Range size and seasonal movement for female woodland caribou in the boreal forest of northeastern Ontario

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Abstract: A preliminary examination was conducted of range size and distribution of female woodland caribou (*Rangifer tarandus caribou*) in northeastern Ontario. Annual and seasonal ranges were calculated using satellite telemetry data collected for 30 female caribou between 1998 and 2001. The mean annual home range size of collared females was 4026 km^2. Seasonal ranges varied in size depending on time of year ($P<0.05$). Calving and summer ranges were significantly smaller than autumn and late winter ranges. Early winter ranges were significantly larger than calving ranges and smaller than late winter ranges. Overall, range sizes of female woodland caribou in northeastern Ontario were larger than those reported for caribou in other Boreal Forest regions across Canada.

Key words: anti-predator behaviour, *Rangifer tarandus caribou*, utilization distribution, woodland caribou.

Rangifer, Special Issue No. 14: 227-233

Introduction

Knowledge of spatial behaviour is central to our understanding of the distribution and abundance of populations, as well as, factors limiting populations. Ungulates exhibit a diversity of movement patterns, ranging from short movements within a small home range to long distance migration between seasonal ranges. Analysis of spatial behaviour at the landscape scale commonly includes delineating annual home ranges, seasonal ranges, migratory behaviour, and home range fidelity (White & Garrott, 1990). Factors influencing animal movement include reproduction and other physiological cycles, as well as, predation and habitat structure.

Burt (1943: 351) defined home range as "that area traversed by the individual in its' normal activities of food gathering, mating, and caring for young". Therefore, reproductive status, forage, and habitat requirements all influence home range size. Other factors found to influence range size in large ungulates include population abundance, ambient temperature, biting insects, snow depth, and availability of cover (Edge et al., 1985; Downes et al., 1986; Sweanor & Sandegren, 1989; Kilpatrick et al., 2001). According to Irwin & Peek (1983), social relationships and population density played a secondary role to food availability in the range size of elk in Montana. Predation and human-induced disturbances such as hunting are also known to be influential (Kilpatrick & Lima, 1999). Hastings (1990) indicated the importance of spatial factors in understanding predator prey interactions. Range size and the tendency of an animal to return to the same range during consecutive years (fidelity) may reflect the pattern and scale at which factors limiting survival (e.g., predation, forage, shelter) are influential (Rettie & Messier, 2001; Johnson et al., 2002).

White & Garrott (1990: 121) defined migration as "a regular, round-trip movement of individuals between two or more areas or seasonal ranges." The occurrence of migratory behaviour within a herd may be influenced by seasonal changes in food avail-

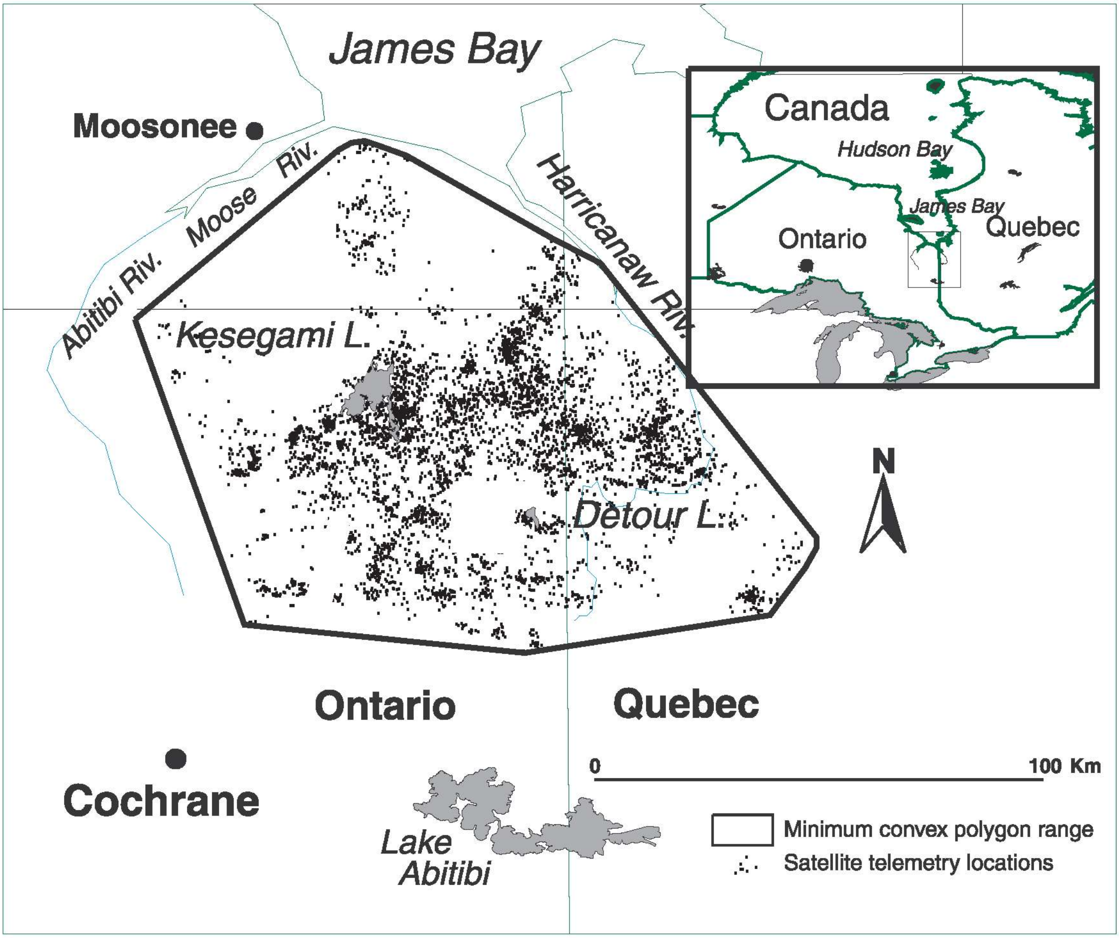

Fig. 1. Collared female woodland caribou distribution south of James Bay, Ontario, Canada, 1998-2001.

ability and the avoidance of predators during calving, rutting, and winter periods (Fryxell et al., 1988; Alcock, 1993). Gasaway et al. (1983) found that predation, severe winters, and harvest by man were additive in their impact on moose and caribou survival in Alaska. Huggard (1993) found that wolf predation on elk increased from 1 animal every 5.4 days with no snow, to 1 every 1.1 days, when snow depth reached 60 cm. Many studies have suggested that wolf predation may limit caribou populations in the boreal forest ecosystem (Edmonds, 1988; Written et al., 1992; Rettie & Messier, 1998).

The forest dwelling woodland caribou (Rangifer tarandus caribou) has declined across North America (Mallory & Hillis, 1998) and is officially listed as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2002). As human disturbances, notably forestry activities, have expanded northward, woodland caribou have become extirpated from most of the southern boreal forest of Ontario, and the present southern limit of their known distribution is just north of Cochrane (Fig. 1). In January 1997, Ontario Ministry of Natural Resources (OMNR) personnel observed approximately 200 animals in a 20 km^2 area adjacent to Detour Lake (Fig. 1). This observation revealed a need for information on the habitat requirements and population status of woodland caribou in the region in order to develop effective forest management strategies. The initial step in this study was to obtain basic descriptive information on the ranging behaviour of these animals.

An additional issue was whether management practices utilized elsewhere in Ontario were relevant for woodland caribou in northeastern Ontario. This would partly depend on regional differences in forest communities and differences in spatial behaviour and home range distributions. Woodland caribou inhabiting boreal forest throughout the year are relatively sedentary and have a high degree of overlap in ranges between successive seasons (Darby &

Pruitt, 1984; Mallory & Hillis, 1998; Rettie & Messier, 2001).

The primary objectives of this study were to examine home range size and seasonal distribution of female woodland caribou in the boreal forest of northeastern Ontario. We hypothesized that: (1) seasonal ranges of female woodland caribou in northeastern Ontario were of similar size throughout the year and (2) female woodland caribou migrate between seasonal ranges. Annual and seasonal home ranges are compared to ranges reported elsewhere in Canada. Seasonal differences in range size and distribution are discussed in relation to theories on reproduction and predator avoidance.

Methods

Study area

The study area of approximately 65 000 km^2 was bounded by James Bay in the north, Lake Abitibi in the south, the Abitibi River to the west, and the Harricanaw River in the east (Fig. 1). Climate in the region is modified continental with compression effects from the cold influence of Hudson Bay and the warmer Great Lakes to the south (Carleton & Maycock, 1978; Legasy et al., 1995). Mean daily temperatures for January and July are -18.2 °C and 16.7 °C, respectively. Total annual precipitation averages 920.1 mm, with a total annual snowfall averaging 316.2 cm (Anon., 1998).

The study site included the southern section of the James Bay lowlands, which is characterized by paleozoic rocks covered by glacial and marine quaternary deposits (Carleton & Maycock, 1978). Little relief occurs in the region, except in areas associated with the Moose River drainage. The area includes the clay belt running across Ontario and Quebec, characterized by a relatively flat plain of lacustrine clay and silt, with high to moderate depths of lime clay more than 9 m deep (Taylor et al., 2000). Peat soils are also common and few lakes exist within the region. The larger Kesagami Lake (171 km^2) occurs near the center of the study site and many smaller kettle lakes were created by ice shed from the receding glacier (Taylor et al., 2000). Rivers and streams in the area are typically clay banked and drain northward into James Bay.

Forest communities in the region are predominantly black spruce stands and treed muskeg. Important tree species include black spruce, balsam fir (*Abies balsamea*), white spruce (*P. glauca*), jack pine, and white birch (*Betula papyrifera*). Common ground and shrub layer species include black spruce, balsam fir, beaked hazel (*Corylus cornuta*), speckled alder (*Alnus incana*), labrador tea (*Ledum groenlandicum*), leatherleaf (*Chamaedaphne calyculata*), bog laural (*Kalmia polifolia*), sheep laural (*Kalmia angustifolia*), creeping snowberry (*Gaultheria hispidula*), small cranberry (*Vaccinium oxycoccos*), *Sphagnum* spp., Schreber's moss (*Pleurozium schreberi*), reindeer lichen (*Cladina rangiferina*), coral lichen (*Cladina stellaris*), cloudberry (*Rubus chamaemorus*), and blueberry (*Vaccinium* spp.). Fens with open ponds or dense shrub cover and tamarack (*Larix laricina*) tree cover occurred most extensively in the north end of the region near James Bay. Mixed deciduous stands were most frequent in the southern end of the area near Lake Abitibi. Common species included trembling aspen (*Populus tremuloides*), balsam fir, mountain maple (*Acer spicatum*), speckled alder, honeysuckle (*Lonicera* spp., *Diervilla lonicera*), wild sarsaparilla (*Aralia nudicaulis*), violet (*Viola* spp.), and Canada mayflower (*Maianthemum canadense*).

Capture and telemetry data

Female caribou were captured and immobilized by herding animals to a net using a helicopter and ground crew. Thirty animals were captured in March 1998 and March 1999 and outfitted with radio-collars equipped with both satellite and very high frequency (VHF) transmitters (model ST-14, Telonics Inc.).

Animal locations were obtained from satellite radio-collar transmitters every 2 days (13 Mar-6 Jul and 15 Oct-15 Jan) or every 7 days (16 Jan-13 Mar and 7 Jul-15 Oct). Locations of inferior quality were removed from the data set based on signal quality class and the number of signals received during the satellite overpass. A geographic information system (ArcInfo v. 3.5, ArcView v. 3.2, ESRI Inc.) was used to project location coordinates from decimal degrees to Universal Transverse Mercator (UTM) units and to calculate home range estimates (Hooge & Eichenlaub, 1997).

Range size and distribution

Five seasonal periods were defined based on calving dates and the movement patterns exhibited by individual animals: calving (May–Jun); summer (Jul–mid-Sep); autumn (mid-Sep–Nov); early winter (Dec–mid-Feb); and late winter (mid-Feb–Apr). Annual home ranges were calculated for female caribou employing the minimum convex polygon method (Mohr, 1947). The minimum convex polygon method was chosen for ease of comparison with other studies. The fixed kernel method (Worton, 1989) was used to calculate seasonal home ranges. According to Seaman & Powell (1996), the fixed kernel estimate is less prone to overestimate the area of utilization and has lower error associated with the

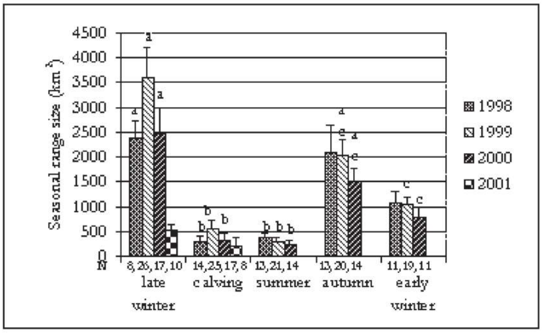

Fig. 2. Seasonal range sizes (km²) of female woodland caribou in northeastern Ontario, Canada between 1998 and 2001. Bars indicate mean value plus 1 SE. Within each year, categories with different letters above the error bar are significantly different (ANOVA of log transformed data with post-hoc Tamhane confidence intervals, $\alpha = 0.05$). No statistical comparisons were made between years.

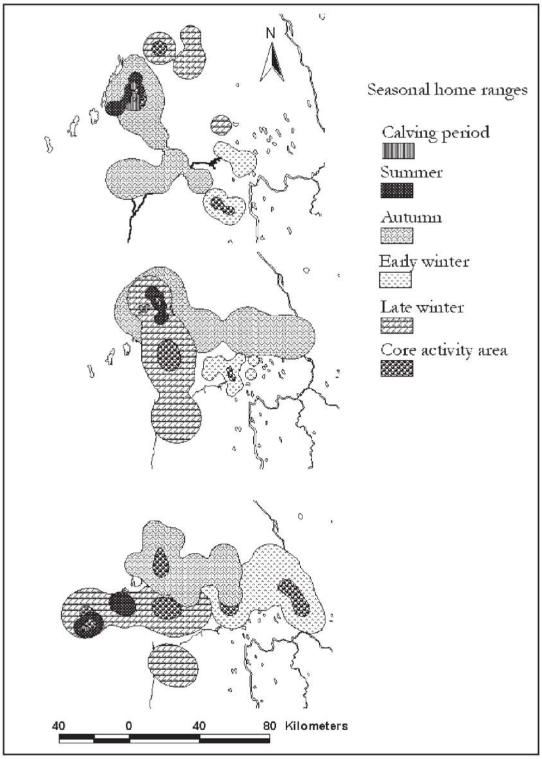

Fig. 3. Seasonal ranges of three adult female woodland caribou in northeastern Ontario, Canada. Fixed kernel estimates are shown for 95% seasonal home ranges and 30% core activity areas.

surface estimate. Annual home ranges (95% minimum convex polygon method) were calculated for animals for which we had locations from all seasons. Seasonal home ranges were calculated using the fixed kernel method and a 95% probability utilization distribution of seasonal data for each animal (Worton, 1989). Seasonal core activity areas were calculated with the fixed kernel method using a 30% probability distribution. A one -way analysis of variance (ANOVA) with post-hoc Tamhane confidence intervals was used to test for differences among seasonal home range sizes. Log transformations were employed to correct for heteroscedasticity in range sizes. Tests were considered to be significantly different at an α of 0.05. Statistical analyses were done with SPSS for Windows version 9 (SPSS Inc., 1998).

For this study, migration was defined as the seasonal movement of animals to separate summer and winter ranges. Migration was assessed by examining the distribution of seasonal ranges of each animal. The presence or absence of overlap in core activity areas for early winter and summer ranges was noted.

Results

Between late winter 1998 and early winter 2001, 5728 telemetry locations were obtained for 30 female caribou fitted with satellite collars and collared animals were monitored for periods ranging from 81 to 1162 days. Twenty-five percent of the collared animals were monitored for more than 828 days, fifty percent were monitored for more than 605 days, while seventy-five percent were monitored for more than 363 days. Of eleven collared animals that died during the study period, seven were attributed to predation.

During 1998, the mean annual home range size of adult females measured 3664 km² (n=13, SE±537 km²) and individual home range size varied between 1135 km² and 8798 km² (Table 1). In 1999, the mean annual home range size was 4790 km² (n=20, SE±451 km²) and individual home ranges varied between 1199 km² and 9582 km². In 2000, the mean annual home range size was 3212 km² (n=13, SE±453 km²) and individual home ranges varied between 593 km² and 5985 km². Pooling the data for 1998 to 2000 produced a mean annual home range of 4026 km² (n=46, SE±292 km²).

Significant differences were found in the size of seasonal ranges for most years (1998: $F=6.29$, $n=50$, $P=0.001$; 1999: $F=24.79$, $n=110$, $P<0.001$; 2000: $F=20.83$, $n=72$, $P<0.001$). In 2001, data were only obtained for the late winter and calving period. No seasonal difference in range size was found for this year (2001: $F=2.93$, $n=17$, $P=0.106$). In general, late winter and autumn ranges were significantly larger than calving and summer ranges (Fig. 2).

Table 1. Preliminary estimates of annual home range size (km^2) and seasonal movement (km) of female woodland caribou in northeastern Ontario, Canada. Ranges were calculated using the minimum convex polygon method for comparison with other studies. Each year was considered to commence in late winter of the year stated and continue to early winter of the following year.

Year	n	Min	Max	Mean	Std. Error	Distance between summer and winter ranges (km)
1998	13	1088	7266	3664	537	53
1999	20	1199	9582	4790	451	34
2000	13	593	5985	3212	453	38

Early winter ranges were significantly larger than calving and summer ranges, but smaller than late winter ranges.

Preliminary evidence suggests that female caribou migrate between summer and winter ranges. Observations of seasonal range distributions indicated that individuals underwent large-scale, distinct movements between early winter and calving ranges. No overlap was observed in the core activity areas for early winter and summer ranges. Fig. 3 illustrates a typical seasonal range distribution of a collared woodland caribou female in northeastern Ontario. Movement was greater during autumn and late winter, as reflected in range sizes (Fig. 3), when animals were traveling to and from summer and early winter ranges. The mean distance between the arithmetic centers of summer and late winter ranges was 53.4 (n=10, SE±13.1 km) in 1998, 33.7 (n=17, SE±5.3 km) in 1999, and 37.9 (n=10, SE±8.9 km) in 2000.

Discussion

Annual home ranges of female woodland caribou in northeastern Ontario were larger than those reported in the literature for other parts of Canada. Mean range sizes of caribou in central Saskatchewan ranged between 208 and 1240 km^2 (Rettie & Messier, 2001). In northwestern Ontario, median annual home range size was 322 km^2 (Racey et al., 1997). Centre to center distance between winter and summer ranges were similar to observations in northwestern Ontario, west central Manitoba, and Alberta (Edmonds, 1988; Racey et al., 1997; Metsaranta, 2002). Seasonal ranges, particularly during the autumn and late winter, were also considerably larger than those reported elsewhere (Darby & Pruitt, 1984; Edmonds, 1988; Rettie & Messier, 2001). However, it is possible that the larger seasonal ranges reported here resulted from using a kernel estimator, which will overestimate range size when sample size is small (Seaman & Powell, 1996). This was expected to be a problem for the shorter calving and summer seasons. Even so, the significant differences found in seasonal range sizes suggest that the kernel estimator was adequate in delineating utilization distributions, in spite of the limitations of small sample size.

The lack of difference in the size of late winter and calving ranges in 2001 suggests year may be a factor influencing range size. Further work will require identifying the importance of annual changes in environmental factors, such as snow, which may influence animal movement patterns.

Similar to other studies of woodland caribou, migration between communal winter ranges by aggregations of animals was not observed (Darby & Pruitt Jr.,1984; Edmonds, 1988; Rettie & Messier, 2001). However, females exhibited large-scale seasonal movement, evident from the large autumn and winter ranges. Examination of autumn locations of collared animals suggested movement in November, following the rut, accounted for most of the range size. Differences in range size among these animals and caribou in other regions suggest that limiting factors may differ in affecting local range use and movement. Rettie & Messier (1998) suggested that predation was the primary limiting factor affecting woodland caribou behaviour in Saskatchewan.

According to Lima & Dill (1990), predation risk is one of the most important factors influencing animal decision-making. This would include choices as to the timing and location of feeding, mating, and caring for young. Fryxell et al. (1988) discussed the importance of seasonal migration in ungulates, as a predator avoidance strategy. Predator avoidance may affect the occurrence and timing of migration, the home range size and location, as well as, habitat selection. Even so, many biotic and abiotic factors interact to influence an animals' spatial behaviour. The relative importance and interaction of variables such as land-cover type, energetic costs of movement, and predation risk may vary in relation to one another and the spatial scale at which animal movements are examined (Brashares & Arcese, 2002; Johnson et al., 2002).

Woodland caribou are known to select isolated areas during calving as an anti-predator strategy

(Bergerud et al., 1984; Bergerud, 1985; Cumming & Beange, 1987) and the relatively large autumn and late winter ranges in our study may reflect movement to areas with fewer predators or greater escape habitat. The use of small calving and summer ranges, compared to other ranges may reflect the relative immobility of calves at this time and the need for adequate cover. Although food availability and quality may also influence home range size, Barten et al. (2001) found that females with young used sites with fewer predators at the cost of less abundant forage. Wilson (2000) found that the abundance of lichens was one of the most important indicators of late winter habitat use by woodland caribou in northeastern Ontario. However, no information is currently available as to summer feeding habits or predator abundance in the region. Future work in this study will require assessing the landscape and habitat characteristics of calving and other seasonal ranges. Seasonal differences in mortality of collared animals will also be examined in relation to spatial behaviour and habitat selection.

The large-scale movement of caribou in northeastern Ontario to relatively small calving and summer ranges suggests predator avoidance may operate at different spatial and temporal scales, depending on the time of year. Ferguson et al. (1998) examined fractal measures of female caribou movements and suggested that female caribou with calves reduce movement rates and pathway complexity to minimize predation. Seasonal migration between ranges would operate at a relatively course spatial scale and involve greater movement rates along linear pathways.

Our findings demonstrate that home ranges of female woodland caribou varied in size depending upon season. Calving and summer ranges were significantly smaller than autumn and late winter ranges. The large variation in seasonal ranges of woodland caribou are indicative of differences in movement rates at different times of year. Further analyses of woodland caribou movement patterns, reproduction, habitat features, and seasonal mortality will be conducted to determine the effect of these factors on annual and seasonal range size.

Acknowledgements

The following industries, government organizations, and academic institutions provided financial and/or logistic support: Malette Inc. (Tembec Ltd., Timmins, Ontario), Abitibi Consolidated Inc. (Iroquois Falls, Ontario), Placer Dome Canada (Detour Lake Gold Mine, Ontario), the Lake Abitibi Model Forest (Iroquois Falls, Ontario), the Ontario Ministry of Natural Resources (Northeast Science and Information Section, South Porcupine, Ontario; Cochrane District Office, Cochrane, Ontario), le Ministère de l'Environnement et de la Faune (Rouyn-Noranda, Quebec), Moose Cree First Nations (Moose Factory, Ontario), Laurentian University (Sudbury, Ontario), and the University of Guelph (Guelph, Ontario). Special thanks to Mick Gauthier for logistic support and insight. This paper was improved by two anonymous reviewers.

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