The Eight North American Caribou Workshop,
Whitehorse, Yukon, Canada,
20–24 April, 1998.

Seasonal distribution and population parameters of woodland caribou in central Manitoba: implications for forestry practices

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Abstract: Woodland caribou (*Rangifer tarandus caribou*) in the boreal forest are believed threatened by human encroachment and associated disturbances such as resource exploration and extraction. We radiocollared and monitored fifteen female woodland caribou in central Manitoba, from 1995 to 1997, to obtain information on their population range, seasonal distribution and movements in relation to forestry concerns. The population ranged over 4 600 km^2 within a large peatland system and concentrated their activities in two areas for both the summer and winter seasons. Females were relatively more solitary during the summer and exhibited fidelity to specific calving and summering areas averaging 83.4 km^2. Individual wintering locations varied between years and among individuals. Post-rut and pre-calving mixed-sex aggregations occurred on the southern portion of the herds range. Caribou from the northern part of the range utilized a traditional travel corridor moving as far as 65 km to access the aggregation areas and their summer or winter ranges. Adult survival during the study period averaged 0.90 (95% CI, 0.80-1.00). Survival of the 1995 cohort appeared to be high as indicated by the 0.65:1 calf-cow ratio, and 30 ± 7% calf composition of observed caribou in the autumn of 1995. The annual rate of change (λ) of 1.19 (95% CI, 1.02-1.36) from January to November of 1995 indicated rhat the population was increasing at that time.

Key words: logging, peatlands, *Rangifer tarandus*, survival.

Rangifer, Special Issue No. 12, 85–94

Introduction

Factors responsible for the decline of woodland caribou in North America include habitat loss and increases in hunting and predation (Bergerud, 1974). Industrial activities such as forestry and petroleum development have the potential to contribute to this decline by altering caribou habitat, and increasing access for both humans and predators into caribou range (Edmonds, 1988; Cumming, 1992; Rettie & Messier, 1998).

Post logging succession in the boreal forest creates habitats that are favourable for moose (*Alces alces*), and subsequently may result in higher moose densities (McNicol & Gilbert, 1980; Thompson & Vukelich, 1981). The associated increase in predators such as wolves (*Canis lupus*) in these areas not only compromise spacing-away strategies used by caribou to minimize encounters with such predators, but may result in higher caribou mortality (Seip, 1992; Stuart-Smith *et al.,* 1997; Rettie & Messier, 1998). This increased risk of encounters with predators can be especially important during the calving and wintering periods when some caribou herds may be more vulnerable to predation (Bergerud *et al.,* 1984; Gautier & Theberge, 1986). The development of logging roads not only has the potential to affect caribou movement and distribution, but the greater access into caribou ranges may increase hunting pressure (Johnson, 1985; Benoit, 1996). Though the full effect of forestry on woodland caribou is still unknown, studies have indicated that in areas where logging occurs caribou are usually displaced from part or the entirety of their former range (Darby & Duquette, 1986; Cumming & Beange, 1987; Chubbs *et al.,* 1993). Through careful management it may be possible for woodland caribou and forestry to coexist, and already there are many plans

attempting to integrate caribou needs and forestry practices (Ministère des Forêts *et al*, 1991; Cichowski & Banner, 1993; Cumming & Beange, 1993; Armleder & Stevenson, 1994). Such mitigating actions, however, can only be drawn up and acted upon if there first exists baseline information on general caribou ecology from the areas of concern.

The forest industry is rapidly expanding in Manitoba and the projected increase in logging in the boreal forest has raised concerns about local caribou herds. Woodland caribou numbers in the province were estimated at >4000 in 1957 but current estimates indicate that the population has declined 50% since that time, with the most noticeable losses documented at the southern portion of their range (Johnson, 1993). Licensed hunting of woodland caribou in Manitoba was closed between 1947 and 1967, then re-opened with restrictions until it was again closed in 1992 (Johnson, 1993). Subsistence hunting of caribou continues but most animals are harvested opportunistically. As the bulk of studies concerning woodland caribou have concentrated on herds in the south-east portion of the province (Stardom, 1975; Darby & Pruitt, 1984; Schaefer & Pruitt, 1991), little information exists from which to formulate any forest management decisions in the context of caribou ecology for central Manitoba.

The main objective of this study was to provide resource managers with information on the population parameters, seasonal distribution, and associated movements of woodland caribou in central Manitoba.

Study area

The 8300 km^2 study area was located in the vicinity of the town of Wabowden (55°55'N; 98°37'W) in central Manitoba (Fig. 1). The area straddles the Boreal Shield and Boreal Plain ecozones (Ecological Stratification Working Group, 1995). The elevation ranges from 200 m above sea level in the north to 260 m in the south-east with major lakes and rivers oriented south-west to north-east, draining into the Hudson Bay. The climate is continental with mean daily temperatures of 16 °C in July and -25 °C in January. Annual precipitation averages 536 mm, of which 34% is in the form of snow (200 cm) lasting typically from October until April. Lakes and rivers normally freeze up in mid November and are totally ice free by mid May (Environment Canada, 1998).

In the north, uplands are dominated by black spruce (*Picea mariana*), jack pine (*Pinus banksiana*) and trembling aspen (*Populus tremuloides*). Subdominant species include white spruce (*Picea glauca*), birch (*Betula papyrifera*), and balsam poplar (*Populus balsamifera*). Lowlands are comprised of dense, wet black spruce stands, black spruce and tamarack (*Larix larcinia*) peatlands, and open peatlands dominated by sedge (*Carex* spp.) and dwarf birch (*Betula glandulifera*). The southern portion of the study area is almost exclusively treed peatlands with lesser amounts of wet black spruce stands and some interspersion of jack pine and black spruce uplands. Moose, wolves, black bears (*Ursus americanus*), and lynx (*Lynx canadensis*) are common in the region while wolverine (*Gulo gulo*) sightings have been infrequent.

The study area is dissected by two main highways, a number of seasonal and all weather logging roads, a railway line and many seismic cut lines. Nickel mining occurred in the area from 1970 to 1975, and mineral exploration is still continuing. Logging of major pulpwood species began in the early 1970s on a relatively small scale and has been rapidly expanding since 1989, with greater increases slated in the future. A full history of forestry in the area is detailed elsewhere (REPAP Manitoba Inc., 1996). Owing to the efforts of fire suppression, relatively few large burns have occurred in the region. Approximately 570 km^2 are of recent fire origin, located in the southern portion of the study area, with the majority stemming from either of the two large fire seasons of 1989 or 1995.

Materials and methods

Capture and radio-tracking

Fifteen female caribou were captured (10 in January 1995, 5 in February 1996) using shoulder-held netguns fired from a helicopter, and manually restrained. Animals were fitted with radio collars (151 Mhz, Lotek Engineering Inc., Newmarket, Ont.) and subsequently located using fixed-wing aircraft and helicopters equipped with directional two-element antennae. Radio-tracking flights were conducted from 25 January 1995 to 30 June 1997 with an attempted 3-4 week schedule. A more intense flying schedule (4-7 day intervals) was implemented during the calving and early winter season. Seasons were selected based on caribou ecology and snow cover, and were defined as winter (1 December to 29 February), late winter/spring (1 March to 30 April), calving/summer (1 May to 15 September), and autumn (16 September to 30

November). Caribou locations were either recorded directly from an onboard Global Positioning System (GPS) unit or plotted on topographic maps (1:250 000 or 1:50 000) and later converted to UTM co-ordinates. During relocation flights, information concerning age (adult or calf), sex, and group size were recorded whenever possible. Sex was determined by the presence or absence of a vulval patch and antler development during the rut. The minimum population size was determined as the maximum number of caribou observed during any one flight over each year. Calf:cow and adult (individuals >1 year of age) sex ratios were also calculated.

Survival and recruitment

Annual adult survival rates of collared individuals were calculated following the methods of Heisey and Fuller (1985) with the aid of the MICROMORT (ver. 1.3) computer program. As the exact date of death for individuals was unknown, the midpoint between last live relocation and first relocation on mortality mode was used for survival analysis (range=4.5-26.5 days). Whenever possible mortality sites were examined for evidence indicating the cause of death. In cases where the mortality sites were not investigated, caribou were assumed dead and included in the analysis. The only estimates of calf recruitment (calf:cow ratios and calf composition of all observed caribou) were obtained from the 1995 autumn relocation flights.

The annual finite rate of change (λ) was calculated from adult survival rates and calf recruitment following the methods outlined by Hatter and Bergerud (1991). Assumptions for this calculation were that the calf sex ratio at this period was 1:1, and immigration and emigration was either balanced or negligible. One thousand estimates of survival and recruitment (based on observed values and their associated error) were produced utilizing Monte Carlo simulations. These values were then used to calculated the mean and 95 % confidence interval for the population rate of change. The exponential rate of increase ($r = \ln\lambda$) was calculated to allow comparison with other studies.

Individual and population ranges

Individual, multi-year home ranges were calculated using the 100% minimum convex polygon (MCP) method (Mohr 1947) and the TRACKER (v. 1.1, Radio Location Systems AS, Hudding, Sweden) computer program. Individual home ranges were then plotted to identify any specific areas of overlap. Population and seasonal ranges were also calculated using the 100% MCP method. To determine if caribou exhibited fidelity to specific calving-summering areas, yearly summer ranges were calculated and plotted. If fidelity occurred multi-year ranges were then calculated and plotted to identify the extent of overlap with other collared females. This could not be done for winter ranges as yearly individual relocations were less than that needed to calculate a seasonal range. Instead, yearly individual locations were examined to determine if caribou were wintering in the same general area.

Movements

All locations were mapped by season, using the computer program TRACKER, to assess movements and to identify possible sites of aggregation. Movement rates could not be calculated due to the discontinuous nature of relocations during certain seasons. Locations were displayed upon Manitoba Forest Resource Inventory maps (1983 issue updated with recent forestry and fire information) using ARC-VIEW® (ver 2.1b, ESERI, Redlands, California) in order to provide an estimate of habitat use and distances to geographical features.

All values are reported as mean ± standard error unless otherwise stated.

Results

Population range and size

The overall population range determined from all relocations (n=456) was 4600 km^2 (Fig. 1). The majority of locations were within a large peatland complex and appeared to be bounded somewhat to the northwest by highway 39. A minimum population size of 50 individuals was determined from the 4 November 1995 relocation flight, while a flight in November 1996 suggested a minimum population of 43 caribou.

Group size

Collared females were essentially solitary (alone or with calf) during the calving/summer period. As the summer progressed, we observed caribou associating with other individual females or a cow/calf pair. During the autumn, winter and spring, caribou were relatively gregarious forming small, loosely associated mixed-sex groups with the largest groups (maximum of 29 individuals) being noted in early November and April (Table 1). Only summer

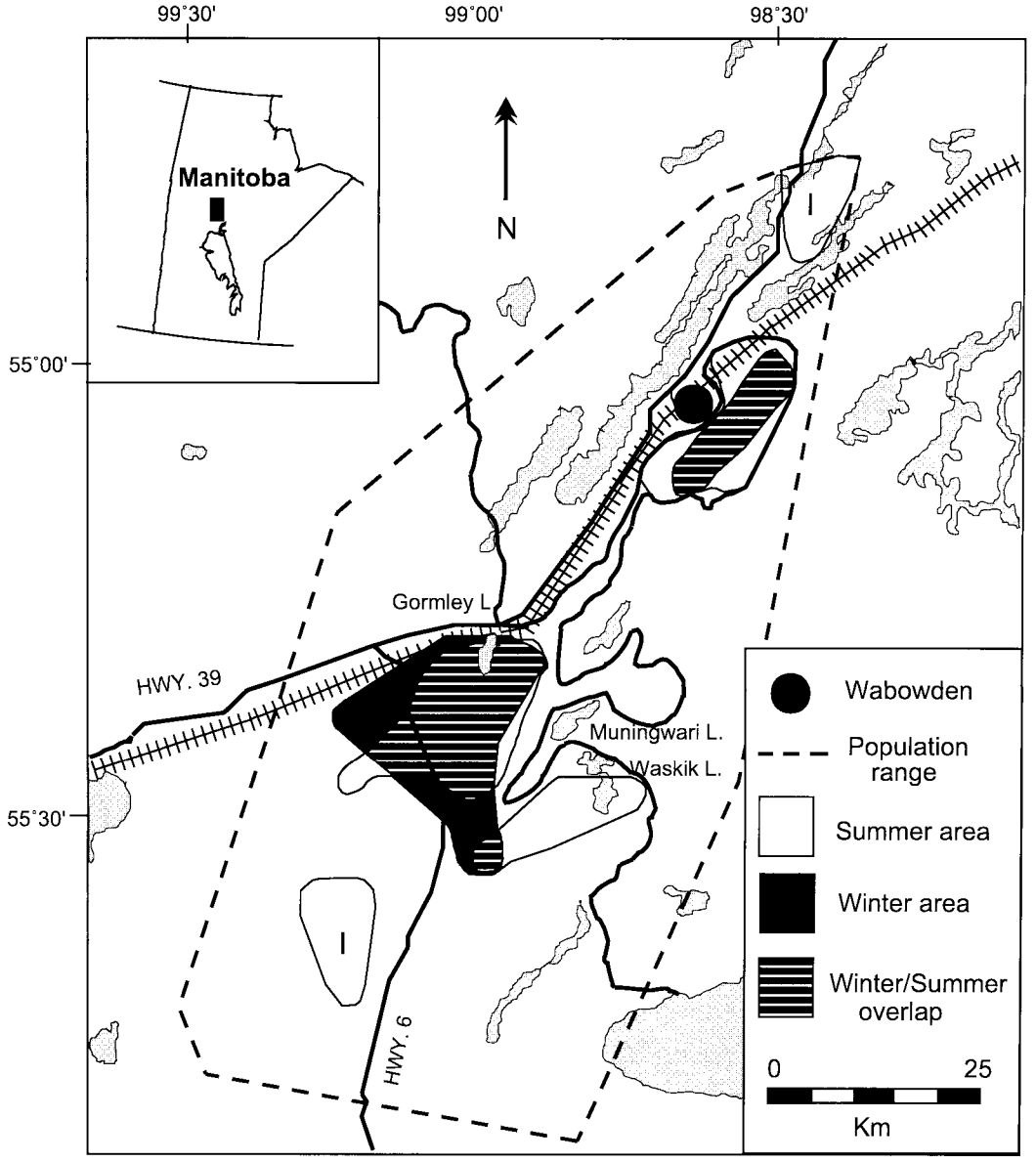

Fig. 1. Study area and general summering and wintering areas of woodland caribou in central Manitoba, 1995-1997. Ranges marked "I" denote solitary individuals. The dotted line represents the northern edge of a large contiguous peatland complex.

group sizes were significantly smaller than all other seasons (Dunn's Multiple Comparison Test, $P<0.05$). In 1995, the sex ratio of adults was 0.54 males:1 female during the rut and 0.50 males:1 female in early November (Table 2). Data for subsequent years were insufficient to calculate adult sex ratios.

Survival and recruitment

During the 10 738 caribou days recorded over the study period, three of the fifteen radiocollared caribou died. One animal was killed by wolves on her summer range while the deaths of the 2 other caribou could not be investigated. We assumed that neither of these animals were killed by hunters, as both locations were relatively remote and inaccessible. The mean annual survival of radiocollared adults based on pooled data was estimated to be 90% with a 95% confidence interval of 80-100%. The extent of direct human-caused mortality on

Table 1. Seasonal group size of woodland caribou in central Manitoba, 1995–1997.

Season	Mean group size	*n*
Summer	1.8 ± 0.2 (1-5)	31
Autumn	7.3 ± 1.0 (2-24)	25
Winter	4.5 ± 0.6 (2-10)	15
Spring	8.8 ± 3.6 (1-29)	7

Data are given as mean±standard error of the mean with range in parentheses. *n* represents number of groups observed.

caribou in the Wabowden area is unknown. During the course of this study (January 1995 to June 1997), one uncollared female was killed by a vehicle and a minimum estimate of subsistence harvest of 9 caribou was reported to the authors. The sex and age of these animals were not ascertained.

Calf recruitment and survival information could only be calculated for 1995 due to low sightability of females (and calves) in subsequent years. Collared females were first noted with calves on 2 June, and by 9 June, 5 out of 8 observed animals were accompanied by a calf. Relocation flights in early November indicated that at least 5 of the 6 females previously located with calves were still accompanied by them. Calf:cow ratios, based on all observed females, were calculated for the autumn only and estimated at 0.62:1 in mid September and 0.65:1 in early November (Table 2). The percentage of calves in the observed groups was estimated to be 30 ± 7% in early November. The annual finite rate of change (λ) calculated for November 1995 was 1.19 (95% C.I., 1.02-1.36). The exponential rate of increase (r) determined for autumn 1995 was 0.17 (95% C.I., 0.02-0.31). These results suggested that at least in 1995 the population was stable to increasing.

Table 2. Adult sex ratios and calf cow ratio of woodland caribou in central Manitoba, as observed during relocation flights in autumn 1995.

	Male:female ratio	Calf:cow ratio	Total no. of cariibou
Sep.17	0.54 ± 0.14	0.62 ± 0.13	21
Nov. 4	0.50 ± 0.11	0.65 ± 0.11	43

Values are mean±standard error of the mean as calculated from the binomial distribution (Zar, 1984, p. 376).

Seasonal ranges and movements

Seasonal ranges for the population were overlapping and variable in size, with winter and autumn ranges of 3200 km^2, a summer range of approximately 2500 km^2 and a spring range of 1770 km^2. Individual caribou home ranges averaged 581±74 km^2 (range=98-1196). All collared females but one had overlapping home ranges that radiated outward from the Gormley Lake area to the north-east, south-west, or south, extending from 23 to 72 km. Individual females exhibited fidelity to specific calving/summering areas. Multi-year summer ranges were calculated and averaged 83±11 km^2 (range=29-180 km^2). Eighty-seven percent (13/15) of collared females possessed a summer range that overlapped with at least one other collared animal. Individual winter ranges could not be calculated but it appeared that caribou were not always faithful to a specific general wintering area.

There were two major peatland areas used by caribou for both summer and winter (Fig. 1). One area was located within a large open and treed peatland complex of approximately 580 km^2, 3.6 km east of the town of Wabowden. This complex was surrounded on all sides by upland forest communities and smaller peatlands. The second area ("Gormley area") utilized by caribou for both the summer and winter was 40 km to the south-west of Wabowden, at the edge of a large contiguos peatland complex.

The six collared females using the Wabowden area during the summer shared approximately half (55±4%) of their summer ranges with each other. One collared female summered apart from this group, 10 km north of the peatland complex, utilizing small peatlands, treed rock, open black spruce stands and lakeshores. All collared caribou that wintered in the Wabowden area restricted their locations within a portion of the summering area (Fig. 1). Most of the summer locations of individuals in the Gormley area were bounded to the north by the railway line, to the west by highway 6, and to the east by Gormley lake, with the exception of one animal whose summer range extended west across the highway. The extent of summer range overlap (37±7%, n=5) of collared females within this area was slightly lower than that observed for females to the north. Two females shared parts of their summer ranges, 5 km to the south-east of this

group, while one collared female summered to the south-west across the highway (Fig. 1). During the winter, caribou locations tended to extend slightly westward and southward. The lone individual to the south-west wintered close to its summer range with uncollared caribou.

For the duration of this study the majority of caribou summered and wintered in the same general peatland areas. However, individual caribou did not always exhibit the same pattern each year. Of the seven collared females summering in the northern part of the study area, three utilized the Wabowden area during both the summer and winter, three switched from wintering in the north to the south in subsequent years, and one wintered exclusively in the south. Of the eight collared females summering on the southern portion of the study area, six utilized the Gormley area for both the summer and winter while two, originally captured in the north during the winter of 1995, wintered in the south the following years. No caribou were observed shifting winter locations from the Gormley to the Wabowden area.

Due to intermittent flight schedules during the autumn, no evidence of specific rutting areas could be determined. We suspect however, that no common rutting area existed as most individuals were still located in or near (<10 km) their summer ranges by mid October. Post-rut aggregations were observed in early November of 1995 and 1996, when the majority (78-80%) of collared females converged on the wintering grounds of the Gormley area. These females were located in groups ranging from 6 to 23 individuals composed of other collared females, uncollared cows and calves, and mature and immature bulls. All females from the north exhibited a synchronous south-westerly movement between mid October and early November, with most individuals travelling approximately 30 to 65 km to access the aggregation areas. A small percentage (two to three individuals each year) exhibited only short movements (<10 km) during this period, with some of these individuals travelling to the south later in the season. Collared females from the south moved very little (0-14 km), as areas of aggregation were either within or near their summer ranges. On 4 November 1995, 32 caribou were observed in 4 groups ranging from 6-11 individuals, in the Gormley area. Three of these groups were within 3-9 km apart while the other group was observed approximately 15 km to the south and appeared to be travelling in a southerly direction. The subsequent relocation flight in mid December indicated that three of the four females originally from the northern complex had returned to the Wabowden area to winter. In 1996 this general pattern of movement and aggregation was repeated with the exception that all but one caribou originating from the northern complex remained in the Gormley area to overwinter. The greater frequency of flights between 4 November and 18 November, allowed us to observe caribou movements at a finer scale. Groups appeared to be dynamic during this period, with individuals breaking away to form new associations or join other groups in the area. These groups exhibited an "out and back" movement from the Gormley area, travelling to the west, south-west, or south up to 45 km, with the majority of individuals returning near their point of origin within a two week period.

Mixed-sex aggregations also occurred in early April 1995 when all collared females converged on the Gormley area in one of three observed groups. Two groups of 5 and 28 individuals, located <8 km apart, were observed feeding and resting in treed peatlands. A small assembly of three individuals was observed 12 km to the north-east, travelling through open peatlands in the direction of the other two groups. The females wintering in the north had travelled to the area between mid March and early April following the same travel route used by caribou in the autumn. Five of these caribou returned north to by mid May to calve, having spent less than a month congregating in the southern portion of the study area. Caribou that summered in the southern portion of the study area were located on their summer ranges as early as 20 April.

Only one spring relocation flight was conducted for 1996 and 1997. Results suggested that if a pre-calving aggregation had occurred it would have been before mid April, as locations after this date indicated that females were dispersing towards their summer ranges.

The movement of females from the north to these aggregations appeared to be guided by surrounding landscape features as caribou utilized a common travel corridor through peatlands, which extended across a secondary highway and forestry access road. Knowledge of this route by local hunters and frequent sightings of caribou during late autumn and early spring where this route intersects roadways suggests traditional use of this travel corridor.

Discussion

Woodland caribou in the Wabowden area form a relatively small herd that exists primarily within a large open and treed peatland complex. Our adult survival rate obtained for the study period is within the 78-93% range observed for caribou throughout North America (Bergerud, 1980; Edmonds, 1988), and at the high end of the 84-90% survival estimated for woodland caribou populations inhabiting the boreal forests of western Canada (Darby, 1979; Fuller & Keith, 1981; Stuart-Smith *et al.,* 1997; Rettie & Messier, 1998). The calf:cow ratio observed for 1995 (0.65) is considerably higher than the 0.27-0.43 range reported during autumn for other woodland caribou studies (Bergerud, 1980; Edmonds & Smith, 1991; Seip, 1992; Chubbs *et al.,* 1993). However, in Newfoundland and Ontario calf:cow ratios have been reported as high as 0.53 and 0.50 in some years (Bergerud, 1985; Chubbs *et al.,* 1993). In addition to the large calf:cow ratio, the high survival of the calves observed in early June, and the 30% autumn calf composition also suggests that calf survival until early November was high for 1995. Though most studies indicated considerable mortality within the first year (Mahoney, 1990; Stuart-Smith *et al.,* 1997; Rettie & Messier, 1998), high calf survival in some years is not uncommon. Autumn calf compositions have been documented as high as 20 and 25% for some forest and mountain dwelling herds (Bergerud & Elliot, 1986; Bergerud & Page, 1987; Edmonds & Smith, 1991). The high calf recruitment and low adult mortality leading to an exponential rate of increase of 0.17 ± 0.15, suggests that the population in 1995 was increasing. Caution is needed however in using these results in the formulation of any management decisions as our data are limited and calf recruitment and adult mortality can vary considerably from year to year (Bergerud & Elliot, 1986; Bergerud & Page, 1987).

Causes of mortality of both adults and calves were largely unknown. In other studies where woodland caribou inhabited peatland dominated systems, wolves were considered as the main source of adult mortality (Stuart-Smith *et al.,* 1997; Rettie & Messier, 1998). Black bears may also kill calves during a short period in the spring when woodland caribou and bears may be using similar food resources and consequently exhibit an overlap of their ranges (Rettie & Messier, 1998).

The sex ratio for adults of 0.5 males per female (approximately 33% males), is similar to the 36% males reported for North American caribou populations (Bergerud, 1980; Edmonds, 1988), but notably less than the 46.5% males reported in peatland systems in north-eastern Alberta by Stuart-Smith *et al.* (1997) and Fuller & Keith (1981).

Home and summer range sizes of the Wabowden herd are consistent with those described for woodland caribou inhabiting peatland systems (Fuller & Keith, 1981; Bradshaw *et al.,* 1995; Stuart-Smith *et al.,* 1997; J. Rettie, pers. comm.). Though these home ranges may be comparable to caribou across Canada, it appears that the summer ranges are on average larger than those reported for caribou utilizing alpine, forest, or island and shoreline systems (Shoesmith & Storey, 1977; Darby & Pruitt, 1984; Cumming & Beange, 1987; Edmonds, 1988).

Fidelity to calving and summering areas by individual cows (as found in this study) has also been observed by caribou to the west of this area (Shoesmith & Storey, 1977), as well as in Labrador (Brown & Theberge, 1985) and Alberta (Edmonds, 1988). Trends in wintering locations, however, showed much variability between and within individuals and this variability was consistent with the behaviour of other woodland caribou populations across Canada (Shoesmith & Storey, 1977; Darby & Pruitt, 1984; Edmonds, 1988; Stuart-Smith *et al.,* 1997). Regardless of individual variability, it appears that woodland caribou herds may possess general wintering areas (this study; Paré & Huot, 1985; Cumming & Beange, 1987; Edmonds, 1988), and as observed here, some populations may exhibit little or no differentiation between winter and summer areas (Paré & Huot, 1985; Ouellet *et al.,* 1996; Stuart-Smith *et al.,* 1997).

The pattern of group formation, with females relatively solitary during the calving and summer periods, and forming larger, loosely cohesive groups during the rest of the year, generally occurs for most woodland caribou populations across North America (Bergerud *et al.,* 1990; Stuart-Smith *et al.,* 1997; Rettie & Messier, 1998). Our study population appears unusual, however, by exhibiting post-rut and pre-calving aggregation periods, where the majority of caribou congregated in mixed-sex groups on a specific portion of their range. Though studies have indicated that woodland caribou may form aggregations during the autumn (Darby & Pruitt, 1984), winter (Cumming & Beange, 1987) or late winter (Brown *et al.,* 1986), the pattern of

these aggregations did not serve to concentrate the population to a specific area. Only certain herds of mountain caribou in British Columbia and Alberta have been observed congregating on traditional rutting areas (Bergerud & Elliot, 1986; Edmonds, 1988). The purpose of these observed aggregations is unknown. It may be that this group formation serves a social function, or is related to certain dietary or mineral needs. Regardless of the function of these aggregations, increased travel by caribou from the northern peatland complex resulted in higher energetic costs and potentially greater predation risks (Bergerud & Page, 1987). The timing of these movements associated with these aggregations (and seasonal range shifts) coincided with periods of increased activity observed for other caribou populations (Brown *et al.,* 1986; Bergerud *et al.,* 1990; Ferguson *et al.,* 1998). Unlike the findings of a number of studies that stated woodland caribou movements were "apparently random" (Darby & Pruitt, 1984; Cumming & Beange, 1987; Stuart-Smith *et al.,* 1997), the seasonal movements of the collared females appeared to be well defined, predictable, and directional.

Predation has been implicated as the primary factor determining woodland caribou population distribution and range. Within this constraint caribou select sites that provide optimal forage resources, escape from biting insects and allow ease of travel in deep snow (Bergerud *et al.,* 1990; Ouellet *et al.,* 1996; Rettie, 1998). The selection of sites to reduce predation risk is especially important during the calving and wintering periods (Bergerud *et al.,* 1984; Gautier & Theberge, 1986). The type of habitat used to space away from predators varies depending on the landscape structure, and caribou have been observed using islands and shorelines (Shoesmith & Storey, 1977; Cumming & Beange, 1987), alpine and subalpine areas (Bergerud et al., 1984; Edmonds & Smith, 1991), forested areas (Edmonds, 1988) and peatland systems (this study; Stuart-Smith *et al.,* 1997; Rettie, 1998) during the calving and summering period. The selection of such sites, however, can sometimes be at the expense of limited food supplies (Bergerud *et al.,* 1984; Ferguson *et al.,* 1988; Edmonds & Smith, 1991).

We suggest that caribou in central Manitoba may be behaving similarly to those described by Stuart-Smith *et al.* (1997). These caribou are likely restricting themselves within a peatland system to space away from predators and alternative prey, and dispersing (spacing out from each other) during the calving period, to increase predator search time (Bergerud & Elliot, 1986; Seip, 1991). The overlap of the summer and winter concentration areas at the population level suggests that these habitats are able to simultaneously provide avoidance to predators as well adequate food supplies throughout the year. Vegetation sampling within these areas revealed that they contained good quantities of foodstuffs such as bog shrubs, graminoids, and horsetails, as well as locally abundant patches of terrestrial and arboreal lichens (K. Brown & F. Messier, unpubl.).

Management implications

To ensure the long-term persistence of caribou in the Wabowden area, the main objective should be to maintain the integrity and connectivity of the peatland system which these animals inhabit. Fragmentation of the area by logging and associated road building should be limited as this may displace animals from such areas, or jeopardize their spacing away strategy, possibly resulting in an increase in caribou mortality. The two areas of concentrated activities should be reserved from cutting if possible. This is especially important considering the southern portion of the study area serves as a focal point for the population. Disturbances in this area that increase mortality, especially during aggregation periods, have the potential to affect the future of the entire population. Buffers should be retained around the peatland system, especially in areas of high use, as cutting stands adjacent to the peatlands may increase local moose densities and facilitate an influx of predators into the system.

The maintenance of the travel corridor between the areas of activity should be considered with a special concern. Additional roads and cutting along this corridor should be minimized. Though this and other populations have been shown to tolerate roads and railways across such traditional routes (Johnson & Todd, 1977), additional disturbances may inhibit caribou movement, resulting in the fragmentation of the herd and possibly overgrazing on parts of the range (Klein, 1980).

If cutting is to occur within the peatland system, access into the caribou range should be minimized. As the amount of legal and illegal harvest of caribou can be a locally important cause of mortality in areas with road access (Johnson, 1985; Benoit, 1996), logging roads within the system should be

closed as soon as possible after forestry operations. The use of winter roads (ice roads), whenever possible, would limit the time when hunters and predators could gain easy access into caribou-sensitive areas. In order to discourage moose in the areas that are harvested within the peatland systems (and subsequently associated predators), forestry practices in these areas should promote the rapid recovery of coniferous species such as jack pine and/or black and white spruce.

Acknowledgements

Drafts of the manuscript were improved by comments from D. Seip, W. J. Rettie, T. Portman and an anonymous reviewer. Funding and logistical support for this study was provided by Manitoba Natural Resources, Tolko Manitoba Inc., University of Saskatchewan, National Sciences and Engineering Research Council (NSERC), and the Northern Scientific Training Program (NSTP). The co-operation provided by C. Smith, H. Lafontaine, J. Lettvenukk, D. Aikman, and the people of Wabowden and Cross lake was greatly appreciated. We wish to thank the many pilots that provided us with safe flights, and R. Thiebeault, T. Casu and K. Eade for their field assistance.

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