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THE ECOLOGY AND STATUS OF MOUNTAIN CARIBOU AND CARIBOU RANGE IN CENTRAL BRITISH COLUMBIA

by

MICHAEL IRWIN BLOOMFIELD

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE ECOLOGY AND STATUS OF MOUNTAIN CARIBOU AND CARIBOU RANGE IN CENTRAL BRITISH COLUMBIA submitted by MICHAEL IRWIN BLOOMFIELD in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in WILDLIFE PRODUCTIVITY AND MANAGEMENT.

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Dedication

To the first, the last and all those in between but most of all to you.

"A small coin before the eyes will hide the biggest mountain" - Nachman of Bratzlav.

Abstract

Mountain caribou (Rangifer tarandus caribou) were studied in Central British Columbia from September, 1975 to December, 1977. Population studies examined seasonal and social habits, distributional patterns and developmental impacts. Phytosociological studies identified six vegetation zones and ten plant associations.

Seasonal movements consisted of bi-annual migratory oscillations optimizing resource exploitation. Caribou demonstrated seasonal preferences for elevation, aspect and habitat. Nearly 50 percent of observations occurred between 1350 and 1700 metres. High elevations were preferred during summer and late winter. Valley bottoms were most important during spring, early winter and autumn. Aspect preferences were related to habitat, season and inclination. Twenty percent of sightings occurred on northwest exposures. Southwest and north aspects followed, comprising 16.8 and 15 percent of observations, respectively. During winter, caribou selected northeast, northwest, southwest and east facing slopes, fir-spruce and cedar-hemlock-spruce forests and subalpine meadows. Cedar-hemlock-spruce forests were preferred in early winter and on northwestern slopes. Fir-spruce forests were important for each season and aspect. Use of subalpine meadows was greatest between April and November and on southerly exposures. Moderate slopes were preferred.

Food habits were determined from feeding site and fecal fragment analyses. Caribou feeding was catholic, favoring new growth and delicate plant parts.

Numerous forage species were used seasonally. Except in late and mid-winter, forbs constituted the major forage group. Seasonal averages for forb consumption ranged from 16.7 percent in the spring to 48.6 percent during late summer. Arboreal lichens accounted for 17.3 percent of the annual diet. However, variability by season and habitat was high. Caribou primarily relied on arboreal lichens for winter forage, particularly late in the season. The most important lichens were _Bryoria sp._, _Hypogymnia physodes_, _Lobaria pulmonaria_, _Parmelia sulcata_ and _Platismatia glauca_.

Baseline information was collected on population structure and ecology. Contemporary and historic distributions were comparatively studied. Observations were organized into nine geographical units. Population and band sizes have declined in all areas. Average groups consisted of 2-5 caribou; rutting and wintering groups being the largest. Even the most liberal population estimates do not exceed 500-600 animals.

Historic evidence suggested great mobility. Caribou were known to range over an area of at least 48 kilometres. A minimum of 32 potential movement routes were identified. However, current barriers and increased hunting pressure have isolated individual bands. Consequently, traditional patterns of movement and range use have been disrupted.

The caribou decline was attributed to the cumulative effect of several factors: Habitat destruction, increased access and recreational hunting played principle roles. The critical decline period probably occurred between 1960 and 1974. Logging disrupted normal movement patterns and destroyed lichen-bearing forests. Access increased latent caribou susceptibility to over-harvests, and liberal harvests approached and exceeded annual calf increments. Cow hunting seasons reduced the calf producing cohort and transmission of herd traditions. Other factors, particularly aircraft and all-terrain vehicle harassment and hydro-electric developments, may pose potential threats in the future.

Caribou survival is contingent upon maintenance of critical habitats and elimination of hunting seasons. Timber harvest practices and land-use policies should be changed to reduce conflicts with caribou management. Furthermore, introduction of new, disturbing influences should be avoided.

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Table of Contents

Chapter | Page

I. INTRODUCTION....1

A. Problem Definition And Research Objectives....1

B. Taxonomy Of Mountain Caribou....2

C. A Review Of Population Dynamics Of Caribou....5

1. Breeding biology and behavior....5

2. Recruitment and productivity....6

3. Causes of mortality....8

4. Population structure and composition....14

D. History Of Caribou Declines In Other Areas....16

II. ENVIRONMENTAL SETTING - THE STUDY AREA....23

A. Location....23

B. Abiotic Environment....23

1. Topography....23

2. Soils....26

3. Climate....26

C. Biotic Environment....30

1. Flora....30

2. Fauna....38

D. History Of Land Use and Regional Development....40

1. Regional history....41

2. Regional development and land use....42

III. PATTERNS OF RESOURCE UTILIZATION - SEASONAL HABITAT SELECTION....52

A. Introduction....52

B. Field Methodology....53

C. Numerical Analysis..................................56

D. Results And Discussion..............................57

1. Spatial distributions of mountain caribou by topography....................60

2. Seasonally preferred areas...............70

3. Factors influencing seasonal movements and habitat selection...................81

IV. PATTERNS OF RESOURCE UTILIZATION - SEASONAL FOOD HABITS.......................................88

A. Introduction.....................................88

B. Field Methodology................................89

C. Fecal Fragment Analysis..........................92

D. Numerical Analysis...............................99

E. Results and Discussion..........................101

1. Feeding behavior..........................101

2. Comparability of feeding site and fecal fragment analyses.......................107

3. Seasonal dietary composition.............111

4. The dietary importance of lichens.......133

V. POPULATION STATUS...................................139

A. Introduction.....................................139

B. Methods..139

C. Population Dynamics.............................140

1. Breeding behavior and recruitment.......140

2. Population composition and structure....142

D. Comparison Of Contemporary And Historic Populations.......................................145

1. Overview.................................145

2. Historic and contemporary populations by distribution, size and important range.....................................152

3. Contacts between population groups.......171

4. Areas of special significance............176

VI. IMPACT OF DEVELOPMENT, SETTLEMENT AND ASSOCIATED ACTIVITIES ON MOUNTAIN CARIBOU..................184

A. Cumulative Effect Concept......................184

B. Major Causes Of The Decline And Mitigative Measures..................................184

1. Habitat destruction.....................184

(1) Loss of calving sites, mineral licks and migration routes....................188

(2) Loss of wintering areas................189

(3) Barriers to movement...................195

2. Access and hunting.......................198

(1) Increased susceptibility to over-harvest..........................200

(2) Excessive harvests......................201

(3) Consequences of liberal hunting regimes..................................214

C. Implications Of Other Pressures On a Declining Population...........................224

1. Additional habitat alienation.............224

2. Harassment................................226

3. Predation.................................229

4. Poaching..................................231

D. Conclusions...................................233

VII. LITERATURE CITED..............................235

VIII. APPENDICES...................................253

LIST OF TABLES

Table		Page
2-1	Mean precipitation (cm) at weather stations in Central British Columbia	29
2-2	Mean monthly and annual temperatures (°C) in Central British Columbia	31
2-3	Monthly wind velocity, percentage frequencies, and mean velocities (km/h) at Prince George, B.C	32
2-4	Forested and non-forested land in the public sustained yield unit forests of the study area	49
2-5	Classification of land in the Longworth Public Sustained Yield Forest, Central British Columbia	50
3-1	The frequency distribution of caribou sightings during this study	58
3-2	Systematic relationships between environmental features of caribou sightings	61
3-3	Seasonal distributions of mountain caribou during this study	63
3-4	Topographical distriubtion of mountain caribou during this study	65
4-1	Field categorization and description of the feeding activity of mountain caribou	91
4-2	Diagnostic features used for determining food habits by fecal fragment identification	98
4-3	Nominally scaled fecal fragment identification frequency classes	100

4-4 Distribution of feeding site and fecal fragment samples by season and location....................108

4-5 Dietary correlation coefficients for caribou diets by season and vegetation zone...............109

4-6 Most important food plants used seasonally by mountain caribou.................................113

4-7 Preferred mountain caribou forage species within various vegetation zones...........................116

5-1 Sightings of juvenile and calf caribou during this study......................................141

5-2 Seasonal sizes and overall compositions of mountain caribou bands in the study area..........144

5-3 Estimates of caribou population abundance by geographical unit...............................151

6-1 Mathematical representation of calf production under typical conditions..........................203

6-2 Estimated annual caribou harvest for Province and Game Management Area 20: 1962-1977..........209

6-3 Annual caribou hunter success for Province and Game Managment Area 20: 1964-1977.................211

6-4 Estimated annual number of licenced caribou hunters: 1964-1977..................................213

6-5 Reported caribou poaching incidents in the study area 1960-1977......................................232

LIST OF FIGURES

Figure		Page
2-1	Location of the Raven Lake Mountain Caribou Study	24
2-2	Boundaries of caribou population and habitat study areas	25
3-1	Seasonal caribou distributions by elevation	71
3-2	Seasonal caribou distributions by aspect	72
3-3	Seasonal caribou distributions by vegetation zone	73
4-1	Seasonal composition of caribou diets	119
4-2	Known composition of caribou diets by plant group and vegetation zone	120
5-1	Boundaries of geographical caribou distribution units	146
5-2	Historic sightings of mountain caribou in Central British Columbia	147
5-3	Known and possible caribou migration routes and travel corridors in Central British Columbia	148
5-4	Caribou sightings in the study area, 1975-1977	150
5-5	Important caribou wintering areas in Central British Columbia	180
5-6	Mineral licks used by caribou in Central British Columbia	183

6-1 Length of caribou hunting seasons, in Central British Columbia, 1950-1977......................207

LIST OF APPENDICES

Appendix		Page
Appendix A.	Flora of the Raven Lake area	254
Appendix B.	Fauna of the Raven Lake area (1975 to 1978)	263
Appendix C.	History of regional fires exceeding 20 hectares (1940 to 1977)	266
Appendix D.	Chronological listing of all known caribou sightings recorded during the Raven Lake Mountain Caribou Study, 1975 to 1977	269
Appendix E.	Ecology, importance and utilization of forage plants known to be used mountain caribou	278
Appendix F.	Known historic sightings of mountain caribou in Central British Columbia, prior to September 1975	284
Appendix G.	Historic and contemporary caribou migration routes and travel corridors in Central British Columbia	290
Appendix H.	Annual caribou hunting seasons and regulations, 1950-1977	295
Appendix I.	Outline for caribou management and research in British Columbia	301
Appendix J.	Mountain caribou questionnaire:Raven Lake Mountain Caribou Study	309

I. INTRODUCTION

A. Problem Definition And Research Objectives

This study was initiated in response to a general decline in the size of caribou populations resident in the Prince George region. Without urgently needed information concerning population and habitat composition, effective programs for management of caribou and forest resources could not be properly prepared.

Designed out of necessity, this study was intended to take a holistic approach. A broad base of information was crucial to reduce the impact of accelerating regional development on populations already seriously harmed by recreation and development. Previous research on mountain caribou was simply too limited to suitably meet this requirement.

Knowledge of the local caribou and their seasonal ecology was limited to vague generalities and reports on general locations. Literature on the local caribou also was non-existent. It was generally conceded that the population was decreasing but the extent of the decline was unknown. This was evident from disparate predictions of caribou numbers by wildlife and forestry personnel.

Caribou management is currently surrounded by uncertainty and controversy. The situation in Central

British Columbia is no exception. Logistic difficulties and the high expense associated with caribou studies can be overwhelming. This, therefore, is the first intensive field investigation in the region.

The principle objective of this study was to obtain information on the status, range and seasonal patterns of resource utilization of mountain caribou in Central British Columbia. Identification of decline causing factors and preparation of management policy recommendations followed. The overall objective was to provide information necessary to effect a caribou population recovery.

B. Taxonomy Of Mountain Caribou

Specific nomenclature for mountain caribou has varied since their original description by Seton (1899). Since that time the taxonomic status of mountain caribou has changed repeatedly. Grant (1902) subsequently separated the genus Rangifer into two series, the barren-ground and woodland caribou. Seton's <u>Rangifer montanus</u> was maintained and treated as a distinct species of the woodland group. Several naturalists familiar with both eastern and western woodland caribou disagreed (Hollister 1912a, 1912b; Holsworth 1930). They argued that mountain caribou were in essence the same form as the woodland caribou. Nonetheless Grant's treatment, recognizing eleven species within these two groups, was widely accepted in North America for nearly sixty years.

A major revision of the genus _Rangifer_ was published by Jacobi in 1931 (cited in Banfield 1961). This monograph restored some order to caribou systematics by reducing the number of Canadian species from eleven to four. However, _Rangifer montanus_, apparently due to the similiarity of some specimens to _Rangifer arcticus_, was placed in the barren-ground series as _Rangifer arcticus montanus_.

Jacobi's classification was used until Banfield's monograph was printed in 1961. After comprehensive systematic studies, it was concluded that caribou and reindeer belong to a single polytypic species, _Rangifer tarandus_. Favoring synthesis and simplification, this system classified all forest-dwelling North American caribou under one sub-species, _Rangifer tarandus caribou_. Despite some misgivings, this will be the designation affixed to the caribou of this study. Further evaluation is required.

While the population of caribou previously considered as _Rangifer montanus_ is treated only as a deme by Banfield (1961), this in no way "minimizes the uniqueness" of the mountain caribou (Layser 1974). Indeed, isolation from other populations of woodland caribou, for thousands of years, has resulted in divergence sufficient to cause treatment of mountain caribou at various taxonomic levels (Layser 1974).

Woodland and mountain caribou have certain unique characteristics. Unlike the barren ground caribou, _Rangifer tarandus groenlandicus_, these animals are only moderately gregarious and do not join into large herds. Groups in excess of 30 have been observed but these reports are uncommon, especially in recent years.

Migrations of forest dwelling caribou are similiarly not on the same large scale as those of the barren ground caribou. Seasonal movements are largely altitudinal and local in character (Allen 1900; Edwards and Ritcey 1959; Freddy 1974). These patterns have been referred to as erratic and restless wanderings within a variable home range (Layser 1974).

Divergent food preferences also have been recognized though all caribou are primarily grazers. These differences in dietary composition probably reflect the relative importance of individual plants and habitats and can be ascribed to environmental variability.

Considerable geographic variation also exists within Rangifer tarandus caribou (Fashingbauer 1965). These animals, therefore, would not be expected to be identical throughout their vast range (Banfield 1961). Some attributes are only significantly expressed within specific populations.

Clines exist in size, antler conformation, coloration, behavior and patterns of resource utilization. The mountain caribou of the Cordilleran region of British Columbia appear to be a well defined deme (Banfield 1961). They are generally larger, darker and more robustly antlered than other populations in the woodland caribou series (Fashingbauer 1965). Mountain caribou also exhibit several major differences in patterns of resource use. To some extent these characteristics may represent polymorphism, but these divergent habits may be attributable to a differential selection process and geographical isolation. These characteristics are significant ecologically and may provide sufficient evidence to warrant distinct nomenclature.

C. A Review Of Population Dynamics Of Caribou

This review is limited to aspects of caribou ecology relevant to mountain caribou. Unfortunately research to date has been limited. Consequently it was considered prudent to refer to detailed accounts for other members of the genus Rangifer. Only the most pertinent available information was used.

1. Breeding biology and behavior

Caribou are polygynous breeders with restricted cyclic breeding periods (Skoog 1968). The rut is preceeded by the ritualistic removal of the velvet from the antlers of adult males. Rutting bulls may be aggressive and unwary and their activity is unrelentless. Conversely, cows and juveniles seem increasingly cautious and more easily frightened. Espmark (1964a) described male activity as furious and intense and documented that bulls of each age group came into rut simultaneously. Harems have been reported (Child unpubl. rept.) but promiscuous breeding appears to be more common.

During the rut caribou tend to aggregate and are highly mobile. Activity can be described as a continual intermingling and dispersal of individuals involving a complicated behavior pattern composed of courtship, competition, display and herding (Henshaw 1970). The constant movements and increased densities appear to be strongly related to sexual activity, as demonstrated by the simultaneous occurrence of fall movements and the rut (Banfield 1954; Henshaw 1970; Kelsall 1968). Pruitt (1966) reported a correlation between antler contact and erotic stimulation. Antler contact and large numbers in close proximity increases the intensity of sexual activity (Skuncke in Henshaw 1970). Sexual activity decreases with a reduction in herding or animal densities (Espmark 1964a; Henshaw 1970; Lent 1965a). Sex ratios are another important determinant of breeding success (Bergerud 1971; Reimers 1975).

2. Recruitment and productivity

Caribou have a low reproductive rate (McEwan 1963; Kelsall 1968; Bergerud 1974b) and high natural calf mortalities (McEwan 1959; Kelsall 1968; Bergerud 1971b). Calf production is further hampered by the often sizeable delay between physiological and breeding maturity.

Females occasionally are mature as yearlings but the majority do not reach maturity before two years and quite commonly are not bred until approximately 28 or 40 months (Bergerud 1971b; McEwan 1963; Parker 1972; Skoog 1968). Male maturity follows a similar pattern. Mature sperm are first produced at about 18-20 months (McEwan 1963). However, bulls often are not sexually active prior to two years and most activity is restricted to the 4-7 year old age class (Bergerud 1967; Espmark 1964a; Pruitt 1960c; Skoog 1968). Animals under four years, are typically subordinate (Bubenik 1975; Espmark 1964b; McEwan 1963).

Pregnancy rates are considered to be low, range from 63-88% and average approximately 70% (Kelsall 1968; Parker 1972; Skoog 1968). The lower levels may result from declines in reproductive vigor with age, poor winter forage, severe weather or harassment (Kelsall 1968; McEwan 1960; Reimers 1975; Skoog 1968).

Calves are born during May and June (Bergerud 1975; Freddy 1974; Kelsall 1968; Ritcey in Flinn 1956). Short, peak calving seasons are indicative of synchronous mating (Dauphine 1974). Synchronous births probably reinforce gregarious habits and select for calf survival (Bergerud 1974a; Espmark 1964b; Dauphine 1974).

Typical adult sex ratios consist of one male per two females (Bergerud 1971b; Kelsall 1968; Skoog 1968). As a result, calves should represent at least 23% of the population at birth (Bergerud 1974b). Calf mortalities, however, are typically high and severely limit the annual increment. Bergerud (1967) reported mortalities of 71% in Labrador and thereby an increment of only 11%. Similar mortalities have been reported for barren-ground caribou (Kelsall 1968).

Evidence indicates calf mortalities are strongly selective for males (Kelsall 1968; McEwan 1959; Thomas 1960). Physiological, behavioral, and environmental factors have been implicated. The reason is unknown, but it appears most pressure is exerted during the first 5-6 months. Consequently, though sex ratios at birth favor males, the adult population has a large majority of females (Kelsall 1968).

In Wells Grey Park, Ritcey (1970) estimated a calf crop of 16%. Kelsall (1968) reported annual increments ranging from 6.9% to 26.6% over 15 years. Alaskan caribou calves comprised an average of 19.0-22.3% of the total population. Parker (1972) reported annual recruitments between 9.9% and 16.3% for the Kaminuriak herd.

3. Causes of mortality

Numerous factors contribute to caribou mortalities. Unique behavioral and physiological characteristics predispose caribou to some losses. Accidental, environmental, pathological and sociological (human) factors contribute to annual mortalities.

Mortalities are particularly high in animals less than one year old, followed by a substantial drop for several years (Skoog 1968). Kelsall (1968) reported calf losses approaching 50% in the first month. In Newfoundland most mortalities occurred between calving and October (Bergerud in Skoog 1968). Losses were reduced considerably between one and five years (Skoog 1968).

a. physiological mortalities

Certain innate characteristics probably reduce an individual's ability to survive. The offspring of young cows, especially those calving for the first time, are more likely to die (Skoog 1968). Abandonment is the major cause. Other deaths are associated with pregnancy, calving, malnutrition, over-exertion and physical injury. Nutritional deficiencies may occur in all age classes but abandoned calves and those with cows not producing milk are the most seriously threatened. However, there is little evidence of large scale starvations (Skoog 1968). Fright or over-exertion caused by disturbance also may have deleterious effects.

b. environmental

Severe weather during the calving season has caused substantial calf losses in barren-ground caribou (Banfield 1954; Kelsall 1957, 1958; Skoog 1968). This was attributed to a pneumonia complex caused by an increased rate of heat transfer from wet fur to the environment (Lentz and Hart 1960). Poor post-rut weather also may contribute to mortalities. Nutritional reserves required for winter survival are lost (Skoog 1968). Unfavorable snow conditions also may increase vulnerability to predation and reduce available food supplies (Bergerud 1974a; Edwards 1956; Pruitt 1960a; Skoog 1968).

Wolf predation is often cited as a major source of caribou mortality (e.g. Bergerud 1974b; Kelsall 1968; Kuyt 1969; Murie 1944). Though caribou, including calves, often are able to evade wolves, the wolf is an important natural predator. However, Skoog (1968) characterized the wolf-caribou relationship as an important element of herd quality evolving over a long period. Predation by other animals is probably limited and largely restricted to very young calves (Layser 1974; Skoog 1968).

c. behavioral

Individuals exhibit some wariness, but caribou, particularly in groups, are curious and may not frighten easily (Banfield 1954; Skoog 1968). In fact there is little evidence suggesting that large groups, even under continual harassment, become more cautious toward humans (Bergerud 1967, 1974a; Cringan 1956). Yearlings and two-year-olds tend to be the most curious and often approach strange objects (Skoog 1968). Females are seemingly more alert than males and more likely to defend their young (Skoog 1956, 1968).

Synchronous behavior is an important component of caribou survival (Dauphine 1974). Consequently numerous signals and sign stimuli promoting cohesiveness and survival have evolved (Bubenik 1975; Pruitt 1960c). The high level of caribou socialization is demonstrated by their two phase alarm reaction comprised of olfactory and visual components (Lent 1964; Quay 1955). Olfactory stimuli rank second only to optical cues in the hierarchy of social releasers. Scent dispersal is facilitated by circling to the lee side of the disturbance. As a result, some individuals may become more vulnerable.

d. accidental

Accidental deaths are common. Some are attributed to a disregard for dangerous places (Skoog 1968). Caribou may fall from steep, rocky slopes and ledges. Others may drown, especially during spring break-up (Clarke 1940; Kelsall 1957; Murie 1944). Icy lakes, used for winter travel, and snow slides may claim additional lives (Bonner 1958). Several studies indicated a relationship between fire and caribou declines (Edwards 1954; Kelsall 1968; Scotter 1964).

Highway deaths are a relatively recent development (Freddy 1974; Johnson et al. 1977). Salt mixtures used during winter maintenance attract caribou to roadways and increase the chance of collision with vehicles (D. Ferguson pers. comm.; Johnson et al. 1977).

Poaching and losses to hunters unable to distinguish caribou from other cervids may contribute to mortalities (Evans 1960; Johnson et al. 1977; Layser 1974). Furthermore some antlered cows are mistaken for bulls and shot.

Calves, low in the pecking order, regularly sustain injuries (Skoog 1956). During movements calves may be trampled (Kelsall 1968). Orphans and strange calves are not readily accepted and may become the victim of malnutrition or abuse.

e. pathological

The significance of disease and parasite infestations for mountain caribou is somewhat unclear. However, several comprehensive papers have been published on the parasites and diseases of barren-ground caribou (Broughton and Choquette 1969; Neiland 1972a). Compared to most mammals, caribou are host to a relatively small number of parasites (Skoog 1968). Several, including tapeworm and the larvae of certain flies, are common. Subcutaneous warble fly larvae are often found but there is little evidence of direct mortality (Skoog 1968).

Insect harassment affects caribou during the summer. Animals seek relief on persistent snowfields and wind blown ridges. Irritation may be evidenced by twitching, head shaking, sneezing, snorting, coughing and galloping (Skoog 1968). Mortalities are rare but the harassment may be sufficient to cause some debilitation.

A variety of infectious diseases may affect caribou but the role and impact of these pathogens is virtually unknown (Neiland 1972b; Kelsall 1968).

f. sociological

Sociological mortalities are associated with the activites of man. Large population losses and declines have been associated with hunting (e.g. Bergerud 1974a; Cringan 1969; Evans 1960; Layser 1974). Various authors have attributed declines to habitat losses due to fire, logging, agriculture, settlement and industry (e.g. Banfield 1961; Cringan 1956; de Vos and Peterson 1951; Edwards 1954; Fashingbauer 1965; Freddy 1974; Moisan 1959).

Harassment related to recreational and industrial activities probably has deleterious effects. Aircraft disturbance is one example (Calef et al. 1976). The long-term and less obvious effects are difficult to measure.

Several other potential mortality factors were discussed under accidental deaths. The consequences of man's activities are treated in detail in Chapter VI.

4. Population structure and composition

Sex and age groups are distinguished on the basis of physical features (Kelsall 1968). However, distinctions are difficult to make and the only definitive method is through examination of genitilia and incisor bars. Consequently, even our most detailed information is somewhat limited (Kelsall 1968).

a. sex ratio

Adult sex ratios show a preponderance of females (Kelsall 1968; Parker 1972; Skoog 1968). Parker (1972) estimated an adult ratio of 55 males per 100 females for the Kaminuriak herd. The Nelchina and Forty-mile herds had ratios of 59:100 and 65:100 respectively (Skoog 1968). The Alaskan arctic herd had a bull to cow ratio of 62:100 (Hemming and Glenn in Parker 1972). McEwan (1960) estimated adult sex ratios of 60-79:100 for the Beverly Lake herd. In Newfoundland, woodland caribou populations had 56 bulls per 100 cows (Bergerud 1969). Moisan (1959) reported adult ratios of 44:100 on the Gaspe peninsula. Caribou herds in Wells Grey Park had ratios of 56:100 (Ritcey 1970). Herds in the mountains of Alberta and British Columbia exhibited ratios of 48:100 (Cowan 1950).

b. age ratio

Age and sex classes can be recognized by morphological variations as well as seasonal and sexual segregations. Males three years or older and females over two years are most easily recognized. Most mature bulls lose their antlers by December-February, have pronounced ventral manes and show the earliest spring antler development. Younger males retain immature antlers longer. Female antlers are smaller and more delicate and are not shed until after calving (Johnson and Miller 1979; Kelsall 1968; Lent 1965; Skoog 1968). Juveniles and calves are distinguished by their smaller size. The most difficult groups to identify are 1-3 year old animals and antlerless females.

Body size and strength signficantly influence distributions by sex, age and season (Bergerud 1967). Adult cows, juveniles and some immature bulls are separated during the spring. Summer bands are mixed but nonetheless are dominated by either adult males or females (D. Ferguson pers. comm.). Solitary individuals also are common. During the rut caribou coalesce into well mixed groups with bulls typically at the periphery. Post-rut dispersals result in large-scale segregations particularly in deep snow areas.

Most studies have ignored the numerical relationship between calves, juveniles and adults. Heavy emphasis has been placed on the annual calf increment. Some information detailing age class distributions does exist. In the area of

Baker Lake, N.W.T., calves and yearlings contributed 21.3% and 3.3% of the population respectively (Parker 1972). Adult bulls accounted for 11.7%, while cows made up 21.3% of the herd. Unclassified adults comprised 42.4% of the population. Skoog (1968) estimated a calf:bull:cow ratio of 22.3:33.3:44.4 for Alaskan caribou. The Lake Melville, Labrador caribou consisted of 14% calves, 6% yearlings, 61% adult females and 19% mature males (Bergerud 1967). In Jasper National Park, caribou calves averaged 20.5% of the total population. Adult cows and bulls accounted for 54.3% and 25.3% of the herd respectively.

D. History Of Caribou Declines In Other Areas

The numbers of caribou have generally declined since the late 19th and early 20th centuries when the settlement of North America intensified (Bergerud 1974). Presently, woodland and mountain caribou populations have been reduced throughout their range, and the southern boundaries of their distribution are continually moving northward (Banfield 1961).

Rangifer tarandus caribou, "formerly ranged from Prince Edward Island and Nova Scotia, to Western Alberta and British Columbia, south into New York, New Hampshire, Vermont and Maine in the east, and Minnesota, Wisconsin and Michigan in the Great Lakes Region, north to southern Ungava in the east, and the Northwest Territories in the West"

(Cringan 1969). Evidence also indicates that as recently as the 1850's and later in some instances, woodland caribou were plentiful in Oregon, Wyoming and particularly Montana, Idaho and Washington (Evans 1960; Layser 1974).

Papers detailing the chronology, magnitude, causes and consequences of individual declines are numerous. Several excellent review papers discuss these histories from various perspectives (Banfield 1961; Bergerud 1974; Cringan 1956; 1969; Evans 1960, 1964). The causes affixed to population reductions, and in some cases extinctions, are of particular interest in this study.

Numerous studies show that major caribou declines have occurred due to large scale habitat modification and reduction of climax forests by fire, commercial logging and settlement. Cringan (1956), describing the decline of caribou in eastern Canada, argued that "the lasting diminution and eradication of woodland caribou has almost always been associated with important changes in the environment." Caribou simply do not effectively adjust to habitat modifications (Layser 1974).

Reports of earlier and simultaneous declines in other districts of eastern Canada substantiate Cringan's overall assessment (Adams in Cringan 1969; Anderson 1938, 1946; Banfield 1961; de Vos in Cringan 1969; de Vos and Peterson 1951; Moisan 1959; Palmer 1938; Riis 1938; Seton 1927). Much the same pattern was evident in the Great Lakes States. The last caribou had vanished from Minnesota by 1940 (Banfield 1961; Fashingbauer 1965). Habitat modification also was purported to be the major cause of wholesale declines in the small, remnant caribou populations which have been intensively studied in the northwestern United States (Evans 1960; Fashingbauer 1965; Flinn 1956; Freddy 1975; Layser 1974).

Studies in Wells Gray Park and in the Selkirk Mountains of British Columbia, demonstrated reliance of caribou on climax plant communities. Both considered the loss of this essential habitat a serious threat to mountain caribou survival (Edwards and Ritcey 1959, 1960; Freddy 1974).

Scotter (1964, 1967a, 1970) conducted extensive studies on the impact of fire on lichen pastures and the barren-ground caribou, and expressed little doubt that forest fires may have been an important cause in caribou declines. Edwards (1954) thought a major decrease in caribou numbers followed a series of large forest fires in Wells Gray Provincial Park, British Columbia. Fire destruction also was blamed for a large reduction in the caribou populations of Prince Albert National Park, Saskatchewan (Banfield 1961).

Bergerud (1974) disagreed with the habitat destruction hypothesis. His position was supported by evidence of herding behavior, wandering habits, and low reproductive potentials, qualities suggested to cause caribou to be more vulnerable to hunting than any other North American cervid. It was further proposed that caribou need not rely on lichens for winter survival and therefore do not require climax forests. Murie (1935), Skoog (1968) and Bergerud (1972) corroborated this premise by reporting various populations of caribou surviving the winter season by using forage plants other than lichens.

Over-hunting has been cited quite often as a major cause in the decline of various caribou populations. Declines in such widely separated areas as Ungava, Alaska and Alberta have been credited to overhunting (Bergerud 1974; Lynch and Pall 1973).

Investigators in several areas indicated that habitat disruption and coincident liberal hunting programs were responsible for caribou declines (Anderson 1938, 1946; Banfield 1961; Cringan 1969; Moisan 1959; Riis 1938). While hunting closures were eventually introduced in many cases, enforcement programs were ineffective in saving already seriously damaged populations. Anderson (1938) for instance reported the killing of 120 caribou in a single day. Within forty years of the incident, caribou disappeared from the mainland of Nova Scotia (Anderson 1946).

In the western portion of woodland caribou range, there also were numerous accounts which considered hunting the primary cause of decline. The most notable impacts have been described by Evans (1960, 1964), Layser (1974) and Lynch and

Pall (1973). Herd structure, traditional patterns, the curiosity of individual caribou and increased access are the most often cited causes for high susceptibility.

A few biologists consider the mutually exclusive hunting or habitat destruction hypotheses too simplistic to be entirely acceptable. Cringan (1956) examined the decline of woodland caribou in eastern Canada and concluded over-exploitation, following large scale habitat modification caused population reductions. Lynch and Pall (1973) conceded hunting initially was limiting caribou populations but following improved regulations, the recent increase in development and resource extraction will become the greatest threat to herd survival in Alberta.

Though the vast majority of declines were attributed to recreational hunting or habitat modification, other causes have been suggested. Malaher (in Cringan 1956) revealed that a serious decrease in population size occurred in Manitoba between 1930 and 1950 without large scale habitat destruction. The cause remains a mystery.

Deer and moose increases have accompanied caribou declines but there is no evidence of concomitant inter-specific competition. In fact over vast areas, caribou, deer and moose ranges overlap. Where such co-existence does occur, species inhabit distinct niches and compete very little for food or territory.

Emigration also has been suggested as a cause of caribou declines, particulary in the maritime provinces, New England, New York, Quebec, Ontario and Minnesota. These claims are largely unsubstantiated. Subsequent population increases in adjacent areas have only been reported in the large populations of Alaskan caribou (Skoog 1968).

Predation is intermittently suggested as a major factor in reducing caribou populations. However, Layser (1974) argued against this for mountain caribou, citing the deep snow and the high elevations in areas utilized during the critical winter months. Wolves were typically scarce or absent during the decline of woodland caribou in the east (Cringan 1956). Fashingbauer (1965) and Layser (1974), both felt that predation was traditionally over-emphasized as a major cause of caribou declines. Bergerud (1974) did not agree. However, it was generally conceded that for a threshold or sub-threshold population any mortality factor could be critical.

Barren-ground caribou are hosts to many parasites and diseases (Kelsall 1968). Unfortunately there is very little information on the parasites and diseases of mountain caribou. However, no evidence exists which would suggest that the western caribou have declined for these reasons (Freddy 1975; Layser 1974).

Calf mortality in barren-ground populations usually is high (Kelsall 1968), but this is unclear for woodland or mountain caribou (Fashingbauer 1965). However, it is typically assumed that mortalities for forest dwelling populations are similar.

II. ENVIRONMENTAL SETTING - THE STUDY AREA

A. Location

Botanical surveys were conducted in a transitional area between the northwest perimeter of the Caribou Mountains and the northwest edge of the Fraser Plateau (Figures 2-1 and 2-2). Raven Lake, located at 121°34' north latitude and 53°45' west longitude, was central to the 100 km² study area. The watersheds examined empty into the Fraser River System, which in turn drains south and west into the Pacific Ocean.

To examine regional population dynamics and distributions, the survey area was expanded to a zone covering approximately 15,000 km², extending on a north latitude from 54°10' to 53°40' and on a west longitude from 122°42' to 122°30'. The expanded study region included the Longworth Public Sustained Yield Unit (P.S.Y.U.), site of the vegetation surveys, the Purden and Monkman units, and a small portion of the Robson and Big Valley P.S.Y.U.'s (Figures 2-1 and 2-2).

B. Abiotic Environment

1. Topography

The local terrain consisted of mountains separated by deep valley trenches existing below 1000 meters. Hortie

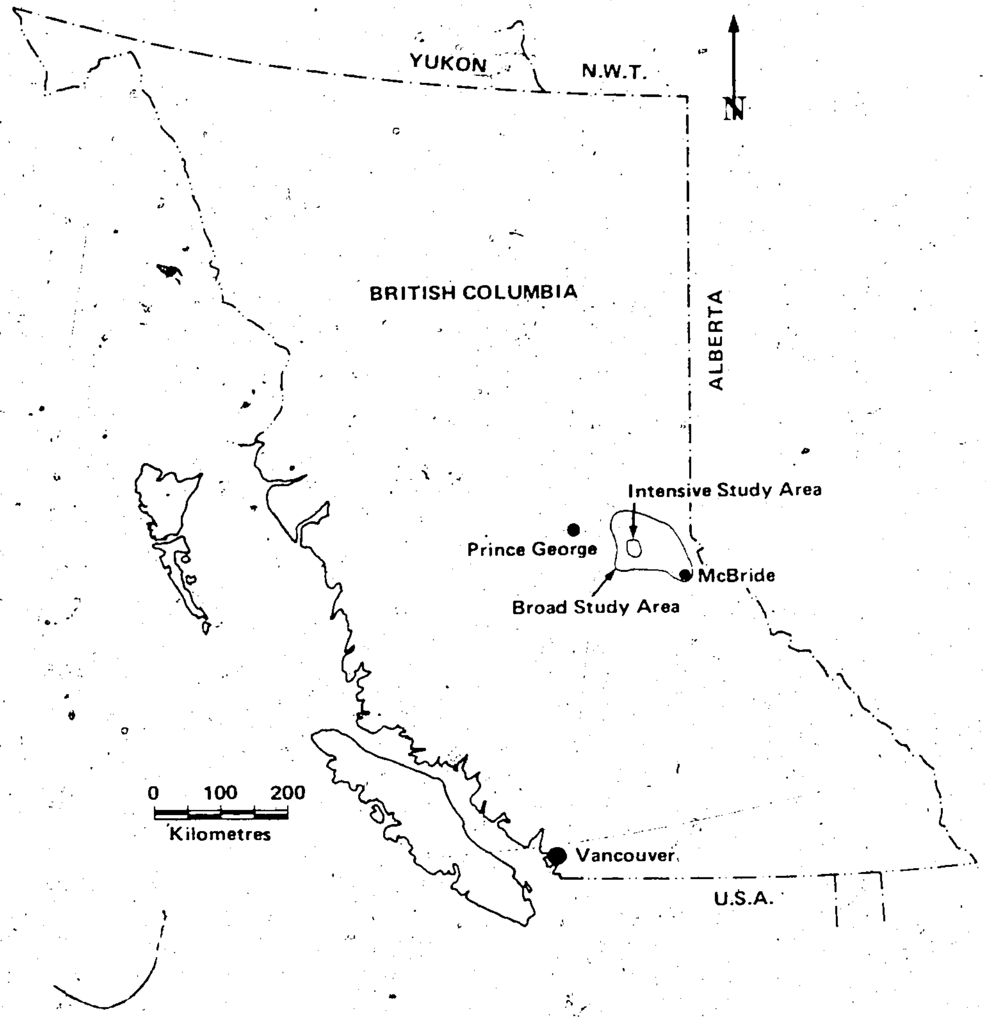

Figure 2 - 1 Location of the Raven Lake Mountain Caribou Study

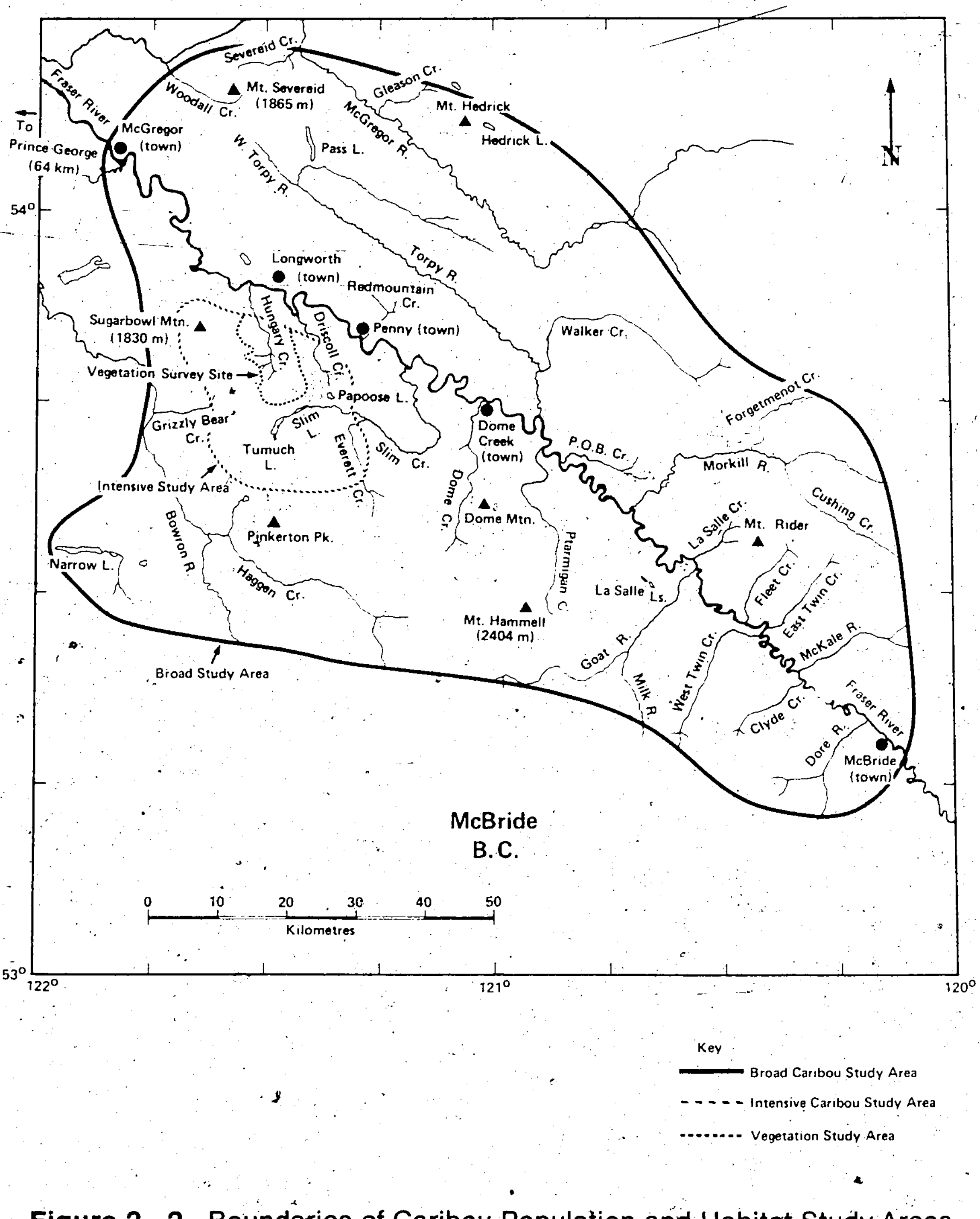

Figure 2 - 2 Boundaries of Caribou Population and Habitat Study Areas

(1970) described the area as a rolling till plain interspersed with numerous glacial lake basins. Raven Lake is surrounded by mountains and lies in a less precipitous range west of the continental divide, north and adjacent to the Cariboo Mountains (Columbia Complex) and south of the Park Ranges. Composition is bedded and metamorphased sedimentary rock, principally quartzite, of the Protozoic and Cambrian age. During the Wisconsin stage of the Pleistocene epoch, these mountains were intensively glaciated, as reflected by drumlins, eskers, and other features of the local topography (Environment Canada 1970).

2. Soils

Soils of the region are from Wisconsin glacial deposits modified by streams and rivers and materials originally contained in glacial lakes (B.C. Lands and Forests 1964). The only exceptions are ground water soils associated with bogs and meadows. In all cases podzolization and gleysation were the prevalent soil-forming processes. Most area soils developed under forest cover, and are basically podzolic and representative of the Podzol Great Group. To some extent, the Gray Wooded Great Group also is represented (Hortie 1970).

3. Climate

The study area was located in a complex Cordilleran climatic region, possessing a Koppen climatic classification of Dfc (Wali 1973). Long, cold winters and short, cool summers, attributable to a Pacific maritime influence, are characteristic (E. Wilke pers. comm.). Mountainous terrain provides a local climate of extreme variability and dramatically increases the role of altitude as a climatic determinant. In fact, the series of peaks and valleys reduces the number of warm fronts and promotes the common development of occluded fronts, invading from the west (E. Wilke pers. comm.).

As a whole, the area receives moderate precipitation and a wide range of seasonal temperatures. The mountains experience the greatest temperature fluctuations and receive considerably more precipitation than the Interior Plateau.

Due to the predominance of shallow layers of continental arctic air, gentle outbreaks of cold weather are typical (E. Wilke pers. comm.). Arctic fronts are initially hindered by the Rocky Mountains 30 miles north of the area. As a result several days typically pass before the system deepens sufficiently to provide significant snowfall. In general, winter weather fluctuates between dry, cold and relatively clear periods and mild, moist and cloudy conditions depending on whether arctic or maritime systems prevail.

Shallow layers of arctic air also cause extreme and strong inversions during winter. Temperature increases of 30°C over a rise of 600 meters are not uncommon and it is not unusual to have strong northerly winds in the bottomlands while brisk southerly winds prevail at 1220 meters.

The average yearly precipitation ranges from 52-93 cm in the region although the general pattern throughout the area is similar (Table 2-1). Snow accounts for 33-50% of the annual precipitation. Rainfall varies widely on an annual and monthly basis. Spring is the driest season, particularly before May when rainfall begins to gradually increase. By late June a decrease in precipitation begins, followed by another peak early in August, and a second reduction beginning in September. The majority of the precipitation is received during the summer in the form of convective showers resulting from maritime influences and increases in daytime temperatures (E. Wilke pers. comm.). The numerous lakes in the region also contribute to shower activity.

Snow may fall any time from September through May, but the major accumulations occur between November and February. The greatest monthly snowfall usually occurs during January. Snowpacks, an important factor in winter travel and foraging, vary from 1-2 meters in the valleys to 4-5 meters at timberline. Generally, 2-3 meters accumulate during the peak snow season though occasional warm periods may result in reduced depths.

From November through March the mean monthly temperatures are generally below freezing at all locations

Table 2-1 Mean Precipitation(cm) At Weather Stations In Central British Columbia

Station	Years Observed	Altitude (m)	Ann Pptn* (cm)	Ann(cm) Rain fall	Ann(cm) Snow fall	Highest Monthly Rain fall	Highest Monthly Snow fall	Highest Monthly Precipitation	# Days Measurable Snowfall
Prince George	30	676	62.0	39.9	233.4	Aug	Jan	Oct	74
Aleza Lake	79	625	93.0	55.6	374.3	Oct	Jan	Jan	59
Dome Lake	30	648	75.3	47.0	282.9	Aug	Dec	Dec	46
McBride	20-24	723	52.4	32.0	197.7	Sept	Jan	Jan	44
Robson	20-24	1060	70.0	52.0	180.0	June	Jan	Jan	31

*
Annual precipitation=rainfall+(snowfall/10)

(Table 2-2). January has the coldest mean daily temperature, averaging -9.8°C. July and August are the warmest months, experiencing mean daily temperatures of approximately 15.5°C. The lowest temperatures ever recorded, were -58°C and -50°C for Prince George and McBride, respectively.

South is the prevailing wind direction, followed closely by northerly winds during the winter and spring. The average annual wind velocity at Prince George is 11.6 km/h (Table 2-3), but strong gusts as high as 20-80 km/h are typical and frequent in the mountains, particularly during the winter.

C. Biotic Environment

1. Flora

The vegetation in the study area had not been classified previously. Only vague and general descriptions of broad biogeoclimatic zones were available. Consequently extensive phytosociological studies were completed to provide a precise and unambiguous representation of caribou range and a basis for studying seasonal patterns of resource utilization (Bloomfield 1979). In this section brief descriptions of the distributions and characteristic features of local plant communities provide a suitable introduction to subsequent chapters on the seasonal food habits and habitat selection of mountain caribou.

Table 2-2 Mean Monthly And Annual Temperatures (°C) In Central British Columbia

	Prince George	Aleza Lake	Dome Creek	McBride	McGregor	Robson
Years observed	25-29	19	14	20-24	20-24	20-24
Jan	-11.8	-12.4	-11.2	-9.1	-11.6	-2.9
Feb	-6.2	-6.3	-5.1	-4.3	-5.6	-0.3
Mar	-2.1	-2.4	-1.1	-0.7	-2.2	3.2
Apr	3.9	3.2	4.9	5.1	3.4	8.5
May	9.4	8.9	10.0	10.3	9.3	12.9
June	13.0	13.2	13.9	13.8	13.2	16.3
July	14.9	15.2	16.1	15.9	15.1	19.8
Aug	13.7	14.1	15.0	14.5	14.3	18.6
Sept	9.8	9.9	10.9	10.6	10.4	14.3
Oct	4.7	4.7	6.2	5.7	4.3	8.2
Nov	-2.8	-2.8	-2.4	-1.8	-3.0	2.6
Dec	-7.6	-8.3	-7.2	-6.3	-8.2	-0.7
Mean Annual	3.2	3.1	4.2	4.5	3.3	8.4
Hottest Month	July	July	July	July	July	July
a. Mean Daily	14.9	15.2	16.1	15.9	15.1	19.8
b. Mean Max*	22.1	22.5	24.9	23.8	22.5	28.5
c. Mean Min**	7.7	7.8	7.2	8.0	7.6	11.2
Coldest Month	Jan	Jan	Jan	Jan	Jan	Jan
a. Mean Daily	-11.8	-12.4	-11.2	-9.1	-11.6	-2.9
b. Mean Max*	-7.2	-7.5	-5.6	-5.2	-6.8	-0.4
c. Mean Min**	-16.4	-17.8	-16.8	-13.1	-16.4	-5.3

* Mean Daily Maximum Temperature
** Mean Daily Minimum Temperature

Table 2-3 Monthly Wind Velocity, Percentage Frequencies, And Mean Velocities (Km/h) At Prince George B.C.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	YR
	%	%	%	%	%	%	%	%	%	%	%	%	%
N	29	19	2[illegible]	14	14	11	12	11	14	12	18	25	17
NNE	3	4	[illegible]	4	4	3	3	3	3	3	3	3	3
NE	2	2	3	4	4	3	3	2	2	2	2	2	3
ENE	1	1	1	1	1	1	1	1	0	1	1	1	1
E	1	1	2	2	1	2	1	1	1	1	1	1	1
ESE	1	0	1	1	1	0	1	1	0	0	0	0	0
SE	2	2	2	3	3	2	3	2	2	2	2	2	2
SSE	5	6	7	6	5	6	6	7	7	8	7	6	6
S	26	31	27	25	19	24	24	29	31	39	36	31	29
SSW	4	5	5	6	6	7	6	6	7	7	5	5	6
SW	2	2	3	5	6	6	6	5	4	3	2	2	4
WSW	1	2	2	4	4	5	3	3	3	2	1	1	3
W	2	3	4	6	8	7	7	5	4	3	2	2	4
WNW	1	2	2	3	5	4	4	3	2	2	1	1	3
NW	2	2	3	4	6	5	5	4	3	2	2	2	3
NNW	7	6	5	5	5	5	4	4	5	3	6	6	5
Calm	11	12	9	7	8	9	11	13	12	10	11	10	10
Mean Veloc (km/h)	12	12.4	12.7	13	11.6	10.6	9.5	9	10.3	13.5	12.7	12.4	11.6

(Adopted from Canada Atmospheric Environment Service Annual Meteorological Summary and Long Term Records Prince George B.C. 1971)

Within the study area, the vegetation was rich, diverse and luxurious. One-hundred and thirty vascular plants were identified. Non-vascular species also were numerous. Thirty-six terrestrial lichens, 21 mosses and 28 arboreal lichens were identified.

The vascular plants typically were dominated by perennial species, which demonstrated reasonably uniform distributions. The flowering herbs usually were the most abundant plant group, followed by the shrubs in importance. Terrestrial, non-vascular plants made a relatively small but consistent contribution. Moss coverage generally exceeded the cover provided by the more diverse terrestrial lichens. An abundant and rich arboreal lichen layer was present in forested areas.

Although a large number of species with varying frequencies would suggest heterogeneity, considerable overlap existed in floristic composition. Nonetheless, major differences were apparent, and six vegetation zones were recognized.

Two forest zones were identified. Forested stands generally exceeded the 121-140 age class and the 30-38 meter height class, and were in one of the two mature stocking classes (B.C. Lands and Forests, Area Volume Summaries). Logged areas were the typical exception. A tendency toward fewer but larger trees per hectare, and heavier, more luxuriant understory vegetation also was noted. In more accessible areas, however, there was an apparent trend toward early successional stands.

a. subalpine fir-engelmann spruce zone

The uppermost coniferous forest, named for its tree dominants, was the subalpine fir-engelmann spruce zone (*Abies lasiocarpa* - *Picea engelmannii*). Forests between 1100 and 1750 meters were almost entirely this type. All aspects were occupied and moderate slopes were preferred. These dense forests contained many snags and rotting logs. The understory vegetation was rich and luxuriant and dominated by the herbaceous vegetation of the field layer. Flowering herbs and graminoids were particularly important. The primary understory species included *Rhododendron albiflorum*, *Ribes lacustre*, *Veratrum eschscholtzii*, *Valeriana sitchensis*, *Tiarella unifoliata*, *Cornus canadensis*, *Athyrium felix-femina*, *Streptopus roseus* and *Peltigera apthosa*. *Alectoria sarmentosa*, *Parmelia sulcata*, *Hypogymnia physodes* and several species of *Bryoria* dominated the abundant arboreal lichen flora.

b. western red cedar-western hemlock-engelmann spruce zone

The western red cedar-western hemlock-engelmann spruce zone was the second coniferous forest (*Thuja plicata* - *Tsuga heterophylla* - *Picea engelmannii*). These moist, cool forests occurred on all exposures and were best developed below 1125 meters. Cedar, hemlock and spruce, respectively, were dominant in 48%, 29% and 23% of the stands in this zone. Moisture played an important role in spatial distributions. Colonization was favored on low elevation sites with good water balance.

Tree luxuriances and site indices surpassed fir-spruce forest values. Many stands exceeded 40 meters and 250 years. The shrub layer was especially well developed and contributed greatly to an abundant and rich understory. Herbs also contributed substantially to the cover. Numerous snags and rotting logs promoted extensive cryptogamic development. The major understory species were _Oplopanax horridum_, _Athyrium felix-femina_, _Alnus crispa_, _Cornus canadensis_, _Galium triflorum_, _Rubus pedatus_, _Peltigera canina_ and _Cladonia coccifera_. An abundant and diverse epiphyte flora also existed and was dominated by _Lobaria pulmonaria_, _Platismatia glauca_ and _Hypogymnia physodes_.

c. subalpine meadow zone

The subalpine meadow zone was regularly dispersed througnout the forest zones. Meadows were distributed from 1000-1700 meters, though the majority occurred above 1350 meters. Individual meadows were a mosaic of diverse moisture conditions and luxuriant vegetation. Southern, southwestern and northeastern exposures and moderate slopes were most commonly occupied.

Nearly two-thirds of the vegetation was contained in the dense and diverse herb layer. Shrubs were restricted to the periphery. Moss and terrestrial lichen cover was well below average. Among the major plant species were Heracleum lanatum, Luzula wahlenbergii, Carex nigricans, Arnica latifolia, Caltha leptosepala, Claytonia lanceolata, Valeriana sitchensis, Tiarel'a unifoliata, Equisetum pratense, Peltigera canina and several species of adonia.

d. krumholz zone

Characterized by stunted trees, diffuse margins and a gradual reduction in tree heights, the krumholz zone occupied an ecological boundary between the coniferous forests and alpine meadows. Most sites occurred between 1650 and 1850 meters. Easterly and westerly exposures were preferred with the greatest number of sites occupying southeastern and eastern aspects.

The vegetation was composed of shrubby and herbaceous plants unique to the zone and a variety of invaders from subalpine areas. Shrubs and trees were poorly developed, and distinctive growth forms resulted from harsh climatic conditions. Mosses and terrestrial lichens were poorly developed, though the lichens occasionally formed rich mats. However, the field layer contributed approximately 85% of the vegetation and was dense and profuse. The most important plants in this zone included Salix glauca, Phyllodoce *empetriformis*, *Cassiope mertensiana*, *Claytonia lanceolata*, *Senecio triangularis*, *Pedicularis bracteosa*, *Trollius albiflorus* and *Valeriana sitchensis*.

e. alpine zone

Above timberline the alpine zone predominated. The vegetation, exposed to long, severe winters and limited growing seasons, was dominated by suppressed perennials, s abby woody species and luxuriant cryptogamic carpets. Most sites occurred above 1750 meters. Wind eroded sites and rock outcrops were common but the most diverse and abundant vegetation occupied gentle slopes and flat areas.

Trees were absent and shrubs were sparse and poorly developed. The forbs were the major contributor to the alpine vegetation and were diverse and abundant in all locations. Graminoids and water-loving herbs were of particular importance. Most areas also had moderately abundant cryptogamic carpets. The primary plant species included *Salix glauca*, *Salix nivalis*, *Cassiope mertensiana*, *Gentiana glauca*, *Erigeron humilis*, *Pedicularis bracteosa*, *Phleum alpinum*, *Poa alpina*, *Lupinus nootkatensis*, several species of *Saxifraga*, *Cladonia rangiferina*, *Cladonia mitis*, *Stereocaulc ande* and *Stereocaulon paschale*.

f. disturbance areas

Disturbed areas were the result of recent logging activities. The character and magnitude of disturbances were dependent on topographical features and harvest methods. Nearly all sites occurred between 750 and 1400 meters in the fir-spruce zone. The structure and floristic composition of these disturbed areas was significantly altered. The widespread occurrence of slash, stumps and other debris was quite noticeable.

Trees were usually absent. Where reforestation did occur, the sites were poorly stocked with immature trees seldom achieving heights of 2-3 meters.

Shrubs were well represented and accounted for 40% of the vegetation. Most sites had moderately developed field layers though cover-abundance values were considerably below average. Terrestrial lichens and mosses provided minimal cover. The lichens were particularly restricted, perhaps due to soil desiccation. The major plant species occurring in this zone included *Sambucus melanocarpa*, *Rubus parviflorus*, *Rubus strigosus*, *Epilobium angustifolium*, *Actaea rubra*, *Gymnocarpium dryopteris*, *Galium triflorum*, *Equisetum pratense*, *Heracleum lanatum* and several species of *Cladonia*.

2. Fauna

A wide variety of animals, native to the subalpine forests, inhabited the study area (Appendix B). Moose (*Alces* al. es) are the most widespread and abundant of the resident ungulates (Environment Canada 1970). They are particularly common in the Interior Plateau, where large burns and logging activity have created extensive early successional communities. Summer distributions are widespread, ranging from valley bottomlands to high alpine meadows. However, during the winter season populations are concentrated at lower elevation locations which provide sufficient browse. Mule deer (Odocoileus hemionus), though once numer us, are present only in low numbers, and are widely scattered throughout their summer range. During the winter they are severely restricted by deep snows and are subsequently limited to areas of limited snowfall and accessible forage. Mountain goats (Oreamnos americanus), and bighorn sheep (Ovis canadensis), also inhabit the region in limited numbers. Very little is known of their status or distribution. Black bears (Ursus americanus) are common and widely distributed throughout wooded areas, whereas grizzly bears (Ursus arctos horribilis) are only present in low numbers and are restricted to the more remote regions. Wolves (Canis lupus), and coyotes (Canis latrans) are the most common predators, though both are only present in low numbers (K. Fujino pers. comm.). Lynx (Lynx lynx), bobcats (Lynx rufus), cougar (Felis concolor), and wolverines (Gulo gula), occasionally frequent the area, but they are not common. Only the lynx and wolverine have ever been present in significant numbers. At higher elevations, Columbian ground squirrels (Spermophilus columbianus), hoary marmots (Marmota caligata), and porcupines (Erethizon dorsatum) are quite common. Only the porcupine, however, is regularly observed in lower, forested areas. Other furbearers common in the area include the fisher (Martes pennanti), pine marten (Martes americana), long-tailed weasel (Mustela frenata), and american beaver (Castor canadensis). Wolverine, lynx, coyotes, and wolves also are commercially trapped.

D. History Of Land Use And Regional Development

Within the Raven Lake Study area, all lands are jointly administered by the British Columbia Forest Service and Northwood Pulp and Timber Limited. The site primarily lies within the Longworth Public Sustained Yield Unit (P.S.Y.U.) Forest (Figure 2-2). Logging is the principal economic activity. The expanded caribou population study region, adds the Monkman and Purden P.S.Y.U.'s and a small portion of the Robson and Big Valley Forests. Purden Lake Provincial Park, encompassing 140 hectares, was established in August of 1971 in the Purden Forest. The small villages of Penny, Upper Fraser, Sinclair Mills, Dome Creek and McGregor, and several homesteads also are located in the study region. Nonetheless, the land resource is largely committed to forest industries.

1. Regional histcry

Prior to the 1793 expedition of the North West Fur Trading Company, led by Alexander Mackenzie, only the Sekani and Carrier Indians occupied the area (Morice 1904; Runnalls 1946). However, by 1807 Simon Fraser had established company posts at Fort Fraser, Fort St. James and Fort George. For nearly 55 years the fur trade flourished even though settlement was limited. Not until the Caribou Gold Rush and construction of the Collins Overland Telegraph, in the mid-1860's, were any significant number of Europeans located in the area.

In 1913, 42 years after joining confederation, British Columbia received the transcontinental railway. Construction and completion of this rail system stimulated a new wave of settlement bringing farmers, loggers, trappers, prospectors and real estate speculators to the area. Small sawmills were established at scattered locations along the Grand Trunk Pacific Railway (Canadian National Railways), and access provided by railroad construction stimulated agricultural homesteading. The region then experienced its first major period of growth (Siemens 1972). Development continued until World War I, when growth and settlement sharply declined (B.C. Dept. Lands, Forest, Water Resources 1964).

The economic slump, precipitated by a lack of markets, continued until 1940 when the area began an unprecendented period of expansion and growth. Between 1941 and 1961 the Prince George population grew rapidly from 13,366 to 49,901 (B.C. Lands, Forests, Water Resources 1964). By 1974, the estimated population was nearly 65,000 (B.C. Regional Index 1975).

A tremendous increase in the activity of the forest industries has been instrumental in stimulating the recent industrial expansion and population growth. The central and strategic location of Prince George, the regional transportation centre, also was enhanced by major highway and railroad construction in recent years. The Pacific Great Eastern Railway was extended south to Quesnel in 1952 (E. Rutley pers. comm.). In 1958, a northern extension connected Prince George to the Peace River area. During 1952 the John Hart Highway, connecting Prince George and Dawson Creek, was completed. Sixteen years later the Department of Highways concluded a ten year construction project linking McBride and Prince George (W. Ball pers. comm.). Subsequent to completion of these major transportation programs, industrialization of the region has accelerated and further growth is imminent.

2. Regional development and land use

a. agriculture

From 1811, the date of the first successful agricultural experiment west of the Rockies, until

1950-1955, agriculture in the region was limited to supplying goods for local consumption. Today, concurrent with regional expansion, agriculture is growing. Approximately 29,950 hectares of the 120,000 hectares of potentially arable lands are cleared and in production. Farm size and income also is increasing, due to improved marketing practices. From 1931 to 1964 the number of farms and ranches in operation declined from 1200 to 300 but the average farm size increased from three to nearly 250 hectares (Anderson 1947; B.C. Regional Indices). During this time period a concomitant shift from cereal and vegetable crops, to livestock and forage production also occurred. This probably reflects rapid growth in regional settlement and economic wealth. Nonetheless, problems associated with marketing, climate, and the expense of land clearing have thus far prevented agriculture from becoming a major element in the region's economy.

b. fire

Forest fires, although apparently not a major ecological factor in the habitat study area over a short time period, nonetheless have been widely reported in the region. Most fires have been caused by lightning strikes but a large number, deliberate and accidental, have been ascribed to human activities (Appendix C).

During the period from 1940-1949, the first decade for which fire histories were readily available, twelve fires were reported in the habitat study area. Most of these fires, all less than or equal to 20 hectares, occurred in the MacClaurin Creek area. The years 1946 and 1948 were particularly fire prone. During the 1940's, eleven major fires totalling 3000 hectares, and ranging from 28 to 1336 hectares, were recorded in the region. Eighty-two percent of these fires, along with the largest fire, located south of the Bowron River near Pritchard Lake, occurred during 1942. Two other major fires in the same year, burning 290 and 135 hectares respectively, occurred northeast of the confluence of Slim Creek and Swish Creek and west of Dome Creek on the north side of Slim Creek, east of Swish Creek. Numerous fires burning less than 20 hectares also were recorded, with the majority located near human activity in the Fraser River Valley.

From 1950 to 1959, all of the major fires covered less than 120 hectares, and only seven fires larger than 20 hectares occurred throughout the region. The largest fire burned 100 hectares in the vicinity of the 1942 Pritchard Lake fire. In the region, 1957 and 1958 were the most notable years of fire occurrence. However, the only fire recorded in the habitat study area during the decade, burned near MacClaurin Creek, east of Driscoll Creek, during 1954. It consumed less than 20 hectares of timber. Again, the majority of reported fires occurred in the settled areas of the Fraser River Valley.

Fire damage between 1960 and 1969 was the most severe for the 40 year period reviewed. Seventeen fires, mostly reported during 1960-1961, and destroying 10-15 hectares of timber each, were chronicled in the habitat study area alone. The Hungary Creek-Slim Lake area sustained five fires, while the remainder were recorded in the Lunate, MacClaurin, Driscoll and Slim creek watersheds. A similar pattern was obvious throughout the region, with the majority of the abundant damage sustained during twenty major fires, occurring during 1960 or 1961. The seven largest fires alone, accounted for 96.9% of 27,635 hectares of timberland burned (Appendix C). Major fires during the 1960's ranged from 20 to 15,737 hectares. The largest fire occurred during July of 1961, and burned in the area of Tsus Creek, near Fly, Swamp and Kenneth creeks, and northwest of the Bowron River. Two of the other six fires exceeding 200 hectares were located in the habitat study area. The first, destroyed 202 hectares of fir-spruce timber southeast of Papoose Lake, near the confluence of Slim and Everett creeks, while the second fire, burned 8225 hectares near Haggen Creek and northwest of Dominion Creek and Clear Mountain. As was the case in the two previous decades most of the fires, including the four remaining major fires, occurred in the Fraser River Valley and the northern portion of the study region (Appendix C).

Contrary to the 1960-1969 period, the first seven years of the 1970's experienced a reduction in the number of fires. Nine fires exceeding 20 hectares were recorded, though not one occurred in the vegetation survey area (Figure 2-2). These fires, ranging from 22 to 290 hectares, were considerably smaller, with only two greater than 200 hectares. Both of these fires were located north of the Fraser River and east of Crescent Spur. During the 1970's, all of the fires in the study area and the majority of those in the region, were recorded in 1971. The three fires located in the habitat study area, primarily affected the Slim Creek-Everett Creek area.

Generally no tree species or forest type exhibited a disproportionate susceptibility to fire. Additional information concerning the characteristics of affected stands was not available. However, reports did indicate that fires typically started in slash, logging debris, heavy windfall and other highly combustible material. There also appears to be a trend toward an increase in the number and percentage of fires initiated by man (Appendix C).

c. forestry

Since 1950 the logging industry in Central British Columbia has undergone major changes. Small, seasonal logging operations have been replaced by large, centralized, industrial complexes. Highways, all weather roads, rubber-tired machines, clear-cut logging practices and other changes in equipment and technology have combined with increased demand to elevate the forest industry into prominence. Today it is the mainstay of the region's economy.

The Purden P.S.Y.U. is administered in the south at Prince George, and in the north at Aleza Lake. Logging activity of any consequence did not occur before 1966. Major development only commenced about 1970, when 910 hectares were logged. From 1971 to 1976 the quota fluctuated between 450 and 2675 hectares and production costs doubled. Under the sustained yield program the 1977 harvest, representing a full commitment to the stabilization quota, was reduced to 1620 hectares (F. Turner pers. comm.).

Initial development in the Monkman P.S.Y.U. occurred between 1968 and 1970, though some limited harvesting was completed as early as 1965. From the earliest logging period, quotas have gradually increased. The Forest Service, however, anticipates a maximum allowable cut of 1400-1450 hectares annually, commencing during 1977. Supervision of this forest management program will be conducted at Aleza Lake in the west and McBride in the eastern section.

In the Longworth P.S.Y.U., small volumes of timber ha been cut along the Canadian National Railway and the Frase River since the 1940's. Nonetheless, prior to completion o Highway 16 in 1968, logging development was limited. Since that time and until 1977 annual quotas fluctuated between 550 and 1950 hectares. Currently, however, the Longworth forest also has been placed on a stabilization program, jointly administered at Aleza Lake and McBride. An upper limit of 1400-1450 hectares has been set on the annual timber harvest.

The Purden, Monkman and Longworth forests comprised the vast majority of the extensive study area (Figure 2-2). Table 2-4 details the distribution of land between forested and non-forested land. Most of the vegetation studies were conducted in the Longworth Forest. Table 2-5 describes Longworth land classifications, and characterizes the distribution of forest types.

d. guide outfitting

Provincial law requires that non-resident hunters secure the services of a licensed guide. Nearly one third of these individuals select to visit the central district, where 28% of the province's guides account for 22% of the provincial industry's annual income. Although some disparity exists, many profitable guiding businesses are operated in the region by local inhabitants and residents of other zones. In fact nine individuals currently do business in the study area alone.

e. transportation

Improving transportation facilities have played an important role in the growth and industrialization of the

Table 2-4 Forested And Non-Forested Land In The Public Sustained Yield Unit Forests Of The Study Area

	Area (Hectares)		
Forest	Forested	Non-Forested	Total
Longworth	345,573	146,368	491,941
Monkman	302,464	245,558	548,022
Purden	215,904	23,149	239,053

Table 2-5 Classification Of Land In The Longworth Public Sustain Yield Forest, Central British Columbia

Site Types	Mature Timber (Hectares)	Total (Hectares)	% Of P.S.Y.U.
Douglas Fir Pure and Dominant Mixed Forests	353	683	0.14
Cedar Pure and Dominant Mixed Forests	53,385	53,457	0.46
Lodgepole Pine Pure and Dominant Mixed Forests	8,042	10,545	2.63
Fir Pure and Dominant Mixed Forests	80,015	89,031	17.42
Hemlock Pure and Dominant Mixed Forests	15,182	16,725	3.22
Spruce Pure and Dominant Mixed Forests	142,312	152,017	29.71
Miscellaneous Deciduous Forests	1,237	7,225	1.44
Miscellaneous Residual	5,716	15,890	3.01
Poorly Stocked	nil	2,911	0.51
Non Commercial	nil	8,078	1.46
	nil	nil	0.00
Forest Subtotal	306,242	356,562	67.63
Krumholz	*	18,612	3.64
Alpine	*	108,486	21.23
Water	*	11,295	2.21
Disturbed Areas	*	7,508	1.46
Roads	*	468	0.009
Non-Forested Subtotal	*	146,369	28.64
Alienated Land	*	18,976	3.73
Grand Total	306,242	521,907	100.00

* Non-forested Land

Prince George region. Two railway systems combine to provide freight and passenger service to and from Prince George, McBride and the outlying villages.

Completion of the Prince George-McBride Highway, in 1968, probably was the most significant regional development. Prior to 1969, all the roads in the region were dirt and gravel. Now major, all-weather, paved highways connect Prince George to centres in all directions and have resulted in increased tourism and commerce. Accompanied by an extensive network of logging roads, this development also led to centralization of the forest industry.

Construction and maintenance of rail and highway facilities was not without consequence. Both the British Columbia Railway and Canadian National Railway cleared and now maintain a minimum right-of-way of 15 metres on either side of the rail bed (J. Mekechuk pers. comm.; E. Rutley pers. comm.). The highway's department engineering section also utilizes a right-of-way which was increased to 45-60 metres. In either case, once altered, the habitat is continually controlled to avoid significant regrowth of vegetation.

III. PATTERNS OF RESOURCE UTILIZATION - SEASONAL HABITAT SELECTION

A. Introduction

Caribou exhibit movement strategies designed to optimize seasonal resource utilization and maximize survival, but the level of attachment to traditional areas is imprecise (Cowan 1974). However, broad generalizations describing caribou movements as aimless wandering over extensive areas are misleading. All wild animals have limited individual ranges. The size and importance of these ranges are simply unknown for mountain caribou (Layser 1974).

It has been proposed that the unpredictable movements of mountain caribou may be largely attributed to the seasonal variability in their food supply (Fashingbauer 1965; Chapter IV). Subsequent spatial adjustments probably result from reactions to topographical and climatic conditions. This is particularly true during the winter season (Edwards 1956).

Past research indicates that mountain caribou migrations are altitudinal and local in character (Allen 1900; Flinn 1956; Freddy 1974; Edwards and Ritcey 1959). These movements appear to have seasonal implications (Evans 1960). The nomadic and restless behavior of caribou also contributes to the complex nature of seasonal movements

(Evans 1960), which Edwards and Ritcey (1959) characterized as biannual migratory oscillations. This nomadic behavior takes the caribou through a wide variety of plant communities each year (Skoog 1956), and reduces the opportunity for observation.

Though general, seasonal movement patterns have been described, relatively little is known about the seasonal habitat preferences of mountain caribou. In this study, habitat studies were designed primarily to determine seasonal choices and strategies. Considerable attention also was directed toward an understanding of the influence of environment on movement, distribution and habitat selection.

B. Field Methodology

The spatial distributions, and seasonal movement patterns of the local caribou were evaluated in several ways. Techniques included aerial reconnaisance, ground surveillance and communication with local residents and resource personnel.

Aerial reconnaisance, travelling in all directions, was conducted on a random basis. The rugged terrain, large study area and small caribou population precluded the use of fixed area or line-transect census methods (Siniff and Skoog 1964). A total of approximately 115 hours of surveys was completed using a Bell Jet Ranger helicopter. The general survey routes were established on the basis of previous research and the known habits of the local bands.

The majority of aerial counts occurred during the late winter and early spring, when snow cover and concentrations of caribou above timberline increased sampling success. Surveys conducted to determine seasonal distributions and preferences were attempted on a monthly basis. Although considerable time was expended examining persistent alpine snowfields, a concerted effort was made to inspect all areas equally. This assured uniformity in examination of seasonal habits and optimized the allocation of sampling efforts.

During air and ground surveys, the areas examined were thoroughly searched for animals, tracks and pellets. Any actual sightings or animal signs were recorded on observation sheets. Maximum and minimum estimates were made during each survey. Characteristics of the topography and vegetation were described for each encounter; and where possible, notes were made on the abundance, aggregation, composition, behavior, condition and activity of the animals sighted. Attempts also were made to examine inhabited areas on the ground, but because of a firm policy to avoid harrassment, this was not possible in each case.

Ground surveys provided a great deal of the population data. Periodic visits were made to each section of the study area. In addition areas of reported or observed caribou activity were examined. A caribou census taking network, involving many local residents and industrial and government employees, maximized the opportunities for successful surveillance. Caribou or caribou tracks were followed, and movements, numbers and activities monitored. Motorized vehicles were not used.

Ground and aerial surveys were combined to obtain monthly and total population estimates. It was assumed that maximum counts, aerial and ground combined, provided the most representative appraisals of minimum population size. Every attempt was made to avoid duplication by giving precedence to ground counts and accounting for known movement corridors (Freddy 1974). Sightings were compiled on a 1:250,000 topographic map.

Additional information was obtained from a questionnaire circulated amongst agencies and individuals with knowledge concerning the status, trends and habits of the local mountain caribou. Many residents, particularly guides, government officials and sportsmen, also were interviewed.

To facilitate discussion and examination of seasonal strategies each year was divided into six equal seasons reflecting changes in weather and the spatial distribution of the caribou populations. The results and discussion emphasize the physical, climatic, and vegetative characteristics of seasonally preferred areas. The factors influencing seasonal patterns are treated in subsequent sections of this chapter. Seasonal food preferences and feeding habits are discussed in detail in the following chapter and are only briefly mentioned here.

C. Numerical Analysis

All recorded observations, whether live animals, pellets or tracks, were tabulated. The distribution and frequency of the individual cases within the variable categories were subsequently analyzed and presented as one-way tables of frequency distributions. Frequency tests were conducted in the general or variable mode in deference to the nominally and intervally scaled data classes (Nie et al. 1975).

Following examination of the distribution of cases, the relationships between groups of two variables were analyzed. Contingency table (crosstabulation) analyses were selected from the comprehensive statistical package developed in the social sciences (Nie et al. 1975).

Crosstabulation procedures provided a display of frequency distributions for multiple classificatory variables (Nie et al. 1975). The subprogram CROSSTABS, permitted computation of joint frequencies and demonstrated the relationships between discrete variables represented in crosstabulation tables, such as vegetation zone vs. season.

Chi-square tests were used to examine statistical significance and systematic relationships. Results were significant at .05 levels of confidence. To facilitate comparisons, probabilities were reported instead of chi-square values.

Frequency distributions were summarized, and the magnitude of relationships between variables examined by the Lambda measure of association. This statistic determined the gain in predictive ability, or proportional reduction in error, realized when the values of the independent variable were known. Individual values obtained by asymmetric lambda explained the variability between two variables in both directions. These results were averaged by the symmetric statistic, thereby analyzing the overall improvement in predictive capability.

D. Results And Discussion

During this study, a total of 134 observations, distributed between four sighting classes, were recorded (Appendix D). The total included 12 sightings made immediately prior to initiation of the study in September of 1975. Thirty-four percent of the sightings were reported by persons not directly involved in the research program. Observations were made during all six seasons described (Table 3-1). All elevations, aspects, slopes and vegetation zones were represented (Table 3-1). A chronological list of

Table 3-1 The Frequency Distribution Of Caribou Sightings During This Study

Relative Frequencies (%) And Case Distributions

Season

Dec 15–Feb 14	Feb 14–Apr 14	Apr 15–June 14	June 15–Aug 14	Aug 15–Oct 14	Oct 15–Dec 14
17.7	17.7	23.9	18.6	14	11

Field Study Year

1975	1976	1977
21.2	35.4	43.4

Elevation (Meters)

650–1000m	1001–1350m	1351–1700m	over 1700m
31.9	20.4	38.1	9.7

Aspect

NE	N	NW	SE	S	SW	E	W
10.6	15.0	20.4	10.6	11.5	16.8	8.8	6.2

Slope (%)

Gentle (0-15)	Moderate (16-35)	Steep (36-50)
24.8	52.2	23.0

Vegetation Zone

Fir-Spruce	Cedar-Hemlock-Spruce	Subalpine Meadow	Krumholz	Alpine	Disturbance	Lakes Muskey
31.0	22.1	17.7	10.6	10.6	1.8	6.2

Table 3-1 Continued

Observation Type			
Caribou	Pellets	Tracks	Activity Sign
62.8	8.8	22.1	6.2

Activity Type						
Travel	Rest	Feeding	Unknown	Activity sign*	Licks	Crossed road
25.6	10.6	27.4	17.7	8.8	3.5	6.2

*Considerable, undetermined localized activity sightings is presented in Appendix D.

All sightings were tabulated and analyzed on the basis of topographical and seasonal characteristics. Table 3-2 illustrates the systematic interrelationships between important characteristics of caribou observations, and the strength of association between significant variable pairs. The seasonal distributions and activities of mountain caribou were strongly related to topographical and vegetative parameters. Caribou activity also demonstrated seasonal variability. Elevations, aspects, and vegetation zones also were strongly interrelated with the seasons.

1. Spatial distributions of mountain caribou by topography
a. elevational distributions

Nearly 50.0% of caribou observations occurred between 1350 and 1700 meters, and 9.1% were above 1700 meters. Seasonal distributions ranged between 732 and 1830 meters. The highest elevations typically were utilized from February 15 to April 14 and June 15 to October 14 (Table 3-3).

A strong relationship existed between elevation and utilization of vegetation zones (Tables 3-2 and 3-4). Presence in cedar-hemlock-spruce and fir-spruce forests dominated animal distributions below 1350 meters, with the former zone particularly important from 650-1000 meters. From 1351-1700 meters, fir-spruce forests, subalpine meadows, and krumholz areas were utilized equally. Above

Table 3-2 Systematic Relationships Between Environmental Features Of Caribou Sightings

Tests of Significance - Chi-Square Probabilities (p)*

	Season	Year	Elevation	Aspect	Slope	Vegetation Zone	Activity
Season							
Year	.0007						
Elevation	.0271	.0038					
Aspect	.0081	.3527	.2573				
Slope	.0042	.3815	.3818	.0002			
Vegetation Zone	.0156	.3669	.0000	.0376	.4911		
Activity	.0067	.0001	.0436	.2047	.9094	.2419	
Observation Type	.0056	.0326	.0123	**	**	.7380	.0203

*significant at .05 level of confidence or better ($p \leq .05$)

Measures of Strength of Association - Lambda Statistics

Asymmetric Lambda Statistic

Dependent Variable	Season	Year	Elevation	Aspect	Slope	Vegetation Zone	Activity
Season	—	.151	.105	.198	.105	.163	.139
Year	.218	—	.172	—	—	.125	—
Elevation	.100	.100	—	—	—	.386	.143
Aspect	.144	—	—	—	.078	.111	—
Slope	.111	—	—	.185	—	—	—
Vegetation Zone	.103	0.0	.167	.103	—	—	—
Activity	.098	—	.037	—	—	—	—
Obervation Type	.093	.047	.200	—	—	—	.136

Table 3-2 Continued

	Symmetric Lambda Statistic				
Dependent Variable	Season	Year	Elevation	Aspect	Slope
Season	——	——	——	——	——
Year	.130	——	——	——	——
Elevation	.103	.134	——	——	——
Aspect	.170	——	——	——	——
Slope	.108	——	——	.131	——
Vegetation Zone	.134	.062	.270	.107	——
Activity	.119	.124	.086	——	——
Observation Type	.046	.028	.200	——	——

**Relationship of minimal importance and not examined

Table 3-3 Seasonal Distributions Of Mountain Caribou During This Study (%)

	Dec 15-Feb 14	Feb 15-Apr 14	Apr 15-June 14	June 15-Aug 14	Aug 15-Oct 14	Oct 15-Dec 14
Elevation (Meters)						
650-1000	30.0	5.0	44.4	14.3	21.4	45.5
1001-1350	25.0	20.0	33.3	33.3	7.1	9.0
1351-1700	35.0	40.0	18.5	47.6	57.1	45.5
Above 1700	10.0	25.0	3.7	4.8	14.3	0.0
Aspect						
NE	20.0	15.0	7.4	14.3	0.0	0.0
N	5.0	5.0	33.3	19.0	14.3	0.0
NW	35.0	20.0	25.9	9.5	7.1	18.2
SE	10.0	5.0	3.7	23.8	7.1	18.2
S	0.0	10.0	3.7	19.0	28.6	18.2
SW	0.0	40.0	11.1	9.5	21.4	27.3
E	20.0	5.0	3.7	0.0	14.3	18.2
W	10.0	0.0	11.1	0.0	7.1	0.0
Slope						
Gentle (0-15%)	55.0	20.0	7.4	9.5	21.4	54.5
Moderate (16-35%)	30.0	60.0	66.7	57.1	42.9	45.5
Steep (36-50%)	15.0	20.0	25.9	33.3	35.7	0.0
Vegetation Zone						
Fir-Spruce Forest	20.0	30.0	44.4	33.3	28.6	18.2
Cedar-hemlock-Spruce Forest	45.0	10.0	16.7	14.3	7.1	45.5
Subalpine Meadows	0.0	5.0	24.1	28.6	21.4	27.3
Krummholz	15.0	15.0	3.7	4.8	21.4	9.1
Alpine	10.0	25.0	0.0	9.5	21.4	0.0
Disturbance	0.0	0.0	7.4	0.0	0.0	0.0
Lakes, Muskegs	10.0	15.0	3.7	9.5	0.0	0.0

Table 3-3 Continued

	Dec 15-Feb 14	Feb 15-Apr 14	Apr 15-June 14	June 15-Aug 14	Aug 15-Oct 14	Oct 15-Dec 14
Activity						
Travelling Through	40.0	20.0	18.5	38.1	35.7	18.2
Resting	5.0	15.0	7.4	9.5	0.0	9.1
Feeding	20.0	30.0	18.5	23.8	35.7	54.5
Unknown	20.0	10.0	25.9	23.8	7.1	9.1
Much Localized Activity	5.0	0.0	18.5	4.8	21.4	0.0
Mineral lick	0.0	0.0	11.1	0.0	0.0	9.1
Crossing Road	10.0	25.0	0.0	0.0	0.0	0.0
Observation Type						
Live Animals	45.0	70.0	63.0	61.9	64.3	81.8
Pellets	5.0	0.0	3.7	33.3	7.1	0.0
Tracks	45.0	20.0	25.9	0.0	14.3	18.2
Local Activity*	5.0	5.0	7.4	4.8	14.3	0.0

*Considerable, undetermined localized activity

Table 3-4 Topographical Distributions Of Mountain Caribou During This Study

	Elevation 650-1000 Meters	1001-1350 Meters	1351-1700 Meters	Above 1700 Meters
Vegetation Zones				
Fir-Spruce Forest	36.1	39.1	27.9	[illegible]
Cedar-Hemlock-Spruce Forest	47.2	34.8	0.0	0.0
Subalpine Meadow	11.1	17.4	27.9	0.0
Krumholz Forest	0.0	0.0	27.9	9.1
Alpine Meadow	0.0	0.0	4.7	90.9
Disturbance Area	2.8	4.3	0.0	0.0
Lakes, Muskeg	2.8	4.3	11.6	0.0

	Aspect NE	N	NW	SE	S	SW	E	W
Slope								
Gentle 0-15%	41.7	17.6	21.7	8.3	15.4	15.8	90.0	0.0
Moderate 16-35%	33.3	70.6	47.8	66.7	38.5	73.7	10.0	57.1
Steep 36-50%	25.0	11.8	80.4	25.0	46.2	10.5	0.0	42.9
Vegetation Zone								
Fir-Spruce Forest	66.7	23.5	13.0	25.0	30.8	36.8	30.0	42.9
Cedar-Hemlock-Spruce Forest	25.0	11.8	43.5	33.3	7.7	15.8	20.0	0.0
Subalpine Meadow	8.3	23.5	13.0	33.3	30.8	10.5	0.0	28.6
Krumholz Forest	0.0	11.8	17.4	8.3	0.0	10.5	30.0	0.0
Alpine Meadow	0.0	17.6	8.7	0.0	23.1	15.8	10.0	0.0
Disturbance Area	0.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0
Lakes, Muskeg	0.0	0.0	4.3	0.0	7.7	10.5	10.0	28.6

Table 3-4 Continued

	Slope Gentle 0-15%	Moderate 16-35%	Steep 36-50%
Vegetation Zones			
Fir-Spruce Forest	28.6	32.2	30.8
Cedar-Hemlock-Spruce Forest	28.6	23.7	11.5
Subalpine Meadow	7.1	20.5	23.1
Krumholz Forest	17.9	8.5	7.7
Alpine Meadow	14.3	6.8	15.4
Disturbance Area	0.0	3.4	0.0
Lakes, Muskeg	3.6	5.1	11.5

1700 meters, alpine locations comprised 90.9% of the sightings, while krumholz areas were occupied 9.1% of the time. However, to a large extent these results may be attributable to the relationship between vegetation zones and their distributions on an elevational gradient (Bloomfield 1979).

b. distributions by aspect

Mountain caribou also demonstrated differential distributions by aspect (Tables 3-1 and 3-3). Twenty percent of the sightings were recorded on northwest exposures. Southwest and north aspects followed, comprising 16.8% and 15.0% of the annual observations, respectively (Table 3-1). Western exposures accounted for the lowest overall percentage of caribou observations (Table 3-3).

Seasonal differences also were apparent (Table 3-3). During early winter (December 15-February 14), northwestern, northeastern and eastern aspects were most heavily used. Later in the winter (February 15-April 14) southwestern and then northwestern slopes were preferred. Northern slopes were particularly favored for the duration of the spring season. Summer selection was less precise, and caribou occupied all slopes but eastern and western. Early autumn distributions appeared to be predisposed to southern and southwestern exposures. From mid-October to mid-December, all aspects except north, northeast and west were commonly used.

Caribou distributions by vegetation zone and aspect also were interrelated (Table 3-2). Use of northeastern exposures was not reported in plant communities above 1650 meters, and was very limited in open areas below that elevation (Table 3-4). On the contrary, heavy use was recorded in forested areas, particularly in the fir-spruce zone, where all exposures were inhabited sometime during the year. Cedar-hemlock-spruce forests were most prominently used when located on northwestern aspects. This relationship was an important reflection of early winter habitat selection and exposure preferences. Subalpine meadow sightings were most prevalent from April 15 to August 14 and on north, south, and southeast exposures. During late fall and early winter caribou also widely inhabited these meadows, particularly on southern aspects. Krumholz areas were most frequently used on northwestern exposures, above 1600 meters and during autumn and early winter (Table 3-4). In the autumn season krumholz habitats on eastern and northern slopes were preferred. Alpine areas also were selected twice annually. Use of southwest and northwest exposures was most common during the late winter period. Southern and southwestern slopes were most densely inhabited during the autumn season when caribou also were located above timberline. Lakes and muskegs were primarily used from December 15 to April 15 and again from June 15 to August 15. During the winter primarily, western, eastern and northwestern exposures were inhabited. Northwestern and especially southern aspects were preferred during most of the summer. All observations in disturbed areas occurred on southerly slopes during the spring season.

c. distribution by slope

Use of slope and aspect were strongly correlated (Table 3-2), though the vast majority of sightings occurred on moderate slopes (Table 3-1). Only observations on southern exposures were more common on the steeper inclines, whereas distributions on northeastern and eastern aspects were more typical on slopes of less than 15%. This apparent combined interaction may reflect seasonal shifts in elevation induced by climatic changes.

The steepest slopes primarily were occupied during the snow-free months, especially from May 15-October 15. Some use also was noted at higher elevations during the late winter period. Gentle slopes experienced their heaviest use from October 15-February 15, particularly while caribou were located below 1350 meters (Table 3-3).

A significant relationship between slope and vegetation zone also existed (Table 3-2). The most precipitous slopes were used when caribou inhabited subalpine and alpine meadows and embankments along waterways. Slight inclines were more heavily utilized in forested and krumholz areas, though a large number of summer, alpine observations similarly occurred. However, moderate slopes were occupied in all zones (Table 3-3).

2. Seasonally preferred areas

a. mid-winter (December 15-February 14)

During the mid-winter season, mountain caribou were quite mobile, moving in small, usually mixed bands, and rarely remaining in any locality very long. Early in the season the majority of caribou were distributed below 1350 meters (Figure 3-1). Northwestern, northeastern and eastern aspects and moderately sloped terrain were preferred (Figure 3-2, Table 3-1).

Cedar-hemlock-spruce forests were a major constituent of caribou range, particularly where the forest edge contacted muskegs, lakes and other riparian communities (Figure 3-3). In these humid, partially open areas arboreal lichens flourished. The caribou also foraged for terrestrial lichens and a variety of persistent vascular plants wherever the snow cover remained shallow (Chapter IV). Mature, open-canopied, fir-spruce forests located below 1480 meters and on intermediate mountain slopes (16-35%) also provided important habitat. Densely forested sites were favored when the caribou were able to continue successfully foraging for terrestrial vegetation. When the canopy no longer prevented snow from accumulating on the ground, open areas within the forest or along its edge became more important. Snow depths

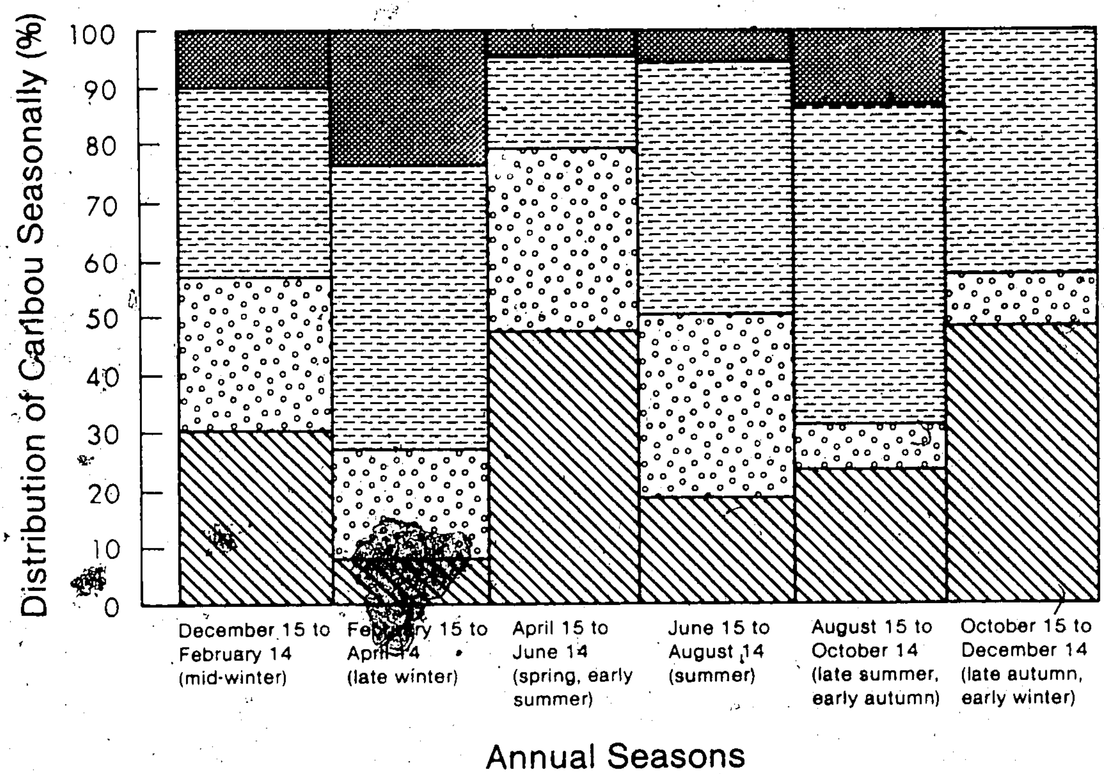

Figure 3 - 1 Seasonal Caribou Distributions by Elevation

Key

Seasonally Preferred Elevations

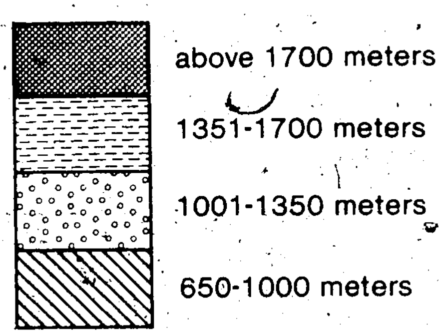

Figure 3-1

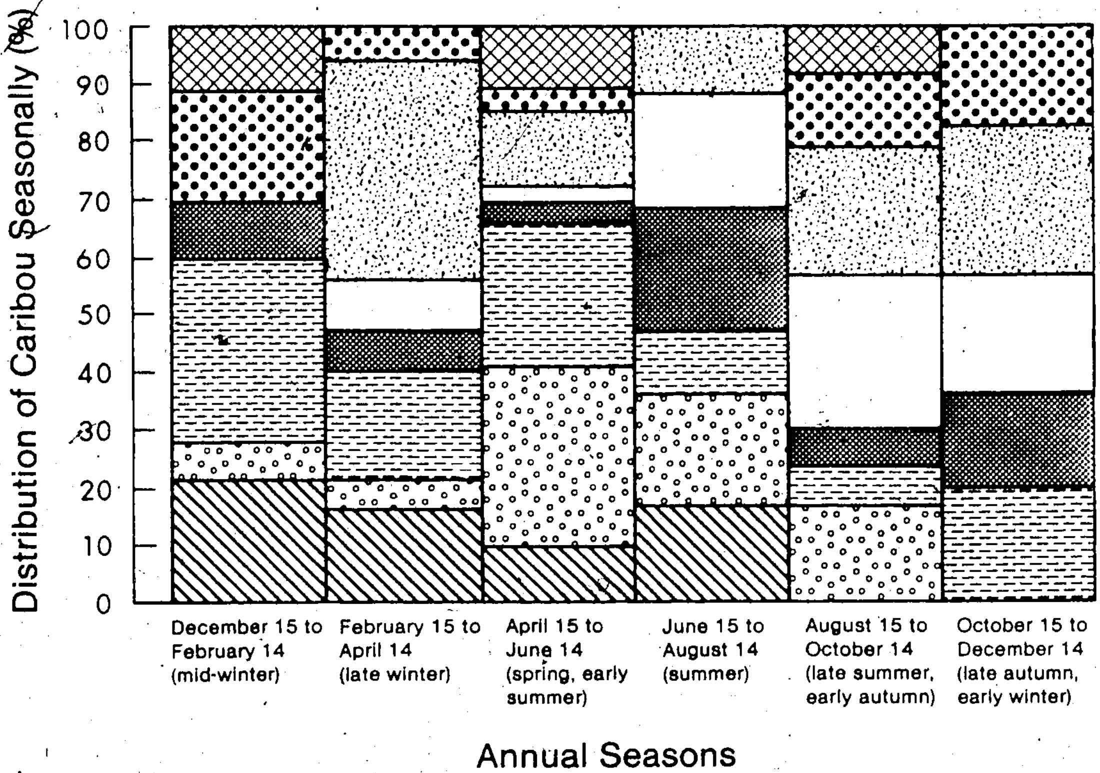

Figure 3 - 2 Seasonal Caribou Distributions by Aspect

Key

Seasonally Preferred Aspects

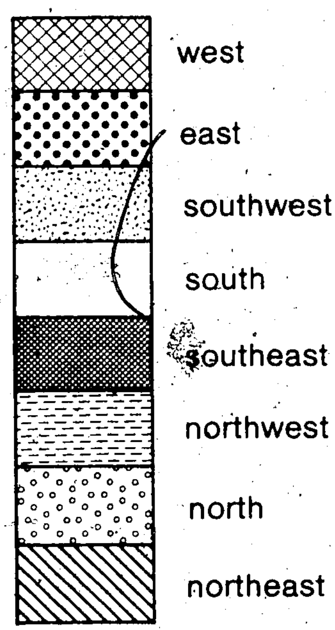

Figure 3-2

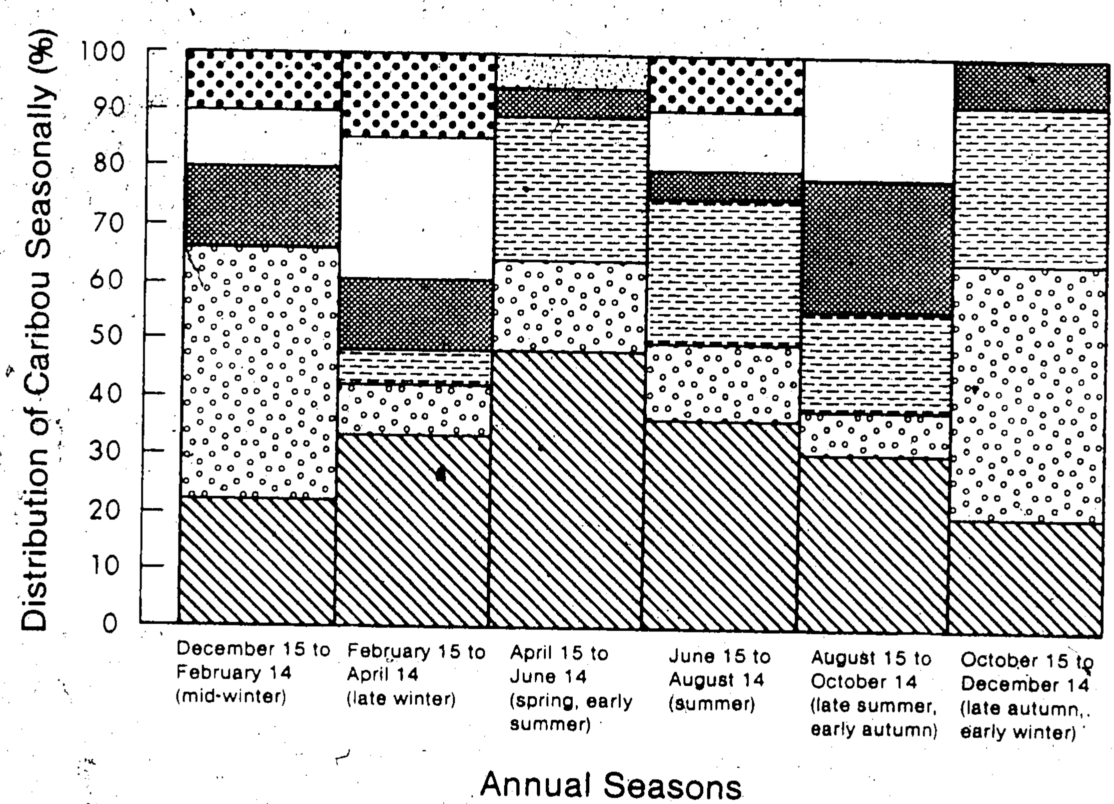

Figure 3 - 3 Seasonal Caribou Distributions by Vegetation Zone

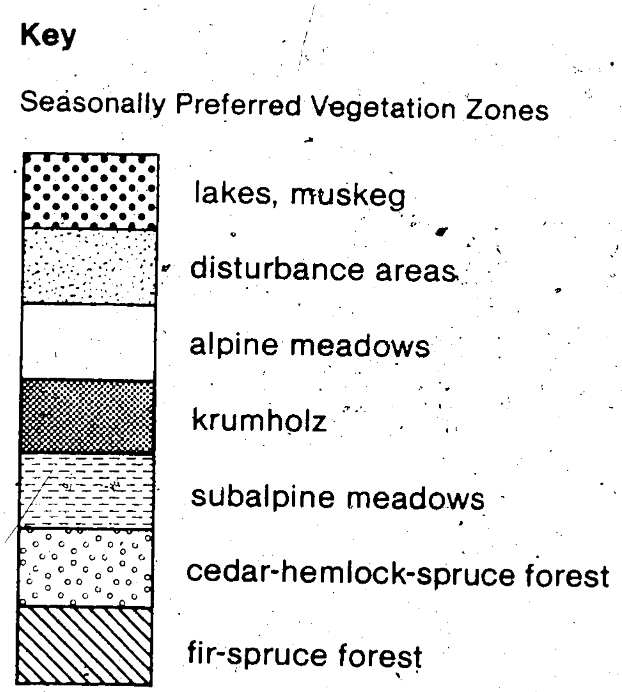

Figure 3-3

exerted the greatest influence on the relative availability of food plants and thereby strongly dictated food habits. The caribou avoided prolonged inhabitation of exposed areas, perhaps to minimize the severity of high winds and low temperatures.

Later in the season, beneficial changes in nival conditions permitted the caribou to extend their winter range to higher elevations. As the snows settled, and became crusted the caribou climbed to fir-spruce forests above 1500 meters and into the krumholz and alpine zones. Here, the caribou showed a preference for moderately and steeply sloped, benches, basins and windswept knolls. Northern and eastern exposures were still preferred (Table 3-3). Timberline forests and alpine meadows provided cover and food. During this portion of the winter a variety of arboreal lichens dominated their diet. Windswept areas, particularly in the alpine, provided some forage but within late winter ranges, snows were deep and very little was available except for epiphytic lichens.

b. late winter (February 15-April 14)

By the middle of February most of the caribou had reached their late winter habitat located in the high country near and above timberline. Sixty-five percent of the animals observed were located above 1350 meters, and 25% occupied krumholz and alpine sites (Table 3-3). Some animals remained at the lower extremes of their range, whenever food remained relatively abundant. However, the majority ascended to higher vegetation zones where winter forage was more readily available. During periods of moderate weather caribou fed on arboreal lichens at the forest's edge and terrestrial vegetation bared in the alpine zone. However, severe winter storms drove the animals into the high elevation fir-spruce forests, where both cover and food were available. Moderate southwestern and northwestern slopes were preferred, probably because the deep snows were more settled and provided the greatest support.

At this time, cedar-hemlock-spruce forests became considerably reduced in seasonal importance (Table 3-3). The caribou spent most of their time in mature fir-spruce forests, particularly where high moisture stimulated luxuriant arboreal lichen growth (Smith 1962). Muskegs and wet meadows adjacent to forested areas were especially important. Densely wooded areas were preferred during inclement weather, but did not provide a comparable source of food. Deep, compact winter snows made terrestrial vegetation unavailable except on the occasional windswept ridge. In fact, though the specific composition changed, arboreal lichens remained the main component of caribou diets (Chapter IV).

Rotational use of wintering areas remained common, but the caribou occasionally became stationary and increased their local feeding activity (Table 3-3). This was especially true when slides and ridges became free of snow after winter storms. Perhaps this phenomenon explains the noticeable increase in live animal sightings, particularly during periods of mild weather. The cessation of severe storms allowed animals driven to timberline the opportunity to again collect in bands.

c. spring and early summer (April 15-June 14)

The warm weather and melting snows of spring triggered a retreat from timberline to the lowland forests, located below 1350 meters (Table 3-3). Henshaw (1964) explained these movements as preference for conditions favoring survival. Indeed travel was necessary before the onset of deteriorating snow conditions seriously reduced mobility and food supplies. The caribou moved quickly through the fir-spruce forests, stopping only briefly to feed on a variety of epiphytic lichens. Movement was continuous and interrupted only by poor weather conditions. Travel appeared greatest during bright, relatively cloud-free weather, when favorable snow conditions prevailed. On occasion, however, caribou were observed during pleasant weather, basking in the sun (D. Ferguson pers. comm.).

Sometime after the middle of May, the greatest percentage of caribou bands once again frequented mountain valleys below 1000 meters (Table 3-3). Arrival in these localities coincided with the emergence of early spring vegetation. Most animals sought rapidly growing, green plants and ate few arboreal lichens. Open areas, particularly subalpine parklands and meadows, constituted preferred habitat. This probably reflected exploitation of the earliest, local snowmelt areas. Northwestern, southwestern and western exposures, and moderate or steep slopes, were most commonly used (Table 3-3).

Although most caribou quickly reached the lowland forests and meadows, some remained in wooded areas above 1275 meters. Their distribution seemed to be dependent on arboreal lichen pastures. These animals congregated in small groups along forest edges, lake shores, riversides, muskegs, streams and wet meadows. In these locations, the caribou continued to forage for epiphytic lichens. Northern and northeastern slopes were heavily used, probably because snow conditions provided better support. Several animals also were observed feeding on exposed terrestrial vegetation and eating slush in riparian habitats.

d. summer (June 15-August 14)

Late in June, the caribou bands began to reascend the mountain slopes toward their summer range. Subalpine parklands and meadows, interspered within the mature fir-spruce forests above 1250 meters, were preferred. Timberline and alpine meadows also were an important range component (Table 3-3). Throughout this season caribou, though more sedentary than during other periods, actively shuttled between wooded and non-forested areas. Lush, wet areas provided luxuriant mats of graminoids and flowering herbs.

The caribou travelled at a reduced pace and appeared to follow spring growth up the slopes and fed on new, succulent vegetation as the snow receded. They sought rapidly growing plants, heavily fed on several species and then abruptly switched to others as they appeared. Locations of tr ks and pellets indicated that the animals usually remained jus above the receeding snowline.

During the early part of the season, the caribou intensively foraged in the subalpine forests and meadows, and demonstrated preferences for southeastern, southwestern, northwestern and southern slopes (Table 3-3). Caribou were most frequently observed alone or in groups of 2-3 (Chapter V).

Later, however, the pattern was somewhat different. As the animals reached areas adjacent to and above timberline, northern and northeastern exposures increasingly were favored. Here, remnant snowfields and cool breezes probably provided mid-day relief from warm temperatures and insect harassment. The caribou appeared to be most active during the morning, late afternoon and evening. High elevation basins, lakeshores and wet meadows provided a rich and abundant diet.

e. late summer and early autumn (August 15-October 14)

During the late summer and early autumn, the mountain caribou remained near timberline and continued to forage for plants similar to those comprising the summer diet. Open glades, ridges beyond the forest's edge and wet meadows continued to be of particular importance (Table 3-3). A noticeable decrease in the use of northeastern, southeastern and northern exposures and a concomitant increase in the utilization of southern, eastern and southwestern aspects occurred (Table 3-3). This probably resulted from disappearance of persistent snowfields and seasonal changes in vegetation caused by early frosts. Steep slopes also became more important (Table 3-3).

Weather conditions determined food and habitat selection by dictating the availability of various forage species. The caribou were quite mobile during this time and often exhibited continual, highly localized activity. Most movement was lateral to elevation as individuals travelled along ridgetops and other favorable topographic features. Nonetheless, early snowshowers and frosts encouraged the caribou to use openings within the subalpine fir-spruce forests more frequently. Cold-hardy species of grasses, horsetails, sedges and herbs became increasingly important. Caribou concentrated on slopes where food plants persisted.

f. late autumn and early winter (October 15-December 14)

Autumn distributions primarily depended on snow conditions. When early winter snows arrived, the mountain caribou moved back into the subalpine fir-spruce forests located below 1700 meters (Table 3-3). Early in the season most animals remained between 1350 and 1700 meters, feeding on a variety of understory plants, including terrestrial lichens. Dense forests were preferred because of their ability to minimize snow accumulations on the forest floor and thereby prevent the loss of terrestrial forage. Travel also was easier. During this time, southwestern, northwestern, and southern aspects and intermediate and gentle slopes were most heavily used (Table 3-3).

As snow depths increased and strong winds blew the snow from the trees, caribou were continually driven toward lowland forests. Movement only slowed because of high winds and poor snow conditions. Caribou dispersed into small bands, which grazed down the mountain slopes, just ahead of the advancing snowline.

By early November, the percentage of animals occupying the fir-spruce and cedar-hemlock-spruce zones below 1000 meters was considerable (Figures 3-1 and 3-3). Gentle slopes on southeastern, eastern and northwestern exposures had the greatest caribou concentrations.

Local weather affected habitat selection in these areas. During warming trends, caribou selected subalpine meadows and the edge and openings of fir-spruce forests. In these middle elevations, caribou fed on arboreal lichens and available terrestrial plants. When snows deepened throughout the area, mature cedar-hemlock-spruce forests in the valley bottoms greatly increased in importance. Caribou movements were reduced and somewhat localized in these areas until the mid-winter ascent. Arboreal lichens, particularly those of the foliose growth form, continually grew in dietary importance. Vascular plants and terrestrial lichens also were eaten when available.

3. Factors influencing seasonal movements and habitat selection

The seasonal movements of mountain caribou are difficult to anticipate. A multitude of external factors can influence the timing and orientation of their unpredictable migrations (Skoog 1956). Constant movements, characterized as restless wanderings, seem indigenous to the species (Cowan 1974; Evans 1960; Murie 1935; Skoog 1956). They do not exhibit strong territoriality and because of migratory and nomadic habits, they require a large range area (Cowan 1974; Evans 1960). Hemming (1975) referred to this phenomenon as a flexible home range.

Mountain caribou efficiently exploit their environment, rotating briefly from sheltered to open habitats and shifting seasonally between elevations, aspects and plant communities. Even the pace of their movements fluctuates (Henshaw 1964; Skoog 1956). In fact the chief feature of caribou movements is their unpredictability (Murie 1935). Only the opportunistic selection of geographically and physiographically favorable travel routes was predictable.

It is unlikely that our knowledge of caribou ecology and behavior will ever be so intimate that it permits a precise pronouncement of those factors which most notably influence seasonal movements and habitat selection. However, trends exist which strongly indicate that food supplies, feeding pressures, climate (weather) and their interactions have a decided bearing on patterns of resource utilization.

Various encounters with caribou and the evaluation of a sizeable number of reported observations demonstrated that the mountain caribou in the study area had movement patterns very similar to those exhibited by other populations in British Columbia (Edwards and Ritcey 1959, 1960; Freddy 1974; Hamer 1974). The animals were wide-ranging, and seldom localized their activity in any specific area. Seasonal migrations were largely elevational and somewhat local in character, yet significant changes in the selection of slopes and aspects also were detected (Figure 3-2). Movements generally proceeded directly between areas and followed seasonally favorable features of the terrain. During the summer, many caribou moved along benches and ridges. Winter travel routes often followed frozen lakes, rivers, snowfree ridges and crusted and compacted snowfields.

Although no detailed snow or meterological measurements were taken, evidence was available to demonstrate relationships among weather, movements, habitat selection and food habits. During the spring season, caribou abandoned late winter habitats at high elevations for lowland meadows and forests. One reason seemed to be avoidance of entrapment by soft, melting snows. Individuals continuing to forage for arboreal lichens remained at higher elevations and simply shifted to exposures where the effects of early warming trends were minimized. Open, humid areas supporting the most luxuriant lichen growths were selected. Nonetheless, the vast majority of caribou travelled briskly toward areas at lower elevations. The arrival of caribou appeared to coincide with the earliest emergence of growing vegetation. To optimize foraging for the new spring growth, most animals concentrated in open meadows, parklands and riparian habitats, where warm temperatures and strong winds rapidly removed the snow cover. Similar shifts in distribution to seasonally optimal exposures were recorded. It seems apparent that these patterns simultaneously reduced the negative effects of poor nival conditions, provided forage of the highest available nutritional quality, and alleviated the deleterious effects of winter.

After a relatively brief stay in the mountain valleys, the caribou began to reascend to the high country. Summer was the season during which the widest variety of food plants were available, yet the caribou continued to move up the slopes. Two patterns were clear. The caribou attempted to remain in close proximity to cool, wet areas especially where snow persisted. They also fed most heavily on those plant species recently emergent and flowering.

These two activities were not independent. Cool, moist sites, represented by wet meadows or persistent snowfields, provided relief from warm temperatures and probably insects. The lush, wet meadows provided luxuriant growths of graminoids and flowering herbs, which emerged quickly after the disappearance of snow. The caribou continued to follow the receeding snow and thereby utilized snowfields and young high quality food plants with maximum efficiency. While spring green-up occurred in the upper vegetation zones, forage species at lower elevations matured and consequently declined in nutritional quality (Dietz et al. 1962; McClean and Tisdale 1960). Late season shifts to cool aspects provide further evidence of the interrelationship among weather, habitat selection and food habits.

During warm autumn weather the caribou remained in the wet timberline and alpine meadows used during the summer. Even early frosts did not cause the caribou to vacate these areas. The bands simply transferred to exposures and localities least damaged by these conditions, even though adequate forage was available in forested areas. This was thought to result from a need for large open areas to maximize breeding opportunities during the rut. The caribou remained there until early winter snows dispersed their aggregations and forced individuals to seek the food and shelter of the coniferous forest.

Edwards and Ritcey (1959,1960) described winter as a season of survival, not growth. Very early in the season the caribou commonly occupied mature forests, where the ground was relatively snow-free. Terrestrial vegetation was still very important, and slopes providing these foods were selected. Later, when snows reached the forest floor, caribou moved to areas where the accumulations were shallow and powdery and would allow cratering for terrestrial forage plants. The animals continued to move from areas of food scarcity to abundance. Eventually they reached the valley bottoms where both terrestrial plants and epiphytic lichens were utilized. As the snows settled and became compacted, the caribou sought areas which provided the most luxuriant arboreal lichen pastures. The caribou continued to rotate throughout the lower elevations until January or February. Seasonal weather changes settled the snows and created snowcrusts, thereby allowing the caribou to travel more easily and to extend their range. As a result, they moved to the higher elevation forests where each fresh snowfall permitted access to a new layer in the lichen pastures. Nevertheless the animals were not stationary and never appeared to remain in any location for an extended period. Only severe storms seemed to restrict their roaming. Eventually the caribou reached their late winter range at and above timberline. Here they continued to move, searching for foods available at the forest's edge and in the alpine zone. During bad weather the caribou allowed themselves to be covered with snow or sought shelter in the timber (D. Ferguson pers. comm.). Shortly thereafter, they resumed feeding and were especially active where strong winds reduced or removed the snow cover.

Continual movement characterized mountain caribou in winter. Whether this pattern was intentional, motivated by weather conditions, or the result of both factors is unclear. In any case these rotational patterns would tend to minimize the danger of over-utilizing any portion of their range. This has been suggested numerous times (e.g. Edwards and Ritcey 1960; Evans 1960; Freddy 1974; Hamer 1974; Layser 1974). Perhaps constant movements, range rotations and seasonal fluctuations in band size reflect a strategy designed to maintain an adequate available food resource. The benefits are of particular importance in light of the slow regeneration of arboreal lichens (Ahti 1962).

It is clear that mountain caribou display definite responses to changes in weather and food supplies. Not only did the caribou demonstrate seasonal preferences for specific plant communities, but floral phenology, aspect, elevation and snow conditions in these areas were decisive in selection of feeding areas and determining the intensity of foraging within various habitats.

IV. PATTERNS OF RESOURCE UTILIZATION - SEASONAL FOOD HABITS

A. Introduction

Food habits studies were designed to determine the seasonal requirements of mountain caribou; this knowledge was basic tc proper population and habitat management (Ward 1970). In addition, examination of feeding patterns enhanced interpretation of movement patterns. Previous studies on the food and feeding habits of mountain caribou were quite limited.

Mountain caribou were highly mobile and annually travelled through many plant communities. Their range extended to all aspects and between alpine pastures and valley bottomlands. Consequently the potential for dietary variability was tremendous.

During the year caribou utilized numerous forage species associated with the boreal forest (Appendix E). As a result, many similar genera and species have been used by different caribou populations (Layser 1974). Dietary differences probably reflect local abundances, characteristic habitat variability and geographic separation within the expansive range of the North American caribou. Noretheless, food studies in widely separated locations showed remarkable generic overlap (Bergerud 1972; Courtwright 1959; Cringan 1956; Edwards and Ritcey 1960a; Evans 1960; Kelsall 1968).

Many biologists agree that winter forage is a population limiting factor and controls the upper limit of caribou populations (Edwards 1956; Edwards and Ritcey 1960a; Evans 1960; Freddy 1974; Klein 1968). During this period, terrestrial vegetation is virtually unavailable, and mountain caribou necessarily rely heavily upon arboreal lichens for sustenance (Edwards and Ritcey 1959; Flinn 1956; Freddy 1974; Hamer 1974; Layser 1974). However, several studies have concluded that caribou were able to subsist during winter on foods other than lichens (Bergerud 1974; Murie 1935; Skoog 1956). Bergerud (1974) further claimed that the relative abundance of lichens does not dictate carrying capacity.

Food habits appraisals therefore were devised to determine seasonally preferred forage species and plant groups and to assess the importance of arboreal lichens to mountain caribou wintering in Central British Columbia.

B. Field Methodology

Several general reconnaisance methods (Chapter III), supplemented by fecal fragment analyses, were employed to determine the seasonal food habits of mountain caribou. Field studies commenced during September of 1975 and continued through December of 1977. The major activity occurred from February 1976 to September 1977.

The field procedures used to determine seasonal food habits were direct and simple. Determinations were based primarily on the observation of feeding sites and caribou during aerial and ground surveys. Each surveillance of foraging caribou was categorized and described (Table 4-1). The date, season, locality and weather conditions also were recorded. Forage plant selection was assessed with the assistance of binoculars and subsequent examination of feeding areas. Instances of utilization were recorded, and major emphasis was placed on the recognition of plants recently eaten (Table 4-1). Each utilization area was described on the basis of previous habitat studies (Bloomfield 1979) and physiographical characteristics. After feeding areas were vacated, each accessible site was examined to verify forage utilization.

In addition to the direct observation of feeding caribou, individual animals were tracked along travel routes, and all recognizable sign of feeding activity was recorded and described (Harry 1957). Fresh tracks, attributable to caribou, also were followed, and the locations of feeding activity noted and characterized. Feeding sites similarly were examined to determine the degree of utilization of various plant groups and species (Harry 1957; Knowlton 1960; Peek 1975). Numerous local residents and resource personnel also were consulted.

Table 4-1 Field Categorization And Description Of The Feeding Activity Of Mountain Caribou

A. Definition Of Feeding Type
1. Indifferent feeding area; caribou did not demonstrate pronounced affinity
2. Casual feeding area; area occupied for other reasons; cursory foraging
3. Moderately selected feeding area; locally preferred
4. Highly preferred feeding area; intensive foraging

B. Intensity Of Feeding Activity
1. No feeding activity
2. Cursory or desultory feeding
3. Moderate and somewhat localized activity
4. Concentrated, intensive and highly localized activity

C. General Preference - Utilization Rating For A Plant Group Or Species
0. Species not used; 0%*
1. Species rarely utilized; <1%
2. Occasionally or infrequently used; 1-25%
3. Moderate use; 26-50%
4. Species frequently selected; 51-75%
5. Highly preferred species, heavy utilization; 76-100%

D. Visual Estimations Of The Prominence And Abundance Of Plant Groups And Species
1. Very sparse, rare, contributing insignificant cover, often growing solitarily; <1%**
2. Infrequent but common, cover minimal, may form small groups; 1-5%
3. Frequent occurrence, rarely dominant, cover discontinuous, may form small patches; 6-20%
4. Widespread and abundant, locally dominant, cover somewhat continuous, forming small colonies; 21-50%
5. Very abundant, cover usually dense, often growing in large populations; >50%

*Percentage of coverage contributed by a species which was utilized for forage
**Cover-abundance scale

C. Fecal Fragment Analysis

Direct observation of foraging animals and subsequent examination of feeding sites provided useful information on seasonal food habits, but was not without inherent difficulties (Peek 1975). Within the context of this study the relatively limited opportunity to observe feeding caribou was the major problem. Consequently, field results were supplemented and to some extent substantiated by fecal fragment analyses.

One major advantage of the fecal fragment technique was that it required minimal animal contact and therefore did not interfere with the normal habits of the caribou. Collection of qualitative and semi-quantitative feeding habits data by this method was justified for the following reasons:

1. The technique has been utilized for large herbivores in a variety of environments (Casebeer and Koss 1970; Korschgen 1962; Martin 1955; Reynolds 1976; Sparks and Malechek 1967; Stevens 1966).

2. There is little or no digestion of the cutinized epidermal material which is used for identification of plant fragments (Storr 1961).

3. Fecal fragment discernability studies have been widely used (Deardon 1975; Todd and Hansen 1973; Ward 1970).

4. Epidermal material is usually identifiable to genus and frequently to species under low magnification (Free et al. 1970; Hansen 1972; Stewart 1967; Ward 1970).

The histological approach to food habit studies is quite straightforward. During digestion the cuticle is separated from the underlying leaf tissue through degradation of the structural cellulose. The particle then passes through the animal unchanged, except for a mechanical reduction in size. Later it is collected for comparison with reference materials and assessment of dietary composition. Botanists and animal scientists have long recognized the usefulness of cuticular features as identifying characters (Hercus 1960; Martin 1955; Ward 1970).

a. collection of fecal materials

All areas examined during reconnaisance activities were searched for caribou feces and each pellet group found was collected. However, pellets older than 1-2 weeks were not used in food habits studies. The location and site data for each pellet collection were recorded. Droppings were subsequently wrapped in plastic and frozen for shipment. Care was taken to minimize contamination by extraneous materials.

b. collection of plant materials for reference slide preparation

Leaf, flower and stem tissues were collected from all plant species identified during plant community studies (Appendix A; Bloomfield 1979). Particular attention was paid to dominant species and those of known forage value. Collection and storage of materials followed Saville (1973).

c. preparation of reference slides

Unfortunately methods currently available for preparation of reference slides are tedious. Consequently rapid techniques, with minimal reliance on complicated chemical procedures, were selected. Preparations most closely followed Dusi (1949), Williams (1969), and Zyznar and Urness (1969). Modifications were based upon the results of studies by Bennett and Furmidge (1956), Long and Clements (1934), and North (1956). The result was a procedure which faithfully duplicated epidermal features through use of cellulose acetate peels (Bloomfield 1977).

All vascular plant specimens were mounted exposing an adaxial and abaxial surface. Green material was preferred and provided the most accurate representation of topographical characters. Cellulose acetate was applied to an area 10-12 mm on each surface. Peels were about .2-.3 mm thick. They were allowed to air-dry for 30 minutes and were then removed by gently lifting an edge initially freed with a razor blade. The peels were directly mounted or fixed in a formalin-acetic alcohol fixative and individually stored in clearly labelled vials (Berlyn 1976). Fixed peels were safely handled and mounted after treatment with a deformalizing solution (Ward 1970).

During feasability assessments, several problems developed. Recommended modifications were incorporated within the procedural approach described above. However, several major difficulties need to be specified. Dried, pressed herbarium materials were often too brittle to permit successful peel removal and caused a reduction in the clarity of topographical features. The suggested peel thickness reflects hours of calibration. Thinner peels were difficult to remove, while it was difficult to mount peels exceeding the prescribed thickness. Excessive drying reduced the ability to remove peels. Removal of peels before they sufficiently dried caused a distortion of the diagnostic characters. The results, however, were not seriously distorted.

d. mounting reference slides

Fresh or fixed peels were mounted with the surface formerly nearest the plant material placed closest to the slide and the Euparal mounting medium. A cover slip was then added, and the slide labelled and air dried.

e. preparation of fecal materials for examination

Composite fecal samples were dried, thoroughly ground in a Wiley mill and passed through a 20 mesh (1mm) screen (Reynolds 1976; Storr 1961). The procedure imparted uniformity in the size of plant particles differentially affected by digestion (Todd and Hansen 1973). Sufficient homogeneity existed in droppings to allow selection of a subsample for analysis (Reynolds 1976; Storr 1961).

Removal of fecal residues and isolation of cuticular fragments followed Casebeer and Koss (1970) and Storr (1961). Fragments smaller than 0.1 mm, lacked sufficiently identifiable features and were discarded (Martin 1955).

Fecal fragment slides were prepared using methods originally proposed by Dusi (1949). Modifications involved use of Euparal as the mounting medium. Artificial staining was unnecessary. Digestion adequately imparted distinguishability to the desired features.

f. component identification

Dietary sampling methods followed Stewart (1967). Identifications were made using reference slides and verified remnants. Lichens were identified on the basis of gross morphological features and chemical testing (Asahina and Shibata 1971; Hale 1969; Jahns 1973; Poelt 1973). Counts were made by systematically traversing the gridded slides at magnifications of 45x and 100x and tallying fragments located within the 1mm² quadrants. Alternate traverses were omitted to avoid repetitive counts (Stewart 1967). The botanical composition of each sample was determined by examining 20 microfields on each of five slides. An attempt was made to identify each item to species. At times this was not possible, particularly for the Graminae and lichens. Alternatively, mosses were highly fragmented and easily identified even as very small fragments. They consequently received adjusted-estimated percent values. This minimized the under-estimation of other species (Dearden 1975). All species occurrences were recorded as frequency-percentages (Sparks and Malechek 1967).

Diagnostic characteristics were selected for their distinct and consistently detectable features. The smaller plant fragments, mixed with cuticular particles, were too indistinct to be of diagnostic value (Martin 1955). During this study the shape, appendages, orientation and wall configuration of epidermal and cuticular cells were the basis for fragment identification. Previous results provided important descriptions and characteristics of the diagnostic features (Bennett and Furmidge 1956; Chamberlain 1932; Martin 1962; Metcalf and Chalk 1950; North 1956; Palmer 1976; Stewart 1967; Storr 1961; Zyznar and Urness 1969). Table 4-2 provides a detailed account of diagnostic features used in this study.

Table 4-2 Diagnostic Features Used For Determining Food Habits By Fecal Fragment Identification

Feature	Monocotyledons	Dicotyledons
Epidermal Composition	primarily undifferentiated cells, frequently elongate	more irregular and undifferentiated cells
Other Epidermal Cells	stomatal guard cells, silica cells, asperites	unspecialized cells, stomata, asperites
Epidermal Cell	in rows parallel to venation	rarely arranged in parallel
Unspecialized Epidermal Cell Configuration	elongate, rectangular	hexagonal, somewhat rounded, or elongate
Cell Walls	straight, slightly or markedly curved, undulate, crtusely or actually crenate	straight, ~~slightly~~ slightly or markedly cured obtusely or acutely crenate, not undulate
Stomata	restricted to definite sites characterized by number, location, density, pore, orientation, subsidiary cells	randomly located
Trichomes	include a variety of epidermal appendages i.e. hairs, scales, water vessicles, papillae glands: almost endless variation	same features were used as for monocotyledons

D. Numerical Analysis

The results of feeding site and fecal fragment examinations were analyzed to determine the similarity between the two methods. Subsequent tests determined the composition, diversity and overlap in seasonal diets and the relative contributions of each forage component. Species frequencies and importance values were initially determined for the entire, composite sample set. Similar analyses for season, plant group and analytical method followed. Frequency percentages represented species-specific contributions to the total of identifiable plant fragments (Curtis and McIntosh 1950). Importance-abundance values were obtained in the manner of Bergerud (1974). Individual importance values were hierarchically arranged to determine relative dietary abundances and preferences. Both fecal fragment and feeding site analyses were tabulated and hierarchically ordered on the basis of nominally scaled frequency-percentage classes (Tables 4-1 and 4-3).

Analysis of variance was used as a simple test of the equality of the two sample populations (Dixon 1974). The test procedure calculated the statistical significance between results from the feeding site and fecal fragment studies adjusted for seasonal effect. The statistical difference between sample means was determined on the basis of comparisons with the error term. Probabilities for both Type I and Type II errors were determined. The Alpha level

Table 4-3 Nominally Scaled Fecal Fragment Identification Frequency Classes

0.	Species Absent
1.	Less Than 1% And Greater Than 0%
2.	1-25% Of Fragments
3.	26-50% Of Fragments
4.	51-75% Of Fragments
5.	76-100% Of Fragments

Modified from Bergerud (1972)

of the test was chosen to be .01, which implied a Beta level of .13 (Neter and Wasserman 1974).

The approximate contribution of each plant group to the diet was determined for the study period and by season and zone. The procedure followed Bergerud (1974). The importance values for each species in a particular group were summed and divided by the sum for the specified variable class. Results were reported in percentages.

Seasonal dietary overlap was determined by calculation of similarity coefficients, expressing the degree of sample likeness. Sorensen's index of floristic similarity (IFS) was modified for this purpose.

Indices expressed diet similarities and systematically ordered sample units (Mueller-Dombois and Ellenberg 1974). The index examined relationships between theoretical similarities and actual, coincident occurrence (Mueller-Dombois and Ellenberg 1974).

E. Results and Discussion

1. Feeding behavior

The caribou of Central British Columbia are primarily grazers, feeding largely on herbaceous vegetation and lichens. During all seasons and particularly when snow covered the ground, some browse also was taken. To some extent winter use of arboreal lichens can be described as a mixture of grazing and very light browsing. However, in all instances caribou foraging was extensive and cursory (Skoog 1968).

During the spring, summer and autumn, when snow was absent, caribou were widely distributed and continually moving, pausing only to nibble on seasonally preferred forage species. Occasionally animals congregated to feed on unusually luxuriant vegetation, but even during these more leisurely periods animals were rarely stationary. It was more typical to observe caribou alternating brief periods of feeding with considerable movement before consuming additional food some distance from the previous site. Periods of activity, rest and rumination also were alternated, particularly during warm weather.

The only exceptions to this pattern occurred very late in the winter or early in the spring. On several occasions caribou aggregated on recently bared slopes and fed heavily on the exposed green vegetation emerging through the persistent snows. However, despite the increase in band sizes and foraging activity these areas did not appear to be denuded of vegetation. For the remainder of the snow-free periods, increased caribou densities appeared to be accompanied by a reduction in the duration of feeding periods.

Field observations revealed that caribou were selective feeders, frequently switching their preferred forage species and usually choosing the most recent, succulent green growth. Furthermore caribou usually selected the most delicate plant parts. Flowers, leaves and only the most frail stems and twigs were eaten from forbs, shrubs, grasses, sedges and other vascular species. Occasionally roots, stem tips and terminal buds were taken, especially from shrubs. Continual chewing was not observed. Grazing on terrestrial lichens also was light and well dispersed. Although entire podetia or thalli were eaten, the caribou more consistently grazed only the upper portions of fruticose species. This may be attributable to the pungent odor of decaying, lower podetial parts (Scotter 1965). No overall reduction in lichen biomass was obvious.

Early in the winter season, feeding patterns were similar to those described for the snow-free periods. Caribou initially responded to changes in weather and vegetation by travelling to more suitable habitats (Chapter III). At first they fed on exposed vegetation. As the snow accumulated, some pawing was observed but there was no classic cratering as described for barren-ground caribou by Kelsall (1968). Eventually the opportunity to obtain terrestrial vegetation was virtually eliminated by the snowpack. Consequently the caribou were forced to rely more heavily on arboreal lichens.

Snowcrusts now were used for travel and also permitted access to epiphytic lichens. Feeding caribou constantly moved among groves of trees, stopping only briefly to feed. As a tree was approached, the caribou grasped the lichens and pulled clumps from the branches. Lichens were also removed from the trunk when a sufficiently sparse crown permitted access. However, these attempts often were unsuccessful.

Some differences were observed in the manner of foraging for the various lichen groups. The pendant, fruticose lichens were easier to obtain because of their growth form and preponderance on branches. The leafy foliose species, often better developed on the trunk and more closely appressed to their substrate, were more difficult to procure. Occasionally branches were girdled, apparently because the bark was removed more easily from its substrate than the lichens. Blood stains occasionally were noticed on branches in these instances.

During the winter caribou appeared to be more gregarious, feeding and resting in groups more frequently than during the other seasons. These patterns of aggregation, movement and dispersal seemed to be affected by weather and the availability and abundance of forage.

Arboreal lichens on dead and fallen trees also were eaten, although it is doubtful that they made a significant contribution to caribou diets because of their unpredictable availability. On several occasions caribou also were reported eating the roots of the uprooted trees (D. Ferguson pers. comm.). This also was observed by Flinn (1956).

Skogland (1975) described feeding behavior as a dynamic process comprised of learning, nutritional status, food preferences, interspecific interactions and habitat availability. Feeding behavior in turn is significantly affected by selective forces (Skogland 1975). Several characteristics of the foraging behavior of caribou appear to have adaptive advantages and may relieve feeding pressures.

It is widely accepted that the cursory feeding patterns and range rotation demonstrated by caribou in widely divergent locations distributes grazing pressures and reduces the possibility of over-utilization (e.g. Cowan 1974; Evans 1960; Freddy 1974; Layser 1974; Murie 1935; Skoog 1968). Nomadic habits also may be valuable in moving populations from areas of forage scarcity to those of food abundance.

Selection of new growth probably compensates for the relatively poor nutritional balance of the winter forage (Skogland 1975). Early stages of growth have the highest level of nutrition, and nutritive differences between species are largely attributable to variations in development (Courtwright 1959; Dietz et al. 1962; Klein 1970; McClean and Tisdale 1960). During the summer caribou had a wide latitude in food choice. This permitted free expression of their food preferences (Skogland 1975).

However, in winter the diversity and relative abundance of food supplies forced caribou to be less selective and to choose poorer quality, more readily available forages. Although consumption rates presumably declined, animals appeared to spend a disportionate amount of time seeking preferred species. There appears to be a direct relationship between feeding activity and food quality (Thomson 1973).

The cursory nature of caribou feeding behavior also may be a necessary environmental adaptation. Complete and systematic grazing could damage the range for many years. This is particularly true for the arboreal and terrestrial lichens whose growth is very slow (Ahti 1962; Hale 1974; Scotter 1962, 1963). There may be additional advantages. Courtwright (1959) reported that forages grazed or browsed earlier in the season often experience secondary growth. Intensive grazing activity greatly diminshed the development of new growth. Lichens do not demonstrate analogous growth patterns, but it has been reported that light cropping produces accessory branching and may result in an increased volume of forage (Igoshina in Courtwright 1959).

In areas where habitat is limited, social and feeding pressures can quickly and seriously damage the range resource (Hemming 1975). This was graphically demonstrated by the increase and decline of the reindeer population restricted to St. Matthew Island (Klein 1968). A flexible home range permits sufficient time for slow growing vegetation to recover and provides the caribou with the opportunity to locate adequate food supplies (Hemming 1975). Mountain caribou display migratory and nomadic behavior (Edwards and Ritcey 1959; Evans 1960; Fashingbauer 1965; Flinn 1956; Freddy 1974; Hamer 1974; Layser 1974). Animals with nomadic habits need very large, seasonally adequate ranges without which they can not survive (Cowan 1974).

2. Comparability of feeding site and fecal fragment analyses

During this study 25 feeding sites and 19 composite fecal samples were examined in detail. Analyses for both techniques included samples from nearly all seasons, vegetation zones, elevations, and aspects (Table 4-4). The only exceptions occurred for the fecal fragment method. No pellets were collected in disturbed communities or on western aspects. Eighty-three probable forage species were identified (Appendix E). At least 41 species were used regularly.

Mountain caribou demonstrated seasonal food preferences during the study (Table 4-5). The two analytical methods did not differ significantly (alpha=.01, beta=.13). It was therefore highly unlikely that we erred through our inability to recognize existing statistical differences. Consequently, results from the feeding site and fecal fragment analyses were grouped and discussed as a single data set.

Table 4-4 Distribution Of Feeding Site And Fecal Fragment Samples By Season and Location

		Feeding Sites Examined	Fecal Fragment Samples Analyzed
Seasons		%	%
Mid-winter	December 15 to February 14	11.1	21.1
Late-winter	February 15 to April 14	15.5	15.8
Spring, Early Summer	April 15 to June 14	26.6	10.4
Summer	June 15 to August 14	13.5	15.8
Late Summer, Early ~~Autumn~~	August 15 to October 14	17.8	15.8
Late Autumn, Early Winter	October 15 to December 14	15.5	21.1
Vegetation Zone			
Fir-Spruce Forest		22.2	21.1
Cedar-Hemlock-Spruce Forest		24.5	26.3
Subalpine Meadows		22.2	26.3
Krumholz		13.3	15.8
Alpine Meadows		11.1	10.5
Disturbance		0.0	0.0
Lakes, Muskegs		6.7	0.0
Elevation (Meters)			
650-1000		35.6	27.8
1001-1350		15.6	33.3
1351-1700		37.7	27.8
Above 1700		11.1	11.1
Aspect			
NE		6.7	15.8
N		13.3	10.5
NW		22.2	15.8
SE		8.9	10.5
S		13.3	15.8
SW		22.2	21.1
E		6.7	10.5
W		6.7	0.0

Table 4-5 Dietary Correlation Coefficients For Caribou Diets
By Season And Vegetation Zone
(p=significance level)

Similiarities By Season						
December 15 to	1.00					
February 14	p=.001					
February 15 to	.455	1.00				
April 14	p=.001	p=.001				
April 15 to	.672	.123	1.00			
June 14	p=.001	p=.120	p=.001			
June 15 to	.100	.191	.329	1.00		
August 14	p=.169	p=.034	p=.001	p=.001		
August 15 to	.051	.078	.210	.743	1.00	
October 14	p=.315	p=.229	p=.022	p=.001	p=.001	
October 15 to	.704	.272	.778	.166	.004	1.00
December 14	p=.001	p=.004	p=.001	p=.056	p=.484	p=.001
Similiarities By Vegetation Zone						
Fir-Spruce Forest	1.00					
	p=.001					
Cedar-Hemlock-Spruce	.432	1.00				
Forest	p=.001	p=.001				
Subalpine Meadow	.418	.078	1.00			
	p=.001	p=.230	p=.001			
Krumholz	[illegible]	.177	.405	1.00		
	p=.4[illegible]	p=.044	p=.001	p=.001		
Alpine Meadows	.231	.361	.072	.496	1.00	
	p=.013	p=.001	p=.246	p=.001	p=.001	
Lakes, Muskeg	.408	.389	.369	.038	.014	1.00
	p=.001	p=.001	p=.001	p=.358	p=.449	p=.001

Both feeding site and fecal fragment analyses were evaluated using nominally-scaled, preference-abundance classes (Tables 4-1 and 4-3). Assessment of relative forage preferences by the tracking method relied heavily on observer judgement. Although these determinations were based on careful examination of the range and its use, the method was most useful for qualitative and semi-quantitative studies.

Quantitative microhistological studies are even more controversial and may be indefensible. Some previous research indicated differential rates of digestion and fragmentation (Bergerud and Russell 1964; Dearden et al. 1975; Stewart 1967). Others did not agree. Todd and Hansen (1973) reported that only soluble materials were digested and that fragment frequencies were similarly affected for all species. However, Storr (1961) found strong evidence indicating the degree of epidermal cutinization was significantly correlated with fragment identifiability. Further, it also has been suggested that results are influenced by the local abundance of forage species, selective grazing patterns and the differential degradation rates of mono- and dicotyledons (Crocker 1959; Hercus 1960; Martin 1955; Storr 1961; Todd and Hansen 1973). The high fragmentation of mosses, and their subsequent over-estimation, was another confounding factor. It has been suggested that these plants should be ignored in fecal fragment studies (Dearden et al. 1975). Lichens also were very fragile (Kelsall 1968), and fragments often were not identifiable.

Drawbacks notwithstanding, the two complementary techniques used for food habits studies provided considerable information on the use and relative importance of plant groups and individual forage species. Although no attempt was made to determine the relationship between dietary composition and intake, the results are a reasonably accurate representation of the seasonal food habits of mountain caribou.

3. Seasonal dietary composition

Caribou annually consume an extraordinary variety of forage plants. Comparative studies demonstrate that a wide overlap in dietary composition exists between various populations of caribou and reindeer (Kelsall 1968; Skoog 1968). Many caribou forage plants are circumpolar or circumboreal in distribution. Nonetheless relative abundances and preferences may be highly variable between regions (Layser 1974).

Dietary composition changed considerably on a seasonal basis (Table 4-5). Local abundances and availabilities were largely determined by weather and habitat conditions. Most plant groups were not available throughout the year and were most abundant during a particular time period. The epiphytic lichens were the only notable exception. The forbs or flowering herbs made the greatest annual contribution to the diet of mountain caribou; arboreal lichens, shrubs, terrestrial lichens and the graminoids followed. The remaining five plant groups were of relatively minor importance.

Specific importance-abundance values were obtained using nominally-scaled frequency classes and a preference-utilization scale (Tables 4-1 and 4-3). Similarities among seasonal diets were calculated from these results (Table 4-5). Appendix E details the ecology, importance and utilization of all known forage plants in this ecosystem. Cover-abundance and forage importance values are contrasted.

Table 4-6 describes the most important foods of mountain caribou by season. Forage preferences by vegetation zone are illustrated in Table 4-7. The contribution of each plant group to caribou diets also was described by season and zone (Figures 4-1 and 4-2). However, the relative preferences for individual species of plant groups did not necessarily correspond with cover-abundance values. Dietary composition may reflect seasonal preferences, but the contribution of a species to the diet also provides some evidence concerning the availability and ecological importance of each plant group and species (Stoddart and Smith 1955).

Table 4-6 Most Important Food Plants Used Seasonally By Mountain Caribou

	Mid-Winter (December 15 - February 14)	Late Winter, Early Summer (February 15 - April 14)
Heavily Utilized Species	Hypogymnia physodes	Bryoria oregana
	Peltigera aphthosa	Bryoria glabra
	Platismatia glauca	Hypogymnia physodes
	Vaccinium species	Parmelia sulcata
	Cornus canadensis	Bryoria species
	Ribes lacustre	Cladonia species
	Lobaria pulmonaria	
Moderately Used Species	Bryoria oregana	Vaccinium species
	Heracleum lanatum	Cladonia species
	Peltigera canina	Hypogymnia enteromorpha
	Parmelia sulcata	Bryoria fremontii
	Thalictrum occidentale	Peltigera aphthosa
	Tiarella unifoliata	Lobaria pulmonaria
	Carex species	
	Cladonia coccifera	
	Rubus pedatus	
Periodically Used Species	Alectoria sarmentosa	Cladonia ecmocyma
	Rhododendron albiflorum	Stereocaulon species
	Bryoria glabra	Carex species
	Bryoria capillaris	Platismatia glauca
	Alnus crispa	Peltigera canina
	Luzula wahlenbergii	Unidentified Rosaceae
	Carex species	
	Valeriana sitchensis	

Table 4-6 Continued

	Spring, Early Summer (April 15 - June 14)	Summer (June 15 - August 14)
Heavily	Equisetum species	Luzula wahlenbergii
Utilized	Tiarella unifoliata	Carex species
Species	Carex species	Trollius albiflorus
	Cornus canadensis	Caltha leptosepala
	Valeriana sitchensis	Claytonia lanceolata
	Luzula wahlenbergii	Equisetum species
	Peltigera canina	Salix species
	Streptopus roseus	Pedicularis bracteosa
	Graminae-Unidentified species	Epilobium angustifolium
Moderately	Cinna latifolia	Peltigera canina
Used Species	Alnus crispa	Peltigera aphthosa
	Rubus pedatus	Valeriana sitchensis
	Hypogymnia physodes	Saxifraga species
	Clintonia uniflora	Graminae-Unidentified species
	Epilobium species	Poa alpina
	Galium triflorum	Trisetum spicatum
	Peltigera aphthosa	Habenaria species
	Smilacina species	Parnassia fimbriata
		Epilobium species
Periodically	Ribes lacustre	Thalictrum occidentale
Used	Rubus parviflorus	Cladonia species
Species	Bryoria glabra	Heracleum lanatum
	Thalictrum occidentale	Streptopus species
	Festuca ovina	Cladonia mitis
	Viola glabella	Smilacina species
	Platismatia glauca	Cinna latifolia
	Lobaria pulmonaria	Cornus canadensis
		Compositae-Unidentified species

Table 4-6 <u>Continued</u>

	Late Summer, Early Autumn (August 15 - October 14)	Late Autumn, Early Winter (October 15 - December 14)
Heavily Utilized Species	Carex species	Peltigera canina
	Pedicularis bracteosa	Peltigera aphthos
	Phleum alpinum	Cornus canadensis
	Graminae-Unidentified species	Rubus pedatus
	Saxifraga species	Tiarella unifoliata
	Trollius albiflorus	Equisetum species
	Claytonia lanceolata	Cladonia coccifera
	Tiarella unifoliata	Graminae-Unidentified species
	Arnica latifolia	
	Caltha leptosepala	
Moderately Used Species	Compositae-Unidentified species	Polypodiaceae-Unidentified species
	Heracleum lanatum	Hypogymnia physodes
	Thalictrum occidentale	Vaccinium species
	Luzula wahlenbergii	Platismatia glauca
	Trisetum spicatum	Luzula wahlenbergii
	Cladonia species	Smilacina species
	Stereocaulon species	Thalictrum occidentale
	Epilobium species	Cinna latifolia
	Salix species	Valeriana sitchensis
	Equisetum species	Galium triflorum
Periodically Used Species	Habenaria species	Streptopus species
	Cladonia rangiferina	Lobaria pulmonaria
	Rosaceae-Unidentified Species	Bryoria capillaris
	Senecio triangularis	Bryoria species
	Valeriana sitchensis	Ribes lacustre
	Cassiope mertensiana	Alnus crispa
	Poa alpina	Ptillium crista-castrensis
	Rubus pedatus	Sambucus melanocarpa

Table 4-7 Preferred Mountain Caribou Forage Species Within Various Vegetation Zones

	Fir-Spruce Forest	Cedar-Hemlock-Spruce Forest
Heavily Utilized Species	Valeriana sitchensis	Platismatia glauca
	Cornus canadensis	Lobaria pulmonaria
	Tiarella unifoliata	Peltigera canina
	Hypogymnia physodes	Peltigera aphthosa
	Peltigera aphthosa	Cornus canadensis
	Rubus pedatus	Alnus crispa
	Equisetum species	Clintonia uniflora
	Thalictrum occidentale	Cinna latifolia
	Bryoria lanestris	Galium triflorum
Moderately Used Species	Streptopus species	Tiarella unifoliata
	Rhododendron albiflorum	Luzula wahlenbergii
	Alectoria sarmentosa	Parmelia sulcata
	Peltigera canina	Equisetum species
	Ribes lacustre	Rubus pedatus
	Carex species	Smilacina species
	Hypogymnia enteromorpha	Sambucus melanocarpa
	Bryoria species	Bryoria glabra
	Graminae-unidentified species	
Periodically Used Species	Bryoria lanestris	Bryoria oregana
	Smilacina species	Cladonia coccifera
	Heracleum lanatum	Ribes lacustre
	Parmelia sulcata	Hypogymnia physodes
	Cinna latifolia	Vaccinium species
	Vaccinium species	Menziesia ferruginea
	Bryoria oregana	Hylocomium splendens
	Cladonia species	Polypodiaceae-unidentified species
	Polypodiaceae-unidentified species	
	Pleurozium schreberi	
	Ptillium crista-castrensis	
	Lonicera involuccrata	

Table 4-7 Continued

	Alpine	Muskegs, Lakes
Heavily Utilized Species	Stereocaulon species	
	Gentiana glauca	Hypogymnia physodes
	Cladonia species	Streptopus species
	Salix species	Epilobium angustifolium
	Compositae-unidentified species	Graminae-unidentified species
	Saxifraga species	Equisetum species
	Cladonia uncialis	Parmeliopsis species
	Phleum alpinum	
	Epilobium species	
	Cladonia ecmocyma	
Moderately Used Species	Parnassia fimbriata	
	Carex species	Peltigera canina
	Cassiope mertensiana	Alectoria sarmentosa
	Erigeron humilis	Carex species
	Cladonia mitis	Bryoria species
	Pedicularis bracteosa	Hylocomium splendens
	Caltha leptosepala	Cinna latifolia
	Rosaceae-unidentified species	Alnus crispa
	Equisetum species	Ptillium crista-castrensis
Periodically Used Species	Parmellopsis species	Cetraria halei
	Parmelia species	Luzula wahlenbergii
	Bryoria glabra	Cladonia coccifera
	Luzula wahlenbergii	Peltigera aphthosa
	Phyllodoce empetriformis	Thalictium occidentale
	Campanula lasiocarpa	Lobaria pulmonaria
	Dryas hookeriana	Parmelia sulcata
	Troilius albiflorum	Abies lasiocarpa
	Poa alpina	Rhododendron albiflorum

Table 4-7 Continued

	Subalpine Meadows	Krumholz
Heavily	Heracleum lanatum	Pedicularis bracteosa
Utilized	Graminae-unidentified species	Carex species
Species	Pedicularis bracteosa	Trisetum spicatum
	Carex species	Salix species
	Caltha leptosepala	Trollius albiflorus
	Claytonia lanceolata	Poa alpina
	Phleum alpinum	Senecio triangularis
	Trollius albiflorum	Tiarella unifoliata
		Cladonia mitis
Moderately	Valeriana sitchensis	Cladonia rangiferina
Used Species	Luzula wahlenbergii	Graminae-unidentified species
	Arnica latifolia	Vaccinium species
	Thalictrum occidentale	Valeriana sitchens
	Tiarella unifoliata	Stereocaulon species
	Streptopus species	Parmelia sulcata
		Compositae-unidentified species
Periodically	Peltigera aphthosa	Cassiope mertensiana
Used	Equisetum species	Luzula wahlenbergii
Species	Rosaceae-unidentified species	Bryoria glabra
	Bryoria glabra	Bryoria oregana
	Cladonia species	Phleum alpinum
	Saxifraga species	Claytonia lanceolata
	Bryoria fremontii	Cladonia ecmocyma
	Vaccinium species	Saxifraga species
		Arnica latifolia
		Epilobium species

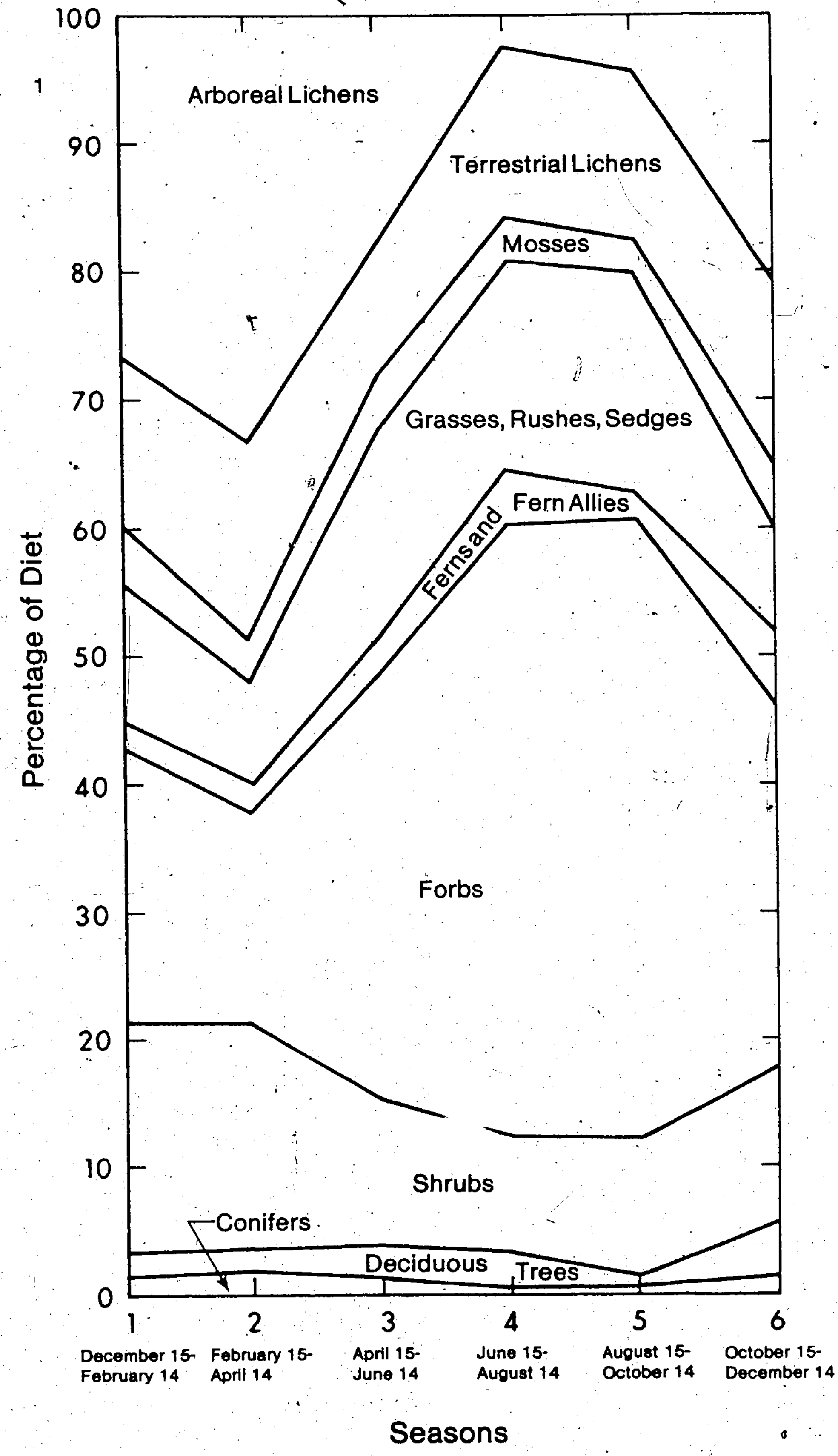

Figure 4 - 1 Seasonal Composition of Caribou Diets Determined By Plant Group

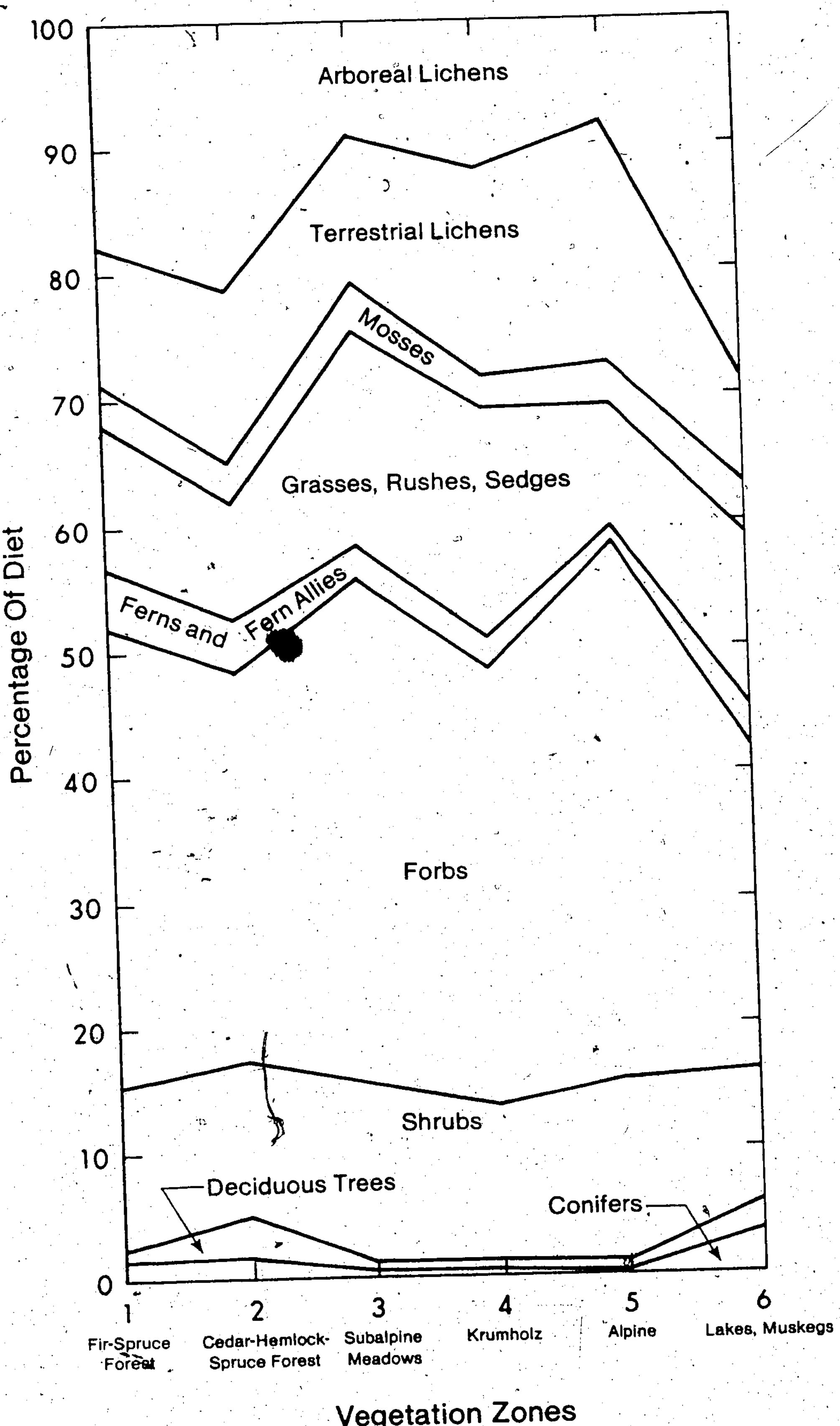

Figure 4 - 2 Known Composition of Caribou Diets By Plants Group and Vegetation Zone

a. mid-winter (December 15-February 14)

Mountain caribou spent the major portion of the mid-winter season in subalpine forests, below 1350 meters. Later, as conditions permitted, their range was extended into the higher zones. Open areas were virtually ignored. The cedar-hemlock-spruce zone provided the single most important component of caribou habitat. Caribou preferred the edge of the forest to its interior.

During this period the major portion of the diet was composed of arboreal lichens, forbs and shrubs which contributed about 26%, 21% and 18%, respectively. Terrestrial lichens and graminoids dominated the remainder (Figure 4-1). Conifers and deciduous trees were of minimal importance and were most likely consumed incidental to lichen foraging.

The variety of available forage plants was considerably reduced. Epiphytic lichens became particularly important to caribou. Approximately 11 species occurred in the mid-winter diets. Hypogymnia physodes, Lobaria pulmonaria and Platismatia glauca were the three most important species, especially in the cedar-hemlock-spruce zone. Five other species also were eaten regularly (Table 4-6). Hypogymnia sp., Parmelia sulcata, Alectoria sarmentosa and several species of Bryoria were most heavily used in the fir-spruce forests.

Shrubs were an integral part of the caribou diet and increased in importance as the snow deepened. The two *Vaccinium* species, particularly *Vaccinium membranaceum*, *Ribes lacustre* and *Heracleum lanatum* made the greatest contributions to this portion of the diet. Although woody materials were taken, caribou mainly fed on fine twigs, buds, frail stems and persistent leaves. The delicate nature of this feeding was not indicative of intensive browsing activity. *Rhododendron albiflorum* also was used substantially in the fir-spruce forests, whereas *Alnus crispa* was a regular dietary constituent in the cedar-hemlock-spruce forest zone. The shrubs also were important in the krumholz zone (Table 4-7).

Forbs, graminoids and terrestrial lichens formed an important segment of caribou diets. The forb species receiving the heaviest use were *Cornus canadensis*, *Valeriana sitchensis*, *Rubus pedatus* and *Thalictrum occidentale*. Many other forage plants were eaten as the opportunity arose but six species appeared to be most important to caribou (Table 4-6). The graminoids accounted for 11% of the forage. *Carex nigricans* and *Luzula wahlenbergii* were the predominant species. This group was most important on wet, seepy and shallow sites. Terrestrial lichens were the fourth most important plant group (Table 4-6). *Cladonia coccifera* was readily utilized, perhaps because of its colonization of rotting logs which pierced through the snow cover. *Peltigera canina* and *Peltigera aphthosa* were abundantly used, particularly where the snows were shallow or drifted. *Hylocomium splendens* and *Polytrichum sp.* were the most common bryophytes in the diet.

b. late winter, early spring (February 15-April 14)

Late in the winter, terrestrial vegetation was either absent or unavailable due to deep snows. Consequently, the utilization of arboreal lichens was heaviest during this period. Once caribou ascended to areas of deep snow near and above timberline, they were almost entirely reliant upon epiphytes for food. These results confirmed the earlier findings of Edwards and Ritcey (1960), Evans (1960) and Freddy (1974).

No less than nine arboreal lichens were common to caribou diets (Table 4-6). A small number of animals remained in the cedar-hemlock-spruce zone and continued to feed on *Lobaria*, *Platismatia* and *Hypogymnia*. However the majority of caribou were located in high elevation fir-spruce, krumholz and alpine habitats. *Bryoria oregana*, *Bryoria glabra*, *Hypogymnia physodes* and *Parmelia sulcata* were the major forage species. These species also were prominent in wet muskegs. Several other species of *Bryoria* and *Hypogymnia enteromorpha* also were commonly eaten (Table 4-6). Girdling was most prevalent during this season.

Shrubs remained relatively important to caribou, particularly in forested areas where snow accumulations were reduced, and on bared, alpine slopes. *Cassiope mertensiana*, *Salix sp*. and an unidentified species from the family *Compositae* were regular dietary constituents in alpine and krumholz areas. *Dryas hookeriana* also was eaten. *Rubus parviflorus*, *Ribes lacustre*, *Vaccinium sp*. and an unidentified species of *Rosaceae* were taken in the fir-spruce zone. *Rubus* was of particular importance during the early spring green-up. Leaves, buds and new shoots were favored.

During this season the forbs made their smallest contribution to the diet. Although some forage from the previous season was taken when available, the greatest portion of this plant group was consumed early in the spring, when the caribou returned to the middle and lower elevations. Various species of *Carex*, *Equisetum* and several unidentified graminoids were used. Nevertheless, no individual forb, graminoid, fern or fern ally was a major dietary component (Table 4-6).

The terrestrial lichens comprised about 15% of the diet and were of particular significance along alpine ridgetops cleared by wind and increasing spring temperatures. Numerous species of *Stereocaulon* and *Cladonia* were utilized (Table 4-6). *Cladonia mitis*, *Cladonia rangiferina*, *Cladonia uncialis* and *Cladonia ecmocyma* were common dietary constituents. *Peltigera aphthosa* and *Peltigera canina* were foraged from rotten logs and the base of trees located in forested areas. Several feather mosses were ingested simultaneously.

c. spring and early summer (April 15-June 14)

Spring was signalled by warmer temperatures and the concomitant emergence of new, green vegetation. Most caribou returned to the lower elevations and quickly altered their diet to include rapidly growing plants; forbs and graminoids were preferred (Figure 4-1).

Consumption of arboreal lichens dropped nearly 50% particularly during May and June. The majority of these plants were consumed by individual animals remaining above 1350 meters and in subalpine forests. _Bryoria oregana_, _Bryoria glabra_, _Bryoria lanestris_ and _Alectoria sarmentosa_ were used in the fir-spruce forests whereas _Lobaria pulmonaria_ and _Platismatia glauca_ were predominant in the cedar-hemlock-spruce zone. Most foraging activity was observed along the forest edge, within sparsely stocked stands and in other humid areas.

The use of shrubs for food also decreased (Table 4-6). This probably was due to the substantial occurrence of caribou in subalpine meadows and parklands. _Alnus crispa_ was selected in riparian habitats and also was eaten with _Rubus parviflorus_ and _Ribes lacustre_ in the cedar-hemlock-spruce forests. The latter two species were common in the diets of caribou in the fir-spruce forests as well. Buds, leaves and early shoots appeared to be preferred.

Forbs were the most abundant forage plant group (Figure 4-1). Caribou foraged for the roots, shoots and flowers of numerous flowering herbs growing in somewhat open habitats. Abrupt changes in species preferences were obvious. The most recent growth was usually selected. _Tiarella unifoliata_, _Cornus canadensis_, _Streptopus roseus_, _Valeriana sitchensis_, _Rubus pedatus_ and many other species were eaten (Table 4-6). _Cornus_, _Clintonia uniflora_ and _Galium triflorum_ were heavily used in the cedar-hemlock-spruce forests. A wide variety of food plants were available in all subalpine zones.

Grasses, sedges and horsetails also were very important in spring and early summer diets. Caribou fed extensively on several species of _Carex_, _Luzula wahlenbergii_, _Cinna latifolia_ and a few unidentified species of _Graminae_. _Festuca ovina_ was a regular forage species. All species of _Equisetum_, although not abundant, were higly preferred. Occasionally, horsetails were grazed to the ground. Dried dead tussocks of grasses sometimes were eaten with the new, green shoots. Two ferns, _Athyrium felix-femina_ and _Gymnocarpium dryopteris_, also were common dietary constituents.

At this time, use of terrestrial lichens reached an annual low (Figure 4-1). Nonetheless, _Peltigera canina_ and _Peltigera aphthosa_ remained important forage plants and were plentiful in the diets of forest-dwelling individuals. Moss content appeared to be highest in the spring diet, but intake probably was incidental to lichen consumption.

d. summer (June 15-August 14)

During the summer caribou were distributed throughout their range. The majority of animals occupied parkland and meadow sites above 1250 meters. Habitats in the fir-spruce and subalpine meadow zones were preferred (Table 3-3). Summer was the season of forage diversity and abundance. Species from all plant groups were represented in the diet. The forbs, graminoids and terrestrial lichens were the most important.

Arboreal lichen use reached its lowest annual level. Small amounts of several species of Bryoria were eaten. Hypogymnia physodes, Parmelia sulcata and Cetraria halei also were found in the diet, but no lichen genus or species was an important dietary component.

Shrub consumption was at its lowest level in summer (Figure 4-1). However, caribou continued to lightly use Rhododendron, Alnus, Ribes and Rubus. The leaves, buds and catkins of Salix glauca and Salix nivalis were highly preferred. Heracleum lanatum also was regularly eaten.

Results indicated that the flowering herbs were the single most important dietary component. Greater than 48% of the diet was contributed by the forb group. A great number of species were heavily used during the summer months. *Trollius albiflorus*, *Caltha leptosepala*, *Claytonia lanceolata*, *Pedicularis bracteosa* and several species of *Epilobium* and *Saxifraga* were most extensively used. Members from all families and most genera were represented (Table 4-6). However, the proportion of individual forage plants was quite variable and the dietary composition at any given time was highly dependent upon weather, phenology and habitat selection.

Many species of grasses, sedges and rushes were used extensively. Together the graminoids accounted for 16% of the summer diet. All grasses, sedges and rushes were eaten and *Poa alpina*, *Trisetum spicatum* and *Carex nigricans* were particularly notable. *Luzula wahlenbergii*, *Cinna latifolia* and *Carex pachystachya* also were important foods.

Horsetails, club-mosses and ferns assumed considerable importance. Several species of *Equisetum*, *Lycopodium annotinum*, *Athyrium felix-femina* and *Gymnocarpium dryopteris* were regularly eaten.

The importance of terrestrial lichens markedly increased. Lichen use rose approximately 30% during summer (Figure 4-1). Lichen thalli were softened by increased summer moisture. *Peltigera canina* and *Peltigera aphthosa* comprised the bulk of lichen forages. Nonetheless, improved succulence and perhaps palatability were accompanied by an increase in the use of fruticose lichens. Several species of

Cladonia, primarily *C. mitis*, *C. uncialis* and *C. rangiferina* were selected repeatedly.

e. late summer and early autumn (August 15-October 14)

Early in the season, the caribou remained in their summer habitats and continued to graze the same forage species. Weather conditions were the major determinants of dietary composition and dictated forage availability and quality. As summer progressed to autumn the quantity and quality of food plants declined. The foliage of the herbaceous vegetation often was adversely affected by cold temperatures, frost and senescence. Subsequently, the graminoids and shrubs sustained some damage. Nonetheless, the forbs remained the greatest dietary component, followed by the graminoids, terrestrial lichens and shrubs (Figure 4-1). During the study period, fall temperatures were often unseasonably mild until late in the season.

Arboreal lichen use increased slightly, indicating some transition to the winter diet. However, consumption was not high and primarily occurred late in the season when caribou numbers increased in the fir-spruce parklands. *Alectoria sarmentosa*, *Parmelia sulcata* and several species of *Bryoria* and *Hypogymnia* were detected.

The shrubs increased in importance and accounted for 11% of the known diet. At higher elevations *Cassiope mertensiana* and two species of *Salix* were heavily utilized

The leaves of Salix glauca were especially preferred. Traces of Dryas hookeriana also were found. Below timberline Heracleum lanatum was most frequently selected. Unidentified species from Compositae and Rosaceae were commonly eaten (Table 4-6). Most samples included some woody material.

Caribou continued to obtain most of their green forage and food from the flowering herbs (Figure 4-1). A minimum of 13 forbs were eaten (Table 4-6). Pedicularis bracteosa, Trollius albiflorus, Claytonia lanceolata, Tiarella unifoliata, Arnica latifolia and Caltha leptosepala were used most extensively, though many species were included in the diet. Changes in availability and abundance were instrumental in the periodic redistributions of caribou.

The graminoids assumed considerable importance as autumn advanced and summer vegetation matured and disappeared. This plant group was most important to the diet during this time period (Table 4-6). Many grasses, sedges and rushes retained green foliage and were intensively foraged by caribou. Phleum alpinum, Luzula wahlenbergii, Trisetum spicatum and several species from the genus Carex and the family Graminae were most prominent in the diet. Carex nigricans and Luzula were favored forage species. The disproportionate representation of these species indicated a high use of wet or moist habitats.

Several species of horsetails provided additional green forage and evidence of movement through wet areas. Equisetum pratense and Equisetum sylvaticum were eaten in large quantities. These plants often grew in dense stands on wet, seepy sites and along creekbeds.

Non-vascular plants also made up a considerable portion of caribou diets. Terrestrial lichens were eaten throughout the season but increased in importance as the availability of green forage decreased. Several species of Cladonia and Stereocaulon were preferred, especially in the areas near and above timberline. Fungi, particularly mushrooms, also were eaten, but species and importances are unknown.

f. late autumn, early winter (October 15-December 14)

Caribou distributions were largely determined by weather conditions. Middle-elevation subalpine meadows and parklands were most commonly used early in the season (Table 3-3). However, accumulating snows continually forced animals into fir-spruce and cedar-hemlock-spruce forests below 1200 meters. The caribou remained here for the greatest portion of the season and demonstrated their most opportunistic feeding patterns. Nearly all understory plants were eaten when available. Dietary composition was simply dependent upon availability and snow conditions. Forbs, arboreal and terrestrial lichens, and shrubs were most important (Table 4-6). However, in comparison to summer the diversity of available food plants was greatly reduced. Many species were covered with snow.

Arboreal lichens increased dramatically in importance and contributed approximately 20% to the known diet. The majority of caribou fed on the foliose species, _Platismatia glauca_, _Lobaria pulmonaria_ and _Parmeliopsis sp_. in the cedar-hemlock-spruce zone. _Bryoria capillaris_, _Bryoria lanestris_ and _Alectoria sarmentosa_ were more important to the remaining caribou wintering in low and middle elevation fir-spruce forests. _Parmelia sulcata_, _Hypogymnia physodes_ and _Bryoria glabra_ were common to caribou diets in both forested zones. Caribou spent much of their feeding time near the edge of the forests.

Shrub consumption increased slightly (Figure 4-1). This was particularly true as the snows deepened and the availability of plants in the field and ground layers decreased. Buds, fine twigs and persistent or evergreen leaves were eaten. _Ribes lacustre_, _Sambucus melanocarpa_ and both species of _Vaccinium_ were most common in the diet. Small amounts of _Rhododendron albiflorum_, _Menziesia ferruginea_ and _Rubus parviflorus_ also were identified. The deciduous trees greatly rose in importance, and _Alnus crispa_ was eaten extensively.

Although sharply reduced in quantity and quality, the forbs remained a common food plant group (Figure 4-1). Caribou pawed through shallow snows and sought favorable snow conditions in order to obtain these food materials. The animals also ate forage protruding through the snow cover.

Tiarella unifoliata, *Rubus pedatus*, *Thalictrum occidentale*, *Valeriana sitchensis*, *Galium triflorum* and *Smilacina sp.* were most abundant in the diet.

Graminoids and horsetails remained common to the diet, although consumption decreased significantly (Figure 4-1). Most of these foods were obtained earlier in the season and in wet areas, particularly along waterways. *Luzula wahlenbergii*, *Cinna latifolia* and several species of *Equisetum* and *Graminae* were eaten most heavily. Ferns contributed substantially more to the diet than during other seasons. Several unknown members of the family *Polypodiaceae*, probably *Athyrium felix-femina* and *Gymnocarpium dryopteris*, were frequently detected.

The terrestrial lichens accounted for 14% of the diet, a contribution surpassed only in the early spring (Figure 4-1). Most forage species colonized rotting logs and elevated sites penetrating the snow surface. *Peltigera canina*, *Peltigera aphthosa* and *Cladonia coccifera* were most readily available. Moss consumption was above average, but no evidence of selection was recorded.

4. The dietary importance of lichens

On an annual basis, caribou ate a wide variety of forage plants. Variability by season and habitat was tremendous. During the snow-free period, forbs were the dominant food group, followed in importance by the shrubs, and graminoids. Conifers, deciduous trees, ferns and mosses were of minimal dietary importance. Some preference for terrestrial lichens was demonstrated, but most species were not abundant in caribou diets.

During the critical winter period, arboreal lichens were the major dietary component. Lichen productivity and caribou ecology are closely related. Consequently, it is important to review lichen contributions to caribou diets by season and habitat.

a. terrestrial lichens

Terrestrial lichens were not abundant in the study area. However, they were the fourth most important dietary constituent (Figure 4-1). These results would imply some preference. Species from the genera <u>Cladonia</u>, <u>Cetraria</u>, <u>Peltigera</u> and <u>Stereocaulon</u> dominated the lichen forage group. The amount of lichen forage eaten varied considerably between vegetation zones. Terrestrial lichens were most abundant in alpine diets (Figure 4-2). Seasonal differences were not as noticeable (Figure 4-1).

<u>Peltigera</u> <u>aphthosa</u> and <u>Peltigera</u> <u>canina</u> were the two most heavily utilized species. They were most extensively foraged during early and mid-winter, spring, summer and late aut[illegible] Table 4-6). Both species were abundant in caribou diets in fir-spruce, cedar-hemlock-spruce and muskeg habitats. <u>Peltigera</u> <u>aphthosa</u> also was regularly eaten in

subalpine meadows. Several species of *Cladonia* were common dietary constituents and many unidentified and known species were consumed. *Cladonia coccifera* was most important in cedar-hemlock-spruce and fir-spruce forests during spring and early winter. *Cladonia ecmocyma* was eaten in all seasons and zones, but mainly in krumholz habitats during late summer and early autumn. *Cladonia mitis*, *Cladonia rangiferina* and *Cladonia uncialis* were preferred in alpine and krumholz areas. The heaviest use occurred from June through October (Figure 4-1). Several species of *Stereocaulon* also were fairly abundant in summer and autumn diets but were more important in the alpine-tundra zone. Species of *Cetraria* were commonly eaten in all seasons but made their greatest contribution during spring and early winter and in cedar-hemlock-spruce forests.

b. arboreal lichens

The arboreal lichens accounted for 17% of the annual diet, a contribution surpassed only by the forbs. However, seasonal and zonal importances were quite variable. Epiphytic lichens were of paramount importance from mid-winter to early spring (Figure 4-1). They were most heavily used late in the winter and in cedar-hemlock-spruce and fir-spruce forests. Use also was high near lakes and muskegs (Figure 4-2). Several species of *Bryoria*, *Hypogymnia physodes*, *Lobaria pulmonaria*, *Parmelia sulcata* and *Platismatia glauca* were most abundant in the diet. Results did not confirm the high preference for Alectoria sarmentosa reported during earlier mountain caribou studies (e.g. Edwards and Ritcey 1960; Freddy 1974; Layser 1974).

Platismatia glauca and Lobaria pulmonaria were heavily foraged when caribou occupied cedar-hemlock-spruce forests from November to January. Hypogymnia physodes, Parmelia sulcata and Parmeliopsis sp. also were consumed in quantity. Bryoria glabra, Bryoria capillaris and Alectoria sarmentosa were occasionally eaten. Most of these areas were below 1000 meters.

Differences in the selection of arboreal lichens also were evident between high and low elevation fir-spruce forests. Between 650 and 1000 meters Hypogymnia physodes, Hypogymnia enteromorpha, Parmeliopsis sp. and Alectoria sarmentosa were most commonly eaten. Alectoria sarmentosa increased in the diet to 1350-1450 meters, where its consumption and abundance dropped markedly. Bryoria capillaris, Bryoria glabra, Bryoria lanestris and Bryoria oregana were eaten in small quantities below 1000-1200 meters but were the mainstays in the diet of wintering caribou occupying higher elevation forests. Many unidentified Bryoria species also were common in the diet. Bryoria oregana and Bryoria glabra seemed to be particularly important during the middle and late winter seasons (Table 4-6). Bryoria fremontii was primarily used at or near timberline but never was extensively eaten. Cetraria ciliaris and Cetraria halei were common to the diets of caribou resident in fir-spruce forests located from approximately 1250 to 1700 meters. Consumption was typically modest. Cetraria distributions were too sparse to provide abundant forage. Parmelia sulcata was a very important forage lichen and was particularly prominent above 1000 and below 1700 meters. Fir substrates were preferred, and caribou consequently ingested some twigs and needles with this foliose species. Parmeliopsis ambigua, common to cedar-hemlock-spruce zone diets, also was regularly eaten in the fir-spruce forests, especially in middle elevation, fir dominated stands. Parmeliopsis hyperopta, however, was unique to the fir-spruce zone and was fairly evenly distributed throughout those elevations above 1000 meters. It was not a major forage species. Hypogymnia physodes and Hypogymnia enteromorpha were commonly eaten throughout the fir-spruce zone and were sporadically taken in cedar-hemlock-spruce forests. Hypogymnia physodes was considerably more important and was heavily utilized during all winter seasons (Table 4-6).

Caribou relied heavily on arboreal lichens for forage during the winter seasons. These foods were particularly crucial when deep snowpacks rendered terrestrial vegetation unavailable. Coniferous forage appeared to be unacceptable, and hence epiphytic lichens usually were the sole, available food source. Preference was not implied or the use of arboreal lichens would have been relatively constant throughout the year. Numerous studies, however, have demonstrated the importance of arboreal lichens for wintering caribou (e.g. Cringan 1956; Evans 1960; Edwards and Ritcey 1960; Flinn 1956; Freddy 1974; Scotter 1962). The results of this study seem to corroborate previous evidence. Arboreal lichens were the critical dietary component during winter.

V. POPULATION STATUS

A. Introduction

Assessing the current status of resident caribou populations was a complicated task. Historical distributions and numbers were largely unknown, and of the forest-dwelling ungulates in Central British Columbia, caribou have the lowest population densities (K. Child pers. comm.). Small populations, inaccessible and remote range, high winter snowfalls and inadequate prior knowledge increased the difficulties of census taking.

B. Methods

Various methods were used to collect baseline information on population dynamics and caribou ecology and to determine contemporary and historic distribution (Chapter III). Additional sources of information were historical, provincial and archival records, museums and annual harvest statistics. These data were supplemented with field surveys to determine trends in the size and distributions of caribou bands. Estimates were based on aerial and ground censuses and information provided by forestry and wildlife personnel, guide-outfitters, hunters, local residents and pilots.

C. Population Dynamics

Information on population demographics was very difficult to obtain. Low population densities and characteristic nomadism greatly limited the opportunity to examine the dynamics of local caribou populations. Consequently, the data obtained were quite limited.

1. Breeding behavior and recruitment

The rut extended from mid-September to late October, apparently peaking during a 4-5 day period early in October. Synchronous mating probably assured calving during a brief, optimal period, thereby assuring similar levels of calf mobility (Chapter I). The gregarious social behavior of caribou thus appears to be reinforced (Dauphine 1974; Espmark 1964b).

Calves assumedly were born during May and particularly in June. Caribou calved in muskeg and high elevation areas, perhaps indicating divergent but mutually effective predator escape strategies. It appears mountain caribou calve in semi-open areas.

Calf production in the study area was very low. Despite numerous attempts very little data were collected, and few calves were observed or reported (Table 5-1). Even when caribou were most visible, calves and juveniles were noticeably absent (Chapter VI). The relative numbers of calves, yearlings and 2-year olds are important indicators

Table 5-1 Sightings Of Juvenile And Calf Caribou During This Study

Date	Location	Animal Sighted
15/5/76	West Twin Creek	1 Bull,3 Cows,1 Juvenile In Cedar Forest
5/7/76	Hungary Creek	1 Cow,1 Juvenile In Cedar-Spruce Forest
21/7/76	McGregor-Sande Rd.	2 Cows,2 Calves Cn Logging Road
26/7/76	Slim-Tumuch Rd. (Mile 19)	2 Juveniles In Subalpine Meadow
27/7/76	McGregor-Sande Rd.	1 Bull,3 Cows,1 Juvenile
29/7/76	Longworth Lookout	1 Bull,1 Calf
6/8/76	McGregor-Sande Rd.	2 Cows,2 Juveniles
27/8/76	Raven Lake	3 Cows,1 Juvenile
8/2/77	Red Mountain-Penny	11 Cows,1 Juvenile In Alpine Basin
9/3/77	McGregor-Pass Lake Rd.	3 Cows,1 Juvenile In Muskeg
4/5/77	Hungary Creek	1 Juvenile
7/6/77	McGregor-Pass Lake Rd.	2 Cows,2 Juveniles
15/6/77	Severeid Creek-Severeid Mtn.	Evidence Of Calving; No Animals Observed
2/16/77	McGregor-Torpy Rd.	1 Juvenile
15/7/77	Pass Lake Ridge	4 Cows,2 Juveniles
10/9/77	McGregor-Pass Lake Rd.	2 Bull,7 Cows,2 Juvenile

of herd status and productivity (Skoog 1968). Although the data are imprecise, each band and the population was dominated by an unusually large adult segment.

2. Population composition and structure

Inherent difficulties associated with classifying caribou were related to bi-sexual antler development, seasonal segregations by sex and age, irregular distributions and continual wanderings. Low population densities and difficult terrain intensified the problems. Some baseline data were collected and compared with the results of previous studies.

a. Band size

The large herds of barren-ground caribou are legendary (Kelsall 1968; Skoog 1968). Mountain caribou also are gregarious but seldom form large groups. Band sizes appear to vary by location and population status. Evans (1960) reported bands of 2-12 caribou. Flinn (1956) rarely saw a band exceeding 23 animals. In Jasper National Park, group sizes ranged from 2-47 caribou (Stelfox 1974). Freddy (1974) documented bands of 20-30 individuals, though groups typically contained 3-7 caribou.

The largest group observed during this study consisted of 22 animals (Appendix D). Bands of 10 or more caribou were recorded 14 times. Bands ranged from 2-22 animals, averaged four individuals and appeared comparable to estimates in other areas (Table 5-2).

The difficulty lies in interpreting the influence of population distributions and densities on band size. Edwards and Ritcey (1959) attributed small bands to a limited population size. This would be consistent with the much reduced band sizes reported in the study area. The significance and causes of reduced band sizes are discussed in Chapter VI.

b. sex ratio

Little is known about the sex ratios of mountain caribou. The information is difficult to obtain and mountain caribou are seldom studied. Generic characteristics were referred to out of necessity (Chapter I).

Roughly estimated ratios were obtained in the study area and reasonable appraisals can be made. Mixed groups seldom had bull to cow ratios narrower than 12.5:100 or one bull per eight cows (Table 5-2). Even during the rutting phase, when sexes were most thoroughly mixed, ratios appeared to be considerably below the typical range of 4-6 bulls per 10 cows (Chapter I). In fact, segregated cow bands were regularly observed during the breeding season. Though sexual segregation has been recognized during all seasons, total separation seldom is the case (Clarke 1940; Kelsall 1968; Lawrie 1948).

Table 5-2 Seasonal Sizes And Overall Compositions Of Mountain Caribou Bands In The Study Area

Typical Seasonal Band Sizes

Season	Total Size
Dec 15 - Feb 14	4-15
Feb 15 - Apr 14	2-5
Apr 15 - June 14	2-5
June 15 - Aug 14	2-9
Aug 15 - Oct 14	2-15
Oct 15 - Dec 14	2-9

Overall Band Size And Composition

Band Sizes		Band Composition(%)	
a. Range	2-22	a. Bulls	12.4
b. Average	4	b. Cows	86.8
c. Typical	2-5	c. Juveniles Less Than	

*Animals who have not reached breeding maturity

D. Comparison Of Contemporary And Historic Populations

1. Overview

Considerable effort was made to elucidate the historical size and distribution of caribou populations in the study area. Unfortunately early settlement was quite limited and largely restricted to the vicinity of Prince George (Chapter II). Many early residents are gone. Consequently, few historic sightings were recorded prior to 1950.

In addition the British Columbia Fish and Wildlife Branch did not compile harvest statistics prior to 1962 (P. Haley pers. comm.). Furthermore, the area was never selected for natural history studies (C. Guiget pers. comm.; C. Van Zyll de Jong pers. comm.). As a result our knowledge of caribou history remains imprecise.

All known contemporary and historic sightings were reviewed. Those presumed to be accurate were organized into somewhat arbitrary but natural geographic units. Boundary definition facilitated assessment and discussion of distributions (Figure 5-1). Results from historic studies indicate caribou were distributed throughout the study area (Figure 5-2). Known and possible travel corridors and migration routes are illustrated in Figure 5-3.

Contemporary sightings represent a collation of animal observations, confirmed reports, track sightings, and pellet collections (see methods Chapter III). Sightings were highly

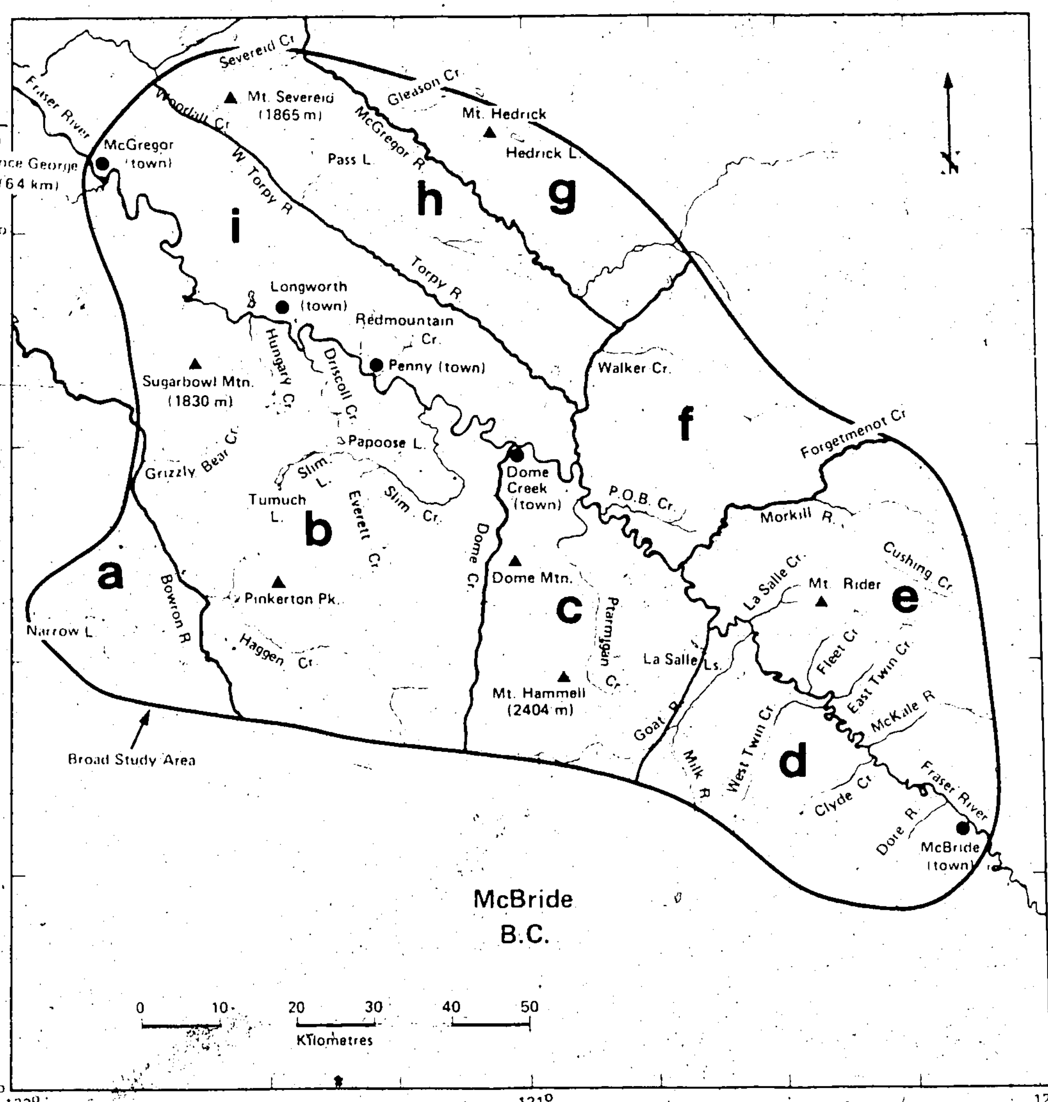

Figure 5 - 1 Boundaries of Geographical Caribou Distribution Units

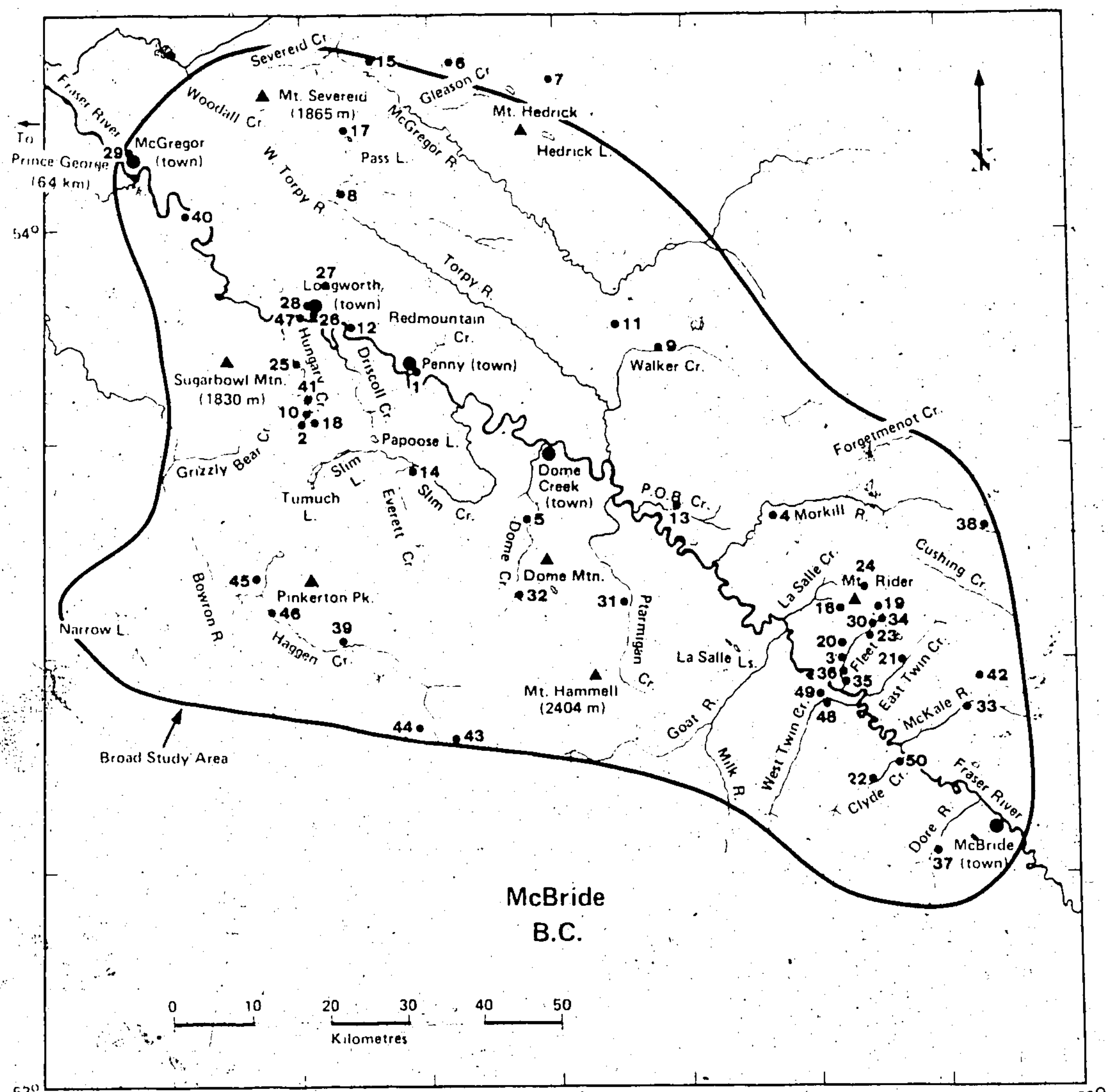

Figure 5 - 2 Historic Sightings of Mountain Caribou In Central British Columbia

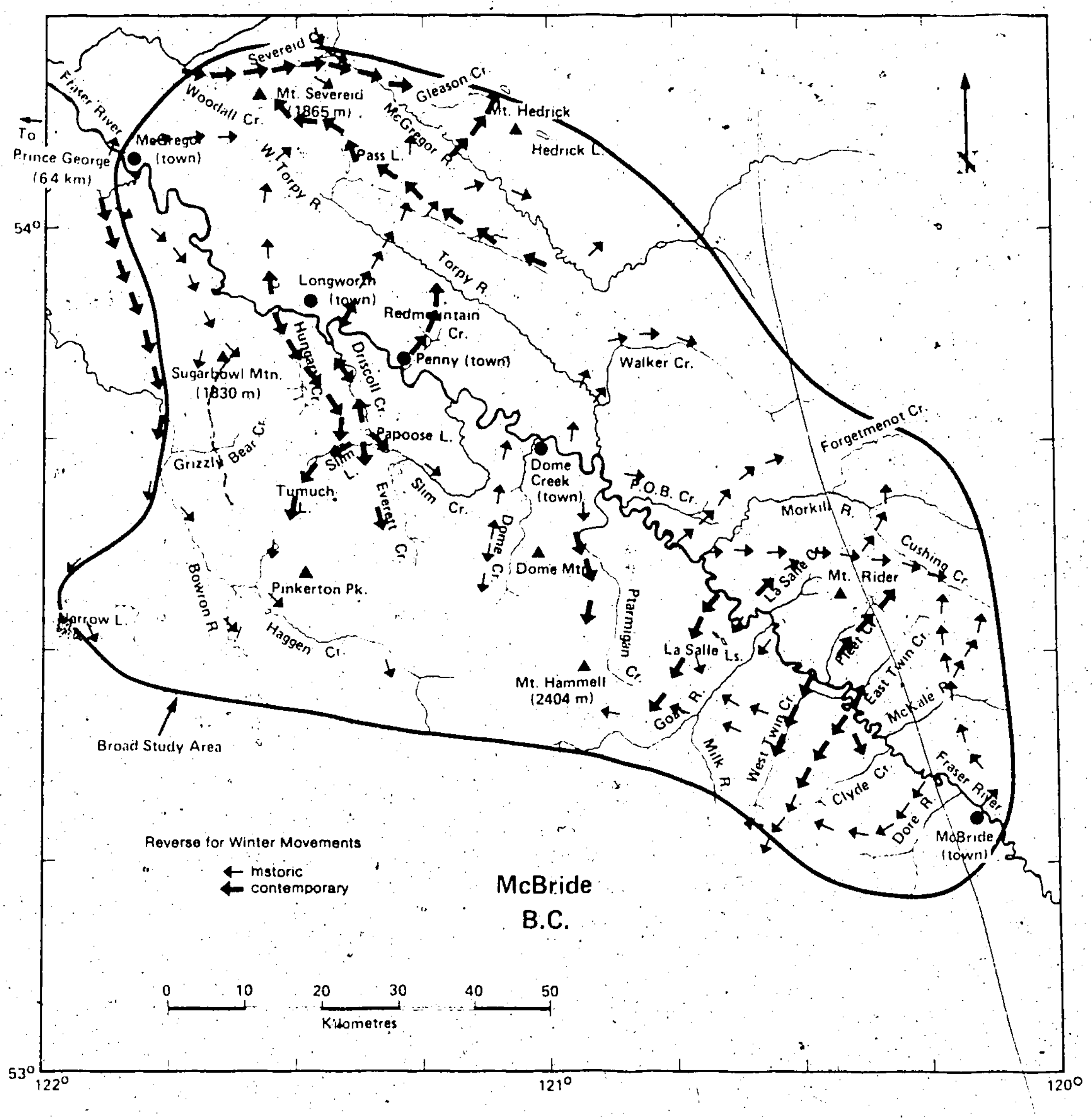

Figure 5 - 3 Known and Possible Caribou Migration Routes and Travel Corridors In Central British Columbia

dispersed (Figure 5-4). Furthermore, due to the inherent difficulties associated with collecting population data and the reduced size of resident bands, the following results are estimates of population sizes and distributions. An exact census is rarely possible and probably not necessary. Limitations of manpower and funding precluded intensive census taking. Consequently comparative estimates should be considered indicators of population size and trend are not necessarily definitive appraisals of current numbers. However, average population sizes, distributions and trends are important parameters of status.

Low population densities and high mobilities confused assessment of affinities for particular watersheds. However, it is clear from earlier results that absence from a particular locality does not necessarily indicate disuse and must not be misconstrued as abandonment (Chapter III). Short-term rotations are typical and demonstrate rotational range utilization. Absences exceeding 10 years, however, may represent local extirpation or loss of range tradition.

During the rut and to some extent in the winter, caribou populations coalesce into their largest annual groupings. These seasonal aggregations promote efficient breeding and range use. They also provided the best opportunities for census taking. Table 5-3 summarizes estimates of caribou population size distributions by geographical unit.

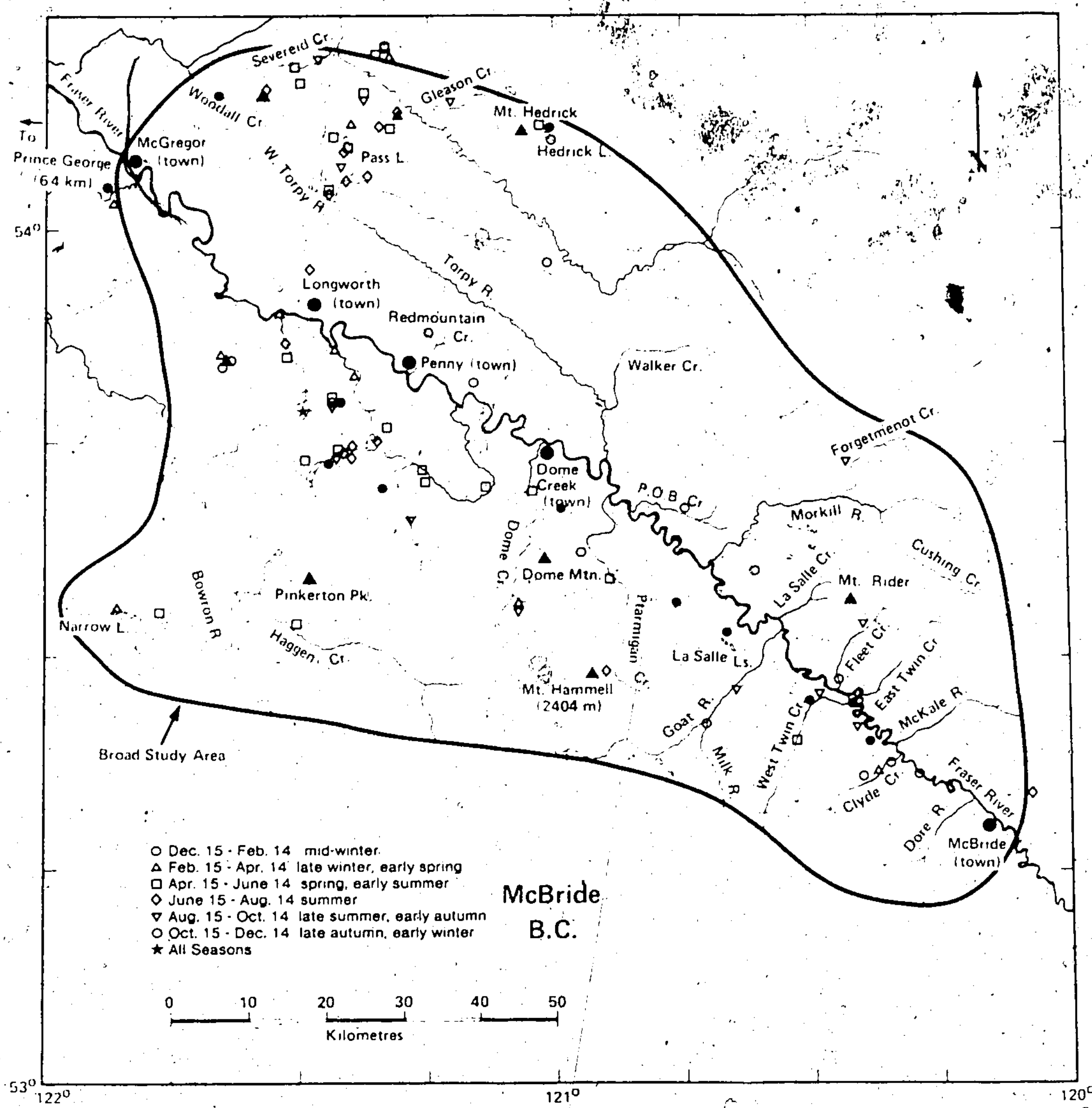

Figure 5 - 4 Caribou Sightings In the Study Area, 1975-1977

Table 5-3 <u>Estimates Of Caribou Population Abundance By Geographical Unit</u>

Geo-graphical Unit*	Population Estimate Minimum**	Maximum	Probable	Relative Abundance	Reliability Estimate***
Zone a	5	15-20	10-15	Poor	Good
Zone b	22	40-50	30-35	Poor To Fair	Good
Zone c	8	45-70	35-45	Poor To Fair	Good
Zone d	15	55-75	20-30	Poor To Fair	Fair
Zone e	10	65-85	35-45	Fair	Fair
Zone f	7	50-70	30-35	Fair	Poor
Zone g	8	35-55	25-30	Fair	Fair
Zone h	12	50-60	35-40	Poor To Fair	Good
Zone i	15	25-40	20-25	Poor	Good

*Refer to Figure 5-1

**Largest band observed, 1975-1978

***Good - Numerous (more than 10) reconnaissance visits, including a minimum of 4 aerial surveys

Fair - Several reconnaissance visits, including 2-3 aerial surveys

Poor - A few reconnaissance visits, including at least one aerial survey

Documentation of areas of known use provided an opportunity to evaluate size and status, particularly when closely compared to historic conditions. Caribou distributions and critical ranges are discussed within this context. Contrasting historic and contemporary population parameters provided ample evidence of a declining population. The causes are discussed in detail in Chapter VI.

2. Historic and contemporary populations by distribution, size and important range

a. south of the Fraser River Valley and west of the Bowron River (Zone a)

Caribou formerly inhabited areas between Prince George and the Bowron River. Activity in the vicinity of Stone Creek, George Creek, Naver Creek, Hixon Creek and Mt. George has been confirmed. Sightings occurred in all seasons and were concentrated near Naver Creek and Mt. George, once described as formerly teeming with caribou (M. Warren pers. comm.). Movements probably followed a route from Mt. George, along George Creek to Naver Creek and west toward Hixon and Terry Creeks. Current sightings were confined to small bands along Naver Creek during the summer and north of Mt. George between December and February (Appendix D).

East of the Willow River most historic activity was documented close to Narrow Lake, Wendle Creek, and the confluence of Tsus Creek and the Bowron River (Appendix F). Contemporary sightings consisted of small groups located in the vicinity of Narrow Lake and Wendle Creek, particularly during the spring season.

Sightings were very infrequent during the study, and the area appeared to be at the fringe of current distributions. Groups surpassing 75-100 animals once were common (M. Warren pers. comm; M. Wilkinson pers. comm.). Current bands, however, are very small and are a mere remnant of the large groups formerly occupying these areas (M. Warren pers. comm.). The largest group observed consisted of five caribou near Narrow Lake (Appendix D). The total population in the zone very likely does not exceed 10-15 caribou (Table 5-3).

b. south of the Fraser River Valley and east of the Bowron River to Dome Creek (Zone b)

Various habitats between the Bowron River and Dome Creek and as far south as the confluence of Haggen and Dominion creeks have been occupied by caribou at least since the early 1930's (Appendix F). During this time a sizeable herd was observed in the Hungary Creek-Raven Lake area (O.J. Prather pers. comm.). Despite its somewhat cyclic nature, the herd flourished until the late 1960's (G. Hooker pers.

comm.; O.J. Prather pers. comm.). Caribou once may have travelled from here as far southeast as Bowron Lakes Park (G. Hooker pers. comm.).

Caribou also were reputed to be numerous in the vicinity of Sugarbowl Mountain and regularly crossed the Fraser Valley between Purden Lake and Hungary Creek. Regular sightings were made on Slim Creek, Everett Creek and Haggen Creek. Bands probably moved into these areas along Kenneth and Hungary creeks and travelled toward Pinkerton Peak, Haggen Creek and possibly Bowron Lakes Park. Caribou also frequented Tumuch Lake and Papoose Lake, particularly during the spring.

Early surveys during the study were concentrated in this area. Consequently, the 41% of all sightings occurring here may be disproportionately high. The majority of sightings were made between and near to Raven Lake and Grizzly Den and during the summer, autumn and late winter (Figure 5-4). The largest group observed, 22 animals, was recorded here (Appendix D). Band sizes noticeable declined in subsequent years and necessitated a shift in research emphasis.

The Sugarbowl Mountain area also was important between December and March and was accepted to be used by the Raven Lake Band. Caribou also were regularly seen along Hungary and Driscoll creeks and in the vicinity of Tumuch, Slim and Papoose lakes. Most Hungary Creek observations were of less than four caribou, occurred during winter and were in the vicinity of a highway crossing. Bands also were known to cross the highway near Purden Lake and Driscoll Creek. All crossings were noted during the snow season due to a reliance on the presence of tracks.

Several sightings were made between Tumuch and Papoose lakes and along the Slim-Tumuch road (Appendix D). Caribou typically travelled through here between mid-April and December and particularly from late May to early September. Movement corridors were recognized between Tumuch and Papoose lakes, along the Slim-Tumuch road near mile 14, and just east of mile 23. Sightings between the two mileposts were fairly regular prior to 1977. Papoose Lake was noted for activity during June and quite possibly the calving season.

Activity during 1977 shifted east and south from the Raven and Tumuch lake areas. Haggen Creek presumably received most of the redistributed caribou, especially in the spring and summer. Increases also were noted along Everett and Slim creeks, during the spring and between September and December (Appendix D). This might have represented traditional range rotation but was suspected to be related to increases in industrial and recreational activity to the north and west. Concurrent reductions in band size further substantiated the probability of a general decline (F. Cushman pers. comm.).

Historically, bands of 20-50 animals, were common particularly during the autumn. It is likely that at least 3-4 bands occupied this area. Since 1975 the largest group observed consisted of 22 wintering caribou. Although it is suspected that a similar number of bands may continue to use this area, group sizes have markedly decreased. A maximum of 40-50 caribou were thought to occur in this zone. However, this is believed to be a liberal estimate (Table 5-3).

c. south of the Fraser River Valley and from Dome Creek to Lasalle Lakes (Zone c)

Recorded sightings of caribou on Dome Creek, from the headwaters to the Fraser River, date back to 1938, and the area has been traditionally used for many years (D. Ferguson pers. comm.). The Goat River area has been used for at least 30 years (D. Ferguson pers. comm.). During the 1960's bands of 30-40 caribou occurred near the river's headwaters and along Bounding Creek (Appendix F). Ptarmigan Creek also was presumed to provide important habitat. As recently as the early 1960's, 20-50 caribou could be observed daily during autumn (G. Hooker pers. comm.). Most activity was located near the headwaters and in the vicinity of Mt. Hammell. An old travel corridor existed from LaSalle Lakes, a historically important wintering area, and along Goat River toward Whitehorse Mountain (D. Ferguson pers. comm.). Some movement also was suspected south along Ptarmigan Creek. Both corridors assumedly fostered contacts with bands in and near Bowron Lakes Park. Bands ranged south, at least to winter ranges along the Caribou River (D. Ferguson pers. comm.).

Dome Creek figured prominently in contemporary distributions, although only small bands occurred. Summer observations were recorded close to the Fraser River Valley. During August and March caribou were present near the headwaters.

The Ptarmigan Creek watershed constituted important range during this study, most notably in the late winter and early summer. Caribou typically frequented open slides and subalpine meadows, though winter tracks also were seen in a cedar-spruce forest. Movements were detected between the headwaters and Mt. Hammell, but other routes appeared to be in disuse.

Several sightings were made east of Ptarmigan Creek. Four wintering cows were observed six miles south along Snowshoe Creek (Appendix D). Another eight caribou were seen feeding on arboreal lichens in a cedar forest adjacent to LaSalle Lakes during December. However, this was the only observation during numerous visits. It was unclear whether increased recreation or reduced caribou numbers were responsible.

Prior to the mid-1960's summer bands of 30-40 caribou were common. Whereas 20 or more animals were regularly seen in a day, only 2-3 caribou could be currently located in a 10 day period (G. Hooker pers. comm.). At least three separate bands existed historically and may continue to use the area. Distributional overlaps are unclear but band sizes have substantially declined. The largest group encountered, eight caribou, occupied the LaSalle Lakes area in December. Probably 35-45 caribou inhabit this zone, though some additional numbers may be located south of Mt. Hammell.

d. south of the Fraser River Valley and east of Lasalle Lakes to Mcbride (Zone d)

Historically caribou regularly occurred along Clyde Creek, West Twin Creek, Legrand Creek and the Dore River (Appendix F). Most were seen in the Fraser Valley, between West Twin and Clyde creeks, from October to December and again during the spring. A minimum of 25-35 animals occupied the West Twin Creek area as recently as 1965 (M. Frye pers. comm.). During 1935, about 60 caribou travelled along a well packed trail and crossed through the river valley 1200 metres east of the current West Twin Creek bridge (Appendix F). Bands travelled this route toward Mt. Rider and Cushing Creek (D. Ferguson pers. comm.).

Clyde Creek was another historically important area. A travel corridor was suspected to exist from Legrand, along Clyde Creek and toward Mt. Halvorson. Caribou reportedly summered in large, open slides along the north fork of the

Dore River (D. Ferguson pers. comm.). They moved as far south as Mt. Quanstrom and in all probability ranged into Wells Grey Park. Another probable migration route led from the Caribou River to the headwaters of the Milk River or Dore River, and north to wintering areas in the Fraser Valley west of McBride (D. Ferguson pers. comm.). Large numbers of caribou, no less th 60-75, crossed through this area during the winter of 1934 (D. Ferguson pers. comm.).

Relatively large numbers of caribou historically travelled through the West Twin Creek area. It is reputed to be of great historic significance. However, current bands were largely reduced (Appendices D and F). Though seven sightings were made, the largest group observed consisted of 15 animals. Caribou occupied low elevation forests along the Fraser Valley and crossed the highway at several locations.

Probable highway crossings were located in other areas. Several winter crossings recently occurred 25-35 kilometers west of McBride, particularly near Clyde Creek. The area was consistently used by historic bands, however, caribou only were observed during the third year of the study. Numerous tracks were sighted during early winter, and three cows were seen in a wooded area near the highway. During February a bull and three cows were observed in a forested area at 1600 metres. Movements in this area did not appear to be attached to traditional travel routes.

Several current sightings were made in the Goat River watershed (Appendix D). Eleven caribou occupied an alpine site during September. The following January, the tracks of 4-5 animals occurred in a forested area west of the confluence of the Goat and Milk rivers. Caribou were seen twice in the vicinity of historic wintering areas south of Legrand. Seven animals were reported in December, and four cows were seen foraging during the following October.

During the 1930's bands often exceeded 30-60 individuals and occupied at least four important drainages. However, current distributions are discontinuous in character due to a large network of roads. Consequently caribou have abandoned former migration routes and were concentrated in small, widely scattered bands (D. Ferguson pers. comm.). Several bands, perhaps four, remain, but average groups include only 2-15 animals. Probably not more than 20-30 caribou currently reside in this geographic zone (Table 5-3).

e. north of the Fraser River Valley and east of the confluence of the Morkill River and Forgetmenot Creek (Zone e)

Caribou regularly occurred along Fleet Creek, Lasalle Creek and East Twin Creek and near Mt. Rider (D. Ferguson pers. comm.). Between 1930 and the late 1960's local bands often contacted caribou along the Goat River and West Twin

Creek. A major travel route connected the areas and probably followed Catfish Creek and the Morkill River. Large populations summered in huge meadows at the base of Mt. Rider and along Hellroaring Creek (D. Ferguson pers. comm.). In 1936, 60-70 caribou, including many calves, were observed (N. Ferguson pers. comm.).

Large groups also travelled the Morkill Valley to its headwaters near Willmore Wilderness (B. Duncan pers. comm.). The Cushing Creek area supported large groups until the mid-1960's (E. Monroe pers. comm.). Caribou traditionally occupied the Sheep Creek-Kakwa River-Narraway River area, and in 1967, 62 caribou were reported (F.J. Pruckl pers. comm.). Caribou formerly ranged along the McGregor River and were particularly important between Buchanan and Bastille creeks (M. Monroe pers. comm.). However, no caribou have been observed here in eight years (E. Monroe pers. comm.).

The area between the Holmes River and Nevin Creek reputedly provided important caribou habitat, particularly in the autumn and prior to mid-December (D. Ferguson pers. comm.). Animals presumably moved along Nevin Creek to the Holmes River and up the Chalco River (M. Vatamaniuk pers. comm.).

During the autumn of 1963, 24 caribou were seen along the McKale River (Appendix F). Additional sightings were recorded along Fleet Creek, particularly between the headwaters and Cushing Creek. A band of 35 animals wintered here during 1935 (Appendix F). Caribou also were known to use a large muskeg near Crescent Spurr during winter. Others used muskegs and high benches along East Twin Creek.

Although surveys were conducted, a great deal of contemporary information was obtained from local residents. Caribou tracks were seen in muskegs near Crescent Spurr. Single sightings also occurred in a meadow near Nevin Creek and along Lamco Road. All occurred between 1100 and 1200 meters and during May (Appendix D). The Nevin Creek sighting was in proximity to a historic migration route (Appendix G). Fleet Creek continued to be used, especially during September and January (Appendix D). However, the large groups supposed to use the area prior to the mid-1960's were not evident.

During the past 15 years caribou have decreased considerably along the Morkill River, and only a small group remains (B. Duncan pers. comm.). Along the Holmes River, the decline began about 12-14 years ago (C. Brooks pers. comm.). Mature bulls have not been observed in recent years (M. Frye pers. comm.). Caribou have not been seen in traditional locations along the McGregor River in about 8-10 years (M. Monroe pers. comm.).

Bands in the Sheep Creek-Kakwa River-Narraway River area have steadily declined since the late 1960's (F.J. Pruckl pers. comm.). Numbers also are relatively low along Cushing Creek despite the presence of large bands prior to the mid-1960's (E. Monroe pers. comm.). Many other areas once considered prime caribou range, including LaSalle Creek, East Twin Creek, Mt. Rider and the Hellroaring basin, were without activity during the study.

During this study the largest band observed consisted of 10 caribou wintering north of Crescent Spurr. Contrasted to the large historic groups, a large scale decline seems apparent. In 1936 nearly 70 caribou were seen in one group. Twenty-four animals were spotted in 1963 (Appendix F). However, most recent sightings have not exceeded 4-6 caribou, and not more than 35-45 caribou likely remain in this area.

f. north of the Fraser River Valley and west of zone e to the confluence of the Torpy River and Walker Creek (Zone f)

Historic activity is unclear in this area. Local residents frequently referred to caribou movements along a well worn trail near Walker Creek. During the summer of 1944 35-50 caribou with at least six calves were seen (J. Gasprey pers. comm.). An abandoned game trail was presumed to be a migration route along Walker Creek. A small band also has regularly wintered along P.O.B. Creek since at least 1952 (D. Ferguson pers. comm.).

Contemporary sightings were quite limited due to the inaccessible and unsettled nature of the area. Caribou were seen only once in the vicinity of winter ranges along P.O.B. Creek, through numerous reconnaisance visits were made (Figure 5-4). The only other sighting consisted of a solitary cow feeding at timberline, northwest of the confluence of Forgetmenot Creek and the Morkill River during September.

Distribution maps prepared by The Fish and Wildlife Branch indicated caribou once were plentiful in this area (K. Child pers. comm.). At least two bands were recognized to use the area. However, current band sizes were not above regional averages and the largest group observed included seven animals (Appendix D). Survey results did not demonstrate former abundances. Population reductions may be further evidenced by abandonment of the Walker Creek trail. Probably not more than 30-35 individuals and perhaps 2-3 small bands continue to utilize this area.

g. north of the Fraser River Valley, north of the Mcgregor River and west of Bastille Creek (Zone g)

Caribou have at least a 40 year history along the McGregor River and were once numerous near the river's falls (E. Monroe pers. comm.). An old, well-worn travel route existed near the headwaters (J. Gasprey pers. comm.). Historic observations occurred on Fontoniko Creek, Herrick Creek, Mueller Creek, Gleason Creek, Cargill Creek and Hedrick Lake. Most sightings were made between May and

October, particularly in muskegs and meadows (Appendix F). The largest group reported was comprised of 30-40 individuals between Herrick and Fontoniko creeks (Appendix F).

Use of several important areas continued. Four observations were made north of Herrick Creek and between Fontoniko and Mueller creeks (Appendix D). Each occurred between February and May and in fir-spruce forests. The largest group consisted of eight animals.

Caribou twice were observed near Hedrick Lake. A group of eight adults, including one bull, were seen during the rut. Seven caribou, also occupying a subalpine meadow, were seen the following December (Appendix D). Two animals were spotted in the vicinity of Hedrick Creek. The only other sighting occurred near the confluence of the McGregor River and Gleason Creek and consisted of 2-3 post-rut caribou in an alpine meadow.

Historic observations were sketchy but indicated wide distributions and bands ranging in size from at least 15-40 caribou. Autumn groups probably were larger (J. Gasprey pers. comm.; D. Minty pers. comm.). Some uncertainty also surrounded contemporary populations but bands were not large and never exceeded eight animals. Typical bands consisted of less than five caribou. Simultaneous but unrelated surveys made in conjunction with a hydro-electric proposal yielded similar results (D. Penner pers. comm.).

Not more than 25-30 caribou are believed to currently occupy this zone (Table 5-3).

h. north of the Fraser River Valley and between the Mcgregor River and Torpy River (Zone h)

During 1948, a band of approximately 45 caribou resided between the McGregor and Torpy rivers (Appendix F). Pass Lake was of particular importance. The surrounding mountains were littered with antlers as recently as 1957 (anonymous questionnaire respondent). Caribou also occurred near Severeid, Crotch, Huble and Woodall creeks, and were suspected to range throughout the area, particularly during the snow-free season (D. Minty pers. comm.; S. Wlasitz pers. comm.). Evidence also strongly indicated the existence of several travel routes (Appendix G). Caribou regularly travelled from Woodall Creek to the headwaters of the West Torpy River and to summer ranges between the Fraser and Torpy rivers. Another route probably extended from Keg and Crotch creeks to the headwaters of Woodall Creek. Other bands routinely moved from Crotch Creek, along Bear Paw Ridge and north toward the McGregor River (D. Minty pers. comm.). This route coincided with the location of an important crossing along an old road descending from the hills adjacent to mile 11.5 on the Pass Lake road (D. Minty pers. comm.).

Examination of this area was facilitated by a large network of logging roads providing access into previously remote areas. Many observations occurred near logging roads and were reported by forestry personnel. In 1976, seven sightings were made. Groups of at least four caribou appeared four times along Sande Road (mile 9) during July and August (Appendix D). A single cow was reported in September. Another lone female was sighted near the Cargyll Road in mid-August. Several other observations were noted. Small bands, or their tracks, were seen between May and July in alpine areas near Severeid Creek and Pass Lake (Appendix D).

Thirteen sightings were recorded during 1977. Most occurred between March and June. Caribou again were seen on the Sande Rd. near mile 10. Three spring-summer observations were made along Pass Lake road, near mile 17, and from mileposts 22 to 25. During September, two bulls, seven cows, and two juveniles occured near mile 8.5. Individual sightings of single caribou were made close to the Torpy and Severeid roads during June (Appendix D).

Use of the Severeid Creek and Pass Lake areas continued. Two late-spring, high-elevation sightings were made near Severeid Creek. The more notable was a calving site (Appendix D). Pass Lake was visited at least three times by caribou from May until June. The largest group, four cows and two juveniles, fed in summer habitat along Pass Lake ridge. Caribou also were seen along Woodall Creek, southwest of Mt. Severeid. Two animals briefly fed in a fir-spruce forest.

One band of at least 45 caribou occurred here during the late 1940's, and the presence of several well-known migration corridors suggested greater numbers. However, most contemporary sightings consisted of less than 6-8 caribou (Appendix D). The largest group observed was comprised of 12 animals. Populations between the Torpy and McGregor rivers probably have decreased rapidly since the mid-1960's (K. Hooker pers. comm.). The situation was very similar in the vicinity of Woodall Creek and the Torpy River (D. Minty pers. comm.; S. Wlasitz pers. comm.). Bands no longer seem to travel from Bear Paw Ridge to the McGregor River or from Key and Crotch creeks to the headwaters of Woodall Creek (R. Mueller pers. comm.; S. Wlasitz pers. comm.). Certainly caribou were not present in their former abundance, and most likely a maximum of 3-4 bands currently occupy the entire zone. The total population size probably does not exceed 60 animals and likely is somewhat lower (Table 5-3).

i. north of the Fraser River Valley and between the Torpy River and Fraser River (Zone i)

Betweeen 1945 and 1969 a large number of caribou frequented the area near Hansard (D. Minty pers. comm.). During the early 1960's, approximately 75-100 caribou gathered annually in October near the current location of the McGregor logging camp (D. Minty pers. comm.; S. Wlasitz pers. comm.). Many caribou wintered along the Fraser Valley between Hansard and Penny. In the fall of 1918 approximately 100 caribou crossed the Fraser River here (Appendix F).

The history of wintering caribou near Longworth dates back before the 1930's (T. Berg pers. comm.). Existing evidence connects the destruction of the Lendrum game trail with construction of the Longworth access road (D. Minty pers. comm.). Large, nearby muskegs also were used by caribou (R. Mueller pers. comm.). An albino caribou was seen travelling in a group of 15-20 animals near here during the autumn of 1959 (D. Minty pers. comm.).

Halfmoon Lake also provided important habitat, especially between October and March (D. Minty pers. comm.). Another key wintering area was Toneko Lake (J. Gasprey pers. comm.; D. Minty pers. comm.). A travel route was suspected to connect important habitats lying between Sinclair Mills and the lake (S. Wlasitz pers. comm.). Abundant caribou were resident in the vicinity of Sinclair Mills and Bear Paw Ridge as early as 1929 (D. Minty pers. comm.; R. Mueller pers. comm.). As recently as 1970, large groups also were evident near Red Mountain and along Redmountain Creek (J. Boudreau pers. comm.).

Several key historic sites were visited periodically without success. Caribou were not evident near Hansard, Toneko Lake and the confluence of the Fraser and McGregor rivers or along the Longworth road. Only small groups were sporadically reported in the vicinity of McGregor and Sinclair Mills.

Two summer sightings occurred near Mt. Averil, in wet meadows at about 1300 meters. On three occasions wintering groups of 8-15 caribou were observed north of Penny and east of Red Mountain. One band fed in a cedar-hemlock stand whereas the others were observed in high elevation, fir-spruce forests.

A pair of summer sightings were made in proximity to the confluence of the Torpy and West Torpy rivers. The only other observation was made near the Longworth Lookout during July. One bull and a lone calf appeared in a forest opening at 1525 meters. Large groups of caribou formerly were known to inhabit this area for many years (Appendix F). Bands occupied important wintering areas and travelled several historically used migration routes. However, recent industrial activity and settlement is widespread. Wintering groups were reduced in size and never consisted of more than 8-15 animals. Caribou were consistently absent from historic areas and often occurred as solitary animals or in small bands. Overall abundances were poor and current totals probably consist of less than 40 caribou (Table 5-3).

j. comparative overview

Population numbers have declined in all areas; only the magnitude of the decline varied among zones. In many cases zone totals did not approach the largest groups reported historically. Although comparative totals for each geographical unit and the study area are somewhat imprecise, they demonstrate a serious population decline. Even the most liberal estimates would not place the total population above 500-600 caribou. Current caribou populations probably range between 250 and 300 animals.

3. Contacts between population groups

Little is known about the home range of mountain caribou (Layser 1974). Daily movements are somewhat of a mystery, though some inconclusive information is available.

Barren-ground caribou apparently can cover great distances easily. Individual animals have moved for short distances at speeds approaching 80 kph (Banfield 1951). Skoog (1956) observed a band of caribou travel about 10 kilometers in 20 minutes.

Daily movements also may be great. Average travel speeds of the Kaminuriak herd in Northern Canada ranged from 15 to 40 kilometers per hour (Parker 1972). Another barren-ground caribou herd reportedly moved 65 kilometers in a single day (Banfield 1954). Spring migrations varied between 25 and 50 kilometers daily (Kelsall 1968).

Some limited information was available for woodland and mountain caribou. Bands in and near Wells Grey Park covered distances of 15-25 kilometers within a few days (correspondence from R.W. Ritcey to P. Flinn on April 17, 1956). Caribou travelling along the Bowron River were thought to cover 25-30 kilometers daily (G. Hooker pers. comm.). During February, 1977, a group of 12 caribou covered a distance of approximately 10-12 kilometers in 30 hours (Appendix D). However, Carbyn (1967) indicated that undisturbed populations of woodland caribou probably do not travel great distances and demonstrate short seasonal migrations. Some uncertainty exists.

The existing historic evidence strongly implies contacts occurred between neighboring bands throughout the study area and beyond. Herds once ranged from Raven Lake to Bowron Lakes Park and might have reached Wells Grey Park (G. Hooker pers. comm.; M. Frye pers. comm.; O.J. Prather pers. comm.). The distances involved ranged from 48 to 132 kilometers. Caribou also probably reached Bowron Lakes Park from the Goat River watershed and wintered along the Cariboo River (D. Ferguson pers. comm.).

Movements from Wells Grey Park are further evidenced by a travel corridor from Mt. Quanstrom, north between the Dore River or Castle Creek to the Chalco, McKale and Holmes rivers, where many caribou summered (D. Ferguson pers. comm.).

Caribou moved from the headwaters of West Twin Creek to Mt. Rider (D. Ferguson pers. comm.). Reported movements between Mt. Halvorson and the McKale River, along Clyde Creek, probably substantiate suspected interchanges. Prior to the mid-1960's bands located along Fleet, LaSalle and East Twin creeks regularly contacted caribou occupying areas south of the Fraser Valley and between the Goat River and West Twin Creek (D. Ferguson pers. comm.). Contacts also occurred west of Dome Creek. Caribou resident between Sinclair Mills and Penny probably contacted bands from Sugarbowl Mountain to Slim Creek, 25-40 kilometers southwest.

Other important movement routes across the Fraser Valley existed near Purden Lake, Longworth and Kenneth, Hungary and Driscoll creeks and provided ample opportunity for contact (K. Hooker pers. comm.; F. Knapp pers. comm.; O.J. Prather pers. comm.). Caribou regularly travelled through the area (Appendix F).

West of the Willow River, interchanges were unclear, but based on caribou travelling habits, regular contacts were highly likely. Groups once typical to Mt. George probably arrived from the south and east (M. Warren pers. comm.).

Population interchanges are presumedly possible between caribou in east-Central British Columbia and west-central Alberta (B. Duncan pers. comm.; C. Fox pers. comm.; F.J.

Pruckl pers. comm.). Historically caribou travelled the Chalco, Holmes and Morkill river drainages to their headwaters and Loren Lake (D. Ferguson pers. comm.). Large groups of caribou traditionally were found on Bastille, Buchanan, Sheep and Cushing creeks and the Narraway and Kakwa rivers (Alberta Fish and Wildlife Division; B.C. Fish and Wildlife Branch; M. Monroe pers. comm.; F.J. Pruckl pers. comm.). Other large bands travelled along the Morkill River into Willmore Wilderness and Jasper National Park (B. Duncan pers. comm.; C. Fox pers. comm.). Consequently, contacts as far east as Alberta probably occurred.

Though it was generally accepted that contacts occurred, the nature and importance of interchange was difficult to interpret. In retrospect, it seems most likely that somewhat discrete units occupied vaguely defined "home" ranges and dispersed and joined as seasonal conditions and forage supplies dictated. Periodically bands formed larger groups, perhaps during the rut when large herds were reported. Individual movements and physical abilities, related to sex and age group, also might have influenced the timing and composition of aggregates. However, because the vast and remote character of historical caribou ranges would allow large-scale population changes and redistributions to go unnoticed, the picture remains unclear.

The limited number of reports and observations and the absence of telemetry equipment made assessment of current contacts very difficult. Opportunities were further restricted by a small population and a large study area. Nonetheless a few key points were of interest.

Historic and contemporary distributions were similar. Although some local extirpation occurred, most areas simply experienced large reductions in population size. Consequently it was assumed that the opportunity for similar contacts remained, although current movements were more localized and largely altitudinal in nature.

Restricted contacts may be more correctly attributed to diminished opportunities rather than reduced population size. Barriers associated with human activity probably have caused increased band isolation and decreased inter-group contacts. Some migration routes also have been destroyed (Appendix G). As a result contacts with adjacent bands have been considerably reduced, and breeding activity may have been seriously hampered. At the same time hunting pressures have increased. The issue, more appropriately examined in Chapter VI, is disruption of movement patterns, discontinuity of range and the loss of herd traditions due to regional development and a concomitant population decline.

4. Areas of special significance

a. travel corridors and migration routes

Several movement routes appear to remain in use but on a limited basis. Six sightings were made along the Slim-Tumuch road between mileposts 19 and 25. These observations demonstrated continuing use of a travel route connecting areas south and west of Tumuch Lake with key locations between Slim and Papoose lakes and perhaps along Slim and Driscoll creeks. A particularly important crossing appeared to be located east of mile 23 (B Weinard pers. comm.; O.J. Prather pers. comm.). Caribou also travelled through in the vicinity of mile 14 (Appendix G). Once during March, the tracks of a small band occurred near Driscoll Creek south of a crossing at Highway 16. The road lies perpendicular to north-south movement corridors. The caribou appeared to head north, and the route easily could have been an extension of the Tumuch-Papoose corridor.

Caribou crossed the highway west of Dome Creek in several other locations. Winter tracks east of the Purden Lake area implied travel through the Bowron River watershed, perhaps along Kenneth Creek and north at least to the Fraser Valley. Hungary Creek was near another important crossing. Four times during February and March, caribou crossed the highway while moving north (Appendix G). Animals travelling from areas south of Slim and Tumuch lakes and bands from

Sugarbowl Mountain may have followed this corridor.

Regular crossings also occurred east of Dome Creek. Use of a corridor connecting the Goat River and Mt. Rider areas continued. Wintering caribou crossed the highway near LaSalle Lakes and LaSalle and Fleet creeks (Appendix G).

The West Twin Creek crossing is perhaps the best known movment route. Caribou were seen in the vicinity seven times during the study (Appendix D). All known activity occurred between October and May. Movements were suspected to link ranges as far south as Mt. Halvorson with the Mt. Rider-Cushing Creek area. Two additional crossings were observed about 15 miles west of McBride. Both occurred during the winter and consisted of mixed bands (Appendix F). By 1977, the crossing point appeared to shift east. In October four cows crossed at Legrand Creek. During December three females moved north along Clyde Creek.

Movement corridors oriented east to west and distant from the highway were not as obvious. South of highway 16, caribou travelled from Sugarbowl Mountain, probably along Kenneth Creek, and south toward Centennial Creek. Additional activity was detected along Haggen Creek, northeast of Dominion Creek. Animals also moved along Ptarmigan Creek, north of Mt. Hammell.

North of the highway movement patterns were equally unclear. Bands assumedly travelled north of the Torpy River, north of Red Mountain and south of Harvie Creek, north of Pass Lake and to the vicinity of Mt. Severeid (J. Boudreau pers. comm.; B. Meinard pers. comm.). Movements were suspected along Woodall Creek to its headwaters (Appendix G). Some animals appeared to deviate from this route between Gleason and Harvie creeks and headed northeast toward a pair of unnamed lakes north of Mt. Hedrick. Two observations were made here (Appendix D). Caribou also crossed the Pass Lake road (Appendix D). Principal corridors appeared to be situated between mile 9.5 and mile 11 and near milepost 17.

Some evidence demonstrated movements from the Fraser Valley, along Redmountain Creek, to the Torpy Valley and north toward the McGregor range. Other movements were suspected between the headwaters of the McGregor River and Walker Creek. Caribou along Forgetmenot Creek probably travelled the Morkill Valley, but may have continued west along Walker Creek.

b. Wintering areas

Habitat studies demonstrated the seasonal mobility of mountain caribou. Range rotation was important, particularly during winter. Other studies concurred (Edwards and Ritcey 1960; Evans 1960; Freddy 1974; Hamer 1974). Consequently, the apparent absence of caribou from a particular location must not be misconstrued as abandonment or disuse.

Figure 5-5 illustrates the most likely boundaries of present, known wintering areas. Each boundary represents a careful collation of survey results, distribution maps, reported sightings, interviews and questionnaires. Important wintering areas were specifically discussed in the section on distributions and important range areas. Descriptions were limited to areas of known caribou use and represent the minimum of important winter range.

c. calving and breeding areas

The calving habits of mountain caribou remain somewhat of a mystery. Calves were seen on only three occasions (Table 5-1). Initially it was thought caribou calved in mid-elevation, forested habitats concealed from predators (Bergerud 1975; J. Stelfox pers. comm.). Historical evidence basically supported this position (D. Ferguson pers. comm.; M. Frye pers. comm.). Forested muskegs, similar to those located west of mile 11 on Pass Lake road and near Papoose and Narrow lakes, were considered typical calving sites (O.J. Prather pers. comm; S. Wlasitz pers. comm.). However, during June, 1977, afterbirth from a single cow was discovered near Mt. Severeid, in a snowfield at about 1570 meters. Whether this was an anomaly, indicative of typical calving, or a demonstration of variable calving behavior is unknown. Freddy (1974) suggested that calving caribou may select, open, high-elevation slopes on southern aspects. The evidence remains inconclusive.

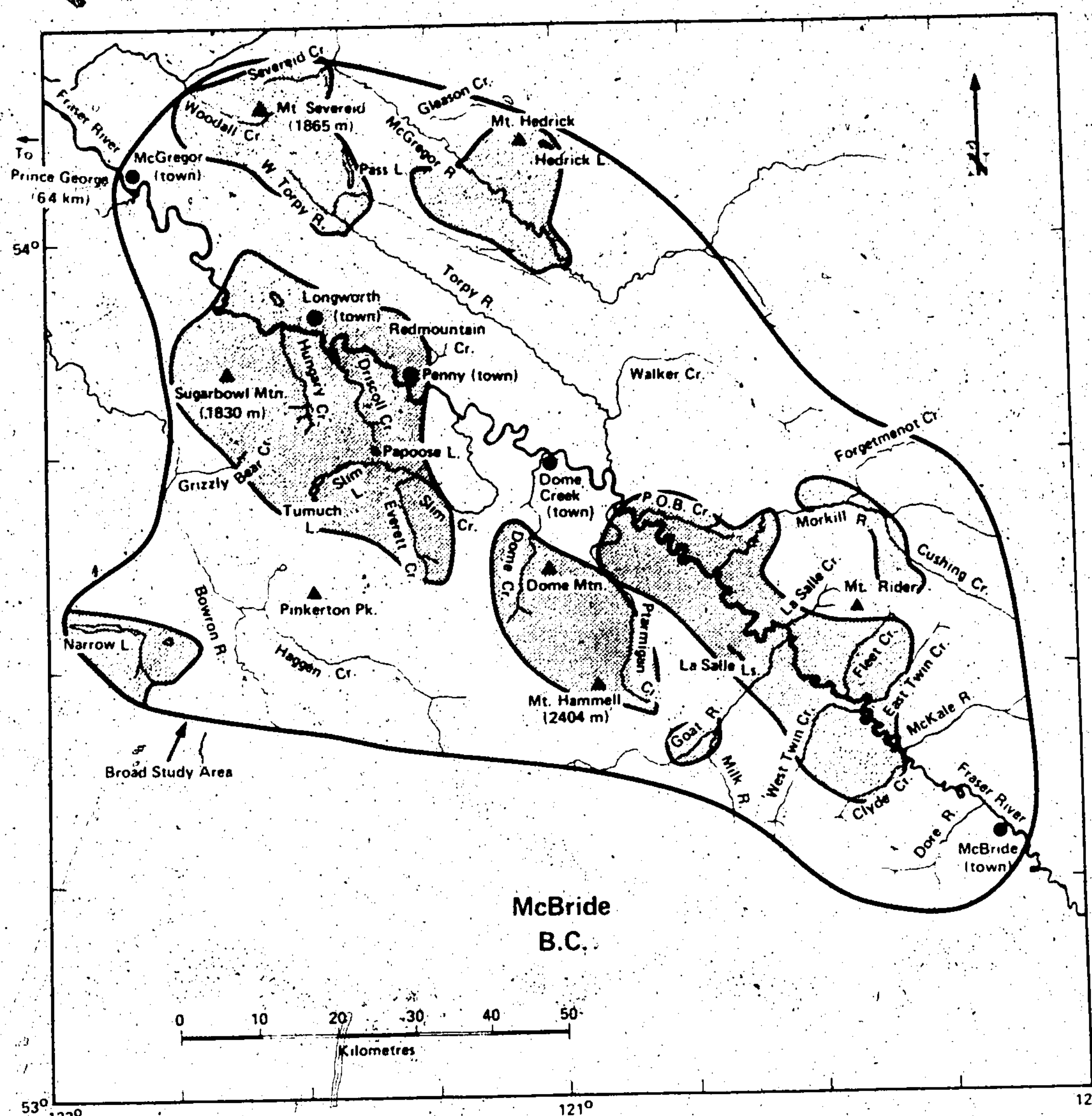

Figure 5 - 5 Important Caribou Wintering Areas In Central British Columbia

The breeding period extended from late September to mid-October. Breeding activity occurred in various locations but primarily in treeless areas near and just above timberline. The rut was largely localized in timberline meadows and krumholz areas. During the rut caribou seemed to coalesce into larger groups but random movement patterns and small population sizes complicated identification of specific rutting areas. However, interview and questionnaire results and the historic location of large autumn bands illuminated several possible breeding sites.

The Raven Lake area supported sizeable autumn herds from 1935 until the late 1960's (O.J. Prather pers. comm.). During 1955 a large group was seen at the confluence of Slim and Everett creeks (J. Gasprey pers. comm.). As recently as 1962, fall groups of 20-50 animals were typical near the headwaters of Dome, Slim and Ptarmigan creeks (G. Hooker pers. comm.).

Several other probable breeding areas have been identified north of the Fraser River as well. Caribou were believed to rut near the headwaters of the Morkill River, Hardscrabble Creek (Alberta) and the Holmes River (B. Duncan pers. comm.). Other suspected areas included Loren Lake and sites between Mt. Rider and Fleet Creek (D. Ferguson pers. comm.). The headwaters of the McKale River may have provided another location (M. Frye pers. comm.).

Further west, caribou were presumed to breed near Toneko Lake, at the confluence of the McGregor River and Cargill Creek and north of Hansard Lake, where the McGregor River empties into the Fraser River (D. Minty pers. comm.; S. Wlasitz pers. comm.). Some breeding may occur in the Red Mountain-Penny area where fall activity has been historically high (J. Boudreau pers. comm.; J. Gasprey pers. comm.). Pass Lake was considered another likely breeding area (anonymous questionnaire respondent).

d. mineral licks

Caribou are known to use natural licks for at least some of their mineral requirements (Calef 1975; Cowan 1949). It is suspected that this practice is particularly important for juveniles and gravid females. In recent years, salts used for winter road maintenance may have provided a supplement or substitute. Figure 5-6 illustrates the location of mineral licks used at some time by caribou. Most sites require further examination and should be protected from damaging activities.

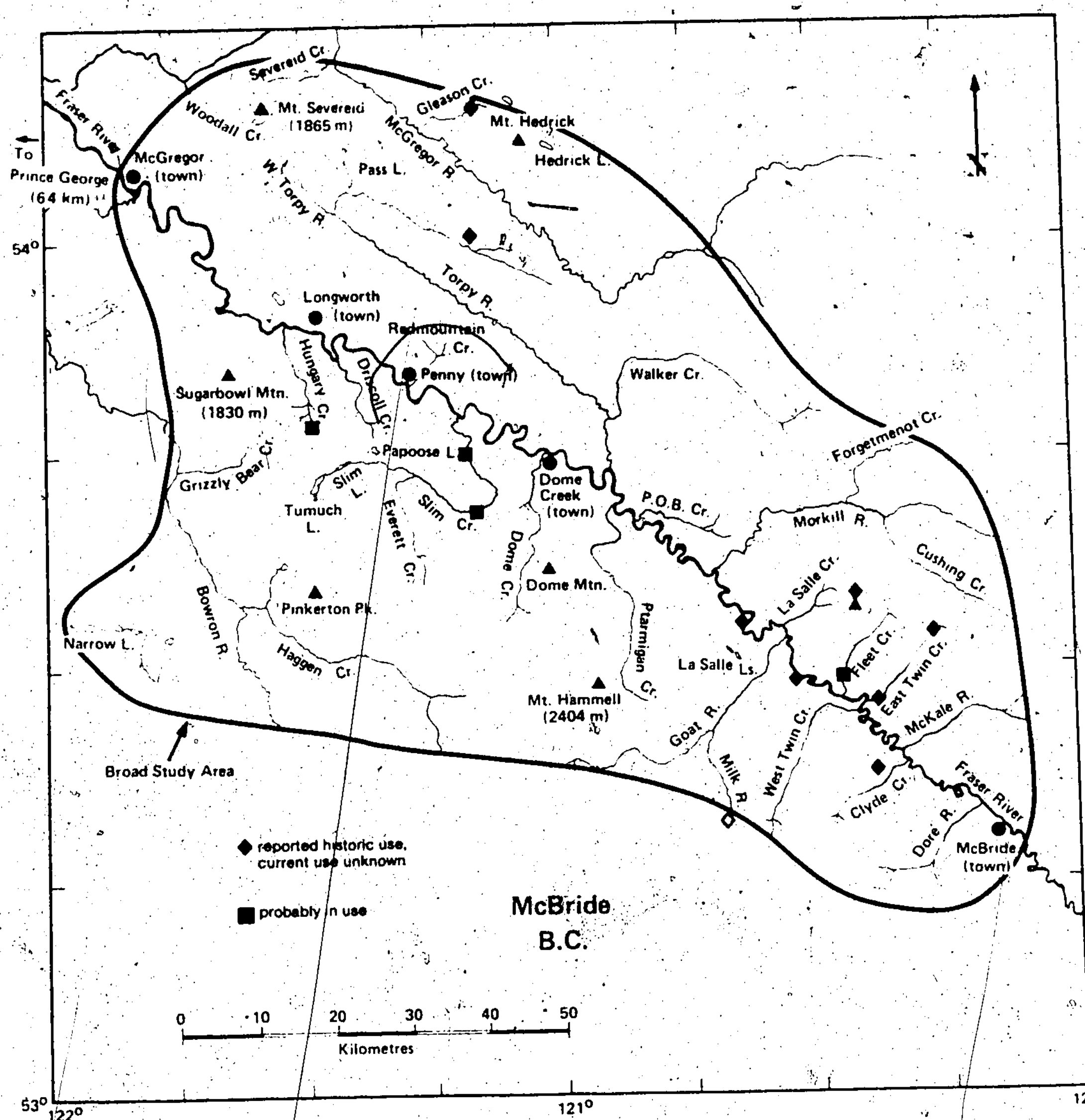

Figure 5 - 6 Mineral Licks Used by Caribou In Central British Columbia

VI. IMPACT OF DEVELOPMENT, SETTLEMENT AND ASSOCIATED ACTIVITIES ON MOUNTAIN CARIBOU

A. Cumulative Effect Concept

Caribou are a sensitive component of a dynamic biological system. Various interacting factors influence their biology and ecology. In recent years the effect of man's activities has intensified and become the predominating influence. Mutually exclusive hypotheses about population declines are untenable. The decline in numbers of mountain caribou in Central British Columbia appears attributable to the cumulative effect of several major factors. Habitat destruction, increased access and recreational hunting played principle roles. Most of the damage to the population probably occurred between 1960 and 1974. To facilitate discussion, component factors are examined individually. Emphasis is placed on the critical time period. The implications of other pressures on declining populations also are examined.

B. Major Causes Of The Decline And Mitigative Measures

1. Habitat destruction

Mountain caribou rely heavily on mature and overmature, lichen-bearing forests particularly during winter (Chapters III and IV). Climax communities provided the essential elements of food and shelter. Several other studies in

British Columbia demonstrated the necessity of climax forests for winter survival (Edwards 1956; Edwards and Ritcey 1956, 1960; Freddy 1974). Consequently, reductions in caribou populations frequently have been associated with the decline of climax communities (e.g. Cringan 1956; Edwards 1954; Fashingbauer 1965; Freddy 1974; Layser 1974). The restricted availability of food becomes the critical factor limiting populations, though secondary influences are of equal importance.

a. fire

Caribou are affected by fire through loss of cover and winter forage. Arboreal lichen pastures flourish in climax communities but require many years to develop (Ahti 1962; Hale 1974). In some areas fire was a major factor causing declines (Cringan 1958; Edwards 1954; Johnson and Rowe 1975; Scotter 1970). Though forest fires were common in the study area, they did not appear to be a principle factor. Nonetheless fire destroyed caribou range in certain key areas and was part of the cumulative effect.

Fire histories already have been reviewed to 1940 (Chapter II). The most severe damage was sustained from 1960 to 1969 (Appendix C). This period was central to the decline syndrome. Approximately 27,635 hectares of timberland were burned. Many important range areas were affected, most notably the Hungary Creek-Slim Lake area, Papoose Lake and the Driscoll Creek, MacClaurin Creek, Lunate Creek, Everett Creek, Slim Creek, Haggen Creek and Dominion Creek watersheds. The two largest fires occurred near Tsus Creek and Haggen Creek. Fire damage north of the Fraser River Valley was even more severe (Appendix C).

b. [illegible]g

Forests represent complex and dynamic ecosystems. Intensive logging operations dramatically restructure plant communities and greatly influence critical resources, including food, water, shelter and space. Mountain caribou exhibit high sensitivity to successional change and consequently are strongly affected by forestry practices. Direct consequences include the loss of key habitats, particularly travel routes and breeding, calving and wintering areas. Important secondary effects include barriers to movement, range discontinuity, increased human access and harassment.

Logging operations in the study area were relatively insignificant prior to 1960 (Chapter II). However, in subsequent years the forest industry became the mainstay of the region's economy. Small, selective logging operations were replaced by intensive, highly mechanized clearcutting systems. Timber harvesting became the major land-use activity. Habitat alienation no longer consisted of gradual attritition but characteristically was comprised of abrupt and large scale changes. The vast majority of caribou range is prime timber-producing land. Consequently, mature and overmature forests, critical to caribou survival, are threatened: The implications are great and numerous. Many local residents, resource managers and sportsmen attributed caribou declines directly to habitat destruction.

Ecologists have expressed concern about management practices creating simplified ecosystems. Though northern forests exhibit natural diversity, the prevailing forest harvesting practices produce large, single species, even-aged stands. The overall results include truncated succession, snag removal and the loss of old-growth forested habitats (Bunnell and Eastman 1976; Telfer 1976). The goal of this approach is to return forests to production immediately after logging. However, removal of substantial amounts of timber over extensive areas during intensive harvesting programs is incompatable with caribou management and contrary to the concept of multiple resource management (Pengelly 1972). Acceleration of early successional stages, usually through scarification, artifical regeneration and control of competing vegetation, reduces the period of browse and herbage availability (Pengelly 1972; Telfer 1976). Forage production is substantially higher and continues for a longer period in unscarified stands (Stelfox 1962; Telfer 1974). Lost old-growth habitats also represent reductions in escape and thermal cover and food. Current management practices increase and intensify timber stand utilization and accelerate the re-establishment of commercially productive forests through reduced rotation periods. A timber industry with the unilateral objective of maximizing production of wood products and maintenance of young, maximum yield forests, will be in direct conflict with caribou management in several ways.

(1) Loss of calving sites, mineral licks and migration routes

Traditional movement routes provide corridors between wintering areas and are crucial to the maintenance of patterns of use between and within watersheds (Freddy 1974). Protection is critical to the sustenance of mountain caribou herds. Particular attention must be directed to preservation of essential routes across Highway 16, connecting ranges north and south of the Fraser River Valley and promoting rotational use of wintering areas. Protective cover should be retained or restored wherever crossings intersect existing access (Peek 1975). Forest cover is equally important along movement routes and should be a minimum of 400 meters wide. Considerable effort should be made to minimize or eliminate development and disturbance along and within all existing and suspected movement corridors. Figure 5-3 illustrates the location of known movement routes described in Appendix G.

Mineral licks, calving sites and breeding locations are seasonally important to caribou bands. Figure 5-6 illustrates the location of mineral licks used by caribou. Several breeding sites and tentative calving areas have been identified (Chapter V). All known and probable sites should be protected. Each location requires further investigation. Adequate forest cover is required to allow continued use of special areas free from harassment. These areas should be surrounded by timber reserves at least 400 meters in diameter.

(2) Loss of wintering areas

The survival of caribou populations is intimately related to the presence and quality of arboreal lichens and climax plant communities. On a seasonal basis, caribou were active in mature and over mature forests about 50% of the time (Chapter III). During the winter, epiphytic lichens were the dominant dietary component (Chapter IV).

Forest characteristics accounted for much of lichen variability, and many lichens were substrate-specific (Bloomfield 1979). The interrelationships among stand-age, height and luxuriance were extensive in stands exceeding 250 years. The most luxuriant and accessible lichen pastures grew in cool, humid fir-spruce forests, and particularly in moderately stocked stands between 140 and 250 years old and 30 to 50 meters high (Bloomfield 1979). Mature cedar-hemlock-spruce forests were critical during early and mid-winter (Chapter III). Lichen development also was extensive adjacent to wet areas. Caribou demonstrated preferences for moderate slopes, particularly in basins and along watercourses where forests and lichens were most productive.

Early successional forests cannot supply necessary winter foods. Caribou are not browsers and consequently were not attracted to young stands. Reductions in climax forests have been followed by decreases in caribou populations, particularly when they occur at optimum densities (Chapter I). Cringan (1958) demonstrated that carrying capacities of one woodland caribou/five square miles (8 km²) in forests over 150 years were reduced to one caribou/100 square miles (160 km²) in stands 91-150 years old. Where the limiting factor is not food, timber extraction may be at the expense of herd traditions and range rotation. Extensive timber harvesting removes large tracts of mature and valuable lichen-producing forests and threatens the maintenance of critical caribou habitat (Freddy 1974).

One concept proposed for caribou management is the designation of special-use areas. Although this may eliminate logging and provide habitat and movement routes, additional critical areas between and beyond designated locations may be omitted (Freddy 1974). Harvestable timber must be sacrificed in key areas and a continuum of adequate and sufficient habitat provided if caribou survival is to be assured.

Key wintering areas at lower elevations must be protected and are illustrated in Figure 5-5. Mature forests, fir-spruce and cedar-hemlock-spruce, provide cover and lichen forage between October and May. Protected areas must be sufficient to accomodate the slow growth and recovery of lichens and be linked by corridors of mature timber (Evans 1960). Specific areas are discussed in Chapter V.

Almost 50% of all sightings occurred above 1350 meters (Table 3-3). Caribou extensively used mature fir-spruce stands supporting the greatest lichen loads. Excepting the period between late October and January, caribou most frequently were found here (Table 3-3). The importance of subalpine forests between 1100 and 1675 meters cannot be overstated. They provided the essential resources of cover and food for a considerable portion of the year (Chapters III and IV).

Successful caribou-forest management hinges on a serious reappraisal of logging policies and practices. The first step should encompass a reduction in the volume of timber extracted in any basin. A maximum of 1/3 of the merchantable timber should be harvested in a rotation period from any drainage in sensitive areas (Johnson et al. 1977). Short rotation cutting, particularly adjacent to previously cutover areas, does not represent compatible forest-wildlife management (Pengelly 1972). Rather than concentrating timber harvests in large cuts, removal should be dispersed over larger areas and in a 3-4 cut-cycle. In addition, residual stands of natural cover must be preserved (Telfer 1974). Movement corridors are required to interconnect and promote full utilization of retention areas.

The size of individual cuts in caribou habitat also require reductions. Further consideration must be given to selective logging and small patch cuts particularly in known and suspected winter ranges. Patchcuts smaller than 15 hectares and with irregular shapes would mimic the configuration of natural openings, retain adjacent and connecting forest cover, perpetuate climax, uneven-aged stands and promote lichen growth and terrestrial forage development. However, to be of value, partial cuts must not substantially reduce the overall age of any stand and should provide a source of lichen dispersal (Ahti 1962; Freddy 1974).

Selective logging, without disrupting normal patterns of movement and resource utilization, would create small openings and stimulate the growth of understory vegetation, including arboreal lichens. Openings smaller in diameter than the average tree height would reduce windfall damage while maintaining other land-use values (Alexander 1971; Spurr and Barnes 1973). Tree-length logging also would produce more efficient use of timber (Johnson et al. 1977).

Another alternative involves distributing clearcuts within individual drainages according to caribou use (Freddy

1974). Local caribou habits would be incorporated into harvest plans. Logging activity could be continued on a restricted basis in areas not used by caribou, providing provisions were made to protect movement routes and retain sufficient buffers adjacent to caribou habitat (Freddy 1974).

Merchantable timber in areas infrequently used by caribou might be harvested in a similiar manner if critical areas including movement routes were protected (Freddy 1974). For either practice to be acceptable, other harvest methods would have to be greatly restricted and priority given to retention of adequate coniferous stands providing for travel corridors and sufficient lichen growth to support wintering bands.

However, each alternative requires intimate knowledge of local caribou distributions and habits. Implementation without prior knowledge could pose serious problems by producing consequences similar to current, indiscriminate logging practices.

Timber harvest practices in areas important to caribou survival should incorporate several other features. Epiphytic lichens were abundant in humid, moderately stocked forests adjacent to lakes and muskegs (Bloomfield 1979; Richardson 1973). Wintering caribou regularly foraged there (Chapter III). These areas should be protected in their natural state whenever they occur in caribou range.

Developmental and recreational disturbances should not be permitted within 400 meters (Johnson et al. 1977). The recent absence of caribou from the LaSalle Lakes area and similiar reductions in the vicinity of Raven Lake probably demonstrate the consequences of unrestricted activity.

Subalpine forests above 1550 meters should be preserved in their entirety (Layser 1974). These areas are critical to mountain caribou during periods when terrestrial vegetation is limited or unavailable. An additional benefit would be protection of watershed values which are high near timberline and can be easily damaged by current timber harvesting activities (Ritcey 1974).

Fire suppression in and adjacent to important range should be given high priority (Freddy 1974; Ritcey 1976). In some instances fire protection practices have been as harmful as wildfires. Slash burns have escaped and destroyed critical caribou range (Ritcey 1976; Appendix C). Current logging practices without close utilization produce considerable slash that necessitates broadcast burning (Bunnell and Eastman 1976). Despite potential reductions in forage accessibility and growth, slash should be allowed to decay naturally unless an extreme fire hazard can be demonstrated (Ritcey 1974). Lopping and scattering slash will overcome this problem. In addition, fire protection policies should be upgraded in the subalpine range although roads created for fire control must be closed to the general public (Freddy 1974; Ritcey 1976).

Heavy commitments to timber harvesting severely restrict opportunities to maintain caribou range in drainages already affected by substantial habitat losses (Ritcey 1976). Furthermore, current forest-caribou management guidelines do not incorporate previously altered habitat into their framework. Remaining caribou populations cannot be protected without a reduction in the annual allowable cut or a lengthening of the rotation period, perhaps from 150 to 250 years. Reductions in the annual cut probably could be compensated by a closer utilization of timber resources.

(3) Barriers to movement

Debris and steep banks, resulting from clearing right-of-ways, may hamper caribou movements and must be removed when they occur within travel corridors (Johnson et al. 1977). Impassable barriers of debris on downhill slopes and steep, uphill cutbanks result from construction of roads on precipitous, heavily timbered slopes. To allow unimpeded movement in both directions, barriers must be broken (Pengelly 1972). Construction of potential barriers, including pipelines, powerlines and permanent roads, must not proceed without consulting the appropriate land and wildlife management agencies (Johnson et al. 1977). Roads into sensitive areas should be closed to public access, recontoured and returned to their original state.

Other barriers to movement, including long windrows of logs, residual slash and stumps, are produced by current logging practices. Windrows should be distributed and oriented in the direction of animal travel. Log landings must consider traditional movements and should be constructed and utilized with minimal impact on special areas. Current practices produce sizeable amounts of almost impassable slash and stumps. Closer timber utilization will reduce residual debris. The remaining materials should be distributed to reduce their impact on the freedom of animal movements (Pengelly 1972).

The overall impact of cumulative barriers effectively causes the isolation of individual bands and reduces opportunities for inter-group contact. Ultimately, wide-ranging traditions are lost, and locally isolated bands will be subjected to intense pressure from industrial and recreational activities.

Disrupted patterns of movement and behavior may have several important consequences. A connection has been demonstrated between disrupted movements and breakdowns in social structure (Espmark 1970; Klein 1971; Miller et al. 1972). Reindeer exhibit strong traditional movements along definite routes and adjust to route realignments with great difficulty (Klein 1971). Ultimately, traditional patterns of movement and range use are abandoned.

Various factors, including highways, dams, logging roads and cuts, railroads and fences create barriers to movement. Banfield (1974) demonstrated that seismic lines also disrupt movements and probably cause band fragmentation. Some additional evidence indicates hesitancy to cross under power transmission lines. It has been suggested that reindeer are disturbed by the buzz from powerlines (Klein 1971).

Caribou confronted by impassable barriers have two alternatives: delay movements until the obstacle is removed or deviate from traditional patterns (Miller et al. 1972). Delays interrupt normal range rotations and increase the chance of forage over-utlization, predation and social disorganization. Permanent barriers probably cause range discontinuity, increased localized movements and lost herd traditions. Isolated bands would be more vulnerable to over-exploitation.

Adjustments in route alignments also would destroy herd traditions and cause increased vulnerability by forcing caribou into unfamilar areas (Miller et al. 1972). The appearance of novel stimuli, through either alternative, would alter activity patterns and produce concomitant physiologic changes (Geist 1971). The after-effects of harassment and the energy costs of excitation may be considerable. The consequences may be injury, illness, death or a reduction in reproduction. Another major impact is the avoidance or abandonment of previously utilized areas.

2. Access and hunting

a. highways and logging roads

Transportation facilities cause problems in addition to the creation of barriers. Improved access significantly increases the impact of human contact. The consequences develop dramatically for populations, like caribou, unable to withstand large harvests (Lynch and Pall 1973).

The Yellowhead Highway (No. 16) was constructed from 1958 to 1969 and was the first route south of the Fraser River Valley (W.R. Ball pers. comm.). Hunting was permitted during construction and the new access was not controlled by special restrictions (G.D. Gosling pers. comm.). Since 1973 discharge of firearms within 1/4 mile of the centre line has been prohibited (G.D. Gosling pers. comm.).

Unrestricted access and hunting along the highway posed certain dangers. Caribou movements intersected the highway in at least five locations (Appendix E). Animals crossing the highway were exposed to dramatic increases in hunting pressure and probably were particularly vulnerable because of the lack of cover and a hesitancy to cross the new road.

Zone b (Figure 5-1) provided a good example. Bands increased until 1967-1968, when the adjacent portion of the highway was completed (W.R. Ball pers. comm.; O.J. Prather pers. comm.). Construction workers and resident hunters killed large numbers of caribou in the vicinity of highway crossings between Kenneth and Hungary creeks and east to Driscoll Creek (O.J. Prather pers. comm.). Caribou declines also were attributed to interference with migration routes, road kills, poaching and harassment (D. Ferguson pers. comm.; K.W. Hooker pers. comm.; O.J. Prather pers. comm.). In addition highway construction greatly stimulated logging development and further creation of access (F.L. Turner pers. comm.).

The principal influence of logging roads is provision of access to hunters (Lynch and Pall 1973). Access to previously remote caribou range has been provided by a vast network of logging roads constructed since the early 1960's. Virtually every watershed in the study area is now accessible and access remains uncontrolled.

Despite numerous attempts, the total mileage of existing logging roads could not be obtained (D.L. Oswald pers. comm.; R. Weinard pers. comm.). However, during 1976, main road construction consisted of approximately 9.6, 8.0 and 11.2 kilometers in the Purden, Longworth and Monkman Forests, respectively (F.L. Turner pers. comm.). In the Longworth Forest, 468 hectares of land are occupied by roads (Table 2-5). Numerous kilometers of sideroads and skid trails exacerbate the access problem.

Excessive local harvest may be obscured by increased access to previously remote ranges and unexploited populations because of large kills in newly exposed areas (Bunnell and Eastman 1976). High percentages of animals are harvested in close proximity to roadways (Lynch and Fall 1973; Murray in Bunnell and Eastman 1976). Nevertheless, no special regulations control hunting along logging roads (G.D. Gosling pers. comm.).

Measures are required to minimize the impact of increased access. Policies should promote the closure of side-roads, restrict access by permit and more intensively regulate hunting adjacent to all roadways. The quality of road construction should be at minimum standards, to facilitate closures and reclamation upon completion of logging and other industrial programs (Johnson et al. 1977).

b. recreational hunting

(1) Increased susceptibility to over-harvest

Several components of caribou biology and behavior greatly increase their susceptibility to over-harvest. Traditional habits, learned behavior, gregariousness and low reproductive potentials are most important. As a result caribou are more vulnerable to hunting than any other North American cervid (Bergerud 1974b).

Caribou often travel in groups and display nomadic behavior. Traditional migratory routes are used to reach important range components. Learned behavior patterns are acquired through association with older animals and regular movements probably simplify hunter access (Bergerud 1974b; Miller et al. 1972).

Individuals exhibit some wariness, but caribou, particularly in groups, are curious and may not frighten easily. Some variability exists by season, sex and age but caution may not remove animals from danger. Others appear to freeze when confronted by unfamiliar or disturbing stimuli. Furthermore, caribou have poor eyesight and apparently do not perceive danger at great distances (Bergerud 1974b; Kelsall 1968). Animals often react to motionless forms as inanimate objects, though they are remarkably perceptive of movements (Kelsall 1968; Pruitt 1960b). Caribou have been exploited by hunters silhouetting caribou shapes.

Caribou have low reproductive potentials, high calf mortalities and delayed onset of breeding (Chapter V). Twins are rare, perhaps due to selective pressure against multiple offspring (Bergerud 1974b). Calves rarely exceed 10-15% of the population (Chapters I and V).

(2) Excessive harvests

Over-hunting has been responsible for caribou declines in many divergent locations (Chapter I). Harvests generally were not adjusted to compensate for increased development, access and hunting pressure. Similiar relationships were demonstrated in the study area.

Population statistics were not available for the period prior to regional development, and calf productions were unknown. Consequently, carefully constructed population estimates were required to comparatively review annual harvests. Table 6-1 is a mathematical representation of the annual calf production for an undisturbed herd of typical density and reproductive capacity (Chapter I).

A carrying capacity of one caribou/8km² was assumed to be a reasonable estimate (e.g. Courtwright 1959; Cringan 1956; Moisan 1959). Estimates were based on habitat studies, historical distributions, snow conditions, lichen biomass estimates and previous caribou studies (Bloomfield 1979; Cringan 1956; Edwards et al. 1960; Schroeder unpubl. rept.; Scotter 1962; Wein and Speer 1975). Sex ratios, pregnancy rates, calf mortalities and sexual maturities represent typical values for caribou (Chapter I).

The net increment may be high for several reasons. It assumes 100% of the study area constituted caribou range and all pregnant females carry calves to term. Nevertheless, this theoretical representation utilizes the best available information and provides a useful estimate for examining the balance between recruitment and hunting mortalities.

Admittedly it is difficult to evaluate the relationship

Table 6-1 Mathematical Representation Of Caribou Calf Production Under Typical Conditions

Population Parameter		Key Sources
Total range in study area (approx. 11,700 km²)		Topographic maps
X Carrying capacity (1 caribou/8km²)		Ahti 1967; Cringan 1956; Edwards et al 1960; Lichen Biomass Studies
Estimated population size	= 1463	
X Sex ratio (bulls=37%; cows=63%)		Bergerud 1971b; Kelsall 1968; Skoog 1968
Total males	= 542	
Total females	= 921	
X 78% potentially breeding females*	= 719	Bergerud 1967; McEwan 1963; Parker 1972; Skoog 1968
X 70% females bred** (pregnancy rate)	= 503	Kelsall 1968; Skoog 1968
X 29% calf survival	= 146***	Bergerud 1967; McEwan 1959; Kelsall 1968; Skoog 1968

*% of female cohort which is sexually mature
**% of female cohort which has reached breeding maturity
***Probable annual calf increment

between mortality and recruitment. Previous population studies were not conducted and harvest statistics are estimated and do not predate 1954 (Child pers. comm.; Haley pers. comm.). However, the empirical evidence is substantial. The vast majority of people queried attributed the decline to excessive hunting. Several questionaire respondants suggested seasons applied to large areas were unable to accomodate disparities in local access and population size (F. Cushman pers. comm.; M. Wilkinson pers. comm.). The failure to restrict hunting along migration routes was cited as a decline-causing factor (F. Cushman pers. comm.; O.J. Prather pers. comm.). Hunting pressure along Highway 16 was tremendous (D. Minty pers. comm.; O.J. Prather pers. comm.). Most damage occurred during the middle and late 1960's (B. Duncan pers. comm.; D. Ferguson pers. comm.). During that period access increased, and the provincial game department encouraged outfitters to convert their profession into an industry and harvest more animals (C. Brooks pers. comm.; O.J. Prather pers. comm.). Conservative seasons were abandoned and the caribou suffered (K. Hooker pers. comm.). An either sex season existed, and annual harvests probably exceeded calf productions (C. Brooks pers. comm.; K. Hooker pers. comm.; O.J. Prather pers. comm.). Recent calf increments have been very low (D. Ferguson pers. comm.; K. Hooker pers. comm.; M. Monroe pers. comm.; M. Vatamaniuk pers. comm.). Current bands are too small to withstand continued hunting pressure (B. Duncan pers. comm.; D. Ferguson pers. comm.; O.J. Prather pers. comm.; F.J. Pruckl pers. comm.; M. Vatamaniuk pers. comm.; M. Wilkinson pers. comm.).

Historically, caribou populations probably possessed a delicate balance between mortality and recruitment (Bergerud 1974b). Consquently, any significant increase in mortality unaccompanied by offsetting gains in recruitment would cause a decrease in population size. As the number of caribou decreased, the decline would accelerate (Bergerud 1974b).

Some doubt has been expressed about the occurrence of excessive harvests. Child (1975) and Ritcey (1974) reviewed provincial hunting statistics and concluded caribou have not been over-harvested. Conclusions were based on three premises:

1. Kills by resident hunters averaged 74% bulls, and the non-resident harvest was even more heavily weighted toward males.
2. Sex ratios of caribou kills have not changed appreciably in 9 years (1963-1972) despite sexually unbalanced harvests and liberal antlerless seasons.
3. Harvest totals and hunter success ratios have been stable despite recent cutbacks in antlerless seasons and some local closures.

These arguments are unrealistic and misleading for several reasons. Sexual segregation of animals killed during the hunting season was nearly impossible. Evidence of sex was not required during transportation of caribou carcasses (prior to 1976), and it is very difficult to distinguish between the sexes if the genitilia are not present. Differentiation of bulls and cows was left to the judgement of the hunter (correspondence from J. Hatter to J.G. Stelfox May 19, 1964). Furthermore, successful hunters were not required to provide particulars about the kill. Many cows, killed during the bull season probably were abandoned or recorded as young bulls (Ritcey 1976; R. Weinard pers. comm.).

Hunters generally select for large antlers and body size (Bergerud 1971c; Reimers 1975). Consequently, because males grow more rapidly and achieve greater body size and antler development, the mature male classes sustain the heaviest harvests (Bergerud 1971c; Reimers 1975). Failure to distinguish sexes and hunter preferences for males resulted in a preponderance of males in harvest samples. Ultimately, changes in age and sex class distributions may have been responsible for reductions in breeding success and calf production (Reimers 1975).

The seemingly stable sex ratios of kills probably were a reflection of hunter preferences rather than population dynamics. Despite liberal cow seasons between 1964 and 1972 (Figure 6-1), harvest were not regulated by sex and age.

Greater pressure was exerted on the bull cohort through longer and perhaps poorly timed hunting seasons. Between

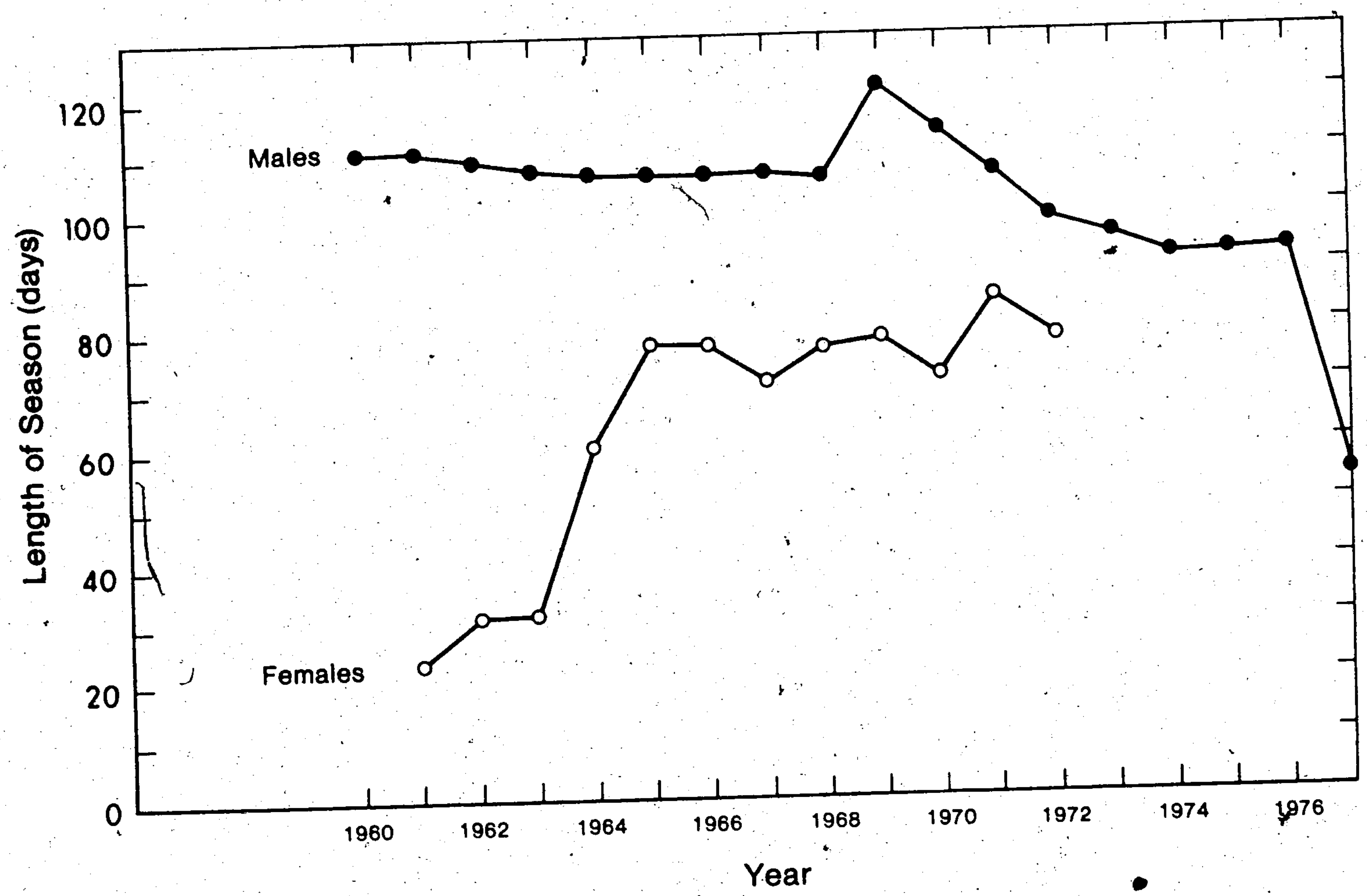

Figure 6 - 1 Length of Caribou Hunting Seasons In Central British Columbia, 1960-1977

1964 and 1974, bull and antlerless seasons averaged 105 and 68 days respectively (Appendix F). Breeding bulls exhibit reduced wariness towards man (Kelsall 1968; Reimers 1975). Post-rut bulls may be more vulnerable because of diminished physical condition (Reimers 1975). Consequently, the detrimental effects of over-harvesting probably were more profound for bulls because of hunter preferences, extended seasons and reduced cautiousness.

Despite distorted sex ratios (Chapter V), declines in the bull segment went undetected because of the closure of antlerless seasons after 1974. As sex ratios distort in favor of cows, female harvests would have increased to compensate for unsuccessful bull hunting (Reimers 1975). Instead, increased access offset decreases in the bull cohort and caribou population and resulted in seemingly constant success ratios.

The final conclusion of stable harvest totals and hunter success ratios was questionable. First, stability is difficult to define. Provincial harvests for 1964 totalled 796 caribou. By 1967 the total almost doubled (Table 6-2). During the next seven years totals steadily climbed, reached a peak of 1925 caribou in 1973 and then dropped nearly 50% for 1974 (Table 6-2). Harvests were hardly stable.

Provincial hunter success ratios fluctuated but were somewhat more stable than harvest statistics. Ratios rose above 30% in 1965 and remained there until 1973 when a

Table 6-2 Estimated Annual Caribou Harvest For Province And Game Management Area 20*: 1962-1977

Season	Total Kills		G.M.A. 20 Distributions Of Kills By Residence Of Hunters	
	Provincial	G.M.A. 20*	Resident	Non-Resident
1962	761	159**	159	N/A!
1963	529	189**	189	N/A
1964	796	139±80**	139±80	N/A
1965	920	243±15	177±15	66
1966	1375	332±27	288±27	104
1967	1583	151±27	121±27	30
1968	1441	75±19	58±19	17
1969	1559	121(est.)	98(est.)	23
1970	1691	97(est.)	78(est.)	19
1971	1637	91±19	76±19	15
1972	1610	59±17	46±17	13
1973	1925	61±19	50±19	11
1974	1044	25±14	23±14	2
1975	993	4± 4**	4± 4	N/A!
1976	847	20± 4	15± 4	5
1977	810	11***	10***	1

*1962-1964-Northern B.C.; 1964-1972 - G.M.A. 20; 1972-1977 - Omineca Subregion of Region 7.
**Resident Kills Only.
***Wildlife Management Units 7-3, 7-4, 7-5, 7-6, 7-7, 7-17, 7-18 Only.
!N/A - Not available
Note: Annual Kills Are Estimated And Reported As Ranges ie. 139±80

steady decline began (Table 6-3). However, improved ratios do not necessarily depict a stable population size but more accurately represent increased opportunities resulting from lengthened seasons and greater access. Significant decreases in season length were not implemented before 1977, although small reductions were made after 1972 (Appendix F). Vast networks of logging roads, a major highway and the availability of all-terrain vehicles provided access to previously remote regions. Increased access to previously remote areas and unexploited populations may obscure excessive local harvests by permitting large kills within newly exposed regions (Bunnell and Eastman 1976). This alternating pattern of isolation and depradation probably caused a population decline without apparent indications throughout the herd.

To approach the problem on a province wide basis is quite unrealistic. Local areas and populations are subjected to disproportionate and unique pressures. Hunting is not evenly distributed. Animals are dispersed throughout their range in varying densities. Harvest schemes should be appropriate for local populations and relevant to reproductive performance. Unfortunately, it appears that harvests in the study area regularly approached and exceeded the estimated annual increment (Table 6-1).

Table 6-1 illustrated the low productivity of caribou and suggested a net calf increment of about 10%. This level

Table 6-3 Annual Caribou Hunter Success For Province And Game Management Area 20*; 1964-1977

Season	Hunter Success	
	Province	G.M.A. 20*
1964	29.0	34.0
1965	31.0	33.0
1966	36.9	33.1
1967	36.3	25.0
1968	32.2	19.0
1969	31.3	23.0
1970	36.7	26.0
1971	36.8	28.7
1972	32.0	29.0
1973	26.1	16.0
1974	21.9	17.0
1975	28.1	0.4
1976	22.0	N/A**
1977	21.0	N/A**

*See Table 6-2 For Explanation Of Name Changes
**Not Available, Sample Size Too Small

is consistent with typical caribou calf production (Chapter V). Over-utilization can be avoided by establishing quotas on the basis of local productivity (Child 1975). Unfortunately, estimates of recruitment were limited and probably excessive. Calf crops in Wells Gray Park were assumed to be at least 16% (Ritcey 1970). No doubt information collected in this area was liberally applied to other regions of British Columbia. Estimates in other areas were even higher (Chapter I).

Between 1962 and 1967, and perhaps as late as 1971, annual harvests in Game Management Area 20 (G.M.A. 20), approximated or surpassed estimated calf crops (Tables 6-1 and 6-2). During this period a negative balance between recruitment and mortality occurred. Reports of local over-harvests were numerous.

Over-harvests resulted from unlimited license sales, lengthy hunting seasons and a general failure to incorporate rapidly increasing development and settlement into management policies (Table 6-4; Appendix F). The impact of increased access, developmental disturbance, disruption of normal patterns and range discontinuity should have been counteracted with shortened seasons, restricted license issuance (e.g. permits) and elimination of the cow season. Instead season lengths increased and were not significantly decreased until 1977, license sales remained unlimited and cow seasons were expanded from 23 days in 1961 to 85 days in

Table 6-4 Estimated Annual Number Of Licenced Caribou Hunters: 1964-1977

Year	Licenced Success	
	Province	G.M.A. 20**
1964*	1568	397±191
1965	2365	508± 33
1966	2251± 214	688± 47
1967	3281±3355	489± 57
1968	3325	299± 43
1969	3270	427
1970	3591	301
1971	3816	258± 44
1972	3579± 590	258± 50
1973	4846± 663	303± 53
1974	3376	170± 37
1975	2828	93± 20
1976	2483	180
1977	2400	165

* Statistics Unavailable Prior To 1964

** 1972-1977 - Omineca Subregion Of Region 7

Note: Annual Licensed Hunters Are Estimated And Reported As Ranges ie. 397±191

1971 (Figure 6-1; Appendix F). Calves could be shot until 1970.

(3) Consequences of liberal hunting regimes

Liberal hunting regulations contributed to a general population decline through harvests of calf-producing females, a reduction in caribou numbers, alterations in population structure and damage to social traditions. Despite the objectives of the Fish and Wildlife Branch to implement stringent regulations to protect easily accessible populations from over-harvests, a major decline occurred (Child 1976; Ritcey 1976). The consequences may be great.

Over-harvests caused a decrease in population size for several reasons. Extirpation of some locally isolated groups occurred. Population growth did not occur because harvests approached calf crops and breeding success declined. Ultimately, calf productions became very small and mortality exceeded recruitment on a regular basis.

Breeding success is affected by several factors. During the rut caribou coalesce in larger groups (Bergerud 1971b; Henshaw 1970; Kelsall 1968). Caribou appear to require movement and constant physical contact to stimulate breeding activity (Chapter V). Sexual activity diminishes with reductions in herding behavior animal densities (Espmark 1964a; Henshaw 1970; Lent 1965a). Apparently social adaptations discourage group dispersal before conclusion of the breeding period (Henshaw 1970; Lent 1965a). As population density and mobility are reduced, such as occurred in the study area, calf productions are likely to decrease.

Sex ratios are an important component of breeding success (Bergerud 1971b; Reimers 1975). At breeding maturity, populations of woodland and barren-ground caribou average approximatelty one bull per two cows (e.g. Bergerud 1969; Cowan 1950; Kelsall 1968; Moisan 1959; Parker 1972; Ritcey 1970). However, mixed groups in the study area rarely exceeded one bull per eight cows (Chapter V). Breeding females regularly were observed without males. Reduced calf crops may be directly related to distorted sex ratios (Reimers 1975). Calf reports were extremely low (Table 5-1).

Unspecified seasons exert disproportionate pressure on mature males and change the structure and size of the bull cohort (Reimers 1975). The over-harvest of adult animals depresses the age structure (pyramid) and increases the proportion of younger males (Bubenik et al. 1975). Abrupt changes in harvest levels and strategies pose the most serious threat and result in alterations in sexual maturity and dominance hierarchies (Bubenik et al. 1975). The detrimental effects are much greater when sex ratios exceed species-specific tolerances (Bishop and Rausch 1974).

Mountain caribou are primarily a trophy species. Consequently hunters have a demonstrated preference for males (Ritcey 1976). Heavily hunted populations experience a reduction in the antler size of males (Bergerud 1971c; Reimers 1975). Furthermore, the fewer and younger bulls appear unable to breed a sufficient portion of the female segment (Reimers 1975). Reduced success may be attributed to variability in the onset of the rut by age group, reduced breeding abilities, diminished social releasers or the inhibitory effect of the remaining mature males (Bubenik 1975; Espmark 1964a, 1964b; Pruitt 1966; Reimers 1975).

The capacity of subdominant males to replace dominant bulls removed from the population is unclear. In caribou populations, antlers are the most important social releaser (Bubenik 1975). The dominance hierarchy in groups of rutting bulls is usually related to two males, the "Alpha" and "Beta" bulls who are responsible for much of the breeding (Bubenik 1975; Espmark 1964a, 1964b). Forest-dwelling caribou exhibit similar patterns of social behavior and rank order (Bergerud 1971; Bubenik 1975; Espmark 1964a; Pruitt 1960). Consequently changes in the size and conformation of the bull cohort may cause decreases in the level and success of breeding activity.

Furthermore, physiological and behavioral maturity differ considerably in caribou (Chapter V). Caribou antlers have high social significance and determine individual rankings within a population (Bubenik 1975; Espmark 1964b). Consequently, male entry into the breeding segment is delayed, and animals under 4 years are subordinate (Bubenik 1975; Espmark 1964a; McEwan 1963). Most breeding activity is restricted to 4-7 year old males (Bergerud 1961; Espmark 1964a; Pruitt 1966; Skoog 1968). These animals have the most complete brow-tine development and the greatest physical vigor (Pruitt 1966). They also provide the most desirable trophies. Although younger and older bulls are physiologically capable, they do not activity participate in breeding (Pruitt 1966).

Optical cues are intimately associated with breeding activity, and male antler configuration is a key element of female receptivity (Espmark 1964a; Pruitt 1966). Simple physical dominance alone does not determine who participates in breeding activities. If antler development and brow-tine conformation determine levels of breeding activity, liberal removal of prime bulls could reduce pregnancy rates and detrimentally affect the population.

Reduction of the bull cohort poses other problems. Segregated females were observed during periods when sex class integration was the rule. As a result, fertile cows may have been unbred. Range discontinuity and band isolation compounded the problem. At best, a few bulls may have been responsible for all breeding activity.

Until 1970, juveniles, including calves, were included in antlerless seasons (Appendix F). Though losses probably contributed to the disrupted mortality-recruitment balance, the size and impact of calf harvests are unclear. It is assumed distortion of sex and age class distributions was enhanced, thereby reducing breeding success and calf production. Calves are at least as vulnerable to hunting pressures as adults (Bergerud 1967).

In many respects liberal cow seasons may have had the most devastating effects. Bands suffered reductions in calf-producing cohorts, productivity levels dropped and social patterns were disrupted.

Thomson (1975) studied leadership activity in wild mountain reindeer and found 80% of leaders were adult females, often breeders of the current year, accompanied by a calf. Leaders were from all dominance ranks. This pattern remained throughout the year. The evidence also suggested age and maternal experience were important components of successful leadership. Furthermore group leaders displayed increased alertness, often functioning as look-outs at the periphery of the herd (Thomson 1975). During critical situations, leadership was usually assumed by an older female (Thomson 1975). This group predominates in leadership roles and acts as essential custodian of various herd traditions (Cowan 1974; Geist in Cowan 1974; Naumov and Baskin in Thomson 1975; Thomson 1975). Similiar patterns have been demonstrated in other cervids including black-tail, white-tail, red and mule deer, and moose (Thomson 1975). Though the pattern is not clear, leadership also is an important aspect of barren-ground caribou behavior (Child in Thomson 1975; Miller in Thomson 1975).

Members of the genus Rangifer have organized and well developed social structures (Cowan 1974; Espmark 1964b; Pruitt 1960c). Behavior patterns are learned through association with adults (Kelsall 1968; Miller et al. 1972). Herd leadership is an important component of group cohesion and learning (Espmark 1964b; Miller et al. 1972). Movement routes are traditional and learned (Baskin in Miller et al. 1972; Miller et al. 1972). Experience performs an important function in environmental interactions and migratory movements (Baskin in Miller et al. 1972). Both instantaneous and delayed forms of active leadership are recognized in the genus Rangifer (Thomson 1975). Leadership is an important aspect of social behavior (Miller et al. 1972; Thomson 1975).

Leadership appears to be an important means of conveyance of patterns of social behavior and resource exploitation. Premature loss of individuals exhibiting leadership may disrupt behavioral patterns and detrimentally alter the relationship between a species and its environment (Espmark 1970; Geist 1971; Miller et al. 1972; Thomson 1975). Successful response of the herd to various situations is directly related to the abilities and experience of its leaders (Thomson 1975). Loss of females during antlerless seasons threatens the quality and nature of herd leadership.

Lead cows may be more vulnerable to hunting because of their location at the front and periphery of travelling bands. Herd traditions and group survival may be endangered through the loss or diminution of experienced leadership, necessary for guiding, directing and protecting movements and social behavior (Thomson 1975).

In addition to lost leadership, cow harvests may cause a reduction in calf production and survival. This occurs for several reasons. Caribou infant-mother relationships are the follower type, where cows and calves remain in close proximity (Lent 1974). The calf's early survival is dependent on the dam's acceptance and a strong cow-calf association (Lent 1966). Maternal-filial bonds provide the critical link between the calf and the remainder of the herd. This enables the infant to participate in the population's activities until it has properly developed its own group responses in synchronism with the rest of the population (Lent 1966, 1974). A strong cow-calf bond provides the best environment for learning and development (Lent 1974; Miller and Broughton 1973). Failure to develop a strong relationship or premature bond breakdown appears to diminish calf survival (Lent 1974; Miller and Broughton 1973; Miller et al. 1972). Consequently cow seasons may have long-term implications.

Amongst the cervids, members of the genus <u>Rangifer</u> have the best developed antlers (Bubenik 1975). In contrast to other members of *Cervidae*, both sexes carry antlers (Henshaw 1969; Lent 1965a). Typically antlered cows comprise a majority of up to 75% of the female cohort (Henshaw 1969; Kelsall 1968; Lent 1965b). The dimorphic nature of antler retention suggests social and survival advantages for antlered females and their calves. Alterations in the ratio of antlered to unantlered females have important implications and may result from hunting.

During the rut, mature antlered males dominate, but by November-February, their antlers are usually lost. On the contrary, females, particularly gravid cows, retain their antlers until post-calving (Espmark 1971a; Kelsall 1968; Lent 1965b). High social status and antler possession are strongly correlated (Espmark 1964a; Pruitt 1960c). At different times, according to sex and age, animals lose their antlers, and the social structure is changed (Espmark 1971b). The change in hierarchy is attributable to learned reactions to antlers (Espmark 1964b).

In general, only gravid females possess antlers during calving (Espmark 1971a; Lent 1965b; Pruitt 1960c). Consequently, antlered cows occupy a dominant position in the social hierarchy, obtain better calving sites and thereby increase the opportunity to form a strong maternal-filial bond without outside interference (Espmark 1971a, 1971b; Henshaw 1969). Antlered females show a pronounced rise in aggressiveness and are probably better able to defend their young from other herd members and predators (Espmark 1971a, 1971b). The development and structure of female antlers favors offensive threats, whereas male antlers are predominantly protective in character (Bubenik 1975).

During winter, antlered cows have a similarly high social rank and a greater ability to compete for food against bulls and barren and unantlered cows (Espmark 1964b, 1971b; Henshaw 1969; Pruitt 1960c). This reorientation of the dominance hierarchy has obvious biological values (Espmark 1964b). Antlered cows are better able to provide food for themselves and their calf and fetus (Espmark 1964b, 1971b; Henshaw 1969). Calves are the lowest ranking individuals and are largely dependent on their mothers for winter food (Espmark 1964b, 1971b). In addition a calf shares the social status of its dam, and thereby has the same advantage in securing food and shelter (Espmark 1964b, 1971b). Fetal survival also is enhanced (Espmark 1964b). Orphaned and abandoned calves are more vulnerable to predation, nutritional deficiencies, accidental death and abuse from adults (Kelsall 1968; Skoog 1956). Therefore, it is an advantage for cows to possess antlers (Espmark 1964b, 1971b).

Cow seasons have become an increasingly common phenomenon in big game management even though the effects on orphaned offspring have not been adequately examined (Lent

1974). Female caribou were lost during both cow and bull seasons. It is strongly suggested that the size and composition of the female cohort has been adversely affected. The likely consequences were reductions in calf production and survival and a loss of herd traditions. Additional losses only would cause further damage to the productivity and social structure of local populations. Permanent closure of cow seasons is essential.

Patterns of hunting in North America have traditionally concentrated on male harvests. However, it is difficult to distinguish between bull and cow caribou in the field. Consequently, an either sex season was established (J. Hatter to J.G. Stelfox pers. comm.). This approach was unsuccessful in harvesting caribou on a self-sustained basis. Further losses are unwarranted, and a total, extended closure is strongly recommended for both sexes. For a nomadic species where sexes occupy different areas seasonally, the loss of traditions carried by males or females could cause extirpation (Cowan 1974). Distorted sex ratios, reduced recruitment, population declines, isolation of bands and breeding animals, increased access and range disruption demonstrate the need and justification for a full closure. In other localities, significant recoveries have not occurred, though populations have somewhat stabilized. Consequently, a long-term closure is envisioned. Closed seasons not withstanding, an effective management program must be developed to prevent further declines (Appendix I).

C. Implications Of Other Pressures On a Declining Population

Although many other causes have been suggested for the caribou decline, there is no indication that most of these played any role in reducing the populaticn tc its present small size. However, for an unstable, declining population all negative influences are of concern. Several potential problems are examined.

1. Additional habitat alienation

a. agriculture

There was no evidence that agricultural practices were a decline-causing factor. However, agriculture has increased considerably, particularly in the eastern pcrtions of the study area and around Prince George (Chapter II). Three potential problems exist. Land clearing is an obvious conflict and must proceed cautiously in critical caribou habitat. Further range modification would not be helpful. Domestic grazing could cause caribou displacements and additional habitat alienation. In addition, transmission of disease might increase mortalities and could result in further reductions in calf producton (Broughton and Choquette 1969; Neiland 1972b). Grazing leases are not recommended on caribou range. The alternative, fenced grazing reserves, could further disrupt migration patterns and create barriers to movement. Fences should not be used unless they are constructed with precise knowledge of traditional caribou movement patterns and routes (Klein

1971).

b. hydro-electric development

Wild ungulates do not typically adjust to dangerous characteristics of altered habitats (Cowan 1974). Hydro-electric projects irreversibly alter essential ranges through inundation of habitat. Acknowledgement of wildlife losses is extremely slow (Oliver 1974). Developers erroneously suggest that displaced animals easily adjust and occupy new habitats. Numerous studies indicate that premise is false.

Wildlife are affected in several ways. Prime habitat is lost and accompanied by large population reductions (Oliver 1974; Peterson and Withler 1965; Stelfox 1972; Stevens 1971). Movement patterns are seriously disrupted. The Castle Reef Dam interfered with elk migrations and flooded bighorn sheep range (Stelfox 1972). Deer and moose are known to drown when attempting to swim irrigation ditches and reservoirs which restrict normal movements (Cowan 1974). The Brazeau Dam in Alberta flooded about 70 square kilometers of prime moose, elk and deer winter range (Stelfox 1972). Reduced water flows, resulting from the Bennett Dam, altered plant communities in the Peace-Athabasca delta and adversely affected 7,000 bison (Stevens 1971). Further losses may accrue because of barriers caused by water, mud and ice (Peterson and Withler 1965). Wildlife losses may be much larger than expected (Oliver 1974).

Concern has been expressed about the impact of several dam and diversion projects proposed in the study area. The most serious proposition is to dam the McGregor River ten miles above its confluence with the Fraser River. The reservoir would cover approximately 128 square kilometers and will most seriously affect the McGregor and Parsnip rivers and Otter, Captain and Herrick creeks. All of these waterways traditionally have been used by caribou (Chapter V). The project will cause additional habitat loss and further disruption of local movement patterns (Chapter V). Klein (1971) indicated hydro-electric projects probably are the most influential of man's activities for reindeer. Dams and reservoirs flooded prime habitat and calving sites and produced dangerous obstructions to movement. Impassable shelves of ice and debris created genuine death traps.

2. Harassment

Harassment increases the physiological cost of body maintenance at the expense of growth and reproduction. Death or injury may result. Another serious consequence can be the avoidance or abandonment by animals of previously used areas. Ultimately, the results are detrimental because of reductions in range and population size.

a. recreation

Although large numbers of hikers and skiers pose a potential problem, the most serious recreational disturbances for caribou are snowmobile and off-highway vehicle harassment. Seismic lines and recreation trails provide increasing access to previously remote areas, and all-terrain vehicle use is expanding. When caribou are frightened, they often panic and flee. Once excited, individuals may run to exhaustion (Baskin in Geist 1975; Espmark 1970). The consequences include physical injury or death. Pregnant cows may abort from over-exertion or striking their bellies on the snow (Zhigunov in Geist in 1975). Panic near calving time can lead to calf abandonment (Baskin in Geist 1975). Reindeer in poor physical condition exhibit greater sensitivity to harassment (Espmark 1970; Klein 1971). Range abandonment probably is more serious for small relic caribou populations using widely dispersed ranges. Snowmobiles are very disturbing to reindeer (Klein 1971). Caribou and reindeer have abandoned large range areas due to snowmobile disturbance (Klein 1971). On several occasions caribou frightened by snowmobiles raced for cover. A band of 12 animals, chased in the Redmountain Creek area, travelled 9-12 kilometers within 30 hours. Only eleven animals remained in the band when they were relocated. During the study period snowmobiles finally gained access to the Grizzly Den-Raven Lake area via hiking trails. Further trails are planned in the Ptarmigan Creek watershed (B.

Weinard pers. comm.). To avoid the obvious conflicts and reduce the impact of recreational snowmobiles (and all-terrain vehicles) on caribou herds, designated use areas should be established, and snow machine travel must be restricted in wintering and calving areas and along migration routes. Educational programs are required to alert snowmobile and all-terrain vehicle users to the benefits caribou receive from controlled access (Johnson et al. 1977). It is very important to avoid the introduction of new types of disturbance, particularly during critical periods (Cowan 1974).

b. aircraft

Aircraft harassment has consequences tc caribou similar to off-road vehicle use. Helicopters are more disturbing than fixed-wing aircraft, and the impact is increased as the overflight height is reduced (e.g. Calef et al. 1976; McCourt and Horstman 1974; Miller and Broughton 1974; Thomson 1972). Some effects are easily observed. Caribou ran three kilometers from a helicopter flying at a distance of 75 meters (Debock and Surrendi in Geist 1975). Similar reactions occurred during the study. On other occasions no reaction was apparent, but the response probably represented a state of active inhibition (Geist 1975). Multiple overflights may be cumulative and could aggravate the effect of harassment (Geist 1971, 1975).

Aircraft were used in the study area by forestry, meteorological and wildlife personnel and by private citizens. Individuals often are tempted to obtain a closer and additional look at wildlife. To minimize impact, this practice should be discouraged. Though the overflight heights creating the least disturbance are unclear, caribou are still disturbed by flights approximately 175 meters above ground (Geist 1975; Klein in Geist 1975). Caution dictates observance of aircraft ceilngs of at least 200 meters and avoidance of prolonged contact. Flights through sensitive zones, particularly for recreational purposes, should be restricted.

3. Predation

Caribou have sustained losses from a variety of predators, but only wolf and grizzly predation have been suggested as potential problems. Grizzly predation does not appear to be of consequence, is quite limited and often circumstantial. Newborn calves probably are most susceptible. However, animals older than 3-5 days easily escape, and adult caribou are rarely taken (Skoog 1956). Consequently the chief predator of caribou, excepting man, appears to be the wolf.

Wolf predation and its impact on caribou is highly controversial. The level of predation is quite variable and population specific. Unfortunately most information has been collected for barren-ground caribou and may not be applicable to the considerably smaller more widely dispersed, forest-dwelling populations. Accurate information on wolf-mountain caribou interactions does not exist.

Current wolf populations in the study area are lower than in previous years and there is no biological evidence numbers are dramatically increasing (K. Child pers. comm.; K. Fujino pers. comm.). Furthermore, the caribou decline developed during a period of extensive wolf control. Nonetheless, several residents were convinced caribou declines could be attributed to wolf predation (F. Colebank pers. comm.; D. Minty pers. comm.; M. Monroe pers. comm.). However, substantantive documentation was not available, and this conclusion appears to be based on coincidental and inferential evidence and perhaps anti-predator sentiments.

Predation traditionally has been over-emphasized as a population limiting factor (Pashingbauer 1965). The low fecundity of caribou probably indicates a relatively low level of predation and a somewhat stable relationship with an obligate predator (e.g. Bergerud 1974b; Evans 1960). Predation probably does not significantly influence the survival of forest-dwelling caribou populations (e.g. Evans 1960; Fashingbauer 1965; Freddy 1974; Layser 1974; Stelfox and Bindernagel 1978). Though losses undoubtedly occur, they are limited by several factors, including low caribou densities, the overlapping distributions of other, larger ungulate populations and some features of caribou range, particularly deep snow and high elevations. Recent results from the largely undisturbed northern portions of Jasper Park support these arguments (Stelfox and Bindernagel 1978). Wolf predation of caribou was insignificant and non-detrimental. Mule-deer and elk comprised the majority of wolf diets.

4. Poaching

Various features of caribou ecology and behavior greatly increase their susceptibility to over-exploitation, and the manpower constraints of enforcement agencies render caribou vulnerable to illegal hunting. Many residents considered poaching and irresponsible hunting serious problems (D. Ferguson pers. comm.; M. Frye pers. comm.; O.J. Prather pers. comm.; F.J. Pruckl pers. comm.; S. Wlasitz pers. comm.). Table 6-5 describes known incidents of caribou poaching since 1960. These probably represent a very small proportion of the illegal kills. Access and poor hunting ethics have caused serious problems in some areas (F. Cushman pers. comm.; D. Ferguson pers. comm.; R. Haslinger pers. comm.). The use of helicopters and off-road vehicles increased enforcement problems and poaching incidents, particularly during the 1960's (e.g. K. Child pers. comm.; F. Colebank pers. comm.; T. Collins pers. comm.; D. Ferguson pers. comm.; F.J. Pruckl pers. comm.).

Nonetheless, the Fish and Wildlife Branch has never considered caribou poaching a serious problem within the

Table 6-5 Reported Caribou Poaching Incidents In The Study Area 1960-1977

When	Description	Locality	Source
Unknown 1960's	7 Caribou On Lamco Rd.	Lamco Rd. At W. Twin Creek	E. Monroe D. Ferguson
Unknown 1960's	Several Abandoned Calves	Beaver River	E. Monroe
May Mid-1960's	24 Killed, Only Tongues Removed	McKale River (Blackwater Rim)	M. Frye
April 1963	Male, Only Trophy Taken, Meat Abandoned	5 Miles West Of Hungary Creek - At Longworth Rd.	S. Wlasitz
September 1967	3 Small Bands Shot And Abandoned	Fraser River Canyon (Dewey-Sinclair Mills)	D. Minty
Lat[illegible] 's To Mid-1[illegible] 's	Artifical, Baited Mineral Lick; 17 Heads Seen At One Time	Slim Creek, South Of Highway 16	B. Weinard F. Knapp
Summer Early 1970's	Helicopter Hunts Near Red Mtn.	Penny	T. Collins J. Gasprey
1974	5 Caribou Shot And Abandoned	Large Muskeg West Of Longworth Rd.	S. Wlasitz R. Mueller
1974-1976	Bull Poached Near Treeline	South Of McBride	M. Vatamaniuk
September 1976	Bull, Only Trophy Taken, Carcass Pushed Over Embankment	McBride Area	D. Ferguson M. Frye
September 19, 1976	Bull Poached, Only Trophy Taken	Tumuch Lake - Everett Creek Area	E. Weinard K. Fujino

study area (G.D. Gosling pers. comm.). From 1950 to 1977 only six reports of illegal harvest were received, and no charges were laid (G.D. Gosling pers. comm.). This position is contrary to results obtained in other portions of mountain caribou range (e.g. Evans 1960; Flinn 1956; Freddy 1974; Johnson et al. 1977). Illegal hunting also had serious consequences for other caribou populations (Chapter I). Though it is not suggested poaching was a major factor, it may have important implications for declining herds. Consequently, successful prosecution of violators and public education programs should be given high priority (Freddy 1974; Johnson et al. 1977).

D. Conclusions

Mountain caribou are well suited to their natural environment but have recently experienced a steady and considerable population decline in the study area. Twenty-five years ago R.Y. Edwards, mentor of provincial caribou biologists, expressed alarm over the decrease of mountain caribou throughout most of British Columbia (Edwards 1954). Since then numerous biologists and provincial residents have voiced concern about the prospects for maintaining provincial caribou herds (e.g. D. Ferguson pers. comm.; Freddy 1974; Hamer 1974; Johnson 1976; C.J. Prather pers. comm.; Ritcey 1976; R. Weinard pers. comm.). Caribou are a sensitive, social species. In recent years human influence on caribou ecology has increased tremendously. However, the impact of development, settlement and associated activities has not been counteracted by adjustments in industrial and wildlife management. As a result, the caribou in Central British Columbia are in the throes of a major population decline. Unmitigated development and continued hunting jeopardize their very existence.

Caribou populations declined because of the cumulative effect of recreational and industrial activities. A comprehensive program is required to resolve the conflict between caribou management and current industrial practices. Recent removal of caribou from the big game season in Central British Columbia was a necessary measure directed toward preservation of local populations, but its timing demonstrates the slow response of managers to serious management problems. The problem is too serious for short-term measures to be effective. An exhaustive review of industrial programs is required and must be followed by development of strict guidelines for activity in caribou range (Appendix I). The caribou season, for both sexes, should be closed for an extended period and must not be reopened until a sizeable and significant population increase has been realized. Failure to implement those measures necessary to prevent additional reductions in caribou numbers and distributions ultimately could result in disappearance of populations in the study area.

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APPENDICES

APPENDIX A

FLORA OF THE RAVEN LAKE AREA

1. Vascular plants (1-130)
2. Terrestrial lichens (131-166)
3. Arboreal lichens (167-195)
4. Mosses (196-216)

Specimens collected by Chris and Michael Bloomfield
May 1 - August 31, 1976 and 1977

Taxonomic identifications;

	Initial identification	Confirmation
Vascular plants*	C. Bloomfield	J. Packer, Dept. of Botany, University of Alberta
Terrestrial lichens	M. Bloomfield	J. Thomson, Dept. of Botany, University of Wisconsin, Madison
	M. See	M. Ostafichuk, Dept. of Botany, University of Alberta
Arboreal lichens	M. Bloomfield	I. M. Brodo, National Museum of Canada, Ottawa
	M. See	M. Bloomfield, Dept. of Animal Science, University of Alberta M. See, University of Manitoba, Field Research Station
Bryophytes	M. Bloomfield	C. Bloomfield, Dept. of Botany, University of Alberta

All specimens are housed in the herbarium, Department of Botany, University of Alberta. Appropriate lichen specimens contributed to the National Museum of Canada and the University of Wisconsin herbarium.

* For sources of scientific nomenclature, refer to Hitchcock and Cronquist (1973), Hulten (1968), and Moss (1959) in literature cited section.

1. Vascular Plant Species List

Species Name	Family Name	Common Name
* = Introduced species.		
1. *Abies lasiocarpa*	Pinaceae	subalpine fir (balsam)
2. *Acer macrophyllum*	Aceraceae	broadleaf maple
3. *Achillea lanulosa*	Compositae	yarrow
4. *Aconitum delphinifolium*	Ranunculaceae	monk's hood
5. *Actaea rubra*	Ranunculaceae	red and white baneberry
6. *Alnus crispa*	Betulaceae	mountain alder
7. *Anemone occidentalis*	Ranunculaceae	chalice flower
8. *Anemone parviflora*	Ranunculaceae	rock anemone
9. *Antennaria rosea*	Compositae	pussy toes
10. *Antennaria umbrinella*	Compositae	everlasting
11. *Aquilegia formosa*	Ranunculaceae	red columbine
12. *Arnica latifolia*	Compositae	arnica
13. *Artemisia arctica*	Compositae	sagebrush
14. *Aruncus sylvester*	Rosaceae	goat's beard
15. *Athyrium filix-femina*	Polypodiaceae	alpine lady fern
16. *Betula papyrifera*	Betulaceae	paper birch
17. *Caltha leptosepala*	Ranunculaceae	mountain marigold
18. *Campanula lasiocarpa*	Campanulaceae	alpine harebell
19. *Cardamine umbellata*	Cruciferae	bittercress
20. *Carex nigricans*	Cyperaceae	black carex
21. *Carex pachystachya*	Cyperaceae	tufted carex
22. *Cassiope mertensiana*	Ericaceae	pink mountain heather
23. *Castilleja rhexifolia*	Scrophulariaceae	mountain red paint brush
24. *Cerastium beeringianum* var. *grandiflorum*	Caryophyllaceae	chickweed
25. *Chrysanthemum leucanthemum**	Compositae	ox-eye daisy
26. *Cinna latifolia*	Graminae	dropping wood reed
27. *Claytonia lanceolata*	Portulaceae	spring beauty
28. *Clintonia uniflora*	Liliaceae	queen's cup
29. *Cornus canadensis* var. *intermedia*	Cornaceae	bunch berry

Species Name	Family Name	Common Name
30. *Corydalis sempervirens*	Fumariaceae	pink corydalis
31. *Dryas hookeriana*	Rosaceae	white dryad
32. *Epilobium alpinum*	Onagraceae	alpine willow-herb
33. *Epilobium angustifolium*	Onagraceae	fireweed
34. *Epilobium lactiflorum*	Onagraceae	milky willow-herb
35. *Epilobium latifolium*	Onagraceae	sweet willow-herb
36. *Equisetum pratense*	Equisetaceae	black r[illegible]ed horse-tail
37. *Equisetum sylvaticum*	Equisetaceae	woodland horse-tail
38. *Equisetum variegatum*	Equisetaceae	clustered horse-tail
39. *Erigeron acris*	Compositae	flea bane
40. *Erigeron humilis*	Compositae	wild daisy
41. *Erigeron peregrinus*	Compositae	wild daisy
42. *Eriophorum viridicarinatum*	Cyperaceae	cotton grass
43. *Festuca ovina*	Graminae	sheep fescue
44. *Galium triflorum*	Rubiaceae	sweet scented bedstraw
45. *Gentiana glauca*	Gentianaceae	rocky gentian
46. *Gymnocarpium dryopteris*	Polypodiaceae	oak fern
47. *Habenaria dilatata*	Orchidaceae	tall white orchid
48. *Habenaria hyperborea*	Orchidaceae	northern green orchid
49. *Habenaria saccata*	Orchidaceae	slender bog orchid
50. *Heracleum lanatum*	Umbelliferae	cow parsnip
51. *Heuchera glabra*	Saxifragaceae	alum-root
52. *Heuchera richardsonii*	Saxifragaceae	alum-root
53. *Hieracium gracile*	Compositae	hawkweed
54. *Leptarrhena pyrolifolia*	Saxifragaceae	leather-leaved saxifrage
55. *Linnaea borealis*	Caprifoliaceae	twin flower
56. *Lonicera involucrata*	Caprifoliaceae	brachted honey-suckle
57. *Lupinus nootkatensis*	Leguminosae	mountain lupine
58. *Luzula wahlenbergii*	Juncaceae	wood rush
59. *Lycopodium annotinum*	Lycopodiaceae	stiff club-moss
60. *Menziesia ferruginea*	Ericaceae	false azalea
61. *Moneses uniflora*	Pyrolaceae	single-flowered wintergreen
62. *Oplopanax horridum*	Araliaceae	devil's club
63. *Osmorhiza depauperata*	Umbelliferae	sweet cicely

Species Name	Family Name	Common Name
64. *Osmorhiza purpurea*	Umbelliferae	sweet cicely
65. *Oxyria digyna*	Polygonaceae	mountain sorrel
66. *Parnassia fimbriata*	Saxifragaceae	grass of parnassus
67. *Pedicularis bracteosa*	Scrophulariaceae	lousewort
68. *Petasites vitifolius*	Composi ae	vine-leaved colts foot
69. *Phleum alpinum*	Graminae	alpine timothy
70. *Phyllodoce empetriformis*	Ericaceae	red heather
71. *Picea engelmannii*	Pinaceae	engelmann spruce
72. *Picea glauca*	Pinaceae	white spruce
73. *Pinus contorta* var. *latifolia*	Pinaceae	lodgepole pine
74. *Poa alpina*	Graminae	alpine bluegrass
75. *Poa arctica*	Graminae	arctic bluegrass
76. *Polygonum viviparum*	Polygonaceae	bistort
77. *Populus tremuloides*	Salicaceae	trembling aspen
78. *Populus trichocarpa*	Salicaceae	black cottonwood
79. *Potentilla diversifolia*	Rosaceae	cinquefoil
80. *Potentilla ledebouriana*	Rosaceae	tufted cinquefoil
81. *Prunus pensylvanica*	Rosaceae	pin cherry
82. *Pyrola asarifolia*	Pyrolaceae	common pink wintergreen
83. *Pyrola secunda* var. *obtusata*	Pyrolaceae	onesided wintergreen
84. *Ranunculus occidentalis*	Ranunculaceae	buttercup
85. *Rhododendron albiflorum*	Ericaceae	white flowered rhododendron
86. *Ribes lacustre*	Saxifragaceae	bristly black currant
87. *Rosa acicularis*	Rosaceae	prickly rose
88. *Rubus parviflorus*	Rosaceae	thimble berry
89. *Rubus pedatus*	Rosaceae	dewberry
90. *Rubus strigosus*	Rosaceae	wild red raspberry
91. *Rumex acetosa*	Polygonaceae	sorrel
92. *Salix glauca*	Salicaceae	smooth salix
93. *Salix nivalis*	Salicaceae	prostrate salix
94. *Sambucus melanocarpa*	Caprifoliaceae	black alder
95. *Sanguisorba sitchensis*	Rosaceae	
96. *Saxifraga ferruginea*	Saxifragaceae	alpine saxifrage

Species Name	Family Name	Common Name
97. *Saxifraga lyallii*	Saxifragaceae	lyall's saxifrage
98. *Saxifraga occidentalis*	Saxifragaceae	mountain saxifrage
99. *Saxifraga tricuspidata*	Saxifragaceae	3-toothed saxifrage
100. *Sedum stenopetalum*	Crassulaceae	common stonecrop
101. *Senecio triangularis*	Compositae	ragwort
102. *Shepherdia canadensis*	Elaeagnaceae	canadian buffalo-berry
103. *Sibbaldia procumbens*	Rosaceae	sibbald
104. *Silene acaulis*	Caryophyllaceae	moss campion
105. *Smilacina racemosa*	Liliaceae	false solomon's seal
106. *Smilacina stellata*	Liliaceae	star-flowered solomon's sea
107. *Solidago multiradiata*	Compositae	golden rod
108. *Sorbus sitchensis*	Rosaceae	mountain ash
109. *Stellaria longipes*	Caryophyllaceae	long stalked chickenweed
110. *Streptopus amplexifolius*	Liliaceae	twisted stalk
111. *Streptopus roseus*	Liliaceae	simple twisted stalk
112. *Thalictrum occidentale*	Ranunculaceae	western meadow rue
113. *Tiarella unifoliata*	Saxifragaceae	false mitrewort
114. *Thuja plicata*	Pinaceae	western red cedar
115. *Trifolium cyanthiferum*	Leguminosae	common clover
116. *Trifolium hybridum**	Leguminosae	alsike clover
117. *Trifolium pratense**	Leguminosae	red clover
118. *Trifolium repens**	Leguminosae	dutch clover
119. *Trisetum spicatum*	Graminae	spike trisetum
120. *Trollius albiflorus*	Ranunculaceae	globe-flower
121. *Tsuga heterophylla*	Pinaceae	western hemlock
122. *Vaccinium membranaceum*	Ericaceae	tall bilberry
123. *Vaccinium ovalifolium*	Ericaceae	oval berry
124. *Valeriana sitchensis*	Valerianaceae	mountain valerian
125. *Veratrum eschscholtzii*	Liliaceae	false hellebore
126. *Veronica alpina* var. *alaschensis*	Scrophulariaceae	alpine speedwell
127. *Veronica americana*	Scrophulariaceae	american brooklime
128. *Vicia americana*	Leguminosae	wild vetch
129. *Viola glabella*	Violaceae	violet
130. *Viola nephrophila*	Violaceae	bog violet

2. Terrestrial Lichen Species List

131. *Cetraria cucullata* (Bell.) Ach.
132. *Cetraria ericetorum* Opiz.
133. *Cetraria nivalis* (L.) Ach.
134. *Cetraria pinastri* (Scop.) S. Gray.
135. *Cetraria subalpina* Imsh.
136. *Cladonia bellidiflora* (Ach.) Schaer.
137. *Cladonia carneola* (Fr.) Fr.
138. *Cladonia cenotea* (Ach.) Schaer.
139. *Cladonia chlorophaea* (Flk.) Spreng.
140. *Cladonia coccifera* (L.) Zopf.
141. *Cladonia coniocraea* (Flk.) Sandst.
142. *Cladonia cornuta* (L.) Schaer.
143. *Cladonia crispata* (Ach.) Flot.
144. *Cladonia ecmocyma* (Ac[illegible]l.
145. *Cladonia gonecha* (Ac[illegible]
146. *Cladonia gracilis* [illegible]*ta* (L.) Willd.
147. *Cladonia mitis* San[illegible]
148. *Cladonia pleurota* (Flk.) Schaer.
149. *Cladonia pyxidata* (L.) Fr.
150. *Cladonia rangiferina* (L.) Wigg.
151. *Cladonia subulata* (L.) Wigg.
152. *Cladonia uncialis* (L.) Wigg.
153. *Lobaria linita* (Ach.) Rabenh.
154. *Nephroma arcticum* (L.) Torss.
155. *Nephroma parile* (Ach.) Ach.
156. *Peltigera aphthosa* (L.) Willd.
157. *Peltigera canina* (L.) Willd.
158. *Peltigera membranacea* (Ach.) Nyl.
159. *Peltigera rufescens* (Weis.) Humb.
160. *Solorina crocea* (L.) Ach.
161. *Stereocaulon grande* (Magn.) Magn.
162. *Stereocaulon paschale* (L.) Hoffm.
163. *Stereocaulon saxatile* Magn.

164. *Umbilicara decussatus* (Vill.) Zahlbr.
165. *Umbilicara deusta* (L.) Baumg.
166.* *Umbilicara hyperborea* (Ach.) Hoffm.

3. Arboreal Lichen Species List

167. *Alectoria sarmentosa* (Ach.) Ach.
168. *Bryoria capillaris* (Ach.) Brodo and D. Hawksw.
169. *Bryoria fremontii* (Tuck.) Brodo and D. Hawksw.
170. *Bryoria glabra* (Mot.) Brodo and D. Hawksw.
171. *Bryoria lanestris* (Ach.) Brodo and D. Hawksw.
172. *Bryoria oregana* (Tuck.) Brodo and D. Hawksw.
173. *Bryoria pikei* Brodo and D. Hawksw.
174. *Bryoria pseudofuscescens* Brodo and D. Hawksw.
~~175. *Bryoria*~~ *trichodes* var. *americana* Brodo and D. Hawksw.
176. *Bryoria vrangiana* (Gyeln.) Brodo and D. Hawksw.
177. *Cetraria ciliaris* Ach.
178. *Cetraria halei* Culb.
179. *Cetraria platyphylla* Tuck.
180. *Cetraria tilesii* Ach.
181. *Hypogymnia austerodes* (Nyl.) las.
182. *Hypogymnia bitteri* (Lynge.) Ahti.
183. *Hypogymnia enteromorpha* (Ach.) Nyl.
184. *Hypogymnia inactiva* (Krog.) Ohlsson.
185. *Hypogymnia imshaugii* Krog.
186. *Hypogymnia physodes* (L.) Ach.
187. *Hypogymnia tubulosa* (Schaer.) Hav.
188. *Letharia vulpina* (L.) Hue.
189. *Lobaria linita* (Ach.) Rabenh.
190. *Lobaria pulmonaria* (L.) Hoffm.
191. *Parmelia sulcata* Tayl.
192. *Parmeliopsis ambigua* (Wulf.) Nyl.
193. *Parmeliopsis hyperopta* (Ach.) Vain.
194. *Platismatia glauca* (L.) Culb. and Culb.
195. *Ramalina thrausta* (Ach.) Nyl.

4. Bryophyte Species List

Species Name

196. *Aulacomnium palustre* (Hedw.) Schwaegr.
197. *Dicranum fuscescens* Turn.
198. *Dicranum scoparium* Hedw.
199. *Dicranum strictum* Mohr.
200. *Distichium capillaceum* (Hedw.) B.S.G.
201. *Drepanocladus uncinatus* (Hedw.) Warnst.
202. *Hylocomium splendens* (Hedw.) B.S.G.
203. *Mnium spinulosum* B.S.G.
204. *Neckera menziesii* Hook.
205. *Plagiothecium elegans* (Brid.) Sull.
206. *Pleurozium schreberi* (Brid.) Mitt.
207. *Pohlia nutans* (Hedw.) Lindb.
208. *Polytrichum commune* Hedw.
209. *Polytrichum juniperinum* Hedw.
210. *Ptillium crista-castrensis* (Hedw.) De Not.
211. *Rhacomitrium aciculare* (Hedw.) Brid.
212. *Rhacomitrium canescens* (Hedw.) Brid.
213. *Rhacomitrium lanuginosum* (Hedw.) Brid.
214. *Rhytidiopsis robusta* (Hook.) Broth.
215. *Sphagnum squarrosum* Crome.
216. *Timmia austriaca* Hedw.

APPENDIX B

Fauna of the Raven Lake Area

Identified During This Study,

1975-1978

Scientific Name	Common Name
Accipiter cooperii	cooper's hawk
Alces alces	moose
Aquila chrysaetos	golden eagle
Buteo jamaicensis	red-tailed hawk
Buteo swainsoni	swainson's hawk
Canachites canadensis	spruce grouse
Canis latrans	coyote
Canis lupus	timber wolf
Castor canadensis	american beaver
Erethizon dorsatum	porcupine
Felis concolor	cougar
Gulo gulo	wolverine
Haliaeetus leucocephalus	bald eagle
Icterus bullockii	bullock's oriole
Lagopus leucurus	white-tailed ptarmigan
Lynx lynx	canadian lynx
Lynx rufus	bobcat
Marmota caligata	hoary marmot
Martes americana	pine marten
Martes pennanti	fisher
Microsorex hoyi	pygmy shrew
Microtus pennsylvanicus	meadow vole
Mustela frenata	long-tailed weasel
Odocoileus hemionus	mule deer
Odocoileus virginianus	white-tailed deer
Parus atricapillus	black-capped chickadee
Peromyscus maniculatus	deer mouse
Rangifer tarandus caribou	mountain caribou
Sorex cinereus	masked shrew
Sorex palustris	american water shrew
Spermophilus columbianus	columbian ground squirrel
Strix varia	barred owl
Strix nebulosa	great gray owl

Scientific Name	Common Name
Surnia ulula	hawk owl
Totanus flavipes	lesser yellow legs
Turdus migratorius	robin
Ursus americana	black bear
Ursus arctos horribilis	grizzly bear

APPENDIX C

HISTORY OF REGIONAL FIRES EXCEEDING 20 HECTARES

(1940 to 1977)

Appendix C. Regional fires greater than 20 hectares, 1940 to 1977.

Ignition Date	Fire Number	2 Mile Grid	Cause	Final Size Hectares (ha)	Timber Type	Other
10/5/42	6	93H/15W	Man caused	60	Slash	-
3/7/42	35	93H/16W	Lightning	140	Scrub	Windfall, brush
3/7/42	41	93H/15W	Lightning	35	Cedar, Hemlock	Windfall
3/7/42	43	93H/11E	Lightning	160	Cedar, Hemlock, Scrub	Windfall
3/7/42	44	93H/11E	Lightning	365	Small Balsam, Spruce	Windfall
3/7/42	47	93H/11E	Lightning	660	Cedar, Scrub	Windfall
3/7/42	79	93H/15W	Lightning	60	Cedar, Hemlock	Windfall
unkn/42	106	93H/13W	Lightning	1350	Lodgepole pine	-
11/8/42	147	93H/14W	Lightning	30	Spruce	-
/43	58	93H/13W	Lightning	-	No fire report	No fire report
6/6/49	54	93H/14E	Lightning	110	Decadent Cedar & S.	Slash
24/6/50	58	93H/14E	Lightning	40	Decadent C/B/S	-
7/7/50	85	93H/7W	Lightning	60	Scrub, Spruce, B.	-
21/4/51	4	93H/15W	Lightning	25	Grass, dead leaves	-
30/7/52	161	93H/13E	Lightning	25	Mature Cedar, Fir, S.	Windfall, Cedar, duff
4/5/55	2	93H/15E	Railroads Op.	65	Old logging decadent, Cedar & B. residual	Stumps, brush, rotton logs
12/7/58	352	93H/13W	Lightning	100	Spruce, Pine	Devil's club
20/7/58	354	93I/5E	Lightning	95	Spruce, Balsam M.T.	Huckleberry bushes, ferns, windfall, alder, snowbrush
8/8/60	181	93H/11E	Lightning	30	Spruce, Balsam	Heavy balsam, windfall
11/8/60	199	93H/14E	Lightning	55	Duff, Alpine, S., B.	-
11/8/60	211	93H/10W	Lightning	100	Alpine, Scrub	-
10/8/60	218	93I/2W	Lightning	1000	Spruce, Balsam	Alder, low brush, windfall
10/8/60	224	93I/7W	Lightning	40	Spruce, Balsam	Alder, low brush, windfall
3/8/60	227	93H/10W	Unknown	40	Dec. C., H., S., B.	-
11/8/60	232	93I/7W	Lightning	185	Spruce, Balsam	Low brush, grass

Appendix C continued.

Ignition Date	Fire Number	2 Mile Grid	Cause	Final Size Hectares (ha)	Timber Type	Other
19/5/61	41	93H/10E	Hangover from slash burning	70	Dec. Cimm. S., B.	Brush
25/5/61	55	93H/10W	Hangover from slash burning	90	Merch, Spruce, Balsam	Windfall, moss
14/7/61	275	93H/13W	Lightning	15740	Spruce, C., F., H.	Windfall, shrubbery
5/8/61	365	93H/15W	Lightning	620	C/H/Spruce, Scrub	Moss
5/8/61	396	93I/3W	Lightning	425	Spruce, Scrub, Balsam	Low alder
5/8/61	402	93H/14W	Lightning	200	Spruce, Balsam	Duff, brush
17/8/61	440	93I/5E	Lightning	620	Spruce, Balsam	Devil's club, brush
16/8/61	446	93H/11W	Lightning	8225	Spruce, Balsam	Moss, light underbrush
31/7/62	152	93H/9W	Lightning	35	Scrub, Balsam	Duff
22/5/63	28	93H/10W	Railroads Op.	85	Spruce	Heavy grass, brush
30/7/65	262	93I/7W	Lightning	70	Mature Spruce	Heavy duff
3/7/68	99	93H/12E	Lightning	35	Spruce, Balsam	Heavy moss
8/7/68	119	93G/16E	Industrial	25	-	Slash, logging debris
16/7/70	239	93G/16E	Lightning	25	Fir, Spruce	Duff, light windfall
7/5/71	84	93H/13W	Logging & Lumber	80	Spruce, Balsam, Slash	Debris
10/5/71	101	93H/10E	Range Burning	265	Pl., A., S., Cedar cottonwood, Balsam	Grass, vegetation
28/5/71	205	93H/13W	Logging & Lumber	22	Spruce, Balsam	Slash
1/8/71	365	93H/9W	Lightning	290	Spruce, Balsam	Duff
7/1/71	374	93H/7E	Lightning	127	H., S., C., Balsam	Buckbrush, windfall
10/5/72	6	93H/13W	Logging & Lumber	155	Spruce, Balsam, Pl.	Regen, heavy windfall
19/7/73	93	93H/10E	Man caused	82	Cedar, Hemlock	Slash
9/8/74	202	93H/13W	Industrial Op.	38	Mature C., Hemlock Immature fir (C., S.)	Shrubs, windfall

Prepared with D. W. Langridge, Forest Protection Division, British Columbia Ministry of Forests, Victoria, B. C.

S - Spruce, B - Balsam, M.T. - Merchantable timber, C - Cedar, H - Hemlock, Dec - Decadent, Pl - Lodgepole pine.

APPENDIX D

Chronological Listing Of All Known Caribou Sightings Recorded During The Raven Lake Mountain Caribou Study

1975 to 1977

* Not represented on Figure 5-4

Date	Location	Elevation (metres) (approx.)	Remarks
10/01/75	Highway,16, 15 miles west of McBride	890 m	Cedar-hemlock-spruce forest used by 3 caribou
26/01/75	West Twin Creek & Hwy. 16	830 m	Cedar-hemlock-spruce forest-15 caribou
08/02/75	Raven Lake	1660 m	Band of 16 caribou in cedar-hemlock spruce forest
13/02/75	P.G.B. Creek	762 m	Band of 7 caribou in cedar-hemlock spruce forest
18/02/75	Raven Lake	1660 m	14 slushing on frozen alpine lake
20/02/75	Hungary Creek at	760 m	2 bulls crossing highway south through balsam-spruce forest
22/02/75	Raven Lake	1660 m	Band of 22(19 cows) in Krumholz area
06/03/75	Hungary Creek at Highway 16	760 m	one mature bull crossing highway
08/03/75	Raven Lake	1660 m	13 caribou(12 cows) on frozen Alpine Lake
27/03/75	Raven Lake	1660 m	5 caribou in timberline forest and on frozen alpine lake
11/04/75	Grizzly Den	1460 - 1520 m	19 caribou in balsam-spruce forest
28/05/75	Slim Creek	762 m	1 caribou at mineral lick, adjacent to balsam-spruce forest
02/06/75	Mt. Averil *	1300 m	Tracks of 3-5 caribou in balsam-spruce forest
06/06/75	Slim Creek	760 m	5 caribou feeding on mud and water at mineral lick.
07/75	Naver Creek *	851 m	Small band in subalpine meadow
18/08/75	Dome Creek - headwaters	1450 - 1500 m	Small band near timberline in balsam-spruce forest
30/09/75	Grizzly Den	1490 m	2 caribou resting in balsam-spruce forest

Date	Location	Elevation (metres) (approx.)	Remarks
01/10/75	McGregor Logging Zone - Huble road	732 m	5 caribou along road and heading toward lick
01/10/75	Forget me not Creek	1430 m	Single caribou feeding at timberline
01/10/75	Slim-Tumuch road - Mile 25	975 m	5 caribou moving north toward mineral lick
15/11/75	McGregor Logging Zone - Church road (C.P.#3)	732 m	6 caribou, cows and young bulls travelling along logging road
19/11/75	Slim-Tumuch road - Mile 19.3	884 m	Caribou carcass found in clear cut
24/11/75	Raven Lake	1590 - 1620 m	Tracks of 3-5 caribou at edge of balsam-spruce forest
12/12/75	LaSalle Lakes	805 m	8 caribou feeding on arboreal lichens in cedar-hemlock-spruce forest
18/01/76	Raven Lake	1670 m	Tracks of a small group at timberline in balsam-spruce forest
30/01/76	Sugar bowl Mountain - Raven Lake	1520 - 1710 m	6-8 caribou travelling in alpine
02/02/76	Grizzly Den - Raven Lake	1710 m	3-5 caribou in alpine area
05/02/76	Grizzly Den	1690 m	Tracks of 3-5 caribou in timberline balsam-spruce forest
06/02/76	McGregor River-Torpy River	1520 - 1710 m	2 caribou feeding in alpine
23/02/76	Raven Lake	1615 m	2 cows at timberline
12/03/76	Driscoll Creek	1590 m	3 cows in balsam-spruce forest
19/03/76	Hungary Creek just south of Highway 16	755 m	4 cows in cedar-hemlock-spruce forest
24/03/76	Highway 16, 6 miles east of Purden Lake	790 m	1 bull, 5 cows in balsam-spruce forest
03/04/76	Driscoll Creek at Hwy 16	835 m	tracks of 2-3 caribou

Date	Location	Elevation (metres) (approx.)	Remarks
12/04/76	Narrow Lake	1680 m	Tracks of 4 caribou in balsam spruce forest
29/04/76	Slim-Tumuch road - mile 22	884 m	6 caribou in balsam-spruce forest
04/05/76	Raven Lake	1660 m	2 cows in balsam-spruce forest
07/05/76	Wendle Creek	1640 m	Tracks of 3-5 caribou in timberline balsam-spruce forest
15/05/76	West Twin Creek	810 m	1 bull,3 cows,1 juvenile in cedar forest
23/05/76	Ptarmigan Creek	1370 m	6 bulls,4 cows feeding in bal[illegible]m-spruce parkland
26/05/76	Severeid Creek	1275 m	Tracks of 2-3 caribou
15/06/76	Papoose Lake	1120 m	1 bull,6 cows around lake
23/06/76	Ptarmigan Creek - west fork	1220 m	mature bull and cow foraging in subalpine meadow
05/07/76	Hungary Creek road - mile 8	1070 m	1 cow,1 juvenile,1bull(very dark) in cedar-hemlock-spruce forest
13/07/76	Raven Lake	1480 m	Pellets,tracks of 3-5 caribou in balsam parkland
14/07/76	Slim-Tumuch road - mile 23	1490 m	Pellets,tracks of 6-8 caribou in meadow
19/07/76	Slim-Tumuch road - mile 19	1520 m	Pellets, tracks of 6-10 caribou; much local activity in timber
19/07/76	McGregor Logging Zone - Pass Lake road - (C.P.#6)	1520 - 1550 m	12 caribou feeding in alpine
20/07/76	McGregor Logging Zone - Sande road - mile 9	823 m	2 cows, 2 calves
21/07/76	McGregor Logging Zone - Sande road - mile 9	823 m	8 cows on road

Date	Location	Elevation (metres) (approx.)	Remarks
26/07/76	Slim-Tumuch road - mile 19 trail	1410 m	2 juveniles on trail in subalpine meadow
27/07/76	McGregor Logging Zone - Sande road - mile 9	823 m	1 bull, 3 cows, 1 juvenile
29/07/76	Pass Lake	1370 m	2 caribou
29/07/76	Longworth Lookout	1525 m	1 bull, 1 calf
06/08/76	McGregor Logging Zone - Sande road - mile 10	1070 m	2 cows, 2 juveniles
06/08/76	Raven Lake	1680 m	Tracks of 4-6 caribou
10/08/76	Raven Lake Trail	1660 m	Pellets, 4-6 caribou in balsam-spruce forest
[illegible]4/08/76	Raven Lake	1752 m	Pellets, tracks of small band in alpine
[illegible]/08/76	McGregor Logging Zone - Cargill road - mile 20	910 m	one cow or young bull
[illegible]8/76	Raven Lake	1660 m	Tracks of 3-5 caribou near timberline meadow
[illegible]/76	Raven Lake	1530 m	3 cows, 1 juvenile balsam-spruce forest
07/09/76	McGregor Logging Zone - Sande road - mile 6	845 m	one cow
10/09/76	Raven Lake	1560 m	2 cows at timberline
16/09/76	Goat River	1770 m	11 caribou in alpine
18/09/76	Fleet Creek - (McKale River)	1510 m	2 caribou in Krumholz zone
18/09/76	Raven Lake area	1740 m	2 cows in alpine
29/09/76	McGregor river - Gleason Crk.	1680 m	Tracks of 2-3 caribou
15/10/76	Snowshoe Creek	1170 m	4 cows in balsam-spruce forest
19/10/76	Tumuch Lake (Dome Creek - Everett Creek)	1560 m	Poached bull located

Date	Location	Elevation (metres) (approx.)	Remarks
21/10/76	West Twin Creek	875 m	Band of 12 caribou
27/10/76	Hedrick Lake	1220 m	1 bull, 7 cows
03/11/76	Grizzly Den	1520 - 1550 m	Tracks of 2-3 in subalpine meadow
06/11/76	Purden Lake & Hwy 16	860 m	2 cows in cedar-hemlock-spruce forest
18/11/76	Hungary Creek Trail (Raven Lake)	1520 - 1550 m	Tracks of 3 caribou in balsam-spruce forest
12/12/76	West Twin Creek	891 m	1 bull, 4 cows in cedar-hemlock-spruce forest & licking salt on hwy.
14/12/76	Legrand Creek	1010 m	7 caribou
21/12/76	Highway 16 - 20 miles west of McBride	800 m	1 immature bull, 8 cows in cedar-hemlock-spruce forest
07/01/77	West of Ptarmigan Creek	790 m	Tracks of 3-7 caribou in a cedar-spruce forest
14/01/77	West Twin Creek	887 m	7 caribou feeding in cedar-hemlock-spruce forest at Highway 16 crossing
18/01/77	Crescent Spurr area	980 m	Tracks of 6-10 caribou
18/01/77	Fleet Creek at Fraser River	1150 m	Tracks of 3-4 caribou
18/01/77	Goat river-west of confluence with Milk River	1570 m	Tracks of 4-5 caribou in balsam-spruce forest
20/01/77	Buckthorn road - 10 miles north of George Mtn *	1168 - 1200 m	3 cows
29/01/77	Clyde Creek	1200 m	Numerous tracks, approx. 8-12 caribou
08/02/77	Red Mountain-Penny	1540 - 1560 m	11 cows, 1 juvenile in alpine basin
09/02/77	Fortidens-Penny	1520 m	8 cows in balsam-spruce forest near timberline
12/02/77	Fontoniko Creek-Herrick Crk.	1065 m	Tracks of 2-3 caribou

Date	Location	Elevation (metres) (approx.)	Remarks
25/02/77	Clyde Creek	1570 m	1 bull, 3 cows
08/03/77	McGregor Logging - Zone Sande road - mile 10	884 m	2 cows
09/03/77	Hungary Creek at Hwy 16	834 m	Tracks of 4-5 caribou in balsam-spruce forest
09/03/77	McGregor Logging - Zone Pass Lake road - mile 17	881 m	3 cows, 1 juvenile in muskeg
20/03/77	Dome Creek headwaters	1710 m	1 bull, 3 cows in alpine
25/03/77	Herrick Creek-Mueller Creek	1380 m	5 caribou
26/03/77	Sugarbowl Mountain	1630 m	Band of 4 caribou
03/05/77	West Torpy River - Torpy River	1470 - 1500 m	Tracks of 3-5 caribou in Krumholz-alpine area
03/05/77	Severeid Creek	1450 - 1500 m	Tracks of 4-7 caribou in Krumholz-alpine area
03/05/77	Hedrick Creek	1670 m	2 caribou along creek
03/05/77	Pass Lake	1680 m	5 caribou near timberline
04/05/77	Hungary Creek	747 m	1 juvenile caribou
05/05/77	West Twin Creek	823 m	1 cow in cedar-hemlock-spruce forest
09/05/77	Raven Lake	1525 m	9 cows, 2 bulls feeding on arboreal lichens
11/05/77	Herrick Creek-Mueller Crk.	1360 m	Small band in balsam-spruce parkland
13/05/77	Slim Creek	1680 m	Band of 4 caribou
13/05/77	Fontoniko Creek-Herrick	1450 m	Tracks of 2-3 in balsam-spruce forest
14/05/77	Slim-Tumuch road - mile 23	834 m	Band of 4 caribou
24/05/77	McGregor Logging area - Severeid road(C.P.#25)	1020 m	Antlers visible, 1 caribou unsexed

Date	Location	Elevation (metres) (approx.)	Remarks
25/05/77	Slim-Tumuch road - mile 8.5	1135 m	Single, anterless cow along edge of clearcut
26/05/77	McGregor Logging Zone Sande road - mile 9.0	671 m	6 cows, 1 immature bull; many tracks in area
27/05/77	Papoose Lake	1110 m	Pellets of band of 6-8 caribou around lake
05/06/77	Dome Creek	1006 m	2 cows on creek bed
07/06/77	McGregor Logging Zone Pass Lake road - mile 25	884 m	2 cows, 2 juveniles
07/06/77	Haggen Creek	1150 m	4 bulls in balsam-spruce forest
08/06/77	McGregor Logging Zone Pass Lake road - mile 22-25	884 m	1 bull, 2 cows
13/06/77	Pass Lake	884 m	2 cows in balsam spruce forest
15/06/77	Mt. Severeid	1570 m	Evidence of calving; no animals seen
19/06/77	West Torpy River-Torpy River	836 m	Tracks of 3-4 caribou
21/06/77	McGregor Logging Zone - Torpy river road (C.P.#9)	793 m	1 juvenile caribou
27/06/77	Haggen Creek	1550 m	3 cow caribou in subalpine meadow
05/07/77	Nevin Creek	1140 m	1 caribou in subalpine meadow
10/07/77	Lamco road *	1180 m	3 caribou on road, 2 others along Highway 16
15/07/77	Pass Lake ridge	1040 m	4 cows, 2 juveniles
18/07/77	Mt. Averill *	1340 m	Tracks, pellets of 6-8 caribou
12/08/77	McGregor Logging Zone - Logan road - mile 31 *	1020 m	4 bulls (2 mature, 2 immature) 1 cow
26/08/77	Everett Creek	1575 m	Band of 3 caribou in subalpine meadow

Date	Location	Elevation (metres) (approx.)	Remarks
03/09/77	Grizzly Den	1405 m	Much activity in balsam-spruce forest,pellets of 8-12 caribou
10/09/77	McGregor Logging Zone - Pass Lake road - mile 8.5-9.0	930 m	2 bulls, 7 cows, 2 juvenile
22/09/77	McGregor Logging Zone - Logging road *	915 m	2 cows
10/10/77	West Twin Creek	850 - 910 m	12 caribou
12/10/77	Legrand Creek at Hwy 16	1035 m	4 cows crossed into a cedar spruce stand
21/11/77	Woodall Creek	980 m	2 caribou in balsam spruce forest
17/12/77	Clyde Creek at Hwy 16	900 m	3 cows at edge of timber
23/12/77	Sugarbowl Mountain	1390 m	Tracks of 4-5 caribou in balsam-spruce forest
27/12/77	Hedrick Lake	1560 m	1 bull, 6 cows in subalpine meadow
28/12/77	Red Mountain-Penny	990 m	Band of 10-15 caribou in cedar-hemlock-spruce forest

APPENDIX E

Ecology, Importance and Utilization of Forage Plants Known to be Used By Mountain Caribou

KEY

Overall Cover-Abundance (Importance values).

1. Generally contributed insignificant cover; widespread and sparse; completely or almost completely confined to one community.

2. Cover contribution small; without pronounced affinity for any community.

3. Frequent occurrence rarely dominant; present in several communities.

4. Frequent occurrence, rarely dominant; generally confined to a single community.

5. Abundant, cover significant; occurred in various communities but predominant in one.

6. Abundant, cover significant; locally dominant; completely or almost completely confined to one community.

Preferred Growth Zone/Zone of Preferred Caribou Use

1. Balsam-Spruce Forest.

2. Cedar-Hemlock-Spruce Forest.

3. Subalpine Meadow.

4. Krumholz Zone.

5. Alpine.

6. Disturbance Areas.

Season of Preferred Caribou Use

1. December 15 - February 14.

2. February 15 - April 14.

3. April 15 - June 14.

4. June 15 - August 14.

5. August 15 - October 14.

6. October 15 - December 14.

Overall Forage Importance Values

1. Minimal use, minimal availability.

2. Rarely or infrequently used though readily available.

3. Occasional, moderate use.

4. Frequently selected, moderately high use.

5. Heavily utilized species.

6. Forage importance unclear.

Forage Plants Used By Mountain Caribou

Forage Species	Overall Cover-Abundance (Importance value)	Preferred Growth Zone	Season of Preferred Caribou Use	Zone of Preferred Caribou Use	Overall Forage Importance Value
Abies lasiocarpa	5	1	3,6	1	6
Alnus crispa	4	2	3	2	4
Anemone species (Unknown)	1	5	4	3	2
Arnica latifolia	3	4	5	3	3
Caltha leptosepala	3	4	4	3	5
Campanula lasiocarpa	1	5	4	5	1
Carex species (2)	3	4	5	3,4	5
Cassiope mertensiana	6	4	2	4	3
Cinna latifolia	3	2	3	2	4
Claytonia lanceolata	3	4	4	4	5
Clintonia uniflora	3	2	3	2	5
Cornus canadensis	5	2	6	1,2	5
Dryas hookeriana	4	5	2	5	3
Epilobium angustifolium	2	1	5	6	4
Epilobium species (3)	2	4	3	2	3
Equisetum species (3)	3	1	4,6	1	4
Erigeron humilis	1	4	2	5	1
Galium triflorum	3	2	6	2	4
Gentiana glauca	4	4	2	5	1
Habenaria species (3)	3	3	4,5	4	3
Heracleum lanatum	5	1	1	3	4
Lonicera involucrata	6	1	1	1	2
Lupinus nootkatensis	3	4	1	4	2
Luzula wahlenbergii	3	4	3,4,6	4,6	5
Menziesia ferruginea	4	2	6	2	3
Parnassia fimbriata	2	4	4	4	4
Pedicularis bracteosa	3	4	5	4	5
Phleum alpinum	2	4	5	3	4
Phyllodoce empetriformis	4	4	2	4	2
Picea engelmannii	5	1	3,6	1	6
Poa alpina	2	4	4	4	4

Forage Species	Overall Cover-Abundance (Importance value)	Preferred Growth Zone	Season of Preferred Caribou Use	Zone of Preferred Caribou Use	Overall Forage Importance Value
Rhododendron albiflorum	6	1	1	1	3
Ribes lacustre	6	1	1,6	1	4
Rubus parviflorus	5	2	3	2	4
Rubus pedatus	3	1	6	1	5
Salix species (2)	4	4	3	4	5
Sambucus melanocarpa	4	2	6	2	3
Saxifraga species	3	3,4,5	4	4,5	5
Senecio triangularis	3	4	4	4	4
Smilacina species (2)	3	1,2	6	1,2	3
Streptopus species (2)	3	1,2	6	6	4
Thalictrum occidentale	5	1	6	1	5
Tiarella unifoliata	5	1,2	1,3	1	5
Thuja plicata	6	2	3	2,6	6
Trisetum spicatum	1	4	5	4	3
Trollius albiflorus	3	3,4	4,5	4	5
Tsuga heterophylla	6	2	6	2,6	6
Vaccinium species (2)	5	1	1	6	3
Valeriana sitchensis	5	1	1	1	5
Veratrum eschscholtzii	5	1	6	1	2
Veronica alpina	1	4	4	5	3
Viola species (2)	2	1,3	3	2	5
Compositae Misc.	*	*	5	4	3
Graminae Misc.	*	*	5	3	5
Polygonaceae Misc.	*	*	5	5	6
Polypodiaceae Misc.	*	*	6	1	3
Ranunculaceae Misc.	*	*	1	6	2
Rosaceae Misc.	*	*	5	3	3
Saxifragaceae Misc.	*	*	5	4	5
Alectoria sarmentosa	6	1	1	1	3
Bryoria capillaris	6	1	6	1	5
Bryoria fremontii	4	1,4	2	3	3

Forage Species	Overall Cover-Abundance (Importance value)	Preferred Growth Zone	Season of Preferred Caribou Use	Zone of Preferred Caribou Use	Overall Forage Importance Value
Bryoria glabra	3	1	6,2	3,4	4
Bryoria lanestris	6	1	3	1	5
Bryoria oregana	6	1	2	4,5	4
Bryoria species Misc.	*	*	6	6	4
Cetraria ciliaris	1	1	3	6	1
Cetraria halei	2	1	2	6	1
Hypogymnia enteromorpha	3	1	2	1	4
Hypogymnia physodes	5	1	2,6	1,6	5
Lobaria pulmonaria	6	2	6	2	5
Parmelia sulcata	5	1	2,6	2,4	3
Parmeliopsis species (2)	3	1	2	5,6	3
Platismatia glauca	6	2	6	2	5
Cetraria species (5) (terrestrial)	2	1,4	6	2	1
Cladonia coccifera	3	1	6	2,6	3
Cladonia ecmocyma	3	1	2	5,6	6
Cladonia mitis	4	4,5	4	4	3
Cladonia rangiferina	4	4,5	5	4	4
Cladonia uncialis	3	4	4	4	3
Cladonia species (1,2) Misc.	*	*	4	5,6	3
Peltigera aphthosa	5	1,2	6,1	1,2	4
Peltigera canina	5	1,2	6,3	2	4
Stereocaulon species (3)	4	4,5	5	5	4
Umbilicaria hyperborea	4	4	5	5	6
Drepanocladus uncinatus	3	3,4	2	4	6
Hylocomium splendens	5	1	6,1	2	3
Pleurozium schreberi	5	1	6	1	3
Polytrichum species (2)	3	1	1	2	2
Ptilium crista-castrensis	5	1	6	1	3
Rhacomitrium species (3)	3	1,2,4	6	4	6
Mosses Misc.	*	*	1	1	2

* Unknown

APPENDIX F

Known Historic Sightings Of Mountain Caribou In Central British Columbia, Prior to September, 1975

(Refer to Figure 5-2)

(Sightings-information had to provide year and location of an actual observation to be included)

Date	Location	Remarks	Reported by
Autumn 1918	Fraser River Valley near Penny, B.C.	Approximately 100 caribou swam across Fraser River	Lew Louie to M. Frye
Winter 1934	Caribou River near Ghost Creek	Large wintering bands	D. Ferguson
Autumn 1935	Raven Lake	Sizeable herd	O.J. Prather
Winter 1935	Fleet Creek	35 caribou	D. Ferguson
July 1936	Hellroaring Creek	60 caribou with many calves	N. Ferguson
Summer 1938	Dome Creek	Small band observed	J. Gasprey
Spring 1940	Herrick Creek - Fontoniko Creek	Band of 30-40 caribou	J. Gasprey
Spring & Summer 1940	Herrick Creek & Mueller Creek	15-25 caribou with 5 calves	J. Gasprey
1940	West Torpy River & Torpy River	Approximately 150-200 caribou located in this area	J. Gasprey
Autumn 1942	Wells Mtn.	18 cows & 3 juvenile bulls	J. Gasprey
June 1944	Cecilia Lake	About 100 caribou in high mountain country just inside Alberta border	J.D. Soper
Summer 1944	Walker Creek	35-50 caribou with 6-10 calves	J. Gasprey
Spring 1946	Raven Lake	5 adult caribou	O.J. Prather
1948	Torpy River & McGregor River	Band of 45 caribou	K.W. Hooker
Autumn 1950	Fraser River & Driscoll Creek	Shot caribou with damaged lungs & spotted, blackish, foul smelling liver	D. Minty
Winter 1952	P.O.B. Creek	Small band	D. Ferguson

Date	Location	Remarks	Reported by
Autumn 1955	Everett Creek & Slim Creek	Large groups of caribou	J. Gasprey
Autumn 1956	Cargill Creek & McGregor River	Shot caribou with previously broken leg, healed in 2 places	D. Minty
Summer 1957	Mount Rider	Several bands in large, open meadows	D. Ferguson
1957-58	Pass Lake	Mountain littered with caribou antlers	Unknown
Autumn 1958	Raven Lake	Increasing caribou activity in vicinity	O.J. Prather
Autumn 1958	Mount Rider & Fleet Creek	30-35 caribou resident	D. Ferguson
December 1958	Fleet Creek	12 caribou	D. Ferguson
July 1959	East Twin Creek	2 caribou	D. Ferguson
Summer 1959	Clyde Creek	Numerous sightings	D. Ferguson
Autumn 1959	Fleet Creek	2 caribou; also cow moose with triplets	D. Ferguson
Autumn 1959	Mount Rider	Frequent sightings	D. Ferguson
Autumn 1959	Raven Lake & Hungary Creek	4 cows, 1 immature bull, 2 calves	O.J. Prather
Autumn 1959	Lendrum game trail (Longworth access road)	Several groups (15-25 animals) were seen here	D. Minty
Autumn 1959	Toneko Lake	Many caribou tracks	D. Minty
Autumn 1959	Lendrum game trail	Observed an albino caribou in a group of 15-20	D. Minty
Spring 1960	Stone Creek	4-6 caribou	M. Wilkinson

Date	Location	Remarks	Reported by
October 1960-63 (Inclusive)	McGregor River & Fraser River	During the early 1960's 100-120 caribou gathered annually near the current site of McGregor logging camp	S. Wlasitz D. Minty
July 1961	St. George Creek (headwaters)	Several caribou sighted	F. Hartman
Summer 1961	George Mountain & Naver Creek	6 caribou	M. Wilkinson
Winter 1961	Hixon Creek	5-6 caribou	M. Wilkinson
1962 (all seasons)	Sheep Creek, Kakwa River, McGregor River, Narraway River	Band of about 67 caribou	F. Pruckl
January 1963	Fleet Creek & Mount Rider	3 bulls & 1 cow	D. Ferguson
Summer 1963	Ptarmigan Creek	20-50 caribou daily	G. Hooker
Autumn 1963	Dome Creek (headwaters)	Good size groups were common	G. Hooker
Autumn 1963	McKale River	Band of 24 caribou	M. Frye
November 1963	Fleet Creek & Mount Rider	3 bulls & 2 cows	D. Ferguson
November 1963	Fleet Creek	4 caribou	D. Ferguson
February 1964	Fleet Creek	18 caribou	D. Ferguson
Autumn 1965	Dore River & Rausch River	Small band of caribou	M. Frye
Autumn 1966	Blue Creek (Jasper National Park) & Morkill River	Rutting activity suspected near headwaters	B. Duncan
Summer 1967	Haggen Creek	Band of 21 caribou	F. Cushman

Date	Location	Remarks	Reported by
Autumn 1967	Beaver River & Loren Lake	Band of 40 caribou	D. Ferguson
October 1967	Bowron Road to Dewey on Fraser River	Caribou regularly seen moving north, disturbed by new highway	S. Wlasitz
Early Winter 1967	Raven Lake	A few caribou, numbers decreasing because of increased hunting pressure	O.J. Prather
Winter 1967	Bullmoose Mtn. & Ruffern Lake	Calving ground north of Ruffern Lake	G. Kalischuk
September 1969	Fleet Creek & McKale River	Group of 19 caribou	M. Monroe
Autumn 1969	Littlefield Creek	Cow & calf	F. Cushman
Autumn 1970	Upper Littlefield Creek	2 bulls	F. Cushman
1970's	Hook Lake		M. Mulvahill
Autumn 1971	Haggen Creek	Large bull shot	F. Cushman
Summer 1972	Haggen Creek	Bull carcass on small nearby lake (assumed predation)	F. Cushman
Autumn 1972	Lendrum game trail	A couple of tracks seen	D. Minty
1973-75	Bullmoose Mtn.	11 adults, 2 juveniles, no calves	G. Kalischuk
Spring 1974	Nav r Creek	Tracks of 2-3 caribou	M. Wilkinson
Summer 1974	E ue Ice Glacier	A band of 10-15 caribou	M. Frye
September 1974	Naver Creek	2 caribou	M. Wilkinson
Winter 1974-75	Legrand Creek & West Twin Creek	Wintering caribou	M. Vatamaniuk

Date	Location	Remarks	Reported by
January 1975	West Twin Creek	8 caribou	D. Ferguson
March 1975	* Highway 16 near Clyde Creek	5 caribou	D. Ferguson
July 1975	George Mountain & Naver Creek	2-3 caribou	M. Wilkinson
Summer 1975	Naver Creek	Lone caribou	M. Wilkinson

* Not recorded on sightings map (Fig. 5-2) but adjacent to study area.

APPENDIX G

Historic and Contemporary Caribou Migration Routes and Travel Corridors in Central British Columbia

Appendix G. Historic and contemporary migration routes and travel corridors.

Number	Location	Remarks	Most recent known year of use	Reported by
1	Mt. George, along George Creek to Naver Creek and west toward Hixon and Terry Creeks	Current bands very small; population marginal	1961	M. Wilkinson
2	Tumuch Lake to Papoose Lake	Late winter, early spring use may nave travelled as far south as Rinkerton Peak	1976	O. J. Prather B. Weinard
3	Lendrum game trail*	Destroyed by Longworth access road may be same as Penny trail.	Early 1960's	D. Minty S. Wlasitz R. Mueller
4	Penny game trail	In 1918 about 100 animals were reported travelling here	Early 1960's	S. Wlasitz R. Mueller J. Boudreau
5	Slim-Tumuch Road mile 14	Caribou crossed logging road	1976	B. Weinard C. Mason O. J. Prather
6	Slim-Tumuch Road between mile posts 19 and 25	Various sightings of caribou crossing road, particularly important area just east of mile 23	1977	O. J. Prather B. Weinard M. Bloomfield
7	West of Driscoll Creek at Highway 16*	May be an extension of the Tumuch-Papoose corridor	1977	M. Bloomfield
8	Bowron River, perhaps along Kenneth Creek about 6-8 miles east of Purden Lake and north to the Fraser River Valley*	A broad travel corridor may have existed between Kenneth and Driscoll Creeks	1975	R. Mueller S. Wlasitz F. Knapp T. Gasprey
9	Haggen Creek, perhaps as far south as Dominion Creek, north along Bowron River to corridor between Kenneth and Haggen Creeks	Animals as far south as Bowron Lakes Park may have used this route	1960's	G. Hooker S. Wlasitz

Appendix G continued.

Number	Location	Remarks	Most recent known year of use	Reported by
10	Papoose Lake between Hungary Creek and Driscoll Creek and toward Halfmoon Lake*	Sizeable herds prior to 1967 completion of Highway 16	1969	O. J. Prather
11	Goat River, to LaSalle Lakes along LaSalle Creek and toward Mt. Rider and Hellroaring Creek	Caribou observed at LaSalle Lakes as recently as 1976	1960's	D. Ferguson
12	Mt. Halvorson, along West Twin Creek up Fleet Creek and toward the Cushing Creek area	West Twin Creek crossing is about 1200 metres east of the bridge may have connected areas near the Cariboo River with ranges north of Mt. Rider; 64 animals at West Twin Creek in 1934; bridge construction blocked route for nearly 2 years	1960's	D. Ferguson M. Monroe
13	Sugarbowl Mtn, possibly along Kenneth Creek and south toward the Centennial Creek area	May be related to route 8	Unknown	O. J. Prather
14	From Mt. Hammel area, along Ptarmigan Creek	May cross Highway between Ptarmigan and Catfish Creeks	1977	D. Ferguson B. Weinard M. Bloomfield
15	North of the Torpy River, north of Red Mtn. and south of Harvie Creek, north of Pass Lake and to the vicinity of Mt. Severeid	Movements may have continued along Woodall Creek to its headwaters	1977	B. Weinard M. Bloomfield

Appendix G continued.

Number	Location	Remarks	Most recent known year of use	Reported by
16	Between Gleason and Harvie Creeks, north past Mt. Hedrick to 2 unnamed lakes	Probably connects with the Torpy River route	1977	B. Weinard
17	Keg Creek at Crotch Creek to headwaters of Woodall Creek	May have connected with McGregor River area	1966	D. Minty R. Mueller S. Wlasitz
18	Below canyon on Fraser River at Toneko Lake		Early 1960's	S. Wlasitz R. Mueller D. Minty
19	Pass Lake road 11.5 mile	Old road where creek comes out of hills is location of important crossing	1977	D. Minty M. Bloomfield
20	Pass Lake road near mile post 17	Caribou are known to cross logging road	1976	M. Bloomfield S. Wlasitz
21	Fraser River Valley along Redmountain Creek to the Torpy River Valley and north toward the McGregor range	Suspected travel corridor movements occurred during study	1976	J. Boudreau
22	Headwaters of McGregor River to Walker Creek	Some movement also along Forgetmenot Creek to McGregor River	1976	J. Gasprey B. Weinard
23	Along Everett Creek to Slim Creek	May be connected to Tumuch-Papoose Corridor	1977	B. Weinard G. J. Prather M. Bloomfield
24	Headwaters of West Torpy River to ranges between Fraser River and Torpy River		1948	K. Hooker

Appendix G continued.

Number	Location	Remarks	Most recent known year of use	Reported by
25	From McGregor River to Bearpaw Ridge to Crotch Creek	Numerous game trails in the area	1962	S. Wlasitz R. Mueller
	Legrand, along Clyde Creek toward Mt. Halvorson	Also some movement along McIntosh Creek	Unknown; possibly 1976	D. Ferguson
26	Along Castle Creek toward Mt. Quanstrom	May have led to Wells Gray Park		D. Ferguson M. Frye
27	Cariboo River area, between Milk River and Dore River and north to the Fraser River Valley	Large numbers travelled this route in 1934	Early 1960's	D. Ferguson
28	Along McGregor River to areas between Buchanan and Bastille Creeks		Unknown	M. Monroe
29	Along Nevin Creek to Holmes and Chalco Rivers	Appears to be in disuse	Unknown; possibly early* 1960's	M. Vatamaniuk D. Ferguson
30	Castle River, up Holmes River to Chalco River	No longer used	Unknown	D. Ferguson M. Frye
31	Catfish Creek to the Morkill River and perhaps toward Mt. Rider		1975	D. Ferguson
32	Along headwaters of McGregor River		Unknown	J. Gasprey

* Crossing at Highway 16.

APPENDIX H

Annual Caribou Hunting Seasons and Regulations, 1950 - 1977

ANNUAL CARIBOU HUNTING SEASON 1950-1977 IN G.M.A. 20

(1972-1977 changed to Omineca Sub-region of Region 7)

Year (s)	Season		Bag Limits			Special Regulations (#Days)
	Dates	Length (Number of Days)	Male	Female	Juvenile (Includes Calves)	
1950 to 1954 (incl.)	Sept. 1 to Dec. 15	106	(1) over one year	nil	nil	South of C.N.R. - Sept. 15 to Oct. 31 (46)
1955	Sept. 1 to Dec. 15	106	(1) over one year	nil	nil	South of C.N.R. a. East of Fraser R. Sept. 15- Dec. 4 (80) b. West of Fraser R. Oct. 1 - Oct. 15 (15)
1956	Sept. 1 to Dec. 15	106	(1) over one year	nil	nil	South of C.N.R. - Oct. 1 - 21 (21)
1957	Sept. 1 to Dec. 15	106	(1) over one year	nil	nil	South of C.N.R. - Sept. 28 - Oct. 20 (23)
1958	Aug. 15 to Nov. 30	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 28 - Oct. 25 (27)
1959	Aug. 15 to Nov. 30	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 26 - Oct. 25 (29)
1960	Aug. 15 to Dec. 4	111	(1) over one year	nil	nil	South of C.N.R. - Sept. 20 - Oct. 16 (26)
1961*	Aug. 15 to Dec. 3	110	(1) over one year	nil	nil	South of C.N.R. - Sept. 1 - Oct. 15 (45)

ANNUAL CARIBOU HUNTING SEASON 1950-1977 IN G.M.A. 20

(1972-1977 changed to Omineca Sub-region of Region 7)

Year(s)	Season		Bag Limits			Special Regulations (#Days)
	Dates	Length (Number of Days)	Male	Female	Juvenile (Includes Calves)	
1961**	Sept. 30 to Oct. 22	23	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1962*	Aug. 15 to Dec. 2	109	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1962**	Sept. 15 to Oct. 15	31	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1963*	Aug. 15 to Dec. 1	108	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1963**	Sept. 15 to Oct. 15	31	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1964*	Aug. 15 to Nov. 29	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1964**	Sept. 12 to Nov. 1	60	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1965*	Aug. 14 to Nov. 28	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)

ANNUAL CARIBOU HUNTING SEASON 1950-1977 IN G.M.A. 20

(1972-1977 changed to Omineca Sub-region of Region 7)

Year(s)	Season: Dates	Season: Length (Number of Days)	Bag Limits: Male	Bag Limits: Female	Bag Limits: Juvenile (Includes Calves)	Special Regulations (#Days)
1965**	Sept. 11 to Nov. 28	78	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1966*	Aug. 13 to Nov. 27	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1966**	Sept. 10 to Nov. 27	78	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1967*	Aug. 12 to Nov. 26	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1967**	Sept. 16 to Nov. 26	71	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1968*	Aug. 17 to Nov. 30	106	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1968**	Sept. 14 to Nov. 30	77	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1969*	Aug. 16 to Dec. 14	120	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)

ANNUAL CARIBOU HUNTING SEASON 1950-1977 IN G.M.A. 20

(1972-1977 changed to Omineca Sub-region of Region 7)

Year(s)	Season: Dates	Season: Length (Number of Days)	Bag Limits: Male	Bag Limits: Female	Bag Limits: Juvenile (Includes Calves)	Special Regulations (#Days)
1969**	Sept. 13 to Nov. 30	78	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1970*	Aug. 15 to Dec. 6	114	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16), changed from either sex, any age to only either sex.
1970**	Sept. 5 to Nov. 15	71	nil	(1)	(1)	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1971*	Aug. 14 to Nov. 28	107	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1971**	Sept. 4 to Nov. 28	85	nil	(1)	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16), juvenile (calf) season closed.
1972*	Aug. 19 to Nov. 26	99	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16), changed from G.M.A. 20 to Region 7 Mt. Robson Park - bull season, Sept.9-Oct. 15(36)
1972**	Sept. 9 to Nov. 26	78	nil	(1)	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16)
1973*	Aug. 15 to Nov. 18	95	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16), Mt. Robson Park - Bull Season

ANNUAL CARIBOU HUNTING SEASON 1950-1977 IN G.M.A. 20

(1972-1977 changed to Omineca Sub-region of Region 7)

Year(s)	Season		Bag Limits			Special Regulations (#Days)
	Dates	Length (Number of Days)	Male	Female	Juvenile (Includes Calves)	
1974*	Aug. 15 to Nov. 15	92	(1) over one year	nil	nil	South of C.N.R. - Sept. 30 - Oct. 15 (16), Mt. Robson Park - Bull Season Sept. 15 to Oct. 27 (43)
1975*	Aug. 15 to Nov. 15	92	(1) over one year	nil	nil	Holmes River closure in M.U. 7-3, changed to M.U. system, M.U. 7-7 closed.
1976*	Aug. 15 to Nov. 15	92	(1) over one year	nil	nil	South of C.N.R. - Aug. 23 to Oct. 15 (23) M.U. 7-5 closed for study
1977*	Aug. 23 to Oct. 15	54	(1) over one year	nil	nil	M.U.'s 7-3, 7-4, 7-17, Aug. 23 to Sept. 18 (36)

* - bulls only

** - cows and calves only (either)

APPENDIX I

Framework for Mountain Caribou Management and Research in British Columbia

The Raven Lake Mountain Caribou Study was the first caribou study conducted in the region. Furthermore, caribou research is difficult and time consuming. Consequently, various aspects of caribou ecology require further investigation and continual monitoring. It is difficult to priorize future research requirements. Nonetheless, further research is necessary because of continued pressure from settlement and development. Field research should concentrate on population dynamics, potentially limiting factors, movement patterns, home range requirements and the impacts of further development. Management objectives should emphasize protection of critical habitats, preservation of essential movement corridors and implementation of strict guidelines for activity in caribou range. Development of public information programs and materials also should be given high priority. The following outline provides a framework for caribou management and research based on the results of this study.

I. REVIEW OF CARIBOU HISTORY, TAXONOMY, BIOLOGY AND ECOLOGY

A. History of Local Caribou

B. Caribou Taxonomy

C. Review of Population Dynamics

1. Breeding biology and behavior

2. Recruitment and productivity

3. Mortality

4. Structure and composition

D. Patterns of Resource Utilization

1. Seasonal habitat selection

2. Seasonal food habits

E. Potential Limiting Factors

1. Predation

2. Weather

3. Habitat alienation

a. logging

b. fires

c. road construction

d. clearing and settlement

e. oil and seismic

f. coal

4. Disease and Parasitism

5. Recreation

6. Hunting

7. Harassment

8. Inter-specific competition

11. MANAGEMENT OBJECTIVES

A. Habitat Protection, Evaluation and Maintenance

1. Maintain suitable and adequate climax habitat in a continuum sufficient to ensure caribou survival
   a. provide suitable corridors connecting key areas, particularly between critical habitats
   b. ensure special areas adequately provide for caribou requirements
2. Safeguard areas of special significance
   a. protect key, low elevation wintering areas sufficient to accommodate slow lichen growth
   b. eliminate logging adjacent to lakes and muskeg important to caribou
   c. prevent developmental and recreational disturbances in calving, wintering and rutting areas, mineral licks and travel corridors; provide protective buffers
   d. preserve subalpine forests above 1550 metres in their entirity
   e. practice fire suppression in and adjacent to important range areas
   f. attempt to reduce or eliminate creation of barriers to movement
   g. preserve essential movement corridors and provide protective cover
   h. protect important subalpine forests between 1100 and 1675 metres

3. Monitor and minimize habitat modifications resulting from current development and land-use practices
    a. propose reductions in annual allowable cuts; sacrifice harvestable timber for caribou management
    b. reduce size of individual logging cuts
    c. reduce volume of timber extracted from any single watershed
    d. lengthen the rotation period for logging operations
    e. restrict hydro-electric developments on caribou range
    f. curtail winter logging programs in critical habitat
    g. prevent substantial reductions in overall age of any stand
    h. distribute cuts within watersheds according to caribou use
    i. continue lichen biomass studies
    j. disperse timber removal over a larger area
    k. restrict agricultural clearing and livestock grazing in caribou habitat
4. Recommend changes in land-use policies and establish comprehensive and cooperative interagency habitat management plans
    a. incorporate previously alienated habitat into forest-caribou management guidelines
    b. develop caribou censusing network to document all caribou observations

c. attempt to develop a comprehensive management program with the Alberta Fish and Wildlife Division to ensure protection of key areas utilized in both provinces

5. Continue research to identify areas of special significance

6. Establish sanctuaries, reservations and special management areas in key habitat of sufficient size to support local caribou populations

   a. restrict recreational and industrial activities in critical areas, especially winter habitat and travel corridors (Figures 5-3 and 5-5)

   b. give priority to establishment of ecological reserves in zones b, c, e, f, g, and h (Figure 5-1)

   c. establish a caribou sanctuary along the Alberta boundary (from latitude 53°19' to 54°9') to exploit the presence of Willmore Wilderness and provide for an enlarged special management area. The sanctuary should extend at least to longitude 120°15'

B. Reduce Mortalities and Harassment Caused by People

1. Restrict access in sensitive areas and inform the public of the benefits of controls

2. Close roads created for fire control, logging and other industrial activities immediately after program completion; road construction should be at minimum to facilitate closure

3. Restrict snow machine and all-terrain vehicle use in wintering and calving areas and along migration routes

4. Implement a full and extended closure for caribou in the Omineca subregion and especially Wildlife Management Units 7-3, 7-4, 7-5(A&B), 7-6, 7-7, 7-17, and 7-18
5. Provide protected status for the remaining caribou
6. Restrict use of aircraft, particularly for recreation, in sensitive areas
7. Strictly enforce hunting regulations and prosecute poachers
8. Promote greater appreciation of caribou through public programs, audio-visual materials and publications relevant to the biology, ecology and social behavior of the species; create public interest in the rare and spectacular mountain caribou
9. Encourage educational institutions to study various aspects of caribou ecology
10. Erect informative signs at caribou highway crossings
11. Prevent establishment of additional recreational facilities in prime caribou habitat

C. Initiate Research on Critical Aspects of the Biology of Caribou

1. Determine home range requirements of individual bands
2. Conduct demographic studies on mountain caribou
    a. assess group composition by season, sex and age
3. Continue comparative evaluation of historical and contemporary population size and distribution
4. Interpret cyclical nature of seasonal patterns of range use, habitat association and behavior

5. Conduct studies on population dynamics including breeding biology and behavior, recruitment, productivity, mortality, composition and structure
6. Evaluate contacts between population groups
7. Further examine implications of various pressures on remaining herds, particularly from oil, gas and coal exploration and logging
8. Further evaluate interrelationships among lichen biomass and timber stand age, height, luxuriance and composition
9. Determine how caribou orient themselves and react to seismic lines and roads encountered and produce a series of alternatives to minimize associated harassment

APPENDIX J

Mountain Caribou Questionaire

Raven Lake Mountain Caribou Study

Mountain Caribou Questionaire

Raven Lake Mountain Caribou Study

Dept. of Animal Science, University of Alberta

Name: ______________ Address: ______________ Occupation: ______________

A. Historical Trends

Concern has been expressed over the province-wide reduction of Mountain caribou herds. However, we are uncertain of the status of some local herds. This section deals with the history of Mountain caribou populations in your area.

1. Year your personal observations of Mountain Caribou in the Prince George region began ______________.
(year)

2. Mountain Caribou population since then has: (check one)

remained stable ______________ steadily decreased ______________

population numbers have fluctuated ______________

3. If you checked declined or fluctuated on question 2, why?:

Check as many as apply and indicate order of importance: 1 for most important: 2, 3, etc..., as importance decreases.

a. predation ______________
b. logging ______________
c. outdoor recreation ______________
d. dams ______________
e. hunting ______________
f. fires ______________
g. logging road (increased access) ______________
h. mining roads (increased access) ______________
i. seismic lines ______________
j. other ______________ Please specify ______________

4. If you checked fluctuated on Question 2: (check one)

has the population size recently stabilized ______________
increased ______________ decreased ______________

5. Do you know the locations of any historic (traditional) migratory routes:
yes ______________ no ______________

a. if yes, are they still used by Mountain Caribou: Yes ______________ No ______________

b. please indicate location: ______________

6. Can you provide from your past records, the locations of Caribou sightings?
yes ______________ no ______________

a. if yes, please use attached sheet.

7. Do you know of contacts between herds from several different areas?
yes __________ no __________

a. Do these contacts still exist? yes __________ no __________

b. If yes, please list the herds and their locations:

____

____

8. Can you estimate past and present population sizes in your area: fill in number of animals:

area described ____________________ past no. and years ____________________ (before 1975)

present no. ____________________

9. What is the largest group of Mountain Caribou you have ever seen together in one place at one time:

no. of animals __________ year (date) __________ location __________

B. Current Status and Ecology of Caribou

1. Habitat Preferences: The information obtained from this section will help in determining what areas caribou prefer and may assist in predicting herd locations. For each category below of a through dd put a check for each season, an area of the type described is used: leave blank where it is not used.

Area Type	Spring	Summer	Autumn	Winter
a. Old timber stands				
b. Mixed age timber				
c. Immature forest				
d. Subalpine meadows				
e. Alpine meadows				
f. Lake areas				
g. Stream, river or creek banks				
h. Old logging cuts (older than 10 years)				
i. Alder patches				
j. Recent logging cuts				
k. North facing slopes				
l. NW facing slopes				

Area Type	Spring	Summer	Autumn	Winter
m. NE facing slopes				
n. South facing slopes				
o. SW facing slopes				
p. SE facing slopes				
q. East facing slopes				
r. West facing slopes				
s. Slightly sloped terrain				
t. Moderately sloped terrain				
u. Greatly sloped terrain				
v. Mixed spruce, cedar, balsalm stands				
w. Cedar-hemlock stands				
x. Cedar stands				
y. Spruce balsalm stands				
z. Balsalm stands				
aa. Elevation 2500-3500				
bb. Elevation 3500-4500				
cc. Elevation 4500-5500				
dd. Elevation above treeline (above 5500)				

Describe, if possible, what you consider typical Mountain Caribou habitat -

Spring:

Summer:

Winter:

Comments, if any -

2. Food Habits: Within preferred habitats it is essential to know what plants are important in the diet of Mountain Caribou. This information will allow for better range management and protection for each food type: Below a through g put a check for each season you know caribou to use that type of plant: leave blank where it is not used: try to answer from your experiences rather than what you have heard or read -

Food Type	Spring	Summer	Autumn	Winter
a. grasses/sedges				
b. mushrooms (fungi)				
c. ground lichens (reindeer mosses)				
d. tree lichens				
e. shrubs				
f. trees				
g. herbs (flowering plants				

In what season (s) have you observed caribou feeding (check) spring __________ summer __________ autumn __________ winter __________. Describe what you observed for the season (s) checked.

Spring:

Summer:

Autumn:

Winter:

3. Population Structure: Information on herd size and sex ratios provides information on the reproductive success of the population and an estimates of the number of animals present.

a. What is the location of the herd you described: ____________________

____________________.

b. Estimated number of animals ____________________.

c. Sex ratio (approximate percentage %) adult bulls ______ juveniles ______
adult cows ______ calf ______.

d. Do you see many calfs in the herd? Yes _____ No _____ How many (#)
1975 ______ 1976 ______.

e. Do you think the number of calves born are enough to replace losses ? yes _____
no ______.

f. Is the calf survival rate low _____ high _____:

1. If you answered low, why do you think it is low? Specify cause ______

____

____

____

g. Do you know of any calving grounds? yes _____ no _____ .

1. If yes, please name the location ____________________

h. What time of the year does calving usually occur in your area: ______ (month).

i. Were there any unusually good or bad calf crops in recent years?

bad years (year) ______________ good years (year) ______________

4. Migration: Migration is an important part of Caribou behavior. We need information on the locations of the routes so they can be preserved in the interest of preventing caribou from being forced to over-utilize any particular area.

a. Can you describe the boundaries of the area used by the herd you are describing?

b. Is this area (check one) the same ______ greater ______ less than ______, in the past?

1. If possible explain boundary changes and the reasons (if they have changed):

c. Do you know of any presently used Mountain Caribou migration routes?
yes ________ no ________.

1. If yes, will you please give the location?

2. do you know of any changes on these migratory routes, caused by man's activities (ie. roads, dams, clear-cuts, powerlines, etc....)
yes ________ no ________

a. if yes, describe them:

3. how do you think that these changes affect the Mountain Caribou?

5. Forest Conditions: Is the Caribou decline in any way attributable to change in forest conditions and forestry practices and if so what, in you opinion, can reduce the harm done to the Mountain Caribou populations?

a. in recent years has the condition of forests used by the Mountain Caribou changed? yes ________ no ________.

1. if yes, the cause has been: (check as many as apply and indicate in order of importance by placing 1 by 1st most important, 2 by 2nd most important and etc...).

a. logging ________

b. forest fires ________

c. dams and diversion of waterways (flooding) ________

d. seismic lines ________

e. highway construction ________

f. other ________ specify ________________________

b. what is the present condition of the forests (check one for each of numbers 1 and 2):

1. Excellent ________ Fair ________ Poor ________

2. Mature ________ Immature ________

3. Improving ________ Declining ________

4. Explain your answer:

c. are you satisfied with current Forest Management Practices? yes ______ no ______

1. if yes what would you like changed?

d. what, if any, problems would your proposed changes solve?

6. Weather Conditions and Caribou Distribution: In our northern environment, weather conditions are a key factor in determining the herd size and condition. I am interested in how caribou react to various weather conditions. Do you most frequently see caribou when it is:

a. cloudy ________ sunny ________ slightly windy ________ still ________

b. above freezing ________ below freezing ________

c. winter ________ spring ________ summer ________ autumn ________

d. morning ________ afternoon ________ evening ________

1. winter: a. shallow snow (less than 3 ft.) ________ medium snow (3-6 ft.) ________ deep snow (above 6 ft.) ________
   b. soft snow ________ light crust ________ heavy crust ________

7. Caribou Management: Is the caribou decline in any way attributable to wildlife management practices: if yes, can adjustments in management help improve the condition of these populations?

a. the bag limits are: too high ________ too low ________ just right ________

b. the bull season is: too long ________ too short ________ just right ________

c. the cow season is : too long ________ too short ________ just right ________

d. is poaching of Mountain Caribou a significant problem: Yes _____ No _____

e. Describe any adjustments in season lengths, bag limits, or enforcement that you recommend:

f. In your opinion, can special closures assist in allowing area Mountain Caribou populations to stabilize: yes _____ no _____
Explain:

g. Do you feel closures are an acceptable management tool in this case?
yes _____ no _____
Why?

h. Would permit hunting be preferrable to a total closure in an area?
yes _____ no _____
In your case, why?

8. Predation: There is uncertainty regarding the impact of predators on Mountain Caribou populations and whether or not predation has played a role in the decline.

a. Have you observed any predation on caribou in your area?
yes _____ no _____, if yes LIST BELOW:

Year	Location	Write type of animal involved (wolves, bears, wolverine, specify other)	No. of predator animals	Describe Caribou killed or injured

(Put additional observations on a blank sheet)

b. Can you estimate predator numbers in your area:

Animal	Number	Status (increasing, decreasing or the same)
a. wolves		
b. grizzly bears		
c. black bears		
d. wolverine		
e. other		

c. Can you describe any particular predator activity associated with Mountain Caribou in your area?

d. What if any role, do you think any of these predators play in the decline of the Mountain Caribou?

8. Predation (cont'd.)

e. If you said predators play a role in the decline, do you believe this is typical of the relationship between predators and a healthy caribou population or only a problem because herds are already reduced due to other damaging factors and thus more vulnerable to any disturbance?

9. Do you have any suggestions for how to improve the conditions of the Mountain Caribou in the Prince George region?

10. Would you be willing (if you are able or in a position to) to collect data on the size and condition of animals shot and/or to collect rumens and other body parts from animals killed?

yes __________ no __________

(These would be used to determine food habits, age, reproductive potential, etc.)