrophotometer.

Area for population density calculation was taken from .305:76250 (1:250,000) scale maps using a planimeter. Winter range population densities were calculated using the contour line 305 m (1,000 f) above the riverbed, not the 305 m (1,000 f) contour line.

RESULTS

Summer Range Distribution

Mountain goats inhabiting the western slopes of the coastal mountain range tend to favour south aspects during the summer months. Approximately 62.9 percent of the goats observed in 1974 occupied south slopes (Table 1), while 20.0 percent occupied west facing slopes, 14.6 percent occupied north facing slopes and only 2.4 percent occupied east slopes. More specifically, approximately 91 and 71 percent of the goats in the coastal watersheds of Stanton and Hoodoo Creeks, respectively were observed on south slopes in 1974. Due to the high proportion of animals occurring on south aspects in these two drainages, only the south aspects were surveyed in 1976. As a result of two mild winters, changes in distribution and aerial survey discrepancies, the goat population changed from 33 to 44 in Stanton Creek and from 28 to 35 in Hoodoo Creek between 1974 and 1976.

In certain drainages, such as the Franklin and Klinaklini River, direct south facing aspects are not abundant. In these cases, mountain goats ummer on S-SE slopes and W-SW slopes, respectively.

There appears to be an elevational cline in summer range utilization from block C to block A (Table 1). Block C watersheds at the head of Knight Inlet supported goats at an average elevation of 1622.9 m (5,321 f) during the two survey years, while block B watersheds averaged 1305.4 m (4,280 f) and block A watersheds averaged 1220 m (4,000 f) elevation.

Interpretation of coastal inventory data indicated that goat densities were moderate to high wherever the Silverthrone formation was exposed. This geologic formation is composed of dacitic and basaltic flows, tuffs and breccias. The past glaciation and weathering pattern has developed steep slopes and loose material in this formation, similar in structure to the sedimentary formations of interior British Columbia.

Table 1. Utilization of coastal mountain goat summer ranges according to physical characteristics.

Area	Mountain Block	Survey Date	Average Elevation In Meters	Aspect	Terrain	Total Goats
Hoodoo	C	Aug./74	1,819	S-NE	Talus Ridgetop	28
		Aug./76	1,708	S	Talus Slope	35
Klinaklini		Aug./74	1,386	SW	Slide Rockbluff Timber	33
Franklin River		Aug./74	1,522	S	Ridge Bluff Timber	25
Stanton Creek		Aug./74	1,472	S	Alpine Bluff Timber	(57)* 33
		Aug./76	1,830	S	Alpine Rockbluff	44
Ahnuhati River Hills Creek Sim-McMynn Creek	B	Aug./76	1,374	S, W, E, N,	Alpine Rock Slide	48
Matsiu River Sallie Creek Kwalate River	A	Aug./76	1,220	S, SW	Rock Timber	5
Catto Creek, At-waykellessee Creek	D	June/76	931	E, S,	Rock Timber	24

* - includes ground count at natural salt lick.

Insufficient quantified information is available for southeastern British Columbia; however, much of the early summer distribution centered on south aspects and appeared similar to that determined by Hjelford's (1971) examination of feeding sites and Casebeer's (1948) observations in Montana.

Mountain goats appear to prefer high elevation alpine ranges, containing high quality forage (Hebert 1972) and associated escape terrain, where they occur.

Winter Range Distribution

Preliminary investigation of coastal mountain goat winter range indicates that goats winter from sea level (along the channels) to about 1,372.5 m (4,500 f) elevation in side drainages such as Stanton Creek. The majority of the coastal winter ranges appear to occur on south slopes from about 366+ m (1,200+ f) to 1,372.5 m (4,500 f) in elevation. Ground inspection of several ranges indicated that they are characterized by a mature canopy (often Douglas fir) overhanging a steep bluff area. The majority of goat movement occurs along the top of the bluff; however, movement between winter ranges appears restricted (track counts).

Coastal snow conditions are harsh. Goat winter ranges receive excessive snow which is heavily packed due to the high water content. This situation makes most or all of the ground vegetation unavailable for much of the winter. Within approximately 30 - 50 km of the ocean, mountain peaks, talus slopes and rock faces remain covered by a deep snow pack for the entire winter. Beyond 30 - 50 km of the ocean and at higher elevations (1,830+ m; 6,000+ f) snow is removed from mountain tops and rock areas by wind and mountain goats are seen to winter at these high elevations.

Characteristic goat winter ranges predominate many of the block C drainages, occur in moderation in the block B drainages and are scarce in block A drainages, within the elevational class 305 m (1,000 f) above the watercourse to 1,525 m (5,000 f), of the coast. Although quantiative evidence is lacking, it appears that the lower elevation, "U" shaped valleys of mountain blocks A and B may provide less servere snow and temperature regimes than do the higher elevation mountain block C drainages.

In the East Kootenay, mountain goats often winter on snow free ridge tops (2,135+ m; 7,00+ f elevation) and mountain peaks and in the Englemann spruce-subalpine fir biogeoclimatic zone (1,525-2,135 m; 5,000-7,000 f elevation) (pers. observ., Phelps et al. 1976) on south aspects. In the Okanagan portion (south central) of the interior of British Columbia they appear to winter at approximately 915-1,220 m (3,000-4,000 f) elevation in the upper ponderosa pine and lower Douglas fir (Krajina 1965) biogeoclimatic zone (pers observ.).

Food Habits

Few, if any, studies have documented food habits of coastal mountain goats, and seasonal food habits studies of goats in British Columbia are lacking completely. However, Rocky Mountain goat food habits have been documented by several workers from the southern to the northern extremities of its range. These studies indicate that the summer food habits of the goat are largely composed of grasses, sedges and forbs (Foss 1962, Kerr 1965, Hjelford 1971, Kuck 1972). The associated winter food habits appear to consist mainly of browse species with lesser amounts of herbaceous material occurring in the diet (Kerr 1965, Kuck 1972, Brandborg 1955).

This food habit information is preliminary and of limited value due to the small sample size; however, it does indicate a difference in summer food habits of coastal and interior mountain goats (Tables 2 and 3).

Table 2. Estimated summer food habits of five mountain goats in the East Kootenay region of British Columbia.

Animal	Grasses %	Browse %	Forbs %	Trace Species
Adult Female	61.5	38.48	- -	Rock, Fir Needles
Adult Female	98.0	2.0	- -	- - -
Adult Female	88.0	12.0	- -	- - -
Yearling Male	53.3	46.6	- -	Fir Needles, Grouseberry
Adult Male	69.0	25.0	6.0	- - -
Average	73.96	24.82	1.20	

Goats of the Rocky Mountain region of British Columbia appear to utilize approximately 74 percent grasses and sedges (August - September sample) and only 25 percent browse species (Table 2), while coastal goats utilize about 53 percent shrubs and only 23 percent grasses and sedges (August sample) (Table 3).

In addition to a comparison of food habits between coastal and interior mountain goat populations, quality of the summer diet of coastal goats can be compared to that of East Kootenay mountain sheep populations (Hebert 1973). Hebert (1973) established regression equations for migratory mountain sheep populations (captive) which relate fecal nitrogen values to crude protein intake as an index of animal condition. Initial collections of goat fecal samples in summer (August) and late winter (April) produced values similar to those for mountain sheep on alpine and winter range diets, respectively (Table 4). The crude protein values of the feed were established from the regression Y = -.9400 + 1.034 x $\pm$4.58; p = .0008 using crude protein values of the fecal sample as x. The August values for mountain goats are only slightly higher than those for captive birhorn sheep on natural alpine range forage. This difference could be attributed to selectivity by free ranging mountain goats. Similarly, the April values for mountain goats and captive mountain sheep are comparable and just below the protein maintenance values established by Hebert (1973). Gasaway and Heimer (1976) determined fecal nitrogen values of 1.7 - 1.8 percent (11 percent crude protein) for Dall sheep collected in April in Alaska.

Based on this preliminary information future work will entail simultaneous collection of seasonal fecal samples from mountain blocks A, B and C in order to relate differences in protein intake to productivity, recruitment and density.

Table 3. Estimated summer food habits of two mountain goats from coastal British Columbia.

Sample	Sex	Age	Volume (ml)	Plant Species	% Occurrence	Total %		
						Shrubs	Grasses	Forbs
1	F	6.5	650	*Vaccinium* spp. (2 spp.)	41.1			
				Lonicera utahensis	14.2			
				Cassiope mertensiana	1.2			
				Phyllodoce glanduliflora	.8			
				Unidentifiable leaves	1.2	58.5		
				Grasses & grass-like spp.	22.9			
				(*Festuca* sp., *Carex* sp., *Luzula* sp.)			22.9	
				Arnica latifolia	15.0			
				Fern (unidentifiable to genus)	1.6			
				Pedicularis racemosa	.8			
				Luetkea pectinata	.8			
				Moss	.4			18.6
2	M	5.5	450	*Vaccinium* (2 spp.)	37.0			
				Unidentifiable leaves	9.1			
				Cassiope mertensiana	1.6			
				Phyllodoce glanduliflora		47.7		
				Grasses & grass-like spp.	23.9			
				(*Festuca* sp., *Carex* sp., *Luzula* sp.)		23.9		
				Arnica latifolia	14.0			
				Luetkea pectinata	9.1			
				Pedicularis racemosa	2.5			
				Fern (unidentifiable to genus)	2.5			
				Moss	.4			28.5
TOTAL (average):								
Shrubs						53.10		
Grasses							23.40	
Forbs								23.55

Density

Determination of mountain goat density has not been accomplished, with the exception of that by Hjelford (1971). Difficulties associated with mountain gaot inventories on both summer and winter range and the lack of knowledge concerning movement and migration patterns, have precluded the use of this statistic. Data collected in coastal British Columbia during 1974 and 1976 allowed calculation of density by watershed and by elevational class corresponding to general summer and winter range distribution (Table 5) but not by specific habita utilized within each elevational class.

Within the coastal study area, the land area below 305 m (1,000 f) elevation above the riverbed declines from 29 percent in block A watersheds which are generally "U" shaped to 3.1 percent in block C watersheds which are generally "V" shaped. Concomitantly, the area within elevational class 305 - 1,525 m (1,000 - 5,000 f) which includes winter habitat, declines from an

Table 4. Fecal and ruminal nitrogen values of mountain goats as compared to those for mountain sheep on known diets.

Animal or Group	Collection Date	Sex	% Fecal N	% Fecal Protein	% Crude Protein CP	% Ruminal N	% Ruminal CP
Goat	8/76		3.52	22.0	21.81	4.11	25.66
Goat	8/76		3.46	21.6	21.4	4.46	27.84
Goat	4/76		1.19	7.44	6.75		
Migratory Sheep Group	7 & 8/70		2.86	17.9	17.57		
	3 & 4/70		.89	5.6	4.85		

average of 64.2 percent in blocks A and B to 28.6 percent in block C. However, the actual amount of winter habitat utilized varies considerably among watersheds within this elevational class but generally increases from block A to C in association with the increase in density shown in Table 5. To date, it has not been possible to completely delineate and map specific winter habitat utilized within the elevational class 305 - 1,525 m for each watershed.

Summer ranges in all block C watersheds are continuous within each watershed, are approximately similar in biophysical characteristics and do not appear to be limiting in nutritional quality and quantity required for population growth. The summer density of the Klinaklini River watershed reaches 2.41 goats per km^2 (6.23 goats per mi^2) when summer range comprises only 13.1 percent of the watershed while summer range densities of Stanton Creek reach only 182 goats per km^2 (2.13 goats per mi^2) when summer range comprises 61.2 percent of the watershed. Therefore, the Stanton Creek south slope summer ranges could accommodate 129 goats at Klinaklini summer densities. This would produce a wintering density of 6.14 goats per km^2 (15.90 goats per mi^2) on Stanton Creek winter range. Presently, the Klinaklini River winter range elevational class contains only 0.50 goats per km^2 (5.43 goats per mi^2) but does not approach the hypothesized 6.14 goats per km^2 (15.90 goats per mi^2). The quality and quantity of actual winter habitat utilized is greater in the Stanton Creek watershed than in the Klinaklini watershed and accounts for the increased winter densities when summer ranges are similar in biophysical characteristics. However, insufficient winter habitat is available to allow densities to approach 6.14 goats per km^2 (15.9 goats per mi^2). This information indicates that summer ranges are not limiting and that carrying capacity within a watershed is limited by the amount of winter habitat available. This relationship is exemplified in the Franklin River drainage where the winter habitat utilized is likewise reduced and summer range densities are dramatically reduced to .10 goats per km^2 (0.27 goats per mi^2) although available summer range comprises 89.4 percent of the watershed.

An adjacent drainage, Block D, is used for comparison, and although the winter range class (305 - 1525 m) comprises about 70 percent of the watershed, it does not contain a high proportion of good winter range. Thus, total watershed and winter range densities are similar to block B figures. Summer range densities are comparable to some block C drainages.

On the basis of total watershed densities, block C drainages rate one to four in density (Table 6), block B rates five (as would Gatto-Atwaykellesse) and the low elevation, rounded valley bottom drainages follow (block A).

It has been determined that mountain goat densities vary among watersheds, based on physical parameters of the watershed and on qualitative descriptions of their component summer and winter ranges.

Group Size

Group size data has been regularly collected for mountain goat populations over many parts of their range (Brandborg 1955, Kerr 1965, Hebert 1967, Cowan, pers. comm., Holroyd 1967, Kuck 1973, 1976). There has been little or no management application of this type of information.

Table 5. An estimation of mountain goat density in Knight Inlet and Wakeman Sound according to the area of the total watershed and elevational designations of winter and summer range.

Mountain Block	Watershed Group	Elevation In Meters	Area (Sq. Km.)	% Of Area	% Of Area Below 305 M	No. Goats	Density 1974 (Sq. Km.)	No. Goats	Density 1976 (Sq. Km.)
A	Matsiu River	Watershed	214.7						.02
	Sallie Creek	305-1525	150.5	70.1	28.7			5	.033
	Kwalate River	1525+	2.59	1.2					1.93
B	Ahnuhati River	Watershed	592.9				.097		.08
	Hills Creek	305-1525	345.8	58.3	23.9	58	.17	48	.14
	Sim-McMynn Creek	1525+	105.7	17.8			.55		.45
C	Klinaklini River	Watershed	104.6				.32		
		305-1525	65.8	62.9	24.0	33	.50		
		1525+	13.7	13.1			2.41		
	Hoodoo Creek	Watershed	110.3				.25		.32
		305-1525	28.5	25.8	16.5	28	.98	35	1.23
		1525+	63.7	57.7			.44		.55
	Stanton Creek	Watershed	146.9				.22		.30
		305-1525	33.4	22.8	18.5	33	.99	44	1.32
		1525+	86.5	58.7			.38		.51
	Stanton Creek (South Aspect Only)	Watershed	87.5						.51
		305-1525	21.0	24.0	14.8			44	2.10
		1525+	53.6	61.2					.82
	Franklin River	Watershed	272.5				.09		
		305-1525	20.5	7.5	3.1	25	1.22		
		1525+	243.7	89.4			.10		
D	Catto Creek	Watershed	332.6						.07
	Atwaykellesse Creek	305-1525	233.6	70.2				24	.10
		1525+	49.7	14.9	14.9				.48

Table 6. Importance of the watershed based on density.

Watershed	Area (Sq. Km.)	Year	Number Goats	Watershed Density (Sq. Km.)	Order by Density
		1974	28	.25	
Hoodoo Creek	110.3	1976	35	.32	3
Klinaklini River	104.6	1974	33	.32	1
Franklin River	272.5	1974	25	.09	4
Stanton Creek	146.9	1976	44	.30	2
Sim Creek Hills Creek McMynn Creek Ahnuhati River	592.9	1976	48	.08	5
Matsiu River Sallie Creek Kwalate River	214.7	1976	9	.02	6
Catto Creek Atwaykellesse Creek	332.6	1976	24	.07	5

A comparison of mountain goat information from coastal British Columbia, the East Kootenay and northern British Columbia (Foster 1976) indicates that group size and the proportion of family groups to total groups may relate to the productivity of the ecotype. In addition, group size appears to relate to the winter range type fround in the three regions and especially to the snow conditions of each area.

The relationship of social organization to productivity indicates that block C drainages of coastal British Columbia have low productivity (13.9 percent kids) associated with a reduced group size of 1.69 (Table 7) and a low proportion of family groups (19.8 percent). In the East Kootenay, higher productivity (21.3 percent kids) is associated with a larger group size of 2.29 (2.75 if aggregations are included) and a higher proportion of family groups (34 percent).

Similar relationships between productivity and social organization from other areas of the Rocky Mountains compare to those of the East Kootenay. Kuck (1976) found that productivity of Idaho mountain goat populations was 20.1 percent kids when group size approached 2.1 goats per group while Holroyd (1967) found an average group size of 6.3 goats associated with a productivity of 33.7 percent in Kootenay National Park.

This relationship with an ecotype may allow stratification of harvest regimes by watershed groups. For example, the low elevation block B watersheds which are generally "U" shaped and have milder winters have an average group size of 1.85 and contain approximately 31 percent family groups in relation to productivity of 16.7 percent.

A comparison of band size frequency between the coast and East Kootenay (Table 8) indicates major differences in the smaller group sizes. Approximately 67 percent of the groups observed on the coast were single animals whereas only 39 percent of the groups in the East Kootenay were single animals. All group size categories above one are larger for the East Kootenay populations than for the coastal population. There are minor differences between the single group category of block C (67 percent and that of block A and B (60 percent) of the coast.

When aggregations are included in the East Kootenay group sizes the smaller group sizes decline slightly while the intermediate group sizes increase above those of the East Kootenay groups without aggregations.

With the exception of two groups the largest group size on the coast is six animals. In the East Kootenay there is a representative number of groups from six to nine.

Productivity

The establishment of productivity and recruitment rates should be prerequisite to development of harvest rates and harvest regimes. A comparison to southern British Columbia ecotypes indicates

Table 7. A comparison of group size between the Rocky Mountains and the Coastal Mountains and within mountain blocks of the Coastal Mountains in British Columbia.

Area	Mountain Block	Survey Date	Number				Average Group Size
			Groups	Adult Groups	Family Groups	Goats	
Hoodoo Cr. Klinaklini R. Franklin R. Stanton Cr.	C	1974	106	85	21	181*	1.70
Hoodoo Cr. Klinaklini R.	C	1975	9	7	2	15	1.66
Klinaklini R. Stanton Cr.	C	1975	22	19	3	30	1.35
Hoodoo Cr.	C	1976	8	5	3	20*	2.50
Stanton Cr.	C	1976	27	22	5	44	1.62
TOTAL OR AVERAGE			172	138	34	290	1.69
Ahnuhati R. Hills Cr. Sim Cr. Glacier Bay	B	1976	26	18	8	48	1.85
Matsiu R. Sallie Cr. Kwalate R.	A	1976	3	2	1	4	1.33
Wakeman R.	D	1976	13	9	4	24	1.85
TOTAL OR AVERAGE			42	29	13	76	1.81
Matsiu R. Sallie Cr. Kwalate R. Ahnuhati R. Franklin R.	A, B, C	April 1976	18	16	2	22	1.22
East Kootenay	Purcell Rockies	1965-67	249	165	84	569	2.29
East Kootenay**	Purcell Rockies	1965-67	207	123	84	569	2.75

* - Omitted one aggregation
** - Included aggregations

(Table 9) that recruitment of coastal goat populations is 13 percentage points lower than that for the Okanagan (south central) but only 2.5 percentage points lower than for the East Kootenay study area. Similarly productivity for the coastal area is 7.4 percentage points lower than that for the East Kootenay.

In the Rocky Mountain chain, the East Kootenay results are similar to the Willmore Wilderness area of Alberta (Hall, pers. comm.) and Idaho (Kuck 1976) but productivity is 12.4 and recruitment 21.5 percentage points lower than that found by Holroyd (1967) for an unhunted population in Kootenay National Park. However, due to the nature of the range in the Park, family groups may be more visible than males or solitary females.

Considering the difficulties associated with establishing sex ratios in mountain goat populations it is presently more appropriate to compare productivity and recuitment figures by ratios based on 100 adults. The East Kootenay and Willmore data collected along the Rocky Mountain chain are comparable (29.6, 9.5, and 31.0, 12.4, respectively) and approximately twice as high as those

Table 8. Frequency distribution of mountain goat group sizes in the Rocky Mountains and within Coastal Mountain blocks of British Columbia.

Area	Mountain Block	Survey Year	Band Size Frequency Percent 1	2	3	4	5	6	7	8	9	10
Hoodoo Cr. Klinaklini R. Franklin R. Stanton Cr.	C	1974 - 1976	(115)* 66.9	(31) 18.0	(11) 6.4	(7) 4.1	(3) 1.7	(3) 1.7			(1) 0.6	(1) 0.6
Matsiu R. Sallie Cr. Kwalate R. Ahnuhati R. Sim Cr. Glacier Bay Wakeman R.	B + A Wakeman	1976	(22) 59.5	(8) 21.6	(3) 8.1	(3) 8.1	(1) 2.7					
East Kootenay	Purcell Rockies	1965 - 1967	(98) 39.4	(80) 32.1	(31) 12.4	(15) 6.0	(9) 3.6	(8) 3.2	(2) 0.8	(2) 0.8	(4) 1.6	
East Kootenay**	Purcell Rockies	1965 - 1967	(73) 35.3	(52) 25.1	(30) 14.5	(15) 7.2	(12) 5.8	(9) 4.3	(6) 2.9	(4) 1.9	(6) 2.9	

* Number of groups
** Includes aggregations.

Table 9. A comparison of sex and age ratios between regions in British Columbia and within Coastal Mountain blocks.

Area	Mountain Block	Survey Date	Total Goats	------- Adults -------					---- Percent ----			Kids/ 100 Ad.	Yrl./ 100 Ad.	Kids/ 100 Female	Yrl./ 100 Female
				Male	Female	Unid.	Yrl.	Kid	Ad.	Yrl.	Kid				
Mateia R. Sallie Cr. Kwalate R.	A	1976	5												
Ahonhati R. Hills Cr. Sim Cr.	B	1976	48	5 (19)	10 (19)*	23	2	8	79.2	4.2	16.7	21.1	5.3	42.1	10.5
Hoodoo Cr.	C	1974	28	-- (13)	-- (13)	26	--	2	92.8	----	7.2	7.7	----	15.4	----
		1976	35	2 (14)	11 (14)	15	1	6	80.0	2.9	17.1	21.4	3.6	42.9	7.2
Klinaklini R. (East & West)	C	1974	69	-- (30)	8 (30)	52	1	8	87.0	1.4	11.6	13.3	1.7	26.7	3.3
Franklin R. Crevice Cr. Fissure Cr.	C	1974	42	2 (17)	2 (18)	31	2	5	83.3	4.8	11.9	14.3	5.7	27.8	11.1
Stanton Cr.	C	1974	33	2 (14)	4 (14)	22	2	3	84.8	6.3	9.1	10.7	7.2	21.4	14.3
		1976	44	19	19	--	--	6	86.4	----	13.6	15.8	----	31.6	----
TOTAL OR AVERAGE - C BLOCK			251		205		11	35	81.7	4.4	13.9	17.1	5.4	34.0	10.7
Wakeman	D	1976	24	-- (9)	1 (10)	18	--	5	79.2	----	20.8	26.3	----	50.0	----
East Kootenay**		1965-67	569	244 (284)	165 (285)	--	39	121	71.8	6.9	21.3	29.6	9.5	73.3 42.5	23.6 13.7
Okanagan		May 1976	69	-- (28)	-- (29)	57	12	--	82.6	17.4	----	----	21.1	----	41.4
Willmore		1973-75	856	60 (298)	150 (299)	387	74	185	69.7	8.6	21.6	31.0	12.4	61.9	24.7

*50:50 Sex Ratio Based on 1976 Stanton Creek Survey. **Male - Female Ratio - 147.9/100 collected in block C drainages (17.1 and 5.4, respectively) of the coastal mountains. However, the recruitment figure for the Okanagan (21.1 yearlings per 100 adults) is approximately four times greater than that for the coast and twice as great as that for the Keast Kootenay area of British Columbia. This may result from milder winters, better wintering conditions in general and lack of hunting pressure (closed season) and human harassment.

A 50:50 adult sex ratio was established in the Stanton Creek drainage (Table 9) and was used to calculate kid and yearling ratios for every 100 females in the remaining coastal drainages. Sufficient animals were identified in the East Kootenay ground surveys to establish an adult sex ratio of 147.5 males per 100 females. By comparison, (Table 9) there were approximately twice as many kids and yearlings per 100 feames in the East Kootenay population as in the coastal population.

If the East Kootenay population contained a 50:50 sex ratio, there would be 25 percent more kids and 28 percent more yearlings for every 100 females, as compared to the coastal goat population. Similarly, if the Willmore population contained a 50:50 adult sex ratio, the productivity and recruitment ratios would be approximately double those of the coast. A basis for comparison of productivity and recruitment ratios per 100 females must depend on establishment of accurate sex ratios among adults.

Harvest

In order to adequately assess population status, it is necessary to relate sex and age ratios obtained from survey information, to harvest and natural mortality rates for the same land unit. Unfortunately, the two systems of data collection have not been tied to the same land unit for most, if not all, of British Columbia. In addition, the British Columbia hunter questionnaire requested hunters to locate their kill to the nearest watershed, landmark or post office. The post office designation is completely inadequate as these goat kills cannot be allocated to a specific watershed. It is not known what portion of the sample is lost because of this system of location.

Hunter harvest information is particularly important for mountain goat management, because sex categories are difficult to ascertain in the field except by an experienced observer, and age categories are impossible to differentiate above the yearling age class. In addition, the great disparity in productivity and especially recruitment rates for British Columbia mountain goat ecotypes necessitates that mortality rates be monitored and be in proportion to recruitment. Dramatic declines have occurred in the goat populations of the Okanagan (British Columbia Fish and Wildlife records 1976), the East Kootenay (Phelps et al. 1976) and Alberta (Quaedvlieg et al. 1973) when these criteria have not been considered.

Unfortunately, British Columbia regulations, season lengths and bag limits were consistent for most of the Province and excessively liberal.

Recruitment rates of coastal goat populations are exceptionally low (4.4 percent yearlings), indicating that the growth rate of the population would be extremely sensitive to the form of the mortality curve and to the effects of hunter harvest on the integrity of the family groups. Considering the inability of hunters to differentiate sex and age categories, it is suggested that hunter harvest should be no more than 4 percent of the total population or less than 5 percent of the adult population. As an example, a maximum of nine animals could be harvested from the 1974 surveyed coastal population of 205 mountain goats (179 adults), using a crude level of knowledge of population structure and assuming natural mortality was insignificant. Known causes of natural mortality include snowslides, falling and wolf and cougar predation all of which may account for 2 percent of the adult mortality (above yearling class). Therefore, only five animals remain to be taken by hunter harvest. If natural mortality accounts for 4 percent, then only two animals remain for hunter harvest.

Natural mortality in coastal goat populations may occur at a constant rate from age 1.5 to 10 - 15 or be concentrated in the oldest age classes. If female and male mortality occurs at a constant rate from age 1.5, potential productivity (3.5 - 10.5 years) would be reduced as would the availability of trophy males. If female and male natural mortality is concentrated in the oldest age classes (10 - 15 years), the availability of trophy males would be higher and the impact on production and rate of growth of the population would be lessened. In either case, the removal of potentially productive females by harvest may lower productivity and recruitment through disruption of the family group. If coastal goat populations are maintaining themselves at somewhat static levels, the form of the mortality curve may be relatively insignificant considering the low recruitment, and therefore, the low natural mortality. In either system, hunter harvest should be concentrated in the oldest male age classes (although not possible under current regulations) if compensatory mortality is involved.

According to group size characteristics (Table 7) and winter range descriptions, the integrity of the family group appears to be an important consideration in maintenance of recruitment to the population. If dominant females in the family group are removed during the fall hunting season, it is possible that winter survival of yearlings and kids may be lowered, especially under the harsh, restrictive coastal conditions.

Available data (Table 10) suggest that both recruitment and productivity may decline when hunting pressure shifts from light to heavy. The observed male and female ratio shifts from 156 per 100 to 65 per 100 females in response to hunter harvest. Since the ratio changes by a factor of 1, the ratio of kids per 100 adults remains approximately equal. The proportion of males in the population declines about 10 percentage points while the female segment appears to increase about 20 percentage points. However, productivity declines 37 percent and recruitment 55 percent in response to an increase in hunter harvest, a resultant change in population structure and a possible realignment in use of winter habitat. Unfortunately, accurate harvest data are lacking for these specific areas and for a sufficient time period to allow assessment of the relationship.

Analysis of the East Kootenay hunter harvest data from 1963 - 1968, inclusive, (Phelps et al. 1976) suggested that 138 males were harvested for every 100 females, with an average yearly harvest of 183 animals. Concomitantly, average age of the harvested animals declined with time and as the population declined. These figures indicate that sufficient potentially productive females were extracted each year to produce a negative effect on the population through changes in productivity and disruption of family groups (recruitment). The information in Table 10 supports this contention; however, it should be tested experimentally through removal of dominant females or by closer land unit alignment of inventory and harvest information.

On the basis of low recruitment rates, the inability of hunters to sex and age individuals of a goat population and a minimum 2 percent natural mortality rate, it is questionable that hunter harvest can be considered compensatory even in the most generous sense.

It has been estimated recently that there are approximately 9,400 (maximum) mountain goats in Region 4 (East and West Kootenay) based on subjective density estimates (Blower 1977). If the population consisted (Table 9) of 21 percent kids (1,974 kids), 7 percent yearlings (658 yearlings) and 72 percent abuldts (6,768 adults, regardless of sex ratio) the basic recruitment can be compared to the average annual harvest. The post-hunting density estimate (Blower 1977) is undoubtedly below the population available during the peark harvest of the 1960's. Therefore, if the population was arbitrarily increased by 50 percent (14,100), harvest and recruitment can be compared to give a range of possible population trends. These calculations are conservative in that they assume harvest was distributed evenly throughout the population. As shown by Phelps et al. (1976) hunter harvest was concentrated by watershed with time.

In order to formulate a harvest-recruitment relationship for the East Kootenay population a recruitment rate of 7 percent of the total population is suitable, rather than the ratio of 9.5 yearlings per 100 adults, since yearlings formed a portion of the harvest. Concomitantly, approximately 680 mountain goats per year (including both sexes and all age classes) were harvested in Region 4 (Hunter sample, British Columbia Fish and Wildlife Branch).

At 7 percent recruitment, approximately 520 animals could be harvested per year, from a population of 9,400 animals. Therefore, about 160 animals per year were harvested in excess of the possible recruitment rate of 7 percent.

Since Phelps et al. (1976) have shown that individual watersheds or areas were harvested intensively over short periods of time, the harvest effect above recruitment increases. If heavy hunting pressure can reduce both productivity and recruitment (55 percent) (Table 10) in addition to hunter harvest, it is obvious why populations in specific watersheds crashed after two to three years of hunting.

If the original population was 14,000 animals and 21 percent were kids (2,940 kids), the harvest, based on recruitment, could be approximately 775 animals (at 7 percent recruitment) which would be about 95 animals above the actual harvest rate of 680 animals. However, as potentially productive females and yearlings were being harvested, an evenly distributed harvest would soon outstrip recruitment. An intensive harvest by watershed (the effects of heavy hunting pressure) would increase the population decline accordingly.

There is speculation that harvest of adult animals, especially males, could stimulate greater productivity in mountain goat populations. There are a variety of factors which prevent this from happening:

(1) age and sex classes are indistinguishable for most hunters;
(2) distribution of hunter harvest is difficult and expense to control;
(3) removal of potentially productive females disrupts family groups and reduces productivity;
(4) winter range distribution, especially on the coast indicates that removal of adult males and females may not allow utilization of that range by other animals in most winters.

Table 10. A comparison of sex and age ratios in lightly and heavily hunted goat populations in the East Kootenay.

Class	All Salt Licks			Unhunted and Lightly Hunted Areas				Heavily Hunted Areas			
	n	: 100 Adults	: 100 Females	n	Percent	: 100 Adults	: 100 Females	n	Percent	: 100 Adults	: 100 Females
Males	210		126.5	175	37.1		156	35	28.2		65
Females	166			112	23.7			54	43.5		
Yearlings	40	11	24	33	6.9	12	29	7	5.6	8	13
Kids	120	32	72	92	19.5	32	82	28	22.6	31	52

Analysis of inventory and harvest statistics has indicated that regulations and harvest regimes must differ according to the ecotype, that traditional biological reasoning for other species must be discarded in relation to goat biology, that population stimulation through removal of adult animals may not be viable at this time, that the role and integrity of the family group must be researched more thoroughly and that experimentrl manipulation of populations must take place in order to better understand the effects of hunter harvest on mountain goat populations.

Habitat Protection

In British Columbia few activities are detrimental to mountain goat summer ranges. However, certain East Kootenay and northeastern British Columbia goat summer ranges are being destroyed by strip mining for coal. Harrassment, associated with strip mining operations, and currently regulated and unregulated hunting activity often produce detrimental impacts on goat populations. At present, this is not an important consideration in much of the coast mountain ranges.

Timber harvest activities in the East Kootenay and coastal regions of British Columbia can often produce detrimental effects on goat winter ranges. In most areas of south coastal British Columbia logging per se does not reduce goat winter ranges because logging access is restricted by the steepness of the valley and number of bluffs paralleling the valley floor.

However, upon termination of logging below the bluffs most areas are slash burned to remove debris and reduce the fire hazard. Often, slash fires escape and fringe burn goat winter ranges above the bluffs, destroying the snow shedding canopy and the ground forage.

Protection of coastal mountain goat winter ranges entails correct placement of roads and cutting blocks away from goat ranges where access is possible and control of post-logging activities.

In the East Kootenay, logging per se can destroy goat winter ranges on steep bluff areas in the subalpine spruce-fir biogeoclimatic zone. Slash burning is not prevalent and fringe burn does not usually occur in high enough frequency to affect goat ranges. Extensive access often promotes overhunting, especially where inventory data, regulations and designation of hunter kill is inadequate to monitor the situation.

In order to protect these ranges and associated populations, wintering populations must be identified through aerial surveys, ground counts or through concentration of pellet groups. In addition, summer suveys will allow assessment of total numbers per area and assessment of priorities during protection of winter ranges.

Salt Licks

Analysis of salt lick material and studies describing lick use by several species of ungulates (Carbyn 1975, Hebert 1967, Dalke et al. 1965, Jordan et al. 1973) have been undertaken in interior areas of North America for many years. There are few instances where natural salt licks have been found adjacent to salt water (Hebert 1967, Heimer, pers. comm.). During the 1974 aerial survey in Knight Inlet a salt lick was discovered on the laterial moraine of a receding glacier in Stanton Creek, approximately eight miles from salt water. The area containing the lick is mainly composed of quartz diorite material.

Early investigators (Stockstad 1953, Smith 1954) found that sodium componds, especially sodium bicarbonate, were preferred by big game animals. Other workers examined licks for their chemical content and suggested that sodium compounds were prominent in most licks and appeared to be the source of attraction to big game (Knight and Mudge 1967, Heath 1942). Recent work (Weeks and Kirkpatrick 1976, Blair-West et al. 1968, Hebert and Cowan 1971) provides physiological evidence that sodium is the primary source of attraction. Jordan et al. (1973) suggested that sodium may be a limiting factor in Isle Royale moose and attempted to calculate the sodium balance. Noting the lack of sodium in most plant species, except some aquatics, they postulate that sodium balance in moose is aided by mineralized storage in hard tissue and substituion of potassium for sodium in saliva, and therefore, in rumen fluid. This has recently been questioned by Weeks and Kirkpatrick (1976).

Development of a conceptual model is required to display the physical and chemical determinants of sodium balance (Fig. 2). It has been determined that sodium values of alpine and winter range vegetation available to mountain goats in the East Kootenay are extremely low (Hebert and Cowan 1971) and that sodium probably serves little or no function in most plant species (Lehr 1941, Harmer and Benne 1945, Epstein 1972). However, certain coastal forage species (Vaccinium, Rubus, Oplopanax) may contain 100 - 900 ppm sodium while plant species growing in or near seepage sites may contain 1,000 - 8,000 ppm sodium (Klinka 1976).

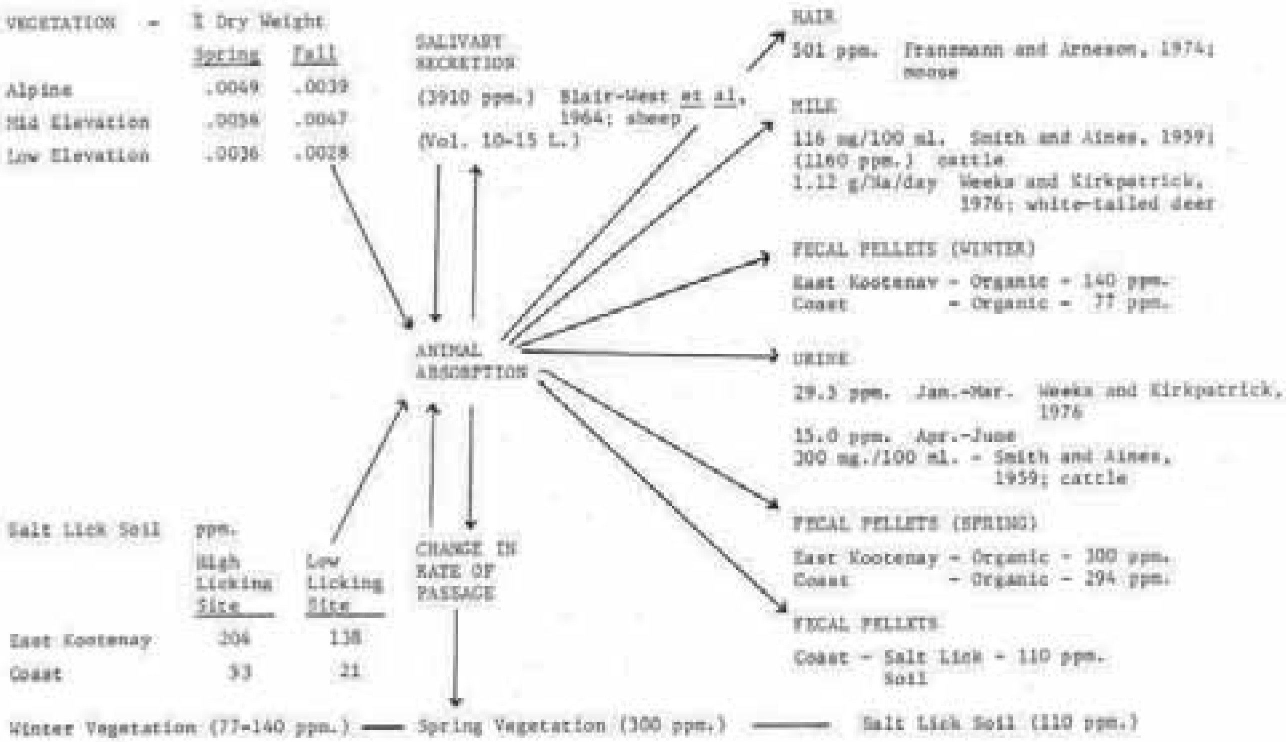

Figure 2. A physical and chemical mechanism for regulation of sodium balance in mountain goats.

Salt lick soil samples for the East Kootenay range from 204 ppm to 138 ppm in high and low licking sites, respectively. Thus, the sodium intake available to wild ungulates may be extremely low with the exception of some coastal vegetation and certain high licking sites. Comparison of the interior and coastal salt licks indicates that chemical content alone may not be sufficient to prevent a negative sodium balance. Thus, postulation of a physical mechanism was necessary to explain control of sodium balance.

Frens (1958) demonstrated that sodium depletion in cattle could result from excessive sodium loss in the fecal material during an increased rate of passage in the spring. Experimental work with East Kootenay mountain goats indicates an increased rate of sodium loss (an increase from 140 to 300 ppm) during a potential increased rate of passage when winter range forage was changed to succulent spring forage. Fecal material was collected near the coastal salt lick in 1976 from goats utilizing winter range forage (hard fibrous pellets) (77 ppm sodium) and from those utilizing new growth forage (294 ppm sodim). The similarity in sodium values between regions while goats are utilizing succulent forage may indicate similarities in the physiological process. It is likely that much of the sodium loss occurs when salivary sodium (3,900 ppm) (Smith and Aines 1959) is removed during the increased rate of passage.

It would appear that the sum of potential sodium loss (milk - 1,160 ppm; hari - 500 ppm (Franzmann and Arneson 1974); urine - 25-29 ppm (Weeks and Kirkpatrick 1976); organic fecal pellets - 300) during the spring and early summer seasons cannot be counterbalanced by the available sodium in the soil and vegetation.

Thus, the chemical process cannot maintain sodium balance.

However, if salivary sodium contributes to sodium loss during increased rate of passage, then a reduction in that rate of passage, regardless of the chemical content of either soil or vegetation, could reduce sodium depletion through an increased rate of absorption (Figure 2).

Thus, when goat fecal material contains 300 ppm when the animal is utilizing succulent vegetation it contains only 110 ppm when the animal is utilizing salt lick soil.

It can be postulated that this system (salt lick soil) reduces the rate of passage at a time when mountain goats are approaching or have reached negative sodium balance. Therefore, as rate of passage is reduced, absorption of salivary sodium, soil sodium and vegetation sodium is increased and fecal sodium loss is reduced.

The sodium balance concept in moose differs from that of mountain goats. Moose can obtain more sodium through their feed (1,000 - 9,000 ppm in submerged and floating plants) and less through their lick material (25 ppm). It would appear that balance by chemical means is more prevalent in moose than in interior goats. If mineralized storage and potassium substitution are functional systems, both could be operative in goats.

Discussion and Conclusions

The development of management systems for mountain goat must depend upon the recognition of population and habitat characteristics of each ecotype. The establishment of productivity and recruitment rates should be prerequisite to development of harvest rates and harvest regimes. The preceeding sequence did not occur in British Columbia for mountain goat during the period 1950-1975 and occurred only infrequently in adjoining States or Provinces. Harvest systems for goats, instituted under traditional biological reasoning appropriate to other species, produced dramatic declines in East Kootenay (Phelps et al. 1976) and Okanagan (Fish and Wildlife Branch 1976) goat populations. Similar harvest systems may now be affecting goat populations of northern British Columbia. Goat populations of coastal and interior ecotypes have significantly different productivity and recruitment rates but have been subjected to standardized liberal seasons and bag limits. In conjunction with an increase in access to interior populations, severe declines resulted. Under similar regulations, most coastal goat populations were spared through limited access to the coastal mainland.

Consideration of all forms of natural mortality indicates that hunter harvest in coastal populations was probably additive rather than compensatory. Extremely low recruitment rates of four to five percent would likely allow declines in most coastal goat populations under existing levels of natural mortality and limited hunter harvest.

Similarly, the relationship of population estimates by density calculation, harvest rates from the hunter sample and inventory information on recruitment for the East Kootenay area indicated that hunter harvest exceeded recruitment. In addition, hunter harvest was concentrated by watershed through time, rather than distributed evenly throughout the population; therefore, harvest greatly exceeded the estimated recruitment. Populations were lowered so substantially in each watershed that recovery was not possible except over long time periods. If intensive hunting pressure reduces producitivity and recruitment rates, then the hunter harvest experienced in the East Kootenay was further damaging to the population.

Winter surveys indicate that mountain goats inhabit winter ranges from sea level to about 1,372.5 m (4,500 f) elevation within 30 - 50 km of the coast. Further inland, goats can winter at higher elevations where the moisture content of the snow is reduced and where wind can remove the snow. Preliminary analysis of goat survey data from the west and east slopes of the coast range (Forbes, pers. comm.) indicates that productivity may be lower within the narrow coastal band and higher on the east slopes.

Concomitantly, the small group sizes of the outer coast (block C) mountains are associated with harsh and restrictive winter conditions, whereas in the interior, larger group sizes are associated with snow free high elevation winter ranges and less restrictive snow conditions of the subalpine zone. The large group sizes of the northern populations (average group size: 8 - Foster 1976) are associated with extensive high elevation snow free areas and reduced areas of subalpine spruce-fir winter ranges.

On the coast, at least, summer range group size appears to be a function of the restrictive nature of the winter range. The majority of summer range on the coast is continuous, similar to that of the East Kootenay. Therefore, it is not likely that the reduced group size is determined by summer range conditions. The number of family groups, as well as family group size may be reduced if harsh winter conditions reduce carrying capacity on individual ranges and restrict productivity. This should result in a reduction of average group size. The separation of family groups and single males and females appears to continue throughout the summer.

Coastal data indicates that summer range is unlikely to be limiting, that a minimum of 10 - 15 percent of an area as summer range is adequate, that most summer ranges are underutilized and that winter range densities are dependent on specific habitat characteristics rather than on an elevational class. The utilization and association of specific winter habitat types with the integrity of the family group appears to be an important point in the maintenance of goat herds. Clearer depiction (quantification) of the specific characteristics and actual amount of winter range utilized within each mountain block will allow a more accurate estimate of winter range distribution and density (based on surveys of summer populations) and categorization of the carrying capacity of various drainages and mountain blocks.

A series of secondary factors can also be considered during the management of mountain goats. Mountain goat distribution in the coastal study area is partially related to geological formation.

Within any geological group, however, both summer and winter distribution is dependent on south aspects. A comparison of group size between the coastal and interior ecotypes indicates that it may be related to productivity and may be useful in determining harvest regimes. The relationship of adult to family groups may be especially important. For example, actual numbers of goats and density estimates for blocks A, B and D were considerably lower than for block C, yet it appears that group size and percent family group information indicates higher productivity. Actual productivity for these low elevation and low density areas is higher and is supported by lower group size frequency of the single animal class. Density levels appear to be controlled by the actual amount of winter habitat available while productivity may be related to the differences in snow type and depths, temperature regimes and forage availability in each mountain block. However, the determination of group size must be standardized among workers. To date, group size information has been collected seasonally, by physiographic unit and by behavioral characteristic. This has produced data which is a combination of individuals, groups and aggregations and which has had little use for management.

The formation of group size in goats can be a function of the sex ratio of the population. Males occur as single animals more often than females (family groups), and therefore, the establishment of group size relationships with producitivyt and winter range conditions can be nfluenced by sex ratios. Thus, part of the difference in group size between the coast (unhunted populations) and East Kootenay (hunted) may be attributed to the effect of hunting on the sex ratio. Similarly, within the East Kootenay ecotype, Holroyd (1967) determined a group size of 6.3 for goats in Kootenay National Park. This elevated group size could be a function of lack of standardization during determination of groups and aggregations and the unhunted status of this particular population.

Mountain goats in the East Kootenay make extensive use of natural salt licks in the early spring and summer. A comparison of sodium values of coastal and interior lick soils indicated that chemical content alone was probably insufficient to maintain sodium balance. The sodium content of aquatic forage utilized by moose and certain browse species possibly used by coastal goats while on the winter range indicates that they could supply a sizeable portion of the sodium requirements. However, physical control, through the rate of passage has the potential to regulate salivary sodium loss and aid in the maintenance of sodium balance.

The majority of accessible goat populations has been affected by an abundance of access and harvest pressure and a dearth of population and habitat information. Until a more complete understanding of goat ecology is available managers should maintain a conservative approach to extraction rates.

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