STATUS OF THE RADIUM BIGHORN SHEEP
HERD AND ITS RANGES: 1984-1985

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ABSTRACT

Status of the Radium bighorn sheep herd and its ranges in and adjacent to Kootenay National Park (KNP) was studied during the period April 1984 to March 1985. This was the first year of a 2-year study (1984-86) and represents the full Canadian Wildlife Service (CWS) involvement as the CWS Parks Research Group was eliminated on 31 March 1985.

This report discusses range condition and trend of summer and winter ranges; their productivity and use by bighorn sheep and other ungulates; locations of seasonal ranges including lambing, rutting and lick areas; seasonal forage quality, diet composition and forage preferences; health of the Radium band including seasonal fecal lungworm larval loads; the impact of human activities and a selected bibliography.

On the winter range, the amount of ground covered by living plants increased by 33% on grazed and 21% on ungrazed ranges, during the 18-year period 1966-1984. The preferred native grasses, rough fescue (Festuca scabrella), Idaho fescue (F. idahoensis) and Kentucky bluegrass (Poa pratensis) were present within the range that was ungrazed for 18 years but not on the adjacent grazed range. Grass cover decreased by 75% following 18 years of protection from grazing attesting to the fact that moderate grazing is beneficial to most range grasses. Unpalatable herb species decreased by 58% on the ungrazed range but increased by 97% on the grazed range in 1984 compared with 1966. Total forage production (dry wt.) was 37 g/m^2 on the grazed and 101 g/m^2 on the ungrazed winter ranges and 72 g/m^2 on the grazed summer ranges.

During summer (July), forage protein content of the high elevation, summer range was 14.8% compared with 11.5% on the intermediate

range and 8.2% on the winter range. By September corresponding values had declined to 8.1%, 8% and 6.4%. The forage on winter range became deficient in phosphorus in summer (<0.20%) but at that time the sheep migrated to the alpine range where the forage provided adequate phosphorus for lactation needs.

The winter forage does not meet the minimum phosphorus requirement for gestation of 0.16% and this may partially explain intermittent trips to Sinclair Canyon to lick mineral soil.

Since 1966 the Stoddart Cr. winter range has remained in poor-fair condition despite the fact that livestock grazing ceased in the 1960s. The Radium bighorn sheep band which numbered at least 133 in 1966 (prior to the die-off), 40-45 in 1967, 109 in 1981 and 114 in March 1985, plus small numbers of deer and elk, have maintained this critical, arid range in an overgrazed condition. The intermediate range along Sinclair Canyon is a vital spring and fall range and lick area. Various seeded grasslands provide much of the forage, in particular crested wheatgrass (Agropyron cristatum), creeping red fescue (Festuca ruba), Kentucky bluegrass (Poa pratensis) and yellow sweet clover (Melilotus officinalis).

The summer range at the headwaters of Kindersley and Sinclair creeks is only lightly grazed and in very good-excellent condition. The 1984 stocking rates of bighorns (with total ungulates in brackets), were 0.34 (0.46) animal-unit-months on the winter range and 0.11 (0.14) on the summer range.

The 1984-85 winter population of 114+ bighorns approached earlier peak populations of 133 in 1966 and 140 in 1938. Lamb production and survival rates have remained high. In October 1984 there were 70.0

lambs and 23.3 yearlings per 100 ewes. The October 1984 to March 1985 lamb mortality was 13.6%.

Fecal lungworm larvae loads that averaged 885 larvae/g (lpg) dry feces during the period June 1984 to February 1985 suggest the band is suffering moderate stress from lungworms while on the winter range. Mean loads were 661 in April to May, 316 in June to July, 480 in August to September, 1031 in October to November and 1735 in December to February. Lambs had the heaviest loads with an April to February average of 1145 and 27% heavy (>1400) loads compared with 926 and 24% for ewes and 582 and 9% for rams.

The mean lungworm larvae load in Kootenay National Park during 1968 and 1969 (Uhazy et al. 1973) was 927 larvae/g (124-2728) with 22% having heavy loads (>1400), compared with a mean of 820 for southwestern Alberta plus Kootenay National Park. At that time 44% of Jasper samples, 12% of Banff and 3% of Waterton samples had heavy loads.

Impacts of human activities on this band, including recreational vehicles, human developments, artificial foods and highway mortalities still has to be assessed. More work is required to document the extent and importance of critical lambing, rutting and lick areas.

A 240 page selected bibliography "Annotated Bibliography of Rocky Mountain Bighorn Sheep Specific to the Management of Bighorn Sheep in Kootenay National Park" was prepared and printed separately (Poll and Stelfox 1985). Produced through the SPIRES and TEXTFORM text processing and editing systems at the University of Alberta it is now housed there, administered by the Faculty of Agriculture-Forestry.

Kootenay National Park Warden Service will continue certain aspects of this study during the period April 1985-March 1986.

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ACKNOWLEDGEMENTS

This study has been a team effort between the Canadian Wildlife Service and Kootenay National Park with considerable support and encouragement from the East Kootenay region of British Columbia Fish and Wildlife Branch. We gratefully acknowledge the complete support received from the entire Warden Service of Kootenay National Park.

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The cooperation of the Alberta government is gratefully acknowledged, in particular the following: Bill Wishart (Unit Leader, Alberta Fish and Wildlife Research and Lab Services) for supplying the Baermann apparatus so we could conduct fecal lungworm larvae analysis; Don Laverty, Director, and Dr. Hua Hsu, Laboratory Supervisor, Alberta Agriculture, Soil and Feed Testing Lab, Edmonton for providing use of macro-Kjeldahl equipment for fecal nitrogen determinations and for providing analysis of seasonal forage samples; Heather Walker, for conducting analysis of lungworm larvae and fecal nitrogen.

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1. INTRODUCTION

This study was initiated by Kootenay National Park (KNP) in 1983 because of concern for the welfare of the Radium band of bighorn sheep (Ovis canadensis). Several bands of sheep on provincial land throughout the East Kootenay region south of KNP had suffered severe losses from a bronchial pneumonia condition during 1981-83. This condition was spreading northward along the east side of the Rocky Mountain Trench towards Radium Hot Springs (Demarchi 1983, Davidson 1982). Because the Radium band had suffered severe losses, in excess of 75% of the population in 1938 and 1966 (Cowan 1943, Stelfox 1976a), KNP managers required information on the current health of this band and that of its summer and winter ranges.

A two-year (April 1984 to March 1986) study was to be conducted by the Canadian Wildlife Service (CWS) in cooperation with the KNP Warden Service. The principal investigator was research scientist, J.G. Stelfox, assisted by Wildlife Technician D.M. Poll while the field coordinator was Park Warden B.R. Sheehan.

Information requirements were described as follows:

1. Assess the range condition and utilization of the sheep ranges;
2. Correlate range data to the ecological land classification of KNP (spcifically ecosite and vegetation types);
3. Delineate the extent and condition of summer and winter ranges on appropriate ELC maps;
4. If possible, repeat the 1966 range studies on the Stoddart Creek winter range to determine the trend between 1966 and 1984.
5. Develop and describe a range monitoring scheme that can be conducted by the Warden Service in subsequent years;

6. Describe and map the migration corridors, lambing and rutting areas, and licks;
7. Discuss mortality factors including highway, hunting, poaching and predation;
8. Describe habitat utilization and the quality and use of important forage species by bighorns.

This is a final report for CWS covering only results from the first year's study due to termination of the CWS Parks Research Section on 31 March 1985. Hopefully, Parks Canada can continue the second year of this study and submit a final report in March 1986.

2. STUDY AREA

Kootenay National Park lies within the Rocky Mountains of southeastern British Columbia between 50°34' and 115°48' and 116°22'W (Fig. 1). Southwestern KNP touches on the southern Rocky Mountain trench of which the eastern wall is the western front of the Rocky Mountains (Achuff _et al_. 1984).

The two low elevation study areas lie just north of Stoddart Creek (SCL-A and SCL-B) and just north of Dry Gulch Creek (DG-C and DG-D) in the southwest corner of the park (Fig. 2). Both of these areas occur within an open Douglas fir (05) (_Pseudotsuga menziesii_) vegetation type. The Stoddart Creek range occurs within a polygon DG3/8 of the Montane Ecoregion (Fig. 3), while the Dry Gulch plots occur within a polygon WY2/8c of the Montane Ecoregion (Figs. 4 and 5). Specifics of elevation, aspect and slope are presented in Table 1.

The grassland vegetation of these winter ranges approximates the H19 (_Agropyron spicatum_ - _Elymus innovatus_ - _Aster conspicuus_) type of Achuff and Dudynsky (1984) without the _Elymus innovatus_. This bluebunch wheatgrass - hairy wildrye - showy aster community occurs on subxeric Montane (1000-1160 m) sites with various slopes and southerly aspects in southwestern KNP. Soils are rapidly drained Orthic Regosols on colluvial and glacial landforms. The study sites also resemble somewhat the 05 vegetation type (_Pseudotsuga menziesii_/_Juniperus communis_/_Arctostaphylos uva-ursi_) which overlies both Regosolic and Brunisolic soils on gullied colluvial landforms. These are among the warmest and driest sites in KNP.

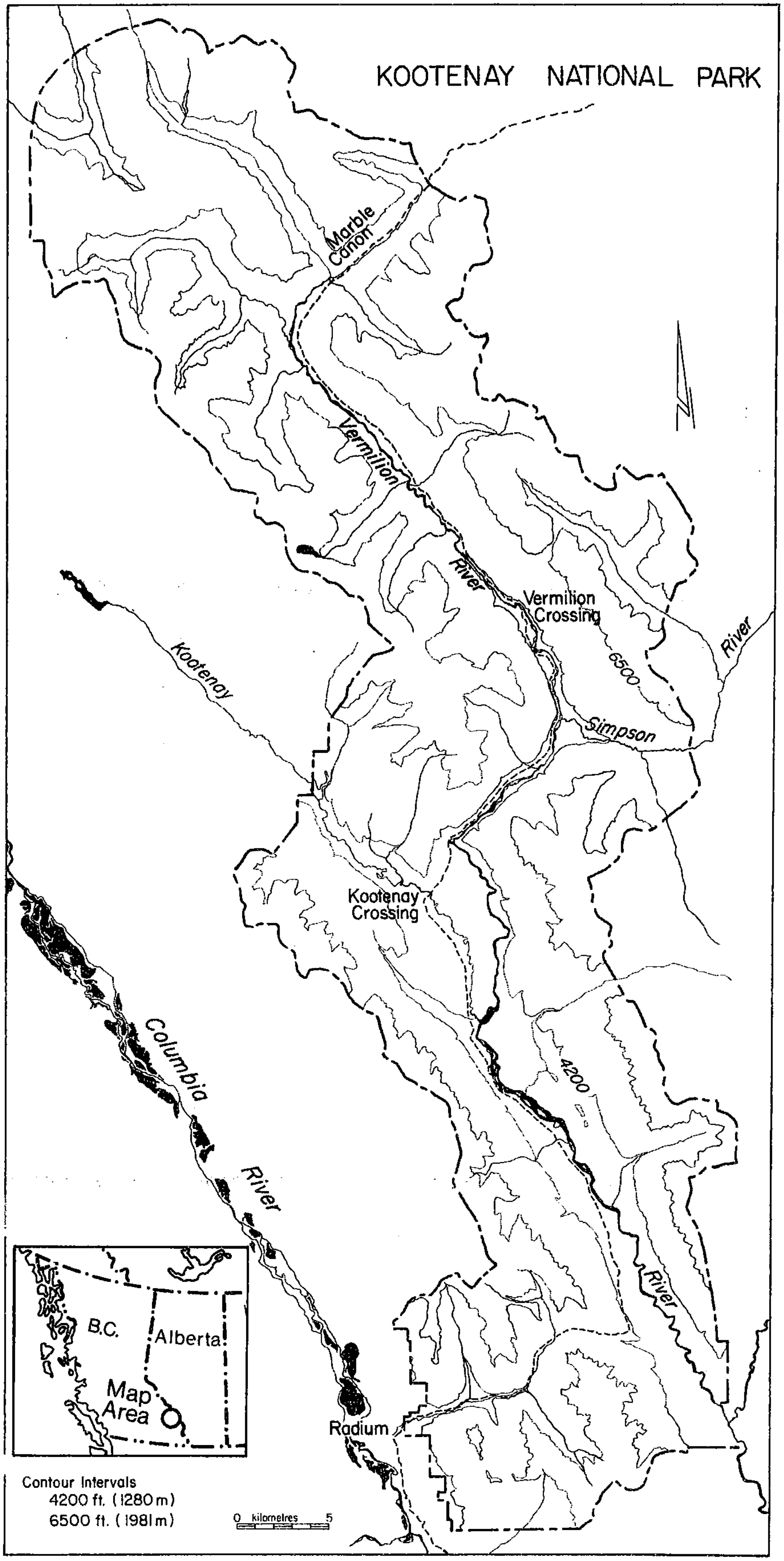

Figure 1. Location and drainage systems of Kootenay National Park (from Achuff et al. 1984).

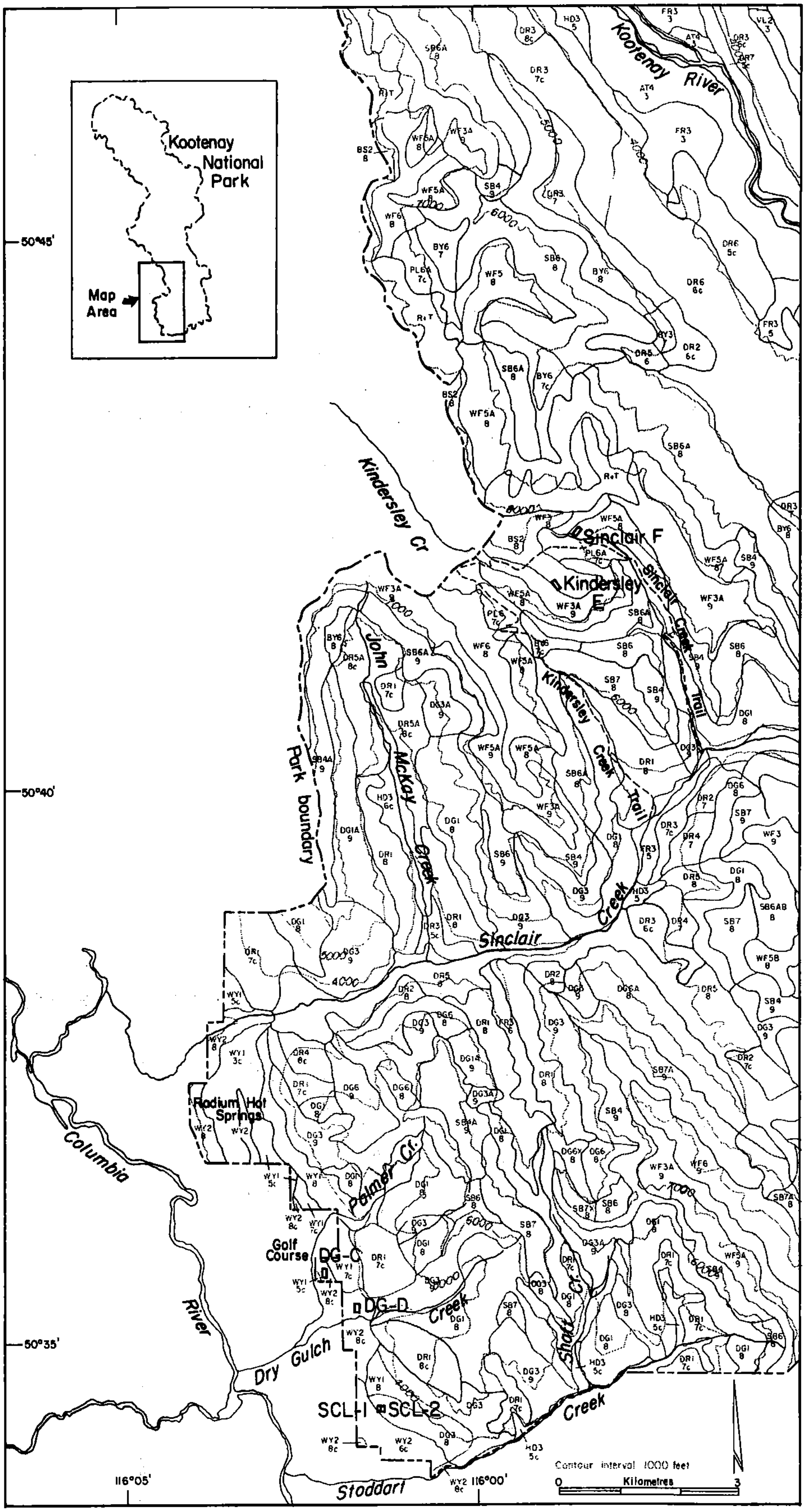

Figure 2. Western portion of Kootenay National Park showing locations of winter and summer range study areas.

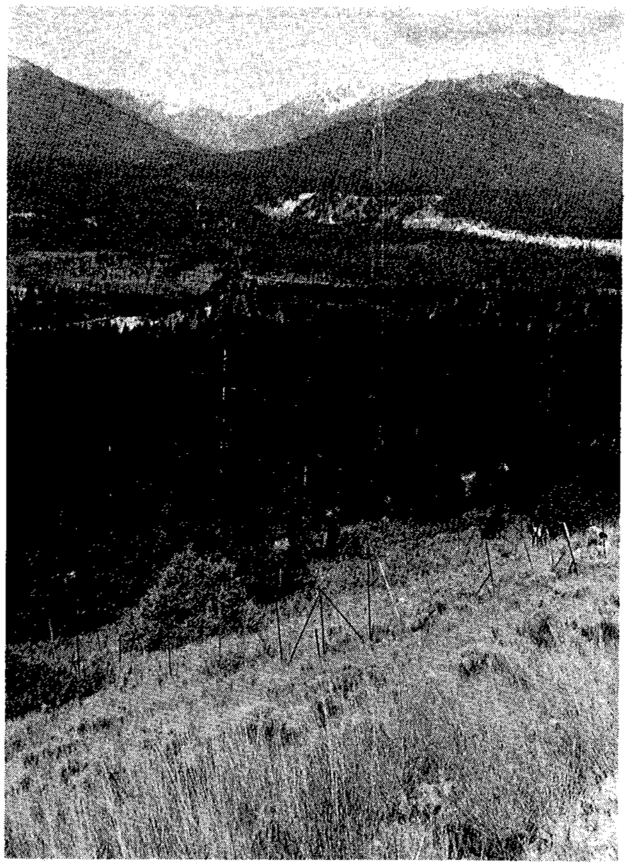

Figure 3a. Looking NW over the Stoddart Creek macroplots towards the Columbia River, July 1984.

Figure 3b. Looking across macroplot SCL-1 (outside) at SCL-2 (inside) the 1966 range exclosure, July 1984.

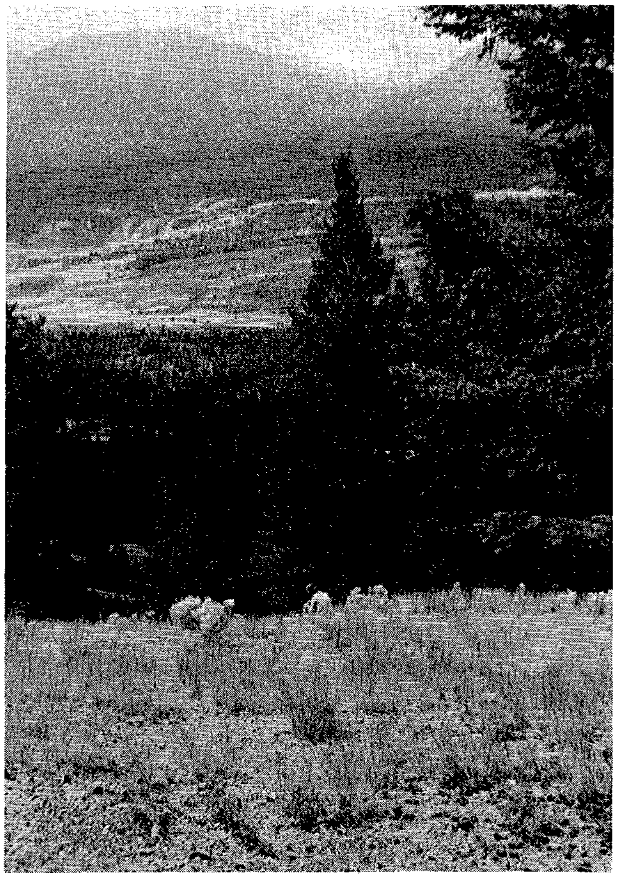

Figure 4a. Looking SW across Dry Gulch Creek (DG-C) macroplot onto the Columbia Valley, July 1984.

Figure 4b. Dry Gulch Creek macroplot (DG-C) above the golf course, looking SW towards the Columbia River, July 1984.

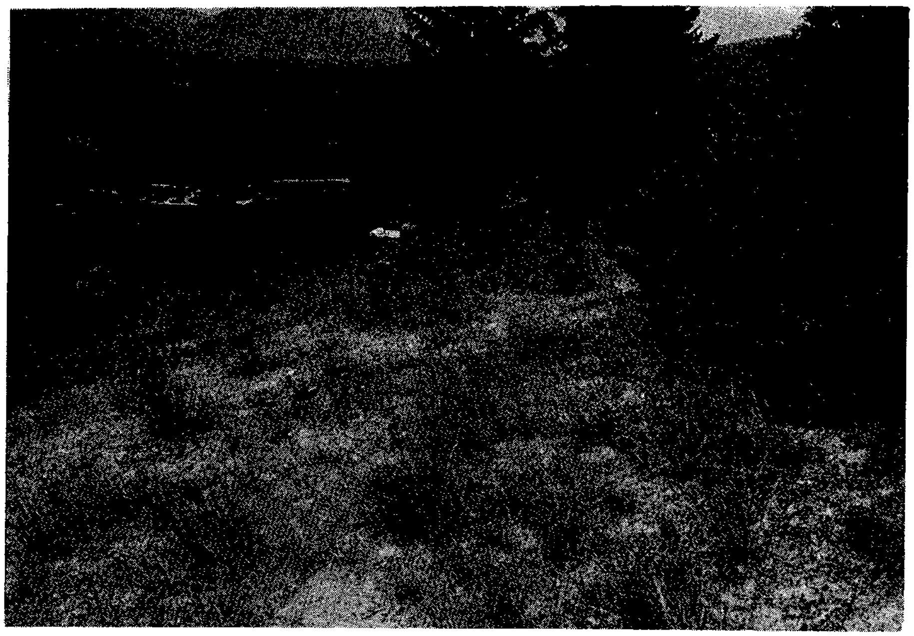

Figure 5. Dry Gulch Creek macroplot (DG-D), just north of the creek, July 1984.

Table 1. Topographical features of winter and summer range study areas.

	Macroplot characteristics				
Study area	Site codes	Elevation (m)	Aspects (°)	Slope (%)	Specifics
Winter ranges					
1. Stoddart Cr.	SCL-1(A)	1052	210 (SW)	68	outside the exclosure
2. Stoddart Cr.	SCL-2(B)	1052	210 (SW)	68	inside the exclosure
3. Dry Gulch Cr.	DG-C	1123	205 (SW)	75	north plot above golf course
4. Dry Gulch Cr.	DG-D	1140	210 (SW)	10	south plot above creek
Summer ranges					
1. Kindersley	E	2260	180 (S)	60	head of Kindersley Creek
2. Sinclair	F	2100	225 (SW)	80	head of Sinclair Creek

Small mammals of these winter ranges are those of Small Mammal Association 1 (Poll and Porter 1984). Deer mice are dominant while others include red-backed vole, yellow-pine chipmunk, long-tailed vole, dusky shrew and Columbia ground squirrels. See Poll et al. (1984) for scientific names of mammals and birds.

Breeding birds are those of Breeding Bird Community (BBC) 3 (Poll and Porter 1984). This community has the second highest average density index (4.9) of all BBC's in KNP. Dominant species are Chipping Sparrow, Yellow-rumped Warbler, Dark-eyed Junco, Golden-crowned Kinglet, American Robin and Mountain Chickadee. Ten other definitive and 21 additional species were listed for this community. This Ecosite is important to Rock Wren and Dusky Flycatcher.

The DG3 Ecosite (Fig. 2) is rated as very highly important to wintering bighorn sheep and mule deer in the Stoddart Creek area. Two DG3 tracts with bluebunch wheatgrass - hairy wild rye - showy aster (H19) and Douglas fir - Ponderosa pine/bluebunch wheatgrass (024) (Walker et al. 1984) in association with WY2 at Stoddart Creek, form the major winter range of the Radium Hot Springs bighorn sheep population. This Ecosite is also highly important to cougar and coyote, especially in winter (Poll et al. 1984).

Mean annual precipitation at Stoddart Creek is 270 mm of which only a small amount falls as snow. The mean annual temperature at the nearby KNP West Gate is 5.3°C with a mean July temperature of 25.9°C (Achuff et al. 1984).

The northern limit of the Stoddart Creek bighorn sheep winter range follows the north side of Sinclair Creek at Radium Hot Springs in

Kootenay National Park while the eastern boundary follows the (5000 ft or 1515 m) contour from Dry Gulch Creek to Stoddart Creek (Demarchi 1968). He reported the 9.6 km^2 winter range to consist of several large alluvial terraces which originate from rocky slopes and bluffs of the Stanford Range. These terraces terminate on flat, glacial-lacustrine deposits which are dissected by several streams; notably Sinclair, Dry Gulch, Stoddart and Shuswap creeks. Demarchi (1968) further remarked that cattle and horses had grazed this range heavily in the past. In the 1960s this grazing was stopped north of Stoddart Creek except for light trespass grazing. He concluded that heavy cattle and horse grazing had created an overgrazed range situation that in the early 1960s was being perpetuated by dense populations of bighorn sheep, elk and mule deer.

Plant communities on this range were drastically altered by severe overgrazing with the result that no relic climax communities existed in 1966 (Demarchi 1968). He speculated that on high alluvial terraces, the grassland climax was probably an *Agropyron spicatum* - *Artemisia frigida* community with a trace of *Koeleria cristata*. On steeper slopes it may have been similar, except that *Agropyron spicatum* was not present. Other climax associations of the area are *Pseudotsuga menziesii* forest with associated *Symphoricarpus albus* and *Calamagrostis rubescens*, or with associated *Juniperus communis*, *Juniperus scopulorum*, *Symphoricarpus albus*, *Arctostaphylos uva-ursi* and *Agropyron spicatum*. He concluded that overgrazing had reduced the communities on the alluvial terraces to an unproductive forage producing community of *Koeleria cristata*, *Stipa comata*, *Antennaria rosea* and *Artemisia frigida*. On grassland slopes, *Agropyron spicatum* and *Artemisia frigida* were more abundant than on the alluvial fans and weedy forbs such as *Achillea millifolium*, *Apocynum androsaemifolium* were also abundant. In the coniferous community he reported that overbrowsing had reduced the productive potential of *Amelanchier alnifolia*. He referred to the SCL-1 and SCL-2 sites as an *Agropyron* - *Artemisia* - *Apocynum* community.

The overgrazed, deteriorated condition of this range in 1966 was also confirmed by Stelfox (1966) who reported the general range condition to be poor and the trend downward.

The two high elevation summer range study areas occur at the headwaters of Kindersley and Sinclair creeks (Fig. 2). The Kindersley E macroplot is situated within a BS2/8 polygon of the Alpine Ecoregion, containing an avens tundra, herb tundra vegetation (H1) (Fig. 6). The Sinclair F macroplot lies within a WF5A/8 polygon of the Upper Subalpine Ecoregion (Figs. 7 and 8). The Ecosite is dominated by a low shrub - herb meadow vegetation due to the influence of snow avalanches. Both sites are on steep, southerly exposures (Table 1, Figs. 6-8).

Vegetation on the Kindersley macroplot area is similar to that of H1 (*Dryas octopetala* - *Salix nivalis* - *Silene acaulis*) type of Achuff and Dudynsky (1984). This mountain avens - snow willow - moss campion vegetation type occurs on mesic to subxeric Alpine sites (2300-2610 m) on southerly to westerly aspects. Soils are well drained Regosols and Brunisols developed on colluvial and morainal landforms. There is a total herb - dwarf shrub layer cover of 20 to 80% with *Dryas octopetela* and *Salix nivalis* dominant. Other common species are *Saxifraga oppositifolia*, *Potentilla diversifolia*, *Oxytropis podocarpa*, *Carex scirpoidea*, *Anemone drummondii*, *Astragalus alpinus*, *Erigeron aureus*, *Antennaria lanata* and *Salix arctica*.

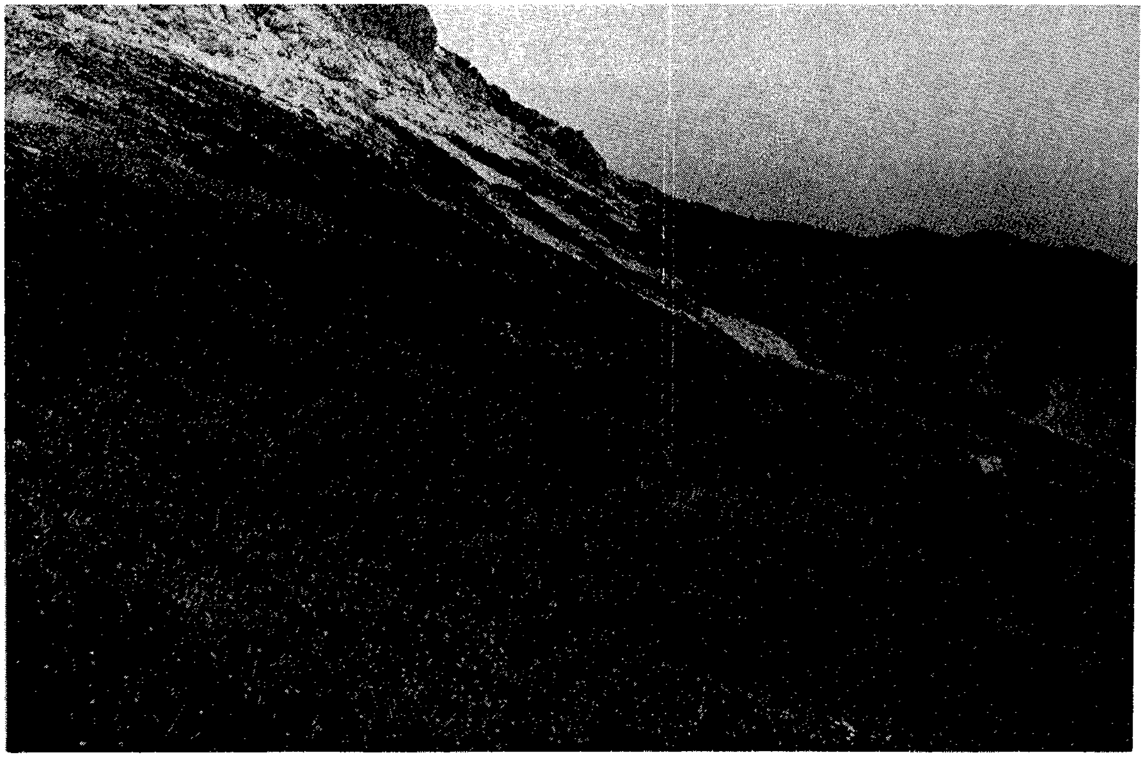

Figure 6a. Kindersley E macroplot from NW corner, looking east along macroplot, 20 July 1984.

Figure 6b. Kindersley E macroplot from SE corner looking NW towards the NW corner of Kindersley headwaters, 20 July 1984.

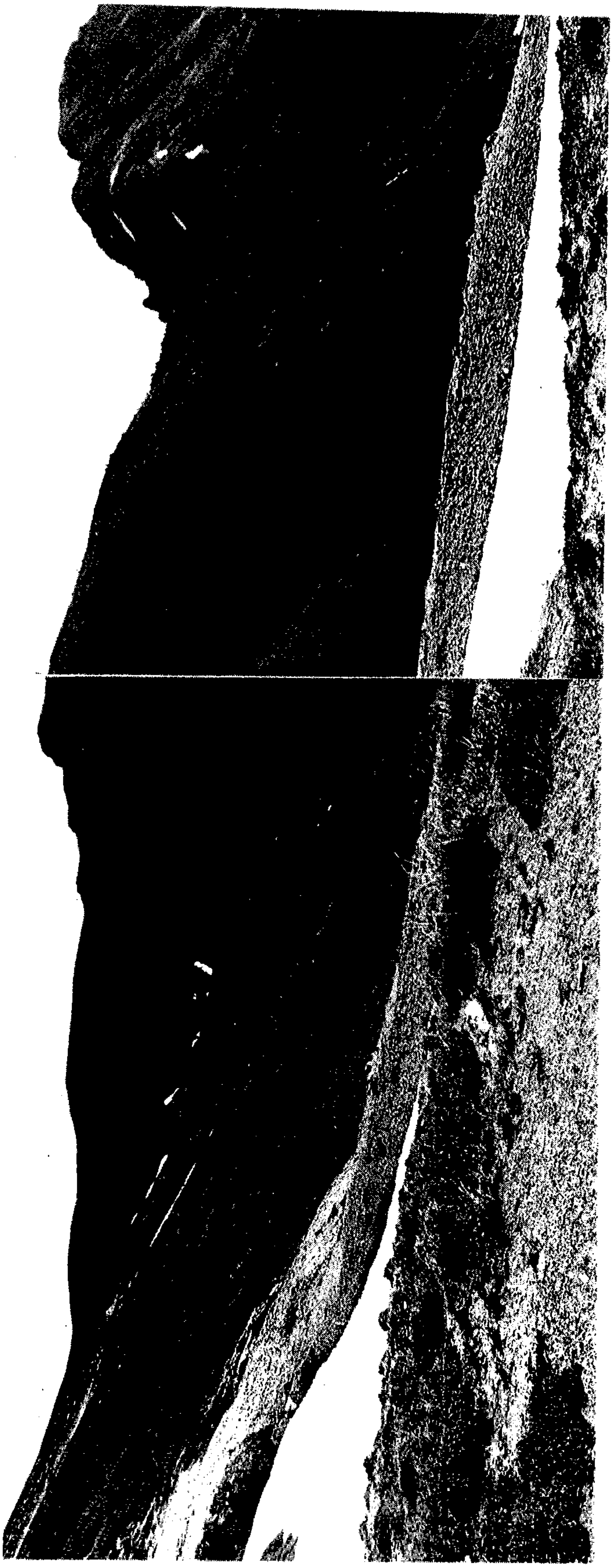

Figure 7. Headwaters of Sinclair Creek as viewed from Kindersley Pass, 11 July 1984.

Figure 8a. View of Sinclair F macroplot from the peak just above the Kindersley E macroplot, 11 July 1984.

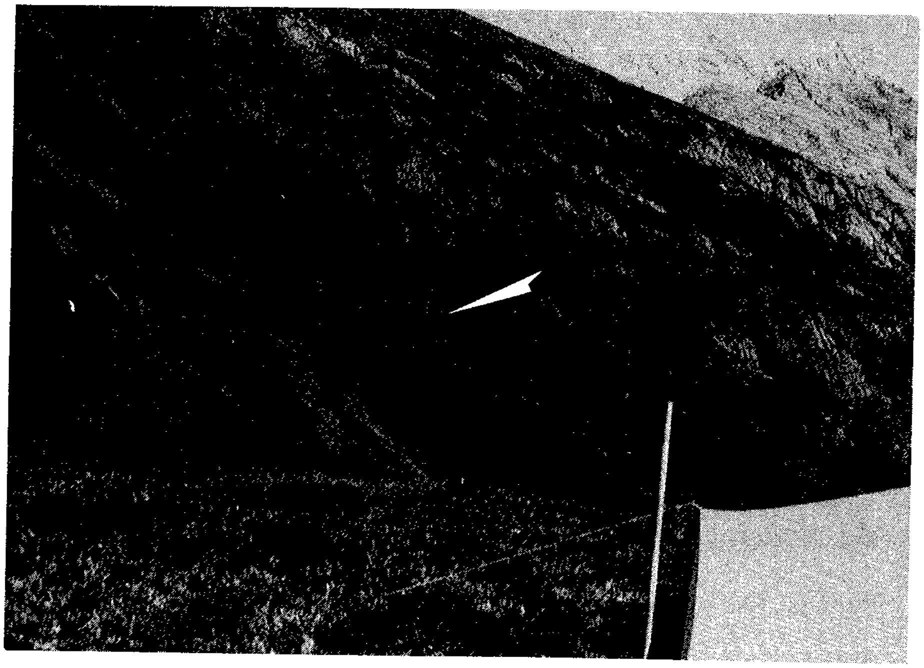

Figure 8b. Fifteen metre tape stretched along the west end of Sinclair F macroplot, as seen from tent camp, 20 July 1984.

Vegetation on the Sinclair macroplot area is influenced by snow avalanches and approximates the H17 (Antennaria lanata - Vaccinium scoparium) herb - dwarf shrub type of Achuff and Dudynsky (1984). This everlasting - grouseberry vegetation type occurs on mesic, Upper Subalpine to Alpine (2200-2440 m) sites on southerly and westerly, moderate to steep slopes. Soils are well drained Sombric, Dystric and Eutric Brunisols on colluvial and morainal landforms. Vegetation cover is 75-100% with the two above species being dominant. Other characteristic species include Anemone occidentalis, Ranunculus eschscholtzii, Sibbaldia procumbens and Phyllodoce glanduliflora. Common species with lower cover values are Veronica alpina, Valeriana sitchensis, Phleum alpinum, Claytonia lanceolata, Erigeron peregrinus and Potentilla diversifolia.

Small mammals typical of both sites are those of Small Mammal Associations 5 and 8 (Poll and Porter 1984). Dominant species are heather vole, long-tailed vole, meadow vole and western jumping mouse. Additional species are red-backed vole, masked shrew, dusky shrew, yellow-pine chipmunk, least chipmunk, northern bog lemming and deer mouse.

Breeding birds are those of Breeding Bird Communities 17 (Moist Upper Subalpine and Alpine Meadows) and 18 (Dry Alpine Tundra). Dominant species are Rosy Finch and Water Pipit. Additional species are Clark's Nutcracker, White-crowned Sparrow, White-tailed Ptarmigan, American Robin, Killdeer, Yellow-rumped Warbler, Spotted Sandpiper, Pine Siskin, Mountain Chickadee, Fox Sparrow, Dark-eyed Junco, Varied Thrush and Townsend's Solitaire.

The BS2 Ecosite is highly important to mountain goats in summer and moderately so in winter. It is very highly important to bighorn sheep and mule deer in summer. They are of low to moderate importance to carnivores (Walker _et_ _al_. 1984).

Mean annual precipitation (Sinclair Pass) is 2.25 times greater than on the winter ranges (608 mm vs 270 mm) and 43% falls as snow. The mean annual temperature is 1.6°C and the mean July temperature is 21.6°C. Mean temperature at the two study sites (elevation 2100-2260 m) would be lower than those given for Sinclair Pass (1370 m).

3. METHODS

3.1.0 RANGE ECOLOGY

3.1.1 Range Condition, Trend and Ungulate Use

The following methods were used to meet the Terms of Reference 1, 2 and 4, namely: assessment of range condition and habitat utilization; correlation of range data to biophysical ecosites and vegetation types; repetition of the 1966 range studies on the Stoddart Creek winter range to determine trend between 1966 and 1984.

The range technique was identical to that used in 1966 on the Stoddart Creek range (Demarchi 1967, 1968, 1971). Basically, this consists of the macroplot design of Poulton and Tisdale (1961) and the canopy coverage technique of plot analysis by Daubenmire (1959 and 1968). Six macroplots (15x30 m) were located as follows.

Stoddart Creek (1052 m) - Two old macroplots erected in 1966 on the winter range adjacent to the southwest boundary of the Park are located in a DG3/8 polygon with open Douglas fir (05) - grassland (H19) complex were designated SCL-1(A) (outside the exclosure) and SCL-2(B) (inside the exclosure). The metal stakes and corner markers for each macroplot were found in May 1984 and the exclosure plot fence was still effective in excluding herbivores (Fig. 3). Slight damage to the east side of the fence was repaired.

It was therefore possible to duplicate the study as conducted in 1966 for these two macroplots.

Dry Gulch Creek (1123-1140 m) - Two new macroplots were erected in a WY2/8 polygon to the north of Dry Gulch Creek (Figs. 2, 4, 5).

Kindersley - Sinclair Summits - Two new macroplots were established on high elevation summer ranges at:

a. the head of Kindersley Creek (2260 m) in a BS2/8 polygon of the Alpine Ecoregion (Fig. 6);

b. the head of Sinclair Creek (2100 m) in a WF5A/8 polygon of the Upper Subalpine Ecoregion (Figs. 7 and 8).

Each macroplot contains five randomly selected transects (15 m long) that contains 10 microplots (20x50 cm) at 1.5 m intervals. A numbered angle-aluminium stake was placed at the start of each transect and another unnumbered stake at the end. These transects and microplots were used to obtain data on plant composition, cover, frequency, and ungulate use.

Plant coverage data was obtained from the 50 microplots by estimating the percentage of each plot covered (foliage cover) by plant species. The 20 x 50 cm plot frame was divided into four portions (20x25, 10x15, 10x10 cm) to improve the accuracy of coverage estimates (Fig. 9). Six coverage classes were used for estimating foliage cover (Table 2). Coverage was determined separately for each species overlapping the plot, regardless of where the individuals were rooted and regardless of superimposed canopies of different species. For this reason the sums of coverage could exceed 100 percent.

Frequency values were determined in addition to percent coverage. Frequency was expressed as a percent of the microplots in which that species occurred.

Ground condition values were obtained for each microplot, using the same six coverage classes (Table 2), for living plants, litter, rock,

Figure 9. Microplot (20x50 cm) frame used for estimating plant foliage cover.

Table 2. Plant foliage cover estimate values.

Coverage class	Range of coverage %	Coverage midpoints (%)
1	0 - 5	2.5
2	5 - 25	15.0
3	25 - 50	37.5
4	50 - 75	62.5
5	75 - 95	85.0
6	95 - 100	97.5

bare ground and cryptogams. Where coverage was less than 1% it was recorded as trace.

Relative range stocking rates of ungulates were determined by: (1) counting fecal groups along each of five transects (15x2 m) within each macroplot for a sample size of 150 m^2 or 1.5% of a hectare. (2) multiplying by 66.7 to get density per ha, and (3) dividing this density value by 14 for bighorn sheep, 15 for deer, and 12.5 for elk (Neff 1968) to get the number of ungulate days-use/ha. During 1966, fecal group counts were made on 54 m^2 or 0.5% of a hectare.

3.1.2 Seasonal Forage Production and Quality

In order to assess forage production on various ranges utilized by the Radium band of bighorn sheep, permanent "clip plots" were established on areas representative of winter, summer and intermediate ranges. Based on known seasonal distribution and range use patterns of the Radium bighorn sheep (Poll *et al*. 1984, Stelfox 1978) permanent clip plots were located at Stoddart Creek (CP-1) (immediately north of the range exclosure established in 1966, Figs. 2 and 3), lower Sinclair Creek (CP-2) (above Iron Gates Tunnel, Figs. 10 and 11), and upper Sinclair Creek (CP-3) (adjacent to the range assessment macroplot, Fig. 8).

At each clip plot site, four 10 m long transects were established, radiating north, south, east and west from a central pin (Fig. 12).

Along each of these transects, 1 m^2 clip plots were placed at one metre intervals. Placement of 1 m^2 plots began on the north axis, one metre from the centre pin, and moved counter-clockwise to the east axis. The distance from the centre pin was increased by one metre on

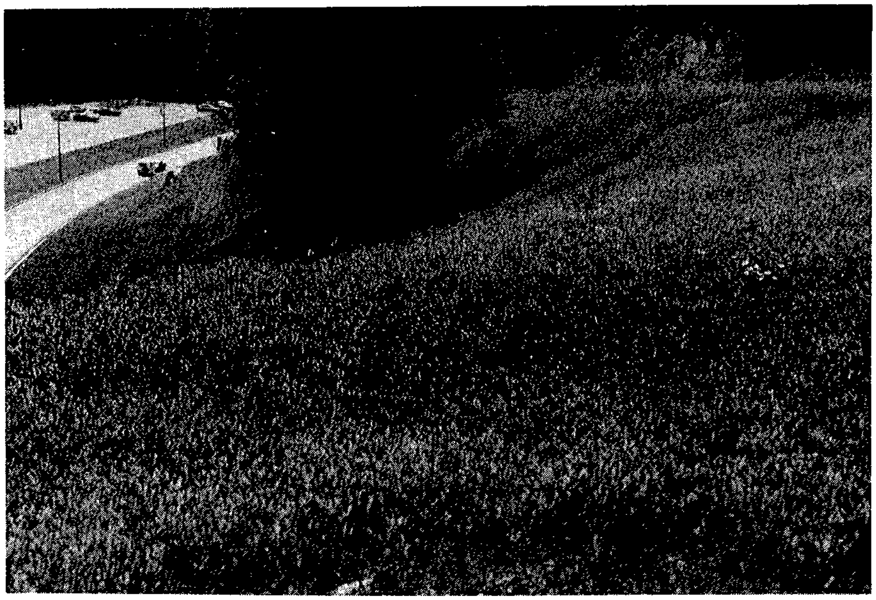

Figure 10. Iron Gates Tunnel intermediate bighorn sheep range along lower Sinclair Creek, 23 July 1984.

Figure 11. 1 m^2 clip plot at Iron Gates Tunnel, 23 July 1984.

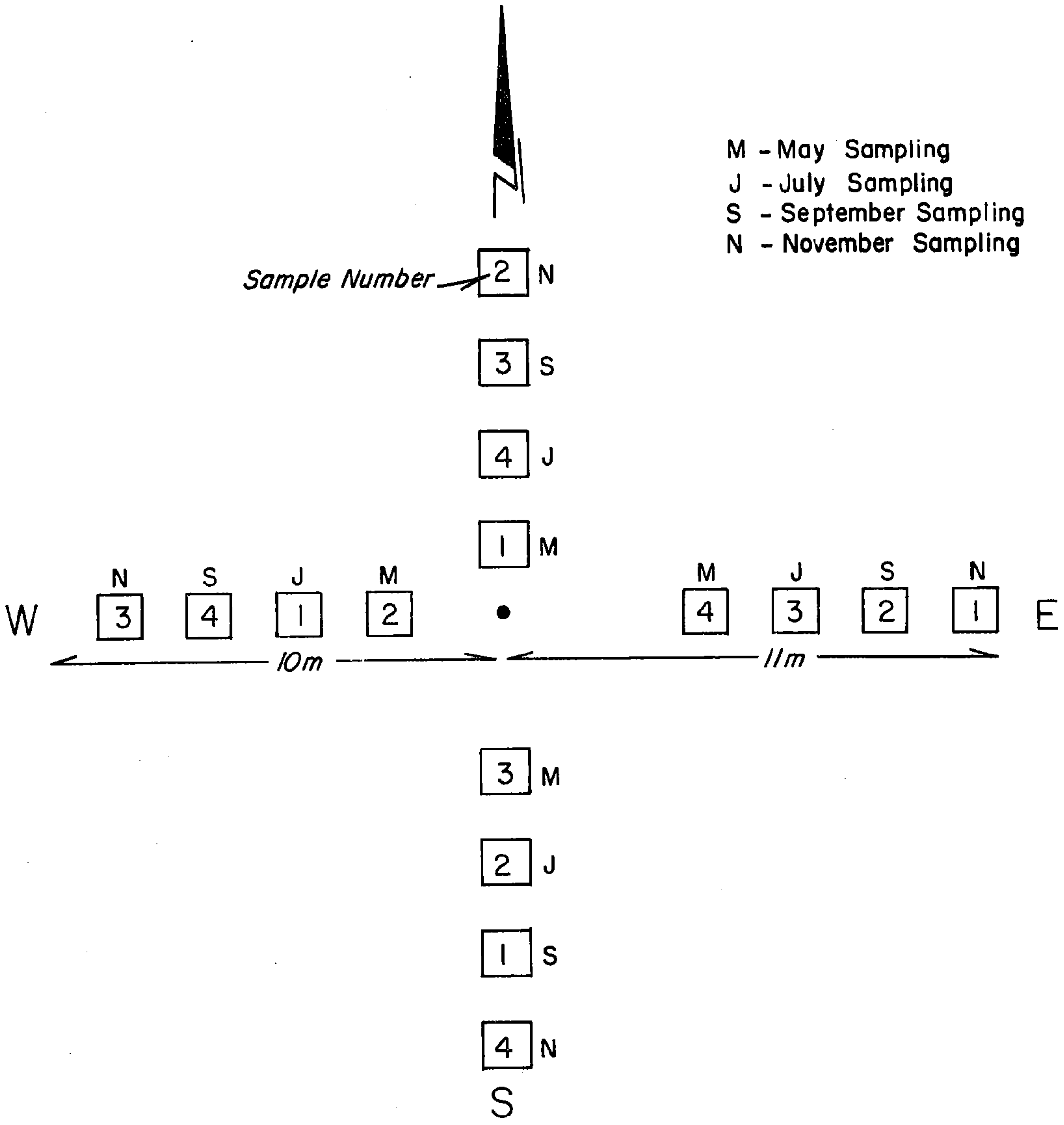

Figure 12. Clip plot design for determining seasonal forage production and quality.

each axis, so that on the east axis the first clip plot was placed four metres from the center pin. The placement of 1 m^2 plots for each successive clipping was one metre beyond the previous clip plot on the opposite side of the transect line (Figs. 11 and 12).

Clipping was to take place once during each of May, July, September and November, 1984. Four 1 m^2 plots were to be clipped at each site during each sampling period. A collapsible 1 m^2 wooden frame was placed on the ground at the appropriate distance from the centre pin along each of the four axes. All living vegetation within the 1 m^2 plot was clipped to within on centimeter of the ground and placed in a cloth bag (Fig. 11). The samples were air-dried for several days and then oven-dried for 48 hours at 60°C. Oven-dried weights were used to calculate total forage production in kilograms/hectare (kg/ha).

In addition to the permanent clip plots, vegetation clipping was conducted on the range condition and trend macroplots during July 1984. On each of the four range condition macroplots (see Section 1.1 above) a 1 m^2 clip plot was placed randomly along each of the five (2x15 m) transects. For convenience and to avoid trampling of vegetation, clip plots were always placed on the upslope side of the transect line. Clipping and handling of samples were done identically to that on the permanent clip plots.

Changes in forage quality throughout the season were assessed through chemical analyses of forage samples. Analyses performed on forage samples included percent protein, fibre, calcium, phosphorus, nitrate and selenium as well as moisture and ash. The analyses were conducted by the Alberta Dept. of Agriculture, Soil and Feed Testing Laboratory in Edmonton.

A further index to seasonal forage quality as well as animal nutrition was obtained from fecal nitrogen determinations. Crude protein (N x 6.25) in the feces is correlated to the protein content of forage consumed (Renecker and Hudson 1985). Individual fecal samples were collected from rams, ewes and lambs each month beginning in May 1984. A macro-Kjeldahl analysis (Lancaster 1949) was used to determine the percent nitrogen in each sample which is equated with protein intake through the relationship %N x 6.25 = protein.

3.1.3 **Forage Preferences and Diet Composition**

Diets of bighorn sheep were studied using a microhistological analysis of plant fragments in fecal material following the procedures of Sparks and Malecheck (1968) and Hansen et al. (1976). The success of this technique is based on the fact that plant epidermal tissue consisting of waxes and lignins, is not destroyed during the digestive process and therefore can be identified in the feces. It has been shown that the relative density of plant fragments in feces is comparable to dry matter intake (Todd and Hansen 1973, Anthony and Smith 1974). Microscopic analysis of the feces of bighorn sheep is a valid, economical index to food habits (Todd and Hansen 1973).

Fresh sheep fecal material was collected monthly, beginning in May 1984 and extending to April 1985. Samples were composited for each month: the goal being to collect 15 individual samples (5 ram, 5 ewe, 5 lamb) for each collection period. A total of 180 fecal groups were collected. A sample consisted of eight pellets or the equivalent from individual pellet groups and no animal was sampled more than once on a given occasion. Composited samples were kept frozen to prevent bacterial destruction of plant fragments.

Before submission for microscopic analysis, monthly composites were placed in fine-mesh nylon bags and thoroughly washed to remove solubles. The washed material was then transferred to tandem sieves (No. 18 and No. 200) to extract material in the size fraction 0.75 mm $< x <$1 mm for preparation of slides (Hansen et al. 1976). Sieved samples were oven-dried at 60°C for 24 hours, subdivided into two equal samples, one portion retained by CWS and the other sent for analysis to the Composition Analysis Laboratory, Colorado State University. The frequency occurrence of plant fragments was determined by reading 10 fields on each of ten slides per monthly composite. A comprehensive list of plants occurring in the study areas was provided to the lab for reference.

In addition to diet composition from fecal analysis, sheep forage preferences were assessed by direct observation during regular population counts. Notes were made on sheep use of forage classes (shrubs, forbs and graminoids) and vegetation species when possible.

3.2.0 POPULATION DYNAMICS

Seasonal, and where possible monthly counts were made of the bighorn sheep band. Search of historic references was used to determine traditional, seasonal distributions and critical ranges (Cowan 1943, Stelfox 1978, Poll and Porter 1984). Most of these were ground counts, although supplemental helicopter counts were made when the animals were on their summer, winter and lambing ranges. Each group of animals was recorded according to sex, age, condition, behavior and location.

3.3.0 SEASONAL DISTRIBUTIONS AND CRITICAL RANGES

The Terms of Reference required that the study describe in detail, and map, the migration corridors, lambing and rutting areas, and licks of the Radium band. Some information on this subject was mapped on 1:50 000 scale biophysical maps and seasonal distribution and critical ranges were related to Ecoregions and Ecosites. Of special interest was the location of lambing sites with special attention given to John McKay Creek which was believed to be the major lambing area. Other potential sites such as the headwaters of Stoddart, Dry Gluch, Kindersley and Sinclair creeks were surveyed. Rutting ranges were determined from ground and aerial surveys conducted during November 1 to December 15 in 1984 and 1985. Information on the locations, periods of use and composition of natural and artificial licks was collected throughout the period April 1984 to March 1985 in conjunction with other aerial and ground surveys.

3.4.0 HEALTH OF BIGHORN SHEEP

Health of the Radium band was to be monitored during the period April 1984 to March 1985 using six techniques:

a) <u>Production, survival and growth of lambs</u> - The proportion of lambs and yearlings to adult ewes is a good measure of health or vitality of a bighorn sheep band (Geist 1971, Shackleton 1973). A further measure of vitality of juveniles is estimation of horn lengths using the technique by Shackleton (1973). Results were compared with those obtained during the period 1966-1972 (Shackleton 1973, Stelfox and Poll 1978).

b) Animal condition - All animals observed were given condition ratings based on 10 condition classes prepared by Stelfox for the 1966-1972 sheep study (Stelfox and Poll 1978). This is a modification of an earlier one by Riney (1960). The 10 condition classes are:

10. A prime fat animal, with smooth lines, heavy legs and round full shoulders; excellent condition.
9. A sheep just beneath optimum appearance. Shoulders, legs and back are not fat appearing but smooth and full; very good condition.
8. An animal still in good condition, but showing either a slight definition about the shoulders or a trace of slenderness in the legs; very good condition.
7. An "average" or good condition with neither fatness nor thinness. A definition of neck from shoulders and more slender legs.
6. At least one of the following are evident:
    a. definition of neck from shoulders; b. upper leg is distinct from the chest; c. noticeable thinness of legs. The animal is in fair-good condition.
5. At least two of the characteristics in number 6 are evident and the condition is only fair.
4. A thin animal with all three characteristics in number 6 evident. The animal is in poor-fair condition.
3. Hide fits loosely about the neck and shoulders. Humerus (upper leg) is still held above a horizontal angle and the back is still level. Walking and running occur without apparent weakness and the animal is in poor (emaciated) condition.

2. All symptoms of malnutrition are obvious; thin legs, humerus held at near-horizontal position, outline of scapula and back is humped or sagged. Running only possible for a short distance and the condition is poor-very poor condition.

1. A stage of malnutrition from which recovery seems impossible. Whole appearance is of weakness; walking is uncertain and on spread toes. Running is not possible; the animal is very emaciated and the condition rating is very poor.

0. A dead animal.

c) External evidence of disease - During monthly sheep counts, any evidence of disease or unthriftiness was recorded such as coughing, nasal discharge, scours, abnormal pelage condition etc. The onset of concentrated lamb mortality has been characterized by many of the above symptoms (Hibler et al. 1982).

d) Fecal nitrogen (Protein) - An index of seasonal changes in forage quality, and indirectly animal health, was determined from fecal crude protein using the macro-Kjeldahl method (Lancaster 1949).

e) Fecal protostrongylus - Lungworm larvae (L1) output per gram of feces from ewes, lambs and rams was determined using the method described by Uhazy (1969). Monthly determinations were made for the period April 1984 to March 1985. Results were compared with those obtained from the same band during the period 1966-1972 (Holmes et al. 1972, Stelfox 1976a) and those obtained from other populations e.g. Festa-Bianchet (1984).

f) Necropsy of mortalities - Animals found dead or in a moribund condition were necropsied at the Alberta Dept. of Agriculture, Veterinary Laboratory. Viscera were collected along with other routine samples required for histology according to the protocol recommended by Dr. D. Onderka, Alberta Veterinary Laboratory (Appendix 1).

3.5.0 SELECTED BIBLIOGRAPHY

A selected bibliography on bighorn sheep with special relevance to southeastern British Columbia and southwestern Alberta was prepared as an adjunct to the final report. All relevant literature in Parks Canada and Canadian Wildlife Service files plus published and unpublished reports, especially those from western Canada and northwestern United States, were catalogued into this selected bibliography.

In addition to a printed format, the bibliography is maintained in a computerized format through the use of the SPIRES data base management system at the University of Alberta Computing Services. The printed version of the bibliography was produced in March 1985.

4. RESULTS AND DISCUSSION

4.1.0 RANGE ECOLOGY

4.1.1 Range Condition and Trend

4.1.1.1 Stoddart Creek winter range - Ground condition improved on both the grazed (SCL-1) and ungrazed (SCL-2) macroplots during the 18 year period between 1966 and 1984 (Tables 3-5). The amount of ground covered by living plants (100%-litter, rock, bare ground, cryptogams) increased by 32.7% outside the exclosure and by 21.2% inside the exclosure. It must be remembered that macroplot SCL-2 was not protected from grazing until after the range study in 1966; then the exclosure was erected.

The amount of litter also increased both on the grazed macroplot (54.7%) and within the exclosure plot (197.2%). For the grazed area this indicates a reduction in grazing pressure, or increased plant phytomass production, or both since 1966 (Table 5).

Foliage cover by grasses (graminoids) and herbs (forbs) decreased while shrub cover increased during the 18-year period on both the grazed and ungrazed plots. Part of the decrease recorded in 1984 for grasses and forbs may be due to more xeric soil moisture conditions which probably reduced production of plant phytomass in 1984 compared with 1966.

The pronounced decrease in grass cover between 1966 and 1984 following 18 years of protection from grazing was expected as other studies of range exclosures within national parks in western Canada have shown similar decreases (Stringer 1969 and 1972, Trottier 1976). Apparently, the increased litter phytomass smothers some grass species and moderate grazing by herbivores stimulates grass production (Flook and

Table 3. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot SCL-2, at Stoddart Cr. (inside exclosure).

Elevation: 1052 m Aspect: 210° Slope: 68%
Date sampled: 6 July 1984 Plot specifics: Inside the exclosure

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A. GROUND CONDITION

	Percent
Living Plants	39.4
Litter	31.5
Rock	10.8
Bare ground	2.7
Crypotogams	15.6

B. PELLET GROUP COUNTS Old/New

		Summer	Winter
Bighorn Sheep	0/0		
Deer	0/0		
Elk	0/0		
Cattle	0/0		
Horse	0/0		

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)

1. **Graminoids**

	C%	F%		C%	F%
Agropyron dasystachum	0	0	Festuca scabrella	0.30	2
A. spicatum	7.90	88	Koeleria cristata	4.10	70
A. trachycaulum	0.05	2	Poa compressa	0	0
Festuca brachyphylla	0	0	P. pratensis	0.30	2
F. idahoensis	1.20	24	Stipa comata	0	0

2. **Forbs**

Achillea millifolium	4.20	62	Linum perenne	0.05	14
Anemone multifida	0	0	Lithospermum ruderale	0	0
Antennaria umbellifera	0.05	2	Lomatium macrocarpum	0	0
Apocynum androsaemifolium	0.60	4	L. triternatum	0	0
Arabis holboellii	tr	2	Oxytropis sericea	0.05	4
Aster laevis & spp.	2.25	30	Penstemon confortus	0	0
Astragalus lotiflorus	tr	6	Senecio canus	0	0
Chrysopsis villosa	0.40	18	Solidago spathulata	1.40	10
Crepis atrabarba	0	0	Taraxacum laevigatum	0.20	16
Erigeron pumilus	0	0	Tragopogon pratensis	0.20	10
Erigeron spp.	0	0			
Fragaria virginiana	0	0			
Gaillardia aristata	0.15	10			
Galium boreale	0.35	4			
Lappula echinata					

3. **Shrubs and low trees**

Amelanchier alnifolia	1.60	16	Juniperus scopulorum	0	0
Arctostaphylos uva-ursi	0	0	Pseudotsuga menziesii	0	0
Artemisia frigida	13.70	88	Rosa spp.	0.20	8
Chrysothamnus nauseosus	1.20	15			

4. **Other species**

Comandra umbellata	tr	2	Trifolium agrarium	tr	2
Artemisia dracunculus	tr	2	Antennaria rosea	tr	2
Physaria didymocarpa	tr	4			

Table 4. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot SCL-1, at Stoddart Cr. (outside exclosure).

Elevation: 1052 m Aspect: 210° Slope: 68%
Date sampled: 5 & 6 July 1984 Plot specifics: Outside of exclosure

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A. GROUND CONDITION

		Percent
Living Plants	:	34.9
Litter	:	16.4
Rock	:	22.6
Bare ground	:	16.7
Crypotogams	:	9.4

B. PELLET GROUP COUNTS Old/New

		Summer	Winter
Bighorn Sheep	:65/0		65
Deer	:15/1		16
Elk	: 0/0		
Cattle	: 0/0		
Horse	: 0/0		

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)

1. **Graminoids**	C%	F%		C%	F%
Agropyron dasystachum	tr	4	*Festuca scabrella*	0	0
A. spicatum	16.50	100	*Koeleria cristata*	1.00	40
A. trachycaulum	0	0	*Poa compressa*	0	0
Festuca brachyphylla	0	0	*P. pratensis*	0	0
F. idahoensis	0	0	*Stipa comata*	0	0

2. **Forbs**					
Achillea millifolium	1.20	24	*Linum perenne*	0.05	12
Anemone multifida	0	0	*Lithospermum ruderale*	0	0
Antennaria nitida	0	0	*Lomatium macrocarpum*	0	0
Apocynum androsaemifolium	0.60	6	*L. triternatum*	0	0
Arabis holboellii	0	0	*Oxytropis sericea*	tr	2
Aster laevis & spp.	2.00	34	*Penstemon confortus*	0	0
Astragalus lotiflorus	0.35	8	*Senecio canus*	0	0
Chrysopsis villosa	3.20	48	*Solidago spathulata**	1.80	24
Crepis atrabarba	0	0	*Taraxacum laevigatum*	0	0
Erigeron pumilus	tr	2	*Tragopogon pratensis*	0.05	2
Erigeron spp.	0	0			
Fragaria virginiana	0	0	**Others**		
Gaillardia aristata	0.05	4	*Physaria didymocarpa*	tr	6
Galium boreale	0.15	6	*some *S. nemoralis* &	0	0
Lappula echinata	0	0	*S. canadensis*	0	0

3. **Shrubs and low trees**					
Amelanchier alnifolia	0	0	*Juniperus scopulorum*	0	0
Arctostaphylos uva-ursi	0.30	2	*Pseudotsuga menziesii*	0	0
Artemisia frigida	2.60	38	Rosa spp.	0.35	24
Chrysothamnus nauseosus	3.35	26			

Table 5. Bighorn sheep winter range condition during 1966 and 1984.

	Stoddart Creek						Dry Gulch Cr.		
	SCL-1 (outside)			SCL-2 (inside)			DG-C	DG-D	
	1966	1984	% Change	1966	1984	% Change	1984	1984	Means
A. GROUND COVER (%)									
1. Living Plants*	26.3	34.9	32.7	32.5	39.4	21.2	24.3	29.7	27.0
Graminoids	27.7	17.5	-36.8	43.5	13.9	-68.0	15.9	11.6	13.7
Forbs	14.7	9.6	-34.7	15.1	9.9	-34.4	6.8	5.3	6.1
Shrubs	5.0	6.6	32.0	11.3	16.7	47.8	1.2	9.2	5.2
2. Litter	10.6	16.4	54.7	10.6	31.5	197.2	28.3	40.7	34.5
3. Rock	16.9	22.6	33.7	10.0	10.8	8.0	11.7	4.3	8.0
4. Bare Ground	46.3	16.7	-43.6	46.9	2.7	-61.0	9.0	9.7	9.3
5. Cryptogams	-	9.4		-	15.6		26.7	15.6	21.2
B. PELLET GROUPS/HA									
Bighorn sheep	925	4335	368.6	10738	0**	-	2868	2068	2468
Deer	925	1067	15.4	925	0	-	400	267	333
Elk	0	0	0	370	0	-	667	267	467
Cattle & Horses	0	0	0	0	0	-	0	0	0
C. PLANT GENERA FOLIAGE COVER (%)									
1. Graminoids									
Agropyron	27.7	16.5	-40.4	38.8	8.0	-79.4	13.7	9.0	11.3
Festuca	0	0	0	tr	1.5	>100.0	0.1	0.1	0.1
Koeleria	0	1.0	>100.0	2.4	4.1	70.8	2.1	2.4	2.3
Poa	0	0	0	0	0.3	>100.0	tr	0.1	<0.1
2. Forbs									
Achillea	0	1.2	>100.0	5.6	4.2	-25.0	1.0	0.2	0.6
Apocynum	10.3	0.6	-941.7	3.4	0.6	-82.4	0	0	0
Aster	1.2	2.0	66.7	2.6	2.3	-11.5	0	0.1	<0.1
Astragalus	0	0.3	>100.0	0	<0.1	>100.0	0.6	0.8	0.7
Chrysopsis	1.3	3.2	146.2	1.8	0.4	-77.8	0.1	0.1	0.1
Gaillardia	0	<0.1	>100.0	0	0.1	>100.0	0.1	<0.1	<0.1
Galium	0	0.1	>100.0	0	0.4	>100.0	0.1	<0.1	<0.1
Linum	0.8	0.2	-75.0	1.2	<0.1	-100.0	0.3	0.3	0.3
Oxytropis	<0.1	<0.1	0	0.5	0.1	-80.0	0	2.2	1.1
Solidago	0.6	1.8	200.0	0	1.4	>100.0	0	<0.1	<0.1
Taraxacum	0	0	0	0	0.2	>100.0	0.1	<0.1	<0.1
Tragapogon	0	0.1	>100.0	0	0.2	>100.0	0.1	0	<0.1
3. Shrubs									
Arctostaphylos	0	0.3	>100.0	0	0	0	0	5.8	2.9
Artemisia	2.8	2.6	-7.1	11.3	13.7	21.2	<0.1	<0.1	<0.1
Chrysothamnus	<0.1	3.3	>100.0	<0.1	1.2	>100.0	1.2	0.4	0.8
Rosa	<0.1	0.4	>100.0	<0.1	0.2	>100.0	0	0.2	0.1

*Difference between total vegetation cover and the sum of graminoids, forbs and shrubs is the foliage cover of juniper and fir plus traces of other species.

**This macroplot was not protected from grazing until after the 1966 survey; thus pellet groups in 1966 but not in 1984.

Stringer 1974, McNaughton 1979). A study in the Bluestem Prairie of Kansas also showed that excessive amounts of litter depress productivity, apparently by shading sunlight and intercepting precipitation (Hulbert 1969).

Coverage by *Agropyron spicatum* declined by 40.4% between 1966 and 1984 on the grazed range and by 79.4% on the ungrazed range within the exclosure (Tables 5 and 6). However, *Festuca* spp. increased from zero and a trace on the two ranges in 1966 to zero on the grazed range and 1.5% on the ungrazed in 1984. The ungrazed range (SCL-2) was inside the exclosure in 1984 but in 1966 the exclosure fence had not been erected so the range was grazed. Similarly, *Koeleria cristata* increased from zero and 2.4% on grazed ranges in 1966 to 1.0 and 4.1% on the grazed and ungrazed ranges, respectively, in 1984. Apparently, wild ungulate grazing during that period favored *Koeleria cristata* but not *Festuca idahoensis* or *Festuca scabrella*. Protection from grazing during an 18 year period resulted in an increase in coverage by *Festuca* spp. and *Koeleria cristata* from 2.4% to 5.6% (133% increase). Unpalatable weedy species (*Achillea millifolium*, *Aster* spp., *Chrysopsis villosa*, *Linum perenne* and *Oxytropis sericea*) declined greatly on the ungrazed range from 12.5% in 1966 to 5.3% in 1984 (-57.6%). Conversely, on the grazed range three of these genera (*Achillea*, *Aster* and *Chrysopsis*) increased by 156.0% while *Linum* and *Apocynum* decreased on both ranges. Palatable forb species that increased under protection from grazing were *Taraxacum laevigatum*, *Tragopogon pratensis*, *Solidago spathulata* and *Galium boreale* (0 in 1966 to 2.2% in 1984).

Table 6. Changes in foliage cover between 1966 and 1984 of plants usually considered as "increasers", "decreasers" and "invaders" on the Stoddart Creek winter range, Kootenay National Park.

	Grazed range (SCL-1)			Ungrazed range (SCL-2)		
	1966	1984	% Change	1966	1984	% Change
Decreasers						
Agropyron	27.7	16.5	-40.4	38.8	8.0	-79.4
Festuca scab.	0	0	0	tr	1.5	>100.0
Totals & Means	27.7	16.5	-40.4	38.8	9.5	-75.5
Increasers						
Koeleria	0	1.0	>100.0	2.4	4.1	70.8
Achillea	0	1.2	>100.0	5.6	4.2	-25.0
Chrysopsis	1.3	3.2	146.2	1.8	0.4	-77.8
Linum	0.8	0.2	-75.0	1.2	<0.1	-100.0
Solidago	0.6	1.8	200.0	0	1.4	>100.0
Arctostaphylos	0	0.3	>100.0	0	0	0
Artemisia*	2.8	2.6	-7.1	11.3	13.7	21.2
Chrysothamnus	<0.1	3.3	>100.0	<0.1	1.2	>100.0
Rosa	<0.1	0.4	>100.0	<0.1	0.2	>100.0
Totals & Means	5.6	14.0	150.0	22.4	25.2	12.5
Invaders						
Poa pratensis	0	0	0	0	0.3	>100.0
Tragopogon	0	0.1	>100.0	0	0.2	>100.0

*Artemisia frigida is a preferred bighorn sheep forage and actually acts as a decreaser on those ranges.

For the shrubs, Artemisia frigida declined slightly under grazing but increased under protection. Chrysothamnus nauseosus increased almost 3-times as much under grazing as under protection (Table 5).

If the range plants are divided into Increaser, Decreaser and Invader species as is the common practice in determining range condition (Stoddart and Smith 1955), the Stoddart Creek range appears to have decreased in condition between 1966 and 1984 (Table 6). Plants known to decrease under heavy grazing (Decreasers) showed a 40% decrease in cover on the grazed and also a 75% decrease on the ungrazed range. This decrease on range protected from grazing is expected (Flook and Stringer 1974, Stelfox 1976b, McNaughton 1979) as discussed above. McNaughton (1979) showed that moderate grazing (defoliation) stimulates primary productivity and increases forage quality by maintaining a high shoot/root level, improved light penetration and nutrient recycling. Plants classified as Increasers (Wroe et al. 1972) increased 150% on the grazed and 12% on the ungrazed ranges. Actually, pasture sage (Artemisia frigida) is a preferred forage of bighorn sheep (Stelfox 1976b) and responds as a Decreaser on heavily grazed winter ranges (Table 6). The major Increaser species on the Stoddart Creek range were Chrysothamnus nauseosus, Solidago spp., Chrysopsis villosa and Achillea millifolium.

Another indication of range trend is forage production. Mean forage yield (dry wt.) for the grazed range during the period 1967-1970 was 40.0 g/m^2 (Demarchi 1968). This compares with 36.7 g/m^2 on the grazed range and 101.2 g/m^2 on the ungrazed range in 1984 (see section 1.2 Seasonal Vegetation Production and Quality). This comparison indicates that forage production declined slightly between 1967-70 and

1984 and that in 1984 production was only about 36% of the site potential under no grazing.

Despite the increase in litter and coverage by living plants, range condition in 1984 remained poor-fair and the trend stable or slightly downward. The status of this range remained similar to that of 1966 when the condition was rated poor and the trend downward (Stelfox 1966). Range condition refers to the state of the vegetation compared with that of the climax or original for the range site (Wroe _et al._ 1972). Four classes express the degree to which the composition of the present plant community has departed from that of the climax; expressed as a percentage of climax vegetation present in the range site. Excellent = 76 to 100%, Good = 51 to 75%, Fair = 26 to 50%, Poor = 0 to 25%. Range studies during the period 1966-68 concluded that the open grasslands were overgrazed, the soils were exposed, unstable and subject to erosion (Demarchi 1968) and that problem continued to 1984.

4.1.1.2 _Dry Gulch Creek winter range_ - The amount of these two winter ranges (DG-C, DG-D) covered by living plants was 27.3% less than on the Stoddart Cr. (SC) ranges (Tables 5, 7, and 8). Grass coverage was 21.7% less than on the comparable Stoddart Cr. grazed range (SCL-1). Similarly, forb cover was 36.5% less on the Dry Gulch (DG) ranges. However, litter cover was 110.4% higher on the DG range indicating that wild ungulates were consuming a higher percentage of the plant material on the Stoddart Cr. range, leaving less to become litter. This is substantiated by pellet group count densities that were 65.3% higher at Stoddart Cr.

Table 7. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot DG-C, at Dry Gulch (N) Cr.

Elevation: 1123 m Aspect: 205° Slope: 75%
Date sampled: 8 July 1984 Plot specifics: North plot at Dry Gulch Cr.

A. GROUND CONDITION

	Percent
Living Plants	24.4
Litter	28.3
Rock	11.7
Bare ground	9.0
Crypotograms	26.7

B. PELLET GROUP COUNTS Old/New

		Summer	Winter
Bighorn Sheep	39/4	0	43
Deer	6/0	0	6
Elk	10/0	3	7
Cattle	0/0		
Horse	0/0		

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)

	C%	F%		C%	F%
1. Graminoids					
Agropyron dasystachum	tr	2	*Festuca scabrella*	0	0
A. spicatum	13.70	98	*Koeleria cristata*	2.10	72
A. trachycaulum	0	0	*Poa compressa*	0	0
Festuca brachyphylla	0.10	16	Poa spp.	tr	8
F. idahoensis	0	0	*Stipa comata*	0	0
2. Forbs					
Achillea millifolium	1.05	46	*Linum perenne*	0.30	46
Anemone multifida	0	0	*Lithospermum ruderale*	0	0
Antennaria rosea	3.05	46	*Lomatium macrocarpum*	0.15	12
Apocynum androsaemifolium	0	0	*L. triternatum*	tr	4
Arabis holboellii	0	0	*Oxytropis sericea*	0	0
Astragalus miser	0.60	26	*Penstemon confortus*	0.05	4
Balsamorhiza sagittata	0.30	2	*Senecio canus*	0.50	22
Chrysopsis villosa	0.05	2	*Solidago spathulata*	0	0
Crepis atrabarba	0	0	*Taraxacum laevigatum*	0.10	14
Erigeron pumilus	0.30	20	*Tragopogon pratensis*	0.10	12
Erigeron spp.	tr	2			
Fragaria virginiana	0.05	2			
Gaillardia aristata	0.10	16			
Galium boreale	0.10	4			
Lappula echinata	tr	2			
3. Shrubs and low trees					
Amelanchier alnifolia	0	0	*Juniperus scopulorum*	0	0
Arctostaphylos uva-ursi	0	0	*Pseudotsuga menziesii*	0.55	26
Artemisia frigida	tr	2	(18 plants)		
Chrysothamnus nauseosus	1.25	14	Rosa spp.	0	0
4. Other species					
Comandra umbellata	tr	2	*Dodecatheon conjugens*	tr	2
Allium cernum	0.05	4			

Table 8. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot DG-D, at Dry Gulch (S) Cr.

Elevation: 1140 m Aspect: 210 (SW) Slope: 10%
Date sampled: 9 July 1984 Plot specifics: South plot at Dry Gulch Cr.

A. GROUND CONDITION

	Percent
Living Plants	: 30.5
Litter	: 40.7
Rock	: 4.3
Bare ground	: 9.7
Crypotogams	: 15.6

B. PELLET GROUP COUNTS Old/New

		Summer	Winter
Bighorn Sheep	:22/9		31
Deer	: 4/0		4
Elk	: 4/0		4
Cattle	: 0/0		
Horse	: 0/0		

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)

	C%	F%		C%	F%
1. **Graminoids**					
Agropyron dasystachum	0.05	4	*Festuca scabrella*		
A. spicatum	8.90	96	*Koeleria cristata*	2.40	72
A. trachycaulum	0.05	4	*Poa compressa*	0.10	8
Festuca brachyphylla	0.10	12	*P. pratensis*	0	0
F. idahoensis	0	0	*Stipa comata*	0	0
2. **Forbs**					
Achillea millifolium	0.15	46	*Linum perenne*	0.25	58
Anemone multifida	0.50	30	*Lithospermum ruderale*	0.40	14
Antennaria rosea	0.05	4	*Lomatium macrocarpum*	tr	2
Apocynum androsaemifolium	0	0	*L. triternatum*	0.05	14
Arabis holboellii	tr	4	*Oxytropis sericea*	2.20	52
Aster ciliolatus	0.15	18	*Penstemon confortus*	tr	8
Astragalus lotiflorus	0.75	18	*Senecio canus*	0.65	60
Chrysopsis villosa	0.10	10	*Solidago spathulata*	tr	2
Crepis atrabarba	tr	2	*Taraxacum laevigatum*	tr	12
Erigeron pumilus	0	0	*Tragopogon pratensis*	0	0
E. filifolius	tr	2			
Fragaria virginiana	0	0	**Other species (herbs)**		
Gaillardia aristata	tr	6	*Allium cernum*	tr	12
Galium boreale	0.05	2	Forb #2		
Lappula echinata	0	0	(*Calochortus apiculatus*)	tr	4
3. **Shrubs and low trees**					
Amelanchier alnifolia	0	0	*Juniperus scopulorum*	2.75	6
Arctostaphylos uva-ursi	5.80	14	*Pseudotsuga menziei*	0	0
Artemisia frigida	tr	2	Rosa spp.	0.25	12
Chrysothamnus nauseosus	0.40	8			
4. **Other species**					
Comandra umbellata	tr	2			

Coverage by *Festuca*, *Koeleria* and *Poa* grass species was higher and by *Agropyron* spp. lower on the Dry Gulch ranges compared with SCL-1 of Stoddart Cr.

A noticeable difference in forb coverage between the DG and SC ranges was the absence of *Apocynum* and lower values for *Aster*, *Chrysopsis* and *Solidago* spp. on the DG ranges compared with the grazed SC range. *Astragalus* and *Oxytropis* spp. were more pronounced on the DG ranges. *Senecio canus* and *Antennaria rosea* were characteristic species of the DG ranges but not the SC ranges.

There were also major differences in the shrubs with *Artemisia* and *Chrysothamnus* being considerably lower and *Arctostaphylos* higher on the DG ranges compared with the SC ranges (Table 5).

4.1.1.3 *Summer ranges* - There were major differences between the summer (Kindersley E and Sinclair F) ranges and the above winter ranges (Tables 3-11). Vegetative cover (foliage) averaged 98.5% on summer range compared with only 31.0% on winter ranges. On the grazed winter ranges, cover was only 27.9% or only 28.3% as much plant cover as on the summer range (Table 11).

There was only 24.5% more grass on the summer range but there was 525.3% more forbs and 265.5% more shrubs than on the winter range (Table 11). The amount of litter on the summer range was only about one-half that on the winter range while the amounts of rock and bare ground were only 8.1% and 6.3% of that on the winter range, respectively. Cryptogams were only 70.8% as frequent as on the winter range.

Major differences in the graminoid species between summer and winter ranges was the predominance of *Carex*, *Juncus*, *Festuca*, *Poa* and *Trisetum* species on the summer range as opposed to *Agropyron* and *Koeleria* species on the winter range (Tables 3-10). Other common grass species on summer range that were absent or scarce on winter range were *Luzula*, *Phleum* and *Danthonia* species.

Forbs were the dominant forage class on summer range with the most abundant ones being *Arnica*, *Potentilla*, *Antennaria*, *Arenaria*/*Stellaria*, *Fragaria*, *Penstemon*/*Pedicularis* species, in decreasing order of abundance (Table 11). Species identification should be verified during the summer of 1985 but some of the major species on the Sinclair range appear to be *Antennaria lanata*, *Arnica alpina*, *Fragaria virginiana*, *Arenaria rubella*, *Arnica mollis*, *Potentilla diversifolia*, *Thalictrum occidentalis* and *Pedicularis contorta*. For the higher Alpine (Kindersley) range the dominant forb species were *Potentilla diversifolia*, *Arenaria rubella*, *Erigeron aureus* and *E. peregrinus*, *Achillea millefolium*, *Astragalus alpinus*, *Ranunculus eschscholtzii*, *Stellaria longipes* and *Myosotis alpestris*, in decreasing order of abundance (Tables 9 and 10).

Low shrubs seemed to be an important source of forage for ungulates on the summer ranges. The common shrub for the Sinclair range was *Vaccinium scoparium* whereas the common shrub for the Kindersley range was *Dryas octopetala*.

4.1.1.4 Range use by ungulates

Winter range - Ungulate use of the grazed Stoddart Cr. range (SCL-1) in 1984 was 25.7% less for bighorn sheep and 15.2% more for deer

Table 9. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot Kindersley E, at summit above Kindersley Pass.

Elevation: 2260 m Aspect: 180°(S) Slope: 8 (45-70%
Date sampled: 20 July 1984 Plot specifics: Head of Kindersley Cr. Ecosite BS2/8

A. GROUND CONDITION

	Percent
Living Plants	79.75
Litter	20.10
Rock	0.20
Bare ground	0.40
Crypotogams	2.00

B. PELLET GROUP COUNTS Old/New

		Summer	Winter
Bighorn Sheep	9/7	16	0
Deer	0/0	0	0
Elk	0/0	0	0
Mtn. Goat	1/0	can't tell	
Horse	0/0	-	-

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)
Vegetation type = H1 (Dryas octopetala - Salix nivalis - Silene acaulis) Herb - Dwarf shrub type of Achuff et al. 1984

1. **Graminoids**	C%	F%
Agropyron dasystachum	0.60	14
A. violaceum	0	0
Carex albo nigra	4.10	56
C. nigricans	1.90	26
C. #1 (scirpoidea)	1.00	30
C. #2 (nardina)	0.40	6
Danthonia spicata	0	0
Festuca baffinensis (#1)	1.20	18
F. ovina (brachyphylla)	0	0
Festuca spp.	0.70	18
Juncus drummondii	0.30	2
Koeleria cristata	2.40	56
Luzula piperi + spicata	1.15	36
Phleum alpinum	0.05	2
Poa alpina	1.65	46
P. arctica	0.60	14
P. rupicola	1.35	24
P. epilis + spp.	0.10	4
Trisetum spicatum	1.95	28
Unknown		
2. Forbs		
Achillea millifolium	1.75	70
Anemone occidentalis	0.30	12
Antennaria lanata	0.10	4
A. racemosa	0	0
A. rosea	0.90	16
Arabis drummondii	0	0
Arenaria* rubella + spp.	4.45	60
Arnica alpina	0.90	36
A. mollis	0.30	12
Astragalus alpinus	1.65	56
Botrichium boreale	0.10	4
Caltha leptosepala	0	0
Castilleja miniata	0.25	10
C. sulphurescens	0.80	12

	C%	F%
Draba	0.30	12
Epilobium alpinum	0	0
Erigeron aureus (#1)	1.95	68
E. peregrinus (2#)	0.70	28
Erythronium grandiflorum	0	0
Fragaria virginiana	0.60	2
Heuchera glabra	0	0
Myosotis alpestris	1.20	48
Oxytropis podocarpa	0.65	26
Pedicularis contorta	0	0
Penstemon fruticosa + confertus	4.15	66
Potentilla diversifolia	6.60	94
P. nivea (=P. #1)	0.25	10
Pulsatilla occidentalis	0	0
Ranunculus eschscholtzii	1.65	56
Saxifraga oppositifolia	0.15	6
Sedum lanceolatum	0.50	20
Senecio lugens	0.65	16
Sibbaldia procumbens	1.10	44
Stellaria longipes	1.30	52
Thalictrum occidentalis	0	0
Valeriana sitchensis	0	0
Veronica alpina	0.55	22
3. Shrubs		
Dryas octopetala	42.15	80
Salix arctica + nivalis	0.45	8
Vaccinium scoparium	0	0
4. Extra species		
Salix spp.		
Pinus albicaulis	0.05	2
Taraxacum officinale	0.05	2

*Small amount of Stallaria and Cerastium with Arenaria

Table 10. Vegetative (foliage) and ground cover plus ungulate use (pellet groups) for macroplot Sinclair F, at Sinclair Basin.

Elevation: 2100 m Aspect: 225° Slope: 9 (70%
Date sampled: 18 & 19 July 1984 Plot specifics: Sinclair F plot (Ecosite WF5A)

A. GROUND CONDITION

		Percent
Living Plants	:	70.20
Litter	:	10.00
Rock	:	1.75
Bare ground	:	0.95
Crypotogams	:	21.75

B. PELLET GROUP COUNTS Old/New

	Old/New	Summer	Winter
Bighorn Sheep	:10/9	19	0
Deer	: 0/0		
Elk	: 0/0		
Mtn. Goat	: 9/0	can't tell	
Horse	: 0/0	-	-

C. FOLIAGE COVER (C) + FREQUENCY (F) OF PLANTS (50 plots)
Vegetation type = H17 (*Antennaria lanata* - *Vaccinium scoparium*) Herb-Dwarf shrub type of Achuff *et al.* 1984.

1. Graminoids	C%	F%
Agropyron dasystachum	0.40	6
A. violaceum	0.05	2
Carex albo nigra	0	0
C. nigricans	0.15	6
C. #1 (scirpoidea)	2.60	64
C. #2 (*nardina*)	0	0
Danthonia spicata	0.30	12
Festuca baffinensis (#1)	0	0
F. ovina (brachyphylla)	0	0
Festuca spp.	0.30	12
Juncus drummondii	5.80	62
Koeleria cristata	0.35	14
Luzula piperi + *spicata*	0.10	4
Phleum alpinum	1.90	66
Poa alpina	0.20	8
P. arctica	0.10	4
P. rupicola	0.55	22
P. epilis + spp.	1.10	44
Trisetum spicatum	3.00	80
Unknown grass	0.05	2
2. Forbs		
Achillea millifolium	2.05	82
Anemone occidentalis	0.05	2
Antennaria lanata	9.70	72
A. racemosa	0.35	4
A. rosea	0	0
Arabis drummondii	0.05	2
Arenaria rubella*	5.95	80
Arnica alpina	9.30	56
A. mollis	4.65	66
Botrichium boreale	0	0
Caltha leptosepala	0.05	2
Castilleja miniata	0.35	4
Crepis spp.	0	0
Draba incerta	0.05	2

	C%	F%
Epilobium alpinum	0.10	4
Erigeron aureus (#1)	0	0
E. peregrinus (2#)	0.05	2
Erythronium grandiflorum	0.10	4
Fragaria virginiana	9.45	90
Heuchera glabra	0.35	4
Myosotis alpestris	0.60	14
Pedicularis contorta	2.55	42
Penstemon fruticosa + *confertus*	0.80	20
Potentilla diversifolia	4.60	74
P. nivea (=P. #1)	0	0
Pulsatilla occidentalis	1.80	32
Ranunculus eschscholtzii	1.35	24
Saxifraga oppositifolia	0	0
Sedum lanceolatum	0.55	22
Senecio lugens	0	0
Sibbaldia procumbens	0.70	28
Stellaria longipes	0	0
Thalictrum occidentalis	2.65	36
Valeriana sitchensis	1.85	24
Veronica alpina	1.00	40
Viola adunca	4.00	70
3. Shrubs		
Dryas octopetala	0	0
Salix arctica + *nivalis*	0	0
Vaccinium scoparium	18.85	80
4. Extra species		
Salix spp.	0	0
Pinus albicaulis	0	0

*Small amount of Stellaria and Cerastium with Arenaria

Table 11. Vegetation and ungulate comparisons of summer and winter ranges in 1984.

	Summer ranges			Winter ranges				
				Stoddart		Dry Gulch		
Range values	KIN-E	SIN-F	Means	SCL-1	SCL-2*	DG-C	DG-D	Means
A. GROUND COVER								
1) Foliage cover								
Graminoids	19.8	16.9	18.3	17.5	13.8	15.9	11.5	14.7
Forbs	33.8	65.1	49.4	9.5	9.9	6.8	5.3	7.9
Shrubs	42.6	18.8	30.7	6.6	16.7	1.3	9.2	8.4
Total Cover*	**96.2**	**100.8**	**98.5**	**33.7**	**40.4**	**24.0**	**26.0**	**31.0**
2) Litter	20.1	10.0	15.0	16.4	31.5	28.3	40.7	29.2
3) Rock	0.2	1.8	1.0	22.6	10.8	11.7	4.3	12.3
4) Bare Ground	0.4	0.9	0.6	16.7	2.7	9.0	9.7	9.5
5) Cryptogams	2.0	21.7	11.9	9.4	15.6	26.7	15.6	16.8
B. PELLET GROUPS								
1) Bighorn Sheep	16	19	17.5	65	0	43	31	46.3
2) Mountain Goat	1	9	5.0	0	0	0	0	0
3) Deer	0	0	0	16	0	6	4	8.7
4) Elk	0	0	0	0	0	10	4	4.7
Totals	**17**	**28**	**22.5**	**81**	**0**	**59**	**39**	**59.7**
C. FOLIAGE COVER (%)								
Agropyron	0.6	0.4	0.5	16.5	38.8	13.7	9.0	19.5
Carex	7.4	2.8	5.0	0	0	0	0	0
Festuca	1.9	0.3	1.1	0	1.5	0.1	0.1	0.6
Koeleria	2.4	0.4	1.4	1.0	4.1	2.1	2.4	2.4
Poa	3.7	1.9	2.8	0	0.3	tr	0.1	0.1
Trisetum	1.9	3.0	2.5	0	0	0	0	0
Total Graminoids	**19.8**	**16.9**	**18.3**	**17.5**	**13.8**	**15.9**	**11.5**	**14.7**
Achillea	1.8	2.0	1.9	1.2	4.2	1.0	0.2	1.6
Antennaria	1.0	10.0	5.5	0	0.1	3.0	0.1	0.8
Arenaria + Stellaria	5.7	6.0	5.2	0	0	0	0	0
Arnica	1.2	13.9	7.6	0	0	0	0	0
Chrysopsis	0	0	0	3.2	0.4	0.1	0.1	1.0
Fragaria	0.6	9.4	5.0	0	0	0.1	0	tr
Penstemon + Pedicularis	4.1	3.4	3.7	0	0	0.1	tr	tr
Potentilla	6.6	4.6	5.6	0	0	0	0	0
Total Herbs	**33.8**	**65.0**	**49.4**	**9.5**	**9.9**	**6.8**	**5.3**	**7.9**
Artemisia	0	0	0	2.6	13.7	tr	tr	4.1
Chrysothamnus	0	0	0	3.4	1.2	1.2	0.4	1.6
Dryas	42.2	0	21.1	0	0	0	0	0
Salix	0.4	0	0.2	0	0	0	0	0
Vaccinium	0	18.8	9.4	0	0	0	0	0
Total Shrubs	**42.6**	**18.8**	**30.7**	**6.6**	**16.7**	**1.3**	**9.2**	**8.4**

*SCL-2 is inside the exclosure and has been protected from grazing since 1966 (18 years).

than in 1966 (Tables 5 and 12). No elk pellet groups were observed in 1984 whereas there was an average of 185/ha in 1966 on the Stoddart Cr. macroplots. In July 1966 when the Stoddart Cr. range study was being conducted by Dennis Demarchi, the Radium band had reached a peak population of about 133 animals in April 1966 (Stelfox 1966). The population die-off began in September 1966 at which time it was estimated from range studies that the band had exceeded the winter range carrying capacity (Stelfox 1966, Demarchi 1968). In the fall of 1984 the minimum population was 114 animals; about 86% of the 1966 peak population.

Animal unit months (AUM's) of range use at Stoddart Cr. for all wild ungulates averaged 0.71/ha in 1966 compared with 0.53/ha in 1984, a decrease of 25% (Table 12). This probably explains the greater amount of litter (forage carryover) in 1984 compared with 1966 (Table 5).

The slightly higher Dry Gulch Cr. winter range received only 70% as much grazing pressure (AUM's/ha) as the Stoddart Cr. range in 1984. However, it did receive 0.10 AUM's/ha of elk use and this is probably because it contains a higher percentage of Douglas fir escape cover and is less subject to human harassment than the lower Stoddart Cr. range. On the Dry Gulch range, 65% of the grazing pressure came from bighorns, 27% from elk and 8% from deer.

Considering both the Stoddart and Dry Gulch winter ranges, bighorns made up 78% of the total animals and 74% of the animal-unit grazing pressure. Comparable values for deer were 16% and 15%, respectively, and for elk 6% and 11%.

There was no evidence of livestock use on either of the winter ranges.

Table 12. Wild ungulate stocking rates on winter and summer sheep ranges: 1966 and 1984.

Ungulate species	Year	Stoddart Cr.	Dry Gulch	Aves. Stoddart Dry Gulch	Columbia[1] Lake	Kindersley	Sinclair	Means
Pellet groups per hectare (PGH)								
Bighorn	1966	5833*						
Deer		926						
Elk		185						
Bighorn	1984	4335*	2468	3401		1067	1267	1167
Deer		1067	333	700		0	0	0
Elk		0	467	234		0	0	0
Mtn. Goat		0	0	4335		67	600	333
Animal months range use per hectare**								
Bighorn	1966	3.47						
Deer		0.55						
Elk		0.11						
Bighorn	1984	2.58	1.47	2.02		0.63	0.75	0.69
Deer		0.63	0.20	0.42		0	0	0
Elk		0	0.28	0.14		0	0	0
Mtn. Goat		0	0	0		0.04	0.36	0.20
Animal unit months range use* per hectare**								
Bighorn	1966	0.58						
Deer		0.09						
Elk		0.04						
Bighorn	1984	0.43	0.24	0.34	1.10	0.10	0.12	0.11
Deer		0.10	0.03	0.07	0	0	0	0
Elk		0	0.10	0.05	0.50	0	0	0
Mtn. Goat		0	0	0	0	0.01	0.06	0.03
Totals		0.53	0.37	0.46	1.60	0.11	0.18	0.14

[1] Davidson (1985).

*1966 values were averages of both SCL-1 and SCL-2. 1984 values for SCL-1 only.

**Based on pellets lasting 4 years; therefore PGH ÷ 30 x 4 or PGH ÷ 120.

***6.00 deer or bighorn sheep or 2.8 elk = 1 animal unit.

$$\text{Animal months/ha} = \frac{\Sigma \text{ Pellet piles/ha}}{[(\text{Daily defecation rate}) \times (\text{No. days range is occupied})]}$$

No. days = 30 x no. months/yr. x
no. yrs. pellets visible

Summary range - The Kindersley and Sinclair summer ranges were stocked by only 7.7% as many wild ungulates as were the winter ranges. The low shrub-herb meadow vegetation on the Sinclair Upper Subalpine range received 66% more grazing pressure than did the avens tundra, herb tundra vegetation on the Kindersley Alpine range. Bighorn sheep comprised 78% and mountain goat 22% of the summer range animals compared with 78% and 0%, respectively, for the winter ranges (Table 12). Therefore, bighorn sheep made up the same percentage of total wild ungulates using both the summer and winter ranges. However, the intensity of use by sheep was three times greater on the winter range.

The summer range stocking rate of 0.14 AUM's/ha was light compared to 0.46 AUM's/ha on the Stoddart and Dry Gulch winter ranges and 1.60 AUM's/ha on the Columbia Lake winter range (Davidson 1985 and Table 12).

There was no evidence of overgrazing on the summer ranges and forage plants were only lightly grazed. Range condition appears to be Very Good to Excellent and the trend is Stable.

4.1.2 Seasonal Forage Production and Quality

4.1.2.1 Vegetation production - Net vegetation biomass (oven-dried) peaked in July at about 890 kg/ha after only about 280 kg/ha in May at the Stoddart Cr. and Iron Gates Tunnel ranges (Table 13). By September, forage biomass had declined to about 725 kg/ha on these two low elevation ranges but was still about 1135 kg/ha on the upper Sinclair Cr. summer range. Vegetation biomass on the Sinclair F summer range was about 27% higher in September than in July (Tables 13 and 14) indicating the peak of forage production was much later on the summer range.

Plant biomass was 63% higher on the Subalpine everlasting-grouseberry vegetation type (H17) at the Sinclair F range than on the higher mountain avens-snow willow-moss campion (H1) vegetation type at the Kindersley E range (Table 14).

For the three months of May, July and September, the average production was similar for both the Stoddart Cr. (CP1) winter range and the lower Sinclair Cr. (CP2) intermediate range over the Iron Gates (Table 13). However, during the month of September, production was 37% higher at CP2 and this was believed due primarily to the unusually heavy production of yellow sweet clover (*Melilotus officinalis*) as seen in Figure 13. On the Subalpine and Alpine summer ranges, herbs and low shrubs comprised much of the forage production (Fig. 14).

On the Stoddart and Dry Gulch winter ranges, production was similar on all three grazed macroplots in July. However, at Stoddart Cr., production was 2.75 times greater within the exclosure plot. Much of this increase in production within the exclosure was the result of greater grass and herb growth (Figs. 15 and 16). The July 1984 dry forage production values at Stoddart Cr. of 577 and 1247 kg/ha for the grazed and ungrazed plots respectively, are considerably higher than comparable values at Columbia Lake (Davidson 1985) of 395 and 560 kg/ha.

4.1.2.2 Forage quality - Three important observations have been made regarding seasonal forage quality on sheep ranges: (1) green, young vegetation is more nutritious, palatable and digestible than dormant, dry vegetation (Cook and Harris 1950, McCann 1956, Capp 1967, Dietz 1970, Hebert 1973, Stelfox 1976b); (2) alpine vegetation is nutritionally

Table 13. Forage production values from permanent clip plots, Kootenay National Park, 1984.

Plot #	Sample #	Date	Oven-dry weight (g/m^2)	Biomass kg/ha	Mean kg/ha	S.D.
CP1	1	May 25	39.8	398		
	2		24.1	241		
	3		51.4	514		
	4		30.4	304	364.3	118.9
CP2	1	May 25	27.0	270		
	2		12.6	126		
	3		13.7	137		
	4		23.7	237	192.5	11.9
CP1	1	July	88.4	884		
	2		139.3	1393		
	3		76.0	760		
	4		67.5	675	928.0	321.6
CP2	1	July	79.1	791		
	2		51.9	519		
	3		104.0	1040		
	4		104.6	1046	849.0	250.0
CP1	1	September	46.1	461		
	2		57.4	574		
	3		75.7	757		
	4		71.7	717	627.3	135.8
CP2	1		35.5	353		
	2		64.4	644		
	3		143.5	1435		
	4		86.9	869	825.3	458.1
CP3 (Sinclair)	1	September	102.7	1027		
	2		118.6	1186		
	3		102.7	1027		
	4		129.7	1297	1134.3	131.8

CP1 - Stoddart - winter range (Montane).
CP2 - Iron Gates Tunnel = intermediate range (Montane).
CP3 - Upper Sinclair (Creek) = summer range (Upper Subalpine).

Table 14. Forage production values (kg/ha) from permanent macroplots, Kootenay National Park, July 1984.

Macroplot	Sample plot (m^2)	Oven-dry weight (g/m^2)	Biomass kg/ha	Mean kg/ha	S.D.
	Winter Ranges				
SCL-1	A1	18.7	187		
	A2	54.1	541		
	A3	46.8	468		
	A4	6.1	61		
	A5	57.7	577	366.8	229.5
	Mean =	36.7			
SCL-2	B1	66.6	666		
	B2	115.3	1153		
	B3	114.7	1147		
	B4	84.6	846		
	B5	124.7	1247	1011.8	245.3
	Mean =	101.2			
DG-C	C1	37.8	378		
	C2	46.5	465		
	C3	53.4	534		
	C4	19.9	199		
	C5	55.2	552	425.6	144.0
	Mean =	42.6			
DG-D	D1	26.1	261		
	D2	32.0	320		
	D3	17.4	174		
	D4	69.8	698		
	D5	22.3	223	335.2	209.7
	Mean =	33.5			
	Summer Ranges				
Kindersley E	E1	30.3	303		
	E2	33.4	334		
	E3	72.9	729		
	E4	75.0	750		
	E5	62.2	622	547.6	215.0
	Mean =	54.8			
Sinclair F	F1	113.3	1133		
	F2	61.6	616		
	F3	86.9	869		
	F4	61.8	618		
	F5	124.4	1244	896.00	288.8
	Mean =	89.6			

*Forage = grasses & forbs not shrubs.
SCL-1: Stoddart Cr. (outside exclosure)
SCL-2: Stoddart Cr. (inside exclosure)
DG-C: Dry Gulch Cr. (north)
DG-D: Dry Gulch Cr. (south)
Kindersley: Alpine
Sinclair: Upper Subalpine

Figure 13. Heavy growth of yellow sweet clover (Melilotus officinalis) along the lower Sinclair Creek intermediate winter range, summer 1984.

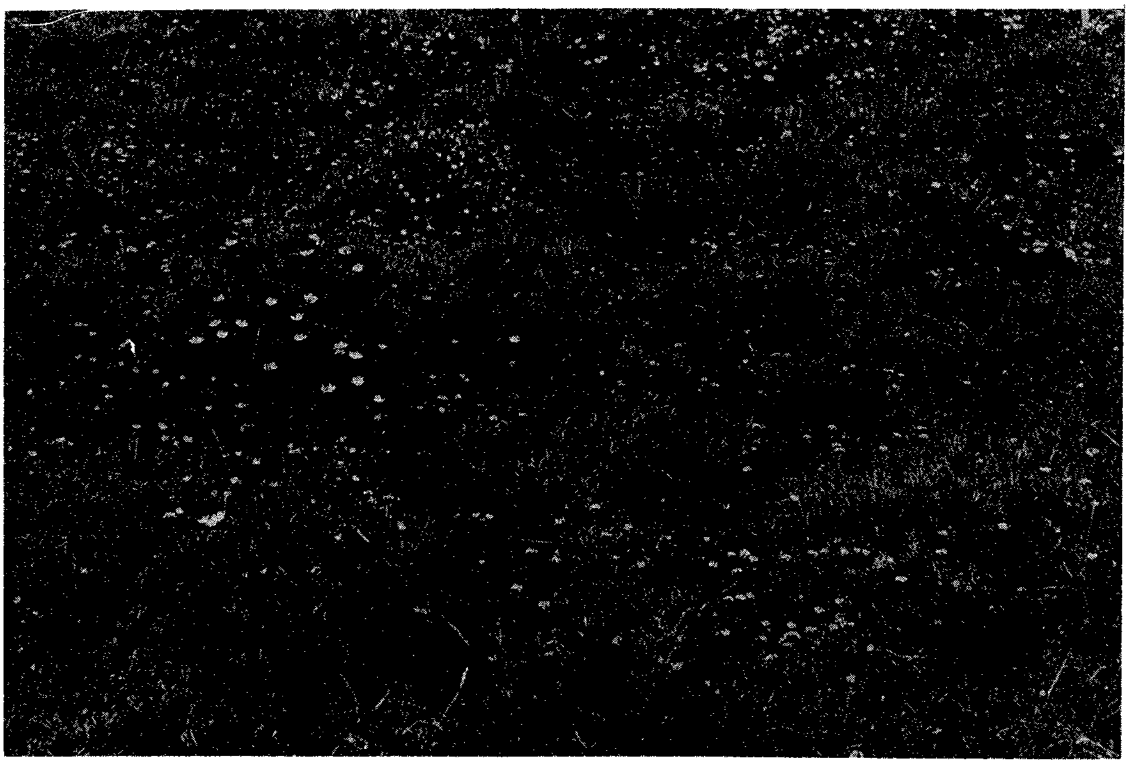

Figure 14. Dense low vegetation growth of Kindersley E Alpine range, July 1984.

Figure 15. Southwest corner of 1966 exclosure showing greater vegetation biomass within the exclosure compared with the grazed area outside.

Figure 16. Dense grass and herb cover within the 1966 exclosure plot at Stoddart Creek (SCL-2) in July 1984.

superior to low-elevation forage when similar species are compared (Johnston et al. 1968, Hebert 1973, Morgantini and Hudson 1983); (3) high elevation bighorn sheep forage is significantly higher in protein, phosphorus and moisture, but lower in crude fibre and calcium than low elevation forage (Stelfox 1976b).

The 1984 study on winter, intermediate and summer ranges of the Radium bighorn sheep band provided the following results:

a) Protein content on the low elevation, winter ranges was highest during May when it averaged 12.0% at Stoddart Cr. and 15.0% at the intermediate Iron Gates Tunnel range (Table 15, Fig. 17). However, during July, forage protein content of high elevation, summer range forage was much higher (15.2% and 14.4%) than on the intermediate range (11.5%) and on the low elevation winter ranges (8.1%, 7.8% and 8.7%) as shown in Table 15 and Figure 17. In the fall (September), protein content declined from July to 6.4%, 8.0% and 8.1% on the low, mid and high elevation sites, respectively. These results concur with other studies that showed the highest protein level occurs in the spring, decreasing steadily through summer and early fall and with high elevation forage containing more protein than low elevation forage during summer (Hebert 1973).

The migration behaviour of bighorn sheep, whereby they use new succulent forage that begins growth first on the low elevation range and then progress up the mountain slopes towards the alpine areas as the snow recedes, provides them with the opportunity to continue using high protein forage for about six months of each year (Stelfox and Taber 1969, Hebert 1973, Stelfox 1978);

Table 15. Seasonal changes in mean forage quality of low, mid and high elevation ranges, Kootenay National Park, 1984.

Location	Site	% Protein	% Fibre	% Ca	% Ph	% Ash	PPB Selenium	% Moisture
Spring (May)								
Low elevation	SCL-1	12.0	32.7	.69	.24	7.5	8	5.5
Mid elevation	TUNNEL	15.0	16.7	1.63	.16	9.5	13	6.6
Summer (July)								
Low elevation	SCL-1	8.1	31.5	.82	.17	8.1	10	6.0
Low elevation	DG-C	7.8	33.9	.68	.18	7.9	11	5.7
Low elevation	DG-D	8.7	31.6	.97	.16	7.8	7	5.6
All low elevations		8.2	32.3	.82	.17	7.9	9	5.8
Mid elevation	TUNNEL	11.5	29.3	1.12	.12	8.1	13	6.0
High elevation	KIND.	15.2	26.2	.93	.22	7.8	12	6.5
High elevation	SINCL.	14.4	33.8	.73	.38	6.8	9	6.3
All high elevations		14.8	30.0	.83	.30	7.3	11	6.4
Fall (September)								
Low elevation	SCL-1	6.4	35.1	.82	.10	7.7	7	6.3
Mid elevation	TUNNEL	8.0	40.7	.78	.09	6.6	9	7.0
High elevation	SINCL.	8.1	39.6	1.00	.20	6.0	14	6.9
Summer (August)* 1970								
Grasses								
Low elevation		8.7	34.3	0.60	0.15			7.1
High elevation		10.2	32.7	0.49	0.21			8.7
Forbs								
Low elevation		11.7	29.2	2.59	0.12			9.2
High elevation		16.7	38.0	2.26	0.25			9.3
Shrubs								
Low elevation		6.2	43.3	1.31	0.10			7.0
High elevation		8.8	43.3	1.25	0.16			6.5

*Low and high elevation forages in Kootenay, Jasper, Banff and Waterton Lakes National parks (Stelfox 1976b).

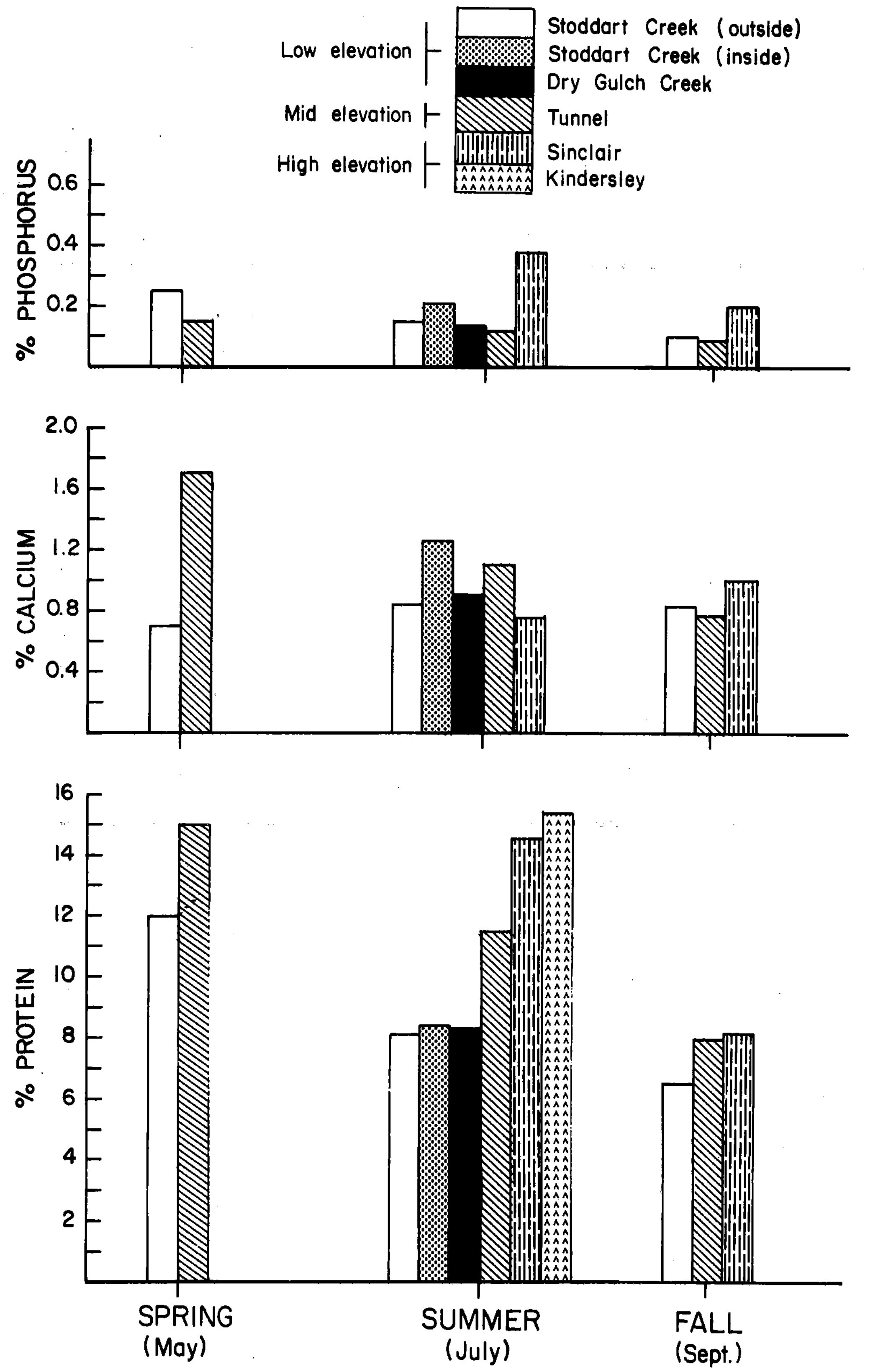

Figure 17. Seasonal changes in protein, calcium and phosphorus on low, mid and high elevation ranges, 1984.

b) Fibre and Moisture affect the palatability of forage with high palatability generally associated with low fibre and high moisture content (Stoddart and Smith 1955). Moisture content did not decline from spring to fall as expected although fibre increased noticeably during this same period especially between July and September on the mid and high elevation ranges (Appendix 2).

c) Calcium and Phosphorus levels in the spring and summer periods on both low and high elevation ranges met minimum dietary levels of 0.24 to 0.34% calcium and 0.16 to 0.20% phosphorus in forage for maintenance and gestation (NRC 1957).

The results were comparable with those obtained on bighorn sheep ranges in Kootenay, Jasper, Banff and Waterton Lakes National parks in 1970 (Stelfox 1976b). For those parks, high elevation summer (August) forage was significantly higher in protein, phosphorus and moisture, but lower in crude fibre and calcium than low elevation forage. Forbs were highest in protein, calcium and phosphorus while shrubs were highest in crude fibre. Shrubs were highest in fibre but lowest in protein, moisture and phosphorus. Forbs were highest in protein, calcium and moisture while grasses were intermediate in protein, moisture and fibre; lowest in calcium and similar to forbs in phosphorus.

This study, the one in the four national parks in 1970 (Stelfox 1976b), and the one for the East Kootenay region of B.C. (Hebert 1972), indicate that winter range forages become deficient in phosphorus in summer and do not meet the minimum phosphorus requirements for lactation of 0.20% (NRC 1963). However, if bighorn ewes migrate to alpine ranges during lactation they appear to receive adequate phosphorus. The Radium winter ranges do not meet the minimum phosphorus requirements for gestation of 0.16% in the fall and winter and this may partially explain the periodic trips made to Sinclair Canyon during fall, winter and spring to lick mineral soil.

4.1.3 Forage Preferences and Diet Composition

General - Strong correlations exist between forage utilization by bighorn sheep and in decreasing order of significance, each of the following parameters: (1) lungworm burden, (2) yearlings:100 ewes, (3) winter weight loss of ewes, and (4) forage production. There is no significant correlation between forage utilization and the number of lambs:100 ewes (Stelfox 1976b). Results from range ecology studies of bighorn sheep in Jasper, Banff and Waterton Lakes national parks (Stelfox 1976b) showed that grass comprised 63 to 80 percent and forbs 18 to 32 percent of the diet with the percentage of forbs increasing as the sheep stocking rate increased. Forage preference is calculated by dividing sheep diet by range composition (% frequency x canopy coverage for each species) whereas sheep diet is the product of diet frequency (% of transects on which the species was utilized) x diet composition (% of all plants utilized that were of that species). For these three parks, wheatgrasses provided the highest percentage of the diet. On the light-moderately stocked Waterton range, rough fescue and Idaho fescue along with wheatgrasses were the main diet species whereas on the heavily grazed Jasper ranges, junegrass, brome and blue grasses provided most of the grass diet abetted by northern bedstraw, shrubby cinquefoil and rose. Diet preferences, in decreasing order, on lightly and moderately stocked winter ranges were forbs, shrubs, grasses, compared with forbs, grasses, shrubs on heavily stocked ranges (Stelfox 1976b).

4.1.3.1 *Winter range* - The 1966 study (Stelfox 1966) showed that in the vicinity of Radium Hot Springs, sheep fed heavily in the fall on *Agropyron cristatum* which remained green until late October. They also fed on *A. spicatum*, *A. subsecundum*, *Koeleria cristata*, *Oryzopsis hymenoides*, *Rosa* spp. and *Prunus virginiana*. Along the lower portion of Sinclair Canyon on the north side, sheep were feeding heavily on *Chrysothamnus nauseosus*, *Amelanchier alnifolia*, moderate use of *Rosa* spp., *Arctostaphylos uva-ursi*, *Oryzopsis hymenoides*, *Cirsium* spp., *Pseudotsuga menziesii*, *Juniperus scopulorum* and light use of *Artemisia frigida*, *Symphoricarpos albus*, *Juniperus communis*, *Agropyron spicatum* and *A. inerme*.

On the Stoddart Cr. range in 1966, heavy use was observed on *Oryzopsis hymenoides*, *Chrysothamnus nauseosus*, *Prunus virginiana*, *Amelanchier alnifolia*, *Acer glabrum* and *Juniperus scopulorum*. Moderate use was observed on *Arctostaphylos uva-ursi*, *Symphoricarpus albus*, *Shepherdia canadensis* and *Pseudotsuga menziesii*, *Chrysothamnus nauseosus* and *Rosa* spp., *Koeleria cristata* and *Poa* spp. Light use occurred on *Agropyron spicatum*, *Solidago*, *Aster* and *Erigeron* species.

4.1.3.2 *Intermediate range* (Lower Sinclair Cr.) - Diet composition results for 1984 revealed that during the early winter period of October to December when the Radium band was on the Sinclair Canyon range, grasses made up about 64% of the diet, forbs 12%, shrubs and trees 23%

and lichens and mosses 1% (Table 16 and Appendix 3). (Fecal material for diet composition determinations were all collected from the Sinclair Canyon area except during July when they came from the alpine summer range.) Results reflect heavy use of domestic grass species (*Poa*, *Festuca*, *Agropyron* and *Bromus*) growing adjacent to the highway and on various seeded sites. *Poa* spp. made up about 32% and *Festuca* spp. 24% of the diet during that period. *Agrostis*, *Calamagrostis*, *Bromus*, *Agropyron* species and *Stipa comata* comprised another 6% and *Trisetum spicatum*, *Koeleria cristata*, *Oryzopsis hymenoides* plus *Elymus* species another 1.5%. The main forbs in the diet were *Artemisia frigida* 7.3% and unknown composites 2.0%. Shrubs and trees that contributed most to the diet were *Berberis* 6.9%, *Pseudotsuga* 5.0%, *Salix* 3.9%, *Shepherdia* 3.9%, *Spiraea* 2.3%, and *Symphoricarpos* 1.1%. Lichens and mosses contributed less than 1% to the diet.

As winter progressed and snowpack conditions made grazing difficult, the amount of grass in the diet declined to about 38% by January. The use of forbs was virtually non existent and shrub-tree forage comprised about 62% of the diet. Five genera supplied 85% of the January diet and these were: *Pseudotsuga* 39.2%, *Poa* 21.6%, *Shepherdia* 17.9% and *Festuca* 6.4%.

During late winter - early spring (April) as snow disappeared from south-facing slopes and green grass and forbs became available, the amount of grass in the diet increased to 49.3% and forbs to 6.5%. There was a proportionate decline in the amount of shrub-tree forage in the diet to 42.6% while lichen-moss supplied another 1.6% to the diet.

Table 16. Monthly diet composition (%) of Radium bighorn sheep band, April 1984 to January 1985.

Forage class & species	Mean percentages of diet from fecal analysis											
	April 1	April 2	May	June	July*	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Means
GRAMINOIDS												
Agropyron	1.26	.84	.51				2.13	.75	1.17	3.72	4.61	1.36
Agrostis	1.55	2.26					1.27	1.22	.58	1.50	1.66	.91
Bromus		1.49				.61		.89	.66	.86	.43	.45
Calamagrostis	.61	3.96						1.44	2.64		1.46	.92
Carex		2.37		7.53	8.48	10.58	6.63					3.24
Danthonia	.68										1.31	.18
Elymus									.68			.06
Festuca	13.33	20.11	7.51	4.50	4.03		9.73	21.38	33.24	16.39	6.38	12.42
Juncus						.72						.07
Koeleria cris.	2.79									.84		.33
Oryzopsis	.84									.79		.15
Poa	20.55	25.90	6.00	6.40	3.60	5.35	13.54	44.03	23.27	29.34	21.62	18.15
Schizachne purp.				4.50								.41
Stipa comata									1.30	2.37	.70	.40
Trisetum spic.										2.30		.21
Total Grasses	**41.61**	**56.93**	**14.02**	**22.93**	**16.11**	**17.26**	**33.30**	**69.71**	**63.54**	**58.11**	**38.17**	**39.24**
FORBS												
Achillea mill.				.58			.51					.10
Aralia nud.			2.92									
Artemisia	4.40	.73						.68	18.77	2.59		2.47
Aster						1.57			.64			.20
Astragalus-Oxyt.	3.76			2.39	1.17	4.82	.59					1.16
Composite	.68		.51	1.55	1.51	.79		.54		5.61		1.02
Equisetum						1.37	1.58					.27
Fragaria-Sibbaldia	1.95		.53	9.25	14.84							2.42
Hedysarum		1.50		.58	1.41							.32
Hydrophyllaceae									.68			.06
Liliaceae						.87						.08

Table 16. Continued.

Forage class & species	Mean percentages of diet from fecal analysis April 1	April 2	May	June	July*	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Means
Penstemon						.59						.05
Potentilla-Geum				3.75	1.17	7.09						1.09
Seeds						1.48				.79		.21
Trifolium						.87						.08
Unkn. Forbs								4.68	2.47			.65
Total Forbs	**10.79**	**2.23**	**3.96**	**18.10**	**20.10**	**19.45**	**2.68**	**5.90**	**22.56**	**8.99**	**0**	**10.43**
SHRUBS-TREES												
Amelanchier	3.62	1.54	.73									.54
Berberis repens	.66	.73			.68		.91	1.14	5.42	14.23	1.57	2.30
Chrysothamnus	.76											.07
Dryas	1.42			.76	.75	2.39	1.13	1.99	.72			.83
Ledum	.66				.62							.12
Pseudotsuga	16.34	10.32							3.38	11.58	39.20	7.35
Rosaceae			1.02			1.27						.21
Salix	10.71	7.44	13.28	19.90	45.91	34.80	17.28	8.34	1.89	1.50	3.12	14.92
Shepherdia	12.64	18.44	58.70	37.93	11.73	23.63	42.44	6.23	1.24	4.18	17.94	21.37
Sorbus			.34									.03
Spiraea			6.19		.51	.59	2.26	4.03	.66			1.29
Symphoricarpos			1.76	.38	3.59	.61		1.71	.59			.79
Total Woody	**46.81**	**38.47**	**82.02**	**58.97**	**63.79**	**63.29**	**64.02**	**23.44**	**13.90**	**31.49**	**61.83**	**49.82**
LICHENS & MOSSES												
Cladonia		2.37						.95		.73		.37
Lycopodium										.68		.06
Moss	.79											.07
Total Lichen-Moss	.79	2.37						.95		1.41		.50

*From Sinclair-Kindersley alpine range. Fecal samples for other months from Sinclair Canyon.

On 26 April 1984, the authors observed six bighorns along Sinclair Canyon feeding on *Medicago falcata*, *Calamagrostis* sp., *Agropyron cristata*, *Poa pratensis*, *Arctostaphylos uva-ursi* and *Spiraea* sp. Two rams were feeding on *Agropyron* spp. and *Amelanchier alnifolia*. Twenty six ewes and immatures were feeding on *Agropyron cristata* and *Bromus inermis*. Another group of 15 ewes and immature were feeding on *Agropyron cristata*, *Festuca rubra* and *Bromus inermis*.

On 5 March 1985 we saw bighorns feeding along south-facing semi-open Douglas fir grasslands that were bare of snow near the Warden headquarters and the Bungalows. They were feeding on forbs and grasses, especially *Melilotus officinalis* and *Agropyron* spp.

A pronounced dietary change occurred during the months of May and June when shrubs and trees were in the rapid stage of growth. Apparently, this succulent browse forage was preferred by sheep during this period as it supplied about 70.5% of the diet (Table 16 and Appendix 3). Two genera contributed most of this forage: *Shepherdia* 48.3% and *Salix* 16.6%. The amount of forbs also increased in the diet to about 11.0% from 6.5% in April and 0% in January. Forbs that contributed most were *Fragaria* - *Sibbaldia*, *Aralia*, *Astragalus* - *Oxytropis*, *Potentilla* - *Geum* and unknown composites. The amount of grass in the diet declined noticeably to 18.5% and most of this was *Poa*, *Festuca*, *Carex* and *Schizachne*.

4.1.3.3 *Summer range* - During the middle of summer (July-August) the amount of shrubs in the diet increased even more and supplied about 63.5% of the diet. *Salix* supplied about 40.4% of the diet and the low, prostrate species such as *Salix arctica*, *S. barratiana* and *S. nivalis* were likely the main species utilized. *Dryas* supplied about 1.6% of the diet, *Shepherdia* 17.7%, *Symphoricarpos* 2.1%, *Rosa* 0.63%, *Spiraea* 0.55%, *Berberis* 0.34% and *Ledum* 0.31%. The use of forbs continued to increase to 19.8% with a greater variety in the forb diet than during any other period. Forbs that contributed to the diet, in decreasing order of importance, were *Potentilla* - *Geum*, *Astragalus* - *Oxytropis*, *Aster*, *Equisetum*, *Liliaceae*, *Trifolium* and *Penstemon* species. The amount of grass in the diet declined from that in the spring to about 16.7%. Carex provided 9.5% of the diet, followed by *Poa* 4.5%, *Festuca* 2.0%, *Juncus* 0.4%, and *Bromus* 0.3%.

While working on the Sinclair-Kindersley summer ranges in July 1984 the authors observed the following forb species recently eaten by bighorn sheep: *Arnica mollis*, *Veronica alpina*, *Pulsatilla occidentalis*, *Ranunculus eschscholtzii*, *Penstemon fruticosa*, *Potentilla drummondii* and *P. diversifolia*, *Senecio lugens*, *Taraxacum* spp., *Astragalus alpinus* and *A. cusickii* as well as some unidentified *Penstemon* and *Potentilla* species. Graminoid species observed utilized included: *Luzula spicata*, *Poa alpina*, *Trisetum spicatum*, *Festuca baffinensis*, *Carex albo nigra* and *C. nigricans*. The only shrub species observed used was *Vaccinium scoparium*. During the same month along Sinclair Canyon, bighorns were observed feeding heavily on *Melilotus officinalis*.

During September when the Radium band began moving towards their rutting range, the amount of grass in the diet (33.3%) was double that of July-August. *Poa*, *Festuca*, *Carex*, *Agropyron* and *Agrostis* species, in decreasing order of abundance, provided the grass diet (Table 16). The amount of forbs in the diet (2.7%) was only about one-sixth as much as during July-August. Equisetum, Astragalus - Oxytropis and Achillea were the main forbs eaten in September. Shrubs and trees made up 64.0% of the diet and this was comparable with that of the previous period. There was less Salix but more Shepherdia and Spiraea eaten compared with the earlier period. On September 20th, 10 ewes and immatures were observed feeding on Poa, Agropyron, Taraxacum, Cirsium, Aster and Acer species.

4.2.0 POPULATION DYNAMICS

From April 1984 to March 1985, seasonal ground and aerial surveys revealed that the population of the Radium band was as high as at anytime during the period April 1980 to March 1984 (Table 17). The March 1985 ground census revealed a minimum population of 114 bighorns on the winter range between Sinclair and Stoddart creeks. This compares to previous spring counts of 89 in 1984, 108 in 1983, 77 in 1982, and 109 in 1981, 133 in 1966 and 140 in 1938 (Kootenay National Park Warden Service files). These counts suggest that the population trend has been stable or slightly upwards during the past five years (Tables 17-19 and Stelfox 1978).

The age-sex structure of the 92 classified animals in March 1985 was: 41.3% ewes, 25.0% lambs and 33.7% rams. There were 60.5 lambs: 100 ewes. Of the 31 rams, four were full curl (class 4), 10 were 3/4 curl (class 3), seven were 1/2 curl (class 2) and 10 were 1/4 curl (class 1). The group of 11 along Sinclair Cr. between the Bungalows and Hwy. 95 at the bottom of the canyon was derived by subtracting the group of seven

Table 17. Maximum counts of bighorn sheep on Sinclair-Stoddart creeks winter range in Kootenay National Park: April 1980 to March 1985.

					YOY*		YLY*	
Date	Total	Rams	Ewes	Unknown	No.	Per 100♀	No.	Per 100♀
1980								
April	81	7	45	2			27	60.0
October	47	11	21		15	71.4		
1981								
March	109			109				
October	52	10	29		13	44.8		
December	74	19	39		17	43.6		
1982								
February	92	8	15	66			3	20.0
March	54	2	36				16	44.4
April	77	18	43	5			11	25.6
October	62	9	35		18	51.4		
November	54	5	32	2	15	46.8		
1983								
April	108	27	43	24			14	32.6
October	78	7		71				
1984								
February	75	10	13	49			3	23.1
March 5	18	18						
March 26	87	9		78				
April	74	9	38	12			15	39.5
October	85	16	30	12	21	70.0	7	23.3
1985								
March	114	31	38	22			23	60.5

*Young of year (YOY) per 100 ewes and young of last year (YLY) per 100 ewes.

at the Warden headquarters during the March 6 census from the 18 counted along the Sinclair Canyon during both March 5 and 7 (Table 18).

Lamb production as determined from lambs:100 ewes in fall (October-November) and the following spring (March-April) remained high during the 1984-85 period despite the high population (Table 19). Production rates were higher in 1980 (increasing population) but lower in 1966 during the population crash (Table 19).

Approximate recruitment rates (yearlings:100 ewes) remained high between 1980 and 1985 while overwinter lamb mortality remained reasonably low (Table 17). For example, in October 1981 there were 44.8 YOY:100 ewes (including yearlings). By December this had declined to 43.6 and the following spring (March-April 1982) to 35.0 lambs per 100 ewes. This represents an overwinter lamb mortality (October-March/April) of 21.9%. Similarly, the overwinter lamb morality between October 1982 and April 1983 was 36.6%. During the winter of 1984-85 lamb mortality was only 13.6% (Table 17). Correspondingly, the number of yearlings per 100 ewes was 31-34 during April to November 1984 (Table 19). That compares to only 22 in October 1966 when the band was suffering from pneumonia lungworm disease. The YLY:100 ewe ratio in March 1985 of 32.7:100 indicates the Radium band is vigorous and showing no evidence of poor production or recruitment.

4.3.0 SEASONAL DISTRIBUTIONS AND CRITICAL RANGES

General - Ground surveys were made of low elevation winter and intermediate ranges during each month for the period April 1984 to March 1985. Ground surveys were also made of the subalpine and alpine regions

Table 18. Bighorn sheep ground census from Sinclair Creek south to 1 km south of Stoddart Creek: 6 March 1985.

Location	Group size	UNK	Rams				Ewes	Lambs (YLY)*
			1	2	3	4		
Sinclair Creek								
(1) Warden hdqs.	7						5	2
(2) Bungalows & lower canyon	11		1	1			5	4
Dry Gulch Cr.	7			2	1	2	1	1
Dry Gulch Cr.	12	12						
Dry Gulch Cr.	7	7						
S. of Dry Gulch	6	3	2				1	
Stoddart Creek								
(1) Exclosure	21		2	1	2		11	5
(2) 0.5 km north	12						4	8
(3) north side	31		5	3	7	2	11	3
(4) 1.0 km south	7	7						
Total Count	121	29	10	7	10	4	38	23
Count Stoddart-Sinclair Crs.	114	22	10	7	10	4	38	23

*YLY = Young of last year.

Table 19. Productivity and recruitment rates of Radium bighorn sheep band, April 1984 to March 1985 compared with 1980 and 1966.

Period	Sample size	YLY* No.	YLY* Per 100♀		Long yearlings* No.	Long yearlings* Per 100♀		Ewes
			SPR.	FALL		SPR.	FALL	
January 1966	89	21	30.9		included with ewes			68
October 1966	156	36		36.7	22		22.4	98
April 1980	72	27	60.0		included with ewes			45
October 1980	36	15		71.4	included with ewes			21
April 198~~8~~4	138	46	57.5		25	31.2		80
Oct.-Nov. 1984	124	38		59.4	22		34.4	64
March 1985	89	24	49.0		15	32.7		49

*May-June = lambing period. In this table lambs are those animals young of last year (YLY). During the fall period (October-November) the number of long yearlings are calculated by doubling the number of yearling rams. The number of ewes is then reduced by the number of yearling ewes.

The number of animals shown include duplicates as the classified counts were taken during a one or two month period.

of Kindersley and Sinclair watersheds during July to September 1984. Helicopter surveys of winter, summer and intermediate ranges were conducted during May, July and September 1984, as well as March 1985. During all surveys, information on distributions, concentrations and critical ranges was recorded. Historical information on lambing and rutting ranges as well as natural lick sites is being reviewed and collated.

4.3.1 Seasonal Distributions

Information on seasonal distributions was accumulated from ground and aerial surveys during 1984 and 1985. To date it appears that seasonal distributions of the Radium band are similar to those reported for the period 1966-1972 (Stelfox 1978) as shown in Figure 18. Revised maps of winter and summer ranges associated with Ecosites are presented in Figures 19 and 20. These are projections based on ecological land classification plus 1984 surveys. The Warden Service plans to gather additional information on seasonal distributions of this band during the 1985-86 fiscal year.

Information to date indicates annual variability in seasonal distributions depending on climatic conditions, primarily snowpack depth and duration.

Basically, the winter range lies between Stoddart and Sinclair creeks and below the 1515 m (5000 ft) elevation as previously described by Demarchi (1968), Stelfox (1978), and Poll et al. (1984). During mild spells and late winter when south and westerly slopes lose their snow there is some use of grasslands along the lower portions of McKay Cr. and

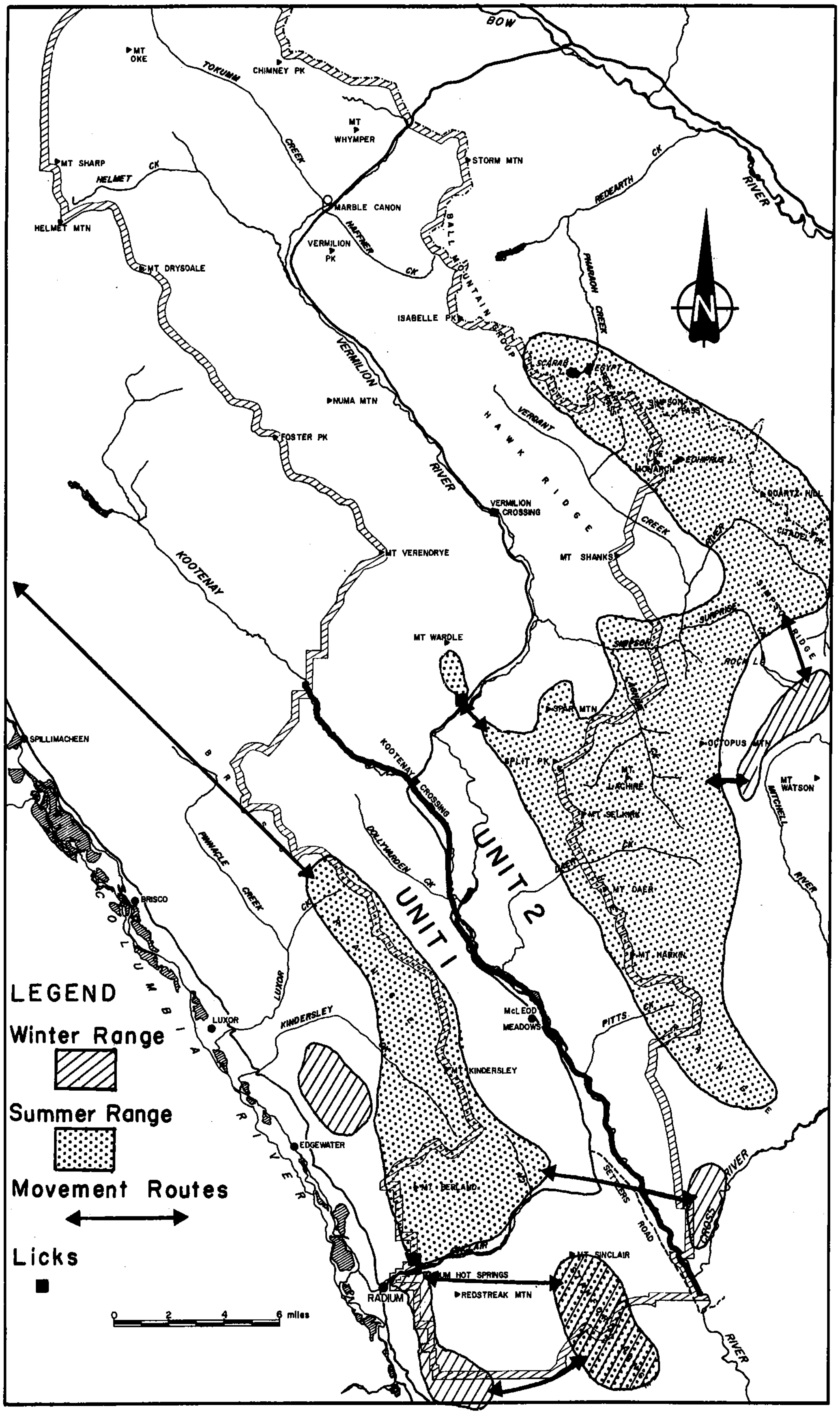

Figure 18. Seasonal sheep distribution in Kootenay National Park, 1966-1971 (from Stelfox 1978).

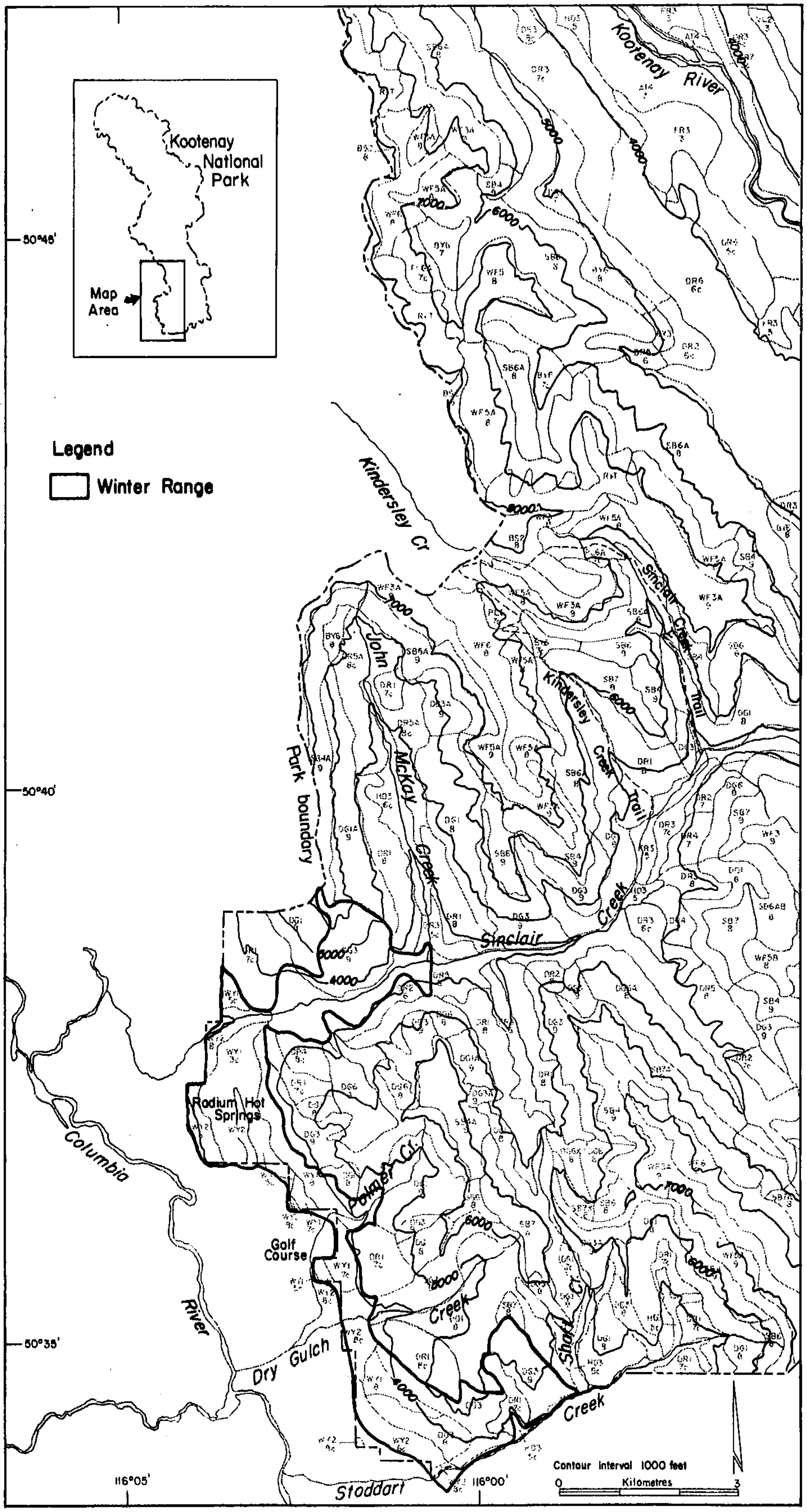

Figure 19. Ecosites on major winter range of Radium bighorn sheep band, 1984.

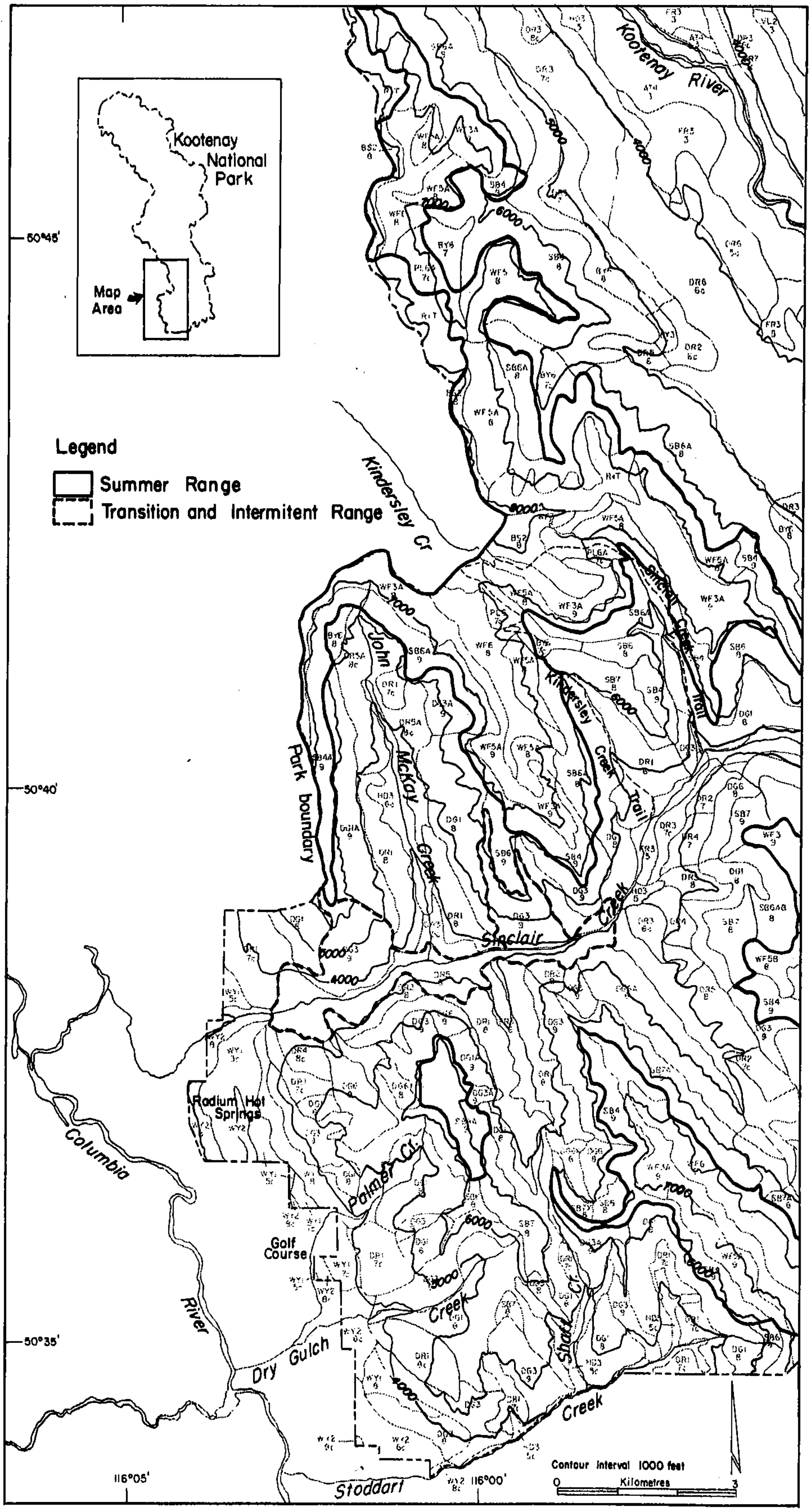

Figure 20. Major summer, intermediate and transition ranges of Radium bighorn sheep band, 1984.

between there and Hwy. 95, just north of Radium (Fig. 19). In the period 1965-67 there were up to 15 sheep wintering east of the Edgewater-Briscoe area. These were mainly rams that left the Stoddart Cr. winter range after the November to December rutting period. Between 1965 and 1975, more than 75% of the Radium band spent the period October to April between Dry Gulch and Shuswap creeks, mainly on provincial crown land south of the park at the 1300 to 1600 m elevation on westerly and south-westerly exposures (Stelfox 1978).

During the winters of 1983-84 and 1984-85 there were no observations of sheep wintering east of the Edgewater-Briscoe area. Rams as well as ewes and immatures were wintering mainly between Sinclair and Stoddart creeks. During the period 1981-83, some sheep were found wintering on the west-facing slopes at the head of Stoddart Cr. (Poll *et al*. 1984). In March 1984, an aerial survey by the Warden Service revealed at least 87 sheep (including 12 rams) wintering between Sinclair and Stoddart creeks. An aerial survey on 12 March 1985 revealed at least 162 sheep (75 ewes, 35 lambs and 52 rams) between Sinclair Cr. and Windermere Creek. Of these, 107 were between Sinclair and Stoddart creeks, four between Stoddart and Shuswap creeks and 50 between Shuswap and Windermere creeks. Those south of Shuswap Cr. are generally regarded to be part of the Columbia Lake band that winters near the gypsum mine east of Windermere. These are the animals that were fed trace mineral supplements and treated with a vermicide during the winter of 1983-84 because studies had revealed heavy loads of lungworms of both *Protostrongylus* spp. plus low levels of selenium, copper and iodine (Schwantje 1984).

Throughout the winter, sheep make frequent trips to the lower Sinclair Cr. range to use man-made grassland areas and disturbed sites from the Aquacourt to Radium townsite as well as the Redstreak campground area. During winters of high snow accumulation, sheep make greatest use of the open coniferous slopes and grasslands between Dry Gulch and Shuswap creeks, with greatest concentrations occurring on the Stoddart grasslands (Poll _et al_. 1984). They report that... "In April and May, much of the band moves into Sinclair Canyon to take advantage of early green vegetation on natural and man-made grasslands along the south facing slopes of Sinclair Cr. from Radium townsite to John McKay Cr. The few sheep remaining on the Stoddart ranges in May move up to Stoddart Cr. to summer in the upper Stoddart, Kimpton and Silt Cr. drainages. By mid-June the Radium band is moving to summer ranges on Mt. Berland and Mt. Kindersley in the upper McKay, Kindersley, Sinclair and Nixon creeks drainages as well as north along the Briscoe Range as far as Luxor Pass. Throughout the summer, groups of sheep (mainly ewes, lambs and yearlings) return to Sinclair Canyon to lick at exposed mineral soil along roads and forage on man-made grasslands" (Fig. 20). Occasionally, they move as far north as Kicking Horse Canyon east of Golden where a Radium-tagged 2-year-old ram was sighted in the summer of 1972 and where as many as 21 bighorns were seen in the summer and fall of 1972, of which at least one had a Radium ear tag (Stelfox 1978). Also in March 1974, a herd of seven were seen on a grassy slope above the railway track east of Golden.

Summer ram ranges are not well known, although some rams are believed to summer north of the Kindersley ewe range towards Luxor Pass, east of Briscoe. In July 1984, the authors saw six rams (classes 3 and 4) at the headwaters of Sinclair Cr. On 6 August 1971, Logan Atwood reported to Ian Jack (Chief Park Interpreter) that he saw six young rams on the west side of Mt. Berland, south of Baptiste Lake. They believed these to be the younger members of the ram group that had frequented the Hot Springs area that spring. Bill Hollingsworth (then Chief Warden) reported that during a helicopter survey on 22 August 1968 he observed a band of nine rams along the west boundary of the park at the headwaters of the north fork of Kindersley Cr. Big game guide Dalton Price (pers. comm.) reported seeing seven rams at the head of Pinnacle Cr. northeast of Briscoe on 6 August 1967. Some rams return to the Hot Springs area during summer, although not as often as ewe and immature groups. Ian Jack (pers. comm.) reported seeing rams and ewes taking soil from this area during July 14-21 and August 12-17, 1968. The authors saw four rams (including a class 2 ram with red ear tag #12) in Sinclair Canyon near the Iron Gates Tunnel on 18 July 1984.

In October and November, sheep return from summer ranges to make heavy use of the lower Sinclair Cr. area from John McKay Cr. to Radium townsite before moving southward toward the Stoddart Cr. winter range in early to mid-December. Much of the rut occurs on these areas in and adjacent to Sinclair Canyon, however breeding also occurs on the Stoddart winter range (Poll _et al_. 1984). A ground survey during November 28 and 29, 1984 showed this band to be distributed along lower Sinclair Cr. and south to Stoddart Cr.

4.3.2 Critical Ranges

4.3.2.1 Licks - Natural and man-made mineral licks occur on low elevation ranges such as at Stoddart Cr. (Figs. 21, 22) and on intermediate ranges such as along lower Sinclair Cr. adjacent to Hwy. 93.

Some samples of mineral lick material had been collected previously by the Warden Service from Sinclair Canyon (Iron Gates Tunnel) and macro-element analysis were conducted by Mr. H.C. Hanson of the Illinois Natural History Survey, Urbana, Illinois in 1977 (Kootenay National Park file C-4072-14/K2, Table 20). Unfortunately, no samples were taken from an adjacent non-lick area to show differences between lick and non-lick sites.

In the 1940s Dr. Ian McTaggart Cowan analysed natural lick material from the Rocky Mountain National Parks including the Mt. Wardle area (Cowan and Brink 1949, Table 20).

In the Radium Hot Springs area along Sinclair Canyon, the Radium band has licked the banks during July and August for many years (Stelfox 1978). The exposure of mineral soil and bedrock in this area is primarily the result of highway construction. Several sites occur along the lower Sinclair Creek: below Sinclair Summit; above Iron Gates Tunnel; and above the Radium Park Lodge and Warden Headquarters. Although used year-round, these licks are used mainly in June-July which corresponds to the peak lactation and molt period. During summer, sheep make frequent trips to this area from the Upper Subalpine and Alpine summer ranges in the upper Kindersley-Sinclair creeks and Mt. Sinclair areas, perhaps attesting to the lack of calcareous outcrops in those

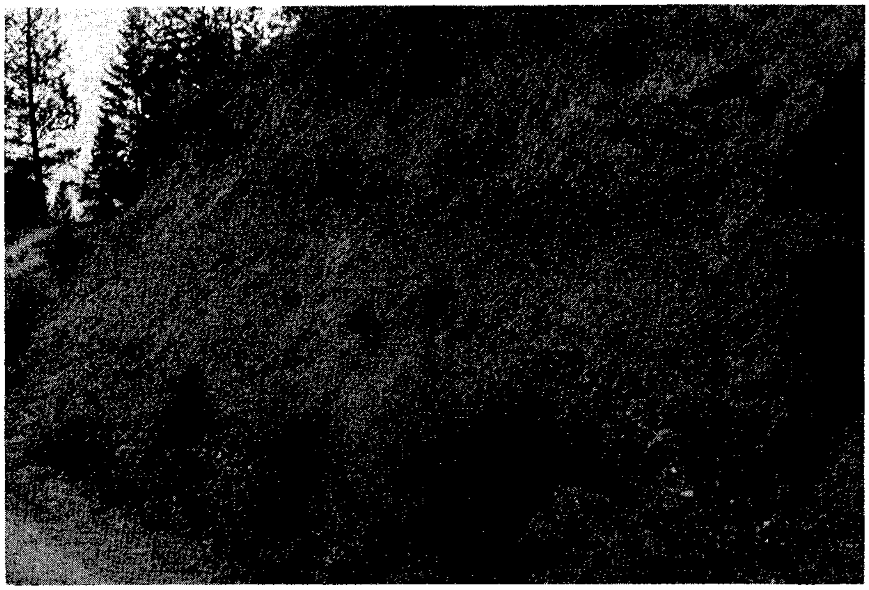

Figure 21. Cutbank along Stoddart Creek used as a natural lick by bighorn sheep, May 1984.

Figure 22. Stoddart Creek natural lick, May 1984.

Table 20. Analysis of bighorn sheep natural lick material at Iron Gates Tunnel, Sinclair Canyon, 1977 and Mt. Wardle.*

Total sulfur (ppm)	SO_4	Na	K	Ca	Mg	Cl	Ph	Conductivity MMMD's	Ext % H_2O
Iron Gates Tunnel									
488	1.96	2.23	0.04	0.15	0.65	1.37	8.2	11.01	24.9
Exchange values		3.72	0.23	39.55	7.24	-	-		
Mt. Wardle									
**676	2.78	0.77	0.08	0.40	2.19	0.37	8.6	4.82	48.9
***151	0.10	0.09	0.01	0.24	0.15	0.27	8.1	1.31	35.8

*Results of lick analyses from Mt. Wardle in the 1940s (Cowan and Brink 1949). Material was light brownish gray silt, very strongly calcareous with a weak argillaceous odor.

**Mt. Wardle goat lick.

***Mt. Wardle elk lick.

areas. It appears, that lower Sinclair Creek is not only an important spring and fall transition range but also an important source of minerals. Observations of sheep using licks in 1984 include the following:

May 25 - A band of 23 sheep (including two young rams) was feeding on exposed mineral soil at the roadside above the Warden Headquarters;

July 23 - Eleven sheep (ewes and immature) were licking along the slope above Hwy. 93 east of Iron Gates Tunnel;

October 9 - Four ewes and immatures were licking the highway 0.25 km west of the Kimpton Cr. bridge;

October 12 - Five rams (Classes 2-4) were licking soil east of Iron Gates Tunnel;

October 22 - Eight ewes and immatures were licking Hwy. 93 at the Compound entrance.

A recent review of mineral licks used by North American ungulates reports that sheep licks are enriched in calcium and magnesium and even higher soluble salt levels (Jones and Hanson 1985). Table 21 is an excerpt from their book and lists the composition of earth materials from 18 licks used exclusively by mountain sheep. Concerning North American wild sheep licks, Jones and Hansen state (pp. 120 and 121) "Sodium is near the grand means in both water and acetate extracts and sulfate is evidently more common than chloride. Total sulfur is near the grand mean but calcium carbonate equivalent is about two times higher in the sheep licks." They also report that sulfate salts of calcium and magnesium occur in several sheep licks, particularly in northern British Columbia. Their examination of information from licks used by several species,

Table 21. Composition of NH_4OAc and saturation-paste extracts of earth materials from licks used exclusively by mountain sheep (from Jones and Hanson 1985).

Analyte & unit of measure	n Samples	GM Geometric mean	GD Geometric deviation
Acetate Extract			
Ca (me/100 g)	18	31.60	1.82
Mg (me/100 g)	18	6.97	2.87
Na (me/100 g)	18	2.03	3.03
K (me/100 g)	18	0.54	2.72
Water Extract			
Ca (me/100 g)	14	0.61	4.21
Mg (me/100 g)	14	0.66	11.20
Na (me/100 g)	14	0.81	9.74
K (me/1.00 g)	14	0.07	3.23
SO_4 (me/100 g)	14	1.48	10.40
Cl (me/100 g)	14	0.16	7.30
Cond. (mmho/cm)	9[a]	5.66	4.56
pH	14	7.66[b]	1.29[c]
Total Analysis			
S (%)	16	0.09	5.44
Ca CO_3 (%)	15	10.80	4.97

[a] Five samples were 1 to 5 water extracts.

[b] Arithmetic mean.

[c] Standard deviation.

concluded that only pH and sulfate served to distinguish lick from nearby control soils. The final conclusion of their study was that magnesium and calcium and, to a lesser extent sodium, were the most important constituents of lick earths. Calcium appeared to be the major sought-after constituent in bighorn sheep, mountain goat, elk and moose licks.

4.3.2.2 Lambing areas - Lambing occurs from mid-May to mid-June with the peak being approximately May 25 to June 5 (Stelfox 1978). An aerial survey conducted 28 May 1984 found ewes with lambs only on the south and west slopes of Mt. Berland in the DG3 and SB4 Ecosites. Ewes and lambs were not located elsewhere, however the sheep are dispersed during this period and it is probable that lambing occurs on other DG3 and SB4 ecosites with southerly aspects in the Redstreak Mountain to Stoddart Cr. area (Fig. 23). Further investigations are necessary to identify more precisely important lambing areas.

4.3.2.3 Rutting ranges - As mentioned in Section 3.2, a major rutting range lies within and adjacent to Sinclair Canyon although rutting also extends south at least as far as Stoddart Cr. (Poll et al. 1984). The main rutting period is November and December at which time most ewes range between Sinclair Canyon and Stoddart Cr. An aerial survey in December 1966 showed 68 sheep between Radium and Shuswap Cr., 10 or 11 along Sinclair Canyon below the Hot Springs, and two near Edgewater. There was one full curl ram east and 6 km north of Edgewater on 9 December 1966 (Stelfox 1978). On 28 November 1984 there were four rams

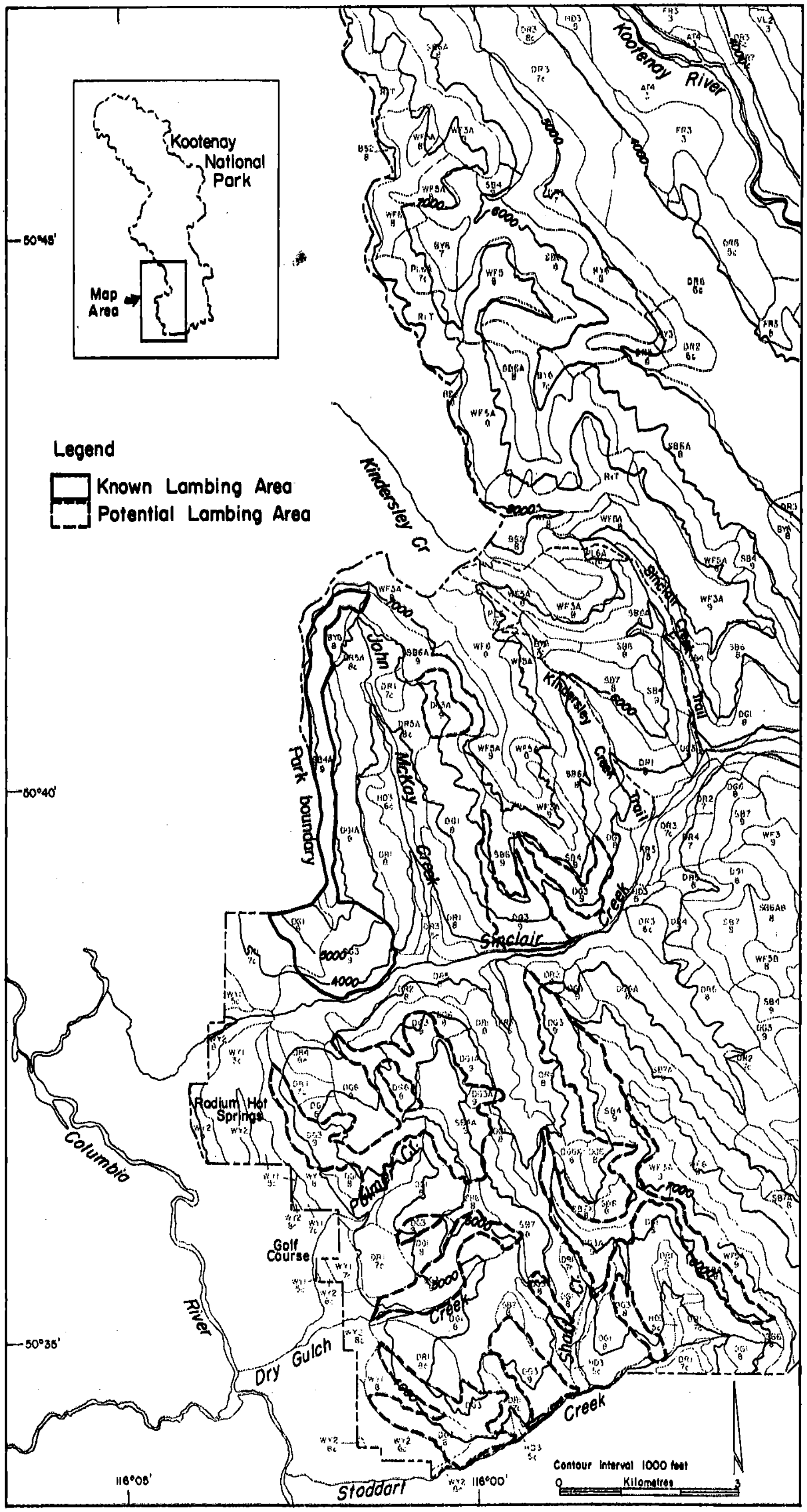

Figure 23. Potential and known lambing areas for the Radium bighorn sheep band.

(1 full curl) with six ewes and immatures along Sinclair Canyon by the West Gate. South of the Park there was a band of 21 (4 rams) along the Gypsum mine road near Windermere Cr. and another nine (8 rams and 1 ewe) above the Gypsum truck garage near where the artificial feeding program occurred during the winter of 1983-84. Apparently, rams move great distances during the rutting period (Geist 1967, 1971, Stelfox 1978) and in the Radium area they probably range all the way from Windermere Cr. to Briscoe.

4.4.0 HEALTH OF BIGHORN SHEEP

4.4.1 Production, Survival and Growth

Production and survival of lambs has been good during the period 1980-84 as revealed in Tables 17-19. Lambs per 100 ewes in the fall (October-December) were 71.4 in 1980, 44.8 in 1981, 51.4 in 1982, 70.0 in 1984. Over-winter survival of lambs was good as shown by corresponding spring (March-April) lambs per 100 ewes values of 60.0 in 1980, 44.4 in 1982, 32.6 in 1983, 41.0 in 1984 and 60.5 in 1985.

Growth rates of immatures appears good from the general appearance of body size and horn growth observed during 1984-85. Estimated horn lengths of lambs and yearlings are being collected and compared with those determined in the early 1970s when this population was expanding following the 1966-67 die-off (Shackleton 1976) (Appendix 4).

4.4.2 Animal Condition

The band maintained good condition between April 1984 and March 1985 as revealed in body condition ratings estimated at 7-8 (good-very good) in March 1984 and 7 (good) in March 1985.

4.4.3 External Evidence of Disease

There has been no external evidence of disease or unthriftiness, such as coughing, nasal discharge, scours or abnormal pelage.

4.4.4 Fecal Protostrongylus

Lungworm (Protostrongylus spp.) larval output during the period June 1984 - February 1985 was determined from 139 fecal samples comprised of 55 ewes, 41 lambs and 43 rams (Table 22, Fig. 24 and Appendix 5). The mean of 885 larvae/g feces (lpg) is similar to the mean of 820 from 409 samples analysed in 1968 and 1969 for southwestern Alberta and KNP (Uhazy et al. 1973). At that time 18 fecal samples from KNP were examined and the mean of dry feces was 927 (124-2728). Four animals or 22% contained heavy levels (>1400 lpg). A light intensity of infection is reported as less than 276 so a moderate intensity would be 277 to 1400 lpg (Uhazy et al. 1973). During the period 1968-69, 44% of the Jasper, 12% of the Banff and 3% of the Waterton samples had heavy intensities of infection.

Of the 139 samples analysed, 18 (20.1%) had heavy (>1400) lungworm larvae loads which compared with 13% of the samples analysed from four park and two non-park regions in 1968-69 (Uhazy et al. 1973). During 1968-69 none of the above populations were experiencing a die-off and they were considered to be reasonably healthy. The average larval load of 885 lpg in the Radium band between June 1984 and January 1985 can be considered a moderate-heavy intensity of infection, indicative of a sheep population under moderate stress from lungworm infection.

Larval counts varied considerably by season or period. When the sheep were on the summer range (June-September) the larval loads were

Table 22. Lungworm (Protostrongylus spp.) larval output in feces of Radium bighorn sheep: April 1984 to February 1985.

	Ewes		Lambs		Rams		All LPG Means
	$\bar{x}$[1]	LPG[2]	$\bar{x}$	LPG	$\bar{x}$	LPG	
April-May	329,13,56, 13, 199, 0	1290,270,273, 506, 3713, 0	275,103,54, 15, 8	1064,406,966, 458, 321	243,55,2, 15,0	957,218, 9, 131, 0,	
Mean HL	101.7	1008.7 1 (16.7%)	91.0	643.0 0 (0%)	63.0	263 0 (0%)	661.4 1 (6.2%)
June-July	0,5,6,272, 81,4,12,98 0,9,126	0,20,22,1544, 350,20,56, 380,38,482	88,44,132, 87,60,11	708,181,785, 915,1073,73	83,67,60,4, 38,35,12,4 128,69,69,38	321,262,228, 146,158,55, 557,305,303, 18,19, 148	
Mean HL	55.7	264.7 1 (9%)	70.3	622.5 0 (0%)	52.7	209.3 0 (0%)	315.8 1 (3%)
August- September	63,12,102, 22,27,36, 1,202,17, 19,0,41 40,253,52	274,54,437, 95,263,207, 38,890,71, 84,0,242, 178,1089,215	8,52,58, 58,131,152, 21,16	180,347,522, 522,2034,180, 2854,247,	2,15,74, 19,508, 33,35,	9,67,589, 83,2212, 150,267,	
Mean HL	59.1	275.8 0 (0%)	62.0	860.7 2 (25%)	98.0	482.4 1 (14%)	480.0 3 (10%)

[1] $\bar{x}$ = Mean number of larvae from three 20 ml aliquot samples.
[2] LPG = Number of larvae per gram of dried feces.

Table 22. (Continued).

	Ewes		Lambs		Rams		All LPG Means
	$\bar{x}$[1]	LPG[2]	$\bar{x}$	LPG	$\bar{x}$	LPG	
October-	67,0.5,916,	290,2,3994,	19,461,38,	84,2021,478,	242,140,	1056,618,	
November	167,129,10,	718,556,46,	18,222,59,	72,1899,198,	166,68,	722,306,	
	320,644,	1206,2578,	605,146,	2423,581,100,	141,353,	613,1298,	
	502,177,	2014,697,	417,76,5	2268,663	75	480	
	94,801	374,3159					
Mean	320.7	1303.0	187.8	927.8	169.3	727.6	1031.2
HL[3]		4 (33%)		4 (36%)		0 (0%)	8 (27%)
December-	843,183,432,	3207,1407,1713,	877,673,	3539,2309,	272,342,56,	1044,1343,211,	
February	449,150,371	1751,567,1443,	495,235,306,	1941,893,1213,	147,218,468	857,1831,581,	
	336,172,592	1311,650,2309,	138,81,1052	528,812,4371	246,272,342	980,1044,1343,	
	329,1748,	1290,6704,	244,275,	948,1067,	158,579,420,	628,2237,1649,	
			832	5268			
Mean	509.5	2032.0	473.5	2080.5	293.3	1145.7	1734.9
HL		7 (64%)		5 (45%)		3 (25%)	15 (44%)
April 1984-							
February 1985							
Mean		928.9		1144.6		582.0	885.3
HL (1400)		13(23.6%)		11(28.8%)		4(9.3%)	28(20.1%)
HL (1000)		16(29.1%)		14(34.1%)		10(23.3%)	40(28.8%)

[1] $\bar{x}$ = mean number of larvae from three 20 ml aliquot subsamples.
[2] LPG = number of larvae per gram of dried feces.
[3] HL = Heavy load (1400/g feces).

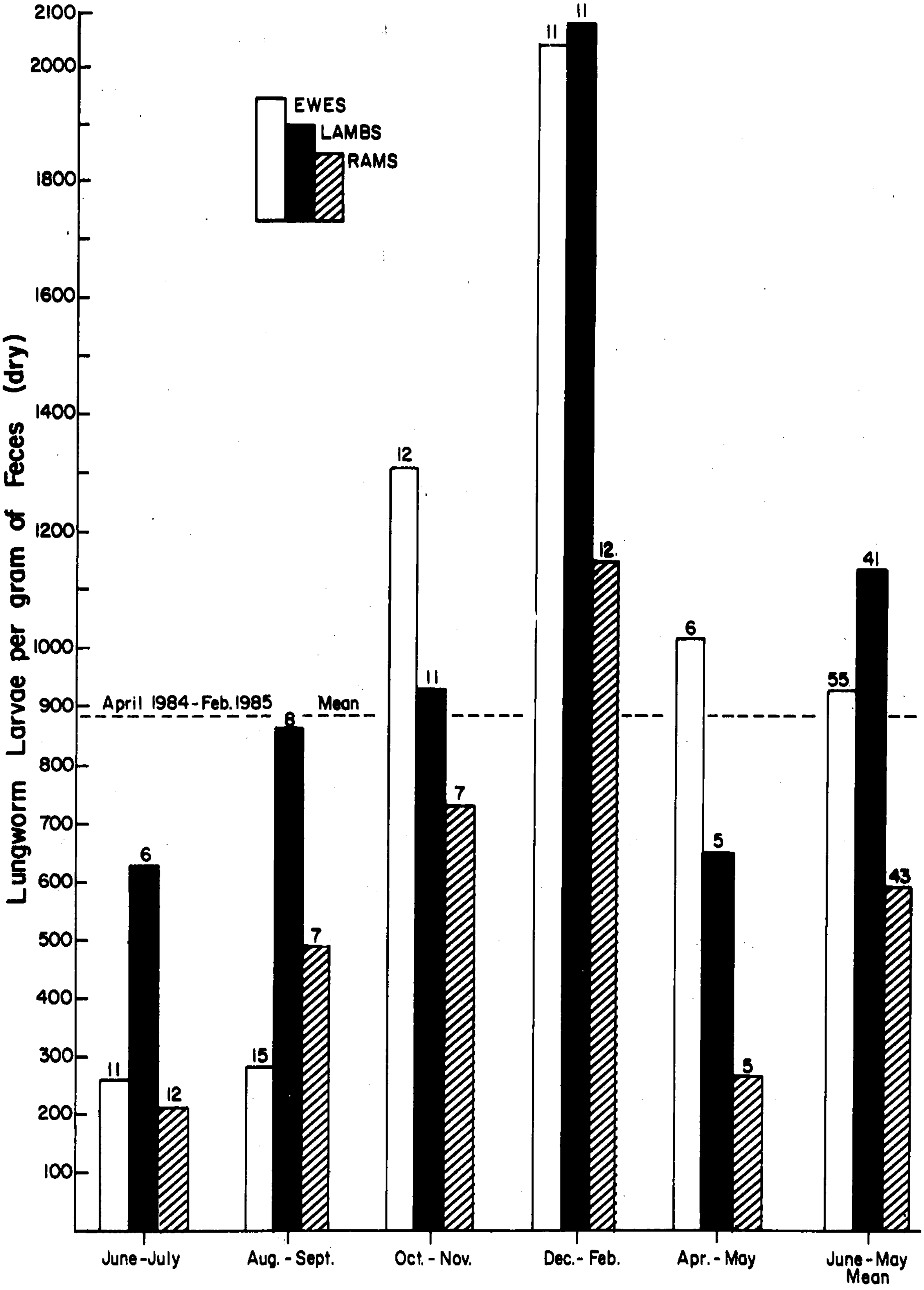

Figure 24. Lungworm (Protostrongylus spp.) larval loads per gram of dried feces from bighorn sheep in Kootenay National Park: April 1984 to February 1985.

lowest (316 and 480). One of the samples (3%) contained a heavy load during June-July and only 10% (2 lambs and one ram) had heavy loads during August-September. However, when the sheep were on the winter range (October-January) larval loads increased greatly. For the fall period (October-November) the mean larval load was 1031/lpg and 27% of the samples had heavy infection. Whereas only 4% of the ewe samples showed heavy loads during the summer, 33% of the October-November and 54% of the December-January samples showed heavy loads. For lambs, comparable values were 0% in June-July, 25% in August-September, 36% in October-November and 45% in December-January (Table 20). Comparable values for rams were 4% for June-November and 25% for December-February.

During spring, larval loads had declined to 38% of the winter loads and only 6% of the samples had heavy loads. Throughout the year, lambs had the highest larval loads (1145 lpg and 27% heavy load). While having no heavy loads during spring and early summer (April-July), and an average of 600 to 650/lpg, average larval outputs increased to 928 in October-November and 2080 in December-February. Dr. W.M. Samuel, Dept. of Zoology, University of Alberta (pers. comm.) believes that any larval outputs in excess of 1000/g feces can be considered high or heavy. Using that criteria, 11 out of 22 lamb fecal samples (50%) had heavy loads of lungworm larvae during October-February (Table 20). Ewes had the next highest loads (929/lpg) with 24% of the samples having heavy loads (>1400/lpg). Only 2 of 32 (6%) had heavy loads during spring and summer and larval levels were only 265 during June-July and 276 during August-September. By October-November the level had risen to 1303/lpg and by December-February to 2032/lpg. Rams had the lightest loads of fecal lungworms averaging 225/lpg during spring and early summer. When they moved to the winter ranges this level increased to 728 during October-November and 1146 in December-February.

One may conclude that fecal larval loads were high on the winter range, especially in lambs and ewes, during 1984-85. These high levels may indicate the Radium band is being stressed by lungworms during the winter even though their general health appears good.

Fortunately the Mt. Swansea (Windermere) band that winters south of the Radium band, and that often intermingles with it, was also reported to be healthy in the spring of 1984 (Davidson 1985). Eleven nasal swabs revealed no Pasteurella bacteria and nine fecal samples were negative for lungworm larvae. This band had been treated during the previous winter with an antihelminthic drug. Lamb survival was reported to be excellent (60-80 lambs:100 mature ewes).

4.4.5 Necropsy of Mortalities

Necropsy of one yearling ewe killed on Hwy. 93 (Sinclair Canyon) revealed no evidence of disease. The report stated "The lungworm fecal larval count in the yearling female submitted was 24 eggs per gram which is a very low load and would be consistent with the very mild lungworm lesions seen on postmortem examination (Onderka 1984).

4.5.0 SELECTED BIBLIOGRAPHY

This bibliography was prepared and is presented as a separate report entitled "Annotated Bibliography of Rocky Mountain Bighorn Sheep Specific to the Management of Bighorn Sheep in Kootenay National Park" (see Appendix 6 for Table of Contents). The compilation was selective and citations were categorized into one of three "Areas" according to its relevance to the park: Area A, East Kootenay Region of southeastern British Columbia; Area B, Canadian Rocky Mountains; and Area C, northwestern U.S.A. and other relevant areas.

References were annotated, categorized by relevant subject area and compiled onto magnetic disc at University of Alberta Computing Services. An example of the format used in displaying the references is given in Appendix 6.

On-line searching capability was achieved through the use of the SPIRES (Stanford Public Information Retrieval System) data base management system at the University of Alberta. This system provides an efficient and versatile storage, retrieval and indexing facility which is easily used and can be continually updated. Instructions for accessing the sheep bibliography ('SHEEP.BIB') subfile through SPIRES at the University of Alberta Computing Services Division are presented in the bibliography.

This bibliography will be available as a public SPIRES sub-file administered by the Faculty of Agriculture - Forestry, University of Alberta.

5. CONCLUSIONS AND RECOMMENDATIONS

1. Study Requirements

This two-year (1984-86) study was interrupted in November 1984 when the federal government eliminated the CWS Parks Research Section. Because the two senior investigators of this study could not continue involvement in this study during the 1985-86 fiscal year, they focused their effort on documenting results obtained between April 1984 and March 1985 on important aspects including range ecology, population dynamics and disease-parasitism. Of the eight information requirements described by Parks Canada (see INTRODUCTION) the following have been discussed in considerable detail in this report:

Assessment of range condition and habitat utilization;

Correlate range data to biophysical Ecosites and vegetation types;

If possible, repeat the 1966 range studies on the Stoddart Creek winter range to determine trend between 1966 and 1984.

Information on these three phases is somewhat weak because time did not permit adequate statistical analysis of the range data nor checking the reliability of field identification of plant species.

Some work was done on the other five phases and reported here. The Warden Service of KNP will apparently continue to gather information during the 1985-86 fiscal year on the following phases:

Describe and map the migration corridors, lambing and rutting areas, and licks;

Discuss mortality factors including highway, hunting, poaching and predation.

We recommend that the Warden Service compile and write up the 1984-86 results on these two phases.

For the remaining three phases of the study, the Warden Service should gather additional information during 1985-86 to add to that obtained during 1984-85. However, the analysis, interpretation and writing up of the results should be a joint effort between a trained range ecologist and the Warden Service. These phases are:

Delineate the extent and condition of summer and winter ranges on appropriate biophysical maps;

Develop and describe a range monitoring scheme that can be conducted by the Warden Service in subsequent years;

Describe habitat utilization and the quality and use of important forage species by bighorns.

2. Range Ecology

a. Range Condition and Trend - Range condition improved and the trend was upward during the 18 year period between 1966 and 1984 according to the following evidence:

(1) the amount of ground covered by living plants increased by 33%;

(2) the amount of litter increased by 55%;

(3) the amount of bare ground/cryptogams decreased by 44%.

Demarchi (1968) described the Stoddart Creek winter range as having been drastically altered by severe overgrazing and no relic climax communities remained. The grassland climax on the high alluvial terraces and steeper slopes was probably an Agropyron spicatum - Artemisia frigida community with a trace of *Koeleria cristata* (Demarchi 1968). Although foliage cover by grasses decreased by 37% on the grazed range it also decreased by 68% in the ungrazed plot during the period 1966-1984. *Agropyron spicatum* decreased and *Koeleria cristata* increased in cover on both the grazed and ungrazed plots between 1966 and 1984. This indicates a downward trend in range condition as *Koeleria cristata* is an increaser and *Agropyron spicatum* a decreaser under heavy grazing (Wroe *et al*. 1981). The decrease in grass cover within the ungrazed macroplot that has been protected from grazing for 18 years is typical of the response of grasses that have evolved under an annual grazing system (Flook and Stringer 1974, Stelfox 1976b, Trottier 1976, McNaughton 1979). Plants that decrease under heavy grazing (decreasers) showed a 13% decrease in cover while plants that increase under heavy grazing (increasers) had a 150% increase in cover on the grazed range between 1966 and 1984. Forage production was also slightly lower in 1984 compared with 1966 and was only about 36% of the site potential under no grazing.

Thus, despite the increase in litter and coverage by living plants, range condition in 1984 remained only poor-fair with the trend stable or slightly downward. This situation is similar to that recorded in 1966 and yet there is not as much evidence of overgrazing as there was in 1966. We recommend that the winter and summer range macroplots be monitored at five or 10 year intervals. This is especially important for the heavily grazed winter ranges. Considering the present high population of the Radium band, the winter range plots should be monitored again in July 1989.

b. Ungulate Stocking Rates and Range Carrying Capacity - Despite the Poor-Fair condition of the Stoddart Creek winter range it continues to support bighorn sheep numbers comparable with those reported earlier. For example, peak populations just prior to die-offs were reported to be 140 in 1938 (Cowan 1943) and 133 in 1966 (Stelfox 1978). In March 1985 our aerial and ground surveys indicated a minimum of 114 animals in the Radium band plus another 50 between Stoddart and Windermere creeks. Lamb crops and recruitment rates remained high during the period 1980-85 suggesting that the Radium band will continue to increase to earlier peak levels of 130-140 animals. Some reasons why the winter ranges have continued to have a high carrying capacity for bighorn sheep despite low range productivity at Stoddart Cr. are:

1) The Sinclair Canyon range has remained available to this band and provides a diverse native and domestic forage assemblage. Diet composition studies indicated that domestic grasses such as *Agropyron cristatum*, *Festuca rubra*, *Poa pratensis* and *Bromus inermis* provide about 50% of the diet for the Radium band using the Sinclair Canyon area during the winter period of October-January. This domestic forage is obtained from seeded slopes adjacent to Hwy. 93, around the Hot Springs Lodge and the lawns of numerous motels and bungalows plus campground areas. In addition to these seeded grasslands which also provide high quality sweet clover and alfalfa legumes, the Canyon provides considerable browse forage during winter, especially *Pseudotsuga*, *Menziesii*, *Shepherdia canadensis*, *Rosa* spp., and *Berberis repens*. This Canyon is an important component of the yearlong range of the Radium band. If it were to become inaccessible to this band, the

carrying capacity of the remaining winter range would probably be no more than 50% of the present carrying capacity.

2) Reduced interspecific competition on winter range during the past 20 years has meant more forage has been available for the Radium band. Cattle and horses grazed the winter range heavily until the early 1960s at which time only light trespass grazing occurred (Demarchi 1968). No livestock grazing above the 1060 m (3500 ft.) elevation is believed to have occurred since 1970 and no fecal groups were observed in 1984. Pellet group counts indicated less competition from elk in 1984 than in 1966. The elimination of forage competition from cattle and horses is significant as one cow is equivalent to five sheep in the amount of forage they consume. Similarly, one elk consumes 2.5 times as much forage as one sheep (Stoddart and Smith 1955).

The intermediate range along Sinclair Canyon is still heavily used as it was in 1966 but there is no significant evidence of overgrazing on the preferred south facing slopes between the Canyon and the Sinclair Warden headquarters. This range is still moderately productive and the trend is stable. Below the Canyon the range along the south facing slope above Sinclair Cr. remains in poor-fair condition as it did in 1966 and 1959 (Flook 1959, Stelfox 1966) but the trend appears stable.

Milder winters with lower snowfall during the 1970s and early 1980s compared with the 1950s and 1960s resulted in lower use of the Stoddart ranges in the past 18 years.

The summer range that centers in the headwaters of Kindersley, McKay, Sinclair and Luxor creeks is only lightly grazed and in very good-excellent condition with the trend rated as stable. Apparently, past and present populations of bighorn sheep and other ungulates have not had any deleterious effect on the productive summer range. The range carrying capacity of the summer range is much higher than the recent ungulate stocking rates.

c. Seasonal Distributions and Critical Ranges - More studies are required during the 1985-86 fiscal year to satisfy information requirements on seasonal distributions and critical ranges. Pellet group counts are required for Ecosites not yet sampled, to evaluate their importance to the Radium band. Known and potential lambing ranges need to be examined in May and June, especially areas along Sinclair Canyon, John McKay, Dry Gulch and Stoddart creeks. Similarly, additional information is required on the location and content of natural and man-made lick areas.

This work is important because lambing and lick areas are usually small in area and yet vital to the survival of bighorn sheep. The future well-being of the Radium band depends upon the continued availablity of these areas to this band.

3. Population Dynamics and Health of the Radium Band

a. Population Dynamics - The winter (1984-85) population of 114+ bighorn sheep between Sinclair and Stoddart creek is approaching earlier peak populations of 133 in 1966 and 140 in 1938 (Stelfox 1978). The population increased from 40-45 in 1967 to 50-60 in 1969 and to 109 in 1981. Based on previous population trends this band will probably increase to 130-140 animals before any major decline will occur. It could reach that number during the summer of 1985 or later depending on lamb production and survival rates. Because the population is close to the level when major die-offs occurred earlier in 1966 and 1940, it should be monitored closely over the next few years in conjunction with observations on the health status and mortality rates. Even if the population reaches 130-140 animals we cannot predict that a die-off will occur because there are so many biotic and abiotic factors that influence bighorn sheep populations.

b. Health Status - Although externally the Radium band appears healthy and productive, high fecal lungworm larvae loads, especially in lambs and ewes, suggest the band may be suffering, at least moderate stress, from lungworm infection. The health status should be monitored closely during 1985-86 and fecal lungworm larvae levels should be determined for the October 1985-February 1986 period.

4. Human Encroachment on Winter Ranges

Nothing was done on this aspect of the study during the 1984-85 fiscal year except to locate previous airphotos of the east side of the Columbia River valley between Briscoe and Invermere. KNP has an up-to-date set of air photos and infrared photos on a continuous role. Kootenay National Park has black and white airphotos for the Radium area as far back as about 1945. Peter Davidson, B.C. Fish & Wildlife Branch, Cranbrook has black and white airphotos for the Radium to Invermere area as far back as 1948. Although this phase of the study was given the lowest priority by Parks Canada some work should be done during the 1985-86 fiscal year if manpower and finances are available.

Certainly, a brief history of man's activities on traditional ranges of the Radium band is required. A comparison of 1940-1950 with 1970-1985 airphotos may show significant changes in man's activities on these ranges. The impact of recent human activities on this population of bighorn sheep should also be documented. These activities include:

(a) Recreation vehicles;

(b) Human developments;

(c) Artificial foods: seeded roadsides, lawns, campgrounds etc.; road surface compounds; food handouts including salt;

(d) Highway mortalities.

5. Selected Bibliography

This 240 page annotated bibliography has been prepared and distributed to cooperating agencies. All references are on a SPIRES public sub-file (SHEEP.BIB) at the University of Alberta Computing Services, administered by the Faculty of Agriculture-Forestry.

This system (SPIRES) is readily accessible to individuals or agencies having a University of Alberta Computing Services account and CSID. The bibliography should be updated every few years. Dave Poll, Parks Canada, Calgary is thoroughly familiar with this bibliography and the SPIRES system and should be contacted when updating is required.

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APPENDIX 1

Protocol for Handling Bighorn Sheep Cadavers from Radium Band

PROTOCOL FOR BIGHORN SHEEP STUDY IN THE KOOTENAY NATIONAL PARK - DISEASE ASPECT

Dr. D. Onderka, Veterinary Services Laboratory
Edmonton, Alberta Department of Agriculture
March 1984

INTRODUCTION:

Investigations into recent die-offs in several BHS herds in Southern B.C. indicate that infectious agents play a major part in the ultimate cause of death - usually Bronchopneumonia. Bacterial agents and the Bronchopneumonia are still present in sheep from Wigwam and Premier Ridge Herds (H. Schwantje, Personal Communications). Population recovery is slow. The Columbia Lake Herd is apparently healthy but has a high lungworm burden which might predispose some sheep to a pneumonia outbreak.

From a wildlife veterinarians point of view, I feel that disease investigations are an intricate part of wildlife management, be it in a National Park or elsewhere. There is really no area large enough to be inert against outside influences be it manmade or through animal migrations.

The following is a protocol to assist in collecting data from sick or dead animals for the purpose of disease investigations:

1. Coughing, weak sheep should be shipped to the lab live if possible. Rompun^R will facilitate handling. If live collection is not possible these sheep should be culled at any rate.

2. Blood samples should be collected whenever possible. 10-20 cc in a serum vial (red stopper) or better in a plastic tube (Serum Monivet, Sarstedt). Allow to clot at room temperature for 2-3 hours. Centrifuge or take off serum and freeze in a deepfreeze (trace mineral analysis, serum enzymes, etc.).

3. Nasal swabs taken deep from each nostril with a culturetee with transport media. Cool or, freeze for transport to lab (bacterial cultures).

4. Fecal samples should be collected fresh from the ground or the rectum and stored in brown paper bags (not plastic) for larvae counts.

5. From dead animals collect entire lung including trachea up to the tongue, thymus and heart. Cool for transport or freeze if storage of more than two days is required.

6. Collect a piece of liver (about 8 cubic cm) kidney and freeze for trace mineral analysis.

7. Submit femur for bone marrow fat analysis (assessment of body condition).

8. Submit any abnormal part for diagnosis (for example abscesses, crusty lesions on feet or lips, etc.)

9. Most valuable would be sick or dead very young lambs as we know little about the causes of neonatal mortality in bighorn sheep.

Coordinate with other data collectors, for example, collect rumen content for forage analysis, feces for nitrogen analysis, etc.

Results from each submission will be forwarded in writing to the submitter with copies to anybody as indicated on the history submission sheet.

APPENDIX 2

Seasonal Changes in Forage Quality at Low, Mid and High Elevations

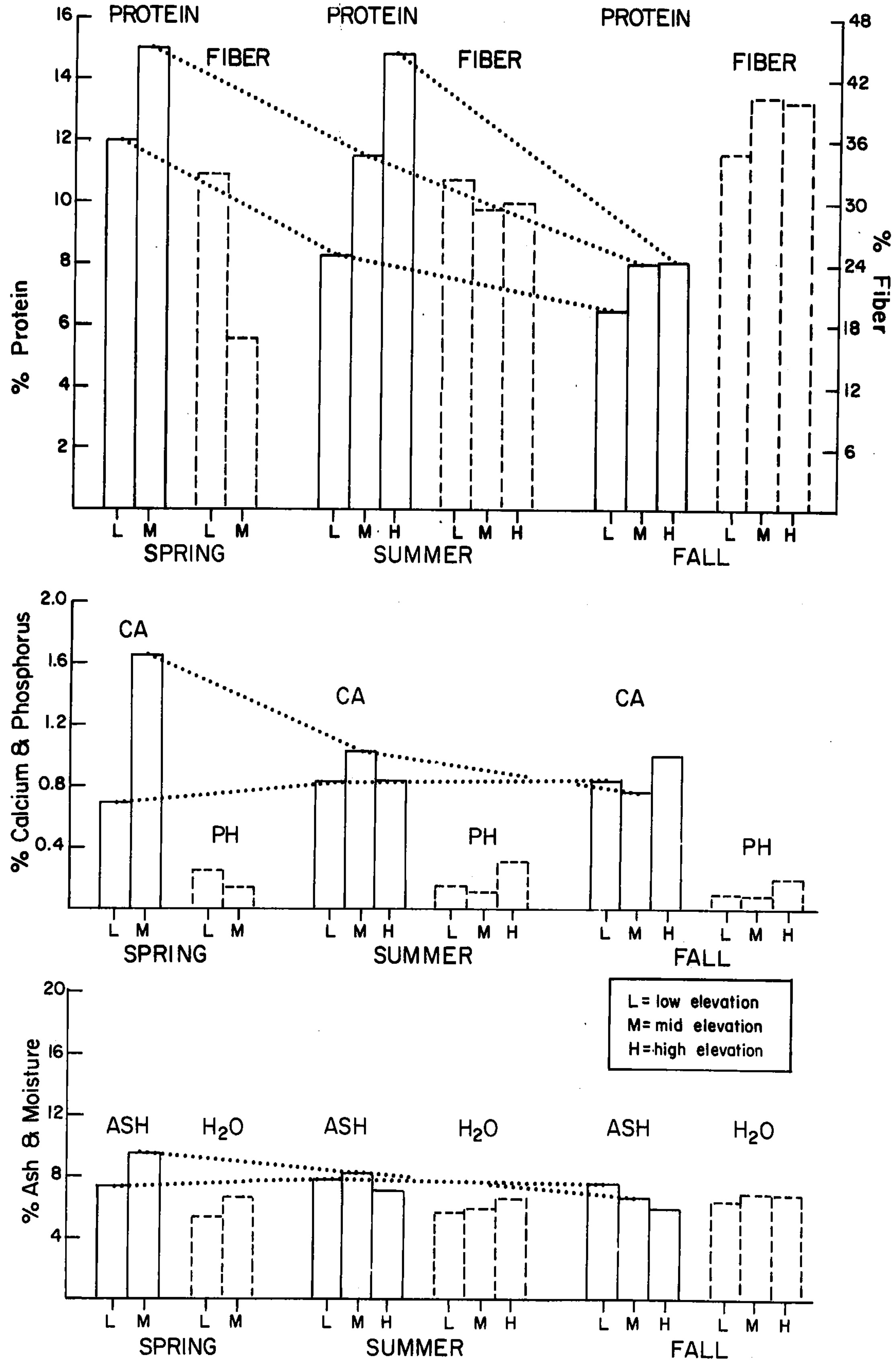
Seasonal changes in forage quality at low, mid and high elevation ranges, 1984

Location	Code	Month	% Moisture	% Protein	% Fiber	% CA	% PH	% Ash	P.P.B. SE
Stoddart Creek	CP1	May	5.6	10.9	39.0	.76	.28	8.9	10
(outside exclosure)	CP1	May	5.5	12.1	31.3	.65	.23	7.0	8
" "	CP1	May	5.4	12.9	30.7	.65	.26	7.2	8
" "	CP1	May	5.5	12.2	29.8	.69	.21	6.7	6
Averages	**CP1**	**May**	**5.5**	**12.0**	**32.7**	**.69**	**.24**	**7.5**	**8**
Tunnel*	CP2	May	6.4	13.6	18.7	1.65	.15	10.3	9
"	CP2	May	6.5	15.0	16.3	1.20	.17	9.3	14
"	CP2	May	6.9	16.6	16.3	1.72	.17	8.8	15
"	CP2	May	6.5	14.6	15.6	1.94	.14	9.7	12
Averages	**CP2**	**May**	**6.6**	**15.0**	**16.7**	**1.63**	**.16**	**9.5**	**13**
Tunnel	CP2	July	6.1	12.2	27.4	1.05	.13	8.4	17
"	CP2	July	6.1	12.1	28.1	1.03	.12	8.2	12
"	CP2	July	5.8	10.7	33.1	1.13	.13	7.3	11
"	CP2	July	6.0	11.0	28.6	1.26	.10	8.6	11
Averages	**CP2**	**July**	**6.0**	**11.5**	**29.3**	**1.12**	**.12**	**8.1**	**13**
Kindersley*	KIND	July	6.8	14.9	26.2	1.03	.24	8.7	14
"	KIND	July	6.2	15.7	23.7	1.03	.21	9.5	13
"	KIND	July	6.7	14.7	28.9	1.00	.20	7.6	14
"	KIND	July	6.3	15.5	26.0	.79	.20	6.5	12
"	KIND	July	6.6	15.2	26.0	.81	.23	6.9	5
Averages	**KIND**	**July**	**6.5**	**15.2**	**26.2**	**.93**	**.22**	**7.8**	**12**
Sinclair*	SINC	July	6.5	14.6	29.7	.82	.34	7.8	12
"	SINC	July	6.1	14.3	40.6	.61	.34	5.0	9
"	SINC	July	6.2	12.4	35.2	.70	.34	6.0	5
"	SINC	July	6.1	14.1	31.7	.66	.35	6.7	7
"	SINC	July	6.8	16.4	31.9	.84	.51	8.6	10
Averages	**SINC**	**July**	**6.3**	**14.4**	**33.8**	**.73**	**.38**	**6.8**	**9**
Stoddart Creek	SCL-1	July	5.9	8.3	30.0	.80	.18	8.2	12
(outside exclosure)	SCL-1	July	6.2	8.3	32.5	.88	.19	8.5	16
"	SCL-1	July	5.9	8.6	31.5	.84	.17	7.9	10
"	SCL-1	July	5.9	7.7	30.7	.79	.14	7.9	6
"	SCL-1	July	5.9	7.7	32.7	.79	.16	7.8	6
Averages	**SCL-1**	**July**	**6.0**	**8.1**	**31.5**	**.82**	**.17**	**8.1**	**10**
Stoddart Creek	SCL-2	July	6.8	8.3	29.7	1.26	.23	8.1	11
(inside exclosure)	SCL-2	July	6.8	8.1	39.6	1.11	.17	6.0	10
" "	SCL-2	July	6.6	8.3	36.4	.87	.22	6.4	14
" "	SCL-2	July	7.2	8.5	35.8	1.35	.20	7.9	11
" "	SCL-2	July	6.9	8.7	33.3	1.49	.23	8.8	15
Averages	**SCL-2**	**July**		**8.4**		**1.22**	**.21**		

Seasonal changes in forage quality at low, mid and high elevation ranges, 1984

Location	Code	Month	% Moisture	% Protein	% Fiber	% CA	% PH	% Ash	P.P.B. SE
Dry Gulch Creek (N)	DGC	July	5.6	7.3	33.5	.78	.20	9.8	19
" "	DGC	July	5.9	8.1	35.2	.84	.21	7.4	7
" "	DGC	July	6.0	7.6	35.2	.83	.16	8.1	16
" "	DGC	July	5.3	8.5	31.9	.44	.20	6.5	8
" "	DGC	July	5.9	7.3	33.8	.51	.14	7.6	5
Averages	**DGC**	**July**	**5.7**	**7.8**	**33.9**	**.68**	**.18**	**7.9**	**11**
Dry Gulch Creek* (S)	DGD	July	5.4	8.2	31.9	.94	.15	6.8	10
" "	DGD	July	5.8	8.8	30.8	.96	.18	9.3	5
" "	DGD	July	4.6	7.6	32.0	.66	.14	7.0	5
" "	DGD	July	5.9	9.2	32.2	.89	.19	7.4	6
" "	DGD	July	6.2	9.9	31.3	1.40	.15	8.4	9
Averages	**DGD**	**July**	**5.6**	**8.7**	**31.6**	**.97**	**.16**	**7.8**	**7**
Stoddart Creek	CP1	Sept.	6.7	6.8	34.5	1.00	.10	8.2	8
(outside exclosure)	CP1	Sept.	6.4	6.9	35.6	.83	.13	7.9	5
" "	CP1	Sept.	6.1	6.1	35.0	.76	.09	8.3	7
" "	CP1	Sept.	6.2	5.8	35.1	.69	.07	6.5	6
Averages	**CP1**	**Sept.**	**6.3**	**6.4**	**35.1**	**.82**	**.10**	**7.7**	**7**
Tunnel	CP2	Sept.	7.2	8.0	38.9	.80	.07	6.8	13
"	CP2	Sept.	6.8	8.0	39.3	.74	.09	6.9	10
"	CP2	Sept.	6.9	8.1	43.5	.77	.12	5.7	6
"	CP2	Sept.	7.1	8.0	41.0	.83	.09	7.1	6
Averages	**CP2**	**Sept.**	**7.0**	**8.0**	**40.7**	**.78**	**.09**	**6.6**	**9**
Sinclair	SINC	Sept.	7.2	8.3	40.7	1.07	.20	5.6	15
"	SINC	Sept.	6.9	8.6	39.7	1.16	.22	6.7	18
"	SINC	Sept.	6.9	7.5	40.3	.94	.17	4.9	11
"	SINC	Sept.	6.8	7.9	37.9	.82	.19	6.8	12
Averages	**SINC**	**Sept.**	**6.9**	**8.1**	**39.6**	**1.00**	**.20**	**6.0**	**14**

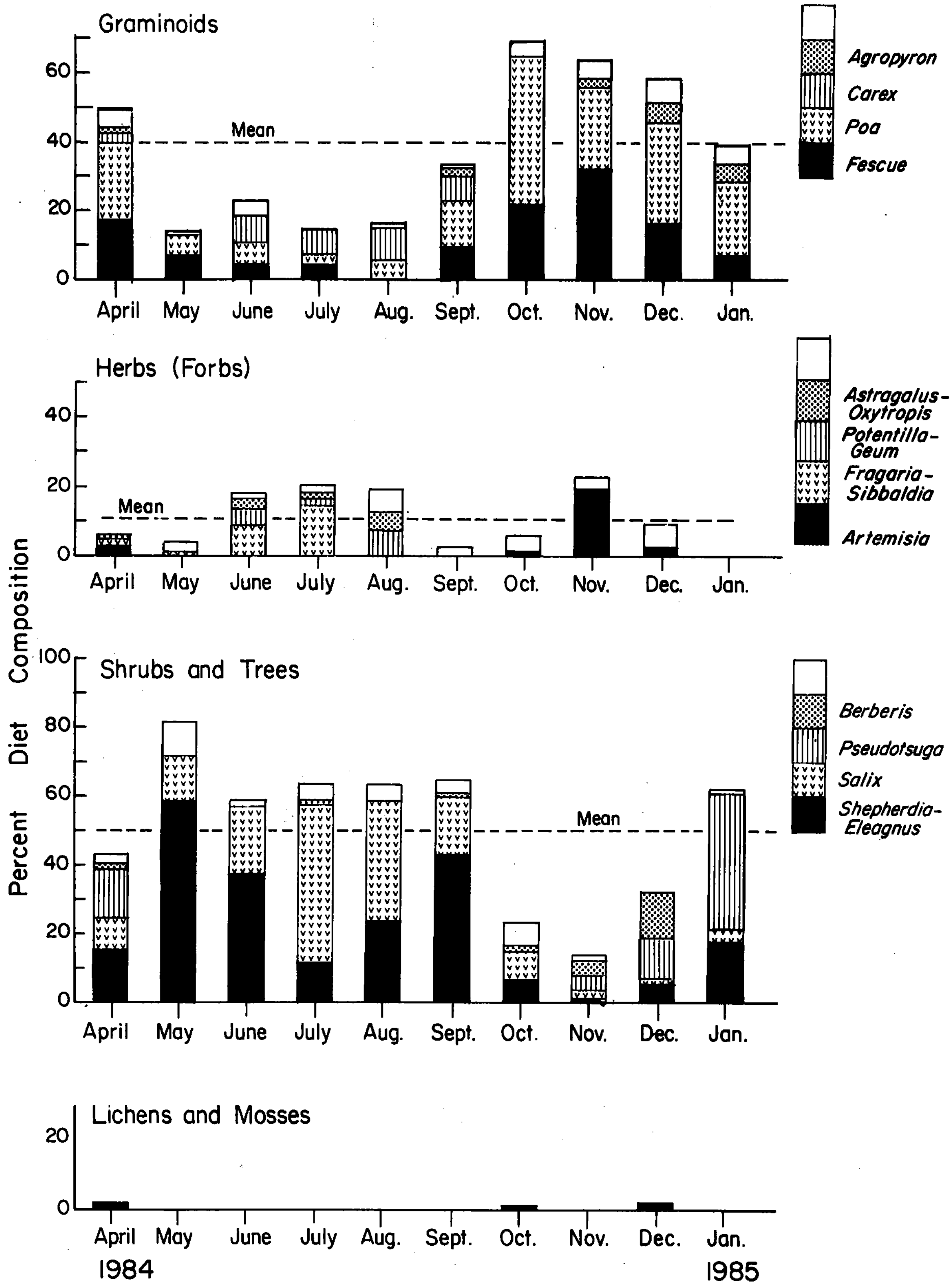
*Stoddart Creek and Dry Gulch Creek are low elevation winter ranges.
Tunnel (Iron Gates) is an intermediate range between summer & winter ranges.
Kindersley and Sinclair ranges are high elevation summer ranges.



Seasonal changes in forage quality on low, mid and high elevation bighorn sheep ranges, 1984.

APPENDIX 3

Monthly and Seasonal Diet Composition: April 1984 to January 1985



Monthly diet composition of bighorn sheep on Sinclair Canyon range.

Mean ($\bar{x}$) and standard deviation of discerned plant fragments found in Bighorn Sheep fecal samples collected by John Stelfox during 1984 and 1985 at Kootenay National Park in Alberta. Calculations based on 10 slides of 10 fields per sample. (Table completed March 25, 1985).

	K260484-1		K26048402		K310584		K250684		K200784		KNP 0884		KNP 0984		KNP 1084		KNP 1184		KNP 1284		KNP 0185	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
	April				May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.	
Agropyron	1.26	2.66	.84	2.66	.51	1.62							2.13	3.49	.75	2.38	1.17	2.47	3.72	3.97	4.61	5.34
Agrostis	1.55	3.29	2.66	5.03									1.27	2.68	1.22	2.59	.58	1.85	1.50	3.17	1.66	3.50
Bromus			1.49	3.14							.61	1.92			.89	2.81	.66	2.08	.86	2.72	.43	1.34
Calamagrostis	.61	1.92	3.96	5.46											1.44	3.13	2.64	3.43			1.46	3.03
Carex			2.37	5.49			6.54	6.75	8.48	11.00	10.58	6.54	6.63	7.46								
Danthonia	.68	2.15																			1.31	2.96
Elymus																	.68	2.13				
Festuca	13.33	11.49	20.11	6.02	7.51	5.76	4.50	5.86	4.03	4.90			9.73	7.02	21.38	10.74	33.24	13.64	16.39	7.98	6.38	5.62
Juncus											.72	2.29										
Koeleria cristata	2.79	3.65																	.84	2.64		
Oryzopsis	.84	2.67																	.79	2.50		
Poa	20.55	12.25	25.90	13.59	6.00	5.41	6.40	5.97	3.60	5.32	5.35	6.62	13.54	8.32	44.03	19.33	23.27	14.33	29.34	19.10	21.62	10.78
Schizachne purpurascens							4.50	9.40														
Stipa comata (type)																	1.30	2.74	2.37	3.85	.70	2.23
Trisetum spicatum																			2.30	3.80		
Unknown sedge							.99	2.16														
Achillea millefolium							.58	1.84					.51	1.63								
Amelanchier alnifolium	3.62	3.87	1.54	3.25	.73	2.30																
Aralia nudicaulis					2.92	4.03																
Artemisia	4.40	6.00	.73	2.30											.63	2.15	18.77	15.49	2.59	5.75		
Aster											1.57	3.31					.64	2.03				
Astragalus-Oxytropis	3.76	5.63					2.39	3.86	1.17	2.51	4.82	5.55	.59	1.87								
Berberis repens	.66	2.10	.73	2.30					.68	2.15			.91	2.68	1.14	3.61	5.42	6.86	14.23	15.85	1.57	3.33
Chrysothamnus nauseosus	.76	2.39																				
Cladonia (type)			2.37	3.86											.95	3.01			.73	2.30		
Composite	.68	2.15			.51	1.62	1.55	3.27	1.51	3.18	.79	2.50			.54	1.70						
Composite I (tomentose)																			5.61	5.41		
Dryas	1.42	3.00					.76	2.42	.75	2.36	2.39	3.87	1.13	2.39	1.99	3.24	.72	2.26				
Equisetum											1.37	2.93	1.58	3.34								
Fragaria	1.95	3.16			.53	1.68	9.25	11.08	14.84	5.63												
Hedysarum			1.50	3.16			.58	1.84	1.41	2.99												
Hydrophyllaceae																	.68	2.13				
Ledum	.66	2.09							.62	1.97												
Lilliaceae											.87	2.75										
Lycopodium																			.68	2.13		
Moss	.79	2.50																				
Penstemon											.59	1.85										
Potentilla-Geum							3.75	6.52	1.17	2.51	7.09	5.82										
Pseudotsuga menziesii	16.34	11.24	10.32	9.31													3.38	3.62	11.58	8.36	39.20	22.10
Rosaceae					1.02	2.29					1.27	2.67										
Salix	10.71	7.94	7.44	7.61	13.28	9.50	19.90	8.45	45.91	13.23	34.80	16.71	17.28	15.11	8.34	8.18	1.89	4.22	1.50	3.17	3.12	5.53
Seed											1.48	3.17							.79	2.50		
Shepherdia-Eleagnus	12.64	9.14	18.44	13.75	58.70	14.60	37.93	18.37	11.73	9.16	23.63	4.41	42.44	13.92	6.23	7.56	1.24	3.91	4.18	6.24	17.94	11.73
Sorbus					.34	1.07																
Spiraea					6.19	9.16			.51	1.61	.59	1.85	2.26	3.78	4.03	8.15	.66	2.08				
Symphoricarpos					1.76	3.83	.38	1.20	3.59	5.67	.61	1.92			1.71	3.64	.59	1.86				
Trifolium											.87	2.75										
Unknown forb																	1.75	5.54				
Unknown forb I															4.68	5.49	.72	2.26				

APPENDIX 4

Crude Protein, Percent Nitrogen
and
Lungworm Larvae Loads
from
Fecal Samples of Radium Bighorn Sheep
during
April 1984 - January 1985

KNP
April, May 1984
(Heather Walker Results)
March 1985

Sample #	Date collected	Crude Protein Weight (g)	Crude Protein Mls filtrated	Crude Protein % N	Crude Protein % CP	Lungworm Larvae Weight (g)	Lungworm Larvae I	Lungworm Larvae II	Lungworm Larvae III	Lungworm Larvae x̄	Lungworm Larvae LPG
A♀ x5 Lodge	26 04 84	2.0027	13.20	1.81	11.31	*5.0988	326	332		329	1290
Lamb x5 Lodge	26 04 84	2.0061	14.25	2.02	12.63	*5.1703	260	290		275	1064
Ram x3 Sinclair	26 04 84	2.0028	13.36	1.84	11.50	*5.0800	251	235		243	957
A♀ WHQ	24 05 84 1	2.0070	17.54	2.42	15.13	*0.9632	8	17	14	13	270
YLY♂ Lodge	24 05 84 2	2.0018	17.29	2.38	14.88	*5.1000	99	108		103.5	406
YLY♂ WHQ	24 05 84 3	2.0080	20.05	2.76	17.25	*1.1175	51	57		54	966
✗YLY♂ WHQ —	24 05 84 4	1.8838	21.09	3.07	19.19						
YLY♂ Lodge	24 05 84 5	2.0094	23.96	3.31	20.69	*0.6548	15	15		15	458
✗YLY♂ WHQ___	24 05 84 6	2.0057	20.40	2.81	17.56						
YLY♂ WHQ	24 05 84 7	2.0046	22.07	3.05	19.06	*0.4979	6	10	8	8	321
Ad♀ C5 Lodge	25 05 84	1.9952	12.31	1.68	10.50	*4.1326	53	60		56.5	273
Ad♀ C2 above Lodge (C5)	25 05 84 1	2.0029	19.54	2.70	16.88	*5.0552	54	44	67	55	218
C2♂	25 05 84 2	2.0019	3.20	.42	2.63	*5.0958	3	2	2	2.3	9
Ad♀ WHQ	25 05 84 2	2.0017	22.14	3.06	19.13	*0.5135	5	24	10	13	506
✗Ad♀ MG Lodge___	25 05 84 2	1.2242	13.34	2.99	18.69						
♂2 yr. #16 Red	28 05 84 1	2.0000	22.08	3.06	19.13	*2.2426	12	15	17	14.7	131
A♀ WHQ	28 05 84 2	2.0037	25.27	3.5	21.88	*1.0717	199	199		199	3713
A♀ #13 Yellow collar WHY	28 05 84 3	2.0015	22.70	3.14	19.63	*0.7650	0	0	0	0	0
♂2 yr. WHQ	31 05 84	2.0036	22.49	3.11	19.44	*1.1235	0	0		0	0

40Y5 84

A

♀7/16

KNP
June, July 1984

Sample #	Date collected	Crude Protein Weight (g)	Mls filtrated	% N	% CP	Lungworm Larvae Weight (g)	I	II	III	$\bar{\bar{x}}$	LPG
A♀ #19 tunnel	24 06 84 1	2.0064	22.74	3.14	19.63	2.3825	0	0		0	0
A♀ tunnel	25 06 84 1	2.0071	10.58	1.44	9.0	5.3280	9	4	3	5.3	20
YLY♂ tunnel	25 06 84 2	2.0081	16.01	2.20	13.75	*2.9267	9	11	12	10.7	73
Ad♀ tunnel	26 06 84 1	2.0063	20.83	2.87	17.94	5.1372	2	9	6	5.7	22
♂C1 WHQ	01 07 84 1	2.0083	14.96	2.06	12.88	5.1670	81	85		83	321
♂C1 tunnel	01 07 84 2	2.0011	18.08	2.50	15.63	5.1050	65	69		67	262
♂C1 WHQ	01 07 84 3	2.0054	16.59	2.29	14.31	5.2732	49	65	66	60	228
♂CL2 Iron Gates	01 07 84 4	2.0097	26.60	3.69	23.06	5.2434	32	40	43	38.3	146
♂C2 tunnel	01 07 84 5	2.0048	24.25	3.36	21.00	*4.3025	4	4		4	19
♂CL2 tunnel	01 07 84 6	2.0027	24.52	3.4	21.25	*5.1505	36	40		38	148
A♀ Iron Gates	01 07 84 7	2.0068	21.26	2.94	18.38	*5.2414	105	148	126	126.3	482
A♀ WHQ	01 07 84 8	2.0000	15.80	2.18	13.63	*5.1630	103	93		98	380
A♀ WHQ	01 07 84 9	2.005	13.36	1.84	11.50	*3.5222	272	272		272	1544
Lamb YOY Lodge	01 07 84 10	1.5793	16.18	2.84	17.75						
Ram Kind Ridge	20 07 84 1	2.0083	20.26	2.80	17.5	4.4384	20	44	41	35	158
Ram Kind Ridge	20 07 84 2	2.0023	23.54	3.26	20.38	4.5291	12	13		12.5	55
Ram Kind Ridge	20 07 84 3	2.0039	21.59	2.97	18.56	4.5740	125	130		127.5	557
Ram Kind Ridge	20 07 84 4	2.0100	26.67	3.70	23.13	4.5412	69	77	62	69.3	305
Ram Kind Ridge	20 07 84 5	2.0073	21.21	2.93	18.31	4.5575	72	66		69	303
Ram Kind Ridge	20 07 84 6	2.0006	20.53	2.84	17.75	4.6885	5	2	6	4.3	18
A♀	20 07 84 7	2.0014	26.81	3.72	23.25	4.6263	84	78		81	350
A♀	20 07 84 8	2.0003	24.71	3.42	21.38	3.5935	3	4	4	3.6	20
A♀	20 07 84 9	2.0048	26.23	3.63	22.69	4.4623	13	12		12.5	56
A♀	20 07 84 10	2.0008	27.65	3.82	23.88	2.1154	0	0		0	0
A♀	20 07 84 11	2.0068	21.13	2.91	18.19	4.5527	7	9	10	8.6	38
Lamb	20 07 84 12	2.0030	24.14	3.33	20.81	2.4867	84	99	81	88	708
YOY	20 07 84 13	2.0068	26.87	3.72	23.25	4.9181	45	44		44.5	181
YOY	20 07 84 14	2.0076	26.98	3.73	23.31	3.3741	139	126		132.5	785
YOY	20 07 84 15	2.0081	18.70	2.58	16.13	1.9134	92	83		87.5	915
YOY	20 07 84 16	1.3729	17.75	3.56	22.25	1.1128	56	63	60	59.7	1073

KNP
August, September 1984
*2 Samples

Sample #	Date collected	Crude Protein Weight (g)	Mls filtrated	% N	% CP	Lungworm Larvae Weight (g)	I	II	III	$\bar{x}$	LPG
A♀ Iron Gates Tunnel E.	23 08 84 1	2.0019	14.96	2.06	12.88	4.6298	65	62		63.5	274
A♀ Iron Gates Tunnel E.	23 08 84 2	2.0024	11.85	1.63	10.19	4.5990	12	13		12.5	54
YOY Iron Gates Tunnel E.	23 08 84 3	1.6907	7.54	1.22	7.63	0.8874	7	9	8	8	180
YOY Iron Gates Tunnel E.	23 08 84 4	2.0096	9.97	1.36	8.50	3.0135	62	42	53	52.3	347
A♂ Iron Gates	19 08 84 1	2.0009	10.14	1.39	8.69	4.5455	2	3	1	2	9
A♀ Iron Gates	19 08 84 2	2.0080	16.90	2.33	14.56	4.6826	107	95	105	102.3	437
A♂ CL2 Iron Gates Tunnel	18 08 84 1	2.0005	11.99	1.64	10.25	4.4567	15	15		15	67
A♂ CL3 Iron Gates Tunnel	18 08 84 2	2.0022	18.66	2.57	16.06	2.5107	71	85	66	74	589
A♂ CL2 Iron Gates Tunnel	18 08 84 3	2.0080	12.77	1.75	10.94	4.5991	18	20		19	83
A♀ Iron Gates Tunnel	18 08 84 4	2.0016	5.87	.79	4.94	4.5490	24	16	25	21.6	95
*						2.0195	26	29	25	26.6	263
A♀ Iron Gates Tunnel E.	18 08 84 5	2.0053	12.50	1.72	10.75	3.4773	32	49	27	36.0	207
YOY Iron Gates Tunnel	18 08 84 6	2.0021	8.69	1.19	7.44	2.2231	62	55	57	58	522
*						1.2880	135	127		131	2034
YOY Iron Gates Tunnel	18 08 84 7	2.0042	15.96	2.2	13.75	1.0650	154	150		152	2854
Ad♀ Sinclair Bridge	25 09 84 1	2.0026	15.57	2.15	13.44	0.6915	2	1	1	1.3	38
CH♂ WHQ	25 09 84 2	1.9987	16.87	2.33	14.56	4.5937	523	493		508	2212
A♀ WHQ	28 09 84 1	2.0061	10.64	1.46	9.13	4.5418	219	168	219	202	890
A♀ WHQ	28 09 84 2	2.0077	10.72	1.47	9.19	4.7058	21	15	14	16.6	71
A♀ WHQ	28 09 84 3	2.0026	11.53	1.58	9.88	4.5288	18	20	19	19	84
A♀ tunnel	28 09 84 4	2.0050	9.95	1.36	8.50	4.5230	0	0	0	0	0
A♀ tunnel	28 09 84 5	2.0045	12.00	1.65	10.31	3.3935	40	42		41	242
A♀ tunnel	28 09 84 6	2.0036	10.89	1.5	9.38	4.4270	39	40		39.5	178
♀tunnel	28 09 84 7	2.0024	13.31	1.83	11.44	4.6464	256	250		253	1089
♀tunnel	28 09 84 8	2.0026	4.76	.64	4.0	4.8869	54	51		52.5	215
♂lodge	28 09 84 9	2.0105	5.82	.79	4.94	4.4720	34	33		33.5	150
♂lodge	28 09 84 10	2.0016	17.86	2.47	15.44	2.6446	31	40	35	35.3	267
YOY WHQ	28 09 84 11	2.0010	13.03	1.79	11.19	1.7281	21	17	26	21.3	247
YOY WHQ	28 09 84 12	2.0100	13.69	1.88	11.75	1.7367	13	19	15	15.6	180

KNP
October, November 1984

		Crude Protein				Lungworm Larvae					
Sample #	Date collected	Weight (g)	Mls filtrated	% N	% CP	Weight (g)	I	II	III	x̄	LPG
A♀ Canyon Camp	22 10 84 1	2.0022	14.22	1.96	12.25	4.5940	76	66	58	66.6	290
A♀ WHQ	22 10 84 2	2.0034	7.48	1.02	6.38	4.5389	1	0		0.5	2
A♀ Canyon Camp	22 10 84 3	2.0019	13.75	1.89	11.81	4.5892	910	923		916.5	3994
A♀ Canyon Camp	22 10 84 4	2.0080	13.37	1.84	11.5	4.6629	154	163		167.5	718
A♀ Red Rock	22 10 84 5	2.0009	10.36	1.42	8.88	4.6435	130	128		129	556
A♀ Red Rock	22 10 84 6	2.0033	11.89	1.63	10.19	4.5013	10	12	9	10.3	46
A♂ CL3 Canyon Camp	22 10 84 7	2.0073	15.55	2.14	13.38	4.5849	251	212	263	242	1056
A♂ CL2	22 10 84 8	2.0027	13.00	1.79	11.19	4.5438	142	139		140.5	618
A♂ CL4 Red Rock	22 10 84 9	2.0011	7.49	1.02	6.38	4.6104	165	168		166.5	722
A♂ CL2 Radium Route Map	22 10 84 10	2.0112	14.85	2.05	12.81	4.4829	71	66		68.5	306
A♂ CL3 Radium Route Map	22 10 84 11	2.0087	14.25	1.96	12.25	4.6190	136	147		141.5	613
YOY♀ Red Rock	22 10 84 12	2.0068	6.48	.88	5.50	4.5065	20	23	14	19	84
YOY♀ West Gate	22 10 84 13	2.0100	15.63	2.15	13.44	4.5671	442	481		461.5	2021
YOY♀Canyon Camp	22 10 84 14	1.9956	12.88	1.77	11.06	1.6122	40	37		38.5	478
YOY♂ WHQ	22 10 84 15	2.072	12.58	1.73	10.81	5.0268	18	21	15	18	72
YOY♀ Canyon Camp	22 10 84 16	2.0059	13.41	1.84	11.5	2.3335	239	206	220	221.6	1899
A♀ Carrot Creek	26 11 84 1	1.9988	7.27	.99	6.19	5.3060	317	323		320	1206
A♀ Radium Lodge Staff Res.	26 11 84 2	2.0018	8.47	1.16	7.25	5.1546	701	619	673	6643	2578
A♀ Thunderbird	28 11 84 1	2.0069	11.73	1.61	10.06	4.9858	495	509		502	2014
A♀ Thunderbird	28 11 84 2	2.0042	12.25	1.68	10.50	5.0954	181	174		177.5	697
A♀ Thunderbird	28 11 84 3	2.0110	10.62	1.46	9.13	5.0583	97	92		94.5	374
Red Metal Tag #683											
A♀ W. office	28 11 84 4	2.0003	11.47	1.57	9.81	5.0719	777	825		801	3159
YOY Redstreak	28 11 84 5	1.9972	9.34	1.28	8.0	4.9945	595	615		605	2423
YOY Thunderbird	28 11 84 6	2.0026	12.02	1.65	10.31	5.0408	152	141		146.5	581
YOY Thunderbird	28 11 84 7	2.0013	8.20	1.12	7.0	7.3530	398	436		417	2268
A♂	28 11 84 8	2.0036	12.15	1.67	10.44	5.4420	400	340	320	353.3	1298
♂C2 Canyon Camp	29 11 84 1	2.0018	8.60	1.17	7.31	3.1232	78	72		75	480
YOY Canyon Camp	29 11 84 2	2.0028	10.55	1.45	9.06	2.2935	75	77		76	663
YOY Canyon Camp	29 11 84 3	2.0103	14.45	1.99	12.44	5.9860	50	70	58	59.3	198
YOY Canyon Camp	29 11 84 4	2.0060	11.80	1.62	10.13	0.9230	6	4	4	4.6	100

KNP
December, January 1984-85

Sample #	Date collected	Crude Protein Weight (g)	Crude Protein Mls filtrated	Crude Protein % N	Crude Protein % CP	Lungworm Larvae Weight (g)	Lungworm Larvae I	Lungworm Larvae II	Lungworm Larvae III	Lungworm Larvae x̄	Lungworm Larvae LPG
A♂ Redstreak Admin	25 01 85 1	2.0022	8.80	1.19	7.44	5.1003	213	224		218.5	857
YOY Redstreak Admin	25 01 85 2	1.9963	10.04	1.36	8.50	5.1015	491	499		495	1941
A♀ Redstreak Admin	25 01 85 3	2.0123	9.07	1.23	7.69	5.1335	460	439		449.5	1751
A♀ Redstreak Admin	25 01 85 4	2.0076	7.91	1.07	6.69	5.3090	157	144		150.5	567
A♀ Redstreak Admin	25 01 85 5	2.0092	10.01	1.36	8.50	5.1405	316	380	417	371	1443
A♂ Redstreak Admin	25 01 85 6	2.0041	8.40	1.14	7.13	5.1175	490	447		468.5	1831
YOY Redstreak Admin	25 01 85 7	2.0082	9.86	1.34	8.38	5.2536	246	217	241	234.6	898
YOY Redstreak Admin	25 01 85 8	2.0084	9.35	1.27	7.94	5.0521	284	317	318	306.3	1213
A♀ Canyon Camp	06 01 85 1	2.0003	8.59	1.16	7.25	5.1254	349	323		336	1311
A♂ Canyon Camp	06 01 85 2	2.0058	10.55	1.44	9.00	5.0283	242	251		246.5	980
YOY Canyon Camp	06 01 85 3		10.36	1.41	8.81	5.2163	125	164	124	137.7	528
YOY Canyon Camp	06 01 85 4	2.0022	9.05	1.22	7.63	1.9685	73	104	65	80.7	812
A♂ Canyon Camp	06 01 85 5	2.0091	9.20	1.24	7.75	5.2221	264	281		272.5	1044
A♂ Canyon Camp	06 01 85 6	2.0008	9.51	1.28	8.00	5.0925	343	341		342	1343
A♀ Canyon Camp	06 01 85 7	2.0000	9.35	1.26	7.88	5.2596	812	875		843.5	3207
A♂ WHQ	31 01 85 1	2.0071	8.57	1.15	7.19	5.2983	65	39	64	56	211
A♂ WHQ	31 01 85 2	2.0056	5.54	.73	4.56	5.0634	140	154		147	581
A♀ WHQ	31 01 85 3	2.0068	7.51	1.00	6.25	5.2185	180	187	+100	183.5	1407
A♀ WHQ	31 01 85 4	2.0062	5.08	.66	4.13	5.2920	167	177		172	650
A♂ WHQ	31 01 85 5	2.0016	9.48	1.28	8.00	5.0208	146	165	162	157.6	628
YOY Carrot Creek RHSL	01 02 85 1	2.0062	9.97	1.34	8.38	*3.1584	857	807		832	5268
A♀ Carrot Creek RHSL	01 02 85 2	2.0016	10.08	1.36	8.50	*5.2161	1579	1918		1748	6704
A♂ Canyon Camp	04 02 85 1	2.0027	8.29	1.13	7.06	5.1774	561	597		579	2237
A♀ Canyon Camp	04 02 85 2	2.0041	8.47	1.15	7.19	5.0441	430	434		432	1713
A♂ Canyon Camp	04 02 85 3	2.0008	8.05	1.09	6.81	5.0936	406	434		420	1649
YOY WHQ	04 02 85 4	2.0007	8.28	1.12	7.00	4.9588	870	885		877.5	3539
YOY Canyon Camp	04 02 85 5	2.0068	8.50	1.16	7.25	4.5474	642	705		673.5	2962
A♀ Canyon Camp	04 02 85 6	2.0066	7.17	.97	6.06	5.1282	583	601		592	2309
YOY Canyon Camp	04 02 85 7	2.0121	8.88	1.21	7.56	4.8132	1050	1054		1052	4371
YOY Canyon Camp	04 02 85 8	2.0043	9.96	1.36	8.50	5.1590	256	233		2445	948

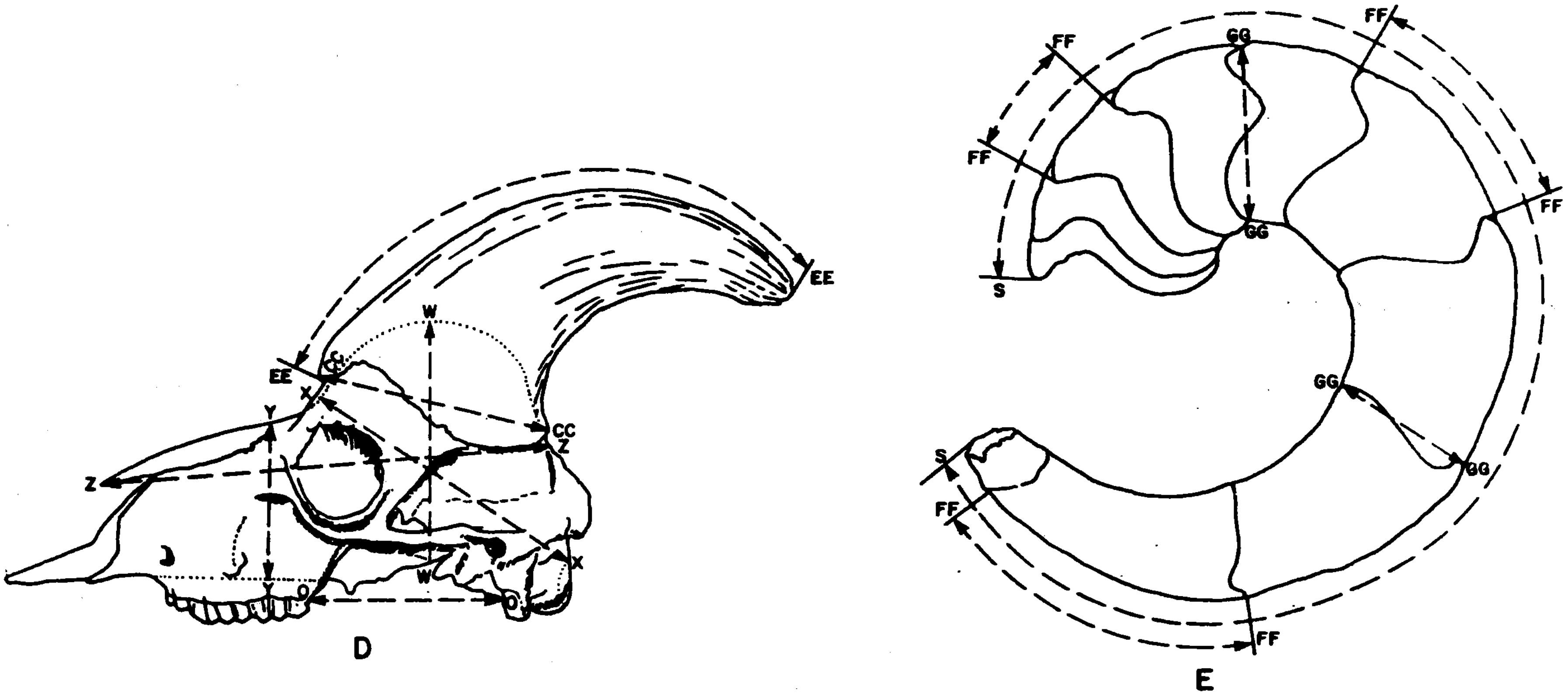
KNP
February 1985

Sample #	Date collected	Crude Protein Weight (g)	Crude Protein Mls filtrated	Crude Protein % N	Crude Protein % CP	Lungworm Larvae Weight (g)	Lungworm Larvae I	Lungworm Larvae II	Lungworm Larvae III	Lungworm Larvae $\bar{x}$	Lungworm Larvae LPG
Ram Stoddart Creek	06 03 85 1	2.0013	2.01	.25	1.56	5.1242	31	32		31.5	123
A♀ Stoddart Creek	06 03 85 2	2.0078	8.16	1.11	6.94	5.1833	255	301	300	285.3	1101
YOY Stoddart Creek	06 03 85 3	2.0071	8.54	1.16	7.25	5.2131	856	956		906	3476
YOY Stoddart Creek	06 03 85 4	2.0030	8.26	1.12	7.0	5.0910	565	531		548	2153
YOY Stoddart Creek	06 03 85 5	2.0095	8.51	1.16	7.25	4.5270	272	272		274	1211
YOY Stoddart Creek	06 03 85 6	2.0100	8.48	1.16	7.25	5.0602	930	920		925	3656
YOY Stoddart Creek	06 03 85 7	2.0055	7.59	1.04	6.5	5.0566	388	401		3945	1560
YOY Stoddart Creek	06 03 85 8	2.0080	8.79	1.21	7.56	3.1496	167	180		1735	1102
Ram Stoddart Creek	06 03 85 9	2.0100	6.58	.9	5.63	5.2800	69	70		69.5	263
Ram Stoddart Creek	06 03 85 10	1.9953	7.62	1.04	6.5	5.3100	127	125		126	475
Ram Stoddart Creek	06 03 85 11	2.0095	7.26	.99	6.19	5.1390	339	362		350.5	1364
Ram Stoddart Creek	06 03 85 12	2.0025	6.68	.91	5.69	5.2053	53	52		52.5	202
A♀ Stoddart Creek	06 03 85 13	2.0027	6.11	.83	5.19	5.3064	176	202	179	185.7	700
A♀ Stoddart Creek	06 03 85 14	2.0002	6.28	.86	5.38	5.1400	133	103	123	119.7	466
A♀ WHQ	22 02 85 1	2.0008	9.47	1.3	8.13	5.2070	946	1010		978	3756
A♀ WHQ	22 02 85 2	2.0073	8.52	1.17	7.31	5.0946	499	518		508.5	1996

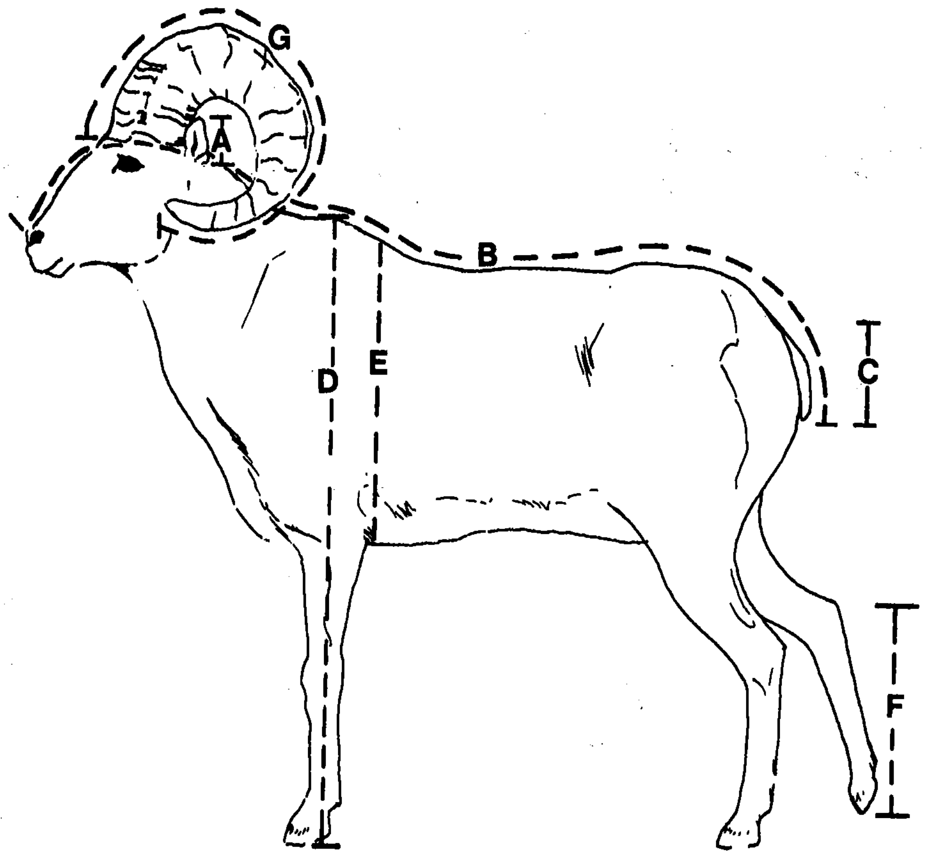
APPENDIX 5

Methods for Measuring Horn and Body Growth Rates

(after Shackleton 1973)



Points of reference for taking skull and horn measurements (from Shackleton 1973).



A	Ear length
B	Total length
C	Tail length
D	Height at shoulder
E	Chest girth: circumference of chest taken behind shoulder
F	Hind leg
G	Horn length and base

Body measurements taken on bighorn sheep.

APPENDIX 6

Table of Contents and Format of
Selected Bibliography of Bighorn Sheep

Annotated Bibliography of Rocky Mountain Bighorn Sheep Specific to the Management of Bighorn Sheep in Kootenay National Park

Edited by

David M. Poll and John G. Stelfox

Compiled by

Stephanie Ibach

Produced by
Canadian Wildlife Service, Edmonton
for
Parks Canada, Western Region
March 1984

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RESEARCH TECHNIQUES (RT1)

- RT2 - Ecological Overlap
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- RT6 - Population Dynamics
- RT7 - Telemetry, Capture and Marking
- RT8 - Necropsy
- RT9 - Forensic Science
- RT10 - Bioenergetics
- RT11 - Food Habits
- RT12 - Forage Analysis

Wyoming. Feb. 10-12, 1976:125-130.

The controlled management, nutrition, capture and transport of Dall, Stone, Rocky Mountain bighorn and California bighorn sheep are discussed. Oberservations on breeding, disease and behavior of the mountain sheep in captivity are cited. Studies were conducted at the Okanagan Game Farm, British Columbia.
Subject: RT7 MA1 NP1 Area: C Source: AFWE

FOOD HABITS

SH0001

Adams, L.G., K.L. Risenhoover and J.A. Bailey. 1982.
Ecological relationships of mountain goats and Rocky Mountain bighorn sheep. North. Wild Sheep and Goat Counc., Proc. of the Third Biennial Symp., Fort Collins, Colorado. March 17-19, 1982:9-21.

Discusses the competition between mountain goats and bighorn sheep after mountain goats were introduced into Colorado. Their ecological relationships and adaptations are also discussed. Management considerations are included.
Subject: BE3 NP2 RA4 MA1 Area: B Source: AFWE

SH0397

Banfield, A.W.F. 1947.
The mammals of Waterton Lakes National Par. 1947.
Can. Wildl. Serv. Wildl. Manage. Bull. Series 1, No. 1. p. 11.
Documents die-offs due to pneumonia, sex and age ratios, condition and distribution, and food habits of bighorn sheep in Waterton Lakes National Park.
Subject: DP1 BE2 NP2 Area: B Source: CWSE ANNB

SH0387

Blood, D.A. 1967
Food habits of the Ashnola bighorn sheep herd.
Can. Field Nat. 81(1):23-29.
Gives a detailed outline of the forage preferences of bighorn sheep of the Ashnola herd. The percentages of each species.
Subject: NP2 Area: B Source: ANNB UOAL

SH0030

Bodie, W.L. and W.O. Hickey. 1980.
Response of wintering bighorn sheep to a rest-rotation grazing system in central Idaho.
Proc. Biennial Symp. of the North. Wild Sheep and Goat Counc., Salmon, Idaho. Apri 23-25, 1980:60-69.

Documents changes in the sex and age structure of bighorn sheep populations, using winter ranges grazed season-long by domestic livestock and ranges with a rest-rotation grazing system in the Morgan Creek area of central Idaho.
Subject: RA4 NP2 MA1 Area: B Source: AFWE