

Recent changes in summer distribution and numbers of migratory caribou on the southern Hudson Bay coast

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Abstract: The status of migratory woodland caribou inhabiting the coastal region in southern Hudson Bay is dynamic. The Pen Islands Herd within that region was defined in the 1990s, but opportunistic observations between 1999 and 2007 suggested that its status had significantly changed since the late 1980s and early 1990s. We undertook systematic surveys from the Hayes River, MB, to the Lakitusaki River, ON, in 2008 and 2009 to determine current distribution and minimum numbers of woodland caribou on the southern Hudson Bay coast from the Hayes River, Manitoba, to the Lakitusaki River, Ontario. We documented a significant change in summer distribution during the historical peak aggregation period (7–15 July) compared to the 1990s. In 2008 and 2009, respectively, we tallied 3529 and 3304 animals; however, fewer than 180 caribou were observed each year in the Pen Islands Herd's former summer range where over 10 798 caribou were observed during a systematic survey in 1994. Over 80% of caribou were in the Cape Henrietta Maria area of Ontario. Calf proportions in herds varied from 8% of animals in the west to 20% in the east. Our 2008 and 2009 systematic surveys were focused on the immediate coast, but one exploratory flight inland suggested that more caribou may be inland than had been observed in the 1980s–1990s. The causes of change in the numbers and distribution in the coastal Hudson Bay Lowlands and the association of current caribou with the formerly large Pen Islands Herd may be difficult to determine because of gaps in monitoring, but satellite telemetry, genetic sampling, remote sensing, habitat analysis, and aboriginal knowledge are all being used to pursue answers.

Key words: aerial survey; distribution; Hudson Bay; migratory; monitoring; Pen Islands Herd; population numbers; range shift; woodland caribou.

Rangifer, Special Issue No. 20: 269–276

Introduction

Woodland caribou (*Rangifer tarandus caribou*) are found throughout northern Ontario and Manitoba across the northern part of the boreal forest and in areas north to the shores of Hudson Bay (Armstrong, 1998). Within this range, two ecotypes of the species have been identified: forest-dwelling and forest-tundra (Courtois *et al.*, 2003) or alternatively sedentary and migratory (Bergerud, 1996; 2000). These ecotypes are distinguished on the basis of their calving strategies: females of the forest-dwelling ecotype disperse after winter to calve in isolation from one another, whereas members of the forest-tundra ecotype migrate north of the tree line to the Hudson Bay coast and aggregate during calving. While the forest-dwelling woodland caribou ecotype has been listed as Threatened in Canada both federally and provincially, the forest-tundra ecotype is not listed under any species-at-risk legislation in Canada. However, with increasing concern about globally synchronous declines in many caribou and reindeer herds (Vors & Boyce, 2009) closer examination of any changes in caribou populations is warranted.

Forest-tundra woodland caribou have been documented as occupying the southern Hudson Bay coast since the 1700s, however, large aggregations were not reported during the first half of the 1900s (Banfield, 1961). In 1979, incidental observations made in early July indicated that caribou were aggregating in significant numbers at the coast near the Ontario-Manitoba border (Abraham & Thompson 1998). Studies in the 1980s-1990s confirmed the presence of summer aggregations during the calving and post-calving period and this group was named the Pen Islands Herd (Thompson & Abraham 1994). By 1994, the herd had grown from about 2300 animals to nearly 11 000 when observed during the peak of calving season (7-15 July; Abraham & Thompson, 1998).

Opportunistic observations between 1999 and 2007 indicated that very few caribou were present in the former range of the Pen Islands Herd during calving and post-calving periods (Magoun *et al.*, 2005; OMNR, unpublished data). In contrast, caribou numbers during calving and post-calving had increased east of the Winisk River, while during the 1979 to 1999 period there were few caribou observed in that area. These opportunistic observations were not based on formal or systematic surveys, and did not cover the complete Hudson Bay coast. Thus, we recognized a need to establish whether there were still concentrations of caribou in the Pen Islands Herd coastal summer range and whether there were other areas of the southern Hudson Bay coast where caribou were forming summer aggregations. To help address

these questions, we undertook a spring and summer aerial survey in 2008 and a summer survey in 2009.

Methods

Study area

Aerial surveys were conducted along the coast of southern Hudson Bay from the Hayes River, Manitoba in the northwest to the Lakitusaki River on the James Bay coast in the Hudson Plains Ecozone (ESWG, 1995), which generally corresponds with the boundaries of the Hudson Bay Lowlands ecozone of Angus Hills (Crins *et al.*, 2009). It is the largest semi-continuous peatland system in Canada and the world's third largest wetland (Riley, 1982; Abraham & Keddy, 2005). Land rises from tidal flats surrounding Hudson and James Bay to a maximum elevation of 240 m west of James Bay (Geological Survey of Canada, 1994). Vegetation across this area shows major north-south changes from treeless coastal tundra in the north to conifer-dominated boreal forest in the south (Riley, 2003). Wetlands, however, are the dominant landcover type at all latitudes covering more than 90% of the ecozone (Riley, 2003). The climate is significantly influenced by Hudson Bay with short cool summers and cold winters (Abraham & Keddy, 2005).

Methods

A fixed-wing survey (calving period, 24-28 May 2008) and two rotary-wing surveys (post-calving period, 10-15 July 2008 and 11-15 July 2009) were conducted in the immediate coastal area of southern Hudson Bay, Manitoba, and northern James Bay, Ontario. The time periods were chosen to match the previously known calving period and the period of highest aggregation post-calving (Thompson & Abraham, 1994). A Twin Otter airplane was used for the spring calving survey and flew at an altitude of 150 m AGL at speeds less than 100 knots. Bell Long Ranger and A-Star helicopters were flown for the summer post-calving surveys and flew at approximately 100 m AGL and speeds of less than 80 knots, slowing when needed. A combination of line transects and dynamic flight lines were flown; the line transects were located in areas of special interest (e.g. up to 30 km inland from coast). The dynamic lines were pre-determined to follow the James Bay and Hudson Bay coast and cover the area within 5 km of the coast where historical surveys had been done (Thompson & Abraham 1994) and were "dynamic" in the sense that they were not fixed point-to-point transects. There was a minimum of three observers to conduct the surveys. Of the observers, one was a navigator

and the primary observation recorder. This person sat beside the pilot and recorded on datasheets and in a GPS unit a description and the location of each observation. All caribou seen within approximately 750 m of the aircraft were recorded and we deviated from the flight lines to obtain definitive counts and classifications and photographs, then the flight line was resumed. The other observers called their observations to the navigator and took photographs of caribou. In-flight estimates of caribou numbers by age-sex classes were generally done for small groups. Larger herds required post-flight analysis of photographs of the groups, which permitted more accurate counting and, with digital image enhancement, often enabled better discrimination of individuals and age and sex classes. Age was classed as calf, yearling or adult based on size and morphology differences. Adult sex was determined from external morphological characteristics when possible, but adults were counted in an "unknown adult" category if the sex was not discernable after image enhancement. Non-photographic observations of caribou groups included group sizes by age and sex class; observations of other species were also recorded (e.g. wolf, polar bear, wolverine, moose). Waypoints and track logs for all surveys were recorded on handheld GPS units (Garmin GPSmap76s).

In addition to the transects flown up to 30 km from the coast in certain sections, (see figures in Results for locations), caribou were recorded on a flight from Peawanuck to Big Trout Lake on 15 July 2009, and during inspection of winter habitat north of Big Trout Lake on 17 and 18 July 2009.

Data on past summer caribou numbers and distribution in southern Hudson Bay were compiled from published literature (Abraham & Thompson, 1998; Magoun *et al.*, 2005), unpublished survey reports, and unpublished Ontario Ministry of Natural Resources data. Data, including date and location of caribou observations; number, age and sex of animals; and survey effort (absence) were used to describe the status and distribution of the caribou in the coastal region over time.

Analysis

The aerial survey data were georeferenced, mapped and spatially grouped by coastline segment. Summary descriptive statistics were computed for the whole survey area and for each coastal segment for total number of animals, number of groups, and average group size and numbers and percentages in each age-sex class. In recognition that some animals or groups were likely missed, the number of animals we report represents a minimum of the number of caribou present at or near the Hudson Bay coastline. It is consistent with the method used to determine minimum numbers in the 1980s-1990s (Abraham & Thompson, 1998). Difficulties in consistently discriminating the sex of caribou in photographs led to an underestimation of numbers of adult female caribou, which would result in overestimation of calves per 100 cows. To provide some bounds on the likely values of cow:calf ratios, given the uncertainty in estimating cow numbers, two measures were computed in addition to calves per 100 cows: i) calves per 100 adult caribou, including those of unknown sex, and ii) calves as a percentage of all caribou observed.

Results

Three aerial surveys, flown in spring 2008 (calving period) and summer 2008 and 2009 (post-calving), totalled 15 survey days. They covered the southern Hudson Bay coast from the Lakitusaki River in the east to the Hayes River in the west and between 2600 and 3800 km of flight lines were flown (Table 1).

Numbers and herd composition

During the May 2008 calving survey, 409 caribou were observed with an average group size of 5.0 (Table 1). The calves constituted 8.8% of all caribou observed, and the overall ratio of calves per 100 adults was 9.7. The calf:cow ratio was 65.5 calves per 100 cows, a likely over-estimation that is an artefact of the particular difficulty in sexing the animals from the Twin Otter at this speed and height.

Table 1. Spring and summer caribou aerial surveys conducted in the coastal area of the Hudson Plains Ecozone in 2008 and 2009.

Survey Id	Dates	Survey Days	Km flown	Caribou Seen	# Groups	Mean Group Size
May-08	24-28 May 2008	3	3050	409	81	5.0
July-08	10-15 July 2008	6	2605	3529	88	40.1
July-09	11-15 July 2009	6	3740	3304	138	23.9

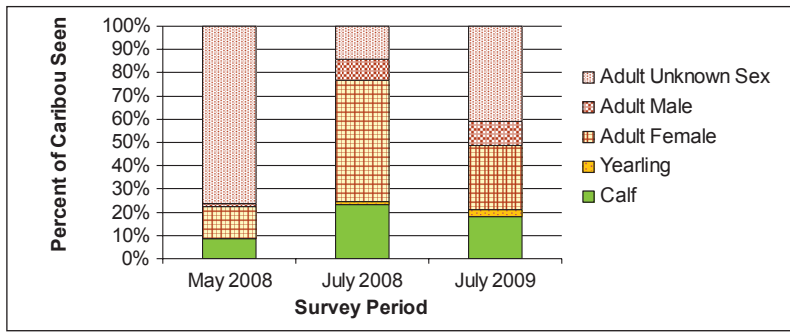


Fig. 1. Summary of age-sex composition of observed caribou for surveys conducted in May and July 2008 and July 2009 of the southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, Ontario.

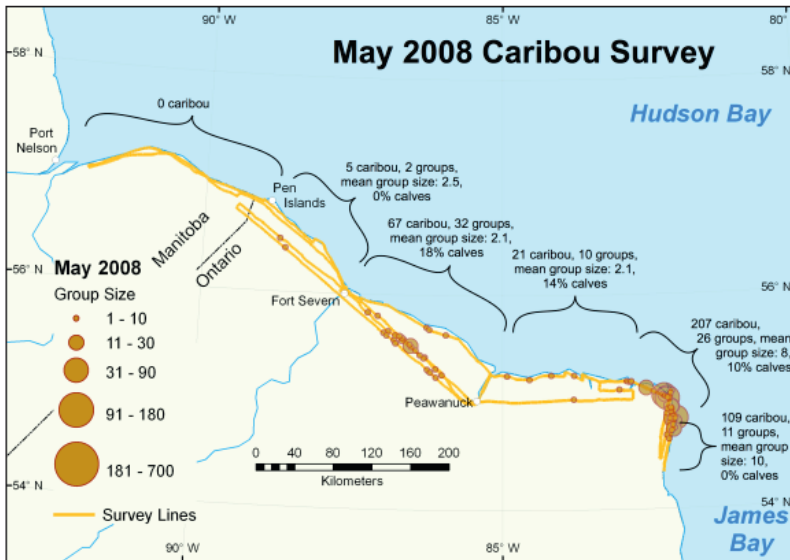


Fig. 2. Caribou distribution during May 2008 calving period aerial survey of the southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, Ontario.

The post-calving surveys of July 2008 and 2009 had total minimum counts of 3529 and 3304 caribou, respectively. Average group size was 40 in 2008 ($n=88$) and 24 in 2009 ($n=138$) and ranged from 1 to 544 during these surveys (Table 1). The calf indices computed from the main post-calving surveys were 30.4 and 20.7 calves per 100 adults for 2008 and 2009, respectively; calves as a percentage of the total number of caribou were 23.1% in 2008 and 16.1% in 2009 and calves per 100 cows were 44.0 in 2008 and 61.5 in 2009 (Table 2, Fig. 1).

Geographic distribution

The calving period survey (May 2008) showed the majority of observed caribou (>300) to be near Cape Henrietta Maria at the eastern end of the southern Hudson Bay coast in Ontario (Fig. 2). There were relatively few animals west of Peawanuck (<75) and even fewer still (<10) west of Fort Severn, which historically was the Pen Islands Herd calving area.

Table 2. Age and sex description in percent of observed caribou for each aerial survey (number of animals seen in brackets) in the coastal area of the Hudson Plains Ecozone.

Survey Id	Total caribou	Adult male	Adult female	Yearling	Unknown age or sex	Calf	Calves/100 cows ¹	Calves/100 adults ²
May-08	409	1.5 (6)	13.4 (55)	0 (0)	76.3 (312)	8.8 (36)	65.5	9.7
July-08	3529	8.1 (285)	52.4 (18.5)	1.2 (41)	15.3 (539)	23.1 (814)	44.0	30.4
July-09	3304	10.2 (337)	27.0 (892)	3.2 (106)	43.0 (1420)	16.1 (549)	61.5	20.7

¹ Calves/100 cows may be overestimated and should be interpreted with caution; this is because discrimination of sex was difficult and there were large numbers of caribou for which assignment of age or sex class was not made.

² The adult class does not include yearlings, but does include the Unknown age or sex class, which are assumed to not be calves.

The distribution of caribou during the post-calving survey in July 2008 (Fig. 3) exhibited a similar pattern to the May 2008 survey; the majority of caribou (>1900) were around Cape Henrietta Maria, with another 1400 just west of the Cape. Few animals were found west of Peawanuck (<210) and fewer still were west of Fort Severn (<63). The post-calving survey of 2009 (Fig. 4) had a pattern very similar to 2008. The majority of caribou (>3000) were in the Cape Henrietta Maria area, with few animals (<300) located west of Peawanuck and fewer west of the Severn River (<210). It is interesting to note that in Manitoba, within close proximity (5 km) of the coast, only 75 caribou were observed in 2009.

The inland transects within 30 km of the coast in Ontario had very few caribou and no large aggregations. On 14 July 2009, we flew 5 transects along beach ridges spaced approximately 5 km apart from 25 km inland to the coast from Hook Point, Ontario (Fig. 4). The coastal transect covered an area of the flight line of 12 July. There were no caribou on the 4 inland transects, confirming their adherence to the immediate coast. The 2009 survey in the Manitoba portion of the range included more inland area than in 2008, extending 30 km inland adjacent to the Ontario border (Fig. 4); in this area only 100 caribou were sighted, approximately equal numbers as were at the coast. On the flight from Peawanuck to Big Trout Lake on 15 July 2009, few caribou and no large aggregations were observed. However, on 17 July, 6 groups totalling 108 (mean 18, range 1 to 75) were observed and on 18 July, 14 groups totalling 350

(mean 24, range 1 to 129) were observed north of Big Trout Lake. Observations of similar groups near the community of Shamattawa, Manitoba, in late July have been reported to VT and DH in each of the past few years.

On the coast in general, larger groups of caribou were observed in the east, in the area of Cape Henrietta Maria. This trend was evident at calving time in

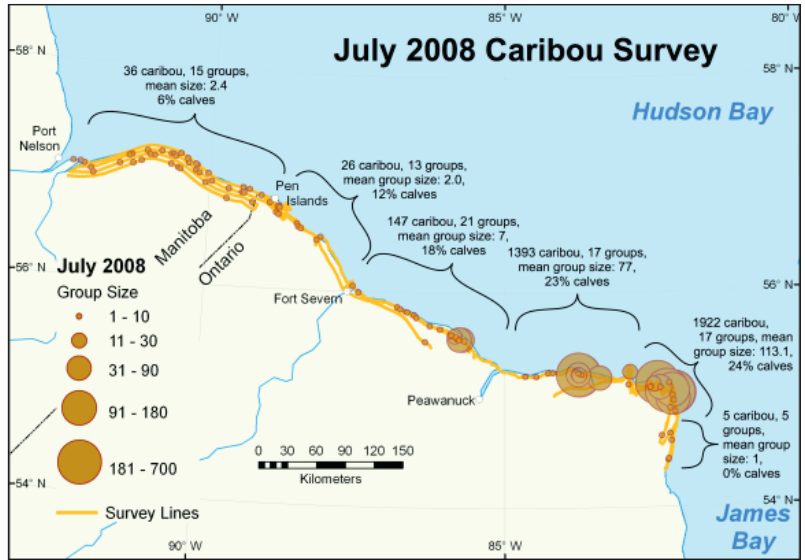


Fig. 3. Caribou distribution during July 2008 post-calving period aerial survey of the southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, Ontario.

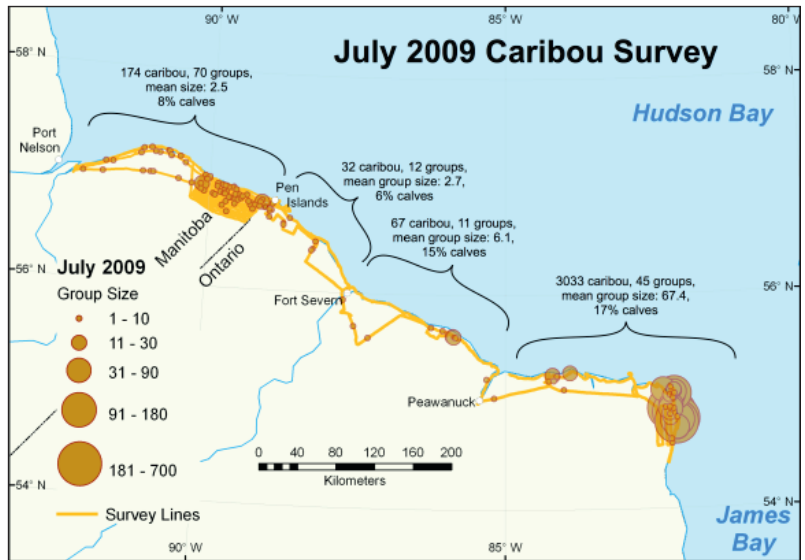


Fig. 4. Caribou distribution during July 2009 post-calving period aerial survey of the southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, Ontario.

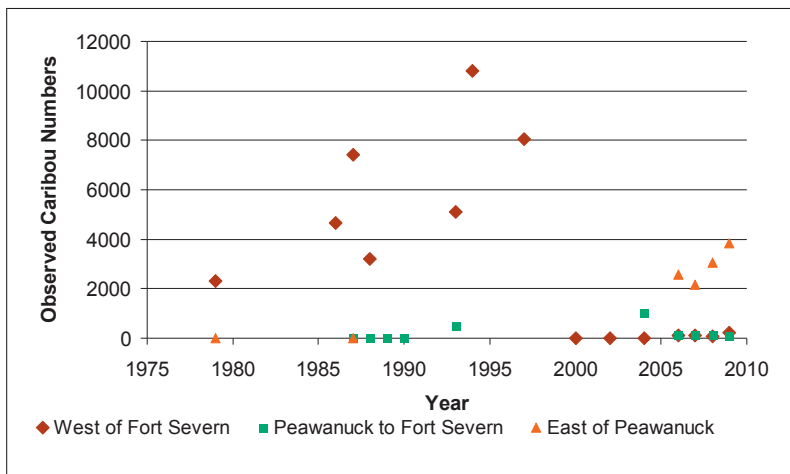


Fig. 5. Summary of total caribou observed at peak of post-calving aggregation in July caribou surveys of the southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, compiled from published and unpublished survey reports 1979–2009.

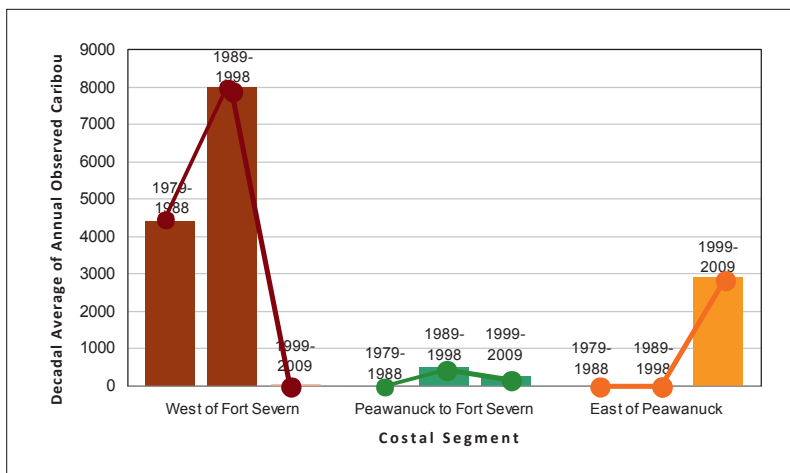


Fig. 6. Trends in annual number of caribou observed at peak of post-calving aggregation in July on the Southern Hudson Bay coast from the Hayes River, Manitoba to Lakitusaki River, Ontario, by coastal segment, averaged by decade.

May (Fig. 2), but was much more pronounced during the July post-calving period in both years (Figs. 3, 4). West of Fort Severn mean group size did not exceed 3 and was less than 7 west of Peawanuck; while to the east, mean group sizes were larger by more than an order of magnitude. There was a similar increasing trend in the calf indices in both post-calving surveys from west (7% and 8% west of Fort Severn in 2008 and 2009, respectively) to east (24% and 17% at Cape Henrietta Maria in 2008 and 2009, respectively).

The compiled past and current data, aggregated by decade and broken down by coastal segment

(Figs. 5, 6), clearly show the changes in coastal distribution of caribou over the last 30 years, with dramatic declines in the west after 1999 and rising numbers in the eastern segments.

Discussion and conclusion

Summer caribou population data from the Hudson Bay coastal area showed a steady increase in the number of caribou using the coast near the Pen Islands from the late 1970s to the mid-1990s (Abraham & Thompson, 1998; Magoun *et al.*, 2005). The summer caribou concentrations in the Pen Islands area increased notably from 2300 in 1979 to reach a peak estimate of 10 798 animals in 1994. During the 1980s and 1990s, summering animals were found mostly around the Manitoba-Ontario border near the Pen Islands and few were found east of the Winisk River (Abraham & Thompson, 1998; Magoun *et al.*, 2005, OMNR unpublished data). However, in the past decade there has been a change in the distribution of caribou along the southern coast of Hudson Bay, Manitoba and Ontario, during the calving and

post-calving periods from predominance of animals occurring in the western portion to predominance in the eastern portion of the Hudson Bay coast. By the early 2000s, the majority of incidental and opportunistic caribou observations were made in the Cape Henrietta Maria area and very few observations were made west of the Severn River (Magoun *et al.*, 2005). Our 2008 and 2009 summer survey data confirm and quantify this significant change. These two years of systematic surveys plus data from opportunistic observations in 2006 and 2007 (Figs. 5 and 6; Abraham, *et al.*, 2010; OMNR unpublished data)

produced similar geographic patterns in numbers, distribution and calf percentages, indicating that this is not an ephemeral change.

The average group sizes in July 2008 (40) and 2009 (24) are significantly smaller than the mean group sizes recorded by Thompson & Abraham (1994) for the period of peak aggregation (cf. 1060, range 209-1978). That difference and the gradient in group size we recorded from west to east may simply be an outcome of the relative density of animals, with large groups less likely to form when overall densities are low. The difference in group size raises the possibility that the timing of the peak of aggregation has changed, and indeed as the timing of peak calving appears to occur later, based on the May 2008 survey, so too might the peak of aggregation be later. Further examination of weekly or biweekly trends is warranted.

Bergerud (1996) identified a threshold of 12-15% calves in a herd in late winter as a requisite for population stability. West of the Severn River during post-calving surveys, we observed a range of 6% to 12% calves in the caribou groups, which is indicative of a herd in decline. In the Cape Henrietta Maria area these values were 24% and 17% in 2008 and 2009, respectively, which suggests that the population of animals in this area is in much better condition than those to the west. Thompson & Abraham (1994) reported values of 24.4% and 29.6% calves for the Pen Islands Herd in 1987 and 1988, respectively, at a time when the herd would have been increasing toward the maximum number (10 798) observed in 1994. Scholten & Chenier (1997) estimated 15% of the Pen Islands Herd were calves in a 1997 survey (8058 animals observed) when the herd was at or past its highest numbers.

The observation of over 450 animals in 20 groups as far inland as Big Trout Lake and the local reports from Shamattawa raises questions of the annual range and possible origin/association of these animals relative to the current and former coastal animals, as well as questions about their movement behaviour, and their ecotype identity. These group sizes are unexpected for the forest-dwelling ecotype at any time of year, but especially summer, and their behaviour is suggestive of the migratory forest-tundra ecotype. Are they remnants of the former Pen Islands Herd with altered spatial and temporal behaviour?

The evidence from our surveys is that the former coastal calving and post-calving grounds of the Pen Islands Herd have been essentially abandoned. If the Cape Henrietta Maria animals represent the descendants of the Pen Islands Herd, then a significant shift in calving grounds of this migratory ecotype has occurred. Calving grounds are usually thought to

be quite stable (Russell *et al.*, 1993). If the inland animals represent the descendants of the Pen Islands Herd, then a significant change in summer habitat use or timing of use has occurred. Both possibilities deserve further investigation.

The change in summer distribution and in numbers, between the Hayes River, Manitoba, and Cape Henrietta Maria, Ontario, may have several causes. The minimum numbers in 2008 and 2009 are less than one-third of the estimated peak Pen Islands numbers in 1994. Is this evidence of a population decline since the 1990s, or simply a redistribution and imperfect sampling? The incidental observations near Big Trout Lake might support the redistribution idea but adequate sampling of the vast interior is a daunting task. A combination of causes for the change may be more likely, including: differential mortality of animals in western versus eastern parts of the Hudson Plains Ecozone due to differences in predation and hunting pressure, nutritional stress due to range deterioration, redistribution of western animals in response to habitat change or to disturbance in the western area; and/or differential natality (e.g. intrinsic growth of the eastern group of animals where predation pressure, including hunting, may be lower and where forage quality may be higher).

Lack of continuous monitoring during the recent period of greatest change makes distinguishing among these alternative hypotheses difficult. However, collaring programs have been initiated in both Ontario and Manitoba, which will enhance our knowledge of current seasonal movement patterns of caribou in all parts of the Hudson Bay Lowland and by illuminating the link between winter concentration areas and the summer coastal distribution, may allow inferences to historical changes. Collaring will also allow identification of calving grounds and perhaps even calving behaviour. Genetic samples obtained during our surveys and collected through other survey and research initiatives at other times (including historical samples from the Pen Islands) will provide additional insight into fine-scale genetic structure in caribou in the Hudson Plains Ecozone, which in turn may provide important clues about long-term caribou movement and adaptation to a changing environment. At minimum, these studies will help delineate the contemporary boundary between forest dwelling and forest-tundra ecotypes.

Acknowledgements

We would like to thank the people who participated in surveys and otherwise contributed to this project: surveyors T. Armstrong, K. Bennett, P. Davis, M. Gauthier, D.

Fillman, C. Lewis, J. Hughes, J. Ray, G. Racey, K. Ross, C. Sadowski, H. Scherr, R. Brook and pilots P. Atkinson, F. Aquino, G. Bain, K. Crant, D. Filliter; those who analyzed aerial photos S. Gan, and D. Hogan; and L. Walton for logistical support during May 2008 surveys. This project was financially supported by the Far North Branch of the Ontario Ministry of Natural Resources (OMNR) through its Far North Information and Knowledge Management initiative, by the Wildlife Research & Development Section of OMNR, and by Manitoba Conservation. We thank J. Ray for her thoughtful review of the manuscript.

References:

- Abraham, K.F. & Keddy, C.J. 2005. The Hudson Bay Lowland. – In: Fraser, L.H., & Keddy, P.A. (eds.). *The World's Largest Wetlands: Ecology and Conservation*. Chapter 4, pp. 118-148. Cambridge University Press, New York, USA.
- Abraham, K.F., Pond, B.A., Tully, S.M., Brook, R., Chenier, C., & Racey, G.D. 2010. Distribution and abundance of caribou in the Ontario Hudson Bay Lowlands in spring 2008 and summer 2008 and 2009. *Far North Technical Report*, Ministry of Natural Resources, Peterborough, Ontario. 21pp.
- Abraham, K.F. & Thompson, J.E. 1998. Defining the Pen Islands Caribou Herd of southern Hudson Bay. – *Rangifer* Special Issue No. 10: 221-230.
- Armstrong, T. 1998. Integration of woodland caribou habitat management and forest management in northern Ontario – current status and issues. – *Rangifer* Special Issue No. 10: 221-230.
- Banfield, A.W.F. 1961. *A revision of the reindeer and caribou, genus Rangifer*. National Museum of Canada Bulletin No. 177 (Biological Series No. 66). Department of Northern Affairs and National Resources, Ottawa, Ontario.
- Bergerud, A.T. 1996. Evolving perspectives on caribou population dynamics, have we got it right yet? – *Rangifer* Special Issue No. 9: 95-116.
- Bergerud, A.T. 2000. Caribou. – In: Demarais, S. & Krausman, P. R. (eds.). *Ecology and management of large mammals in North America*, pp. 658-693. Prentice Hall, Upper Saddle River, New Jersey, USA.
- Courtois, R., Bernatchez, L., Ouellet, J.P., & Breton, L. 2003. Significance of caribou (*Rangifer tarandus*) ecotypes from a molecular genetics viewpoint. – *Conservation Genetics* 4: 393-404.
- Crins, W.J., Gray, P.A., Uhlig, P.W.C., & Wester, M.C. 2009. *The Ecosystems of Ontario, Part I: Ecozones and Ecoregions*. Ontario Ministry of Natural Resources, Peterborough Ontario. 71pp.
- Ecological Stratification Working Group. 1995. *A National Ecological Framework for Canada*. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull.
- Geological Survey of Canada. 1994. *Surficial Materials of Canada*, Map 1880A. Geological Survey of Canada, Terrain Science Division, Ottawa.
- Magoun, A. J., Abraham, K.F., Thompson, J.E., Ray, J.C., Gauthier, M.E., Brown, G.S., Woolmer, G., Chenier, C.J., & Dawson, F.N. 2005. Distribution and relative abundance of caribou in the Hudson Plains Ecozone of Ontario. – *Rangifer* Special Issue No.16: 105-121.
- Riley, J.L. 1982. Hudson Bay Lowland floristic inventory, wetlands catalogue, and conservation strategy. – *Naturaliste can. (Rev. Ecol. Syst.)* 109: 543-555.
- Riley, J.L. 2003. *Flora of the Hudson Bay Lowland and its Post-glacial Origins*. NRC Press, Ottawa. 237pp.
- Russell, D.E., Martell, A.M., & Nixon, W.A.C. 1993. Range Ecology of the Porcupine Caribou Herd in Canada – *Rangifer* Special Issue No. 8: 1-168.
- Scholten, S. & Chenier, C. 1997. Aerial Survey of the Pen Islands Caribou Herd for 1997. OMNR unpubl. report. Moosonee, Ontario.
- Thompson, J.E. & Abraham, K.F. 1994. *Range, Seasonal Distribution and Population Dynamics of the Pen Islands Caribou Herd of Southern Hudson Bay*. Ontario Ministry of Natural Resources, Final Technical Report, Moosonee, Ontario. 94pp.
- Vors, L.S. & Boyce, M.S. 2009. Global declines of caribou and reindeer. – *Global Change Biology* 15(11): 1365-2486.