WOODLAND CARIBOU POPULATION DYNAMICS IN NORTHEASTERN ALBERTA

by

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for

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The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

The Hon. John Roberts
Minister of the Environment
Environment Canada
Ottawa, Ontario

Sirs:

Enclosed is the report "Woodland Caribou Population Dynamics in Northeastern Alberta".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its Terrestrial Fauna Technical Research Committee (now the Land System), under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

W. Solodzuk, P.Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

for A.H. Macpherson, Ph.D
Member, Steering Committee, AOSERP
Regional Director-General
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WOODLAND CARIBOU POPULATION DYNAMICS IN NORTHEASTERN ALBERTA

DESCRIPTIVE SUMMARY

The physical disturbances to the landscape and the additional human activity attending oil sands development are expected to have significant impacts on the population dynamics and ecology of big game species in the AOSERP study area. These populations constitute renewable natural resources having economic, social, recreational, aesthetic, and scientific values. Preservation and management of this big game resource requires information on the natural control and regulation of populations, interaction with man, effects of disturbances from oil sands development on population dynamics, and detailed information about range preferences in the oil sands area of Alberta.

One aim of this research is to determine baseline information on the population dynamics and distribution and abundance of big game populations in the AOSERP study area. A second aim is to identify those environmental factors and intra- and interspecific interactions which have the greatest impact on distribution and abundance.

Specific objectives of this study were to: (1) describe and quantify the baseline states of caribou; determine sex and age ratios, density, distribution during the various seasons, recruitment, and mortality; (2) describe and quantify all interactions between caribou and the vegetation-landform complex including seasonal use of habitats and forages, and quantification of preferences; and (3) describe and quantify the effects of carnivores on caribou, normal mortality, human exploitation, and carnivore predation.

This report has been reviewed and accepted by the Alberta Oil Sands Environmental Research Program.

W.R. MacDonald, Ph.D
Director (1980-81)
Alberta Oil Sands Environmental
Research Program

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ABSTRACT

Studies of woodland caribou (*Rangifer tarandus caribou*) in the Birch Mountains of northeastern Alberta were conducted from January 1976 through June 1978. Twenty-nine caribou were radio-collared and repeatedly located from fixed-wing aircraft. Eight capture-related deaths were associated with increased stress (hazing and handling time) and slow or incomplete absorption of the immobilizing drug. Young bulls (1.0 to 3.0 years old) and adult cows (>3.0 years old) were sometimes indistinguishable from the air due to similar body size and antler morphology. Time of antler drop among bulls was related to age. A population survey combining fixed-wing transect flights and helicopter tracking over 1400 km^2 yielded a late-winter density of 1 caribou/24 km^2. Radio-tracking data indicated that adult bulls concentrated in this area in winter; adjusted resident density was 1/33 km^2. The total caribou population on the 25 000 km^2 Alberta Oil Sands Environmental Research Program study area was estimated at 433. Bulls comprised 42% of animals older than calves. Calves made up 12% of the total fall and winter population. Yearlings comprised 14% of captured caribou, but individuals born from 1972 to 1974 comprised only 15%. This apparently reflected low survival of animals born following winters of deep snow and high food-short lynx (*Lynx canadensis*) populations. Calving occurred from 7 May to 3 June.

The pregnancy rate of adult cows (>3.0 years) was 88%. Calf survival was 42% in the first 2 months of life and 17% annually. Annual survival of radiocollared adults averaged 85%. At least two of four radiocollared adults which died were killed by wolves (*Canis lupus*). The calculated finite rate of population growth (λ = 0.85) indicated a declining population in years with normal snowfall. Radiocollared adult bulls remained solitary in summar, as did cows with calves. Both adult bulls and cows formed mixed groups during the rut in September. Groups of adult bulls remained separated from mixed groups of cows and young bulls in winter. Caribou group sizes were smallest in summer (mean: 1.2) and largest in late fall after the rut (mean: 5.4). Continuous associations of radiocollared caribou were longest in late winter. Seasonal ranges and movement patterns varied greatly between individuals, but seemed traditional among adult bulls. The latter made "long-distance" movements (>11 km) up to five times per year to distinct seasonal ranges. Most cows moved two and sometimes three times per year. The time of such movements by either sex was similar in all years. Seasonal range sizes were similar for bulls and cows, though individual cows were much more sedentary and their seasonal ranges overlapped much more. More annual range size of adult bulls was 1196 km^2 and that of cows was 539 km^2. Seasonal changes in relative use of habitat types seemed related to availability of food resources, snow depths, and social behaviour. Most locations (69%) were in lowland cover, predominantly black spruce (*Picea mariana*) muskegs. Caribou used upland deciduous cover types very little in any season. The great variability in winter habitat use reflected habitat availability within individual winter ranges.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Populations of woodland caribou (*Rangifer tarandus caribou*) across North America vary greatly in density, distribution, movements, group structure, and behaviour (Bergerud 1971; Edwards and Ritcey 1959; Freddy and Erickson 1975). Little is known about this species in the boreal forest of central Canada, and only recently have intensive studies of population dynamics and ecology been initiated [W. Pruitt (University of Manitoba) personal communication; Shoesmith and Storey 1977; Stardom 1975].

The Athabasca Oil Sands region of northeastern Alberta contains one of the largest known oil reserves in the world (Figure 1). Ongoing oil development will soon expose the woodland caribou there to markedly increased human disturbance. The present study was initiated to obtain information on current abundance and distribution within the oil sands region, and on other key elements of population dynamics that will be needed for management. In this paper, the dynamics of the caribou population in the Birch Mountain area are described as determined by field studies carried out from January 1976 to June 1978.

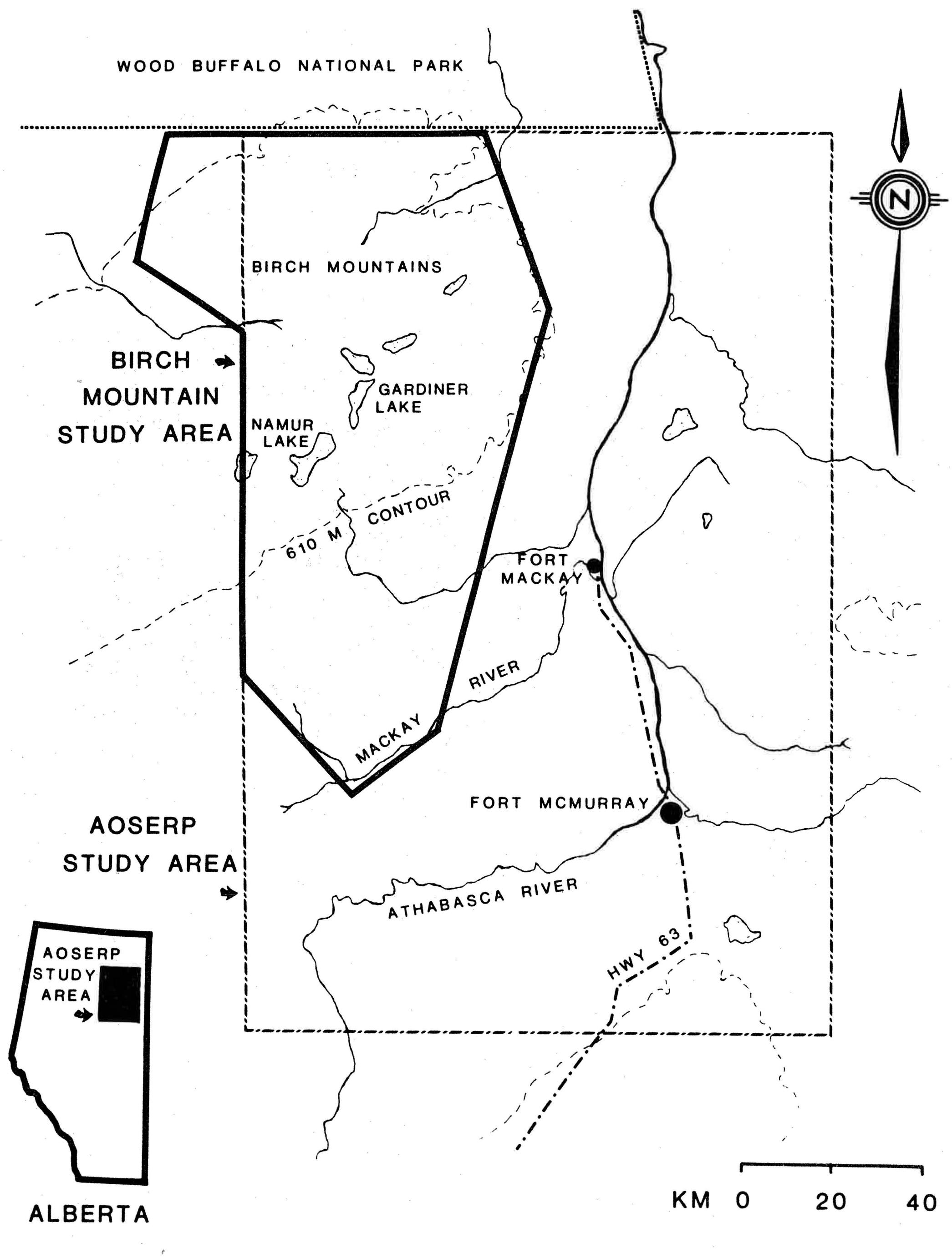

Figure 1. Birch Mountain study area in the province of Alberta.

2. STUDY AREA

Intensive investigations were carried out on approximately 7000 km^2 north and west of the Athabasca River near Fort McMurray, Alberta, including the Birch Mountains and south to the MacKay River (Figure 1). Most of this area was also included in the 25 000 km^2 AOSERP study area.

The Birch Mountains are a relatively flat highland averaging 800 m in elevation, about 500 m higher than the Athabasca River valley. Ridges run southwest-northeast, as do a series of large shallow lakes (15 to 60 km^2), including Namur and Gardiner. The eastern and northern edges of the mountains slope steeply, the southern moderately, and the western gently. The flat area south to the MacKay River averages 500 m in elevation.

The vegetation is boreal forest. Approximately half of the Birch Mountain study area is lowland with black spruce (*Picea mariana*), black spruce-tamarack (*Larix laricina*) muskegs, and open bogs. Ground cover is mainly Labrador tea (*Ledum groenlandicum*), *Sphagnum*, sedges (*Carex*), bog birch (*Betula glandulosa*), and various lichens (*Cladina* and *Peltigera*). Willows (*Salix*) predominate along watercourses.

The uplands are forested with pure or mixed stands of white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), and black spruce; and mixed stands of aspen (*Populus tremuloides*) and white spruce. Aspen monotypes are restricted mainly to a few ridges near the large lakes and to dry lower elevations on the southeast. Alder (*Alnus crispa*), willows, Labrador tea, blueberry (*Vaccinium myrtilloides*), and lichens are common understory species.

The only sizable recent burns occurred in 1959 (107 km^2) and 1961 (28 km^2); about 22% of the study area probably has been burned since the turn of the century (Alberta Forest Service).

Snowfall at Fort McMurray Airport averages 139 cm annually, mostly from November through March [Atmospheric Environment Services (AES)]. Snow depths are greatest on the higher northern elevations in the Birch Mountains. The July mean temperature at Fort McMurray is 16°C and the January mean is -22°C.

A few cutlines provide winter access for native hunters and trappers. There is floatplane and skiplane traffic to a fishing lodge, but other human disturbance has been minimal. Limited oil exploration occurred in the southern part of the study area in the winter of 1977-78.

Moose (*Alces alces*) are scarce in the Birch Mountains during winter, but migrate there in spring and remain through early fall (Hauge and Keith in press). The density of wolves (*Canis lupus*) probably fluctuates with moose numbers and thus in winter few are present (Fuller and Keith in press).

3. METHODS

3.1 CAPTURE AND TAGGING

Woodland and barren ground caribou (*Rangifer tarandus groenlandicus* and *R. t. granti*, respectively) generally have been captured in three ways. They are easily handled without drugs while swimming across rivers or in lakes in spring (Miller and Robertson 1967; Shoesmith and Storey 1977). During winter, large numbers of caribou have been herded into tangle nets set on trails near lake-shores where animals are loafing (DesMueles et al. 1971; Miller et al. 1971). Bergerud et al. (1964) were able to stalk animals on the ground and dart them with a tranquilizer gun.

None of these techniques was feasible in the study area. Animals were scarce, mobile, and difficult to locate. No large groups were located consistently within a particular area, and no traditional migration routes or calving grounds were known.

Caribou were located initially by intensive aerial search with fixed-wing aircraft after fresh snowfalls. Animals were first captured by darting with tranquilizing drugs from a helicopter (Hughes 500 C) during winter. Such darting proved difficult as snow cover was minimal (25 to 35 cm) and most caribou easily eluded the helicopter. Trees often made darting attempts hazardous. These problems, plus several capture-related mortalities, prompted the authors to use the helicopter solely to haze animals within darting range of a man concealed on the ground. A Cap-Chur rifle (0.22 blank) was tried initially but proved inadequate. Darting distances varied from 3 to 45 m and animals could not be darted safely at close range. The authors switched to a Pax-Arms rifle (0.22 blank) with variable power setting and had no further problem with dart impaction.

M99 or Immobilon (etorphine), and later a combination of fentanyl and Rompun, Azaperone and Wydase (J. Haigh in prep.), were used to immobilize the animals.

Drugged caribou were pulled down if standing, rolled upright onto their chests, given eyedrops to prevent cornea damage from freezing, and then blindfolded. Rectal temperature, heart rate, and respiration rate were monitored while body and antler measurements were taken and numbered eartags attached. An outer incisor was pulled on adults for age determination from tooth-cementum annuli (McEwan 1963), although annuli were sometimes unclear and difficult to distinguish. Blood samples were drawn for assessing physiological parameters (LeResche et al. 1974; McEwan 1968), hair samples were taken for mineral analyses (Franzmann et al. 1975), and fecal samples were collected for parasite investigations (Lankester et al. 1976; Low 1976).

A radiocollar with expected electrical life of 1 to 3 years was attached, as was a colour-coded identification collar 18 cm wide. An 8 cm strip of webbing was used to secure the colour collar so that head movements would not be impaired. The blindfold was then removed and the antidote, M50-50 or Revivon (diprenorphine), injected intravenously. A small dose of antidote also was injected intramuscularly to offset the recycling effect of the immobilization drug.

The radio and colour-coded collars enabled the authors to relocate and identify individual caribou quickly throughout the year during relocation or survey flights. Relocations of radiocollared individuals greatly increased the efficiency of tagging their associates at later dates.

3.2 RELOCATION

Relocations of radiocollared animals were conducted from fixed-wing aircraft (Cessna 180, 185) weekly during the rut (September to October) and the calving season (May) and biweekly during the rest of the year. No flights were made from mid-April through June 1977.

The relocation technique described by Mech (1974) was used, and a concerted effort was always made to identify visually the radiocollared animals and their associates. The authors recorded caribou numbers, activity, and sex and age classes; and time of day, topography, vegetation type, cover density and height, and miscellaneous information that seemed relevant. Locations were first plotted on Alberta Forest Cover Maps (1:126 720), then transformed to metric grid co-ordinates. Incidental observations of unmarked caribou were recorded in a similar manner.

3.3 CENSUS

A line-transect survey (east-west, 9.6 km interval) by the Alberta Fish and Wildlife Division (Bibaud 1972) in November 1972, and two line-transect surveys by the authors in January 1976 (1.6 km interval) and February 1978 (4.8 km interval) proved totally ineffective in locating woodland caribou. Because these caribou were largely unobservable from fixed-wing aircraft, the authors tried another means of estimating numbers on a section of the Birch Mountain study area where most radiomarked individuals were present.

Caribou tracks were first located after a fresh snowfall using fixed-wing aircraft to fly line transects 75 to 100 m above ground level and 1.6 km apart (pilot and three observers). The caribou were then tracked down that same day with a helicopter (pilot and one observer). By determining the ratio of marked to total animals observed, the population was then estimated by simple Petersen-index calculations. An estimate of herd sex and age composition and distribution was also obtained.

4. RESULTS AND DISCUSSION

4.1 NUMBER OF CARIBOU RADIOCOLLARED

From early March 1976 through November 1977, 37 woodland caribou (23 adult bulls, 11 adult cows, and three female calves) were captured and radiocollared in the Birch Mountain study area (Figure 2); four were subsequently recollared. Five caribou were marked during March and April 1976, 26 during November 1976 to March 1977, and 10 during October to November 1977. Eight caribou died as the result of tagging procedures (three adult bulls, four adult cows, and one female calf). The remaining 29 individuals were relocated aerially 1001 times from March 1976 through June 1978. Visual contact was more frequent during September to May (91%) than during June to August (61%) due to dense foliage in summer on upland sites. Four caribou (two adult bulls and two female calves) slipped their radiocollars; radios on five others (three adult bulls and two adult cows) ceased transmitting.

4.2 DRUG PERFORMANCE

The effectiveness and safety of an immobilization drug can be influenced by several factors. Drugs are optimally absorbed when injected into such heavy muscle masses as the neck, shoulder, or rump (Haigh et al. 1977; Harthoorn 1976). Injections into the flank or lower leg take much longer to act because of incomplete absorption. Excessive psychological and physiological stress during hazing attempts can increase variation in drug effect. If animals receive incomplete drug doses, additional stress may occur during handling.

Sixteen caribou were immobilized with fentanyl (J. Haigh in prep.) and 25 with etorphine. There was great individual variation in reaction to these drugs, even under similar circumstances. In addition, some animals were much more difficult to haze, or were darted at suboptimal distances. One adult bull died three weeks after tagging due to abdominal penetration by the tranquilizing dart. Seven others (all immobilized with etorphine) died within one week of handling.

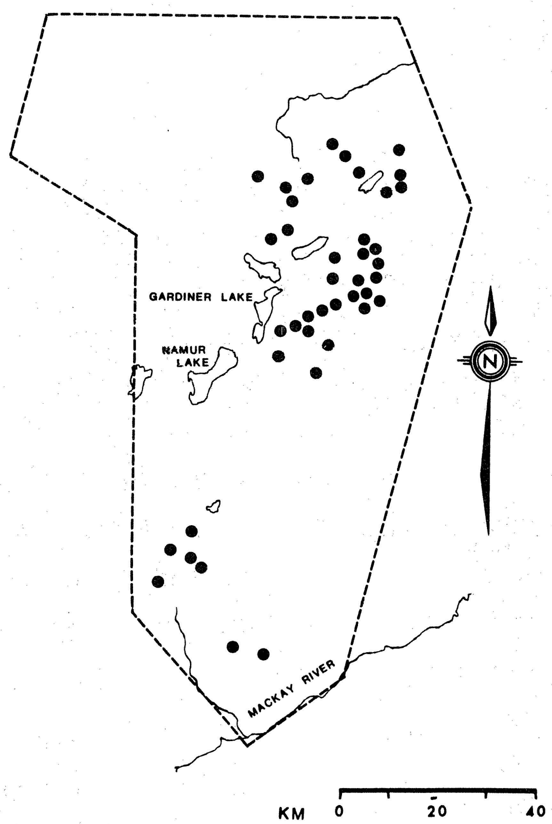

Figure 2. Tagging locations of 37 woodland caribou captured 41 times between March 1976 and November 1977 in the Birch Mountain study area.

Most immobilization statistics for individuals surviving or dying after etorphine injections were not significantly different (Table 1). Three statistics, however, did suggest conditions associated with mortality: (1) longer hazing time; (2) longer immobilization time--a result of poor dart location; and (3) longer handling time. Conditions (2) and (3) were frequently interrelated; more of the caribou that died were restrained during initial handling (87% vs. 6%) due to poor immobilization.

4.3 CAPTURE

Capture techniques were modified constantly throughout the study. Though darting accuracy did not increase significantly from the ground versus the air (1.8 versus 2.0 shots per immobilized caribou), hazing intensity decreased sharply. Significantly more caribou darted from the ground were hazed slowly or for less then 3 minutes. The switch to a variable-power rifle permitted darting without risking serious physical injury, but the plastic Pax-Arms darts sometimes shattered on impact or did not fully discharge the drug. Modifications in dart filling techniques were required to avoid accidental injury. Dense vegetation and poor snow conditions often necessitated two aircraft to relocate and follow drugged animals. Although none of 16 caribou immobilized with fentanyl died, a veterinarian experienced in ungulate immobilization attended to several animals which otherwise might not have survived.

4.4 PHYSICAL CHARACTERISTICS

Estimation of herd sex and age composition and of calf survival depended importantly on distinguishing between the sexes and between adults, yearlings,and calves during relocation flights. Among caribou, age and sex are usually determined from relative body size and antler size and morphology (Bergerud 1971; Parker 1972), and from a knowledge of annual cycles of antler shedding (Bergerud 1976). Body-size differences are often difficult to detect from fixed-wing aircraft (Bergerud 1971), while similarity in antler size and morphology is common (Kelsall 1968; Skoog 1956).

Table 1. Etorphine doses and immobilization statistics for 25 woodland caribou captured in the Birch Mountain study area from March to April 1976, November 1976 to March 1977, and October to November 1977. Seven animals died within one week of capture.

	Means and ranges		P value (t-test)
	Survived[a]	Died	
Etorphine dose (mg)	7.5 (5.5-12.0)	7.6 (5.5-11.0)	NS[b]
Hazing time (min)	6.1 (2-20)	13.0 (3-31)	0.03
Immobilization time (min)	12.3 (4-19)	22.7 (4-44)	0.01
Handling time (min)	25.7 (9-55)	39.1 (20-55)	0.02
Diprenorphine dose (mg)	13.9 (9-27)	15.8 (10-30)	NS
Recovery time (min)	7.7 (1-15)	9.2 (2-25)	NS
Rectal temperature (C)[c]			
pre-handling	41.6 (40.8-42.4)	42.0 (40.8-43.7)	NS
Post-handling	41.9 (40.8-43.0)	42.3 (40.9-43.6)	NS
Heart rate (per min)[d]	61(40-80)	73(50-108)	NS
Respiration rate (per min)[e]	25(4-72)	20(4-35)	NS

[a] Includes one animal that died after three weeks due to penetration of abdomen by a dart.

[b] P >0.30.

[c] Sample of 10 animals that survived and six that died.

[d] Sample of 11 animals that survived and five that died.

[e] Sample of three animals that survived and three that died.

Body measurements of captured woodland caribou confirmed that the age and sex of some individuals would be difficult, if not impossible, to determine from the air. Adult bulls (>3.0 years old) were largest and female calves (>1.0 year old) were smallest (Table 2). However, young bulls (1.0 to 3.0 years old), young cows, and adult cows were all similar in size and intermediate to adult bulls and calves.

Young bulls and adult cows also had antlers that were often similar in both total length (Figure 3) and form (Figure 4). Only cows with antlers >30 cm could be distinguished from young bulls. Furthermore, 92% of 151 cows had antlers. This contrasted with caribou in Newfoundland where 9 to 88% of cows had antlers (Bergerud 1976).

The annual cycle of antler growth and shedding among the radio-marked caribou was similar to that described by Bergerud (1976). Antler growth among bulls 3 to 8 years old began in late March and was somewhat later among older and younger bulls. By July, racks were large and in full velvet; most were free of velvet by mid-August, before the rut. Time of antler drop was related to age (Figure 5); the oldest bulls began in early November but some young ones carried antlers until mid-April.

Antler growth was first observed on cows in early July. Four retained antlers until calving in early May; one 3.0 year old lost her antlers in late April and calved in early June.

Thus, for a good part of fall and winter, adult cows and young bulls looked much alike and were frequently indistinguishable from the air, but adult bulls and calves were easily identified.

4.5 POPULATION DENSITY AND DISTRIBUTION

The combined fixed-wing-transect and helicopter-tracking survey was initiated on 25 February 1978, approximately 24 hours after an 18 cm snowfall. The survey continued through 26 February over the 1400 km^2 that constituted the intensive survey area (Figure 6).

Table 2. Means and standard errors of weights (kg) and selected body measurements (cm) of woodland caribou captured from March 1976 to November 1977 in the Birch Mountain study area. Number of caribou in measurement samples are shown in parentheses.

Age and sex[a]	Weight[b]	Total Length	Chest Girth	Neck Girth	Head Length
Adult bull (17)	190 ± 28.1	219 ± 2.5	154 ± 1.5	77 ± 1.3	51 ± 0.6
Young bull (6)	145 ± 10.5	197 ± 1.9	141 ± 3.5	67 ± 1.8	46 ± 1.5
Adult cow (7)	136	196 ± 1.7	141 ± 4.3	62 ± 0.9	44 ± 0.6
Young cow (3)	(no data)	198 ± 9.7	137 ± 3.4	55 ± 3.3	43 ± 1.3
Calf cow (3)	(no data)	184 ± 7.6	122 ± 8.3	53 ± 1.6	38 ± 0.3

[a] Adult, >3.0 years; young, 1.0 to 3.0 years; calf, <1.0 years; ages determined from tooth-cementum annuli.

[b] Weights were determined for only three adult bulls, four young bulls, and one adult cow.

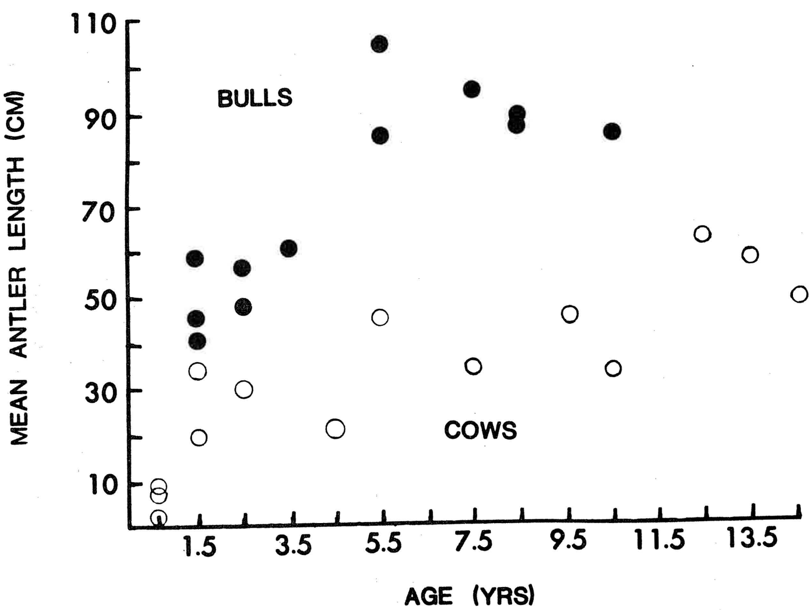

Figure 3. Relationship between mean antler length and age of woodland caribou captured between November 1976 and November 1977 in the Birch Mountain study area.

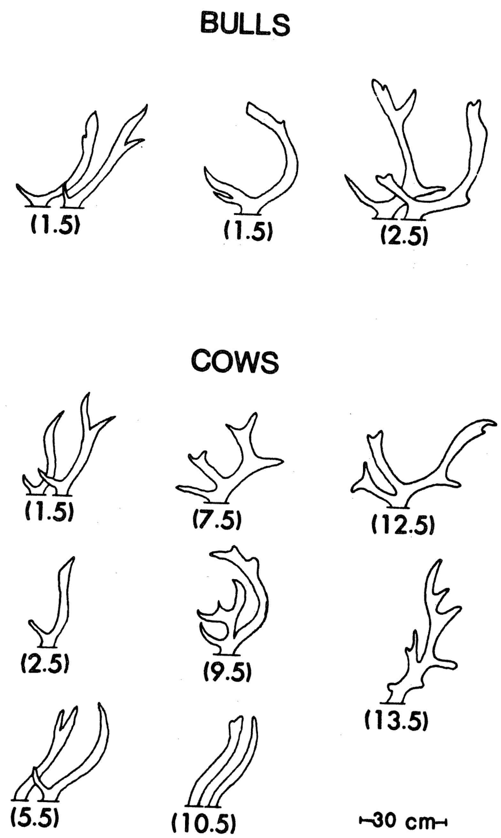

Figure 4. Antler morphology of young bull and cow woodland caribou captured between November 1976 and November 1977 in the Birch Mountain study area.

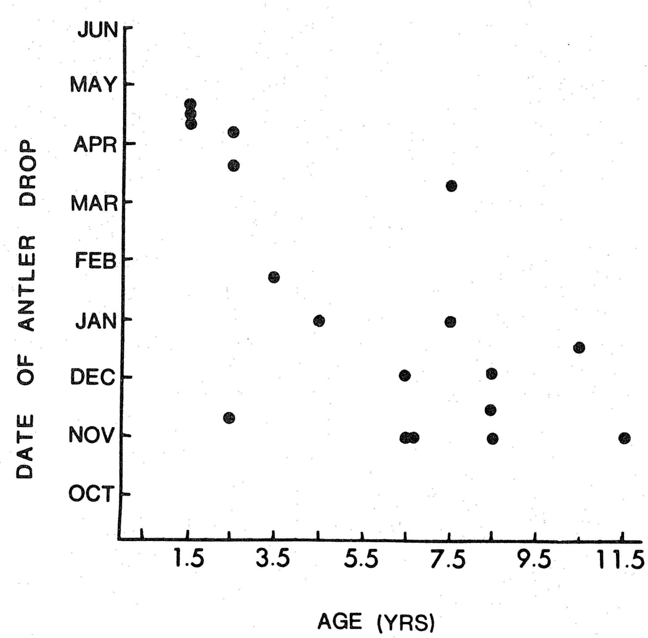

Figure 5. Relationship between age and date of antler drop among radiocollared bull woodland caribou between March 1976 and June 1978 in the Birch Mountain study area.

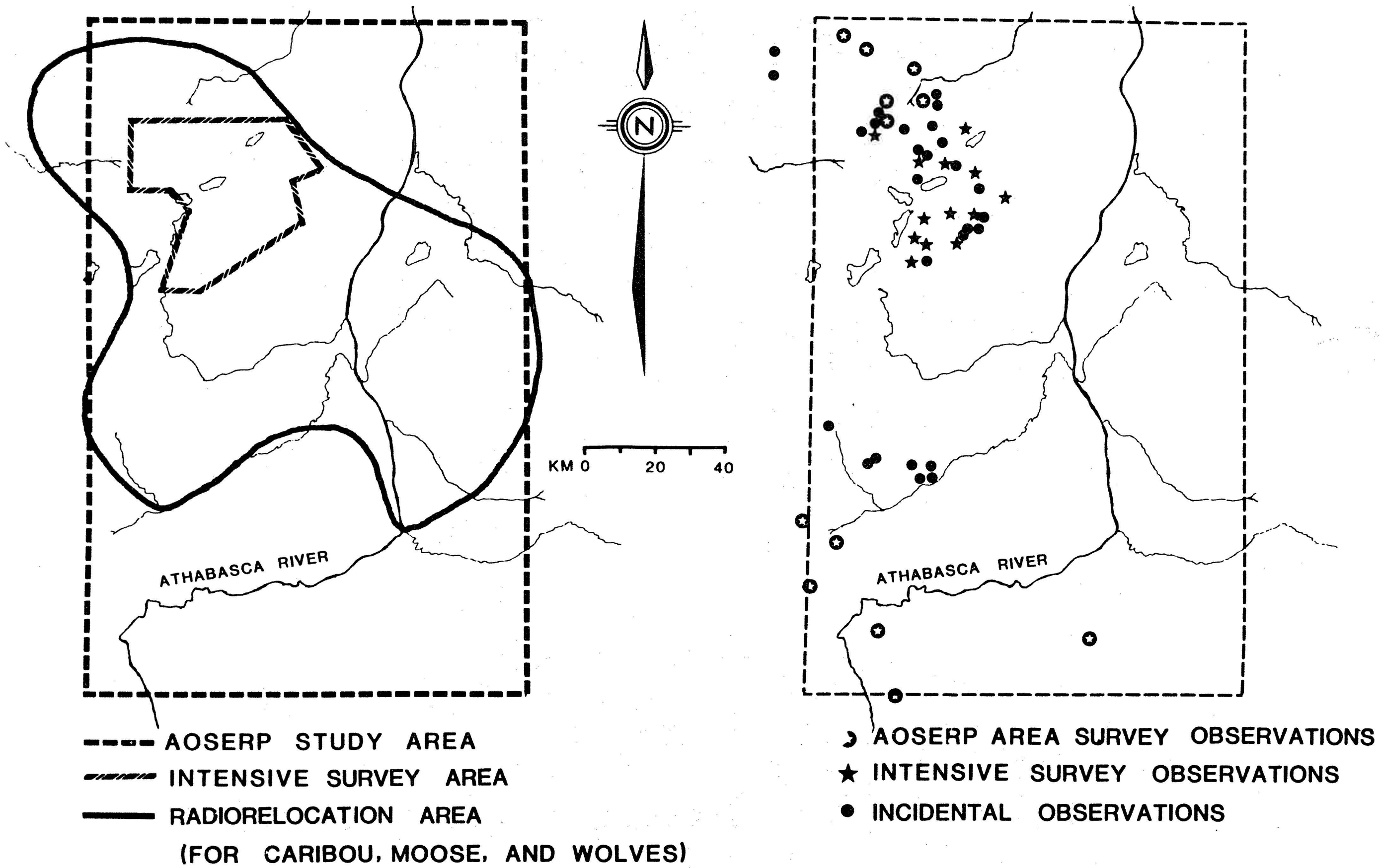

Figure 6. Winter-survey and relocation areas in the AOSERP study area and the distribution of woodland caribou.

Thirty-five sets of tracks were observed: 26 caribou, eight moose, and one wolf. Five sets of caribou tracks had been made before the snowfall and were not completely obscured; seven other sets were continuations of tracks followed earlier during the survey. Eleven of the 14 remaining sets of tracks were followed and the caribou observed and classified; one set was not followed and two others could not be followed through large stands of dense conifers.

Eleven groups totalling 45 caribou were observed; 10 of these animals were marked. Since 13 marked animals were known to be present on the survey area, the resulting population estimate was 59 (45 x 13/10).

One set of tracks which the authors were unable to follow was probably made by only two animals. Another was undoubtedly a group of four which included two radiomarked individuals. A second group of four containing one marked animal was relocated later in the day close to a group found during the survey and probably had been overlooked by us. The set of tracks not investigated likely represented four to five animals (the mean size of observed groups). Thus, the authors can account for a total of 59 to 60 caribou in the intensive survey area, essentially the same number as calculated to be present. The mean winter density, therefore, was 1/24 km^2 (59/1400).

Stardom (1975) reported at least 35 to 37 woodland caribou present in his 235 km^2 winter study area in Manitoba (1/6.5 km^2). In contrast, Parker (1972) reported barren ground caribou densities on winter range of over 20/km^2.

The authors believe that the 1/24 km^2 is an estimate of maximum density in the intensive survey area because adult bulls (>3.0 years old), and possibly young bulls, concentrated there in winter (see Section 5.4). Four radiocollared adult bulls were present in the area in summer; by February, one of these had egressed but four others had ingressed, a net gain from summer of 75%. Four young bulls were tagged and relocated in the survey area between November 1977 and June 1978; one egressed by summer. Four radiocollared cows (three adults and one yearling) remained in the survey area through both summer and winter. Calves probably accompanied their mothers for at least a year (Espmark 1975).

The winter concentration of bulls in the intensive survey area was corrected by calculating their numbers in summer and adding cows and calves (year-round residents). There were 28 adult bulls and nine young bulls among the 53 caribou observed during the February 1978 survey. Three of the six animals not seen were likely adult bulls, and one was likely young. Thus, in summer, 18 adult bulls [(28+3) x 4/7)] and eight young bulls [(9+1) x 3/4)] were probably present, along with 14 cows and at least three calves. The adjusted resident density was thus 1/33 km^2 (43/1400) in the intensive survey area.

Caribou numbers in the entire 25 000 km^2 AOSERP study area were calculated from the winter density estimate of 1/24 km^2 given earlier and an estimate of winter caribou range. Winter distribution (Figure 6) was determined for the northern two thirds of the AOSERP study area from: (1) survey flights; (2) incidental observations during biweekly relocations of caribou, moose, and wolves from November to March in 1976-77 and 1977-78; and (3) known winter locations and movements of radiocollared caribou. Caribou were present only in the Birch Mountains (excluding the area just west and south of Namur and Gardiner lakes) and south of the mountains to the MacKay River. Caribou are not usually present in the Athabasca River valley or to the east of the river, though many areas appear to be suitable.

In the southern third of the area, where no relocation flights were made but where some caribou were known to be present, the authors estimated the amount of suitable habitat (see Section 5.5) and considered all of this occupied.

According to the above assumptions, there were about 10 400 km^2 of range occupied at a mean winter density of 1/24 km^2. Since the range estimate is probably maximal, so too then is the total population estimate of 433 (10 400/24 km^2).

It is not likely coincidental that the only major population of caribou in the northern two thirds of the AOSERP study area is in the Birch Mountains. Moose are scarce there in winter (Hauge and Keith in press), and it is possible that, where enough moose are present to support a year-round wolf population, few caribou can survive. Even in the Birch Mountains where wolf numbers are low (Fuller and Keith in press), the caribou population is apparently declining (see Section 5.2).

4.6 AGE COMPOSITION

Ages of 33 yearling and older caribou captured during the winters of 1976-77 and 1977-78 were determined from tooth-cementum annuli (Table 3). There is no reason to believe that the sample was not representative of the age distribution among animals older than calves. The mean age of bulls (6.1 years) and cows (6.9 years) was greater then the 4.0 and 5.5 years reported by Bergerud (1971) in Newfoundland. This reflected the small percentage (15%) of animals in the Birch Mountain population that had been born from 1972 to 1974. These were in springs following winters of deep snow; they also spanned a period in which lynx (*Lynx canadensis*) were abundant and their staple prey, the snowshoe hare (*Lepus americanus*), was rapidly declining (see Section 5.1).

Yearlings comprised 14% of the 35 captured (Tables 3) and calves averaged 12% (0 to 22%) of incidental observations during fall and winter relocation flights in 1976-78 (Table 4).

Lynch and Pall (1973) reported 12 to 29% calves in fall and winter surveys of woodland caribou populations in Alberta between 1959 and 1971. Bergerud (1971) found an average of 13% (6 to 25%) calves in fall populations of woodland caribou in Newfoundland. Among barren ground caribou, calves have ranged from 7 to 27% of early spring populations (Kelsall 1968; Parker 1972; Skoog 1968). In general, most caribou populations with >15% calves have been increasing, while those with <10% calves were declining (Bergerud 1974d and personal communication).

4.7 SEX RATIOS

The percentage of adult bulls (>3.0 years old) in the population (excluding calves) was estimated at 35%, the unweighted mean of 248 incidental observations between June 1976 and June 1978 (Table 4). The percentage of young bulls (<3.0 years old) was next estimated among

Table 3. Ages of 33 adult woodland caribou captured between November 1976 and November 1977 in the Birch Mountain study area, as determined by tooth-cemetum annuli.

		No. within each age class											Mean age
Sex	Winter	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	(year)
Bulls	1976-77[a]	1		1	1	3	1	3	2	1	1		6.1
	1977-78	2	2			1		1	2		1		
Cows	1976-77[a]	2	1			1				1	1	2	6.9
	1977-78				1		1						
Total	1976-77	3	1	1	1	4	1	3	2	2	2	2	6.3
	1977-78	2	2		1	1		2	2		1		

[a] Age (from annuli) not determined for one bull (>2.5 years) and one cow (>2.5 years) captured during March to April 1976.

Table 4. Sex and age composition of woodland caribou observed incidentally during radiorelocation flights between September 1976 and February 1978 in the Birch Mountain study area.

Month	Total caribou observed	% Calves among total caribou observed[a]	% Adult bulls (3.0 years) among 248 adults
September	41	13	24
October	43	15	41
November	15	14	46
December	37	22	15
January	36	0	22
February	108	10	62
Total and unweighted means	280	12	35

[a] Corrected for 42:58 sex ratio.

the 54 (22% of 248) young bulls and cows which could not be sexed from the air. Since there were five young bulls in the total of 16 young bulls and cows captured, it was calculated that they comprised 7% (0.31 x 22%) of the population (excluding calves). The population sex ratio was thus 42% bulls to 58% cows.

The sex ratio in woodland and barren ground caribou populations, whether hunted or not, exhibits a preponderance of cows (Bergerud 1974c). Kelsall (1968), Miller (1974), and Parker (1972) found from 30 to 40% bulls in areas where hunting pressure was low or non-existent. Where caribou were hunted, bulls comprised from 28 to 42% of the population (Bos 1975; Bergerud 1971).

5. REPRODUCTION

Four radiocollared cows were accompanied by newborn calves when observed from the air on 7 May 1976 and 12, 13, and 19 May 1978; all had been alone during previous relocation flights 6 to 8 days earlier. A fifth marked cow (3.0 years old) had just calved when observed on 2 June 1978, and an unmarked cow was seen with a newborn calf on 28 May 1978.

Rutting activity, as signified by increased associations of cows with bulls, began in early September. Given a gestation period of approximately 229 days (Bergerud 1975), it was concluded that conceptions mostly occurred in mid- to late September, but continued into early October.

The estimates of fecundity are tentative due to the small number of radiocollared cows relocated at calving time; all five adult cows (>3.0 years old) had calves. In addition, two of three adult cows that died after winter tagging were carrying fetuses. The lone barren cow was 10.5 years old. Thus, seven of eight (88%) adult cows were known to have been pregnant or to have given birth.

Most caribou populations calve from mid-May through mid-June (Bergerud 1974b; Kelsall 1968; Shoesmith and Storey 1977; Skoog 1968). Timing of calving appears to be modified by local climatic conditions and uncorrelated with latitude (Dauphine and McClure 1974). Caribou in open tundra calve during a 1 to 2 week period, then form large post-calving aggregations (Bergerud 1974b). Those in forests apparently calve over longer intervals (Bergerud 1973). Synchronous births in tundra populations likely increase calf survival where predators are present (Bergerud 1974d; Dauphine and McClure 1974). In the Birch Mountains, cows calve asynchronously and remain solitary through the summer (see Section 5.3).

Bergerud (1971) estimated that in Newfoundland a mean of 85% of cows >2.0 years old and 96% of cows >3.0 years old were parous. Pregnancy rates of barren ground caribou 2 years and older in Alaska and northern Canada have ranged from 46 to 90% (Bos 1975; Davis et al. 1978; Dauphine 1976; Miller and Broughton 1974; Kelsall 1968; Parker 1972; Skoog 1968).

5.1 SURVIVAL

5.1.1 Calf Survival

Early survival of calves appeared to be low; three of five born to radiocollared cows in spring 1978 disappeared in the first month. One calf born in the spring of 1976 survived through the summer, but in 1977 only one of four radiocollared cows had a calf by early July. Mortality during the first two months of life was at least 50% (three of six known to have disappeared), and may have been as high as 67% (six of nine calves born to 10 cows). The best estimate is 58% mortality (42% survival) in the first two months.

Annual survival of calves was estimated by combining demographic data with adult survival rates based on radiotelemetry. The demographic data were first used to calculate the calf-adult ratio at birth (Table 5). When the resulting 44/100 ratio in mid-May was compared to the observed 10/100 in mid-February (Table 4) and corrected for adult survival of 0.89 during this same interval (see Section 5.1.2), estimated calf survival from May to February was 0.20 (10 x 0.89/44). Because, as noted previously, calf survival from mid-May to mid-July was 0.42, it was possible to calculate also that survival from mid-July to mid-February was 0.48 (0.20/0.42). If one assumes that calf survival between mid-February and mid-May was equal to adult survival (0.96 for three months), then first-year survival of calves was 0.19 (0.96 x 0.20); if calf survival between mid-February and mid-May was equal to the rate for calves during mid-July to mid-February (0.73 for three months), then the first-year survival of calves was 0.15 (0.73 x 0.20). The best estimate of first-year survival is probably the mean value of 0.17.

Bergerud (1971) reported 31 to 70% annual survival of caribou calves in Newfoundland, and 29% 9 month survival in Labrador (Bergerud 1967). Miller and Broughton (1974) estimated 63% survival among barren ground caribou within the first two months of life. Other barren ground caribou studies have found first-year survival of 22 to 60% (Bos 1975; Parker 1972; Skoog 1968). The major cause of mortality in these studies was predation by wolves or lynx.

Table 5. Estimated ratio of calves to adults in the Birch Mountain caribou population at birth; mean date about 15 May.

Proportion of cows in population on 15 May (see Section 4.7)	0.58
Proportion of 2 year olds among cows (Table 3)	0.14
Proportion of 2 year olds in population (0.58 x 0.14)	0.083
Proportion of older cows in population (0.58 to 0.083)	0.497
Pregnancy rate of 2 year old cows[a]	0.07
Pregnancy rate of older cows (see Section 5)	0.88
Relative number of calves produced by 2 year old cows (0.083 x 0.07)	0.006
Relative number of calves produced by older cows (0.497 x 0.88)	0.437
Relative number of calves produced by all cows	0.443
Calves per 100 adults in population on 15 May	44

[a] Mean of reported pregnancy rates in mainland caribou herds (data from Dauphine 1976).

Causes of calf mortality in the Birch Mountains were unknown; but individuals born in the springs of 1972 to 1974 accounted for only 15% of the darted sample. Two explanations for this seem plausible. First, the mean annual snowfall at Fort McMurray airport in the winters of 1971-72 and 1973-74 (265 cm) was 90% greater than that between 1944 and 1970 (AES), and depths in the Birch Mountains likely approached 70 to 80 cm (from ratios of depths measured in 1978). Since late winter pregnancy rates and birth rates appear high and comparable to other populations, the relationship between overwinter snowfall and apparent recruitment to the next year-class likely reflects post-partum losses.

Stardom (1975) determined that depths greater than 60 cm limited woodland caribou feeding activities in Manitoba, but Bergerud (1971) concluded that availability of winter forage did not influence the subsequent survival of calves in Newfoundland. The present data may indicate that adult female caribou are increasingly stressed as snow cover deepens, thereby adversely affecting viability of calves. Bergerud (1975) found that calves born after winters of deep snow weighed less as a result of poor maternal nutrition during winter, and further suggested, in reference to late-born calves, that wolf predation may be more severe on smaller calves. Peterson (1977:145) reported that cohorts of moose calves born after a winter of deep snow and thus nutritional stress, or experiencing such a winter as calves, were smaller and permanently more vulnerable to wolf predation. Caribou calves in the Birch Mountains might be similarly affected.

A second possibility, suggested by A.T. Bergerud (personal communication), is that calf survival was low due to increased lynx predation. Snowshoe hares in the Birch Mountains, as elsewhere in Alberta, exhibit marked 9 to 10 year cycles of abundance (Keith and Windberg 1978). Lynx, the hares' most dependent predator, fluctuates similarly but with a 1 to 2 year time lag (Keith et al. 1977; Brand and Keith in press). The hare population apparently peaked in the Birch Mountains during the winter of 1970-71 and thereafter declined rapidly to a low by 1974-75. The harvest of lynx on Birch Mountain traplines peaked in the winter of 1971-72 and remained high through 1972-73 (A.W. Todd, personal communication). Caribou calves born in the spring

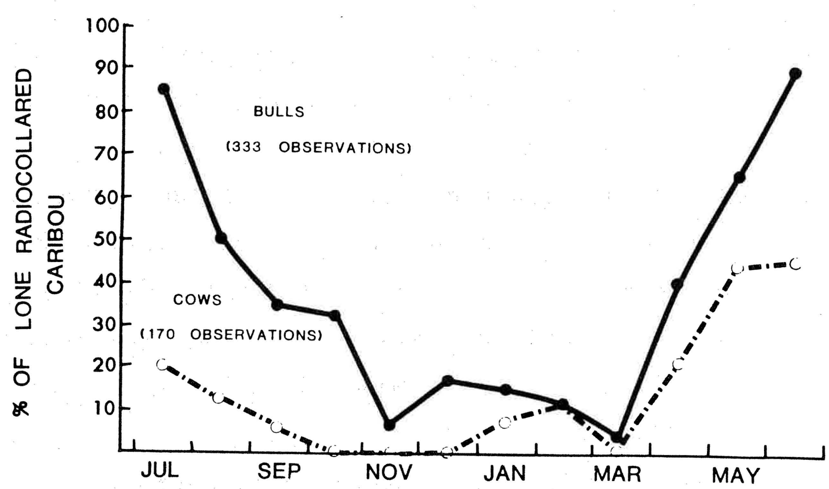

Figure 7. Frequency of lone radiocollared woodland caribou among radiomarked groups relocated in the Birch Mountain study area between March 1976 and June 1978.

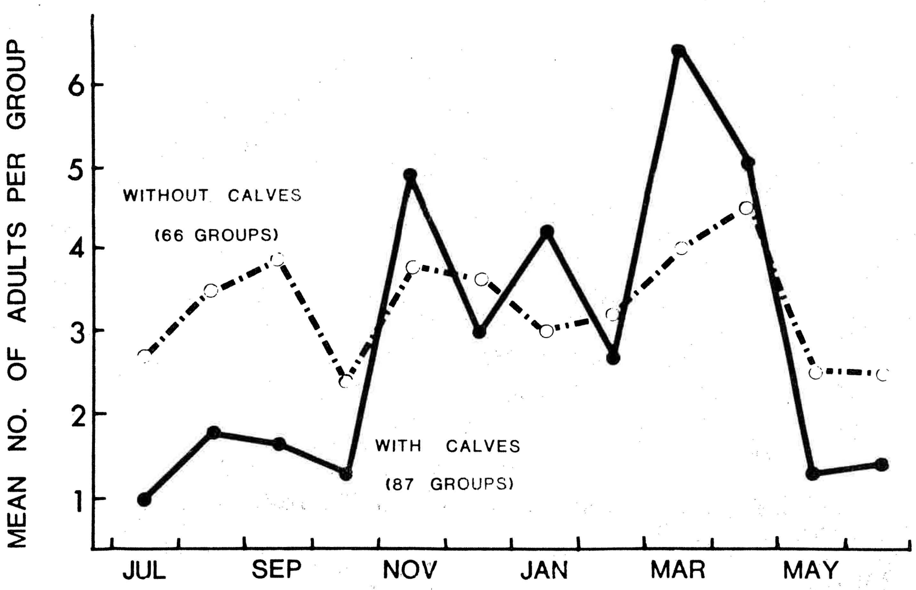

Figure 8. Average number of adult woodland caribou in groups with and without calves in the Birch Mountain study area.

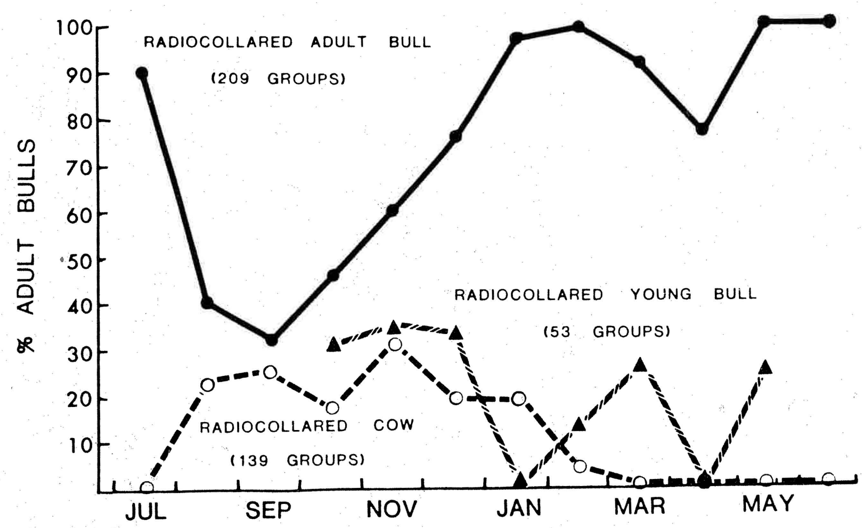

Figure 9. Frequency of adult bulls in groups of woodland caribou observed between March 1976 and June 1978 in the Birch Mountain study area.

and other cows (Figure 8). Cows with calves joined other cows and young bulls in November. From December through April, radiocollared adult bulls were usually associated only with other adult bulls, and cows and young bulls only with cows, calves, and other young bulls (Figure 9).

Mean size of caribou groups, including calves, as determined from observations of groups associated with radiocollared animals, ranged from 1.2 in July to 5.4 in November. The annual pattern of change (Figure 10) was similar each year, with minor peaks occurring during the rut in September and in late winter. Mean group sizes were similar for both radiocollared adult bulls and cows during most of the year, but in March, radiocollared young bulls and cows were together in groups nearly 50% larger than the all-adult bull groups. Only 8% of all individuals observed in any month were in groups larger than six; 48% were alone or in groups of two.

Groups tended to be more stable; that is, animals apparently stayed together longer during late winter than during fall. The mean duration of continuous associations of any two radiocollared adult caribou ranged from just under 3 weeks in November and December to 6 weeks in March and April (Table 6). During the fall and winter, pairs of radio-marked adult bulls tended to remain together longer than did pairs of cows and young bulls. Of 32 adult caribou followed from November through April, 69% stayed with another radiocollared adult for at least 30 consecutive days, 25% for at least 60 days, and 22% for at least 80 days (Figure 11). On eight occasions, pairs of marked adult caribou were located together in successive winters.

In Newfoundland, cows with newborn calves often formed large post-calving aggregations (Bergerud 1971), much like barren ground caribou (Kelsall 1968), but woodland caribou in the Birch Mountains did not. This was perhaps an anti-predator strategy in forested habitat (Cumming 1975). Segregation of adult bulls from all others during winter was more distinct in the Birch Mountains than among either woodland caribou in Newfoundland (Bergerud 1976) or barren ground

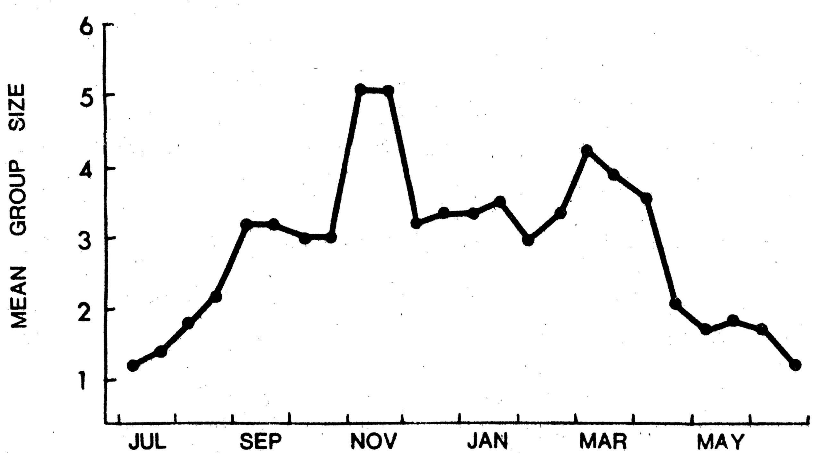

Figure 10. Mean size of 690 groups of woodland caribou located by radiotelemetry in the Birch Mountain study area between March 1976 and June 1978.

Table 6. Mean duration of associations (days) of radiocollared woodland caribou (>1.0 year) relocated in the Birch Mountain study area from March 1976 through June 1978. Duration of each association calculated as the average of the minimum and maximum length of time two marked individuals could have been together. Range of number of days per association is shown in parentheses.

	Cohort			
Months	Adult[a] bulls	All cows and young[b] bulls	Total	Mean no. of days between locations
Nov - Dec	23 (8-43)	14 (6-24)	19	12
Jan - Feb	36 (7-98)	26 (5-91)	32	9
Mar - Apr	46 (15-98)	36 (9-98)	42	12

[a] Adult - >3.0 years.

[b] Young - 1.0 to 3.0 years.

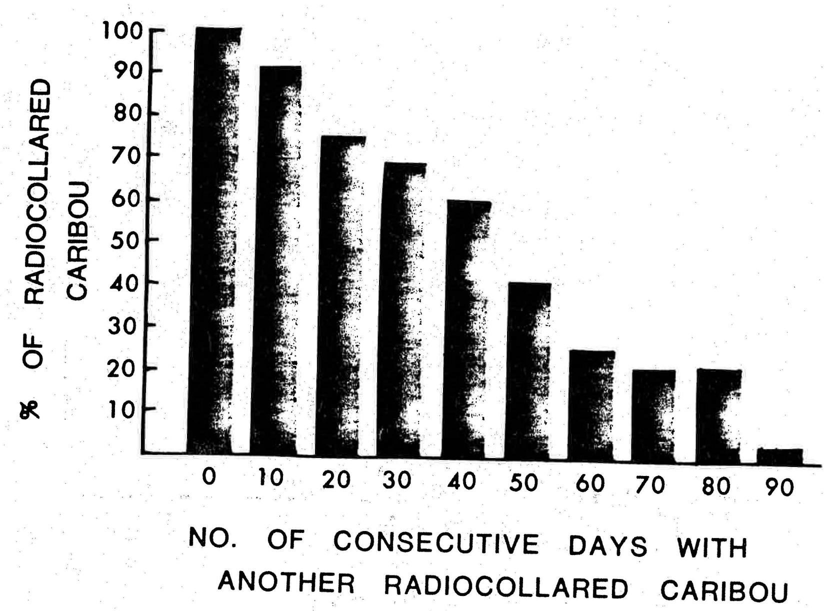

Figure 11. Frequency of longest continuous associations of pairs of radiocollared woodland caribou in the Birch Mountain study area between November and April 1976 to 1978.

caribou in north-central Canada (Miller 1974). The annual pattern of change in mean group size observed in the Birch Mountains was similar to that in Manitoba (Shoesmith and Storey 1977).

5.4 SEASONAL MOVEMENTS AND RANGES

Long-distance herd migration between spring calving grounds, summering areas, and winter ranges are common among barren ground caribou (Banfield 1954; Dauphine et al. 1975; Jakimchuk and McCourt 1975; Lent 1965; Miller et al. 1975). Woodland caribou may also move as herds, especially where calving traditionally takes place on island archipelagoes, but distances are usually shorter (Bergerud 1971, 1973; W. Pruitt, University of Manitoba, personal communication; Shoesmith and Storey 1977; Stardom 1975). Fall rutting movements, where they occur, serve to concentrate animals and thus increase contact between bulls and cows (Bergerud 1974b).

In order to quantify seasonal movements and ranges of caribou in the Birch Mountains, the authors first plotted the frequency of distances moved between successive biweekly relocations throughout the year. On the basis of the resulting distribution of movements (Figure 12), the authors arbitrarily designated those <11 km as "local" and those >11 km as "long distance" and indicating seasonal range shifts. This cut-off was later found to approximate the actual minimum distances moved in a 2 week interval between observed areas of concentrated activity. The frequency distribution of cow movements differed from that of bulls only in that 3% versus 9% were greater than 20 km.

The frequency of movements >11 km between relocations was next plotted semi-monthly for bulls and cows. Among adult bulls, such movements appeared to peak during five periods in both 1976-77 and 1977-78 (Figure 13). Most bulls (75 to 88%) made moves in all except the late winter period (Table 7). Early fall moves to rutting areas had least variance in dates of occurrence (25 August to 20 September) and also were the longest total distances (mean: 48 km; Table 6). Seasonal movement patterns for individual bulls were quite variable, but moves were most commonly made in all five periods (Figure 14).

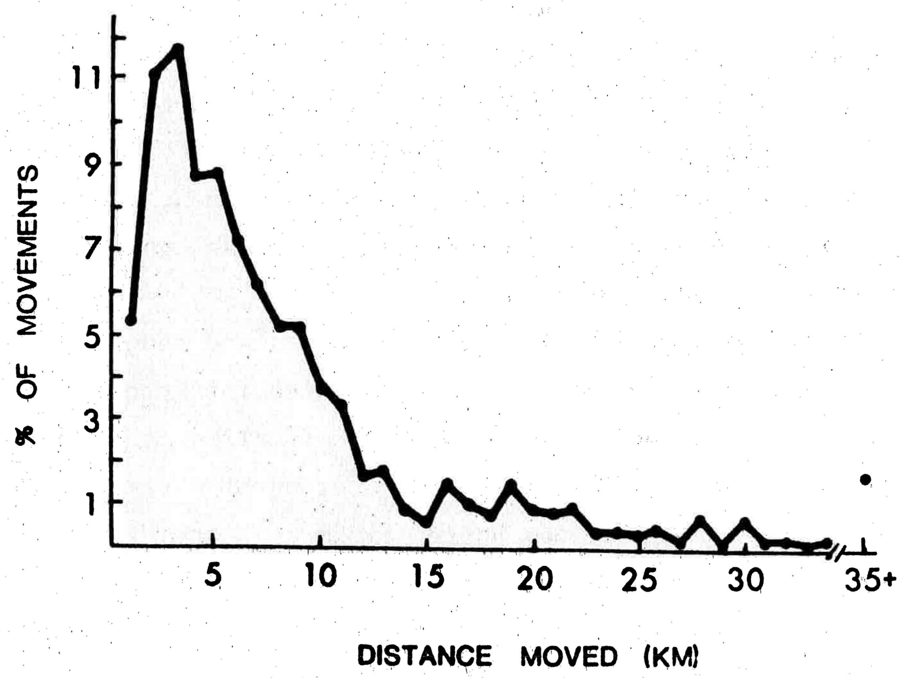

Figure 12. Distances moved by radiocollared woodland caribou between successive relocations in the Birch Mountain study area.

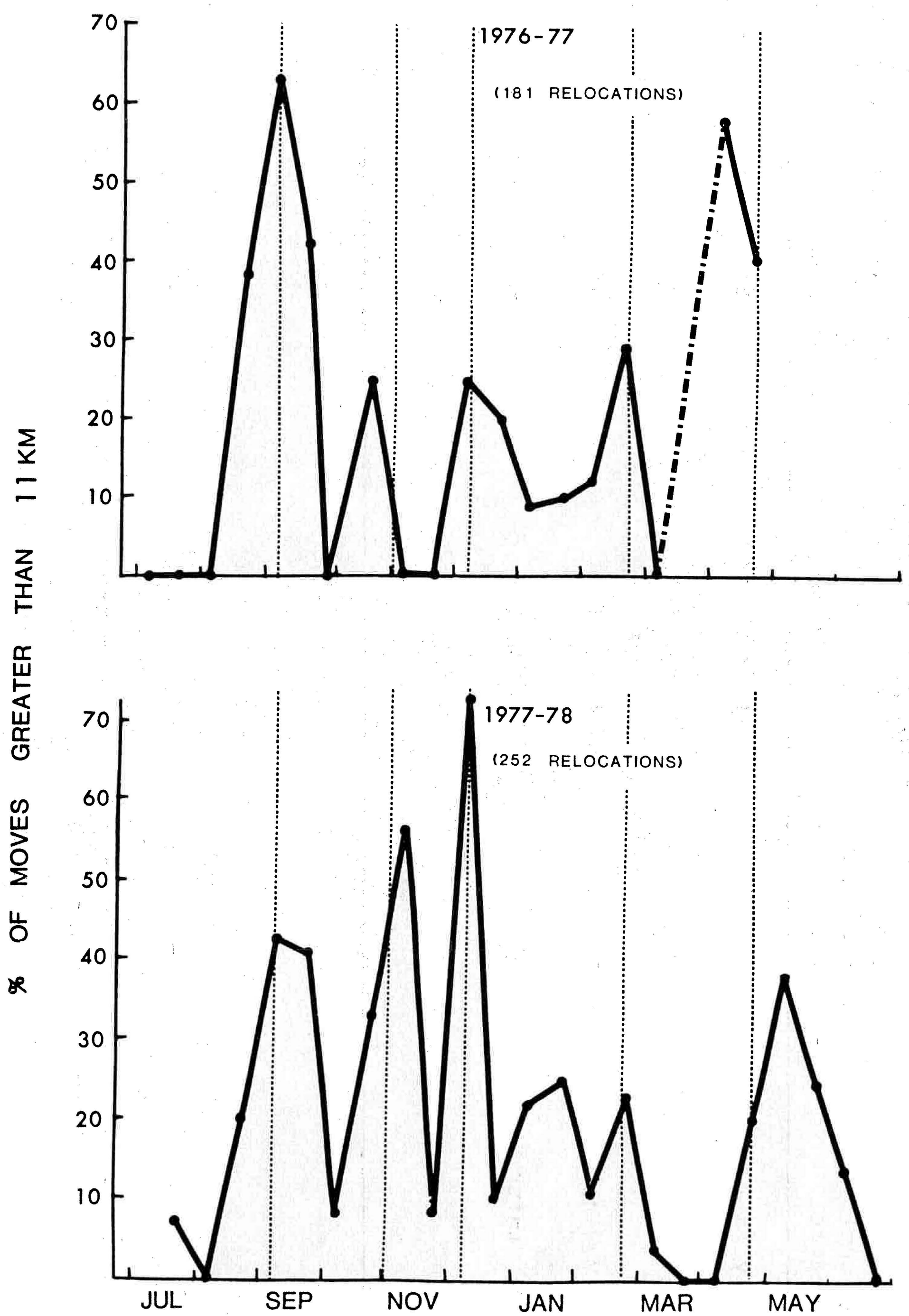

Figure 13. Frequency of movements greater than 11 km between successive relocations of radiocollared adult bulls in the Birch Mountain study area.

Table 7. Timing and frequency of long-distance (>11 km) seasonal movements by adult (>3.0 year) bull and cow woodland caribou in the Birch Mountain study area between March 1976 and June 1978. Longest and shortest total distances moved are shown in parentheses.

	Seasonal movement	No. of radiocollared individuals	Mean date of move (±SD in days)	% of individuals making movement	Mean total distance moved (km)
Bulls	Early fall	16	6 Sept (±8)	81	48 (18-71)
	Late fall	12	13 Oct (±22)	75	37 (24-56)
	Early winter	13	14 Dec (±13)	77	25 (15-35)
	Late winter	16	11 Feb (±11)	38	23 (15-35)
	Spring	24	22 Apr (±18)	88	32 (19-56)
Cows	Fall	7	23 Oct (±41)	71	20 (17-24)
	Winter	7	8 Feb (±22)	29	17 (15-18)
	Spring	9	28 Apr (±5)[a] 29 May (±1)	66	19 (12-30)

[a] Pre- and post-calving movements in spring; see Section 5.4.

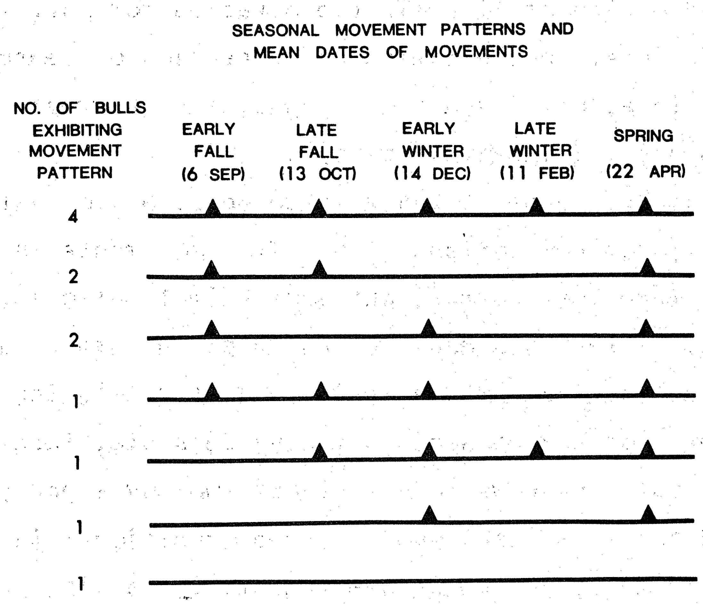

Figure 14. Seasonal patterns of long-distance movements by radiocollared adult bulls that were continuously relocated in the Birch Mountain study area for at least 12 months between March 1976 and June 1978.

Summer ranges of radiocollared bulls were widely scattered throughout the Birch Mountains and movements to rutting areas produced further dispersal (Figure 15a). Most radiocollared bulls in the northern part of the mountains moved to an area north of Gardiner Lake in late fall (Figure 15b), and in early and late winter moved east of the lake (Figure 15c). Adult bulls summering in the south moved northward to winter south of Namur Lake, just off the south slopes of the highlands (Figure 15c). In spring, bulls dispersed to summering areas (Figure 15d). Ten of 11 bulls radiotracked for more than 1 year were highly traditional in the timing and direction of seasonal movements and in the location of seasonal ranges, though great individual variation was apparent (Figures 14 and 15).

There seemed to be at least three peaks of long-distance movements annually for cow caribou (Table 7). Movements in fall (71%) and spring (66%) were most common, but some animals also moved in mid-winter (29%). Three cows made spring moves to summer ranges before calving, and at least two animals moved after losing calves in late May. Three of six cows did not have separate, identifiable seasonal ranges, but five cows made at least two moves per year. Two cows tracked for more than 1 year seemed traditional in the movements they did make, but no herd movements or calving areas were apparent. Mean distances moved between seasonal ranges were less for cows (17 to 20 km) than for bulls (23 to 48 km, Table 7).

Seasonal ranges were deliniated as observed areas of concentrated seasonal activity separated by long-distance movements; range sizes were determined by the minimum-perimeter-polygon method (Mohr 1947). Some radiocollared bull and cow caribou did not make long-distance moves and thus had no separate identifiable seasonal ranges; or they did make long moves but came back to the same area in different seasons. Total summer or winter ranges for these animals were calculated using all locations obtained between mean dates of movements determined for other caribou.

Fall ranges of adult bulls were small (mean: 23 km^2) and used only for about a month during the rut (Table 8). Total winter ranges (includes all winter locations) of young bulls and cows were

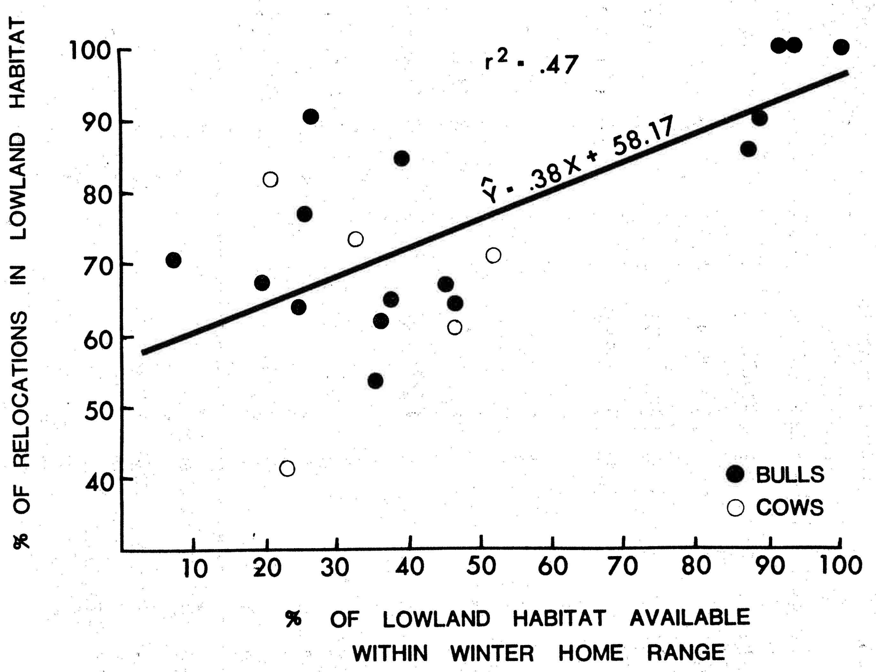

Figure 15. Movements between seasonal range centres of radiocollared adult bulls in the Birch Mountain study area relocated between March 1976 and June 1978.

Table 8. Seasonal range size of radiocollared woodland caribou relocated between March 1976 and June 1978 in the Birch Mountain study area. Largest and smallest values shown in parentheses. Area of ranges is determined by minimum-perimeter-polygon method.

Season	Mean dates on range[a]	Sex and age[b]	Mean range size (km^2)	Mean no. of relocations per range	No. of ranges
Fall	6 Sept.-13 Oct.	ad bull	23 (6-42)	5 (3-9)	7
Total winter	13 Oct.-22 Apr.	ad bull	335 (77-549)	19 (14-26)	12
		yg bull	166 (134-187)	15 (12-17)	3
		cow	137 (32-305)	16 (11-28)	6
Summer	22 Apr.-6 Sept.[c]	ad bull	65 (23-110)	19 (16-23)	5
			61 (15-140)	8 (4-13)	7
		cow	77 (15-200)	9 (5-11)	4
Total year		ad bull	1196 (745-1807)	49 (31-81)	10
		cow	539 (261-810)	62 (43-90)	3

[a] Mean dates of peak movements between ranges from Table 6.

[b] Adult bull, >3.0 years; young bull, 1.0-3.0 years; cow, >1.0 year.

[c] Cows considered on summer range through 13 October.

similar in size, averaging 166 and 137 km^2, respectively. Total winter ranges of adult bulls were twice as large, averaging 335 km^2, due to the movements between partial ranges during winter. The sum of the partial winter ranges averaged 134 km^2 (Table 9), and this was similar to the total winter range of cows and young bulls. Summer ranges for adult bulls and all cows were also similar and about half the size of winter ranges, averaging 63 and 77 km^2, respectively. The total area over which adult bulls ranged throughout the year (mean: 1196 km^2) was approximately twice that of cows (mean: 539 km^2, Table 8).

5.5 HABITAT USE

Woodland caribou, unlike barren ground, may utilize forest habitat year-round, feeding mainly on terrestrial and arboreal lichens and evergreen shrubs in winter, and on a variety of vascular plants in summer (Ahti and Hepburn 1967; Bergerud 1972; Cringan 1957). Bergerud (1972) emphasized that caribou are generalists in their food habits.

The effect of fire on a habitat's capacity to support caribou has been reviewed extensively (Kelsall et al. 1977; Bergerud 1974d). While arboreal lichens may require 60 years to regenerate after fire (Scotter 1964), caribou may also require heterogenic plant cover and non-mature forests (Euler et al. 1976; Miller 1976).

Snow depths significantly affect winter food abundance and caribou activity. Bergerud (1974a) found that the most suitable conditions for winter feeding were: (1) irregular versus regular terrain; (2) scattered trees and a variety of vegetative strata; (3) shallow snow; and (4) hard deep snow or soft shallow snow. Henshaw (1968) noted that deep snow (>60 cm) impaired the ability of barren ground caribou to detect and obtain food. Bergerud (1974b) reported that standing and lying comprised 80% of caribou activity when snow was deep. Stardom (1975) stated that woodland caribou activity in Manitoba moved onto uplands during late winter where snow was softer and shallower.

Table 9. Partial winter range sizes of radiocollared adult (>3.0 yr) bull woodland caribou relocated in the Birch Mountain study area between March 1976 and June 1978. Largest and smallest values shown in parentheses. Area of ranges is determined by minimum-perimeter-polygon method.

Season	Mean dates on range[a]	Mean range size (km^2)	Mean no. of relocations per range	No. of ranges
Early winter	13 Oct.-14 Dec.	56 (2-87)	8 (4-13)	5
Midwinter	14 Dec.-11 Feb.	35 (23-50)	7 (3-10)	5
Late winter	11 Feb.-22 Apr.	48 (4-137)	8 (5-13)	8
Mid- and late winter	14 Dec.-22 Apr.	73 (30-98)	10 (7-12)	5
Means		52	8	
Combined mean for total winter	13 Oct.-22 Apr.	134		

[a] Mean dates of peak movements between ranges from Table 6.

Relative use of habitat types by radiocollared caribou in the Birch Mountain area changed markedly between months and/or seasons (Table 10, Figure 16). Black spruce muskegs were occupied most heavily at all times (44% of all locations), while aspen or aspen-conifer mixes were used very little (2%). Lowland habitats appeared to be selected in all months (69% use versus 49% availability, Table 9) except August.

Patterns of habitat use were similar in 1976-77 and 1977-78; utilization of lowland was greatest after the rut in late September, in midwinter, in early spring, and in late July (Figure 16).

Changes in habitat use may have been due to seasonal availability of certain food items. Increased utilization of lowland areas, especially open muskegs, occurred as snow disappeared in early spring and new growth appeared (Table 10). Peak lowland use in spring occurred about 2 weeks earlier in 1977, corresponding to an earlier snow melt. Usage of upland cover types in spring and summer was likewise concomitant with increased abundance of vascular vegetation.

The shift out of dense upland stands of conifers in late fall (September to December) occurred with increased group size during and after the rut. This change may have a psychological basis, the larger group replacing cover in providing security from predators for the individual (Bergerud 1974c; Peek et al. 1974).

A general increase use of uplands as winter progressed accompanied increasing snow depths (Table 11); snow depths were shallowest in such uplands and the availability of lichens was probably greater. Snow depths did not likely severely limit caribou foraging activities in either winter of the study.

Many areas which burned more than 15 to 20 years ago could not be distinguished from the air. Only jack pine stands <5 m tall were noted as burns. Lowland black spruce appeared to regenerate slowly, but recent burns of treed muskegs could only be distinguished by standing dead trees. Thus, the observed use of lowland and upland burns (mean: 6%) is probably an underestimate.

Table 10. Percent use of different vegetation types by radiocollared woodland caribou in the Birch Mountain study area between March 1976 and June 1978.

Vegetation Type	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Mean	Percent available[a]
Open muskeg	6	3	8	5	9	9	6	8	1	6	20	6	7	
Black Spruce-muskeg	46	21	44	56	59	61	45	45	32	36	35	43	44	
Black spruce	10	16	11	10	5	13	8	11	18	19	20	14	13	
Willow	1		3		3	3	1		1	4	2	3	2	
Spruce burn	3	5	13	4	3	3	7	3		3	1		4	
Total lowland	66	45	79	75	79	89	67	69	52	68	78	66	69	49
Jack pine	4	9	8	6	8	1	15	13	12	6	4	5	8	
Spruce[b]	12	9	3	4	2	5	8	7	10	3	5	16	7	
Jack pine spruce[b]	13	21	3	6	6	5	11	11	25	21	6	8	12	
Jack pine burn		5	2	6	5			1		3	5	2	2	
Aspen-conifer	3	2	1	2								2	1	
Aspen	1	3		1							2		1	
Total upland	34	55	21	25	21	11	33	31	48	32	22	34	31	51

[a] Availability determined from forest cover series maps (Alberta Energy and Natural Resources, 1:126 720) for the Birch Mountains and the area immediately south to the MacKay River.

[b] White spruce and/or black spruce.

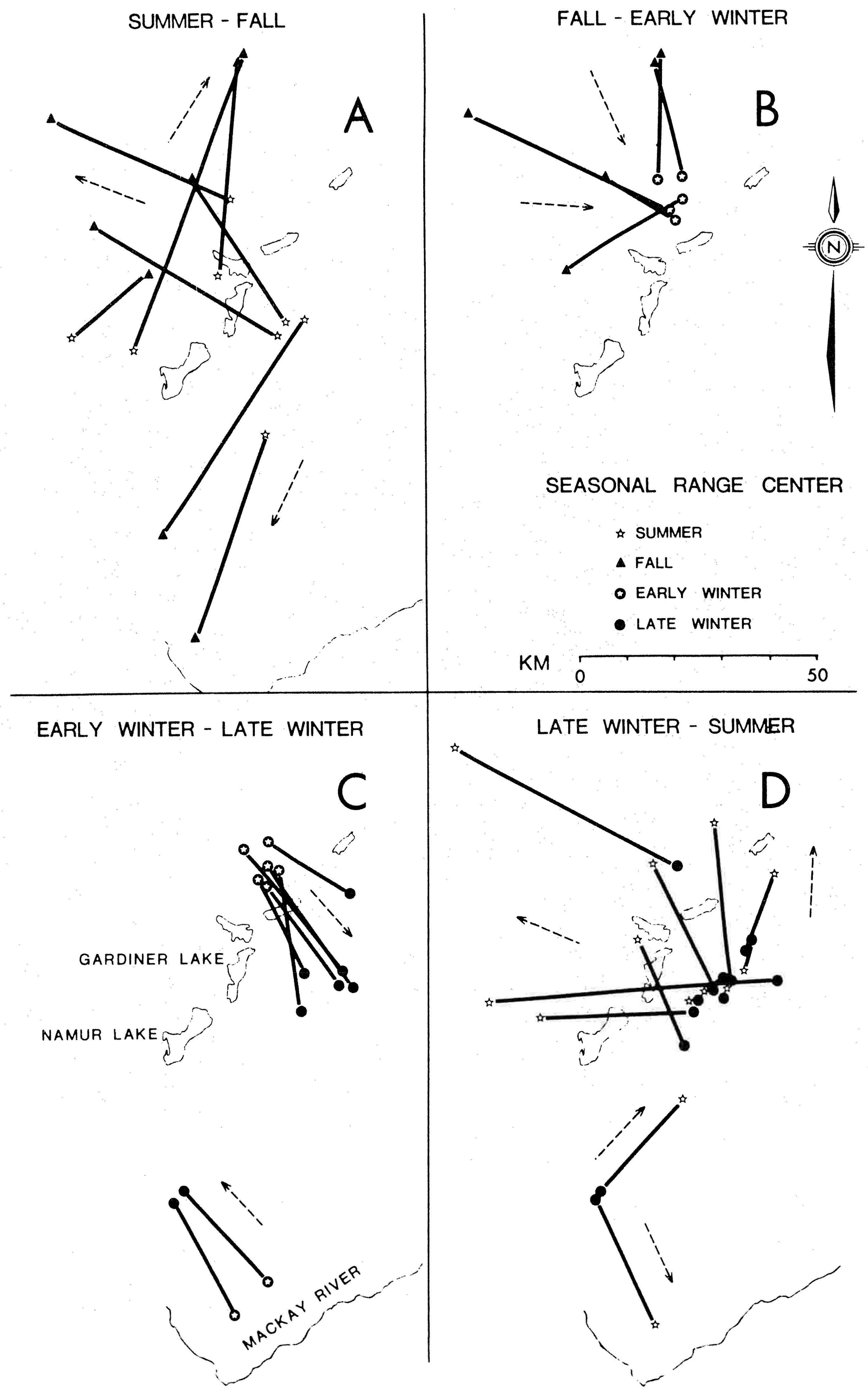

Figure 16. Frequency of lowland habitat use by radiocollared woodland caribou in the Birch Mountain study area.

Table 11. Snow depths in adjacent closed-canopy upland (spruce-jack pine) and open-canopy lowland (black spruce muskeg) sites in or near the Birch Mountains during the winter of 1978.

Month	No. of paired sampling sites	Mean (±SE) snow depth in cm	
		Upland	Lowland
January	3	25 ± 1	31 ± 2
February	4	35 ± 5	42 ± 6
March	4	39 ± 3	52 ± 3

Individual variation in lowand habitat use during winter by radiocollared caribou was considerable (42 to 100%), but appeared to be largely determined ($r^2 = 0.47$) by the percent of lowland habitat available within individual winter ranges (Figure 17). Regardless of availability, lowlands were utilized disproportionately more often by all individuals. Percent occupancy of lowland habitat by bulls differed significantly from that by cows only in January.

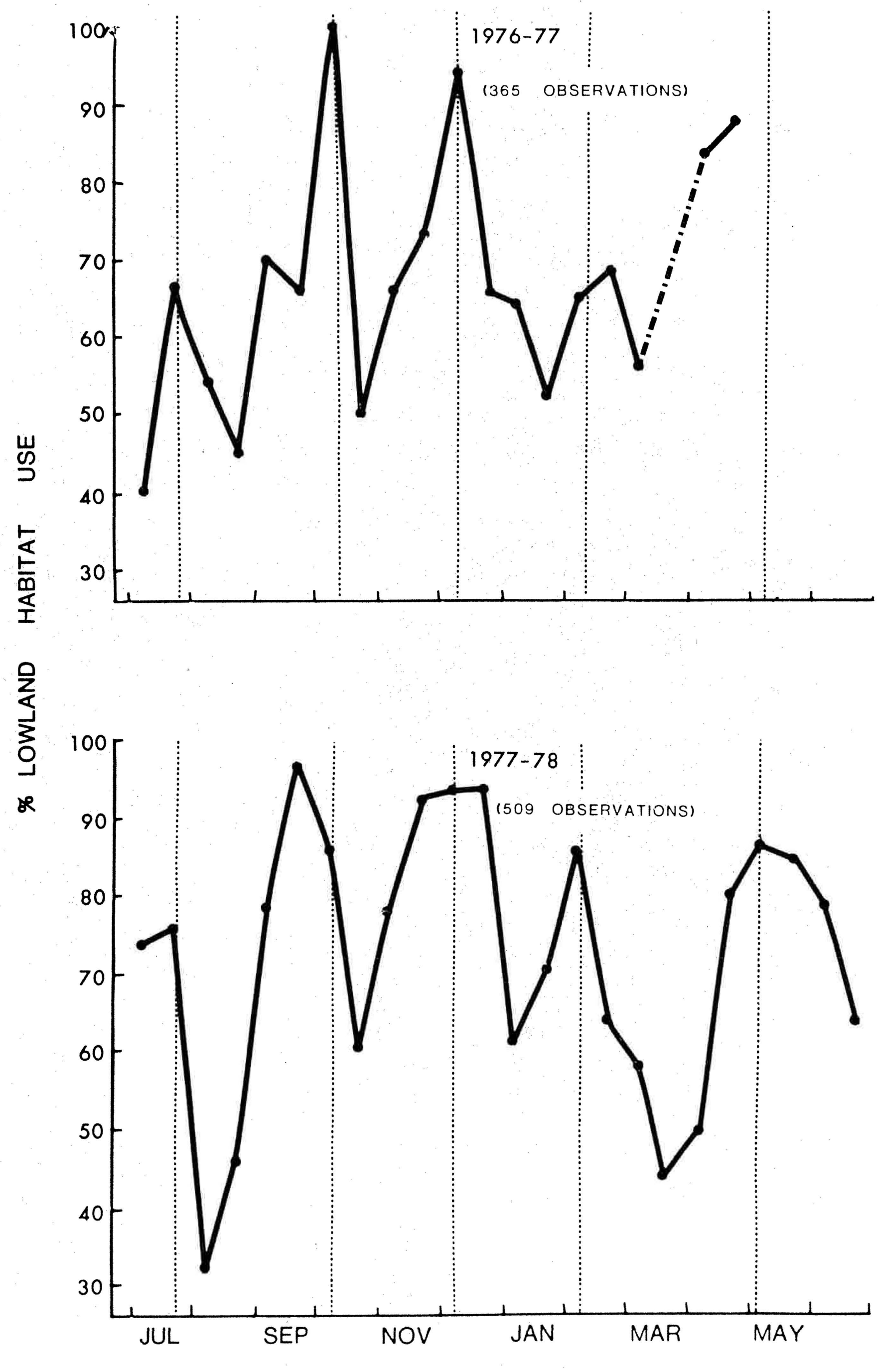

Figure 17. Relationship between the proportion of relocation of woodland caribou in lowland habitat with percent of lowland habitat available during winter and the percent of lowland habitat available within their individual winter ranges in the Birch Mountain study area.

6. CONCLUSIONS

Woodland caribou in the Birch Mountains likely represent a widely scattered, ecologically distinct subspecies. Compared to both barren ground and other woodland caribou populations, densities in the Birch Mountains are low. The density estimate was corrected for the effects of seasonal movements by various sex and age cohorts. Sex ratios and fecundity of this population are comparable to those of other populations however, both calf and adult survival seem low. Small but seasonally fluctuating group sizes are similar to other woodland caribou populations; seasonal separation of some sex and age cohorts is pronounced. The unusual and varying patterns of seasonal movements and range locations have not been reported before, but they are likely influenced by habitat use and rutting activity. Habitat use by the Birch Mountain caribou is similar to that reported for other populations in the Boreal Forest, and is apparently influenced by food availability, snow depths, and social behaviour.

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