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Seasonal habitat use and movements of woodland caribou in the Omineca Mountains, north central British Columbia, 1991-1993

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Abstract: From 1991 to 1993, 30 woodland caribou were captured and fitted with radio-collars west of the Williston Reservoir in north central B.C. Monthly radio-telemetry location flights revealed that caribou in the Northern Area, characterized by a complex of mountain ranges, moved greater distances to calving areas than did those in the South, where only one major mountain range exists. In the year of record heavy snowfall for the area, all collared caribou wintered on windswept alpine slopes, while during the below average snowfall year, many caribou remained in forested habitats. In winter, caribou were found to forage on terrestrial lichens in both lowland lodgepole pine flats and on windswept alpine slopes, and on arboreal lichens in upper elevation Engelmann spruce and subalpine fir forests. There are at least 600-700 caribou in the Omineca Mountains.

Key words: *Rangifer*, snow depths, mortality, population dynamics, habitat use, migration

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Introduction

Woodland caribou on the west side of the Williston Reservoir in north central B.C. are faced with substantial increases in road development and forest harvesting over the next ten to twenty years. With the flooding of the Reservoir in the late 1960's, an extensive area of wildlife habitat and forest resources was lost, placing increased pressure on surrounding lands.

Conflicts with forest harvesting in the range of the mountain caribou ecotype, have focused most habitat use studies of caribou primarily in the southeastern part of B.C. (Stevenson, 1991). Mountain caribou inhabit areas with deep snowpacks and forage primarily on arboreal lichens during winter. The northern caribou ecotype which resides in areas with low to moderate snowdepths and forages primarily on terrestrial lichens, has been the subject of only two major studies in the province (Hatler, 1986; Cichowski, 1989). Only the caribou of the latter study, in west central B.C., are presently subject to forest harvesting concerns.

The objective of Phase 1 of the Omineca Mountains Caribou Project is to describe the seasonal movement patterns, habitat use, and ecology of these caribou by monitoring radio-collared animals over a three year period (1991-1994). These data will aid in designing a caribou/forestry management strategy for the area. Phase 2, which began in 1994, will focus primarily on the use of forested habitats by caribou. In this report, I present data from the first two years of Phase 1.

Study area

The Omineca Mountains study area lies to the west of the Williston Reservoir in north central B.C., and encompasses 21,000 square kilometres (Fig. 1). A diversity of habitats exists within this forest transition area which is reflected by the variety of biogeoclimatic subzones (Meidinger & Pojar, 1991). Biogeoclimatic zones occurring below 1100 metres are the Sub-Boreal Spruce (SBS) in the southern portion of the study area, and the Boreal Black and White Spruce (BWBS) in the north. These zones have extensive wildfire histories (Parminter, 1984), and forests are dominated by lodgepole pine (*Pinus contorta*) and white spruce (*Picea glauca*). Between 900 and 1600 metres, the Engelmann Spruce Subalpine Fir (ESSF) zone occurs in the south, and the Spruce Willow Birch (SWB) zone in the north. Climax tree species in the ESSF are the Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Both white spruce and subalpine fir are found at lower elevations in the SWB, with subalpine fir

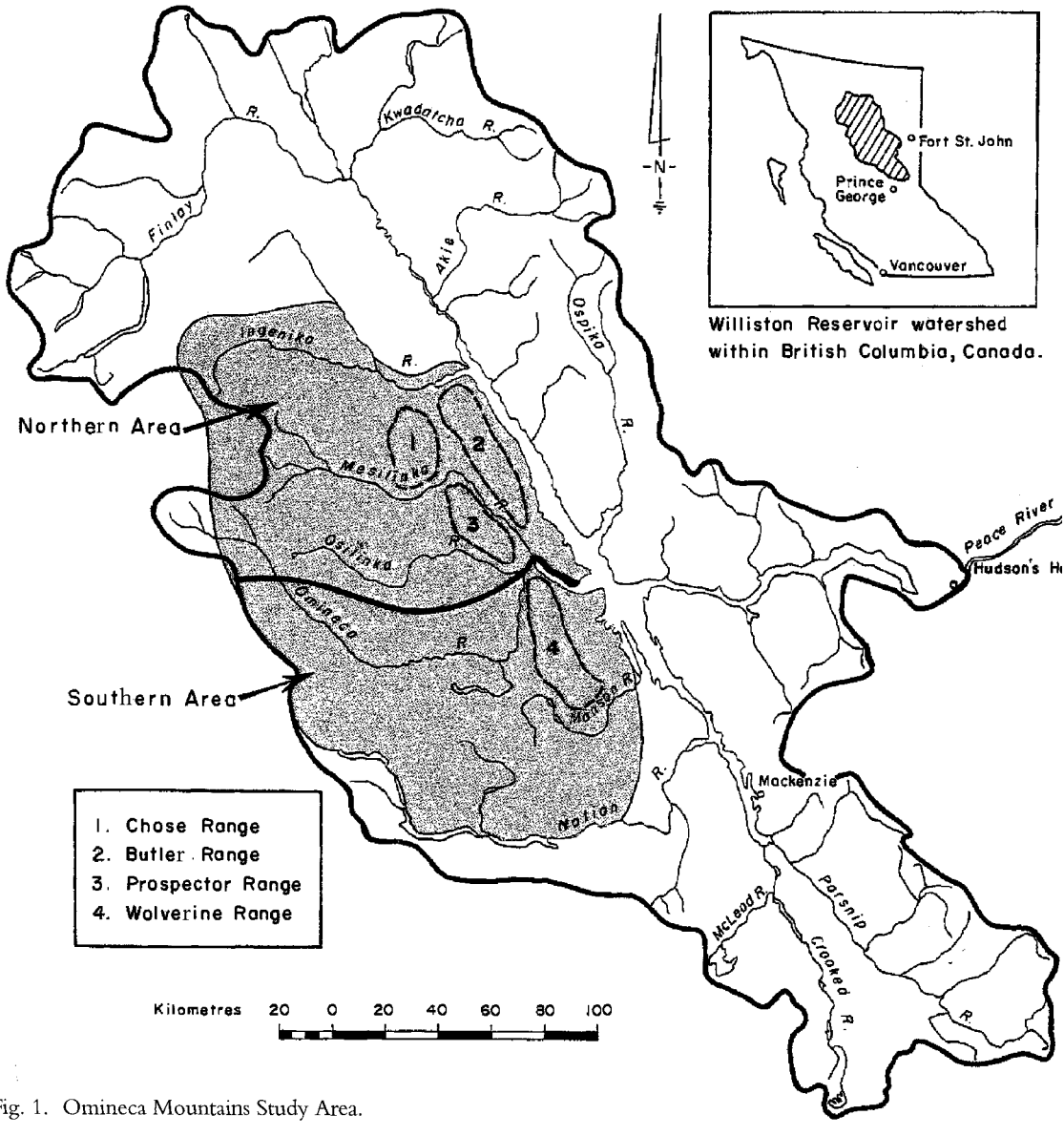


Fig. 1. Omineca Mountains Study Area.

dominating on higher slopes. Extensive lodgepole pine stands in the ESSF and SWB are uncommon as wildfires are less frequent. Alpine Tundra (AT) exists at the highest elevations which extends from 1600 to 2300 metres. Gentle, windswept alpine slopes are common.

I have divided the Omineca Mountains study area into Northern and Southern Areas (Fig. 1); to date, radio-collared caribou in these two areas have remained separate. The Northern Area is characterized by a complex of mountain ranges which extend westward into broad high elevation scrub/parkland plateaus. Clearcut forest harvesting has been extensive in the BWBS zone in the three major river valleys that divide these mountain ranges. The Southern Area is less mountainous, with one primary mountain range, the Wolverine Range, and a few smaller mountain ranges interspersed with broad expanses of lower elevation ESSF, BWBS and forest and meadows. The Wolverine Range is one of very few mountain ranges in the area with gently sloping windswept terrain suitable for wintering caribou in deep snow years. To date, forest harvesting activities in the Southern Area have been minimal and are concentrated on the east side of the Wolverine Range, primarily at low elevations. Some harvesting has also occurred in the ESSF zone.

Other common ungulates in the Omineca Mountains study area include moose (*Alces alces*) and mountain goat (*Oreamnos americanus*), while mule

deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), and Stone's sheep (*Ovis dalli stonei*) are present in small numbers. Potential predators of caribou include wolves (*Canis lupus*), wolverine (*Gulo gulo*), black bears (*Ursus americana*), grizzly bears (*Ursus arctos*), and lynx (*Lynx canadensis*).

Methods

Capture and Radio-Collaring

Between February 1991 and January 1993, 30 caribou (10 females and 4 males in the Northern Area; 13 females and 3 males in the Southern Area) were captured using a handheld net-gun fired from a Bell 206 Jet Ranger helicopter, and fitted with radio-collars equipped with mortality sensors (Model LMRT-4, Lotek Engineering, Newmarket, Ontario). Blood samples were taken from females for analysis of serum progesterone levels.

Radio-Telemetry

Twenty-two radio-location flights from a Cessna 182 fixed-wing aircraft were conducted over a two year period hereafter referred to as 91/92 (April 1991 - March 1992) and 92/93 (April 1992 - March 1993). Monthly flights were attempted, although poor weather conditions prevented flights in some winter months. Three flights were conducted in May 1992 during spring migration. Forest cover type, slope, aspect, elevation and if possible, group size, were recorded for each caribou located. An attempt was made to locate every radio-collared caribou on each flight.

Seasonal Movements and Ranges

Discrete areas used by caribou during different seasons of the year were delineated using geographic (primarily rivers) and elevational boundaries, and referred to as "ranges". Twenty ranges were delineated in the Southern Area, and 25 in the Northern Area ranging in size from 82 to 293 km^2, with a mean range size of 160 km^2 (SE=8.5).

Seasonal movements of collared female caribou were measured as straight-line distances between known seasonal locations. Spring movements were measured between late winter ranges (using February capture locations for 1991, and March locations for 1992) and late May/early June calving locations. Pre-rut movements in both years were measured between summer ranges (using mid-July locations) and rutting areas (using mid-October locations), while post-rut movements were measured between the October rutting locations and late winter ranges (February locations). Differences between spring, pre-rut and post-rut movements between years, and between Northern and Southern Areas, were tested using a two-way analysis of variance for each season (Proc. GLM, SAS, 1988). Differences between the mean pre-rut and post-rut distances moved in each year in each Area were tested using Student's *t*-test.

Habitat Classification and Use

Caribou locations were plotted onto 1:50,000 Forest Cover Polygon Maps (Ministry of Forests, 1990-1993), which when combined with the description of the forest type observed at the time an animal was located, aided in placing each radio-location into a broad Forest Cover Type category. Six Forest Cover Types based on primary tree species, elevation, and seral stage were defined:

1) *Alpine/Subalpine:* alpine and upper elevation subalpine parkland;
2) *Balsam/Spruce: ≥1300 metres:* upper elevation climax stands with subalpine fir and Engelmann spruce dominating;
3) *Pine: >1300 metres:* upper elevation seral stands with lodgepole pine dominating;
4) *Pine: ≤1300 metres:* lower elevation seral stands with lodgepole pine dominating;
5) *Pine/Spruce: ≤1400 metres:* lower elevation mixed stands of lodgepole pine and Engelmann spruce and/or white spruce, interspersed with meadows and black spruce (*Picea mariana*);
6) *Spruce: <1300 metres:* lower elevation climax stands of Engelmann and/or white spruce dominating.

Low elevation early seral stages of immature lodgepole pine (<80 years), trembling aspen (*Populus tremuloides*), non-productive brush and meadow sites were included with *Pine ≤1300 metres*. The proportion of radio-collared caribou locations in each Forest Cover Type was determined for five periods: spring migration (Apr/May), calving/summer (Jun/Jul/Aug), fall/rut (Sep/Oct), early winter (Nov/Dec/Jan), and late winter (Feb/Mar). Data from females and males were pooled, as were locations of caribou in both the Northern and Southern Areas. Snow depths and densities were based on B.C. Environment data from the Germansen Station (B.C. Environment, 1991-1993). At 1500 metres elevation, this station was selected to best represent the Omineca Mountains study area. Other snow stations in the study area and throughout the Williston watershed revealed the same annual trends as the Germansen Station.

Winter Diet

Composite fecal samples were collected from each of four low elevation lodgepole pine sites prior to

the initiation of this study (February 1990), and from five windswept alpine slope locations (three in February 1991, one in February 1992, and one in March 1992). Composite samples were comprised of about five pellets from each of 10 different fecal pellet groups. Samples collected from low elevation lodgepole pine flats were pooled for analyses and called "Pine Flats". Four of the five alpine samples showed similar vegetation composition and were lumped as "Alpine 2", while one sample with a very different composition was treated separately as "Alpine 1". Fecal fragments were identified to forage class (e.g. lichens, conifers) and major species (e.g. *Cladonia, Alectoria*) by the Wildlife Habitat Lab at the University of Washington.

Population Characteristics

Late winter aerial population surveys were conducted on the Wolverine Range in the Southern Area in February 1993, and the Chase and Butler Ranges in the Northern Area in March 1993. An inventory of the Wolverine Range was also conducted in 1989, prior to the initiation of this study. Alpine areas were searched and caribou were classified as adult male, adult female, and calves. Females were identified by the presence of a black vulval patch and males by the lack thereof. The proportion of radio-collared animals observed during the Northern Area survey was used as a sightability correction factor and applied to the total count using the Petersen mark-recapture estimator (Krebs, 1989, eqn 2.2, pg. 17), and variance from White & Garrott (1990, eqn 10.2, pg. 256). Densities were calculated for each of the Northern and Southern study areas by dividing the estimated total caribou population by the maximum area used by radio-collared caribou over the two year period.

The typical group size for each survey was calculated by summing the number of animals that each individual caribou was found with, and dividing by the total number seen on the survey. Typical group size is the size of group in which the average animal finds itself, and is a more accurate measure of the behaviour of individuals than is the frequency of groups as measured by the mean (Jarman, 1974; Heard, 1992). Typical group sizes of radio-collared caribou were calculated by summing the number of individuals in the group that each radio-collared caribou was located in (even if other radio-collared caribou were in the same group), and dividing by the total number of radio-collared animals seen.

Blood samples drawn from females captured in 1991 were analyzed for serum progesterone levels at the Department of Animal Science, University of British Columbia (UBC), Vancouver, B.C. Samples from females captured in 1992 were analyzed at the Endocrine Service Lab at the Western College of Veterinary Medicine, University of Saskatchewan. Measurements of progesterone in blood serum indi-

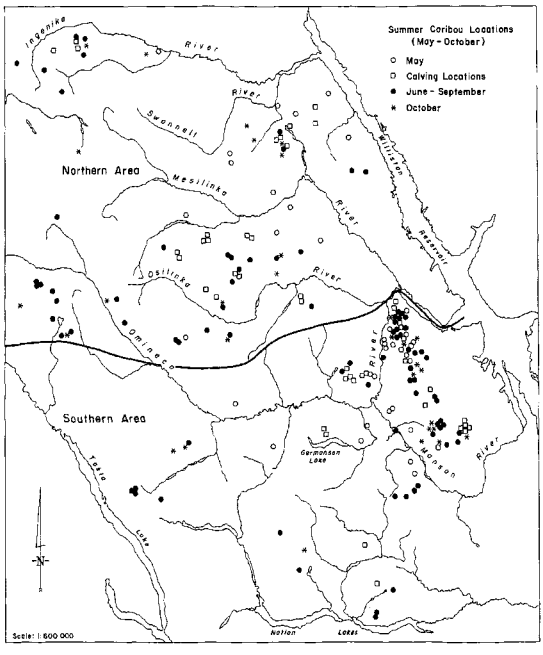


Fig. 2. Locations of radio-collared caribou in summer (May to October) 91/92 and 92/93 combined.

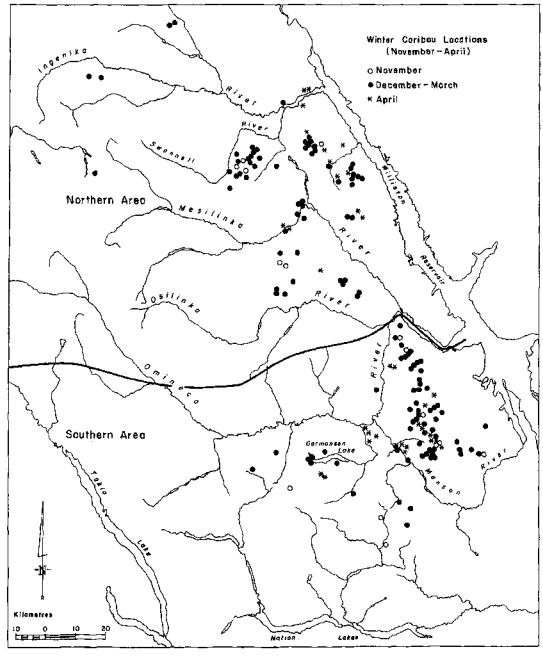


Fig. 3. Locations of radio-collared caribou in winter (November to April) 91/92 and 92/93 combined.

Table 1. Mean migration distances ±SD (km) of female radio-collared caribou between seasonal ranges. (n= number of collared caribou, r= range of distances).

	Northern Area		Southern Area	
Migration Period	91/92	92/93	91/92	92/93
SPRING	58.1 ±22.5	25.0 ±15.0	28.3 ±12.9	16.2 ±10.4
(late winter range	(n=7)	(n=8)	(n=6)	(n=9)
to calving area)	(r=23-88)	(r=8-45)	(r=11-49)	(r=4-31)
PRE-RUT	19.2 ±16.9	28.9 ±28.2	12.6 ±9.0	9.0 ±8.3
(summer range	(n=7)	(n=7)	(n=4)	(n=9)
to rut area)	(r=1-48)	(r=3-88)	(r=4-25)	(r=1-24)
POST-RUT	52.6 ±36.0	30.1 ±31.1	10.4 ±8.3	8.5 ±7.0
(rut area to	(n=7)	(n=7)	(n=4)	(n=9)
late winter range)	(r=13-110)	(r=3-98)	(r=3-19)	(r=4-26)

Table 2. The effects of year (91/92, 92/93) and location (Northern Area, Southern Area) on mean migration distances of collared females during spring, pre-rut and post-rut periods.

Source	D.f.	Sum of Squares	Mean Square	F Ratio	*P*
SPRING					
Among	3	7396.98	2465.66	10.09	.0001
Within	26	6353.89	244.38		
Year	1	3729.62	3729.62	15.26	.001
Location	1	2708.73	2708.73	11.08	.003
Yr x Loc	1	799.70	799.70	3.27	.082
PRE-RUT					
Among	3	1617.83	539.28	1.69	.196
Within	23	7320.29	318.27		
Year	1	50.29	50.29	0.16	.695
Location	1	1055.75	1055.75	3.32	.082
Yr x Loc	1	259.41	259.41	0.82	.376
POST-RUT					
Among	3	8794.32	2931.44	4.75	.010
Within	23	14202.76	617.51		
Year	1	913.17	913.17	1.48	.236
Location	1	6300.70	6300.70	10.20	.004
Yr x Loc	1	653.11	653.11	1.06	.314

cate pregnancy status (Rehbinder *et al.*, 1981). I concluded that values over two ng/ml indicated pregnancy as two caribou with low values of 2.1 and 2.39 were both observed with calves on telemetry flights. Values below 0.1 indicated nonpregnant females or males, based on the value of 0.1 for a tested male.

Collared caribou mortalities were located during radio-telemetry flights with the aid of the motion-sensing mortality collar. Three mortalities were investigated. Annual mortality rates were estimated by summing the number of collared caribou that died each year, and dividing by the number of caribou-years of monitoring.

Results

Seasonal Movements and Ranges

Spring Migration

Most collared caribou moved off winter ranges in April to low elevation forested areas, although some remained on their winter ranges, or moved to other high elevation ranges. Two-thirds (63%, n=35) of all locations of collared caribou during the two spring periods were found in low elevation ranges. All spring ranges used by Southern Area caribou were in the Omineca River valley bottom immediately west of the Wolverine Range (Fig. 1), with the exception of one collared male that used a low elevation spring range further west. Many different spring ranges were used in the Northern Area. A lack of fidelity to spring ranges for two consecutive years was shown by all collared caribou in the Northern Area (n=6), and by five of six collared caribou in the Southern Area.

Both year and location accounted for a significant amount of variation in mean distances moved during spring, with longer distances moved by collared caribou in 91/92 than in 92/93, and with longer distances moved by Northern Area caribou than Southern Area caribou (Tables 1 and 2).

Calving

Timing of calving is between late May and mid June with the peak of calving around the end of the first week in June. Calving areas in the Northern Area were widely dispersed and primarily in the west (Fig. 2). In the Southern Area, most females calved on the Wolverine Range, but some used other small mountain ranges to the south and west (Fig. 2).

In 91/92, all radio-collared female caribou in both Areas moved from winter ranges to different calving ranges. However, in 92/93, two of seven Northern Area females and four of eight Southern Area females used their winter ranges for calving. At least six of ten female collared caribou (three each in the Northern and Southern Areas) showed fidelity to their calving areas in the two years (some calving sites were not confirmed in consecutive years).

Only two of seven collared females in the Northern Area were located on the same range during the calving period in both 91/92 and 92/93. The other five all used different ranges from each other. Similarly in the Southern Area, only two of six collared females used the same range during calving, but only in 91/92. In 92/93, nine caribou were located in only four ranges during the calving period.

Summer

Summer ranges were in the vicinity of calving ranges to the west in the Northern Area (Fig. 2). The primary summer ranges used by Southern Area female caribou were in the east, on the Wolverine Range. In both the Northern and Southern Areas in 91/92, most collared females were located on their calving ranges throughout the summer. However, in 92/93, six of eight females in the Northern Area, and six of nine in the Southern Area moved to other ranges for the summer period. Few data on early calf survival are available, therefore no correlation between early calf loss and subsequent movement to other areas could be made. Collared males in both the Northern and Southern Areas summered on ranges in the west. Eight of ten collared females for which there is two years data (Northern and Southern caribou combined) returned to their same summer range each year, as did the two Southern Area males.

Fall/Rut

Most collared females in the Northern Area spent the fall rutting period on or near their summer ranges in the west. Mean post-rut movements were longer than mean pre-rut movements in 91/92 ($t=2.23$, $p<0.05$), but were similar in 92/93 when two females moved to winter ranges for the rut ($t=0.08$, $p>0.05$) (Table 1). In the Southern Area almost all collared females were located during the rut on the Wolverine Range, usually on or adjacent to their summer ranges. There were no significant differences between mean pre-rut and post-rut distances moved in the Southern Area in 91/92 ($t=0.36$, $p>0.05$) or 92/93 ($t=0.14$, $p>0.05$) (Table 1).

In the Northern Area, most collared female caribou were located on different ranges from each other during the rut in both years, and three of five females returned to their same rutting ranges each year. In contrast, four of five collared females were located on one range during the rut in the Southern Area in 91/92, while two different ranges were used by five and three collared females respectively in 92/93, accounting for all but one collared female (n=9). Three of five females in the Southern Area showed fidelity to rutting ranges in the two years. The only collared male in the Northern Area was not located; one of the two collared Southern Area males (not located in 91/92) used a range on the Wolverine Range in 92/93, while the other used a range in the western part of the study area in both years. No collared females were ever located in this area during the rut.

There were no significant differences in the pre-rut migration distances between years or Areas, or between years for post-rut migration distances (Table 2). However, location accounted for a significant amount of the variation in mean post-rut movements, with longer distances moved in the Northern Area than in the Southern Area.

Early Winter

Early winter ranges in the Northern Area in 92/93 were primarily in the east (only two caribou locations were documented in 91/92) (Fig. 3). The only female caribou for which there is two years early winter data used different ranges each year. Collared caribou in the Southern Area in 92/93 (no data for 91/92) were found primarily on or near the Wolverine Range, or in low elevation ranges to the southwest. Almost half the collared caribou remained on their rutting ranges during the early winter period.

Late Winter

Most collared caribou in the Omineca Mountains wintered in the eastern part of the study area (Fig. 3). In the Southern Area, the Wolverine Range was the most highly used mountain range during the late winter period, while the Butler, Chase and Prospector Ranges were the most heavily used in the Northern Area (Fig. 1). During the late winter period of 91/92, 77% (n=22) of all radio-collared caribou remained within their winter ranges, however, in 92/93, only 50% (n=20) of the collared caribou remained within their late winter ranges.

Most collared individuals wintered on different ranges each year. Of five collared females monitored in the Northern Area over three late winter periods (includes initial capture period), four were located on different ranges each winter. The same lack of fidelity to winter ranges was exhibited by the five collared caribou in the Northern Area which were monitored over two consecutive winter periods. However, over three winter periods in

the Southern Area, only two of seven collared caribou were located on different ranges. One of the remaining five caribou was even found to return to the same range each winter. Of the collared caribou monitored over two winter periods, two of four were located in different ranges each year.

Seasonal Habitat Use

Over 60% (n=93) of the caribou locations in spring (Apr/May) of both years were in forested areas, primarily in low elevation lodgepole pine and pine/spruce forests. Use of those habitats was greater in spring than at any other time of the year (Figs. 4 & 5). Use of early serai stages was also more common in spring than at any other time, and included use of immature lodgepole pine, pine/aspen, non-commercial brush and meadow sites. Females moved to upper elevation calving areas in mid to late May, while all collared males remained in lower elevation forested habitats.

Almost all collared females were located in upper elevation balsam/spruce forests or in alpine/subalpine areas during calving in late May/early June. Those were the primary habitats used throughout the summer as well (Figs. 4 & 5). During the calving period of 1993, most collared females were located in rocky outcrops near treeline (Wood, unpubl. data).

Use of low elevation forests decreased from April to October, while use of alpine/subalpine areas increased. By the fall period (September/October) only 8% (n=40) and 11% (n=18) of all collared caribou in 91/92 and 92/93 respectively, were located in forests below 1300 metres.

In early winter (November to January) of 92/93, 56% (n=34) of the locations of collared caribou were in forested habitats, primarily in the upper elevation balsam/spruce and lower elevation mixed pine/spruce forests (Fig. 5). No data are available for the early winter period of 91/92. In late winter (February/March) of 91/92, all live radio-collared caribou in the Omineca Mountains were located in alpine and subalpine habitats. One dead female radio-collared caribou was located in a low elevation spruce stand (Fig. 4). The pattern of habitat use in the late winter of 92/93 contrasts markedly with the previous year, with only 55% (n=40) of collared caribou locations in alpine and subalpine habitats (Figs. 4 & 5). The use of forested areas during that late winter period, 45% of locations (n=40), reflects only a slight decrease in use from the early winter period when 56% (n=34) of caribou locations were in forested areas. Use of low elevation pine and/or spruce dominated forests remained consistent from early winter (26%, n=34) through late winter (27%, n=40), use of upper

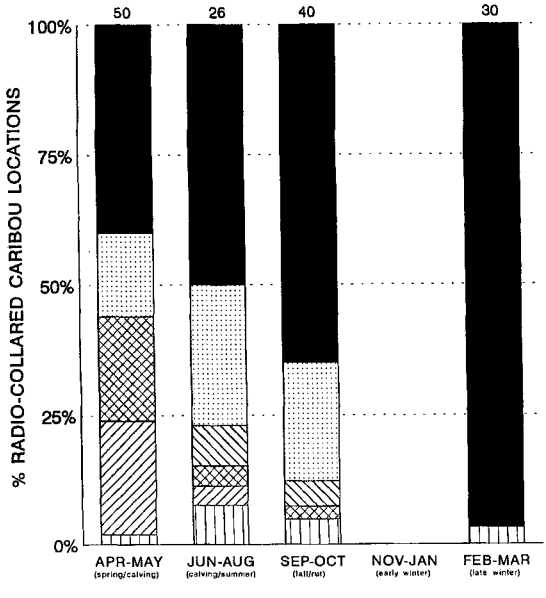
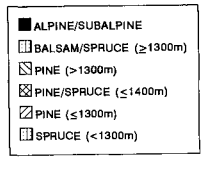


Fig. 4. Proportion of radio-collared caribou locations in different habitat types from April 1991 to March 1992. (Number of locations given above each bar.)



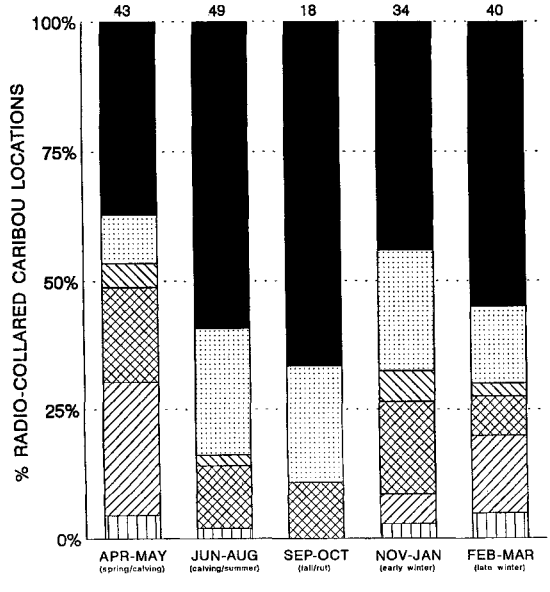


Fig. 5. Proportion of radio-collared caribou locations in different habitat types from April 1992 to March 1993. (Number of locations given above each bar.)

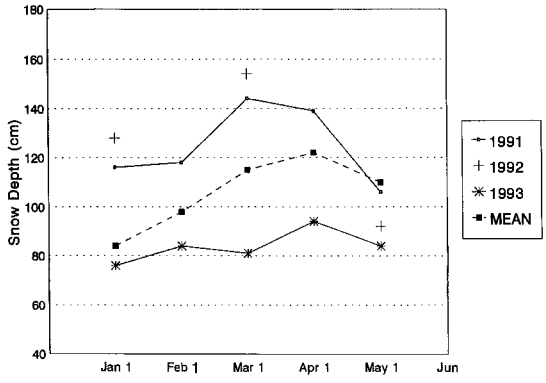


Fig. 6. Snow depths measured at Germansen Snow Station (1500 metres). Mean snow depths based on 31 years data with exception of January (10 years) and February (24 years).

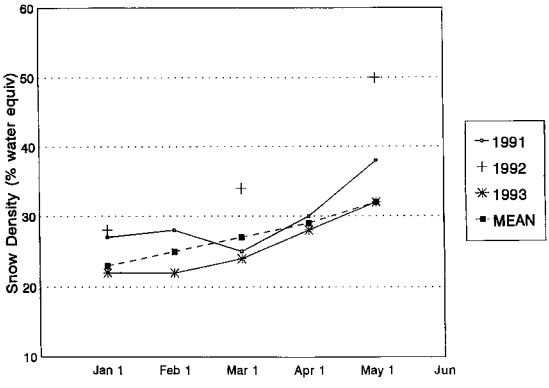


Fig. 7. Snow densities measured at Germansen Snow Station (1500 metres). Mean densities based on 31 years data, with exception of January (10 years) and February (24 years).

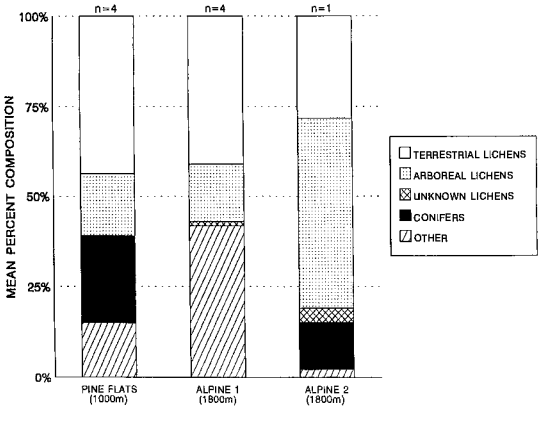


Fig. 8. Mean vegetation composition (%dry matter) of late winter composite fecal samples. (n=# of composite samples.)

elevation forests decreased from 29% to 18%, and use of alpine/subalpine areas increased.

Snow depths were above average in the winter of 90/91 when the first caribou were captured and radio-collared (Fig. 6). Snow depths in the winter of 91/92 were even greater, setting a new record over 31 years for the maximum depth recorded at the weather station in March. Snow densities were also the highest ever recorded for that station (Fig. 7). Snowfall over the winter of 92/93 was below average. Snow depths measured each month were lower than the mean, especially during the latter part of the winter, and approached that of the lowest snow depths on record set in 1980.

Winter Diet

Terrestrial lichens, arboreal lichens and conifers were the primary forage types found in winter fecal samples (Fig. 8). Over 60% (n=4) of the "Pine Flats" samples were comprised of terrestrial and arboreal lichens in a 72:28 ratio. Conifers accounted for an additional 24% of the fecal pellet samples. Lichens made up 58% (n=4) of the "Alpine 1" samples with an identical proportion of terrestrial to arboreal lichens as in the "Pine Flat" samples. Conifers were absent in the Alpine 1 samples, while the remaining 42% included mosses, grasses, shrubs, sedges and forbs in declining order of prominence. Lichens comprised 85% of the only "Alpine 2" fecal sample, with a ratio of 35:65 for terrestrial to arboreal types.

Population Characteristics

Sightability of collared caribou was greater during summer, fall and late winter when more caribou used open alpine and subalpine habitats. Group sizes varied among seasons, with the largest groups observed in October and in late winter (Table 3). In both years, typical group sizes of collared caribou more than doubled from February to March. This trend was also observed during aerial population surveys (Table 4). Lowest typical group sizes were recorded during calving and summer periods.

During a survey of alpine areas on the Wolverine Range in the Southern Area in February 1993, we counted 66 caribou, of which 12% were calves (Table 4). Weather conditions limited access to many alpine areas and none of the twelve radio-collared caribou in the Southern Area were observed on the survey. A winter inventory of the Wolverine Range was also conducted prior to the initiation of this study, in February 1989 (Hatler, 1989), during an average snowdepth winter. On that survey 214 caribou were located, with calves comprising 16% of the caribou observed. Although no collared animals were available to provide a sigh-

tability correction, it is likely that some members of the population were missed. Based on the minimum count by Hatler (1989), and assuming a relatively stable population since that time, I estimate the minimum population in the Southern Area at approximately 200 animals. The maximum area that collared caribou used during the two years of this study was 3780 km^2. Assuming that only caribou that wintered in the census area used that 3780 km^2 area, the minimum density estimate is 0.053 caribou/km^2.

In March 1993, we surveyed the Chase and Butler alpine winter ranges in the eastern part of the Northern Area (Fig. 1), and counted 396 caribou, 90% of which were located on the Chase Range. Calves accounted for 17% of the caribou observed. Three of six collared caribou were observed during the survey, resulting in a population estimate of 690 ± 202 (SD) caribou in the Northern Area. Thus, using the 95% confidence limits, and the minimum number observed on the survey, the population in the Northern Area is estimated to be between 396 and 1085 animals. Collared caribou used a maximum area of 10,700 km^2 during the two years of the study, resulting in a density estimate of between 0.037 and 0.10 caribou/km^2. Based on presently available information, my minimum estimate for the caribou population in the Omineca Mountains (Northern and Southern Areas combined) is approx- imately 600-700 animals, while the actual total could be up to 1200 or more. Both bulls per 100 cows, and calves per 100 cows were lower in the sample from the Southern area than that from the Northern area (Table 4). Serum progesterone levels were greater than two ng/ml for 17 of 20 female caribou at capture indicating that they were pregnant at the time. Serum progesterone levels ranged from 0.04 to 0.1 for non-pregnant caribou, and 2.1 to 9.4 for pregnant females. Of the three caribou with very low values, one was estimated at 21 months of age, while the ages of the other two were not estimated at the time of capture. The pregnancy rate of suspected adult females was 89% (17/19).

To date, eight radio-collared caribou (six captured in 1991, and two in 1992) have died (Table 5). Three mortality sites were investigated; evidence remaining at the sites was scarce but pointed to wolf predation as the primary cause of death. One of the eight, a young male captured in March 1992, died prior to the first telemetry follow-up flight, and capture myopathy is suspected. Five of the remaining

Table 3. Typical group sizes of radio-collared caribou observed during radio-telemetry flights. (n = number of radio-collared animals located, even if in same group; TGS = typical group size ± SD).

	91/92		92/93		Total	
Month	n	TGS	n	TGS	n	TGS
April	2	20.5 ± 16.3	-	-	2	20.5 ± 16.3
May	2	4.5 ± 0.7	12	5.0 ± 4.2	14	4.9 ± 3.9
June	4	2.8 ± 1.5	3	3.3 ± 2.3	7	3.0 ± 1.7
July	3	2.3 ± 0.6	5	2.8 ± 2.7	8	2.6 ± 2.1
Aug	-	-	3	3.3 ± 1.5	3	3.3 ± 1.5
Sep	13	6.6 ± 4.5	-	-	13	6.6 ± 4.5
Oct	11	15.9 ± 9.4	11	10.4 ± 5.7	22	13.1 ± 8.1
Nov	-	-	7	8.9 ± 7.5	7	8.9 ± 7.5
Dec	2	14.5 ± 12.0	-	-	2	14.5 ± 12.0
Jan	-	-	8	5.1 ± 3.4	8	5.0 ± 3.4
Feb	12	7.8 ± 3.8	7	7.3 ± 4.5	19	7.6 ± 3.9
Mar	6	18.5 ± 9.7	14	17.6 ± 12.6	30	18.1 ± 10.9

Table 4. Sex and age composition, and typical group size of caribou observed during late winter surveys of alpine mountain ranges in the Northern and Southern Areas.

Area	Bulls	Cows	Calves	Total Count	Bulls/ 100 Cows	Calves/ 100 Cows	Calves/ 100 Adults	Typical Grp. size
SOUTHERN AREA (Wolverine) 1989	46	133	35	214	35	26	20	14.3 (Feb) (range 2-27)
SOUTHERN AREA (Wolverine) 1993	15	43	8	66	35	19	14	11.2 (Feb) (range 1-16)
NORTHERN AREA (Chase/Butler) 1993	107	222	67	396	48	30	20	42.0 (Mar) (range 3-89)

Table 5. Season, elevation and habitat of collared caribou mortalities during 91/92 and 92/93. M= male, F = female.

Caribou	Month/Year	Season	Elev	Habitat	Area
083* M	Mar-May 92	Spring	1850	Alpine	S
493 F	Apr-May 91	Spring	850	Spruce forest	S
466 F	Apr-Jun 91	Spring	775	Pine/Aspen forest	S
412 F	June 91	Summer	1700	Alpine	N
322 F	Jun-Jul 92	Summer	1250	Pine/Spruce forest	N
332 M	Oct-Dec 91	Early Winter	1850	Alpine	N
392 F	Feb-Mar 92	Lt. Winter	1200	Spruce forest	N
494 F	Feb-Mar 93	Lt. Winter	1200	Pine/Spruce forest	N

* Suspected cause of death: capture myopathy.

seven caribou died while in low elevation forested habitats. In the Northern Area, three of nine collared caribou died in 91/92, and two of ten in 92/93 for an average annual mortality rate of 27% ± 6.6 (SE). In the Southern Area, two of nine (91/92) and none of eleven (92/93) collared caribou died, for an average annual mortality rate of 11% ± 11.1 (SE). However, there was no significant difference between the two mortality rates ($t=1.19$, $p>0.10$). Combined, the average annual mortality rate for the Omineca Mountains caribou between 1991 and 1993 was 19% ± 6.9 (SE).

Discussion

Seasonal Habitat Use and Movements

Telemetry data suggest that at least two populations of caribou reside on the west side of the Williston Reservoir. The term "herd" has been applied to those caribou that congregate in a particular rutting area (Bergerud & Elliott, 1986), while a "population" is defined as a collection of herds sharing a common winter range (Hatler, 1986) or that rut on adjacent ranges removed from other herds by at least 60 km in the fall (Bergerud & Elliott, 1986). To date, no seasonal ranges of collared caribou in the Northern and Southern Areas have overlapped. In addition, one male in the western part of the Southern Area used different seasonal ranges from all other collared Southern Area caribou. He was usually accompanied by other caribou however, and may belong to a third population that inhabits the Takla Lake area.

In the spring (April/May), about two-thirds of all collared caribou moved from winter ranges to low elevation forested areas; primarily lodgepole pine and lodgepole pine/white spruce dominated stands. Use of habitats such as southfacing deciduous hillsides, aspen stands and meadows that become snowfree earlier than heavily timbered areas, was also more common in spring than at any other time. Many Northern Area females moved from winter blocks to lower elevation spring blocks in a direction opposite from their calving areas, and many Southern Area females used low elevation forested areas adjacent to their alpine winter blocks, which they then returned to for calving. These data suggest that caribou were using low elevation forested habitats in spring primarily for foraging, although low elevations were also used during migration to calving areas. Most collared caribou used different spring blocks each year. Unpredictable use of spring ranges may be an effective predator avoidance strategy (Simpson & Woods, 1987).

The mean distance moved from winter blocks to calving blocks (spring migration) was longer in 91/92 than in 92/93. The shorter mean migration distance in 92/93 (after the heavy snowfall winter) may reflect use of some winter blocks that were closer to calving areas than in the previous year. This suggests that caribou did not travel as far to winter ranges during the more severe winter, however, no data are available on the pre-rut or post-rut movements prior to the average snowfall winter of 90/91 for comparison.

Collared caribou calved below treeline, in rocky outcrops at treeline and in alpine areas. Cichowski (1989) and Hatler (1986) also documented use of calving areas below treeline for collared caribou in Tweedsmuir Park and Spatsizi Park respectively, while observations by Bergerud *et al.* (1984) implied use of calving sites in Spatsizi that were mostly rock.

The peak of calving occurred in the first week of June. By that time, most collared females were dispersed in mountainous areas and calved alone, while males remained in low elevation habitats until mid to late June. Dispersion in mountains for calving is considered to be an antipredator strategy of woodland caribou in B.C. (Bergerud *et al.*, 1984). While males remain in areas of higher forage quality, females reduce predation risk by dispersing to mountainous areas to separate themselves from moose and predators in valley bottoms (Bergerud & Page, 1987; Seip, 1992). Collared caribou in the Northern Area dispersed more widely, moving greater distances from winter ranges to calving areas than

did caribou in the Southern Area. This appears to reflect the large expanse of mountainous terrain and dispersed calving habitat in the Northern Area relative to the Southern Area. Calving areas for caribou in the Southern Area were primarily on the Wolverine Range and on two small adjacent mountain ranges. The use of only four ranges by nine caribou during the calving period in 92/93, may be a reflection of the lack of suitable calving habitat in the Southern Area. However, it could also be a reflection of the larger proportion of collared caribou in the Southern Area population, relative to the Northern Area population.

Most summer and rutting ranges used by collared caribou were in the upper elevation balsam/spruce and alpine/subalpine habitats, and were in the vicinity of their calving areas: on mountains in the west for Northern Area caribou, and on the Wolverine Range for those in the Southern Area. Many collared caribou showed fidelity to both calving and summer ranges. Fidelity to calving areas has also been reported in other woodland caribou populations (Shoesmith & Storey, 1977; Hatler, 1986; Edmonds, 1988; Cichowski, 1989). About two-thirds of all radio-collared caribou showed fidelity to rutting ranges too. In the Northern Area, no two collared animals used the same rutting ranges, while in the Southern Area, many ranges were used by two or more collared individuals. Again, this may reflect the larger relative sample size of caribou in the Southern Area, however, it is also likely a result of the lack of mountain ranges in that area. Longer post-rut movements were observed in the Northern Area as summer and rutting areas were much further away from winter ranges than in the Southern Area, where some caribou remained on summer ranges through the winter, or moved only to an immediately adjacent range.

Collared caribou wintered on high elevation alpine or low elevation forested areas in the eastern foothills of the Omineca Mountains. Most collared individuals used different winter ranges each year. Range rotation is thought to occur to reduce grazing pressure on slow growing lichens (Bloomfield, 1980). Snow depths appear to influence movements and habitat use of the Omineca caribou in the early and late winter periods, which has also been documented in northern B.C. (Hatler, 1986) and west-central Alberta (Edmonds & Bloomfield, 1984). In the record heavy snowfall year, deep snows apparently forced caribou onto windswept slopes to crater for terrestrial lichens. Deep snows impede caribou movement and reduce forage availability thus increasing energy expenditures required to obtain the forage (Fancy & White, 1985; Thing, 1977). In the winter of below average snow depths when movement and forage availability were not as restricted, more than half of the early winter collared caribou locations were in low elevation forest. Because many caribou remained there through the late winter period suggests that caribou prefer to winter in forested areas, and are forced onto alpine ridgetops by deep snows.

Although dispersal to other ranges for the calving and early winter periods exists, overlapping use of seasonal ranges by collared caribou in the Southern Area reflects the relative compactness and apparent importance as caribou habitat of the Wolverine Range and its surrounding lower elevation forested areas. On the other hand, lack of fidelity to winter and spring ranges suggests that caribou continue to explore new areas throughout their lives (Simpson & Woods, 1987), and additional areas will probably be documented as more data is collected.

Winter Fecal Analyses

Fecal fragment data suggest that terrestrial and arboreal lichens were the primary food types used in the winters when samples were collected. Samples collected in lodgepole pine habitats not only indicated cratering for terrestrial lichens, but also foraging on arboreal lichens and conifers. The high proportion of terrestrial lichens, mosses, shrubs and grasses in most of the alpine samples reflected use of open treeless habitats, while one alpine sample comprised of high proportions of arboreal lichens and conifers reflected use of upper elevation Engelmann Spruce Subalpine Fir (ESSF) forests in winter. Analyses of plant fragments in fecal pellets usually overestimate proportions of mosses and shrubs, resulting in incorrect proportions of the remaining forages such as lichen (Boertje *et al.*, 1985). Thus, lichens were likely an even more important component of these caribou's diet.

Population Characteristics

The largest typical group sizes were found in October when caribou congregated in rutting areas, and in late winter when caribou were concentrated on winter ranges. Typical group sizes of collared caribou more than doubled from February to March in both years. Increased snow depths and densities through late winter may force caribou to concentrate in smaller areas where forage is accessible, or to increase foraging efficiency. Russell & Martell (1984) report that groups of caribou can crater through deeper snow (80-90 cm) than solitary animals (50-60 cm). Increased group size in March could also be a defence against predation. Snow density increases through late winter, making it easier for wolves to move across the snowpack and

access high elevation winter ranges. Caribou already concentrated on alpine winter ranges may form larger aggregations thus reducing the risk to each individual through increased numbers (risk is shared among more individuals) and increased vigilance.

At least 600-700 caribou reside in the Omineca Mountains in two populations, with a high observed pregnancy rate of 89% indicating that the populations are not nutritionally stressed (Skogland, 1985). If the observed indicators of recruitment and mortality rates are representative, then the moderate calf recruitment and low mortality rate in the Southern Area would suggest a stable or increasing population, and the high calf recruitment but even higher mortality rate in the Northern Area would suggest a decreasing population. However, the survival and mortality rates are based on extremely limited data, and these results should be interpreted very cautiously.

Predation was suspected to be the primary cause of death for collared adult caribou that died at low elevations in the Omineca Mountains area. Although no data are available on wolf densities in the study area, the higher observed adult mortality rate in the Northern Area cautiously suggests that wolves may be more abundant there than in the Southern Area. However, observed bull/cow ratios were much lower in the Southern Area (35/100) than in the Northern Area (48/100), suggesting greater mortality from predation in the Southern Area. Adult males are thought to die at greater rates than adult females when predation is high (Bergerud & Elliott, 1986). The proportion of males in the population was 22% in the Southern Area, and 27% in the Northern Area, which are comparable with other populations in northern B.C., but below the mean of 36% for North America (Bergerud, 1980).

Based on data gathered to date, caribou were present at densities of 0.056 caribou/km^2 in the Southern Area, and between 0.037 and 0.10 caribou/km^2 in the Northern Area. These figures compare to the mean density of 0.06 $\pm$ 0.022/km^2 calculated for 24 caribou populations in North America where wolves are unexploited (Bergerud, 1992).

Forest harvesting activities have been extensive in the Northern Area. A large proportion of the major river valley bottoms have been clearcut harvested, and harvesting continues. Little timber extraction has occurred in the Southern Area: harvesting there has primarily occurred on the eastern side of the Wolverine Range and very few collared caribou have ever been located in that area. The continuation of this study of the woodland caribou in the Omineca Mountains aims to explore the relationship between forest harvesting and these two caribou populations.

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