Herd structure, movements, calving grounds, activity periods, home range similarity, and behaviours of migratory and tundra-wintering barren-ground caribou on mainland Nunavut and eastern mainland Northwest Territories, Canada

Technical Report Series 2012 – No. 01-12
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January 2012

Acknowledgments

We would like to thank the Northwest Territories Government Department of Environment and Natural Resources for supplying the collar based movement data used in this analysis. Without this information this analysis would not have been possible. We gratefully acknowledge the support and direction of community based wildlife management organizations across the caribou herd ranges. This local knowledge and support provided by these organizations was instrumental in the completion of this report. We would also like to thank the many staff behind the scenes too numerous to list, whose hard work, vision, dedication to caribou conservation, and high standards of professionalism built the database on which these and other analysis rely.

Executive Summary

The herd structure of barren-ground caribou on mainland Nunavut (NU) and eastern mainland Northwest Territories (NT), Canada, was recently described using satellite tracking data obtained during 1993-early 2009 and cluster analyses. However, enough cows had not yet been collared in the Baker Lake, NU area to reliably define the herd structure of caribou calving near the Queen Maud Gulf, NU. With collar deployments north of Baker Lake in late 2008 and 2009 this situation was remedied. This report provides a summary of the results of analyses of satellite tracking data obtained for 306 barren-ground caribou cows during 1993-early 2011 to define herd structure, movements, calving grounds, activity periods, range similarity, and behaviours of migratory and tundra-wintering barren-ground caribou on mainland NU and eastern mainland NT.

Number of barren-ground caribou herds on mainland Nunavut and eastern mainland Northwest Territories

Hierarchical and fuzzy cluster analyses indicate that there are six barren-ground caribou herds on mainland NU and eastern mainland NT. These include the migratory Bathurst, Beverly, and Qamanirjuaq herds and the tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay herds. Caribou assigned to each herd by fuzzy clustering had a significantly higher probability of belonging to that herd than to the other herds. The Bathurst, Beverly, Qamanirjuaq, and Lorillard herds were robust (i.e., cows in these herds were strongly spatially affiliated with each other throughout the year); the Queen Maud Gulf and Wager Bay herds were organized as individuals (i.e., cows in these herds were not strongly spatially affiliated with each other throughout the year).

Most cows that were assigned by fuzzy clustering to the Beverly herd were collared in areas where one would have expected to collar Beverly caribou, i.e., on the previously described winter range and “traditional” calving ground of the Beverly herd; a map showing this is provided. Most of the cows that were assigned to the Queen Maud Gulf herd were collared in areas where one would have expected to collar Queen Maud Gulf caribou, i.e., north and west of

Baker Lake or southwest of Chantrey Inlet near the 1983 and 1995 Queen Maud survey stratum; a map showing this is provided.

Maps showing the seasonal movements of cows in each herd during 1996-2010 are provided. The areas used during winter by some cows that were tracked for 4-7 years in the migratory and tundra-wintering herds were highly variable; maps illustrating these variations are provided. Some migratory Bathurst and Qamanirjuaq cows that were tracked 5-7 years wintered on the tundra during one or more winters. One Queen Maud Gulf cow that was tracked for 5 years wintered below treeline during one winter. If we assume that these caribou or the herds they belonged to changed behaviour each time their winter range use shifted from below to above treeline or vice versa, some of these herds would have changed behaviour a number of times during 1996-2010. Long-term tracking data are required to document the distribution and movements of caribou in all herds within a region to determine whether shifts in distribution or behaviour have occurred.

Calving dates and locations and delineation of calving grounds

Calving dates and sites were estimated by examining the late May-early July daily movement rates of cows assigned by fuzzy cluster analyses to the Beverly, Qamanirjuaq, and Queen Maud Gulf herds. The mean calving date for Beverly and Qamanirjuaq cows was 12 June; that for Queen Maud Gulf cows was 15 June. Although a majority of the cows that were assigned to each herd and tracked for ≥2 years used only one calving ground, some used two or more.

The locations of calving grounds used by the Qamanirjuaq, Lorillard, and Wager Bay herds were consistent with those previously described. The locations of calving grounds used by the Beverly and Queen Maud Gulf herds indicated that these cows calved in distinct but overlapping areas. Although some cows in the robust Beverly herd calved on the “traditional” Beverly calving ground near Garry Lakes, most calved near the western Queen Maud Gulf coast. Cows in the distinct tundra-wintering Queen Maud Gulf herd calved near the eastern Queen Maud Gulf coast. Queen Maud Gulf cows were more dispersed and on average calved three days later than Beverly cows.

Because the calving areas used by the Beverly and Queen Maud Gulf herds overlap, a survey of the area south of the Queen Maud Gulf coast would indicate an area of continuous calving. If one believed that every area of continuous calving is only used by one herd, then they would conclude that one herd currently calves near the Queen Maud Gulf coast. However, analyses of the annual distribution and movement data for the caribou that currently calve near the Queen Maud Gulf coast indicated that two behaviourally different herds calve there, i.e., the migratory Beverly and tundra-wintering Queen Maud Gulf herds. This indicates that herds cannot be reliably identified using calving ground surveys alone. Herds and the calving grounds they use should be defined by tracking the annual distribution and movements of satellite collared cows to avoid confusion.

Home range similarity

There was a high degree of within herd overlap among home ranges of cows assigned by fuzzy clustering to the Beverly and Qamanirjuaq herds, however, there was only a slight degree of between herd overlap among home ranges of cows in these herds. This indicates that these migratory herds had distinct ranges and there was not much variation in the areas used by cows in each herd.

There was only a moderate-fair degree of within herd overlap among home ranges of cows assigned by fuzzy clustering to the Queen Maud Gulf, Lorillard, and Wager Bay herds, and there was only a slight degree of between herd overlap among home ranges of cows in these herds. This indicates that the tundra-wintering herds had distinct ranges but there was greater variation in the areas used by cows in each herd than observed for cows assigned to the migratory herds.

There was a fair-moderate degree of overlap among ranges used by Beverly and Queen Maud Gulf cows indicating that some Queen Maud Gulf cows used some of the same areas used by some Beverly cows.

Activity periods

Daily travel rates of cows assigned by fuzzy clustering to the tundra-wintering Queen Maud Gulf herd did not change significantly during late December-end of March (95 days). Following an increase in daily travel rates during early April, these rates did not change significantly during early April-end of May (55 days).

Daily travel rates of cows assigned by fuzzy clustering to Beverly and Qamanirjuaq herds decreased progressively and significantly during late November-early April (135-140 days) and then increased progressively and significantly during early April-end of May (51-55 days). The first period corresponds with the early, mid, and late winter activity periods while the second period corresponds with the spring and spring migration activity periods of these migratory caribou.

Although there were similarities among the activity periods and daily movement rates of cows assigned by fuzzy clustering to these caribou herds, there were notable differences that indicated that cows in the migratory Beverly and Qamanirjuaq herds behaved differently from those in the tundra-wintering Queen Maud Gulf herd.

Comparison of Beverly vs Queen Maud Gulf and Qamanirjuaq vs Queen Maud Gulf caribou daily travel rates

Daily travel rates of cows assigned by fuzzy clustering to the tundra-wintering Queen Maud Gulf herd were significantly different from those assigned to the migratory Beverly and Qamanirjuaq herds during four time periods. Most notably, those of Queen Maud Gulf cows were significantly higher than those of Beverly and Qamanirjuaq cows during 5 February-14 April (mid to late winter, 65 days). These results further indicated that cows in the tundra-wintering Queen Maud Gulf herd behaved differently from those in the migratory Beverly and Qamanirjuaq herds.

Conclusions

The migratory Beverly herd continues to occupy the range between the migratory Bathurst and Qamanirjuaq herds. Although some Beverly cows still calve on their "traditional" calving ground near Garry Lake, most now calve near the western Queen Maud Gulf coast. A similar shift in calving ground use was documented for the Bathurst herd during 1986-1996. The Queen Maud Gulf herd, originally described in the mid 1980's, continues to calve near the eastern Queen Maud Gulf coast. The Beverly and Queen Maud Gulf herds occupy adjacent calving areas.

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Section 1: Introduction

Nagy et al. (2011) used satellite tracking data obtained for barren-ground caribou cows tracked between 1993 and early 2009 to described the herd structure of migratory and tundra-wintering barren-ground caribou on mainland Northwest Territories (NT) and Nunavut (NU). Their analyses indicated that two herds calved near the Queen Maud Gulf coast; these were the tundra-wintering Queen Maud Gulf herd as originally described by Heard et al. (1986) and Buckland et al. (2000) and the migratory Beverly herd. However, they lacked data for a sufficient number of caribou to clearly describe the number of herds that calved in the area near the Queen Maud Gulf coast. Additional collars were deployed in late 2008 and 2009 in an area believed to be within the winter range of the Queen Maud Gulf herd (M. Campbell, pers. comm.); data for these collared caribou were not included in Nagy et al.'s (2011) analyses. With the benefit of a larger sample size of collared cows and two more years of satellite tracking data we re-examined the herd structure of migratory and tundra-wintering barren-ground caribou on mainland NU and eastern mainland NT.

For clarity and consistency we provide maps of the following areas and land marks that are referred to in this document:

- Ellice, Perry, and Simpson Rivers and Bathurst Inlet, Adelaide Peninsula, Garry Lakes, and Chesterfield Inlet (Fig. 1-1);
- Queen Maud stratum (Stratum 7) surveyed in 1983 by Heard et al. (1986) and in 1995 by Buckland et al. (2000)(Fig. 1-1);
- we refer to caribou in the area of the Queen Maud stratum (Stratum 7)(Fig. 1-1) as Queen Maud Gulf caribou;
- the 1986 Queen Maud Gulf calving ground (Fig. 1-2) as mapped by Gunn et al. (2000);
- the 1995 Bathurst calving distribution that was based on surveys conducted 1-16 June 1995 (Fig. 1-3) and mapped by Sutherland and Gunn (1996),
- the 1996 survey area (Fig. 1-4) as mapped by Gunn and Fournier (2000), and
- the winter range of the Beverly herd as described by Gunn (1989)(Fig. 1-5); note most of the winter range had been burned by fires by the mid 1990's.

Our objectives were:

1) To re-examine the herd structure of migratory and tundra-wintering barren-ground caribou on mainland NU and eastern NT, i.e., within the area occupied by the Bathurst, Beverly, Qamanirjuaq, Queen Maud Gulf, Lorillard, and Wager Bay herds, using hierarchical and fuzzy clustering (Section 2).

2) For caribou assigned to each herd by fuzzy clustering, to map their movements during significant time periods including: the annual movements of cows in each herd tracked during 1996-2011; the winter movements of cows in each herds tracked during winters 1996-2011; the cumulative movements during calving, summer, fall, rut, winter, April, and May of cows in each herd; the cumulative movements of cows in each herd tracked during 1993-2011; the variation in areas used during winter and calving by some cows in each herd; and the variation in areas used by some cows in the Bathurst, Qamanirjuaq, and Queen Maud Gulf herds that wintered below and above treeline (Section 2).

3) For cows that were assigned to each herd by fuzzy clustering, to examined changes in movement rates of cows during the calving period to determine calving sites, calving dates, and calving periods for each herd, to delineate and map the calving grounds used by each herd, and to determine where cows calving near the Queen Maud Gulf coast were collared (Section 3).

4) For cows that were assigned to each herd by fuzzy clustering, to determine how similar the home ranges used by each cow in each herd was to those used by other cows in the same herd and to those used by cows in all other herds, i.e., did cows in each herd use distinct home ranges that were different from those used by cows in the other herds (Section 4).

5) To determine if the cows assigned by fuzzy clustering to the migratory Beverly and Qamanirjuaq herds were behaviourally different from those assigned to the Queen Maud Gulf herd by describing and comparing their annual activity periods (Section 5) and daily travel rates (Section 6).

These analyses were required to i) describe the herd structure and the ranges used by caribou herds on mainland NU and eastern mainland NT and ii) to determine whether more than one barren-ground caribou ecotype calved near the Queen Maud Gulf coast.

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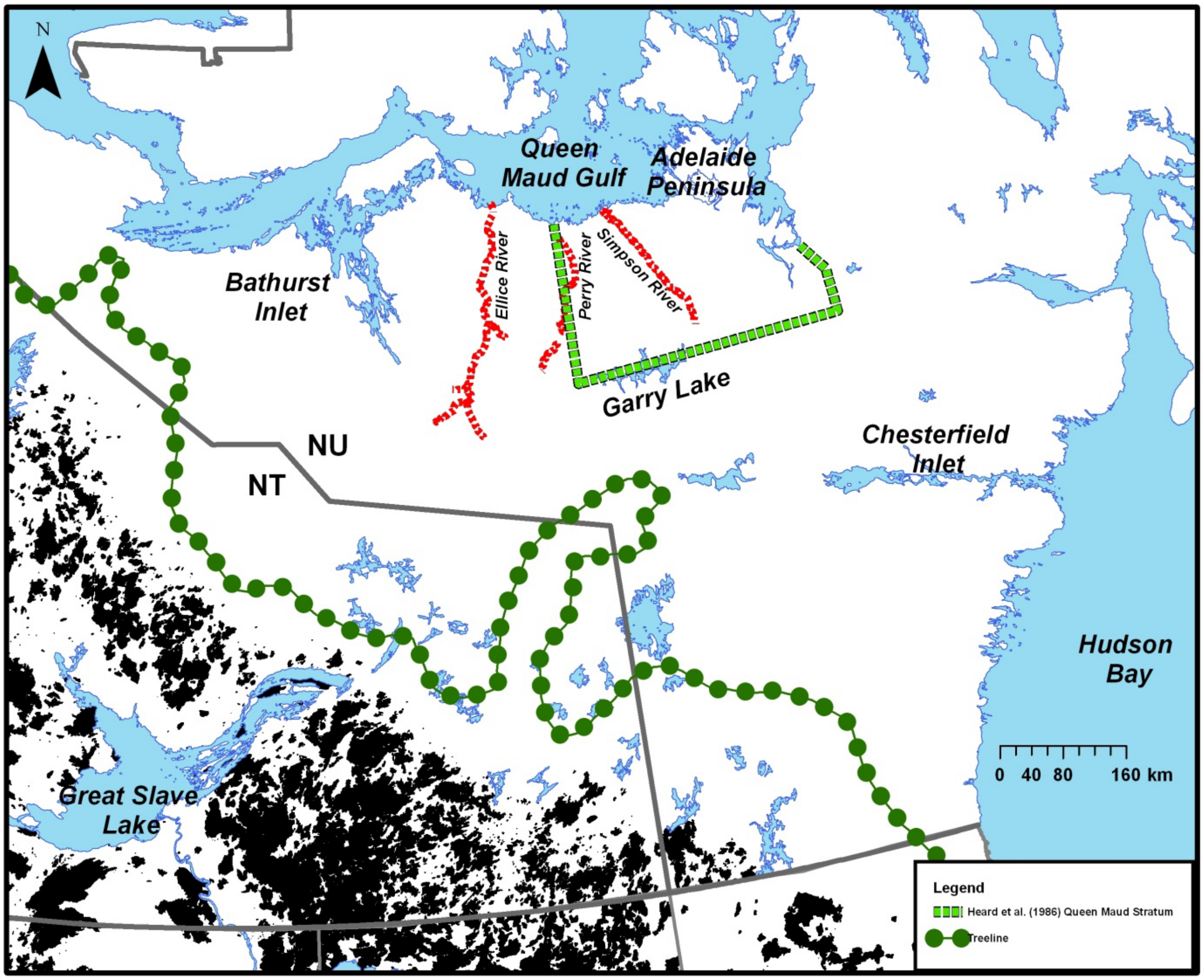
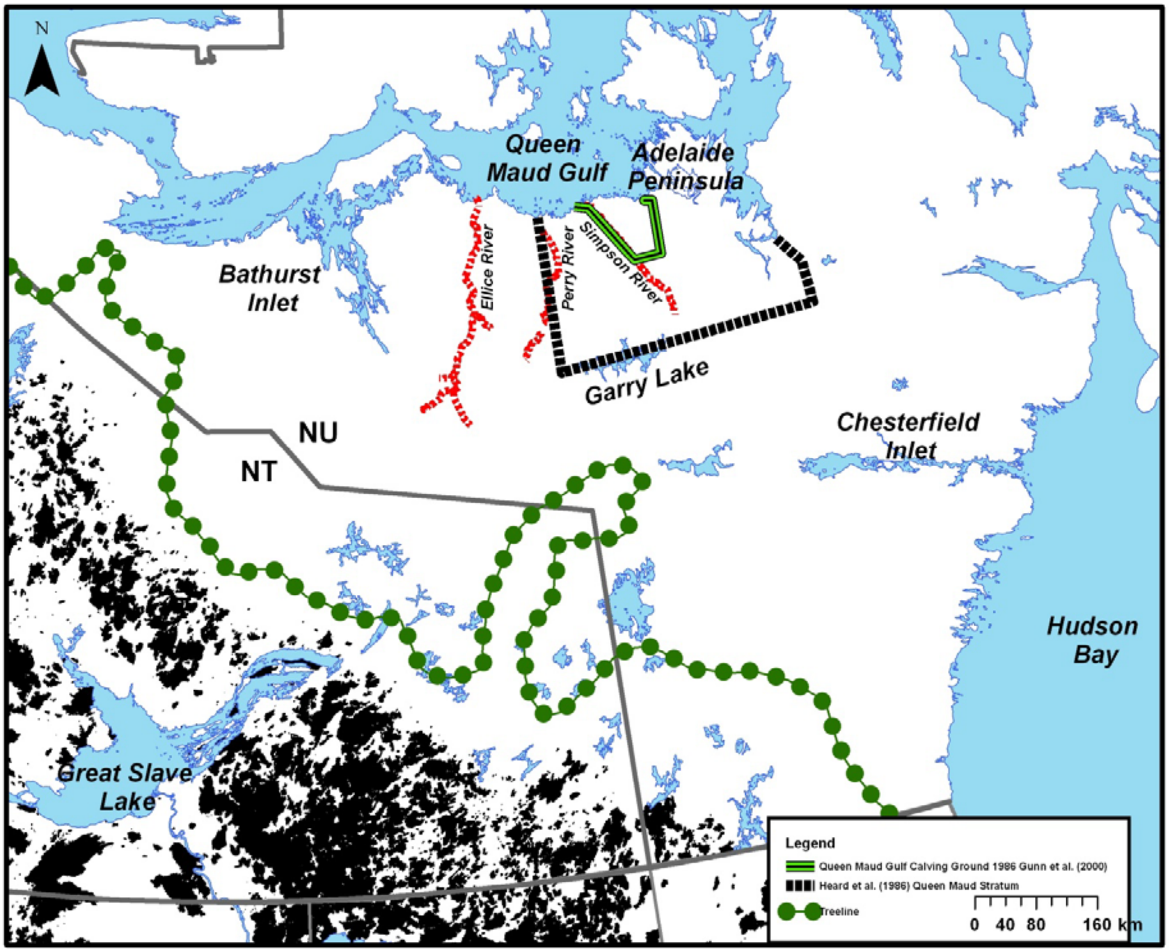


Fig. 1-2. Approximate boundaries of the 1986 Queen Maud Gulf caribou calving ground (Gunn et al. 2000) in relationship to the Queen Maud stratum (stratum 7) surveyed in 1983 and 1995 by Heard et al. (1987) and Buckland et al. (2000), respectively.



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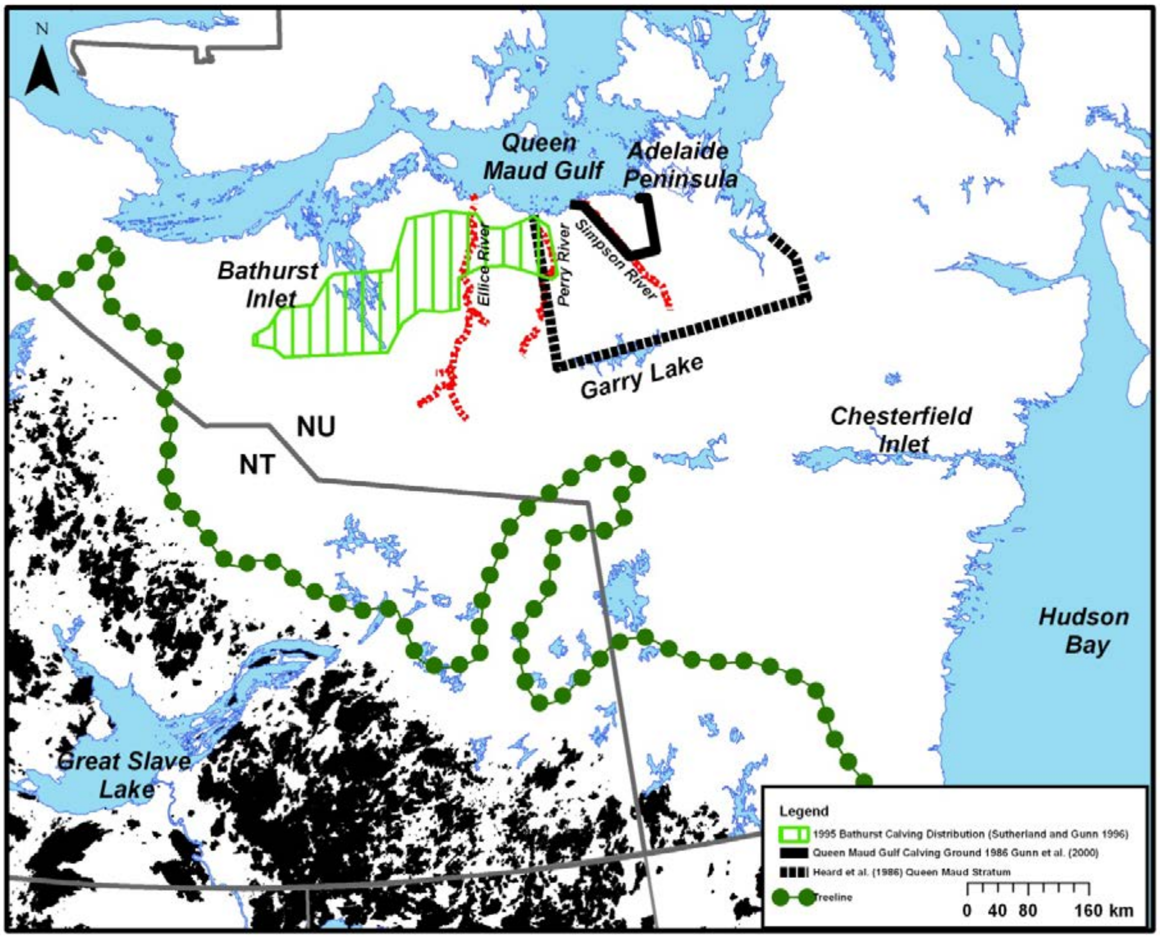

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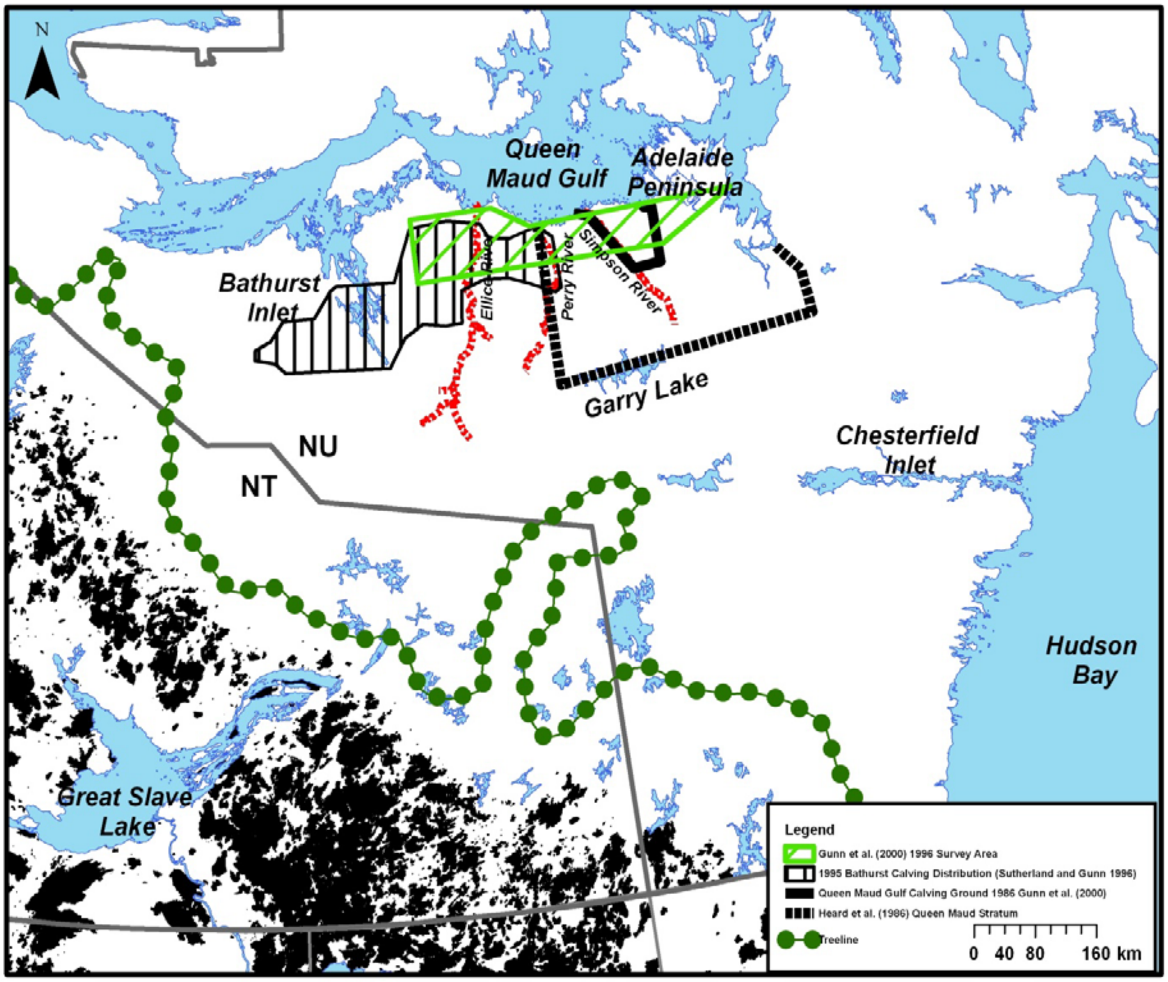

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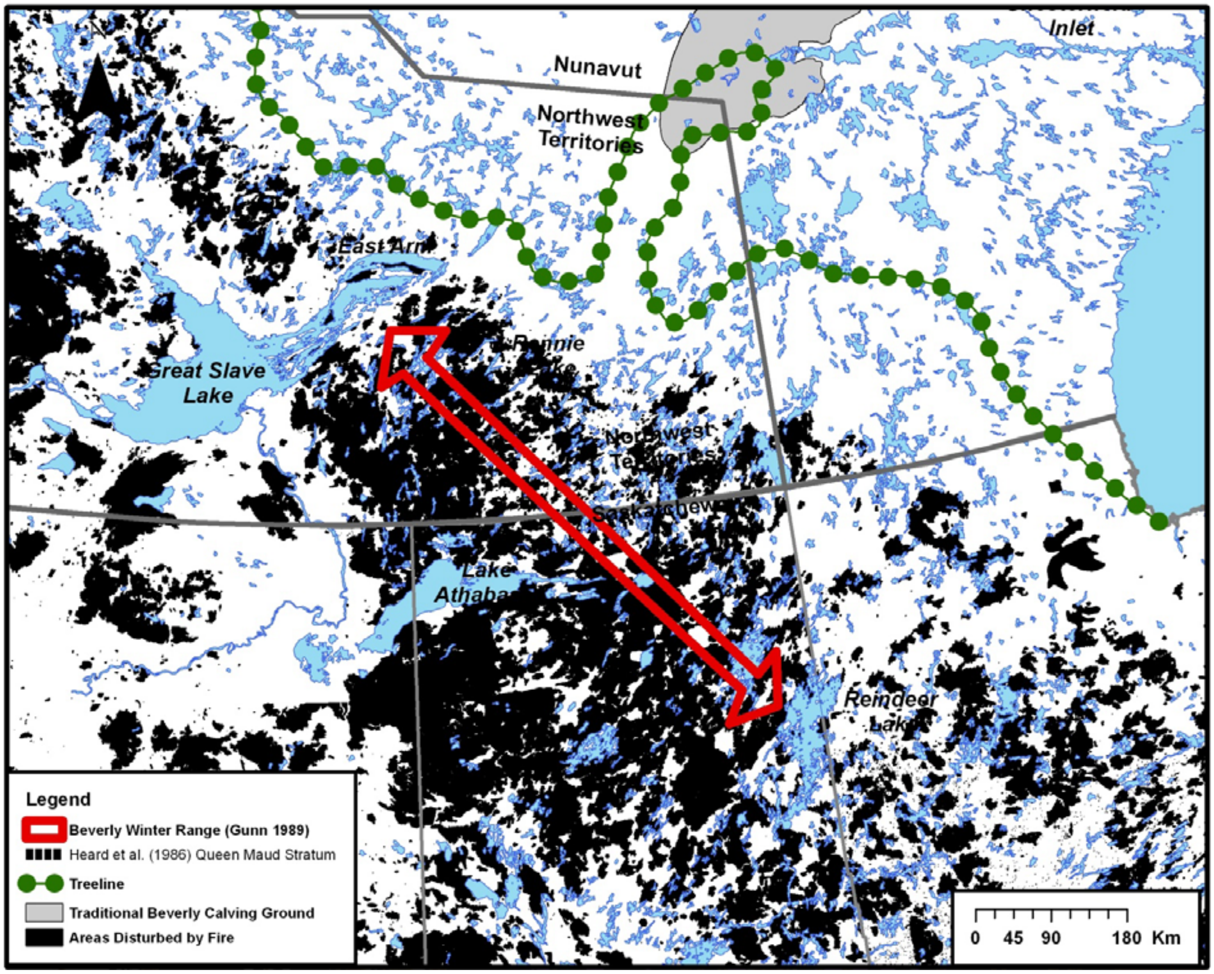

Section 2: Herd structure of caribou on mainland Nunavut and eastern mainland Northwest Territories, Canada

Methods

1) Number of caribou herds

We used location data obtained for barren-ground caribou cows tracked with Doppler shift (DS) and Global Positioning System (GPS) satellite collars (Telonics, Mesa, Arizona, USA and Service Argos, Landover, Maryland, USA) by the governments of the NT and NU during 1993 to 2011. DS and GPS collars provided locations on 1- to 10-day and 0.5- to 1-day intervals, respectively; all data were sub-sampled to one location per day. We projected the longitude and latitude coordinates obtained for each location to the NAD 1983 projection datum of the North America Lambert Conformal Conic coordinate system. We converted longitude and latitude data to *x*, *y* coordinates using Hawth's Tools (Beyer 2007). We divide the data for each year 1993 to 2011 into 26 consecutive 2-week periods (numbered 1 to 26). We aggregated the data across years for each 2-week period for each caribou and calculated median *x*, *y* coordinate using SPSS 11.5 (Chicago, Illinois, USA). We included cows in the analyses if they had x, y coordinate data for each of the 26 2-week periods (52 variables) and used calving grounds D to I during calving (Fig. 2-1), i.e. we excluded individual cows that used calving grounds D and C. The median location was used to account for data asymmetries (Sokal and Rohlf 1998). All geographic information system (GIS) analyses used ArcMap 9.3 (Environmental Systems Research Institute, Inc., Redlands, California, USA).

We used a two step approach to i) identify distinct well organized herds (hereafter "distinct")(Triantafilis et al. 2001) and 2) determine how individuals assigned to each distinct herd were organized (i.e., as robust herds or as individuals)(Nagy et al. 2011, Nagy 2011). Robust herds are formed by caribou that were strongly spatially affiliated throughout the year (e.g., migratory barren-ground caribou) while those that are organized as individuals are comprised of caribou that were largely spatially independent of each other (e.g. some tundra-wintering, Dolphin and Union island, and boreal caribou)(Nagy et al. 2011, Nagy 2011).

In step one, we used sums-of-squares agglomerative hierarchical linkage (Ward's; Bethke et al. 1996) and fuzzy *c*-means clustering (Schaefer et al. 2001) of the 26 2-week interval x, y coordinate data (52 variables) to identify distinct herds (Triantafilis et al. 2001). We conducted hierarchical clustering with PC-ORD 5 (MjM Software Design, Glenden Beach, Oregon, USA) and STATA 9 (STATCORP, College Station, Texas, USA) and used a sharp rise in the values of the post-hierarchical clustering Duda-Hart pseudo t-test to indicate the number of distinct herds (Rabe-Hesketh and Everett 2007). We conducted fuzzy *c*-means clustering with the program FUZME 2.0 (Minasny and McBratney 2002) using the diagonal distance transformation option to standardize measurements to equal variance and prevent *y*-coordinates from dominating *x*-coordinates. We specified fuzzy exponents (*m*) in increments of 0.1 from 1.5 to 3.0 (Odeh et al. 1992b) and 2-15 potential herds and used the fuzzy performance index (FPI) and normalized classification entropy (NCE) validity functions to identify the optimal number of herds (Odeh et al. 1992a). Herds were distinct when the post-hierarchical clustering Duda-Hart pseudo t-test and the validity functions indicated the same number of herds (Schaefer et al. 2001), ≥90% of the individuals were assigned to the same herds by hierarchical and fuzzy (m=2.0) clustering, and ≥90% of the individuals were consistently assigned to the same herd by fuzzy clustering for most values of *m*. Assignment consistency was determined by comparing each individuals assignment at m=2.0 (moderate level of fuzziness) with those at m=1.5-1.9 (less fuzzy) and m=2.1-3.0 (more fuzzy).

In step two, we conducted fuzzy *c*-means clustering on the 26 2-week interval *x*, *y* coordinate data (52 variables) for individuals that were assigned to each distinct herd for m=2.0 in step one. We specified fuzzy exponents (*m*) in increments of 0.1 from 1.5 to 3.0 (Odeh et al. 1992b) and 2-15 potential herds for migratory and 2-*n* potential herds for tundra-wintering barren-ground caribou. Herds were robust when the validity functions were ≥0.90 for most $m \geq 2.0$ indicating that there were no significant substructures in the data. If significant substructures were found and sample sizes were adequate, we repeated step two on the data for individuals assigned to each herd for m=2.0 until the analyses indicated they were robust or organized as individuals (Nagy et al. 2011).

The program FUZME 2.0 (Minasny and McBratney 2002) calculates the probability that an individual belongs to the herd to which it was assigned and to all other herds identified. For each step of the analyses we used analysis of variance (ANOVA) and Tukey's honestly significantly different (HSD) pairwise comparisons (SPSS 11.5, Chicago, Illinois, USA) to determine if the probability that all individuals assigned to a herd at m=2.0 was significantly different from their probability of membership in other herds identified.

2) Annual and seasonal movements

We mapped the annual paths (1 March to 28 February) taken by each caribou each year in each herd and paths taken during the calving (4-24 June), summer (4 July to 21 September), fall (22 September-17 October), rut (18 October-4 November), winter (1 December-31 March), April (1-30), May (1-31) periods. We mapped the annual paths for 1 March to 28 February because most caribou were captured in March and this allowed us to maximize use of the data. We mapped paths to show the variation in movements that occurred within herds in April to coincide with the periods when Gunn et al. (2000) collared caribou east of Bathurst Inlet and in May to coincide with the time periods when Heard et al. (1986) and Buckland et al. (2000) conducted surveys in the Queen Maud stratum in 1983 and 1995, respectively. All paths were created using Hawth's tools (Beyer 2007).

3) Variation in winter range use by migratory barren-ground caribou

Some Bathurst (n=4) and Qamanirjuaq (n=4) caribou were tracked for 4-5 and 4-6 years, respectively. We created minimum convex polygons (MCPs) around the calving and winter locations of these cows to show the variation in areas they used during these periods.

4**) Caribou that wintered below and above treeline**

Some migratory and tundra-wintering barren-ground caribou used winter ranges below and above treeline. We mapped the annual winter distributions of some of these cows to show the variations that occurred.

Results

1) Number of caribou herds

A total of 306 barren-ground caribou cows that used calving grounds D-I (Fig. 2-1) were tracked with satellite collars on mainland NU and eastern mainland NT in 1993-2010. We obtained at least one full year of location data (i.e., 26 two-week interval x, y coordinates) for 232 of these cows (Fig. 2-2).

i) Cluster analysis step one

In cluster analysis step one the post-hierarchical clustering Duda-Hart pseudo t-test indicated four to eight groups of caribou (Table 2-1) while fuzzy clustering revealed three groups (Table 2-2). However, both methods indicated three major groups of caribou including: i) migratory caribou that primarily used calving grounds D, E-1, and F (Bathurst/Beverly group, n=108), ii) migratory caribou that primarily used calving ground G (Qamanirjuaq group, n=67), and iii) non migratory caribou that primarily used calving grounds E, H, and I (tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay group; n=57; Fig. 2-3 and 2-4).

For fuzzy clustering in step one, a total of 230 of 232 caribou (>99%) were consistently assigned to the same groups for all values of the fuzzy exponent *m* (1.5-3.0) indicating that, at this geographic scale, there were three distinct groups of caribou. The mean probability of group membership was significantly higher for caribou that were assigned to the Qamanirjuaq (87%) than the Bathurst/Beverly (82%) or tundra-wintering groups (78%; ANOVA $F_{2,229}$=9.408, P<0.001; Tukey's HSD pairwise comparisons P<0.05; Table 2-3) indicating that there was more variation in area use by Bathurst/Beverly and tundra-wintering than Qamanirjuaq caribou. Caribou assigned to the Bathurst/Beverly group had a significantly higher probability of belonging to that group than to the Qamanirjuaq (9%) or tundra-wintering (9%) groups

(ANOVA $F_{2,321}$=2214.489, P<0.001; Tukey's HSD pairwise comparisons P<0.05). Similarly, caribou assigned to the Qamanirjuaq group had a significantly higher probability of belonging to that group than the Bathurst/Beverly (7%) or tundra-wintering (6%) groups (ANOVA $F_{2,198}$=2482.340, P<0.001; Tukey's HSD pairwise comparisons P<0.05) and, caribou assigned to the tundra-wintering group had a significantly higher probability of belonging to that group than the Bathurst/Beverly (13%) or Qamanirjuaq (9%) groups (ANOVA $F_{2,168}$=929.037, P<0.001; Tukey's HSD pairwise comparisons P<0.05; Table 2-3).

ii) Cluster analysis step two: fuzzy clustering of data for group i) Bathurst/Beverly caribou

In cluster analysis step two fuzzy clustering revealed two groups of caribou in the Bathurst/Beverly group, i.e., the Bathurst and Beverly herds (Table 2-4; Fig. 2-5 and 2-6). A total of 108 of 108 of the caribou in the Bathurst/Beverly group (100%) were consistently assigned to the Bathurst or Beverly herd for all values of fuzzy exponent m (1.5-3.0) indicating that, at this geographic scale, these herds were distinct. The mean probability of group membership was significantly higher for caribou that were assigned to the Bathurst (85%) than the Beverly group (79%; ANOVA $F_{2,321}$=2214.489, P<0.001; Table 2-3), however this difference may be due in part to the fact that we excluded cows from this analysis that mainly used calving ground D but also used calving ground C at least once. Caribou assigned to the Bathurst group had a significantly higher probability of belonging to that than the Beverly group (15%; ANOVA $F_{1,168}$=1223.826, P<0.001; Table 2-3); those assigned to the Beverly group had a significantly higher probability of belonging to that than the Bathurst group (21%; ANOVA $F_{1,110}$=886.531, P<0.001; Table 2-3). Fuzzy clustering of the data for caribou assigned to the Bathurst (Table 2-5) and Beverly (Table 2-6) groups revealed that each herd was robust.

iii) Cluster analysis step two: fuzzy clustering of data for group ii) Qamanirjuaq caribou

In step two fuzzy clustering of the data for caribou assigned to the Qamanirjuaq group revealed that they formed a robust herd (Table 2-7, Fig. 2-7).

iv) Cluster analysis step two: fuzzy clustering of data for group iii) tundra-wintering caribou

In cluster analysis step two fuzzy clustering revealed three herds of caribou in the tundra-wintering group, i.e. the Queen Maud Gulf, Lorillard, and Wager Bay herds (Table 2-8, Fig. 2-8 and 2-9). A total of 56 of 57 caribou (>98%) were consistently assigned to the same herd for all values of the fuzzy exponent *m* (1.5-3.0) indicating that these were distinct herds. The mean probability of group membership was significantly higher for caribou that were assigned to the Lorillard (84%) than to the Queen Maud Gulf (71%) or Wager Bay (65%) herds (ANOVA $F_{2,54}$=9.112, P<0.001; Tukey's HSD pairwise comparisons P<0.05; Table 2-3) suggesting that there was more variation in area use by Queen Maud Gulf and Wager Bay than Lorillard caribou. Caribou assigned to the Queen Maud Gulf herd had a significantly higher probability of belonging to that than the Lorillard (15%) or Wager Bay (14%) herds (ANOVA $F_{2,66}$=280.263, P<0.001; Tukey's HSD pairwise comparisons P<0.05 Table 2-3). Similarly, caribou assigned to the Lorillard herd had a significantly higher probability of belonging to that than the Queen Maud Gulf (7%) or Wager Bay (9%) herds (ANOVA $F_{2,54}$=313.622, P<0.001; Tukey's HSD pairwise comparisons P<0.05) and, those assigned to the Wager Bay herd had a significantly higher probability of belonging to that than the Queen Maud Gulf (14%) or Lorillard (21%) herds (ANOVA $F_{2,42}$=97.645, P<0.001; Tukey's HSD pairwise comparisons P<0.05; Table 2-3).

Fuzzy clustering of data for caribou assigned to the Queen Maud Gulf herd revealed that these cows were not strongly spatially affiliated (the validity functions minimized at 23 or the total number of caribou in the group for 10 of the 16 values of the fuzzy exponent *m*; Table 2-9), those in the Lorillard herd formed a robust herd (Table 2-10), and those in the Wager Bay herd were not strongly spatially affiliated (validity functions minimized at 15 or the total number of caribou in the group for 9 of the 16 values of the fuzzy exponent *m*; Table 2-11). This suggests that the spatial organization of Queen Maud Gulf and Wager Bay caribou is different from that of caribou in the tundra-wintering Lorillard and migratory Bathurst, Beverly, and Qamanirjuaq herds.

v) Hierarchical vs fuzzy classification

In step one the post-hierarchical clustering Duda-Hart pseudo t-test indicated four to eight herds (Table 2-1) while fuzzy clustering steps one and two revealed six herds. For six herds, both clustering methods assigned 95.7% (222/232) of individual caribou to the same herds (Table 2-12). Both methods assigned the same individuals to the Bathurst (n=52), Qamanirjuaq (n=63), and Wager Bay (n=11) herds (Table 2-12). In comparison, for the caribou assigned to the Beverly (n=57), Lorillard (n=21), and Queen Maud Gulf (n=28) herds by hierarchical clustering, fuzzy clustering assigned 3 Beverly to the Qamanirjuaq herd, 2 Lorillard to the Qamanirjuaq (n=1) and Wager Bay (n=1) herds, and 5 Queen Maud Gulf to the Beverly (n=2) and Wager Bay (n=3) herds (Table 2-12).

2) Annual and seasonal movements

The annual movements (1March to 28 February) of cows tracked in each herd during 1996 /1997 to 20010/2011 are shown in Figs. 2-10 to 2-24. All herds had at least one satellite collared cow in years 2002/2003 to 2006/2007. The winter paths of cows tracked in each herd during 1996 /1997 to 20010/2011 are shown in Figs. 2-25 to 2-39. Note the east-west variation in winter range use by Bathurst and Qamanirjuaq cows and the north to south variation in winter range use by Beverly cows. Also note that some satellite collared Bathurst and Qamanirjuaq cows were on the Beverly winter range (between Great Slave Lake and Reindeer Lake) during four winters (1997/1998 Fig. 2-26, 1999/2000 Fig. 2-28, 2004/2005 Fig. 2-33, and 2007/2008 Fig. 2-36). Similarly some satellite collared Bathurst cows were on the Beverly winter range during three winters (1998/1999 Fig. 2-27, 2000/2001 Fig. 2-29, and 2005/2006 Fig. 2-34). In addition, some satellite collared Qamanirjuaq cows were on the Beverly winter range during five winters (2001/2002 Fig. 2-30, 2002/2003 Fig. 2-31, 2003/2004 Fig. 2-32, 2006/2007 Fig. 2-35, and 2010/2011 Fig. 2-39).

The paths of cows in each herd for each activity period are given in Figs. 2-40 to 2-46. Note the concentration of paths of cows in the tundra-wintering herds (Queen Maud Gulf, Lorillard, and Wager Bay) in the central barrens between Chesterfield Inlet and Bathurst Inlet during winter (Fig. 2-44). The area includes Garry Lake and the “traditional” Beverly calving ground. Also note the concentration of paths of cows in the tundra-wintering herds in the Garry

Lake/“traditional” Beverly calving ground area during April (Fig. 2-=45). In addition, note that the paths of the Beverly cows are oriented toward the Garry Lake/“traditional” Beverly calving ground in April (Fig. 2-45) and by May (Fig. 2-46) the paths are oriented almost due north and heading toward the western Queen Maud Gulf coast east of Bathurst Inlet.

We mapped all paths used by Bathurst (Fig. 2-47), Beverly (Fig. 2-48), Qamanirjuaq (Fig. 2-49), Queen Maud Gulf (Fig. 2-50), Lorillard (Fig. 2-51), and Wager Bay (Fig. 2-52) satellite collared cows. Note that the map showing the paths used by Bathurst cows excludes Bathurst cows that also used the calving ground of the Bluenose-East herd (calving ground C, Fig. 2-1); those cows were not included in our cluster analyses.

3) Variation in winter range use by migratory barren-ground caribou

The winter and calving ranges used by four Bathurst (tracked 4-5 years) and four Qamanirjuaq cows (tracked 4-6 years) are shown in Fig. 2-53 to 2-60, indicating that there was large variation in areas used during winter by these cows. Note that one Qamanirjuaq cow wintered above treeline during 1 of the 6 winters it was tracked (Fig. 2-58).

4) Migratory barren-ground caribou wintering above treeline; tundra-wintering caribou wintering below treeline

Bathurst cows BG184, BG194, and BG198 wintered on the tundra north of Contwoyto Lake in 2008; BG184 and BG194 were collared during winter 2004 and tracked for five winters and BG198 was collared in winter 2006 and tracked for three winters (Fig. 2-61, 2-62, and 2-63). BG184 and BG194 wintered on the tundra during one of five winters and BG198 for one of three winters they were tracked.

Qamanirjuaq cows QA_62 and QA_73 (Fig. 2-65 and 2-66) were captured on the tundra south of Chesterfield Inlet near Hudson Bay in winter 1997. Cow QA_62 was below treeline in winters 1998 and 1999. Cow QA_73 was tracked for 7 winters; it was below treeline during winters 1998 and 1999, it was above treeline north of Garry Lake in winter 2000, and then was below treeline in winters 2001, 2002, and 2003. Qamanirjuaq cow QA_113 was captured below treeline during winter 2004, was below treeline in winter 2005, and was then on the tundra near Chesterfield Inlet in winter 2006.

Queen Maud Gulf cow QMG_172 was tracked for 5 winters (Fig. 2-68); it was at or above treeline during all winters 2004 to 2009 except 2007 when it was below treeline near the Saskatchewan border north of Lake Athabasca.

Conclusions

Our analyses indicate that mainland NU and eastern mainland NT are occupied by four robust barren-ground caribou herds including the migratory Bathurst, Beverly, and Qamanirjuaq and tundra-wintering Lorillard herds. In addition there were two distinct herds of tundra-wintering caribou including the Queen Maud Gulf and Wager Bay herds. Maps of annual paths of satellite collared cows show that there is some overlap in range use during most years among herds indicating that these herds are not closed and there are no fixed boundaries between them.

The north-south variation in winter range use and high frequency of use of areas above treeline by Beverly cows may be a result of the impacts of fire disturbance and the high frequency of occurrence of Bathurst and Qamanirjuaq caribou on the Beverly winter range. The shift in calving ground use by the Beverly herd from its “traditional” to the western Queen Maud Gulf area may have been influenced by the winter distribution and April and May spring migration of the Bathurst herd and the April and May range use patterns of the tundra-wintering herds.

There was large annual variation in the areas used by individual migratory barren-ground caribou cows during winter. In addition, some migratory and tundra-wintering barren-ground caribou used winter ranges above and below treeline; some Bathurst and Qamanirjuaq cows that were tracked for >3 years wintered above treeline during at least one winter and one Queen Maud Gulf cow was below treeline during one of the six winters it was tracked. This indicates that all barren-ground caribou found below treeline during winter do not necessarily belong to the migratory ecotype; all barren-ground caribou found above treeline during winter do not necessarily belong to the tundra-wintering ecotype. Further, these results indicate that we should not use short-term data (≤2 years) to reliably conclude that a cow or herd has changed behaviour because it wintered below treeline one year and then above treeline the next, or vice versa. If one selected data for pairs of successive winters for Bathurst cows BG184, BG194, and BG198 or Qamanirjuaq cows QA_62, QA_73, and QA_113 or Queen Maud Gulf cow QMG_172 and assumed that these cows or the herds to which they belonged changed behavior when shifts in winter ranges use from above to below treeline or vice versa occurred, then some of these cows/herds would have changed behavior multiple times during the years they were tracked. Long-term tracking data are required to document the distribution and movements of caribou in a herd in order to determine whether shifts in distribution or behaviour have occurred.

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Fig. 2-1. Barren-ground, Dolphin and Union island, and boreal caribou calving grounds or sites in the Northwest Territories, Nunavut, and northern Alberta (Nagy et al. 2011, Nagy 2011).

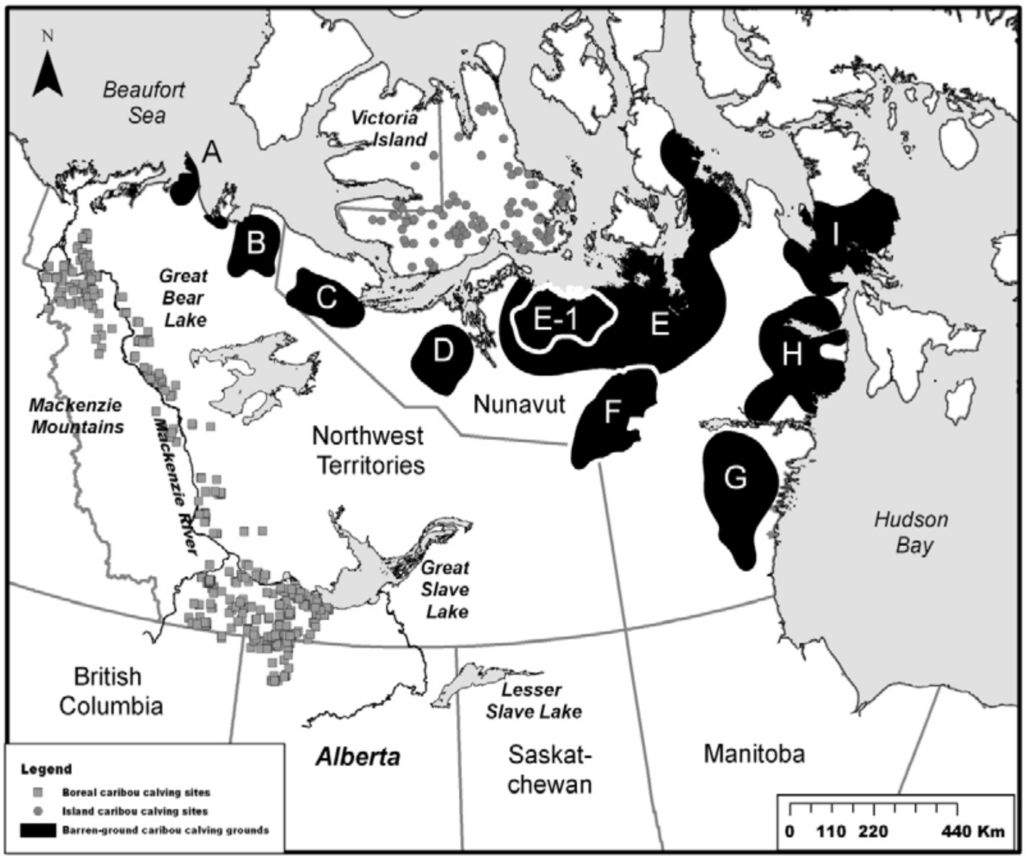
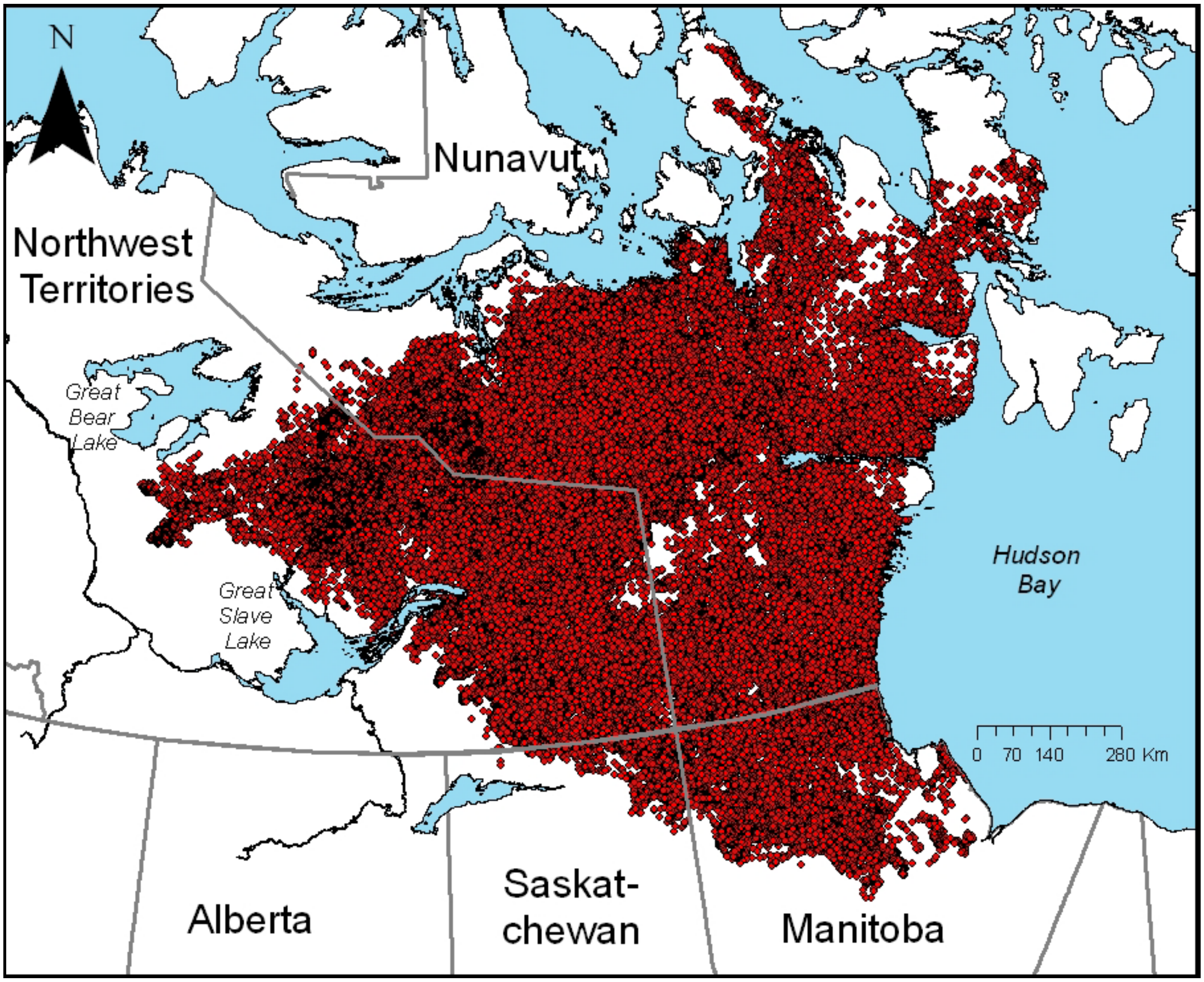


Fig. 2-2. Distribution of 232 migratory and tundra-wintering barren-ground caribou cows included in hierarchical and fuzzy cluster analysis of herd structure on mainland Nunavut and eastern Northwest Territories.



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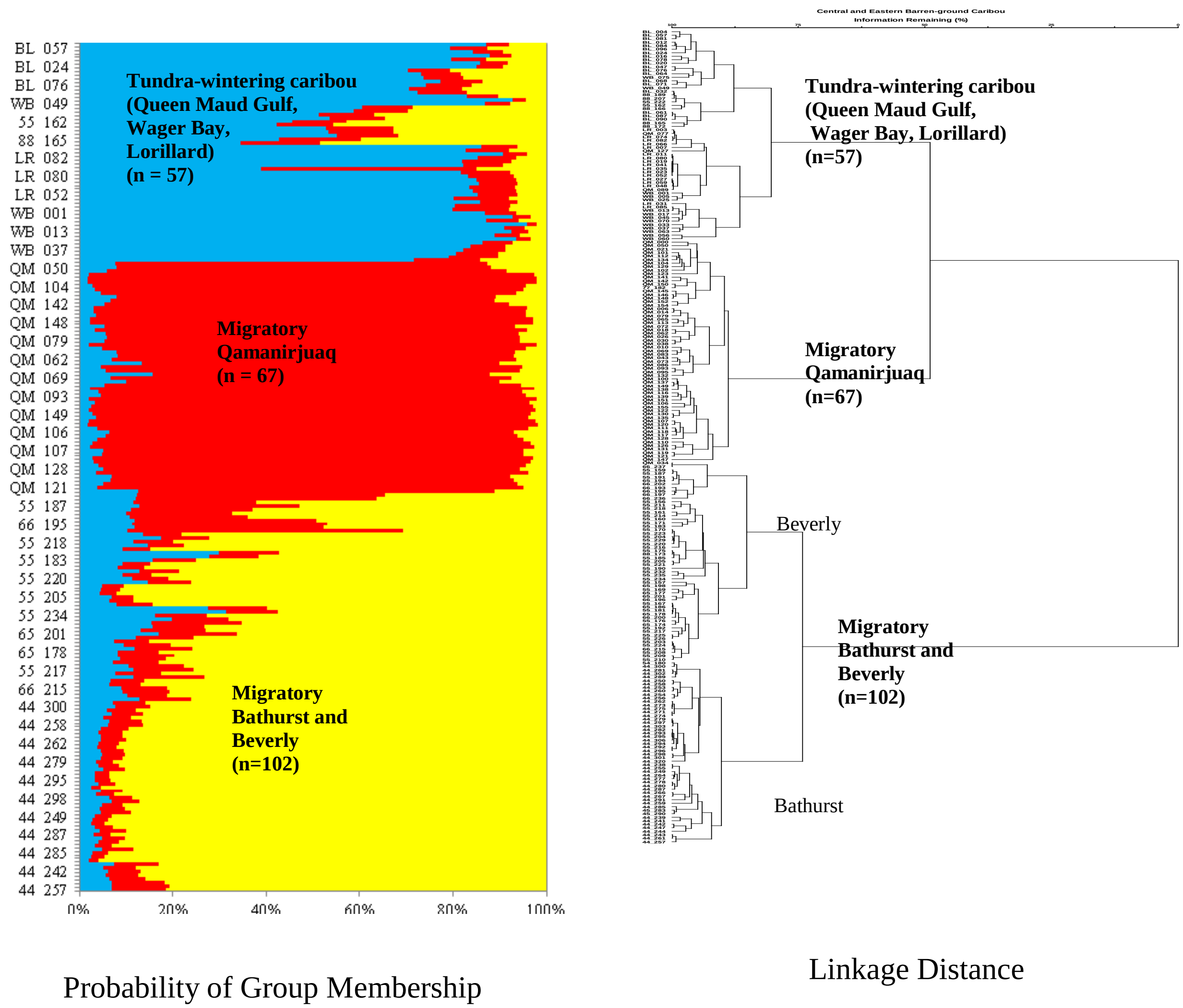

Fuzzy *c*-Means Clustering

Hierarchical Clustering

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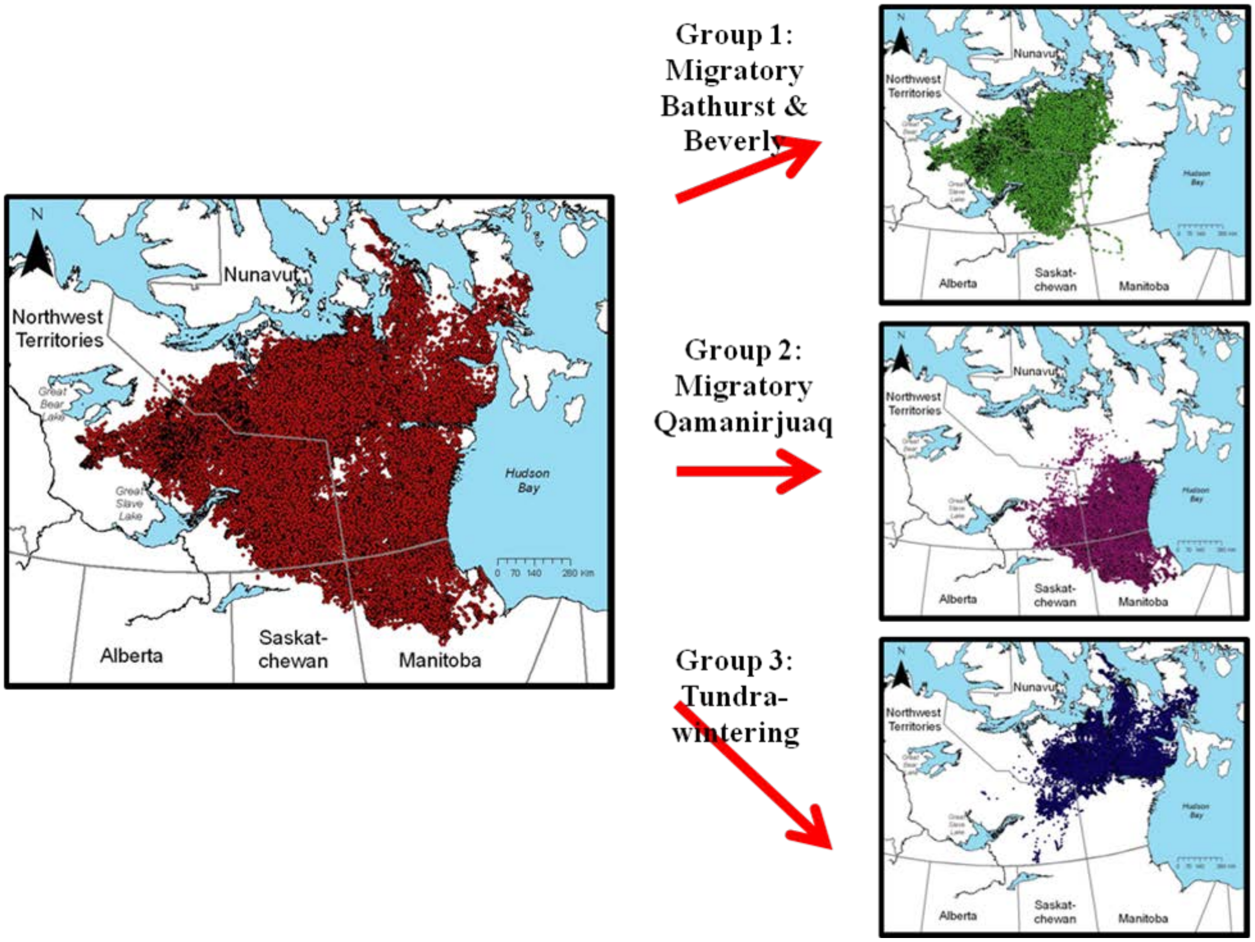
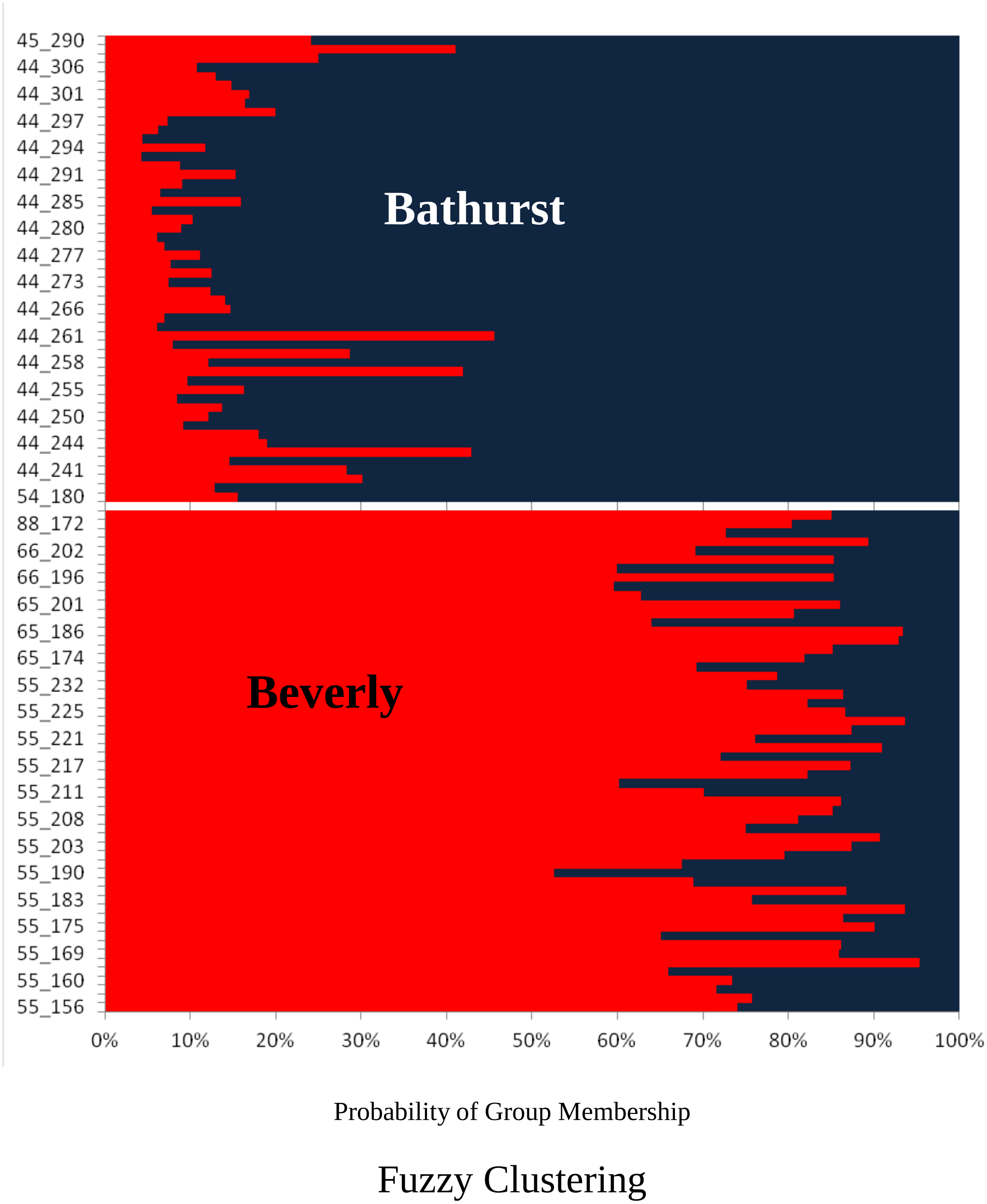


Fig. 2-5. Step 2 fuzzy *c*-means clustering of 2-week interval *x*, *y* coordinate data for step 1 group 1 caribou revealed the migratory Bathurst and Beverly barren-ground caribou herds. The Bathurst and Beverly herds were robust. Values on the y-axis are individual caribou id numbers.



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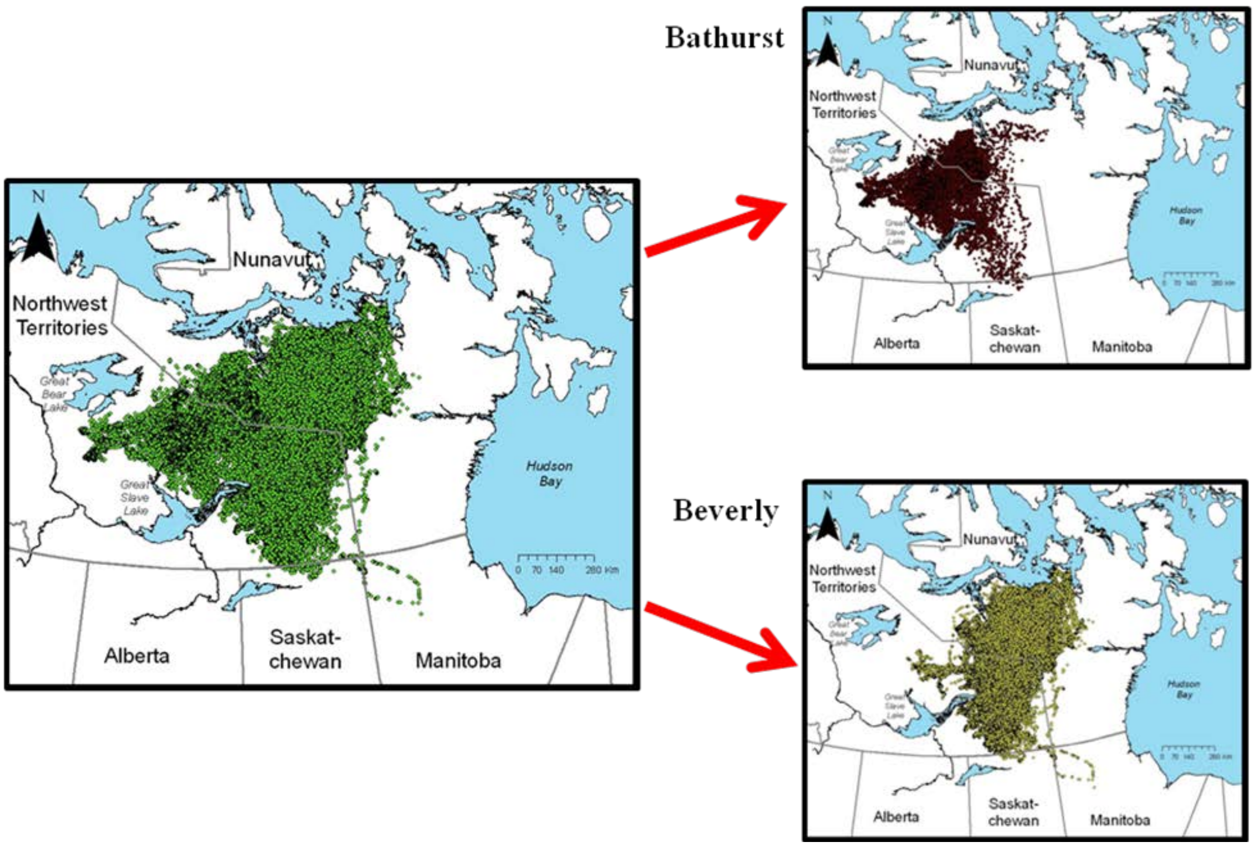

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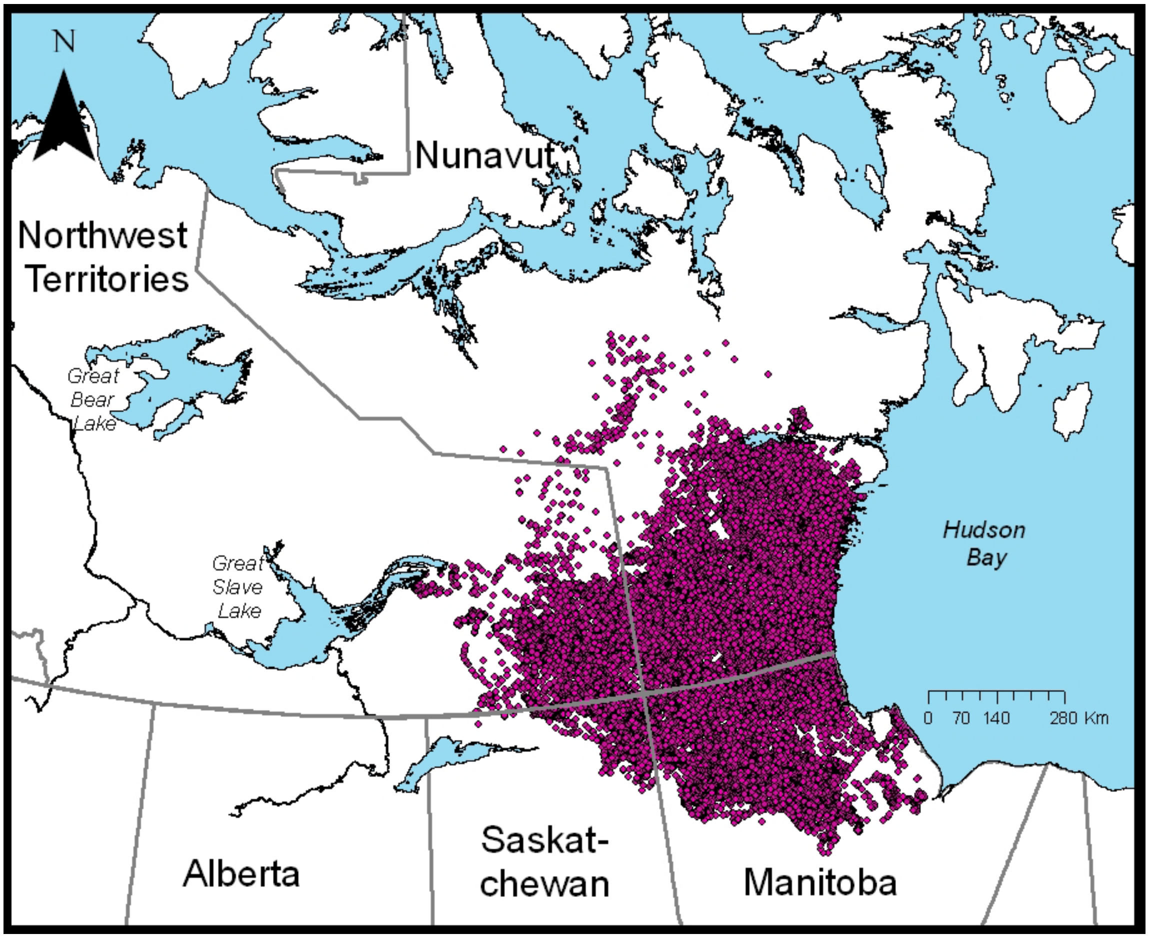

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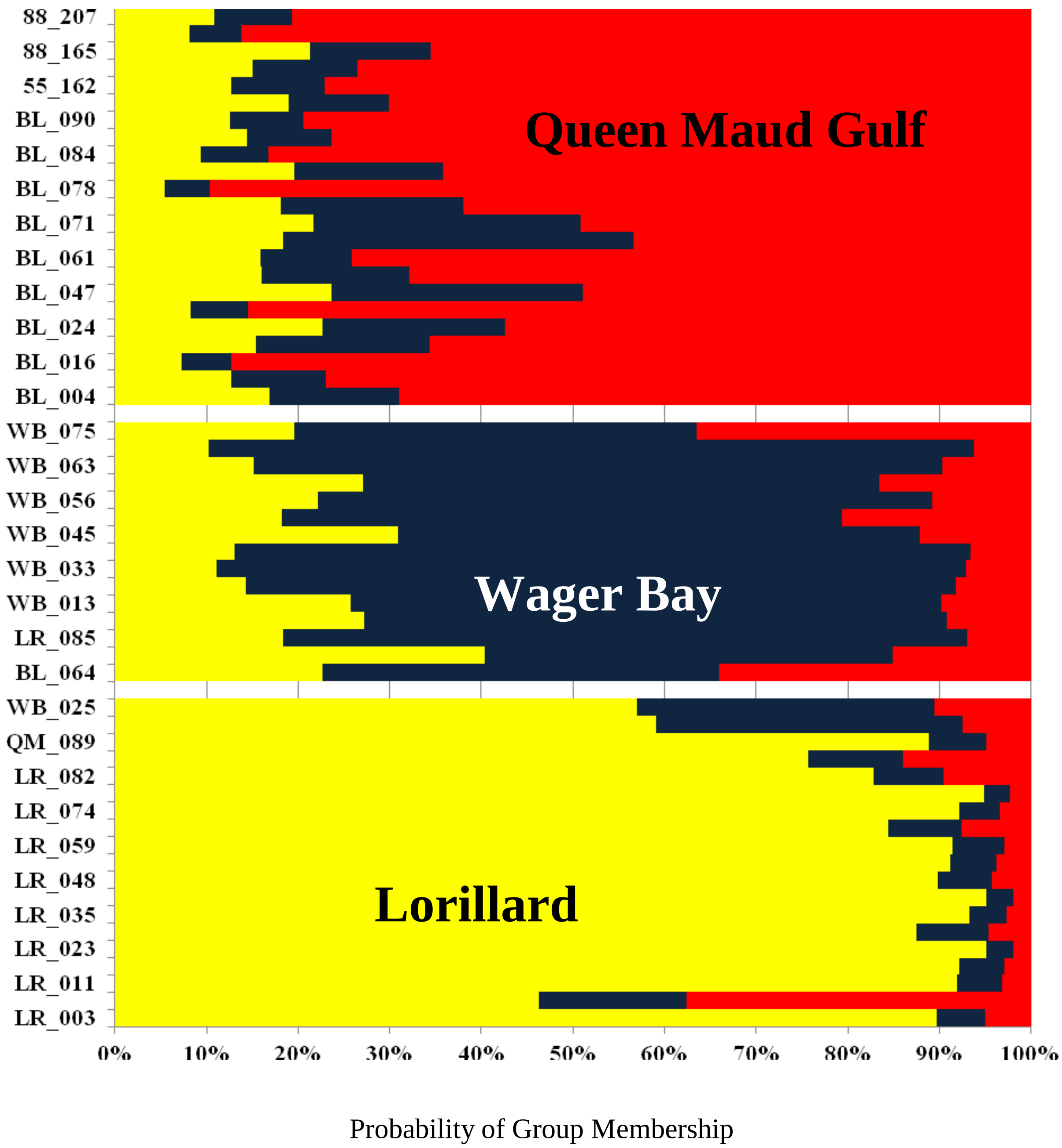

Fuzzy Clustering

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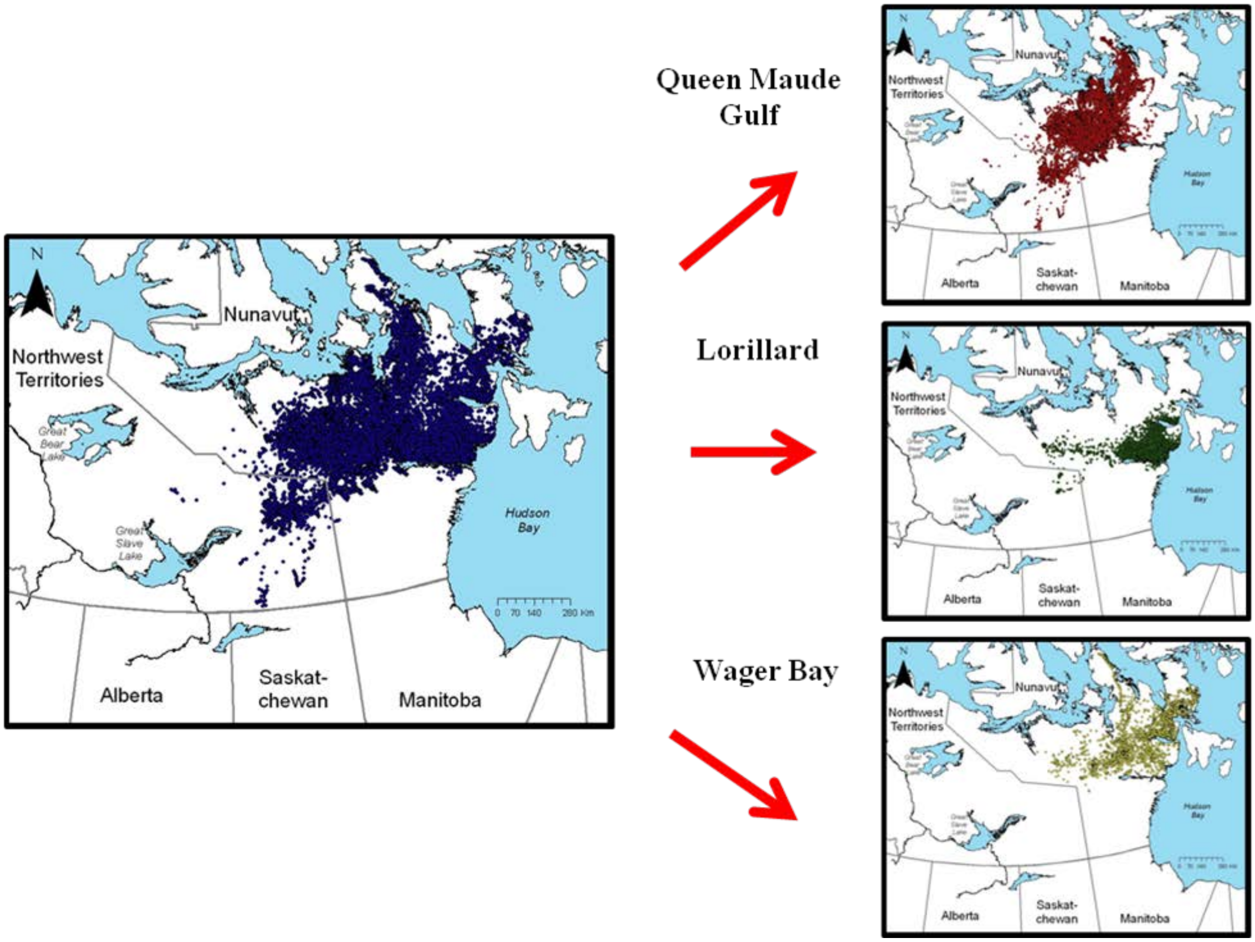

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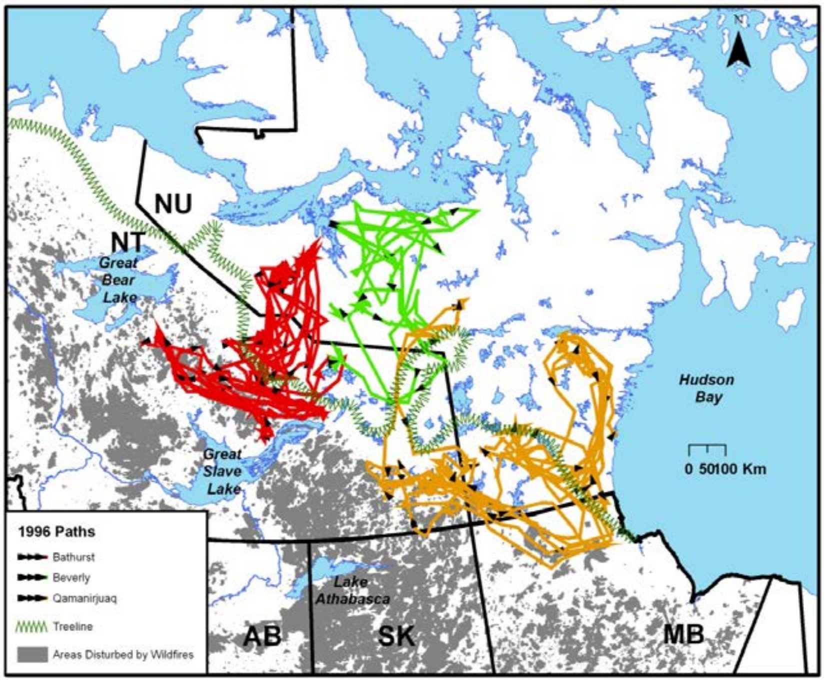

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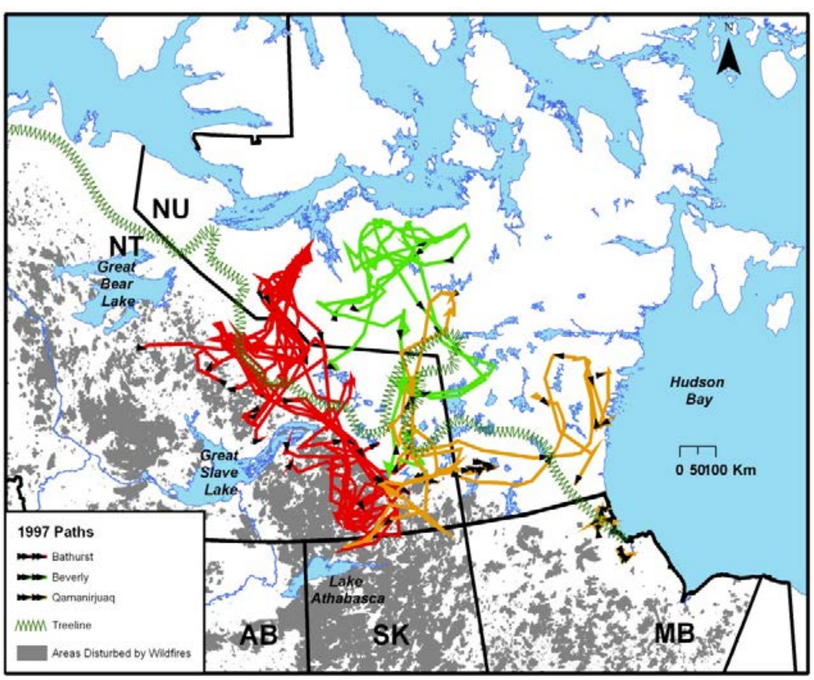

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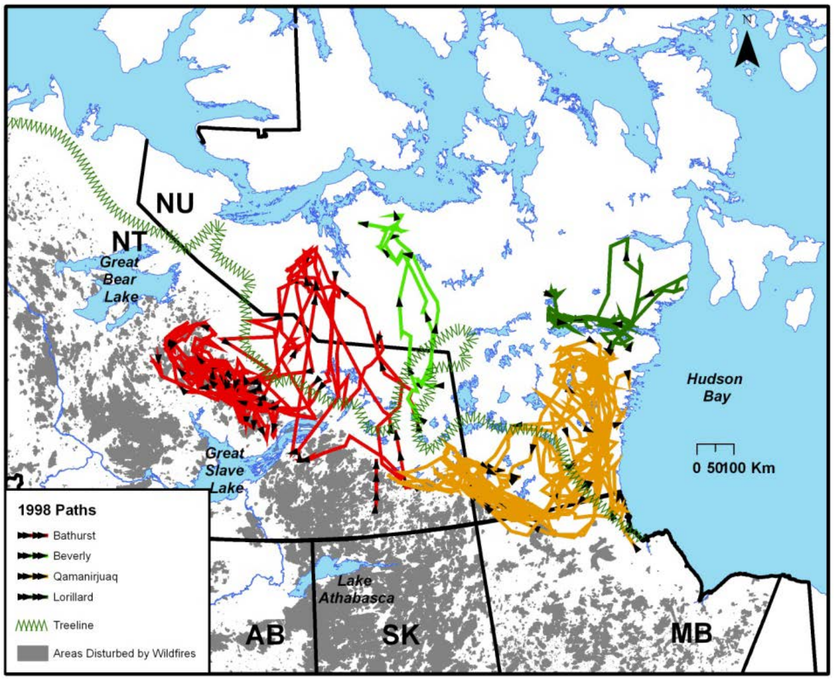

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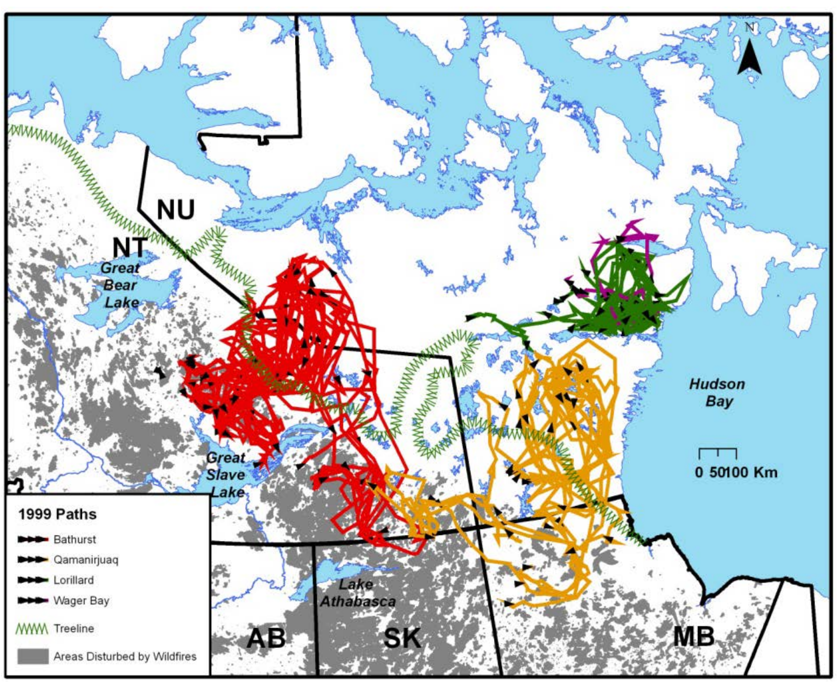

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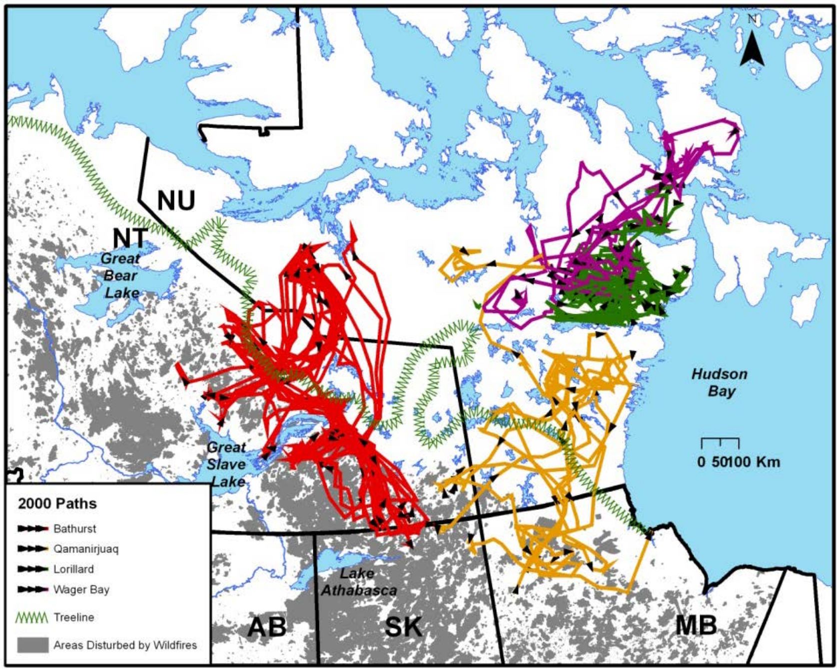

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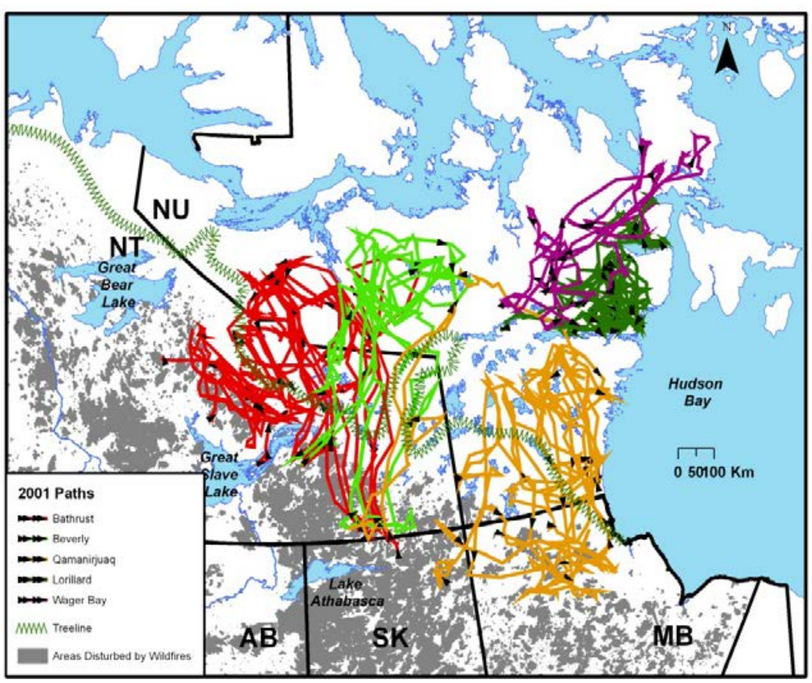

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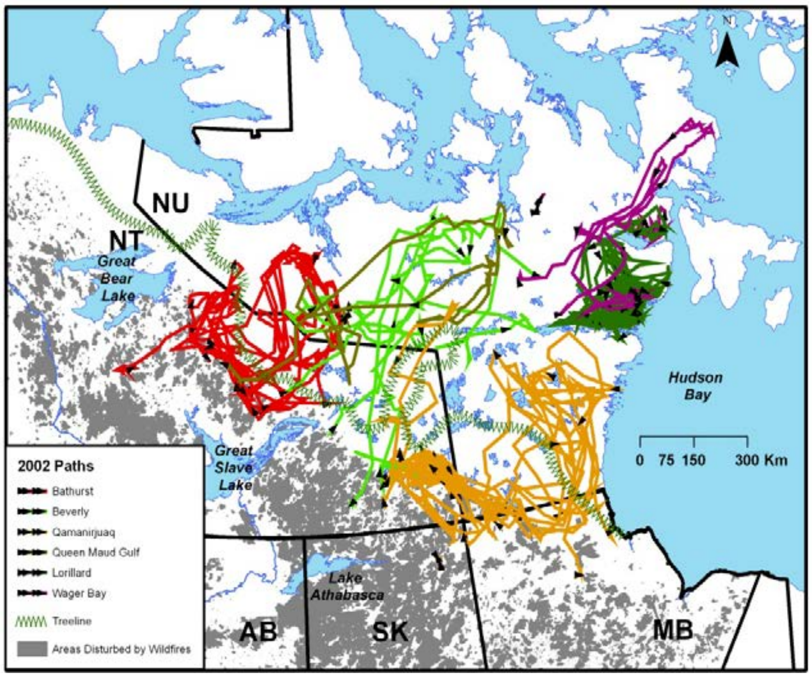

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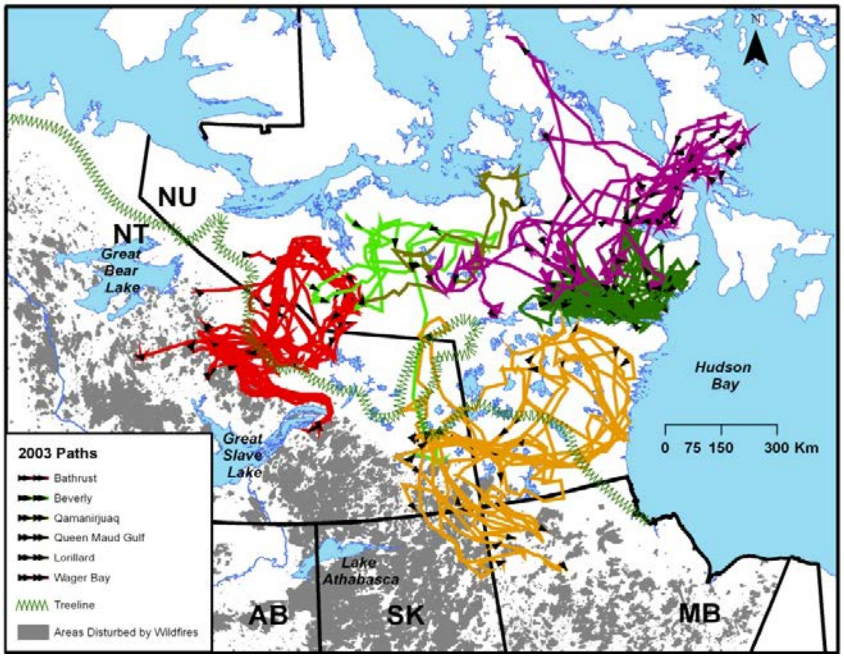

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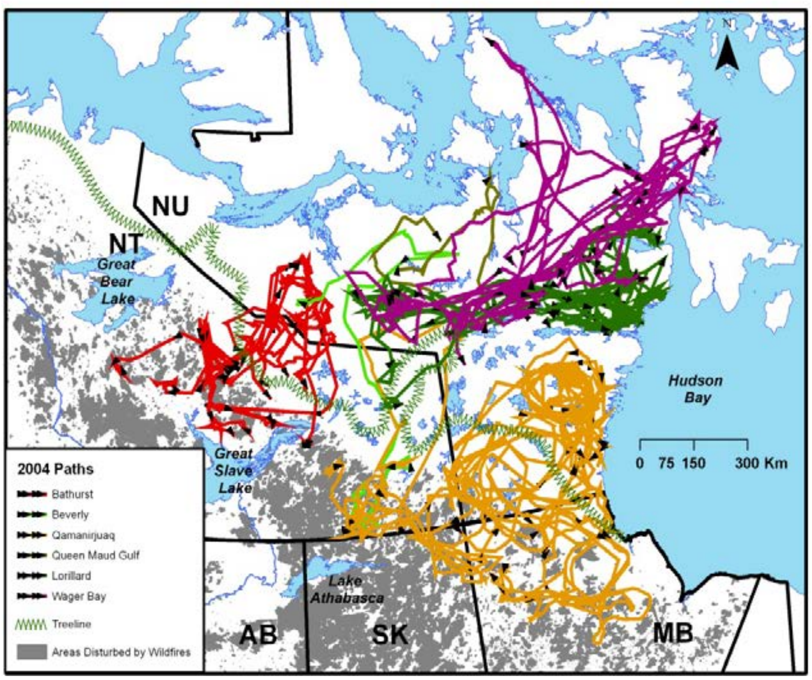

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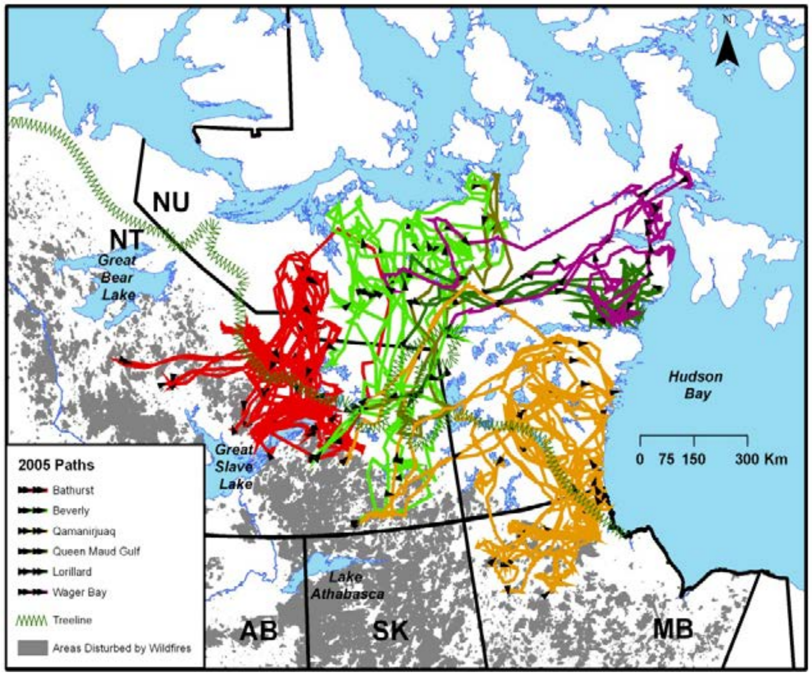

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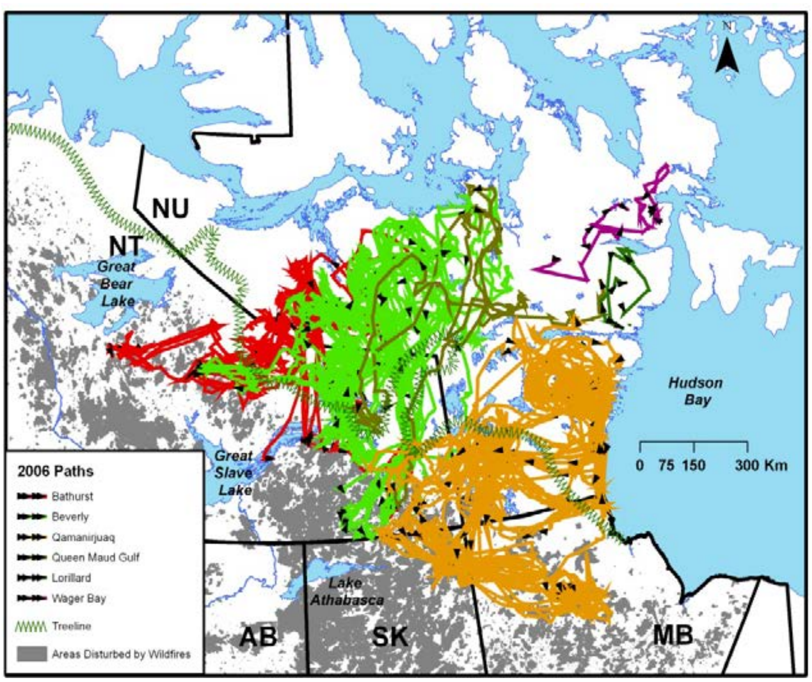

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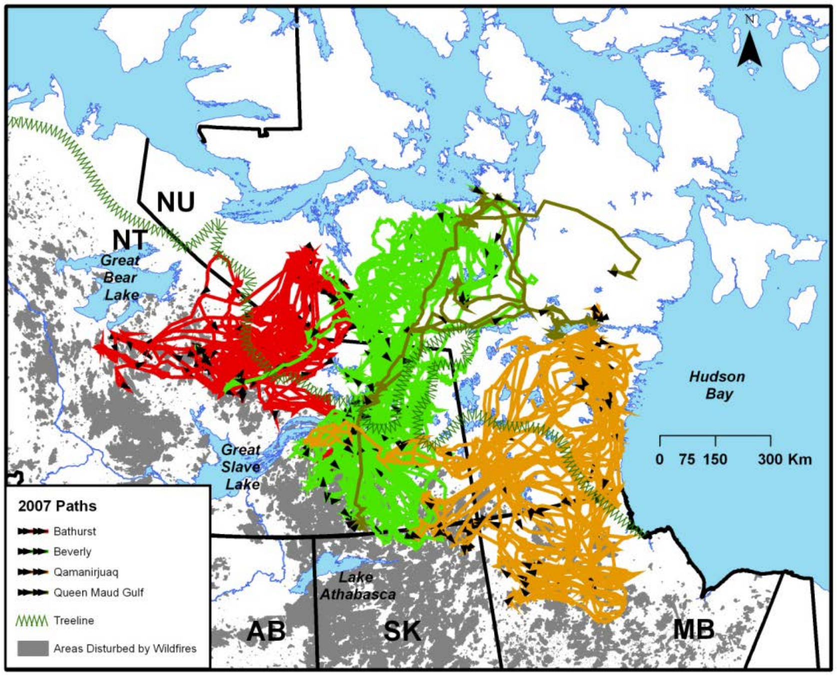

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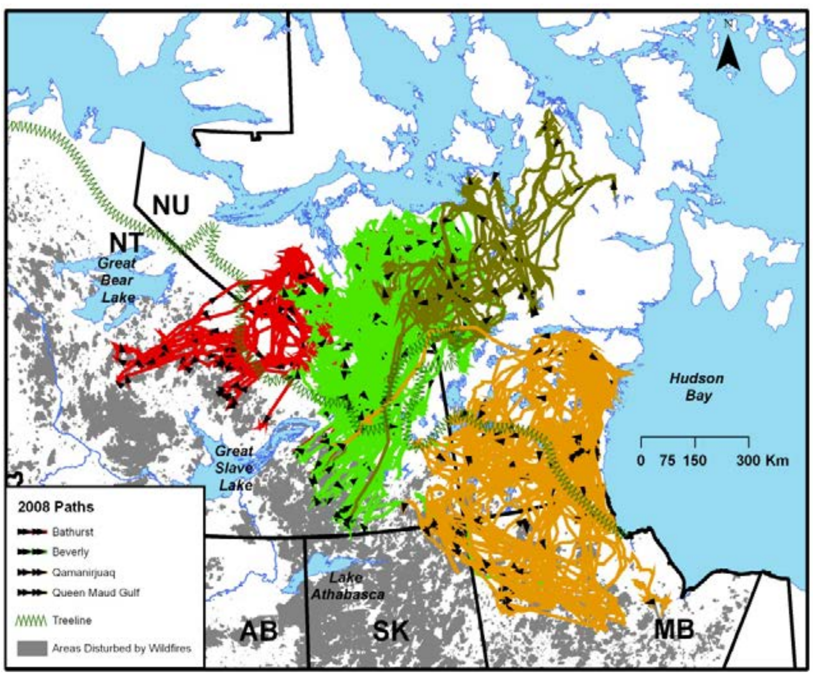

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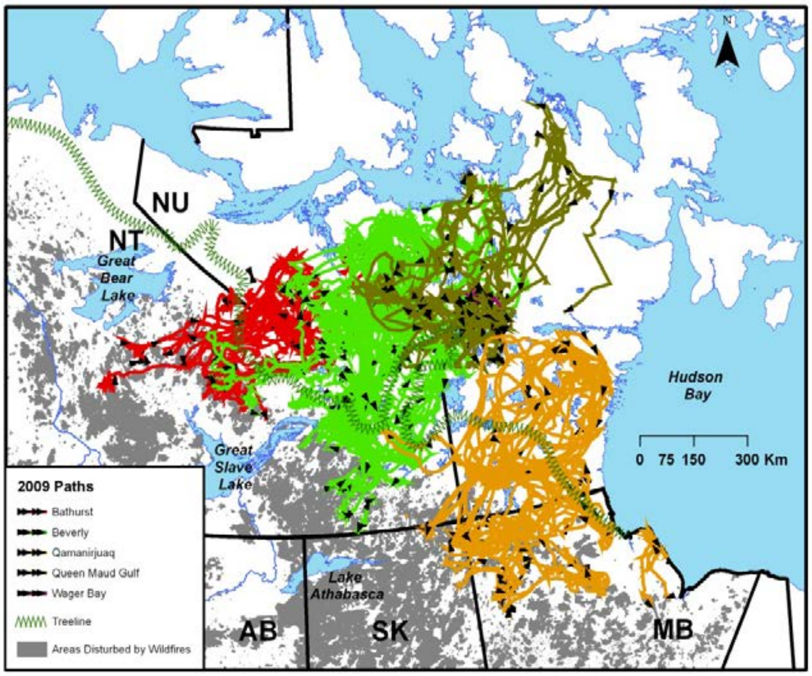

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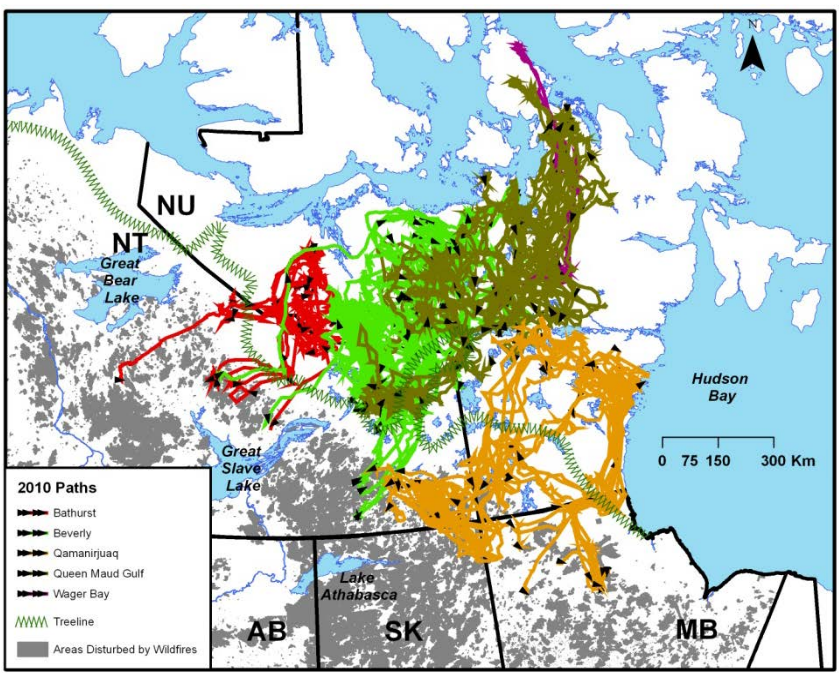

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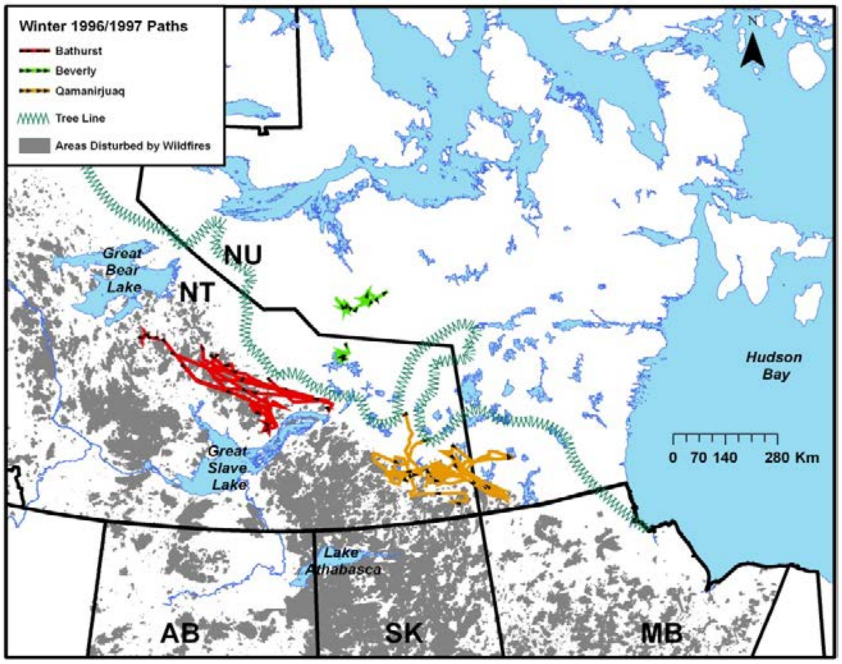

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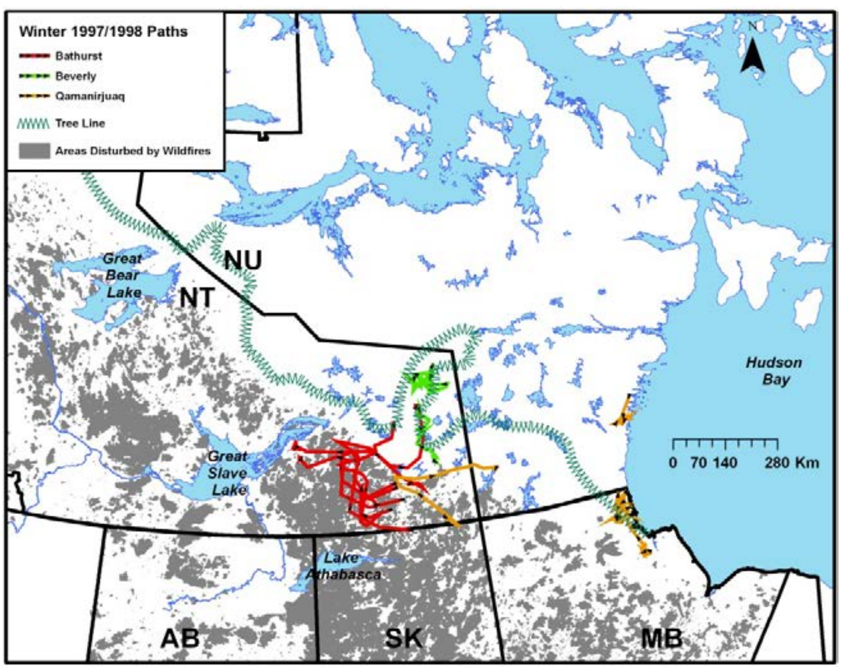

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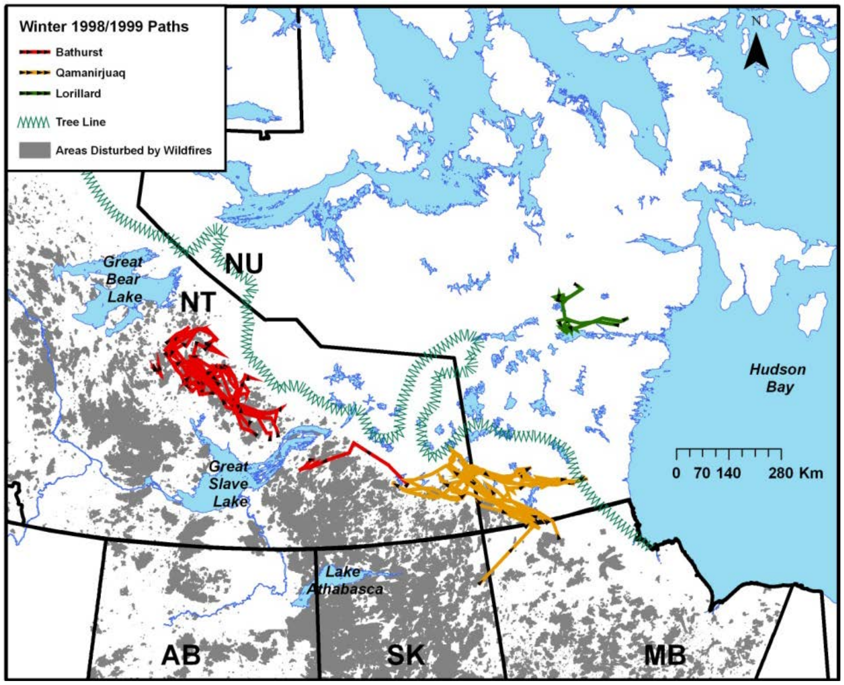

Winter 1998/1999 Paths
Bathurst
Qamanirjuaq
Lorillard
Tree Line
Areas Disturbed by Wildfires
Great Bear Lake
NU
NT
Hudson Bay
0 70 140 280 Km
Great Slave Lake
Lake Athabasca
AB
SK
MB

Fig. 2-28. Paths of Bathurst (n=13), Qamanirjuaq (n=7), Lorillard (n=6), and Wager Bay (n=1) barren-ground caribou tracked in winter (1 December-31 March) 1999/2000.

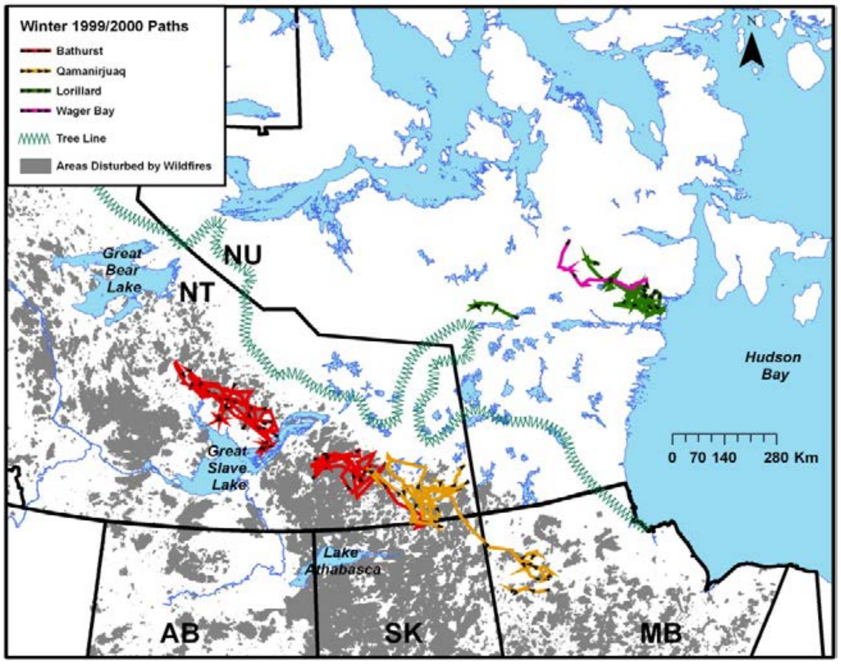


Fig. 2-29. Paths of Bathurst (n=12), Qamanirjuaq (n=3), Lorillard (n=9), and Wager Bay (n=6) barren-ground caribou tracked in winter (1 December-31 March) 2000/2001.

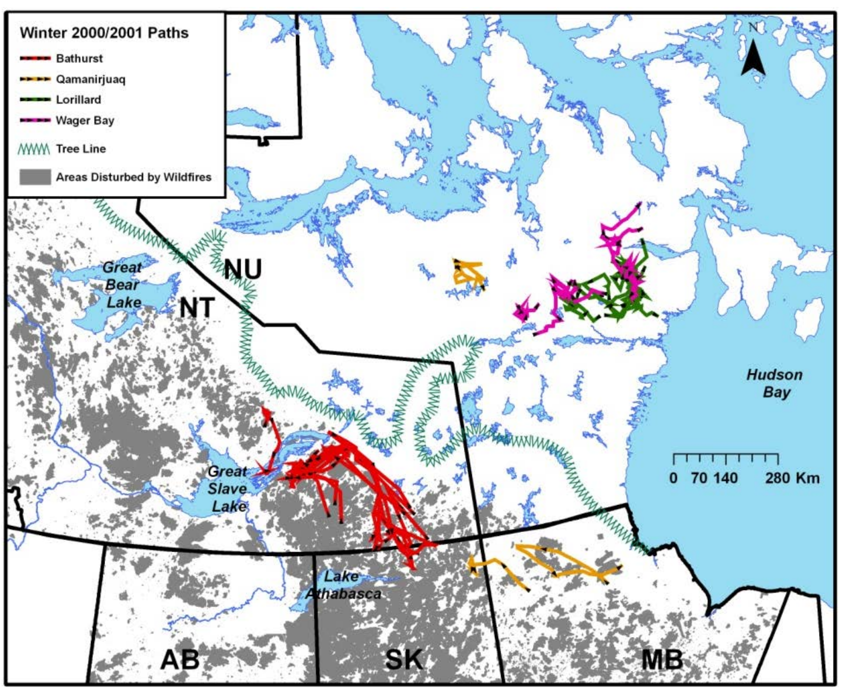


Fig. 2-30. Paths of Bathurst (n=9), Beverly (n=6), Qamanirjuaq (n=8), Queen Maud Gulf (n=1), Lorillard (n=7), and Wager Bay (n=4) barren-ground caribou tracked in winter (1 December-31 March) 2001/2002.

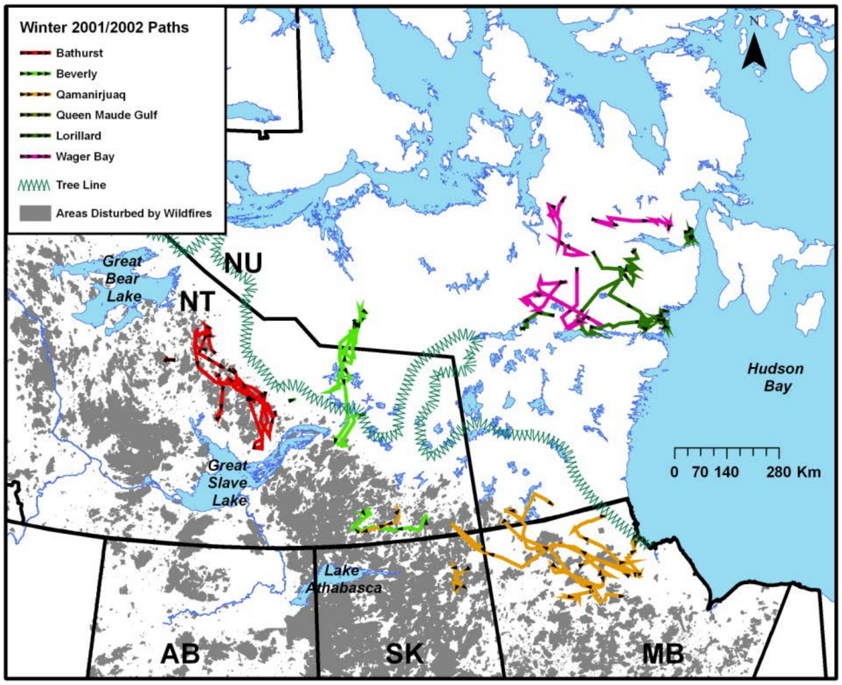


Fig. 2-31. Paths of Bathurst (n=10), Beverly (n=4), Qamanirjuaq (n=7), Queen Maud Gulf (n=1), Lorillard (n=10), and Wager Bay (n=3) barren-ground caribou tracked in winter (1 December-31 March) 2002/2003.

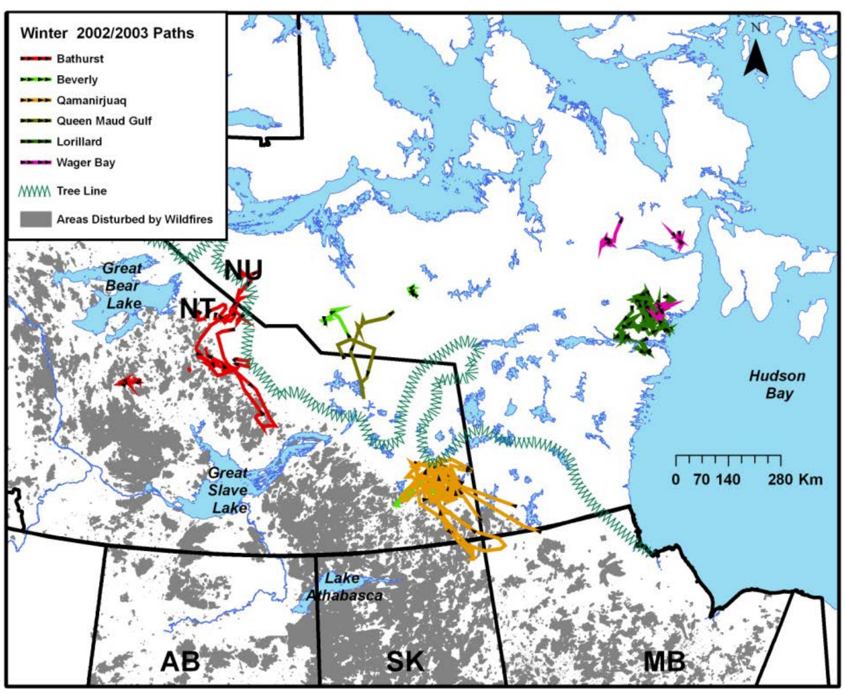


Fig. 2-32. Paths of Bathurst (n=8), Beverly (n=2), Qamanirjuaq (n=7), Queen Maud Gulf (n=1), Lorillard (n=12), and Wager Bay (n=10) barren-ground caribou tracked in winter (1 December-31 March) 2003/2004.

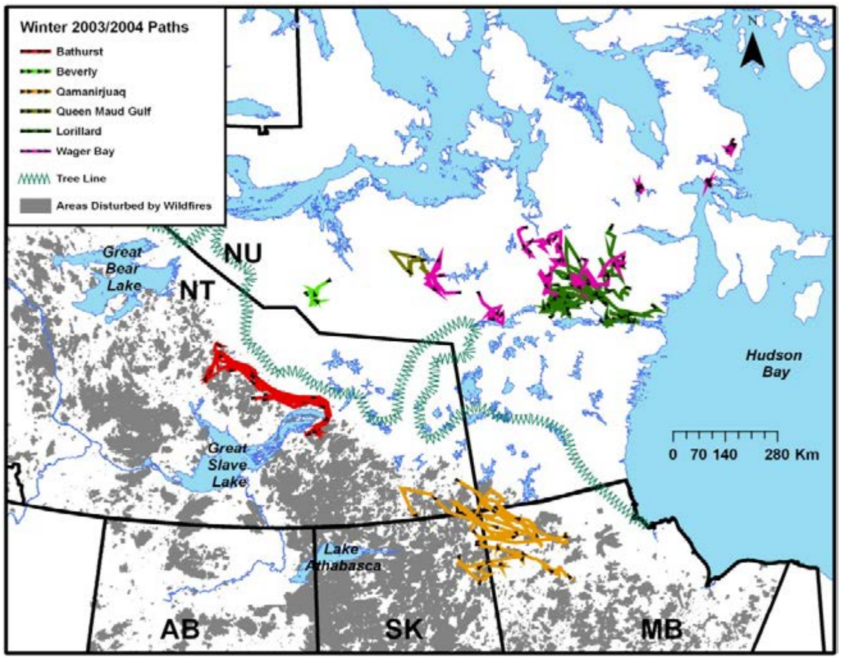


Fig. 2-33. Paths of Bathurst (n=11), Beverly (n=7), Qamanirjuaq (n=10), Queen Maud Gulf (n=1), Lorillard (n=8), and Wager Bay (n=8) barren-ground caribou tracked in winter (1 December-31 March) 2004/2005.

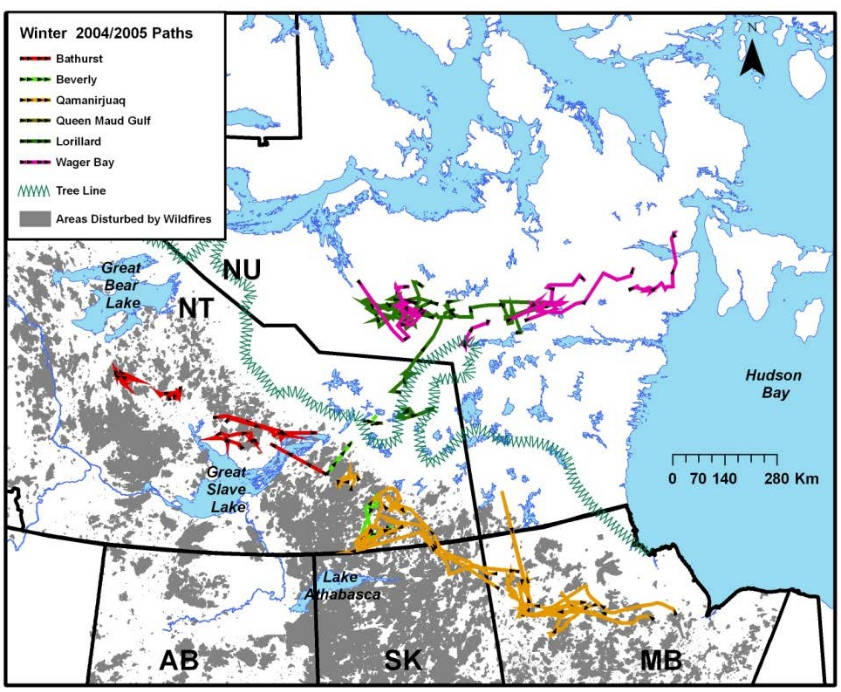


Fig. 2-34. Paths of Bathurst (n=12), Beverly (n=19), Qamanirjuaq (n=18), Queen Maud Gulf (n=2), Lorillard (n=3), and Wager Bay (n=3) barren-ground caribou tracked in winter (1 December-31 March) 2005/2006.

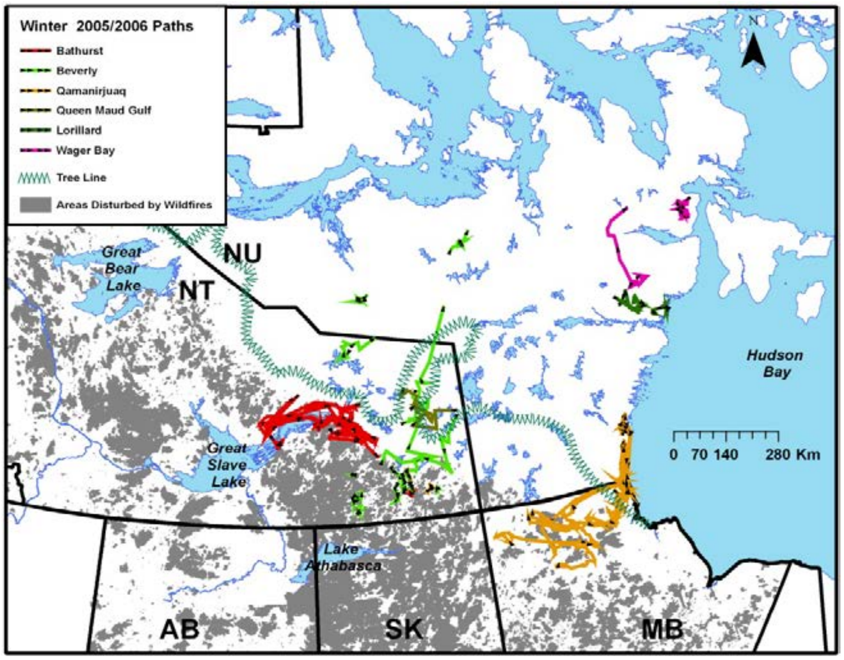


Fig. 2-35. Paths of Bathurst (n=18), Beverly (n=17), Qamanirjuaq (n=23), Queen Maud Gulf (n=2), and Wager Bay (n=1) barren-ground caribou tracked in winter (1 December-31 March) 2006/2007.

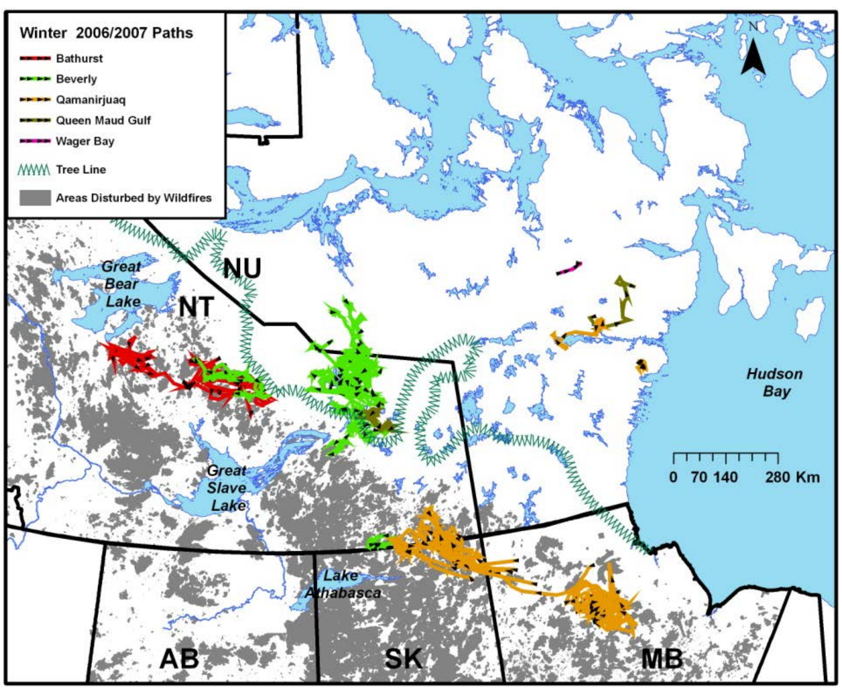


Fig. 2-36. Paths of Bathurst (n=15), Beverly (n=24), Qamanirjuaq (n=16), and Queen Maud Gulf (n=2) barren-ground caribou tracked in winter (1 December-31 March) 2007/2008.

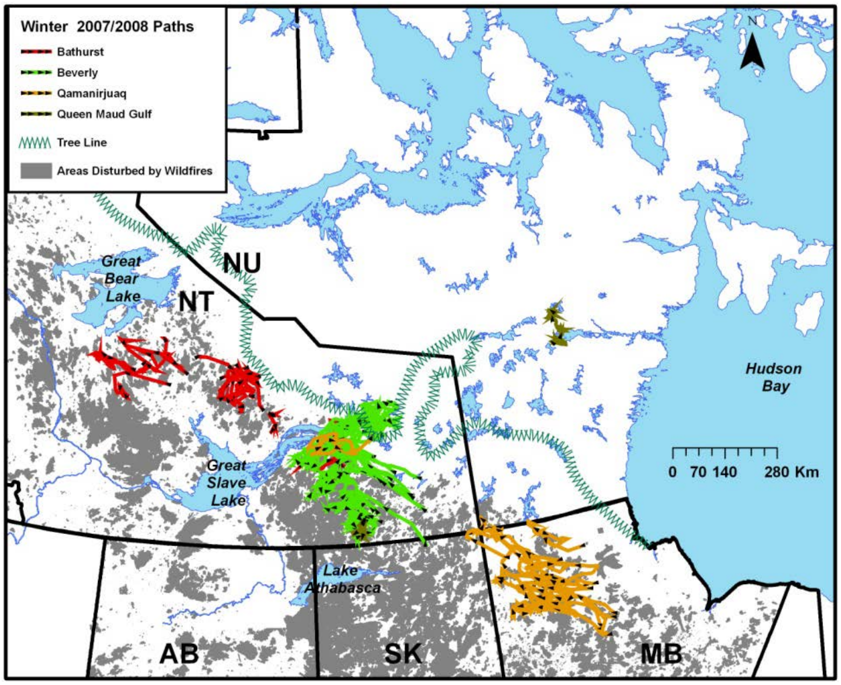


Fig. 2-37. Paths of Bathurst (n=18), Beverly (n=40), Qamanirjuaq (n=27), and Queen Maud Gulf (n=10) barren-ground caribou tracked in winter (1 December-31 March) 2008/2009.

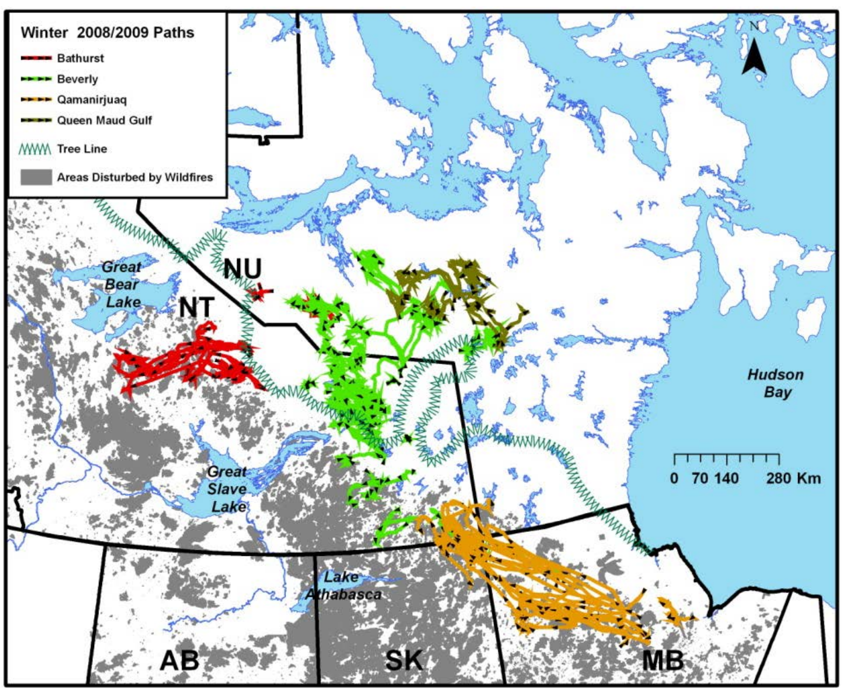


Fig. 2-38. Paths of Bathurst (n=9), Beverly (n=23), Qamanirjuaq (n=12), Queen Maud Gulf (n=17), and Wager Bay (n=1) barren-ground caribou tracked in winter (1 December-31 March) 2009/2010.

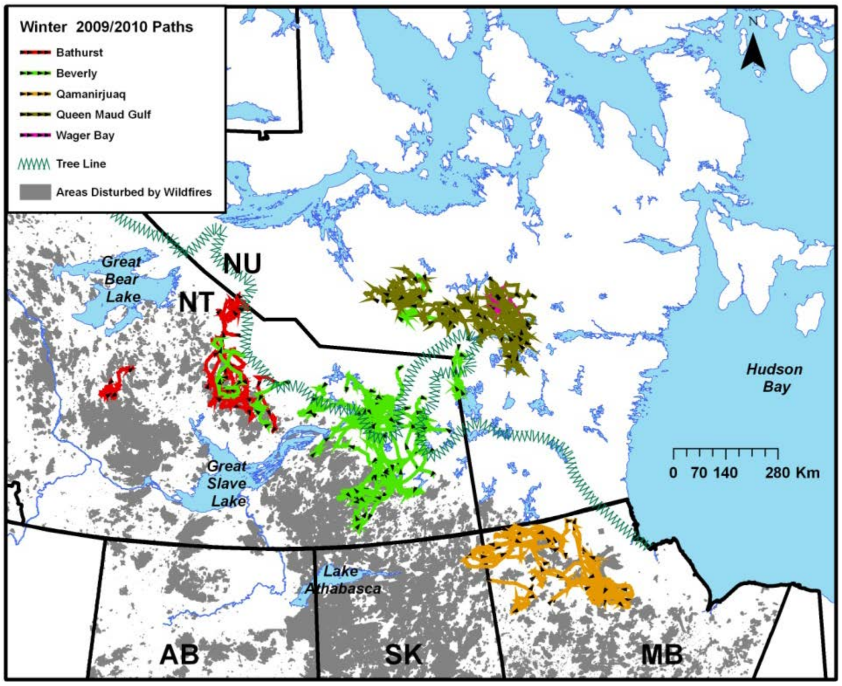
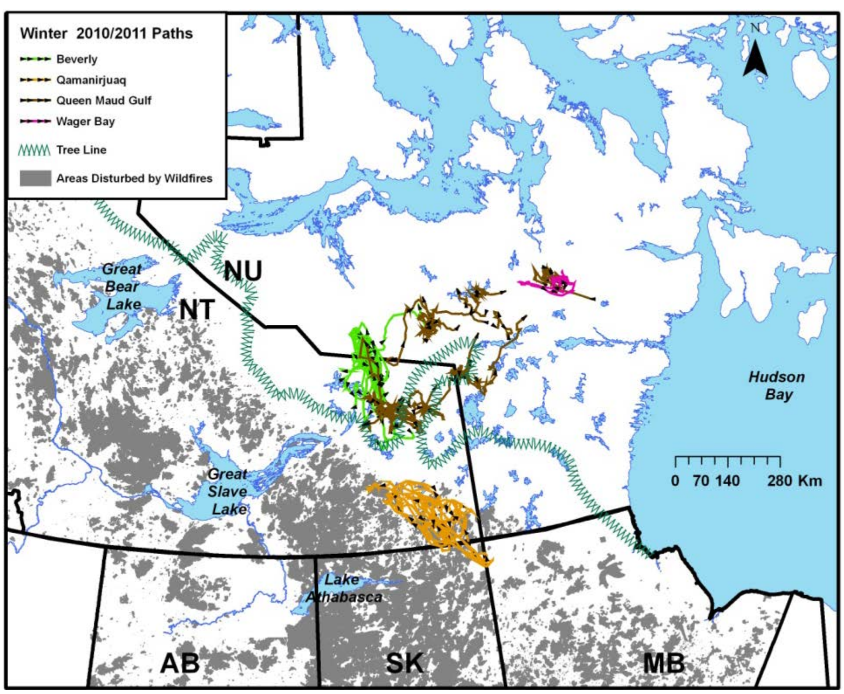


Fig. 2-39. Paths of Bathurst (n=1), Beverly (n=16), Qamanirjuaq (n=8), Queen Maud Gulf (n=16), Lorillard (n=12), and Wager Bay (n=1) barren-ground caribou tracked in winter (1 December-31 March) 2010/2011.



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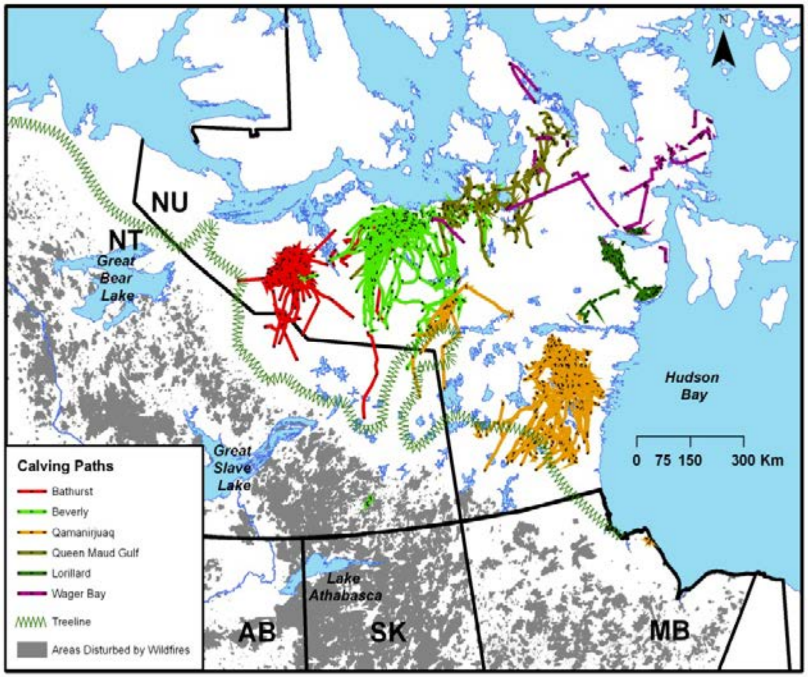
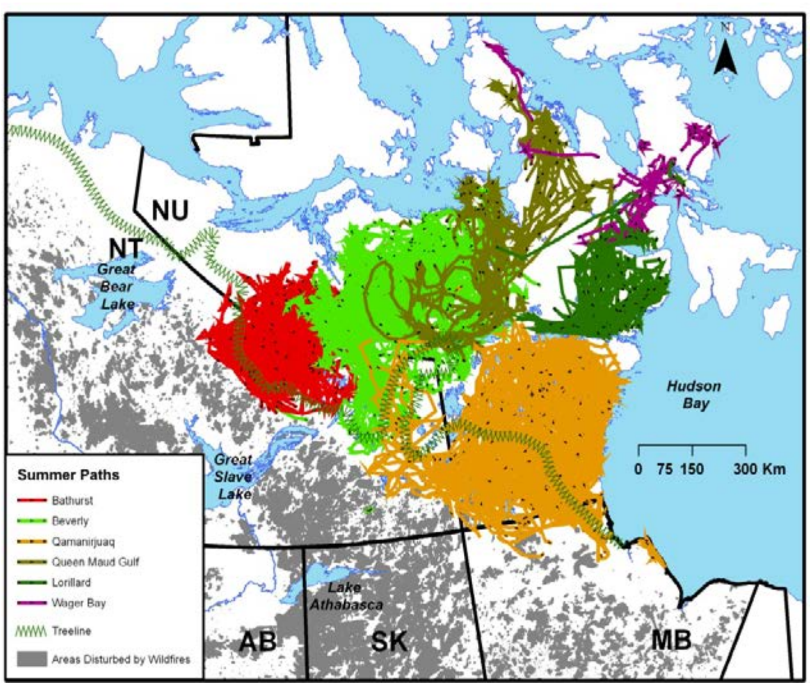


Fig. 2-41. Paths of Bathurst (n=144), Beverly (n=163), Qamanirjuaq (n=184), Queen Maud Gulf (n=44), Lorillard (n=67), and Wager Bay (n=37) barren-ground caribou tracked during the summer period (4 July-21 September).



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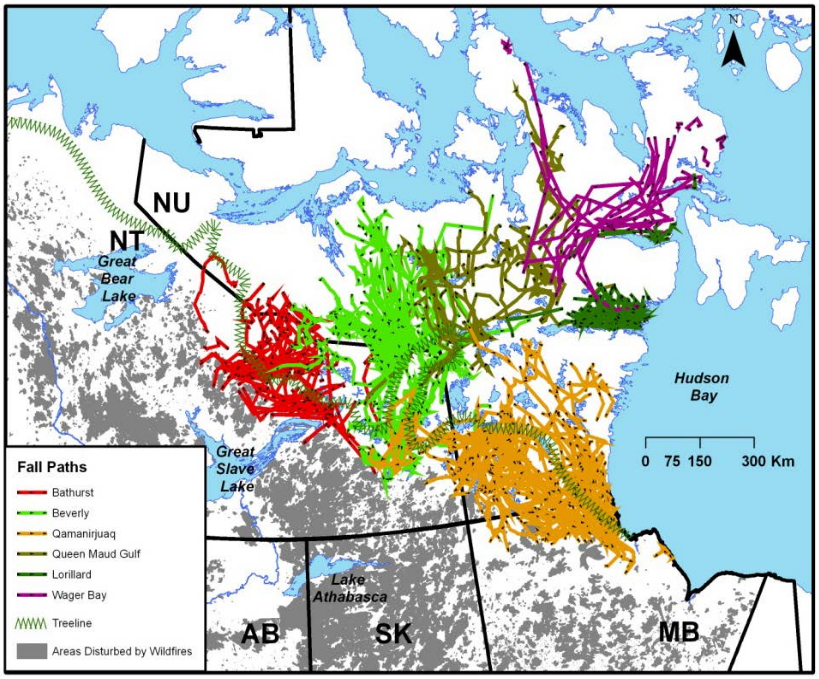

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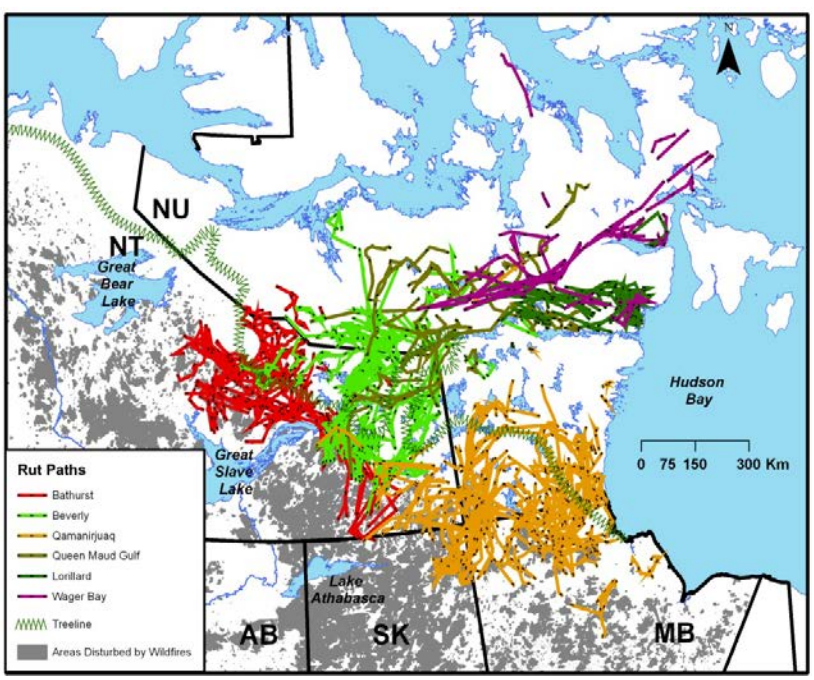

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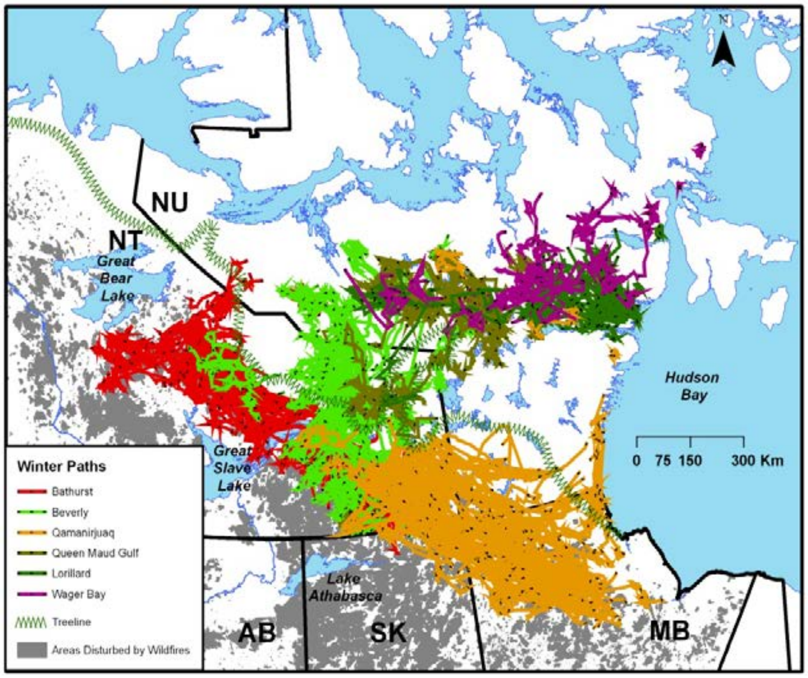

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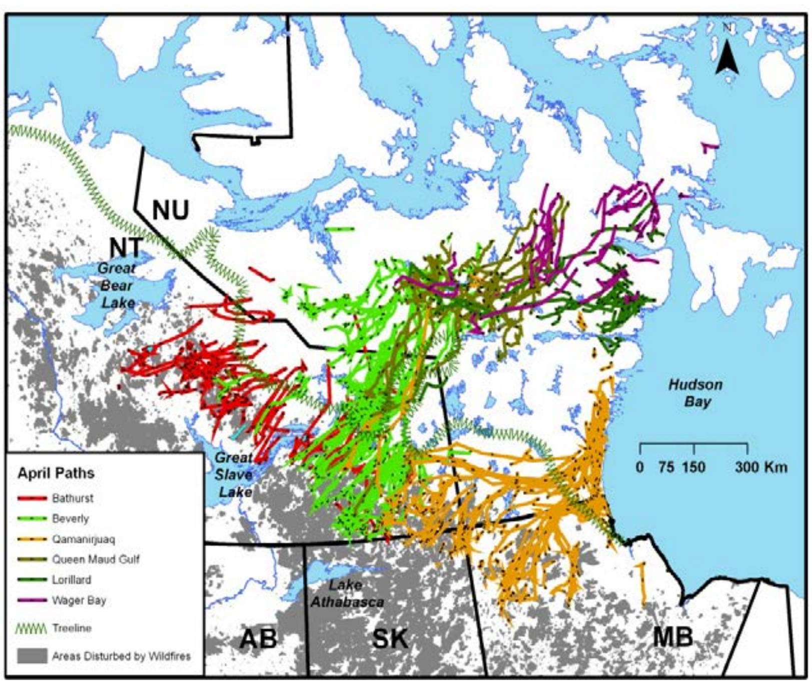

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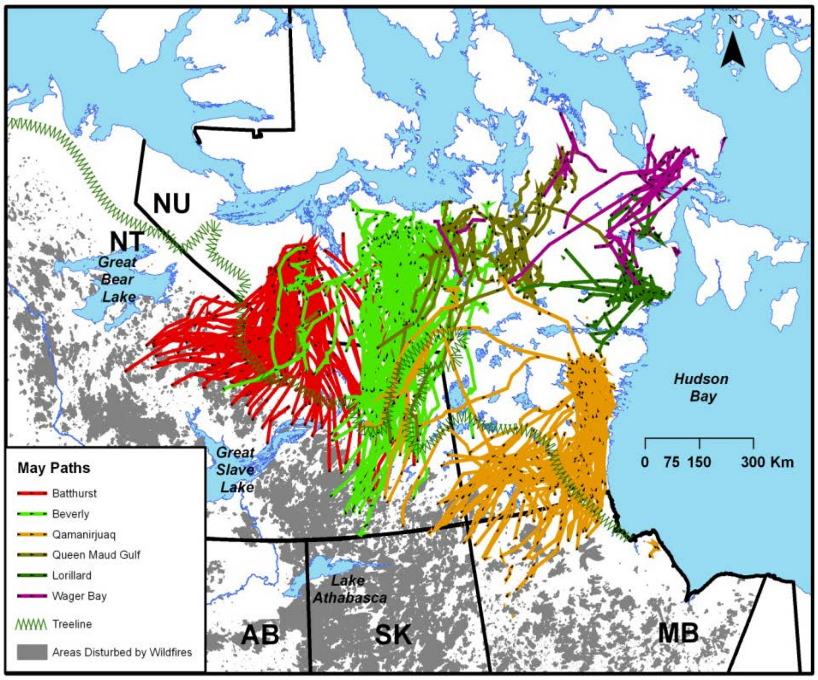

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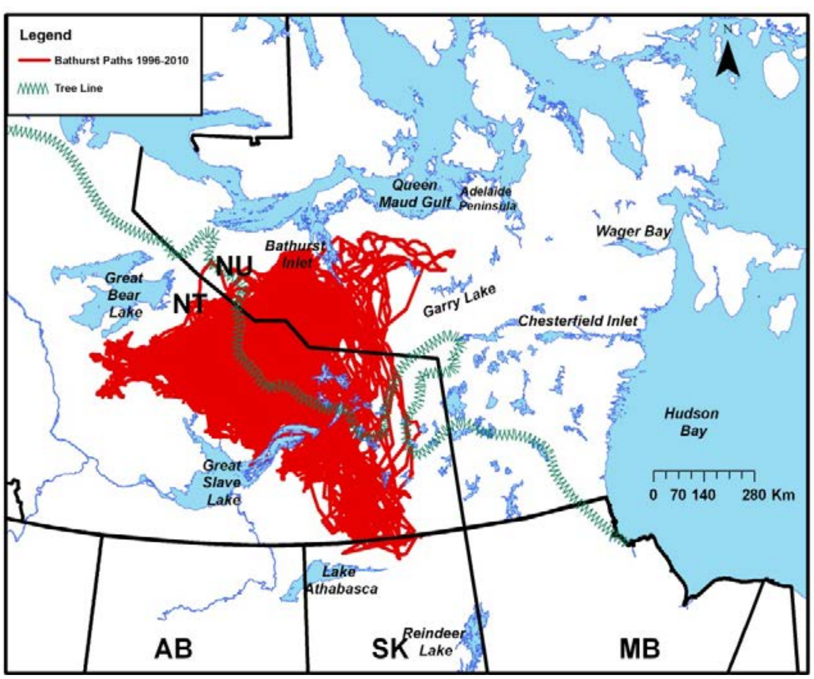

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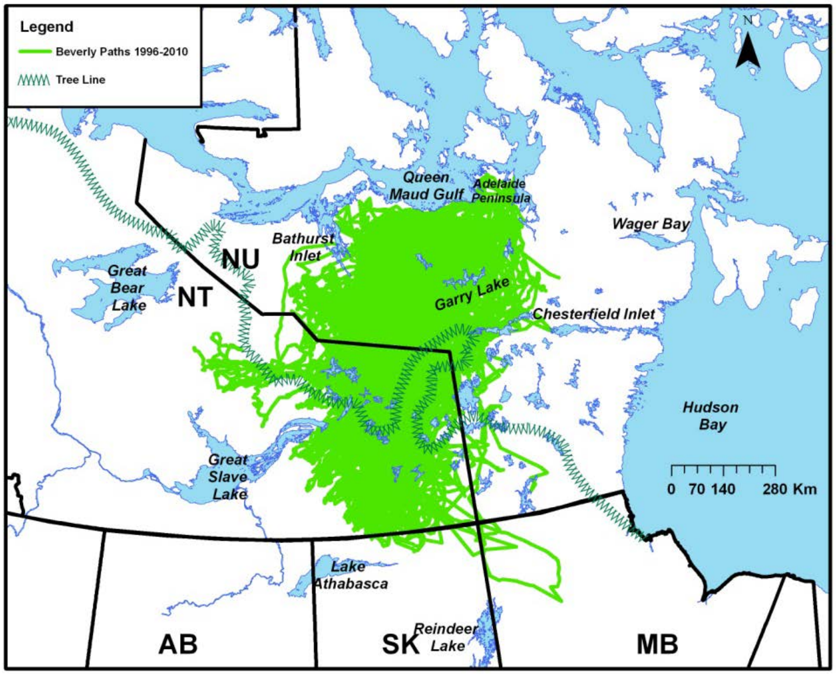

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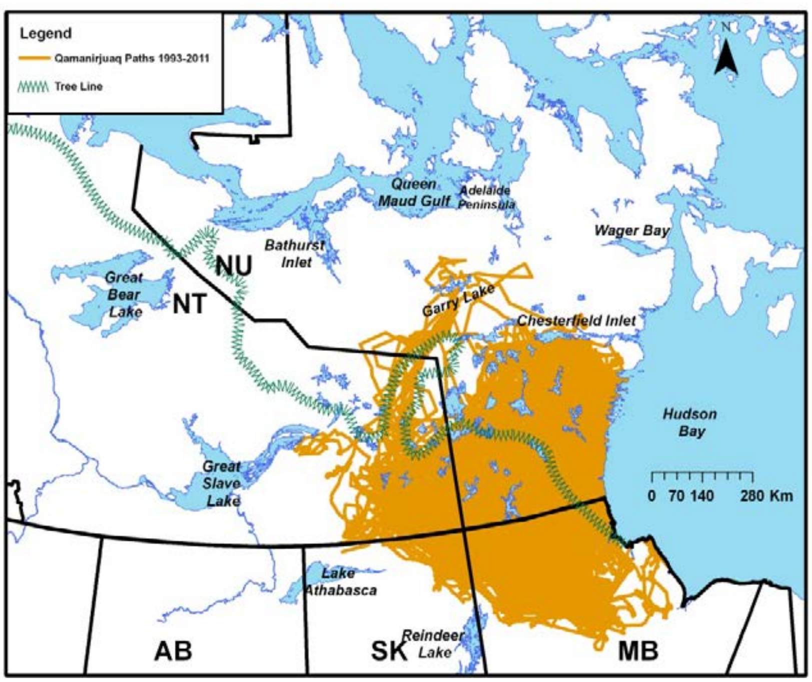
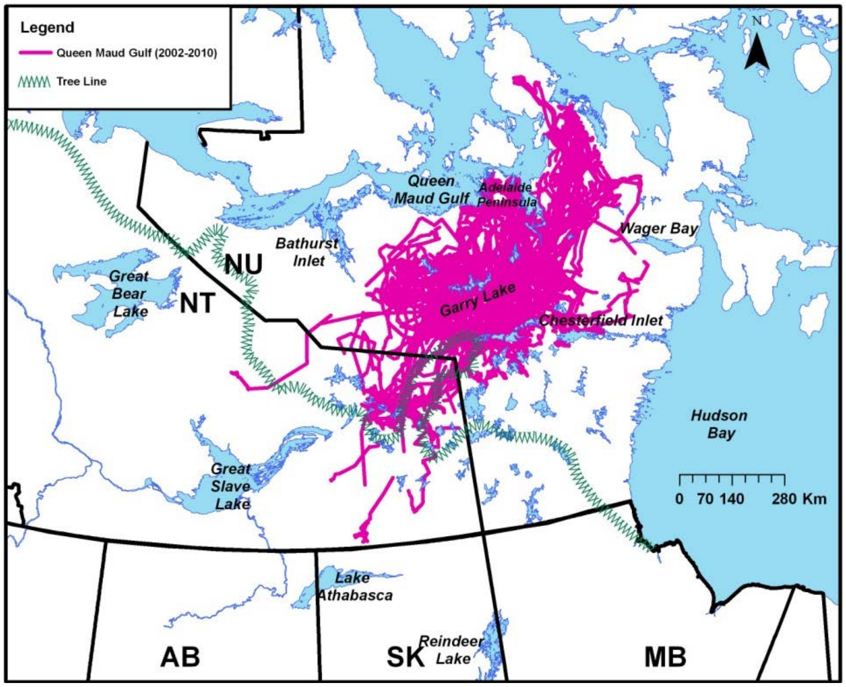


Fig. 2-50. Paths of Queen Maud Gulf barren-ground caribou tracked during 2002-2011.



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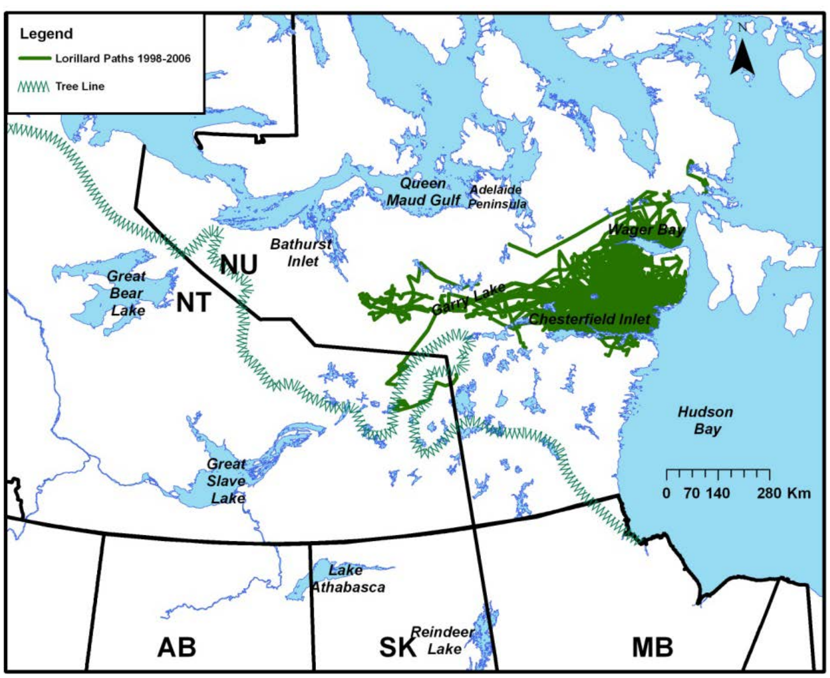


Fig. 2-52. Paths of Wager Bay barren-ground caribou tracked during 1999-2010.

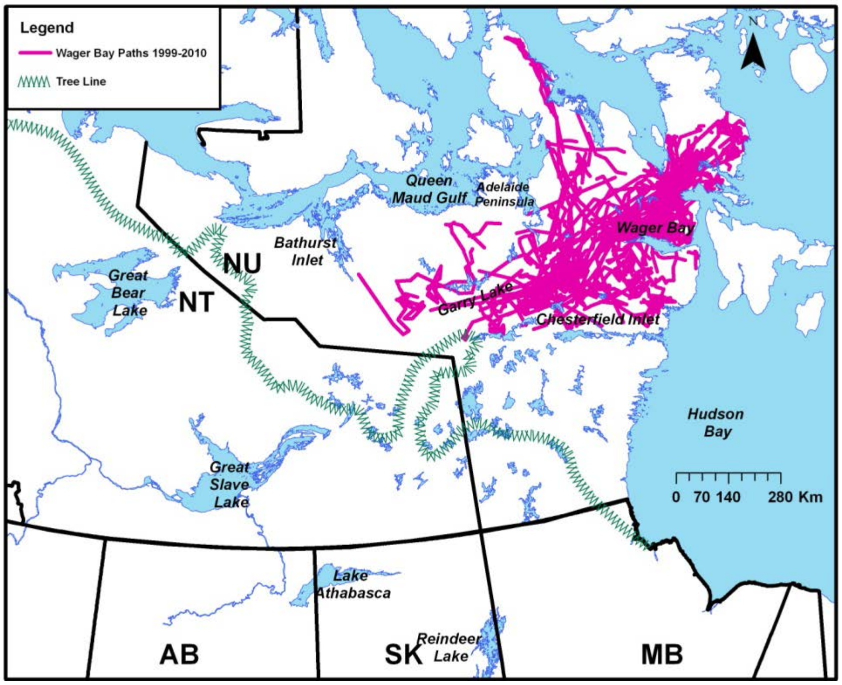
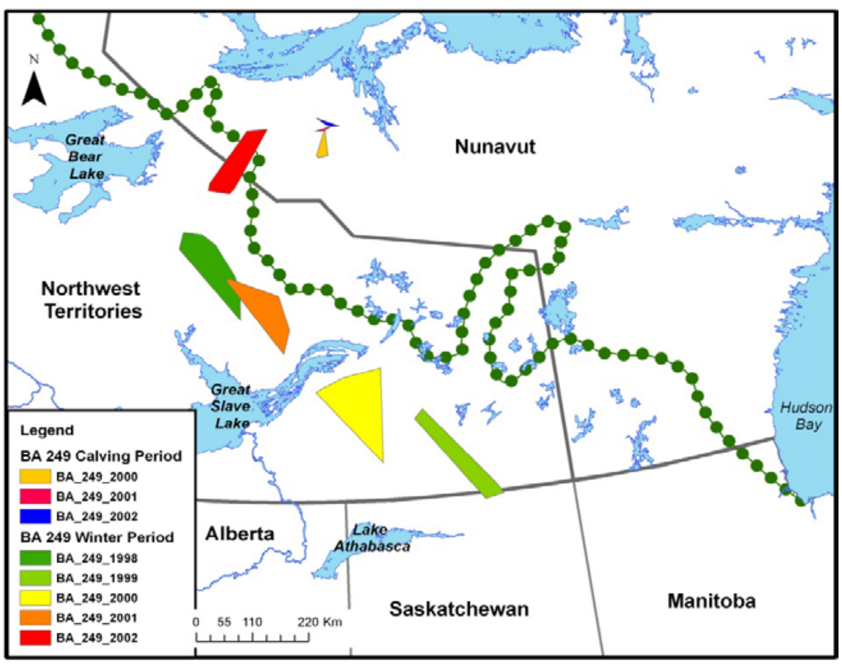


Fig. 2-53. Variation in areas used by Bathurst cow 249 during calving 2000-2002 and winters 1998/1999-2002/2003.



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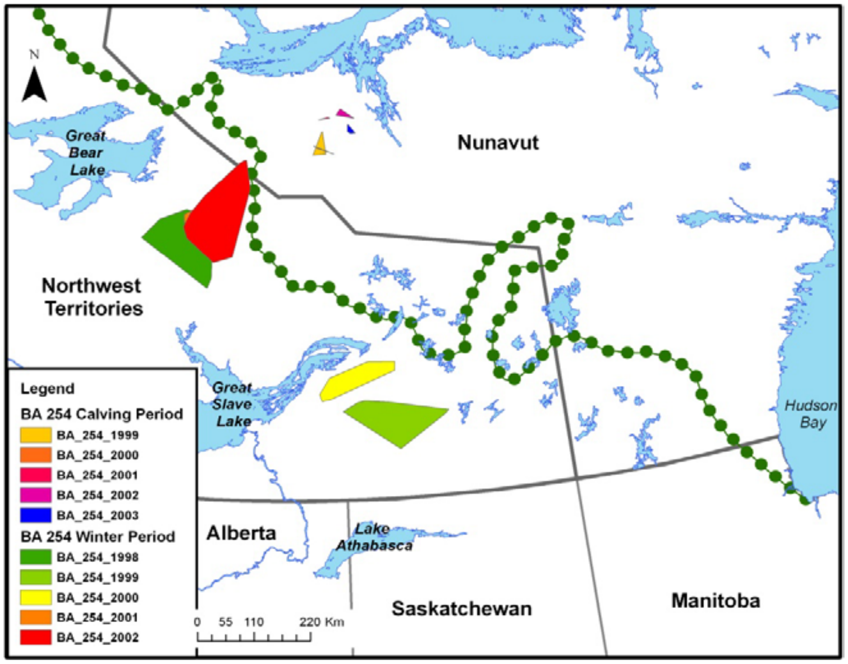

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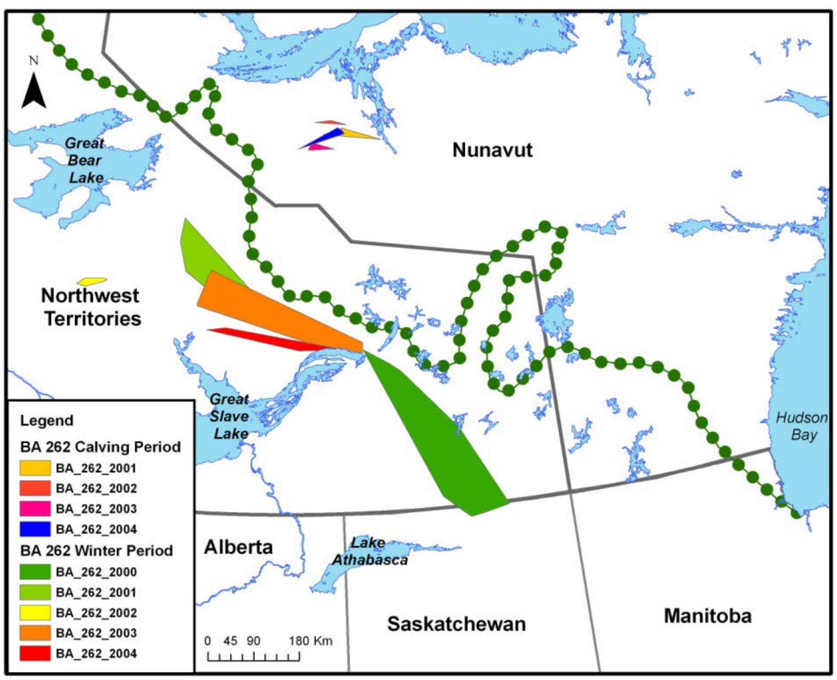

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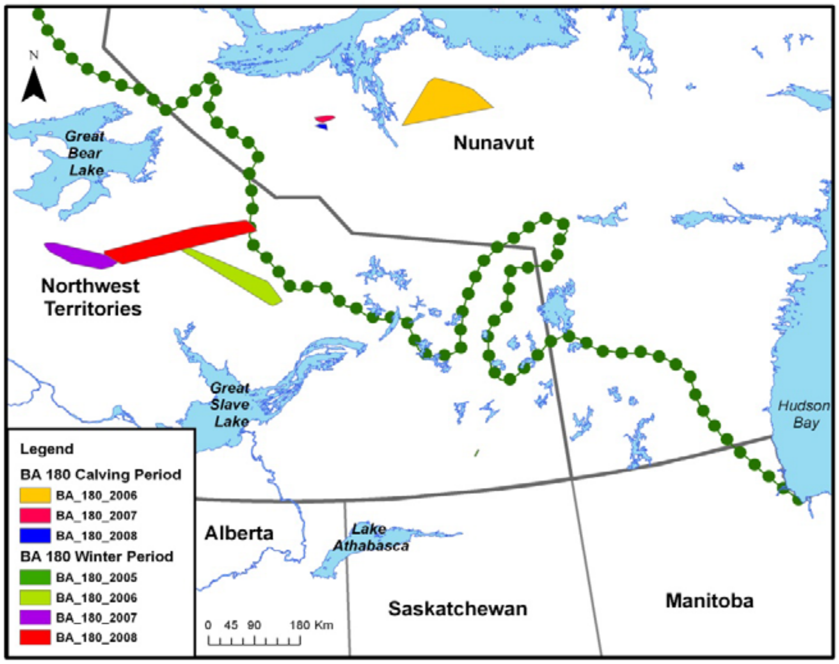


Fig. 2-57. Variation in areas used by Qamanirjuaq cow 93 during calving 2000-2004 and winters 2000/2001-2003/2004.

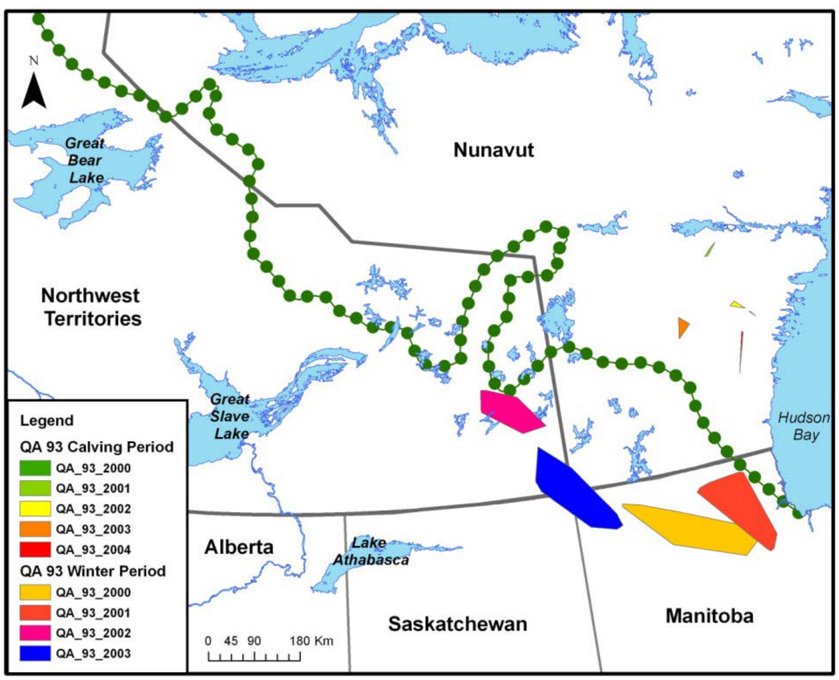


Fig. 2-58. Variation in areas used during by Qamanirjuaq cow 73 during calving 1998-2003 and winters 1998/1999-2003/2004.

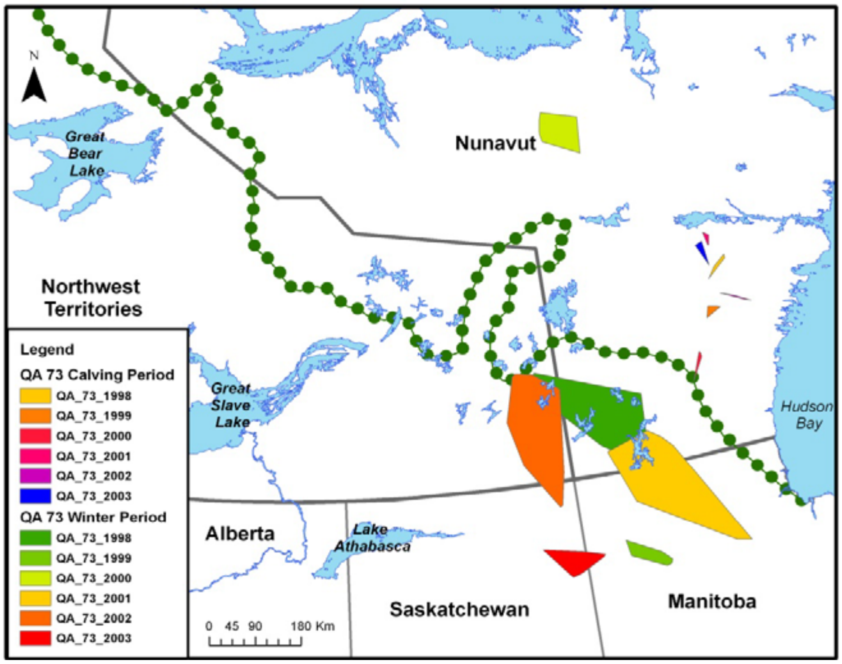


Fig. 2-59. Variation in areas used by Qamanirjuaq cow 123 during calving 2006-2006 and winters 2005/2006-2008/2009.

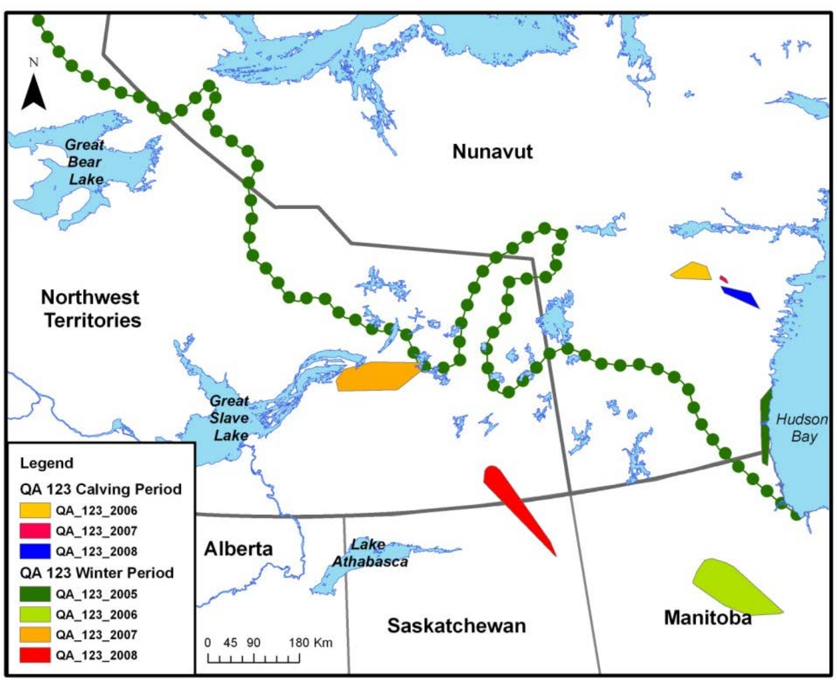


Fig. 2-60. Variation in areas used by Qamanirjuaq cow 93 during calving 2004-2008 and winters 2004/2005-2007/2008.

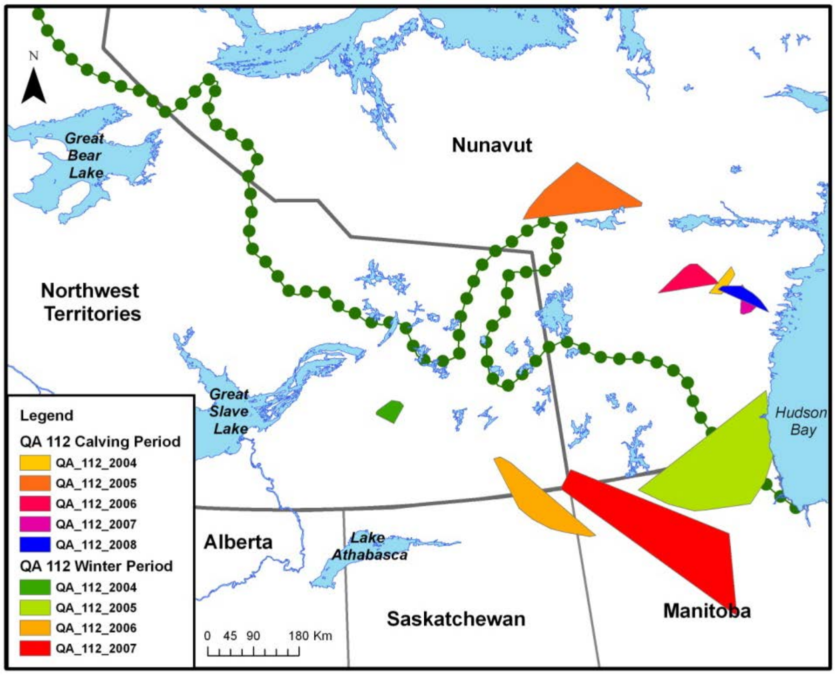
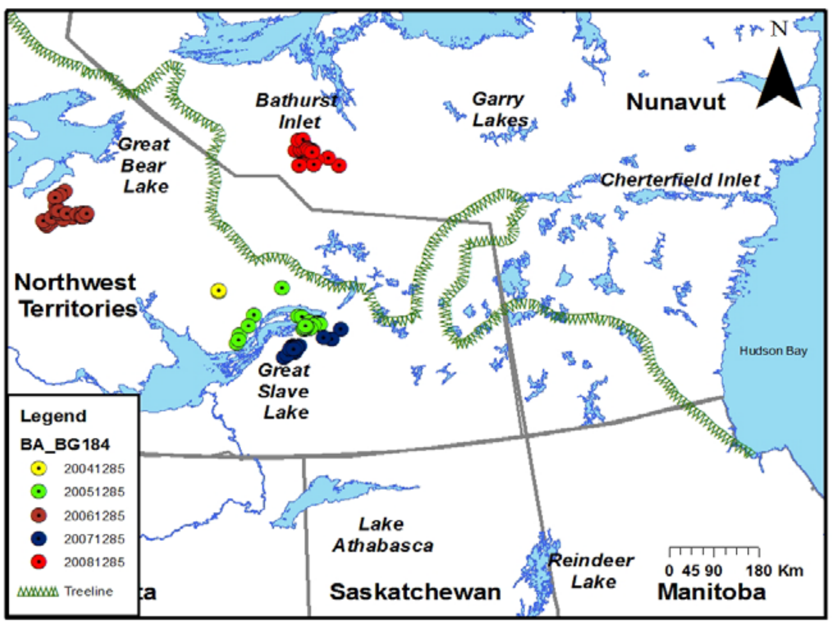


Fig. 2-61. Distribution of Bathurst cow BG184 during winters 2004-2008.



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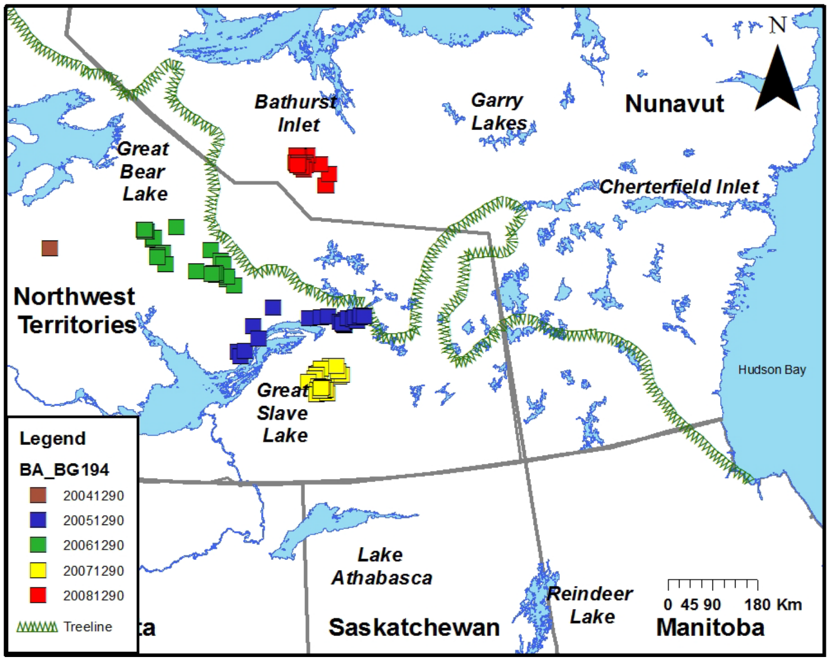

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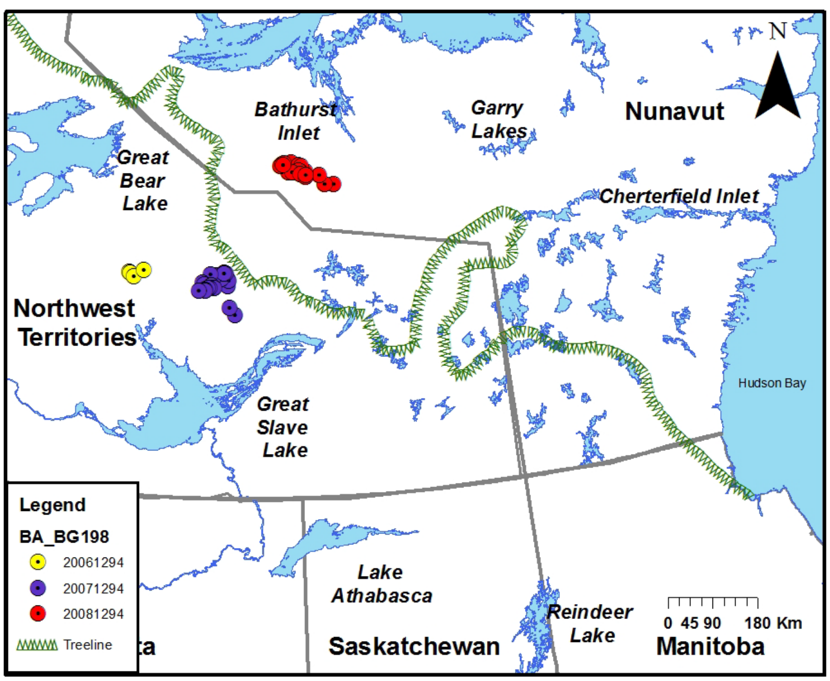

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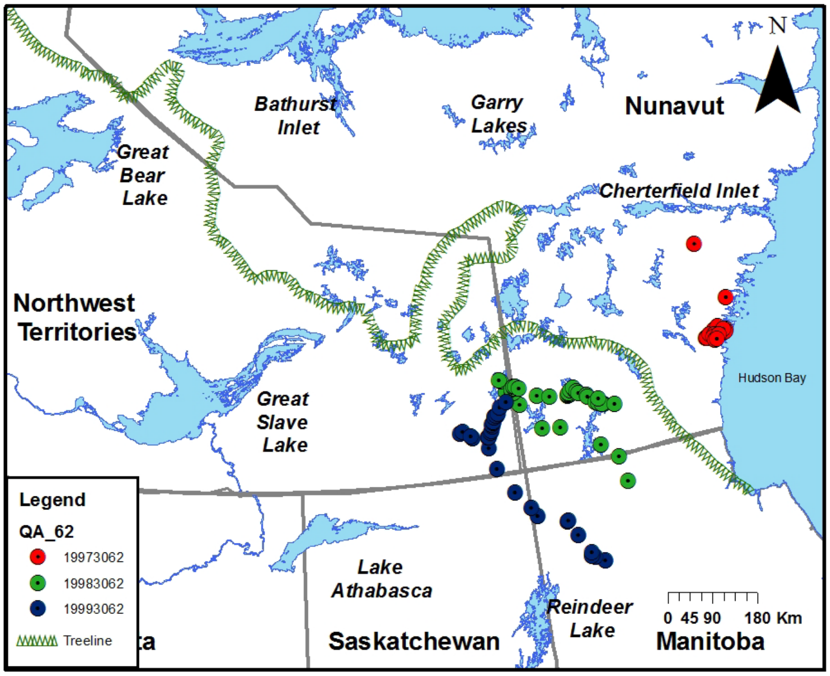
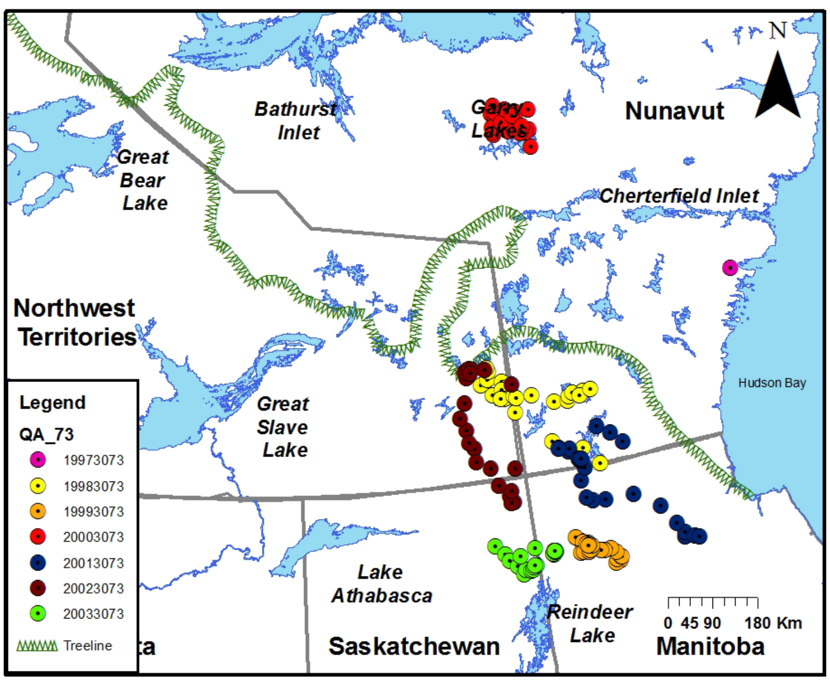


Fig. 2-66. Distribution of Qamanirjuaq cow QA_73 during winters 1997-2003.



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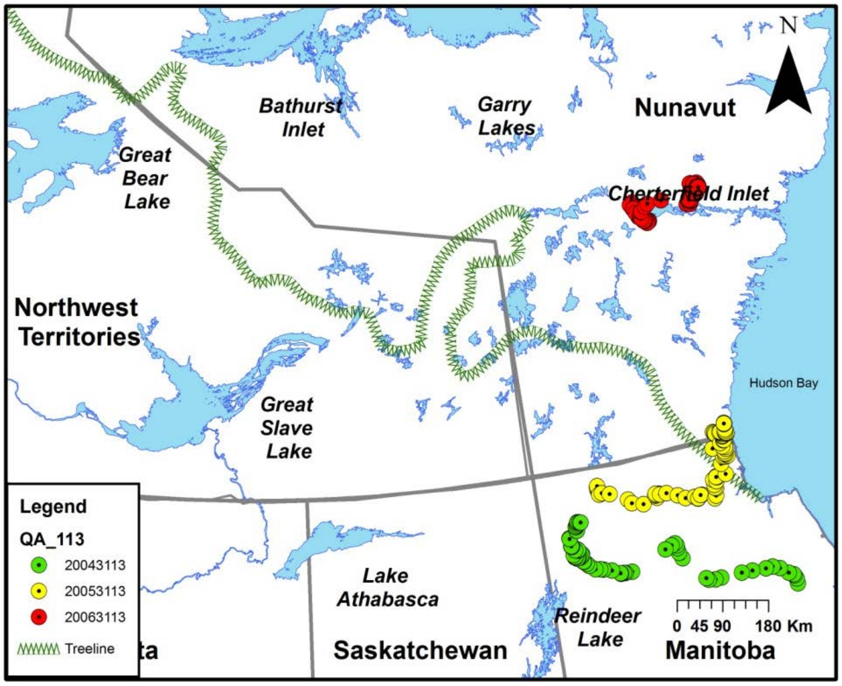

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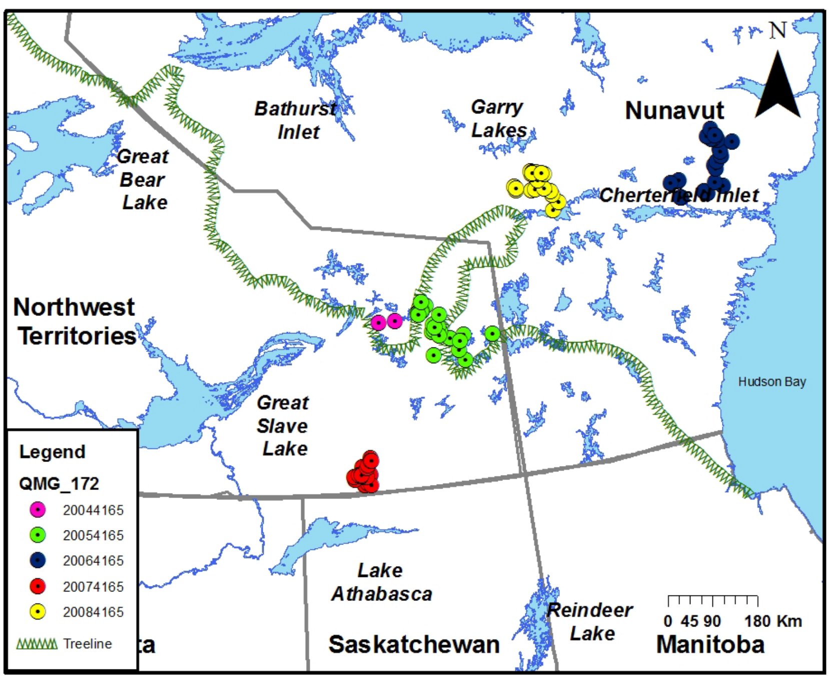
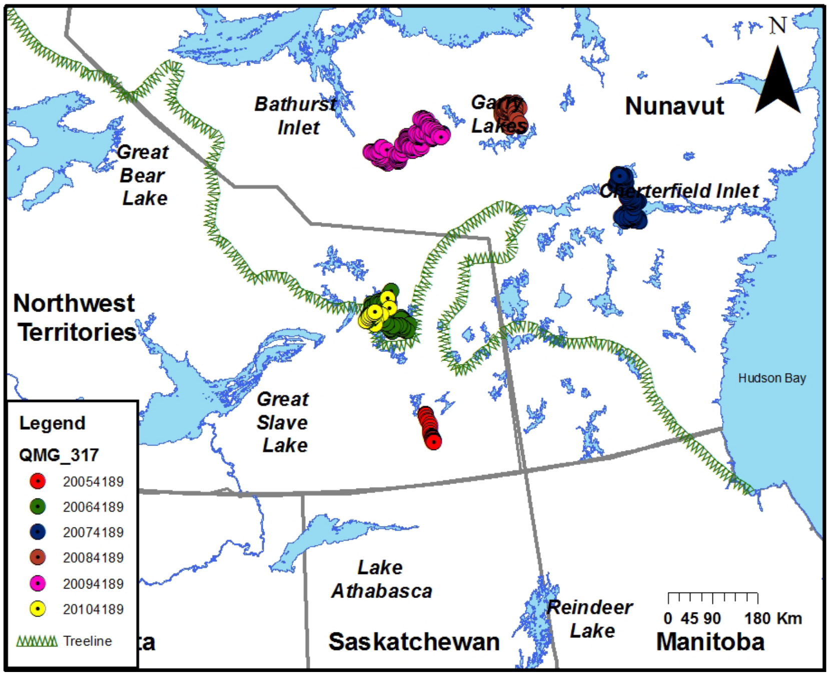


Fig. 2-69. Distribution of Queen Maud Gulf cow QMG_317 during winters 2005-2010.



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Number of Herds	Duda-Hart t-test statistic
1	221.06
2	220.13
3	115.75
4	57.18
5	33.70
6	**26.10**
7	**22.28**
8	**13.52**
9	17.83
10	15.21
11	12.41
12	7.73
13	7.53
14	9.68
15	6.44

Table 2-2. Analysis step 1: number of herds indicated by fuzzy clustering of movement data for migratory and tundra-wintering barren-ground caribou cows that used calving grounds D, E-1, E, F, G, H, and I in Nunavut, Canada. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate optimal numbers of herds.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	0.27	**0.12**	0.16	0.25	0.27	0.27	0.20	0.27	0.30	0.34	0.37	0.37	0.39	0.44
1.6	0.32	**0.17**	0.22	0.24	0.26	0.34	0.38	0.35	0.39	0.44	0.44	0.47	0.52	0.51
1.7	0.38	**0.23**	0.28	0.31	0.33	0.41	0.45	0.44	0.54	0.53	0.58	0.55	0.59	0.61
1.8	0.44	**0.29**	0.35	0.37	0.47	0.52	0.52	0.57	0.55	0.62	0.64	0.64	0.67	0.68
1.9	0.49	**0.35**	0.41	0.44	0.53	0.55	0.58	0.64	0.65	0.68	0.68	0.68	0.73	0.73
2	0.54	**0.42**	0.48	0.50	0.57	0.58	0.64	0.69	0.72	0.73	0.73	0.76	0.78	0.78
2.1	0.58	**0.47**	0.53	0.55	0.63	0.68	0.69	0.73	0.75	0.78	0.79	0.80	0.81	0.83
2.2	0.63	**0.53**	0.58	0.60	0.68	0.72	0.76	0.78	0.79	0.80	0.83	0.83	0.85	0.86
2.3	0.66	**0.58**	0.63	0.65	0.71	0.74	0.77	0.80	0.82	0.83	0.85	0.86	0.87	0.88
2.4	0.70	**0.62**	0.67	0.69	0.75	0.79	0.80	0.83	0.85	0.86	0.87	0.88	0.89	0.90
2.5	0.73	**0.66**	0.70	0.73	0.78	0.81	0.84	0.85	0.87	0.88	0.89	0.90	0.90	0.91
2.6	0.75	**0.69**	0.73	0.76	0.81	0.83	0.85	0.87	0.88	0.90	0.90	0.91	0.92	0.92
2.7	0.78	**0.72**	0.76	0.78	0.83	0.85	0.88	0.88	0.90	0.90	0.91	0.92	0.93	0.93
2.8	0.80	**0.75**	0.79	0.81	0.85	0.87	0.89	0.90	0.91	0.92	0.92	0.93	0.94	0.94
2.9	0.82	**0.77**	0.81	0.86	0.86	0.88	0.90	0.91	0.92	0.92	0.93	0.94	0.94	0.95
3	0.83	**0.79**	0.83	0.85	0.88	0.89	0.91	0.92	0.93	0.94	0.94	0.94	0.95	0.95
	Normalized classification entropy (NCE)													
1.5	0.32	**0.15**	0.18	0.24	0.24	0.23	0.19	0.22	0.24	0.26	0.28	0.28	0.29	0.32
1.6	0.39	**0.21**	0.24	0.25	0.25	0.30	0.32	0.30	0.32	0.35	0.36	0.36	0.39	0.38
1.7	0.45	**0.28**	0.31	0.32	0.33	0.37	0.39	0.38	0.44	0.43	0.47	0.45	0.46	0.46
1.8	0.51	**0.35**	0.38	0.38	0.44	0.47	0.46	0.49	0.48	0.51	0.52	0.52	0.54	0.54
1.9	0.57	**0.42**	0.45	0.45	0.50	0.50	0.52	0.55	0.56	0.57	0.57	0.57	0.61	0.61
2	0.62	**0.48**	0.51	0.51	0.56	0.56	0.58	0.61	0.62	0.64	0.63	0.65	0.66	0.66
2.1	0.66	**0.54**	0.56	0.56	0.60	0.64	0.63	0.66	0.66	0.69	0.69	0.69	0.70	0.71
2.2	0.70	**0.59**	0.61	0.61	0.65	0.68	0.70	0.70	0.72	0.72	0.73	0.73	0.75	0.75
2.3	0.73	**0.63**	0.65	0.66	0.70	0.71	0.72	0.74	0.75	0.76	0.76	0.77	0.79	0.78
2.4	0.76	**0.67**	0.69	0.70	0.72	0.75	0.75	0.77	0.78	0.79	0.79	0.80	0.81	0.81
2.5	0.79	**0.71**	0.72	0.73	0.75	0.77	0.79	0.80	0.81	0.81	0.81	0.82	0.83	0.83
2.6	0.81	**0.74**	0.75	0.76	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.84	0.85	0.86
2.7	0.83	**0.76**	0.78	0.79	0.81	0.82	0.84	0.84	0.85	0.85	0.86	0.87	0.86	0.87
2.8	0.84	**0.79**	0.80	0.81	0.83	0.84	0.85	0.86	0.86	0.86	0.87	0.88	0.88	0.89
2.9	0.86	**0.81**	0.82	0.84	0.84	0.85	0.87	0.88	0.88	0.88	0.88	0.89	0.89	0.90
3	0.87	**0.82**	0.83	0.85	0.87	0.87	0.88	0.88	0.89	0.90	0.90	0.90	0.90	0.91

Table 2-3. Probability of group membership of caribou that were assigned to each herd during each step of the fuzzy cluster analyses.

Analysis Step and Herds		Probability of Group Membership (Fuzzy clustering) by Herd					
Step 1:		Tundra-wintering		Qamanirjuaq		Bathurst/Beverly	
Herds	N	Mean	STDEV	Mean	STDEV	Mean	STDEV
Tundra-wintering (TW)	57	**78**	±13	9	±3	13	±10
Qamanirjuaq (QA)	67	6	±5	**87**	±10	7	±7
Bathurst/Beverly (BABV)	108	9	±7	9	±8	**82**	±12
Step 2 group 1:		Beverly		Bathurst			
Herds	N	Mean	STDEV	Mean	STDEV		
Beverly	56	**79**	±10	21	±10		
Bathurst	52	15	±10	**85**	±10		
Step 2 group 3:		Lorillard		Wager Bay		Queen Maud Gulf	
Herds	N	Mean	STDEV	Mean	STDEV	Mean	STDEV
Lorillard (LR)	19	**84**	±14	9	±9	7	±8
Wager Bay (WB)	15	21	±8	**65**	±14	14	±10
Queen Maud Gulf (QM)	23	15	±5	14	±8	**71**	±13

Table 2-4. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for migratory barren-ground caribou cows that formed group 1 (Bathurst and Beverly caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate optimal numbers of herds.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	**0.22**	0.31	0.32	0.41	0.44	0.47	0.54	0.60	0.61	0.62	0.62	0.65	0.62	0.63
1.6	**0.29**	0.39	0.52	0.51	0.56	0.61	0.67	0.68	0.70	0.73	0.74	0.75	0.76	0.76
1.7	**0.37**	0.47	0.51	0.60	0.65	0.71	0.75	0.75	0.80	0.79	0.81	0.80	0.83	0.83
1.8	**0.43**	0.55	0.67	0.68	0.72	0.78	0.79	0.83	0.85	0.84	0.85	0.86	0.87	0.88
1.9	**0.49**	0.62	0.73	0.74	0.78	0.82	0.85	0.86	0.88	0.89	0.90	0.91	0.92	0.91
2	**0.55**	0.67	0.78	0.79	0.84	0.86	0.87	0.89	0.90	0.91	0.92	0.93	0.93	0.94
2.1	**0.60**	0.72	0.82	0.83	0.85	0.88	0.90	0.91	0.92	0.93	0.94	0.94	0.95	0.95
2.2	**0.64**	0.77	0.85	0.88	0.91	0.90	0.91	0.93	0.93	0.94	0.95	0.95	0.96	0.96
2.3	**0.68**	0.80	0.87	0.90	0.92	0.93	0.93	0.94	0.95	0.95	0.96	0.97	0.96	0.97
2.4	**0.72**	0.83	0.89	0.91	0.93	0.94	0.95	0.96	0.96	0.97	0.96	0.97	0.97	0.98
2.5	**0.74**	0.86	0.91	0.93	0.94	0.95	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.98
2.6	**0.77**	0.88	0.92	0.94	0.95	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.98
2.7	**0.79**	0.89	0.93	0.95	0.96	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98
2.8	**0.81**	0.90	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.99
2.9	**0.83**	0.91	0.94	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99
3	**0.85**	0.92	0.95	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99
	Normalized classification entropy (NCE)													
1.5	**0.29**	0.34	0.34	0.39	0.41	0.42	0.45	0.49	0.50	0.50	0.50	0.52	0.50	0.50
1.6	**0.37**	0.43	0.51	0.49	0.51	0.55	0.58	0.58	0.59	0.60	0.63	0.62	0.63	0.63
1.7	**0.45**	0.52	0.53	0.57	0.60	0.64	0.66	0.65	0.69	0.68	0.69	0.68	0.71	0.71
1.8	**0.52**	0.59	0.67	0.65	0.68	0.71	0.71	0.74	0.75	0.74	0.75	0.76	0.76	0.77
1.9	**0.58**	0.66	0.72	0.71	0.73	0.76	0.77	0.79	0.80	0.81	0.82	0.82	0.83	0.82
2	**0.63**	0.71	0.77	0.76	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.85	0.86	0.86
2.1	**0.68**	0.75	0.80	0.80	0.81	0.83	0.84	0.85	0.86	0.86	0.87	0.88	0.88	0.88
2.2	**0.72**	0.79	0.83	0.85	0.87	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.90	0.90
2.3	**0.75**	0.82	0.88	0.87	0.89	0.90	0.89	0.90	0.90	0.90	0.91	0.92	0.91	0.93
2.4	**0.78**	0.85	0.88	0.89	0.91	0.91	0.92	0.92	0.93	0.93	0.92	0.93	0.93	0.94
2.5	**0.80**	0.87	0.90	0.91	0.92	0.92	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.95
2.6	**0.82**	0.89	0.91	0.92	0.93	0.93	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95
2.7	**0.84**	0.90	0.92	0.93	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.96	0.96	0.96
2.8	**0.86**	0.91	0.93	0.94	0.95	0.95	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96
2.9	**0.87**	0.92	0.94	0.94	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.97	0.97
3	**0.89**	0.93	0.94	0.95	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97	0.97

Table 2-5. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for migratory barren-ground caribou cows that formed group 1a (Bathurst caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate FPI and NCE were ≥0.90. The Bathurst herd was robust.

Fuzziness exponent (m)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	0.59	0.65	0.69	0.71	0.71	0.70	0.72	0.73	0.71	0.70	0.71	0.67	0.70	0.68
1.6	0.68	0.76	0.79	0.80	0.82	0.84	0.86	0.87	0.88	0.87	0.83	0.84	0.84	0.82
1.7	0.76	0.84	0.85	0.87	0.87	0.88	**0.90**	**0.91**	**0.91**	**0.91**	**0.91**	**0.91**	**0.90**	**0.90**
1.8	0.82	0.89	**0.90**	**0.91**	**0.92**	**0.92**	**0.92**	**0.93**	**0.93**	**0.94**	**0.94**	**0.94**	**0.91**	**0.92**
1.9	0.87	**0.93**	**0.95**	**0.93**	**0.94**	**0.95**	**0.95**	**0.95**	**0.96**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**
2	**0.91**	**0.95**	**0.97**	**0.95**	**0.95**	**0.96**	**0.96**	**0.96**	**0.97**	**0.97**	**0.97**	**0.96**	**0.97**	**0.97**
2.1	**0.94**	**0.97**	**0.98**	**0.98**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.98**	**0.98**	**0.98**
2.2	**0.97**	**0.98**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**1.00**	**0.98**	**1.00**	**0.98**	**1.00**	**1.00**	**0.98**
2.3	**0.98**	**0.99**	**0.99**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
	Normalized classification entropy (NCE)													
1.5	0.66	0.67	0.67	0.67	0.67	0.66	0.67	0.67	0.64	0.64	0.64	0.60	0.64	0.61
1.6	0.74	0.77	0.77	0.76	0.77	0.79	0.81	0.83	0.83	0.81	0.77	0.79	0.79	0.76
1.7	0.81	0.85	0.84	0.84	0.84	0.85	0.86	0.87	0.88	0.87	0.88	0.88	0.87	0.87
1.8	0.87	0.90	0.89	0.88	0.89	0.89	0.89	**0.90**	**0.90**	**0.91**	**0.91**	**0.91**	0.87	0.89
1.9	**0.91**	**0.93**	**0.94**	**0.91**	**0.91**	**0.92**	**0.93**	**0.92**	**0.94**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**
2	**0.94**	**0.96**	**0.96**	**0.93**	**0.93**	**0.94**	**0.94**	**0.95**	**0.95**	**0.95**	**0.95**	**0.94**	**0.96**	**0.96**
2.1	**0.96**	**0.97**	**0.98**	**0.98**	**0.95**	**0.95**	**0.95**	**0.96**	**0.96**	**0.96**	**0.96**	**0.96**	**0.96**	**0.97**
2.2	**0.98**	**0.98**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.97**	**0.99**	**0.97**	**0.99**	**0.99**	**0.97**
2.3	**0.99**	**0.99**	**0.99**	**0.99**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Table 2-6. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for migratory barren-ground caribou cows that formed group 1b (Beverly caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate FPI and NCE were ≥0.90. The Beverly herd was robust.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fuzziness performance index (FPI)														
1.5	0.69	0.67	0.66	0.71	0.75	0.77	0.75	0.74	0.71	0.68	0.71	0.70	0.69	0.68
1.6	0.79	0.78	0.79	0.83	0.84	0.86	0.88	0.89	0.90	0.87	0.88	0.88	0.89	0.89
1.7	0.87	0.87	0.88	**0.90**	**0.92**	**0.94**	**0.94**	**0.95**	**0.95**	**0.93**	**0.93**	**0.94**	**0.94**	**0.94**
1.8	**0.92**	**0.94**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.95**	**0.95**	**0.95**
1.9	**0.97**	**0.97**	**0.95**	**0.96**	**0.96**	**0.97**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**
2	**1.00**	**1.00**	**0.99**	**0.97**	**0.97**	**0.98**	**0.98**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**
2.1	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Normalized classification entropy (NCE)														
1.5	0.75	0.70	0.66	0.69	0.71	0.73	0.68	0.69	0.64	0.62	0.64	0.64	0.61	0.62
1.6	0.84	0.80	0.78	0.81	0.81	0.82	0.84	0.85	0.85	0.82	0.83	0.84	0.84	0.85
1.7	**0.90**	0.88	0.87	0.89	**0.90**	**0.92**	**0.92**	**0.93**	**0.93**	**0.90**	**0.91**	**0.91**	**0.91**	**0.92**
1.8	**0.94**	**0.94**	**0.92**	**0.93**	**0.94**	**0.95**	**0.95**	**0.95**	**0.96**	**0.96**	**0.96**	**0.93**	**0.93**	**0.93**
1.9	**0.97**	**0.97**	**0.94**	**0.95**	**0.95**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**
2	**1.00**	**1.00**	**0.99**	**0.96**	**0.96**	**0.97**	**0.97**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.99**	**0.99**
2.1	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Table 2-7. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for migratory barren-ground caribou cows that formed group 2 (Qamanirjuaq caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate FPI and NCE were ≥0.90. The Qamanirjuaq herd was robust.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	0.66	0.69	0.60	0.68	0.72	0.74	0.76	0.74	0.73	0.72	0.72	0.73	0.73	0.74
1.6	0.76	0.80	0.85	0.88	0.89	0.83	0.84	0.86	0.86	0.87	0.87	0.87	0.87	0.87
1.7	0.84	0.88	**0.91**	**0.93**	**0.94**	**0.95**	**0.95**	**0.96**	**0.96**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**
1.8	**0.90**	**0.93**	**0.95**	**0.96**	**0.97**	**0.97**	**0.97**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**
1.9	**0.95**	**0.97**	**0.98**	**0.98**	**0.98**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**
2	**0.98**	**0.99**	**0.99**	**0.99**	**0.99**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.1	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
	Normalized classification entropy (NCE)													
1.5	0.73	0.72	0.58	0.64	0.67	0.68	0.69	0.66	0.67	0.63	0.64	0.65	0.65	0.65
1.6	0.82	0.82	0.85	0.86	0.87	0.78	0.79	0.80	0.81	0.81	0.81	0.81	0.81	0.81
1.7	0.88	0.89	**0.91**	**0.92**	**0.92**	**0.93**	**0.93**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**
1.8	**0.93**	**0.94**	**0.95**	**0.95**	**0.96**	**0.96**	**0.96**	**0.96**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**
1.9	**0.96**	**0.97**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**	**0.98**
2	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**	**0.99**
2.1	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Table 2-8. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for tundra-wintering barren-ground caribou cows that formed group 3 (Lorillard, Queen Maud Gulf, and Wager Bay caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate optimal numbers of herds.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	0.26	**0.25**	0.29	0.29	0.30	0.35	0.35	0.30	0.34	0.27	0.32	0.33	0.38	0.38
1.6	0.34	**0.32**	0.37	0.37	0.38	0.40	0.39	0.42	0.46	0.39	0.44	0.45	0.44	0.49
1.7	0.42	**0.39**	0.44	0.45	0.47	0.51	0.55	0.52	0.52	0.56	0.55	0.53	0.54	0.53
1.8	0.49	**0.45**	0.51	0.52	0.55	0.62	0.56	0.62	0.60	0.64	0.64	0.63	0.63	0.62
1.9	0.55	**0.52**	0.57	0.59	0.62	0.65	0.72	0.68	0.69	0.74	0.71	0.69	0.70	0.71
2	0.61	**0.57**	0.62	0.65	0.68	0.70	0.77	0.75	0.75	0.78	0.76	0.76	0.76	0.78
2.1	0.66	**0.62**	0.67	0.70	0.73	0.77	0.78	0.78	0.79	0.82	0.81	0.79	0.82	0.81
2.2	0.70	**0.67**	0.71	0.75	0.77	0.80	0.83	0.83	0.83	0.84	0.84	0.84	0.85	0.83
2.3	0.74	**0.71**	0.75	0.79	0.81	0.85	0.86	0.85	0.85	0.86	0.85	0.86	0.87	0.83
2.4	0.77	**0.74**	0.78	0.82	0.84	0.85	0.88	0.89	0.90	0.89	0.87	0.88	0.88	0.88
2.5	0.79	**0.77**	0.81	0.84	0.86	0.90	0.91	0.91	0.90	0.91	0.89	0.91	0.88	0.89
2.6	0.82	**0.80**	0.83	0.86	0.88	0.90	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.91
2.7	0.84	**0.82**	0.85	0.88	0.90	0.92	0.93	0.94	0.94	0.93	0.93	0.91	0.93	0.93
2.8	0.85	**0.84**	0.87	0.90	0.91	0.93	0.94	0.95	0.95	0.95	0.96	0.95	0.94	0.94
2.9	0.87	**0.86**	0.88	0.91	0.92	0.94	0.95	0.95	0.96	0.96	0.95	0.96	0.96	0.95
3	0.88	**0.87**	0.90	0.92	0.93	0.95	0.95	0.96	0.96	0.97	0.97	0.97	0.96	0.94
	Normalized classification entropy (NCE)													
1.5	0.33	0.28	0.30	0.29	0.29	0.32	0.31	0.28	0.30	**0.25**	0.28	0.28	0.31	0.30
1.6	0.42	0.36	0.38	0.37	0.37	0.38	0.36	0.39	0.41	**0.35**	0.38	0.38	0.37	0.40
1.7	0.51	**0.44**	0.46	0.45	0.46	0.48	0.50	0.48	0.48	0.49	0.48	0.46	0.47	0.46
1.8	0.58	**0.51**	0.53	0.52	0.54	0.58	0.53	0.56	0.55	0.57	0.56	0.55	0.55	0.54
1.9	0.64	**0.57**	0.59	0.59	0.60	0.62	0.66	0.62	0.62	0.65	0.63	0.62	0.62	0.62
2	0.69	**0.62**	0.64	0.65	0.66	0.68	0.71	0.69	0.68	0.70	0.69	0.69	0.68	0.70
2.1	0.73	**0.67**	0.69	0.70	0.71	0.74	0.74	0.73	0.73	0.75	0.74	0.73	0.74	0.73
2.2	0.77	**0.71**	0.73	0.75	0.76	0.77	0.78	0.77	0.77	0.78	0.78	0.77	0.78	0.76
2.3	0.80	**0.75**	0.76	0.78	0.80	0.81	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.78
2.4	0.82	**0.78**	0.79	0.81	0.83	0.83	0.84	0.84	0.85	0.84	0.82	0.82	0.82	0.83
2.5	0.84	**0.80**	0.82	0.84	0.85	0.87	0.87	0.87	0.85	0.86	0.84	0.86	0.83	0.84
2.6	0.86	**0.83**	0.84	0.86	0.87	0.88	0.89	0.88	0.88	0.88	0.88	0.88	0.88	0.86
2.7	0.88	**0.85**	0.86	0.88	0.89	0.90	0.90	0.91	0.91	0.90	0.89	0.88	0.89	0.89
2.8	0.89	**0.86**	0.88	0.89	0.90	0.91	0.91	0.92	0.92	0.92	0.93	0.92	0.91	0.91
2.9	0.90	**0.88**	0.89	0.91	0.91	0.92	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.92
3	0.91	**0.89**	0.90	0.92	0.92	0.93	0.93	0.94	0.94	0.94	0.95	0.95	0.93	0.91

Table 2-9. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for tundra-wintering barren-ground caribou cows that formed group 3a (Queen Maud Gulf caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate optimal numbers of herds. The Queen Maud Gulf herd was organized as individuals.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds																					
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Fuzziness performance index (FPI)																					
1.5	0.34	0.47	0.42	0.38	0.37	0.32	0.34	0.30	0.29	0.28	0.20	0.18	0.23	0.21	0.14	0.14	0.10	0.10	0.07	0.06	0.02	**0.00**
1.6	0.44	0.59	0.52	0.48	0.47	0.47	0.46	0.39	0.41	0.39	0.36	0.32	0.30	0.26	0.26	0.22	0.18	0.14	0.10	0.07	0.04	**0.00**
1.7	0.53	0.68	0.61	0.57	0.57	0.53	0.55	0.52	0.49	0.48	0.42	0.39	0.36	0.32	0.29	0.24	0.20	0.16	0.12	0.08	0.04	**0.00**
1.8	0.60	0.75	0.68	0.64	0.64	0.65	0.61	0.58	0.54	0.50	0.45	0.42	0.38	0.34	0.30	0.25	0.21	0.17	0.13	0.08	0.04	**0.00**
1.9	0.67	0.81	0.74	0.71	0.71	0.70	0.66	0.62	0.57	0.52	0.48	0.44	0.39	0.34	0.30	0.26	0.22	0.17	0.13	0.08	0.04	**0.00**
2	0.72	0.85	0.79	0.77	0.76	0.76	0.69	0.64	0.59	0.55	0.49	0.44	0.40	0.35	0.31	0.26	0.22	0.17	0.13	0.09	0.04	**0.00**
2.1	0.77	0.88	0.83	0.86	0.88	0.81	0.86	0.66	0.60	0.55	0.50	0.45	0.40	0.65	0.52	0.26	0.22	0.56	0.13	0.09	0.04	**0.00**
2.2	0.81	0.90	0.86	0.89	0.91	0.91	0.89	0.82	0.81	0.79	0.74	0.74	0.40	0.74	0.57	0.27	0.52	0.18	0.13	0.56	0.04	**0.00**
2.3	0.84	0.92	0.89	0.91	0.93	0.94	0.90	0.84	0.84	0.83	0.79	0.79	0.78	0.74	0.74	0.70	0.74	0.70	0.70	**0.65**	0.70	**0.65**
2.4	0.86	0.93	0.91	0.92	0.94	0.95	0.90	0.89	0.84	0.84	0.79	0.79	0.79	0.79	0.74	0.70	0.78	**0.65**	0.74	**0.65**	0.74	**0.65**
2.5	0.88	0.94	0.93	0.94	0.95	0.95	0.95	0.89	0.84	0.84	0.79	0.79	0.95	0.79	0.79	0.79	**0.70**	0.79	0.74	**0.70**	0.74	0.74
2.6	0.90	0.95	0.94	0.95	0.96	0.96	0.90	0.89	0.95	0.84	0.84	0.79	0.79	0.79	**0.74**	0.79	0.79	**0.74**	0.79	0.91	0.78	**0.74**
2.7	0.91	0.96	0.96	0.96	0.96	0.97	0.95	0.95	0.92	0.95	0.84	0.84	0.79	0.95	0.75	0.79	0.95	0.91	0.79	0.79	0.79	**0.74**
2.8	0.93	0.96	0.97	0.96	0.97	0.97	0.96	0.95	0.95	0.88	0.95	0.84	0.79	0.79	0.95	0.79	0.95	**0.74**	0.79	0.79	0.79	0.95
2.9	0.94	0.97	0.98	0.97	0.99	0.98	0.96	0.96	0.95	0.89	0.92	0.95	0.84	0.95	0.79	0.79	0.91	0.79	0.95	0.83	**0.74**	0.87
3	0.95	0.97	0.98	0.98	0.98	0.98	0.98	0.99	0.96	0.96	0.95	0.96	1.00	0.95	0.95	0.91	0.83	0.95	0.95	0.96	0.95	**0.79**
	Normalized classification entropy (NCE)																					
1.5	0.43	0.52	0.44	0.39	0.38	0.33	0.34	0.30	0.28	0.26	0.20	0.17	0.21	0.19	0.13	0.12	0.09	0.09	0.06	0.05	0.02	**0.00**
1.6	0.53	0.63	0.54	0.49	0.48	0.47	0.45	0.38	0.39	0.36	0.34	0.30	0.28	0.24	0.23	0.20	0.16	0.13	0.09	0.06	0.03	**0.00**
1.7	0.61	0.71	0.62	0.58	0.57	0.53	0.53	0.51	0.46	0.45	0.40	0.37	0.33	0.30	0.27	0.22	0.18	0.15	0.11	0.07	0.03	**0.00**
1.8	0.68	0.78	0.69	0.65	0.65	0.63	0.60	0.56	0.53	0.48	0.44	0.41	0.37	0.32	0.28	0.24	0.20	0.16	0.12	0.07	0.04	**0.00**
1.9	0.74	0.83	0.75	0.72	0.71	0.69	0.64	0.61	0.56	0.51	0.47	0.42	0.38	0.33	0.29	0.25	0.21	0.16	0.12	0.08	0.04	**0.00**
2	0.79	0.86	0.80	0.77	0.76	0.75	0.68	0.63	0.58	0.54	0.48	0.44	0.39	0.35	0.30	0.26	0.21	0.17	0.13	0.08	0.04	**0.00**
2.1	0.82	0.89	0.84	0.85	0.87	0.79	0.84	0.65	0.60	0.55	0.50	0.44	0.40	0.64	0.51	0.26	0.22	0.55	0.13	0.09	0.04	**0.00**
2.2	0.85	0.91	0.87	0.88	0.90	0.89	0.88	0.80	0.79	0.78	0.73	0.73	0.40	0.73	0.56	0.26	0.52	0.18	0.13	0.55	0.04	**0.00**
2.3	0.88	0.93	0.89	0.90	0.92	0.92	0.89	0.83	0.83	0.82	0.77	0.77	0.77	0.73	0.73	0.68	0.73	0.68	0.68	**0.64**	0.69	**0.64**
2.4	0.90	0.94	0.91	0.92	0.93	0.93	0.89	0.88	0.83	0.83	0.78	0.78	0.78	0.78	0.74	0.69	0.78	**0.64**	0.73	**0.64**	0.73	**0.64**
2.5	0.91	0.95	0.93	0.93	0.94	0.94	0.93	0.89	0.83	0.83	0.78	0.78	0.93	0.78	0.78	0.78	0.69	0.78	0.73	**0.69**	0.73	0.73
2.6	0.93	0.96	0.94	0.94	0.95	0.95	0.90	0.89	0.94	0.83	0.83	0.78	0.78	0.78	0.74	0.78	0.78	0.74	0.78	0.89	0.78	**0.73**
2.7	0.94	0.96	0.95	0.95	0.96	0.96	0.94	0.94	0.91	0.94	0.83	0.83	0.79	0.94	0.74	0.78	0.94	0.90	0.78	0.78	0.78	**0.74**
2.8	0.95	0.97	0.97	0.96	0.96	0.96	0.95	0.95	0.94	0.88	0.94	0.83	0.79	0.79	0.94	0.78	0.94	**0.74**	0.78	0.78	0.78	0.94
2.9	0.95	0.97	0.98	0.96	0.98	0.97	0.95	0.95	0.95	0.88	0.91	0.94	0.83	0.95	0.79	0.79	0.90	0.78	0.95	0.83	**0.74**	0.87
3	0.96	0.98	0.98	0.97	0.97	0.97	0.98	0.99	0.95	0.95	0.94	0.95	0.99	0.95	0.95	0.90	0.83	0.95	0.95	0.95	0.95	**0.78**

Table 2-10. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for tundra-wintering barren-ground caribou cows that formed group 3b (Lorillard caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate FPI and NCE were ≥0.90. The Lorillard herd was robust.

Fuzziness exponent (m)	Values of the fuzziness performance index and normalized classification entropy by number of herds																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Fuzziness performance index (FPI)																	
1.5	0.52	0.35	0.42	0.37	0.35	0.42	0.43	0.42	0.40	0.38	0.35	0.29	0.25	0.20	0.13	0.10	0.05	0.00
1.6	0.67	0.48	0.53	0.48	0.46	0.52	0.53	0.52	0.44	0.41	0.35	0.30	0.26	0.20	0.15	0.10	0.05	0.00
1.7	0.79	0.77	0.63	0.58	0.56	0.68	0.62	0.54	0.48	0.42	0.36	0.31	0.26	0.21	0.16	0.10	0.05	0.00
1.8	0.88	0.86	0.85	0.66	0.75	0.77	0.74	0.77	0.71	0.66	0.67	0.32	0.73	0.21	0.52	0.10	0.05	0.00
1.9	**0.94**	**0.92**	**0.94**	**0.91**	**0.92**	**0.93**	0.78	0.79	0.79	0.78	0.89	0.78	0.78	0.67	0.78	0.11	0.62	0.00
2	**0.99**	**0.95**	**0.96**	**0.92**	**0.93**	**0.93**	**0.94**	**0.94**	0.89	0.94	0.84	**0.95**	0.89	0.89	0.89	0.63	0.73	**0.95**
2.1	**1.00**	**1.00**	**0.97**	**0.97**	**0.93**	**0.93**	**0.94**	**0.94**	**0.94**	0.89	**0.94**	**0.95**	0.84	**0.94**	0.89	0.84	0.89	0.84
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.94**	**0.94**	**1.00**	**0.95**	0.89	**0.90**	**0.95**	**0.95**	**0.95**	0.79
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.90**	**0.95**	**0.95**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**0.95**	**1.00**	**1.00**	**0.90**	**0.90**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**	**0.95**	**0.95**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.89
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**	**1.00**
	Normalized classification entropy (NCE)																	
1.5	0.60	0.40	0.43	0.38	0.35	0.39	0.40	0.38	0.37	0.34	0.32	0.26	0.23	0.17	0.11	0.09	0.04	0.00
1.6	0.74	0.53	0.54	0.48	0.46	0.49	0.49	0.48	0.41	0.39	0.32	0.29	0.25	0.18	0.14	0.09	0.05	0.00
1.7	0.84	0.79	0.63	0.57	0.54	0.66	0.61	0.51	0.46	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	0.00
1.8	**0.91**	0.87	0.82	0.64	0.72	0.74	0.71	0.73	0.67	0.63	0.64	0.31	0.70	0.20	0.49	0.10	0.05	0.00
1.9	**0.96**	**0.92**	**0.93**	0.88	**0.90**	**0.91**	0.75	0.77	0.77	0.76	0.87	0.75	0.77	0.65	0.77	0.10	0.60	0.00
2	**0.99**	**0.95**	**0.95**	0.89	**0.90**	**0.91**	**0.92**	**0.93**	0.87	**0.93**	0.82	**0.94**	0.89	0.88	0.88	0.61	0.71	**0.94**
2.1	**1.00**	**1.00**	**0.97**	**0.97**	**0.91**	**0.92**	**0.92**	**0.92**	**0.93**	0.89	**0.93**	**0.94**	0.83	**0.94**	0.88	0.84	0.88	0.83
2.2	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.93**	**0.93**	**1.00**	**0.94**	0.88	0.89	**0.94**	**0.94**	**0.94**	0.77
2.3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.89**	**0.94**	**0.95**
2.4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**0.94**	**1.00**	**1.00**	**0.89**	**0.89**
2.5	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**	**0.95**	**0.95**
2.6	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
2.7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.89**
2.8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	**1.00**
2.9	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
3	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.94**	**1.00**	**1.00**

Table 2-11. Analysis step 2: number of herds indicated by fuzzy clustering of movement data for tundra-wintering barren-ground caribou cows that formed group 3c (Wager Bay caribou) in step 1. Results are based on fuzzy clustering of median 2-week interval *x*, *y* coordinates for each caribou (i.e., 52 variables). Numbers in bold indicate optimal numbers of herds. The Wager Bay herd was organized as individuals.

Fuzziness exponent (*m*)	Values of the fuzziness performance index and normalized classification entropy by number of herds													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Fuzziness performance index (FPI)													
1.5	0.45	0.26	0.33	0.31	0.34	0.33	0.29	0.25	0.22	0.16	0.14	0.08	0.02	**0.00**
1.6	0.55	0.34	0.41	0.42	0.45	0.42	0.38	0.33	0.28	0.22	0.16	0.12	0.03	**0.00**
1.7	0.65	0.42	0.50	0.58	0.48	0.48	0.43	0.38	0.30	0.24	0.18	0.13	0.05	**0.00**
1.8	0.73	0.50	0.57	0.66	0.59	0.54	0.45	0.39	0.33	0.26	0.19	0.13	0.07	**0.00**
1.9	0.79	0.57	0.64	0.72	0.64	0.57	0.49	0.41	0.34	0.27	0.20	0.13	0.07	**0.00**
2	0.85	0.63	0.70	0.76	0.67	0.59	0.49	0.42	0.35	0.27	0.20	0.14	0.07	**0.00**
2.1	0.89	0.69	0.74	0.79	0.81	0.60	0.51	0.43	0.35	0.28	0.21	0.14	0.07	**0.00**
2.2	0.92	0.74	0.78	0.81	0.82	0.74	0.69	0.43	0.36	0.73	0.67	0.14	0.07	**0.00**
2.3	0.94	0.78	0.81	0.82	0.85	0.86	0.74	0.68	0.36	0.79	0.66	0.14	**0.07**	0.73
2.4	0.96	0.81	0.83	0.85	0.86	0.86	0.80	0.80	0.80	**0.29**	0.60	0.60	0.60	0.73
2.5	0.97	0.85	0.84	0.86	0.86	0.86	0.80	0.86	0.80	0.67	**0.60**	0.67	0.73	0.80
2.6	0.99	0.92	0.93	0.86	0.94	0.87	0.81	0.87	**0.68**	0.87	0.80	0.87	0.80	0.80
2.7	0.99	0.93	0.93	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.68	0.87	**0.67**	**0.67**
2.8	1.00	0.98	0.94	0.94	0.94	0.87	0.94	0.87	0.86	0.80	0.87	0.87	0.87	**0.67**
2.9	1.00	1.00	0.94	1.00	0.87	0.94	0.87	0.87	0.87	0.87	0.81	**0.80**	0.87	0.87
3	1.00	1.00	1.00	0.94	1.00	0.94	0.87	0.87	0.87	0.81	0.87	**0.80**	**0.80**	0.87
	Normalized classification entropy (NCE)													
1.5	0.53	0.29	0.34	0.32	0.33	0.33	0.28	0.23	0.20	0.14	0.13	0.07	0.02	**0.00**
1.6	0.63	0.39	0.43	0.42	0.45	0.40	0.35	0.31	0.27	0.20	0.15	0.11	0.03	**0.00**
1.7	0.72	0.47	0.51	0.57	0.47	0.46	0.41	0.36	0.29	0.23	0.17	0.12	0.05	**0.00**
1.8	0.79	0.55	0.58	0.64	0.58	0.53	0.43	0.38	0.32	0.25	0.19	0.12	0.06	**0.00**
1.9	0.84	0.62	0.65	0.70	0.62	0.56	0.48	0.40	0.34	0.27	0.20	0.13	0.06	**0.00**
2	0.88	0.68	0.70	0.74	0.66	0.58	0.49	0.42	0.34	0.27	0.21	0.14	0.07	**0.00**
2.1	0.92	0.73	0.74	0.76	0.78	0.60	0.52	0.44	0.36	0.28	0.21	0.14	0.07	**0.00**
2.2	0.94	0.77	0.78	0.78	0.80	0.73	0.68	0.43	0.37	0.72	0.66	0.14	0.07	**0.00**
2.3	0.96	0.81	0.81	0.80	0.84	0.84	0.73	0.68	0.37	0.77	0.64	0.14	**0.07**	0.72
2.4	0.97	0.84	0.83	0.84	0.84	0.85	0.79	0.79	0.79	**0.30**	0.59	0.59	0.59	0.72
2.5	0.98	0.87	0.84	0.85	0.85	0.85	0.79	0.85	0.79	0.66	**0.59**	0.66	0.71	0.80
2.6	0.99	0.93	0.93	0.86	0.93	0.86	0.80	0.86	**0.67**	0.86	0.80	0.86	0.80	0.80
2.7	1.00	0.94	0.93	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.67	0.86	**0.66**	**0.66**
2.8	1.00	0.98	0.94	0.94	0.94	0.86	0.93	0.86	0.85	0.80	0.86	0.86	0.86	**0.67**
2.9	1.00	1.00	0.94	1.00	0.87	0.94	0.87	0.87	0.86	0.86	**0.80**	**0.80**	0.86	0.87
3	1.00	1.00	1.00	0.94	1.00	0.94	0.87	0.87	0.87	**0.80**	0.87	**0.80**	**0.80**	0.87

Table 2-12. Comparison of the classification by hierarchical (Ward's method) and fuzzy *c*-means (*m*=2.0) clustering of caribou on mainland Nunavut and eastern Northwest Territories and, Canada.

Herds from	Herds from fuzzy clustering						
hierarchical clustering	Bathurst	Beverly	Lorillard	Qamanirjuaq	Queen Maud Gulf	Wager Bay	Total
Bathurst	52						52
Beverly		54		3			57
Lorillard			19	1		1	21
Qamanirjuaq				63			63
Queen Maud Gulf		2			23	3	28
Wager Bay						11	11
Total	52	56	19	67	23	15	232

Table 2-13.Number of cows for which annual and monthly/activity period paths were created and mapped for each barren-ground caribou herd in eastern Northwest Territories and mainland Nunavut, 1996-2010.

	No. Paths Per Herd					
Path Type	Bathurst	Beverly	Qamanirjuaq	Queen Maud Gulf	Lorillard	Wager Bay
Annual						
1996	7	4	7			
1997	7	4	11			
1998	17	3	7		2	
1999	14		7		9	1
2000	13		7		11	6
2001	12	5	9		8	6
2002	5	6	8	1	11	4
2003	10	3	7	1	12	11
2004	12	2	13	1	12	10
2005	12	7	10	1	8	5
2006	12	19	23	2	3	3
2007	18	26	22	2		
2008	23	42	31	10		
2009	17	39	27	22		1
2010						
Month/Activity Period						
May	152	164	197	44	69	41
Calving	147	155	186	44	65	41
Summer	144	163	184	44	67	37
Fall	123	150	173	41	63	37
Rut	138	149	169	41	60	40
Winter	163	166	180	53	57	38
April	154	167	196	48	67	45

Section 3: Delineation of barren-ground caribou calving grounds on mainland Nunavut and eastern mainland Northwest Territories, Canada

Methods

1) Calving dates and locations

We examined the daily movement rates during 15 May-15 July of cows that were assigned to each herd by fuzzy clustering to estimate calving dates and sites (Nagy 2011, Nagy et al. 2011). We calculated the period when most cows calved on the primary calving grounds of each herd (mean calving dates ±1.96×STDEV) and considered this period to be the main calving period (Nagy 2011). When sample sizes were adequate we used analyses of variance (ANOVA) and Tukey's honestly significant difference (HSD) pairwise comparisons (SPSS 11.5, Chicago, Illinois, USA) to determine if calving dates varied significantly among herds and among years within herds.

2) Delineation of calving grounds

We generated 50, 60, 70, 80, 90, and 95% utilization distributions (UD)(Rodgers et al. 2007) using i) estimated calving sites and ii) locations obtained for each cow during the main calving period (subsampled to one location per day) to delineate the primary calving grounds used by cows assigned to each herd except the Bathurst. We generated a path for each cow using the locations obtained during the main calving period to show the direction of movement. We overlaid the estimated calving sites, locations obtained during the main calving period, and the caribou paths on the 50-95% UDs. We also mapped the locations obtained during the main calving period for the five cows collared during the spring/spring migration period in April 1996 near Bathurst Inlet (Gunn et al. 2000) in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), the 1996 survey area (Gunn et al. 2000), and the 50-95% calving period UDs for the Beverly and Queen Maud Gulf herds for comparison.

3) Patterns of calving ground use by cows in all herds

We mapped the locations obtained for each cow during the main calving period to determine which calving grounds they used (Fig. 2-1). Because some cows calved in more than one area during the years they were tracked we classified calving grounds that were used by the majority of cows assigned to each herd by fuzzy clustering as “primary” and others used by these cows as “secondary” calving grounds.

4) Patterns of calving ground use by cows assigned to the Beverly herd

We determined the sequential pattern of calving grounds used for cows that were assigned to the Beverly herd, were tracked for 2-5 consecutive years, and used the Beverly-north and –south calving grounds to determine if there was a directional shift in calving ground use.

5) Capture locations, spring/spring migration to peak of calving paths, and calving ground use of cows calving near the Queen Maud Gulf coast

We mapped the capture locations and spring/spring migration to peak of calving paths for cows assigned by fuzzy clustering to the Beverly (10 April-12 June) and Queen Maud Gulf (10 April-15 June) herds in relationship to the calving grounds used by these herds and the extent of the Beverly winter range as described by Gunn (1989). Gunn’s (1989) described the winter range of the Beverly herd during 1939-1989 (50 years) as stretching from the East Arm of Great Slave Lake to Reindeer Lake on the Saskatchewan-Manitoba border. The winter range of the Beverly herd also overlapped that of the Qamanirjuaq herd in Manitoba and, during three winters in the 1980’s it overlapped that of the Bathurst herd north of the East Arm of Great Slave Lake (Gunn 1989). Gunn (1989) also noted that some Beverly caribou also wintered on the tundra. We considered the area between the East Arm of Great Slave Lake and Reindeer Lake as the primary winter range of the Beverly herd and created a shapefile to show the extent of this area.

Results

1) Calving dates and locations

We estimated the dates and sites of 79 calving events for cows that were assigned to the Beverly herd; 72 of these occurred near the western Queen Maud Gulf coast (Beverly-north) and 7 occurred on the "traditional" Beverly calving ground (Beverly-south). In addition, we estimated the dates and sites of 68 and 23 calving events for cows that were assigned to the Qamanirjuaq and Queen Maud Gulf herds, respectively.

Calving dates varied significantly among herds (ANOVA $F_{3,166}=6.938$, $P<0.001$). Calving dates for cows using the Beverly-north and Beverly-south calving ground were not significantly different and the data were pooled. Mean calving dates for Beverly (12 June ±1.96×3.177 STDEV) and Qamanirjuaq (12 June ±1.96×3.903 STDEV) caribou were not significantly different; mean calving dates for these caribou were significantly earlier than those for Queen Maud Gulf caribou (15 June ±1.96×2.865 STDEV).

Sufficient numbers of calving dates were obtained for Beverly caribou in 2006-2007 (n=14), 2008 (n=16), 2009 (n=27), and 2010 (n=20) and Qamanirjuaq caribou in 2004-2006 (n=16), 2007-2008 (n=26), and 2009-2010 (n=21) to examine trends in calving dates. Calving dates for the Beverly herd did not vary significantly among the four periods (ANOVA $F_{3,73}=2.356$, $P=0.079$) however the data suggested a trend for earlier calving between 2008 and 2010 (Fig. 3-1A). In comparison, calving dates for the Qamanirjuaq caribou varied significantly among the three time periods (ANOVA $F_{2,60}=4.958$, $P=0.010$; Tukey's HSD $P=0.059$) and suggested a trend for later calving (Fig. 3-1B).

2) Delineation of calving grounds

Locations were obtained during the main calving period for 437 calving events for cows assigned by fuzzy clustering to the Beverly (Beverly-north n=122, Beverly-south n=20), Qamanirjuaq (n=162), Queen Maud Gulf (n=44), Lorillard (n=63), and Wager Bay herds (n=26)

(Fig. 3-2 and Table 3-1). The 50-95% utilization distributions defining the boundaries of primary calving grounds based on calving sites with calving sites overlain and those based on locations obtained during the main calving period with locations and caribou paths overlain, are shown for the Beverly-north (Fig. 3-3, 3-4, and 3-5), Beverly-south (Fig. 3-6, 3-7, and 3-8), Queen Maud Gulf (Fig. 3-9, 3-10, and 3-11), Qamanirjuaq (Fig. 3-12, 3-13, and 3-14), Lorillard (Fig. 3-15 and 3-16), and Wager Bay (Fig. 3-17 and 3-18) calving grounds. The Beverly-north calving ground is located near the western Queen Maud Gulf coast; the Queen Maud Gulf herd calving ground is located near the eastern Queen Maud Gulf coast. The core Queen Maud Gulf calving ground is consistent with the area defined as the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000) and fell within the Queen Maud stratum surveyed in 1983 and 1995 by Heard et al. (1986) and Buckland et al. (2000), respectively.

The paths of Bathurst, Beverly, and Queen Maud Gulf cows during April, May, and the main calving period are shown in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), and the 1996 survey area (Gunn et al. 2000) in Figs. 3-19 to 3-21. By May (Fig 3-20) most of the Beverly cows were west of the Queen Maud survey area and were either in or approaching the area of overlap between the 1995 Bathurst calving distribution and the 1996 survey area. In comparison, most of the Queen Maud Gulf cows were east of this area. By calving the separation between the two herds was more pronounced, with most of the Beverly cows in the area of overlap between the 1995 Bathurst calving distribution and the 1996 survey area near the western Queen Maud Gulf coast, while most of the Queen Maud Gulf cows were near eastern Queen Maud Gulf coast.

Four of the five cows collared in April 1996 were on the mainland during the calving period in 1996 and 1997; one (PTTID 803) was offshore on an island in the Queen Maud Gulf (Fig. 3-22). Of the four cows that were on the mainland, two (PTTID 804 and 805) were in the area of overlap between the 1995 Bathurst calving distribution and 1996 survey area in 1996 and 1997 and two (PTTID 800 and 802) were within the area of overlap between the 1995 Bathurst calving distribution and 1996 survey area during one calving period and near the boundary of the 1986 Queen Maud Gulf calving area during one calving period. During the calving period in

1996 and 1997 cows PTTID 802, 804, and 805were largely within the area that we defined as the 50-90% calving UD for cows assigned by fuzzy clustering to the Beverly herd and used the Beverly-north calving ground (Fig. 3-23 and 3-24).

3) Patterns of calving ground use by cows in all herds

A total of 48 of the 52 cows assigned to the Bathurst herd were tracked during ≥2 calving periods; 44 only used the Bathurst calving ground while four cows used the Bathurst but also the Beverly-north calving ground at least once. Four cows were tracked for one calving period; all used the Bathurst calving ground. Note that we excluded individual females that used calving grounds D and C from our analyses (Fig. 2-1).

A total of 46 of the 56 caribou assigned to the Beverly herd were tracked during ≥2 calving periods. For these cows, 36 only used the Beverly-north, one only used the Beverly-south, six used the Beverly-north and Beverly-south, one used the Beverly-north and Bathurst, and two used the Beverly-north and the area between the Beverly-north and -south at least once. Ten cows were tracked for one calving period; three used the Beverly-south, six used the Beverly-north, and one was classified as a non breeder.

A total of 59 of the 67 cows assigned to the Qamanirjuaq herd were tracked during ≥2 calving periods. For these cows, 54 only used the Qamanirjuaq and three only used the Beverly-south calving ground. Two cows used the Qamanirjuaq but also used the Beverly-south or the Lorillard calving grounds during at least one calving period. Eight of the 59 cows were classified as non breeders during at least one year. Eight cows were tracked for one calving period; all used the Qamanirjuaq calving ground.

Eleven of the 23 cows assigned to the Queen Maud Gulf herd were tracked during ≥2 calving periods. All 23 cows used the Queen Maud Gulf calving ground.

Sixteen of the 19 cows assigned to the Lorillard herd were tracked during ≥2 calving periods; 15 of these only used the Lorillard calving ground while one used the Lorillard and

Beverly-south calving ground at least once. Three cows were tracked for one calving period; all three used the Lorillard calving ground.

Thirteen of the 15 cows assigned to the Wager Bay herd were tracked during ≥2 calving periods. Four of these cows only used the Wager Bay while four used the Wager Bay and Queen Maud Gulf calving grounds, two used the Wager Bay and Lorillard calving grounds, one used the Wager Bay, Lorillard, and Queen Maud Gulf calving grounds, and two only used the Lorillard calving ground. For the cows tracked for one calving period, one used the Wager Bay and one used the Queen Maud Gulf calving ground. Four cows assigned to the Wager Bay herd did not use the Wager Bay calving ground; two only used the Queen Maud Gulf and two only used the Lorillard calving grounds.

4) Patterns of calving ground use by cows assigned to the Beverly herd

Location data were obtained during 2-5 consecutive main calving periods (6-26 June) during 2005-2010 for 43 of 56 cows assigned to the Beverly herd by fuzzy clustering. These cows were located on the following calving grounds during the main calving periods:

i) **for cows located during two successive calving periods (n=11)**, four were on the Beverly-south calving ground in both years, two cows were on the Beverly-south calving ground in year one and then on the Beverly-north calving ground in year two, four cows only used the Beverly-north calving ground, and one cow moved from the Beverly-south to the Beverly-north calving ground during the calving period.

ii) **for cows located during three successive calving periods (n=19)**, 16 cows only used the Beverly-north calving ground while three cows used the Beverly-south in year 1 and then the Beverly-north in years 2 and 3.

iii) **for cows located during four successive calving periods (n=9)**, five cows only used the Beverly-north calving ground, two cows used the Beverly-south calving ground in year 1 and then the Beverly-north calving ground in years 2 to 4, one cow used the Beverly-south calving ground during years 1 and 2 and then the Beverly-north calving ground during years 3 and 4, one cow used the Beverly-south calving ground in years 1 to 3 and then the Beverly-north in year 4, and one cow used the Beverly-south calving ground in years 1 and 3 and the Beverly-north calving ground in years 2 and 4.

iv) **for cows located during five successive calving periods (n=4),** three cows only used the Beverly-north calving ground; one cow used the Beverly-south calving ground in year 1 and then the Beverly-north calving ground in years 2-5.

In all cases where cows used the Beverly-south and -north calving grounds, the shift in calving ground use was from the Beverly-south to the Beverly-north calving ground.

5) Capture locations, spring/spring migration to peak of calving paths, and calving ground use of cows assigned to the Beverly and Queen Maud Gulf herds

A total of 47 (84%) of the 56 cows assigned by fuzzy clustering to the Beverly herd were collared during the late winter or early spring; 9 of the 56 cows were collared during early July (Fig. 3-25). The majority of cows assigned to the Beverly herd (51 of 56 or 91%) were collared in areas where one would have expected to capture Beverly caribou, i.e., near or below treeline on the know Beverly herd winter range (Gunn 1989)(n=42) or on the “traditional” Beverly calving ground (Beverly-south)(n=9)(Fig. 3-25). Five cows were collared on the tundra: two northeast of Contwoyto Lake and three east of Bathurst Inlet. As indicated by Gunn (1989) some Beverly caribou were known to winter on the tundra. The spring/spring migration paths of Beverly cows indicate that most currently migrate towards but by-pass their “traditional” calving ground near Garry Lake and continue on to calve near the western Queen Maud Gulf coast (Fig. 3-25).

All 23 cows assigned to the Queen Maud Gulf herd were collared during the early winter to spring period. The majority of cows assigned to the Queen Maud Gulf herd (18 of 23 or 78%) were collared in areas where one would have expected to capture tundra-wintering Queen Maud Gulf cows, i.e., on the tundra north and west of Baker Lake (n=17) or southwest of Chantrey Inlet (n=1) near the Queen Maud stratum surveyed in 1983 and 1995 by Heard et al. (1986) and Buckland et al. (2000), respectively (Fig. 3-26). For the remaining five cows: two were collared on the Beverly herd winter range, one was collared on the Bathust herd winter range, and two were collared near treeline (Fig. 3-26). The spring/spring migration paths of Queen Maud Gulf cows largely lead from late winter ranges above treeline to calving sites near the eastern Queen Maud Gulf coast west of Chantrey Inlet and to areas near the coast east of Chantrey Inlet (Fig. 3-26).

Conclusions

Most of the cows assigned by fuzzy clustering to Beverly herd were captured in areas where one would have expected to capture Beverly caribou, i.e., on the known Beverly herd winter range and “traditional” Beverly herd calving ground. Although most of these cows calved near the western Queen Maud Gulf coast, some still calved on the “traditional” Beverly herd calving ground near Garry Lake.

Most of the cows assigned by fuzzy clustering to the Queen Maud Gulf herd were captured in areas where one would have expected to capture Queen Maud Gulf caribou, i.e., north and west of Baker Lake near the 1983 and 1995 Queen Maud survey stratum; these cows calved near the eastern Queen Maud Gulf coast west of Chantrey Inlet or near the coast east of Chantrey Inlet.

Queen Maud Gulf cows were more dispersed during calving and calved on average three days later than Beverly cows.

The calving areas used by the Beverly and Queen Maud Gulf herds were distinct but overlapping and, in combination, would indicate one area of continuous calving near the Queen Maud Gulf coast. Following conventional thinking one would have concluded that one herd calved near the Queen Maud Gulf coast. However, our analyses of the annual distribution and movements of caribou that currently calve near the Queen Maud Gulf coast indicate that two behaviourally different caribou herds calve in that area, i.e., the migratory Beverly and the tundra-wintering Queen Maud Gulf herds. This indicates that herds cannot be reliably identified using calving ground surveys alone; the annual distribution and movements of cows using each calving ground must be determined to verify whether one or more herds use the area during calving.

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Fig. 3-1. Mean calving dates (±1.96 SE) for the migratory Beverly (2006-2010) and Qamanirjuaq (2004-2010) barren-ground caribou herds on mainland Nunavut and eastern mainland Northwest Territories, Canada.

Fig. 3-1A. Beverly herd (Julian date of 161 = 9 June; ANOVA $F_{3,73}$=2.356, P=0.079; Tukey's HSD for pairwise comparisons P=0.081).

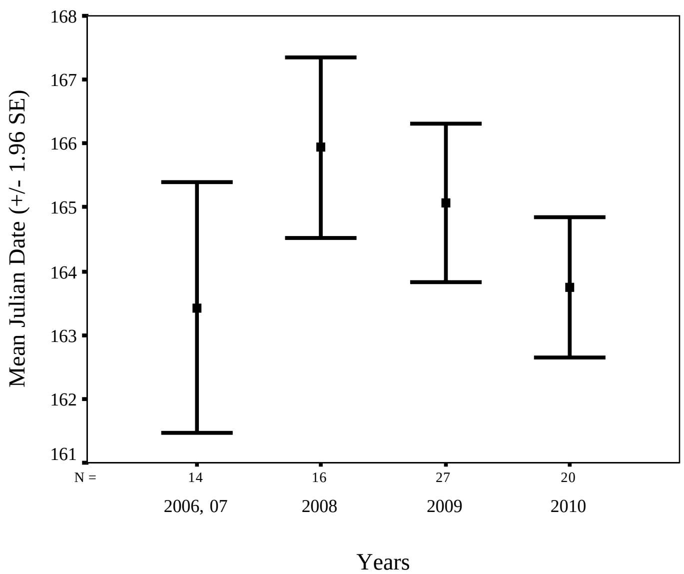


Fig. 3-1B. Qamanirjuaq herd (Julian date of 160 = 8 June; ANOVA $F_{2,60}$=4.958, P=0.010; Tukey's HSD for pairwise comparisons P=0.059).

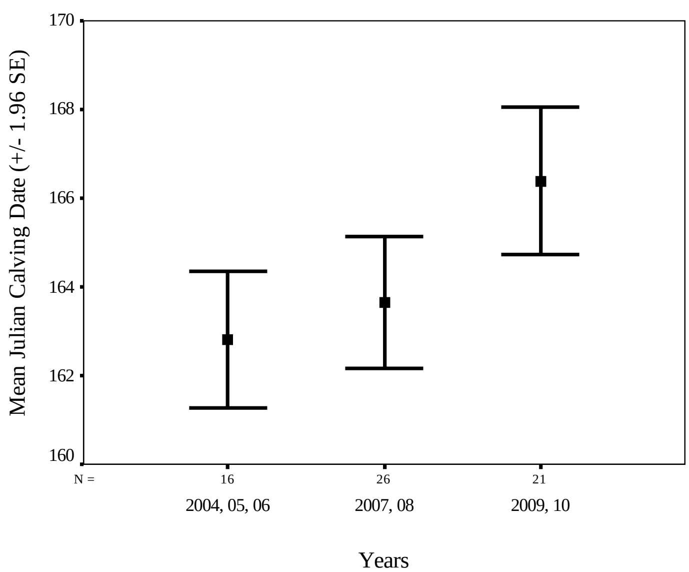
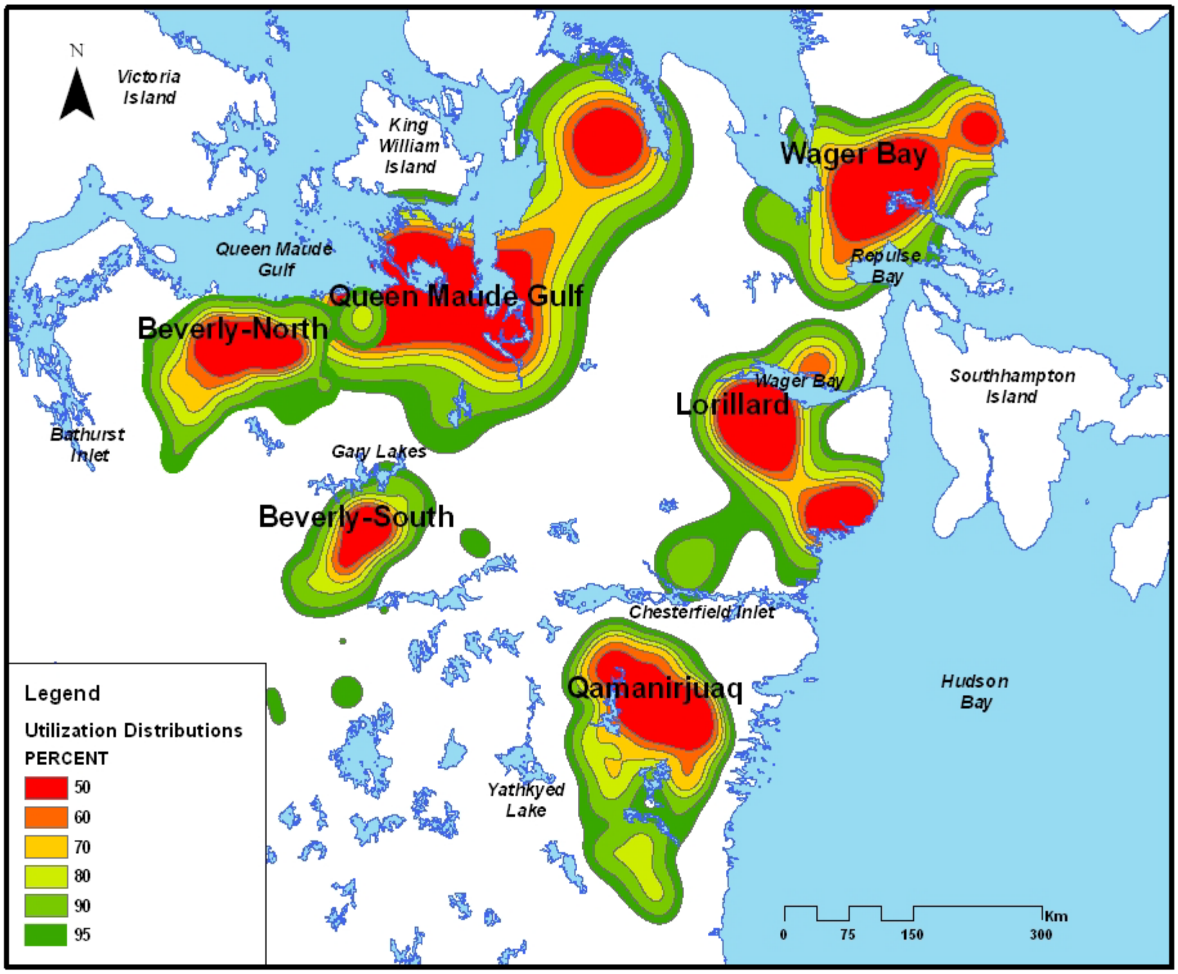


Fig. 3-2. Location of the calving grounds of the migratory Beverly (north and south) and Qamanirjuaq and tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay barren-ground caribou herds in Nunavut, Canada. Utilization distributions are based on locations obtained for cows during the main calving period.



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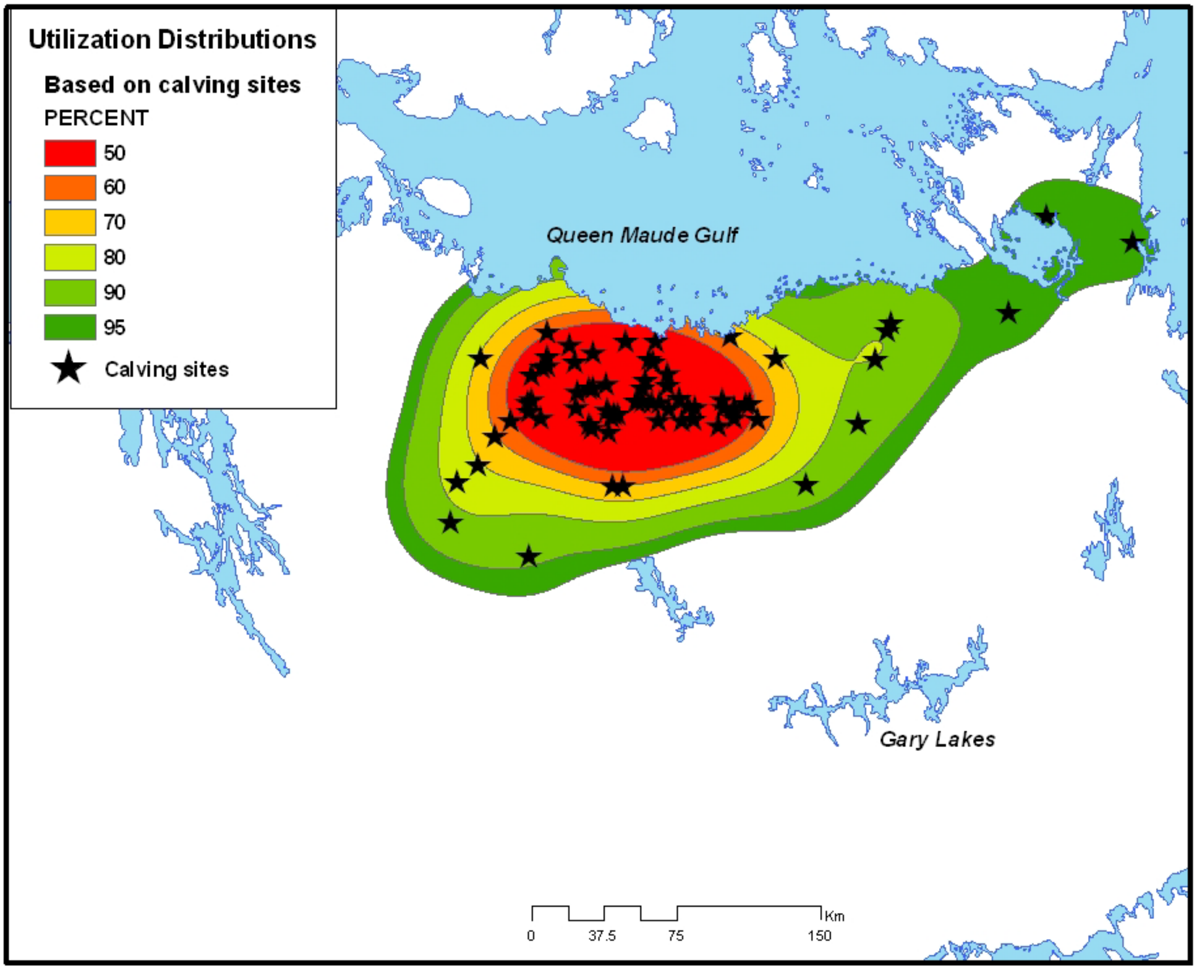


Fig. 3-4. The northern calving ground of the migratory Beverly barren-ground caribou herd. Utilization distributions are based on 1312 locations obtained during 121 annual calving ground use events for satellite collared cows during 6-18 June (mean calving date 12 June ±1.96×3.177 STDEV), 1996-2010.

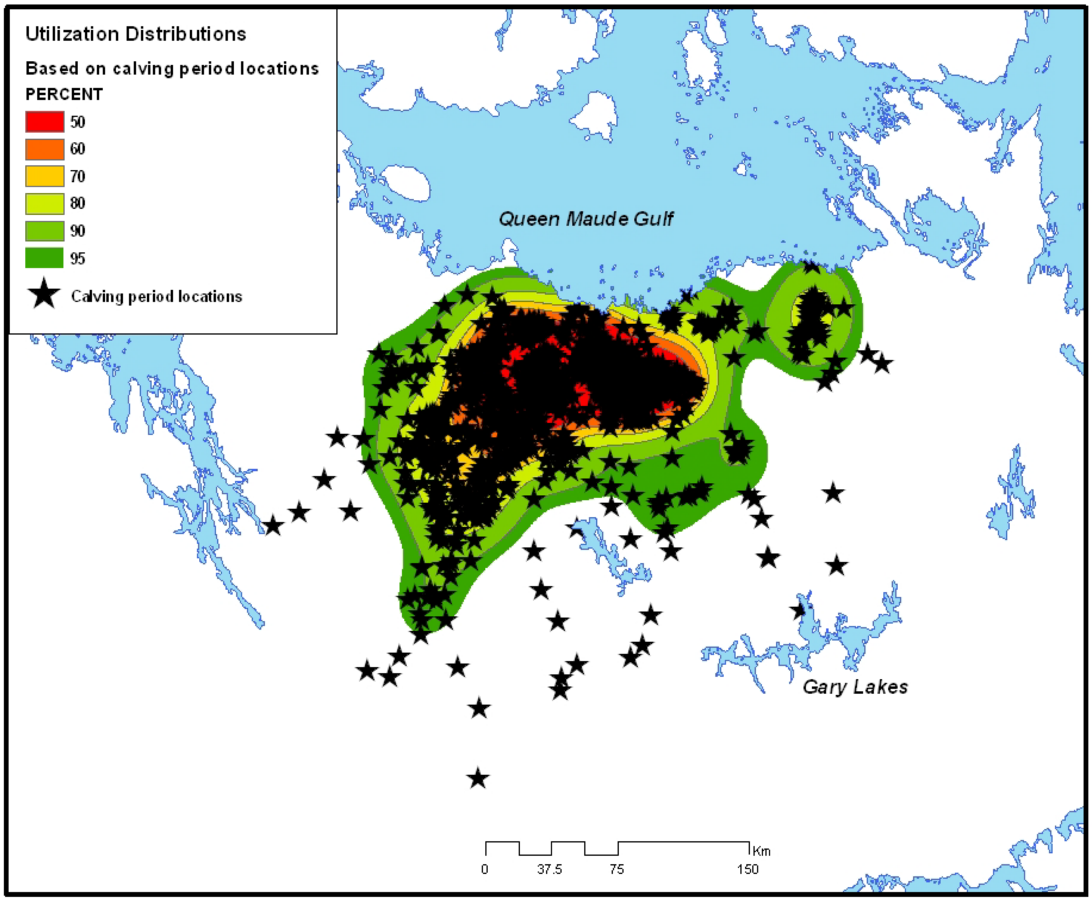


Fig. 3-5. The northern calving ground of the migratory Beverly barren-ground caribou herd. Utilization distributions and caribou paths are based on 1312 locations obtained during 121 annual calving ground use events for satellite collared cows during 6-18 June (mean calving date 12 June ±1.96×3.177 STDEV), 1996-2010.

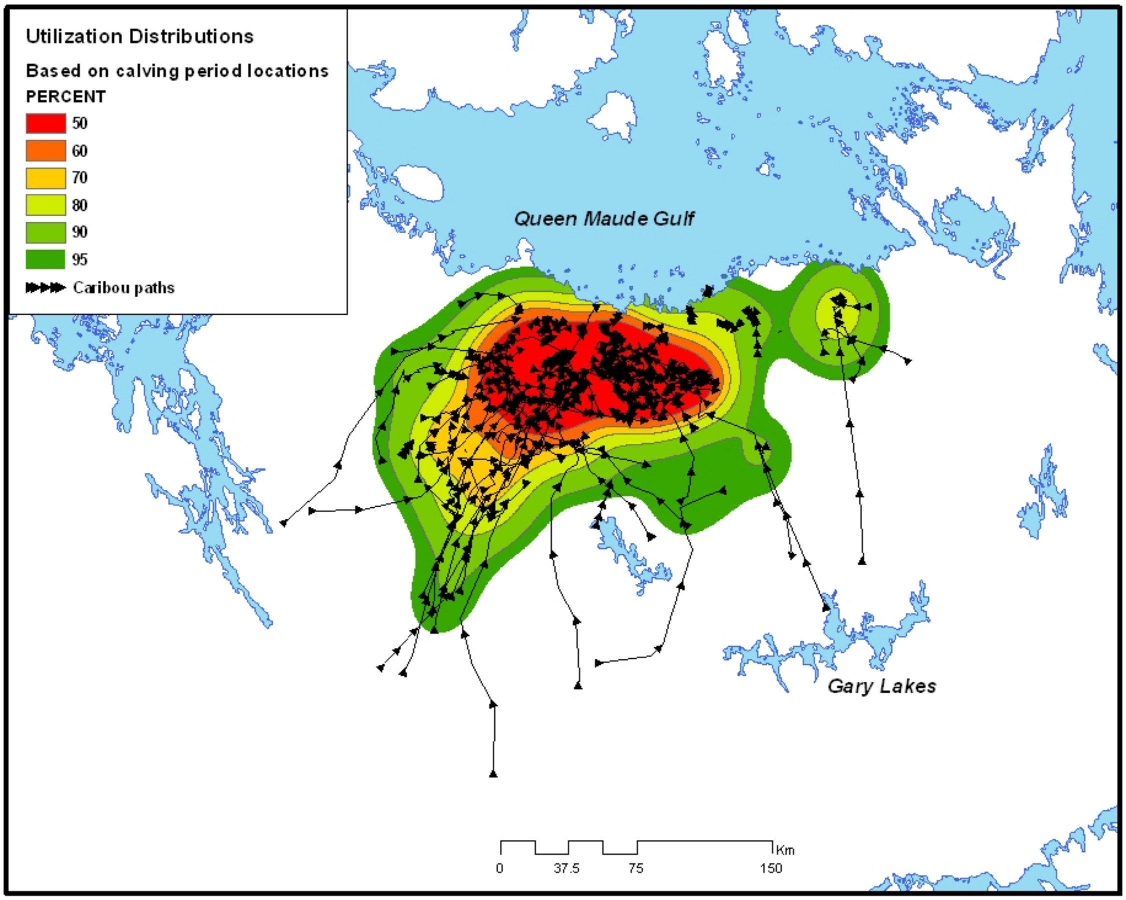
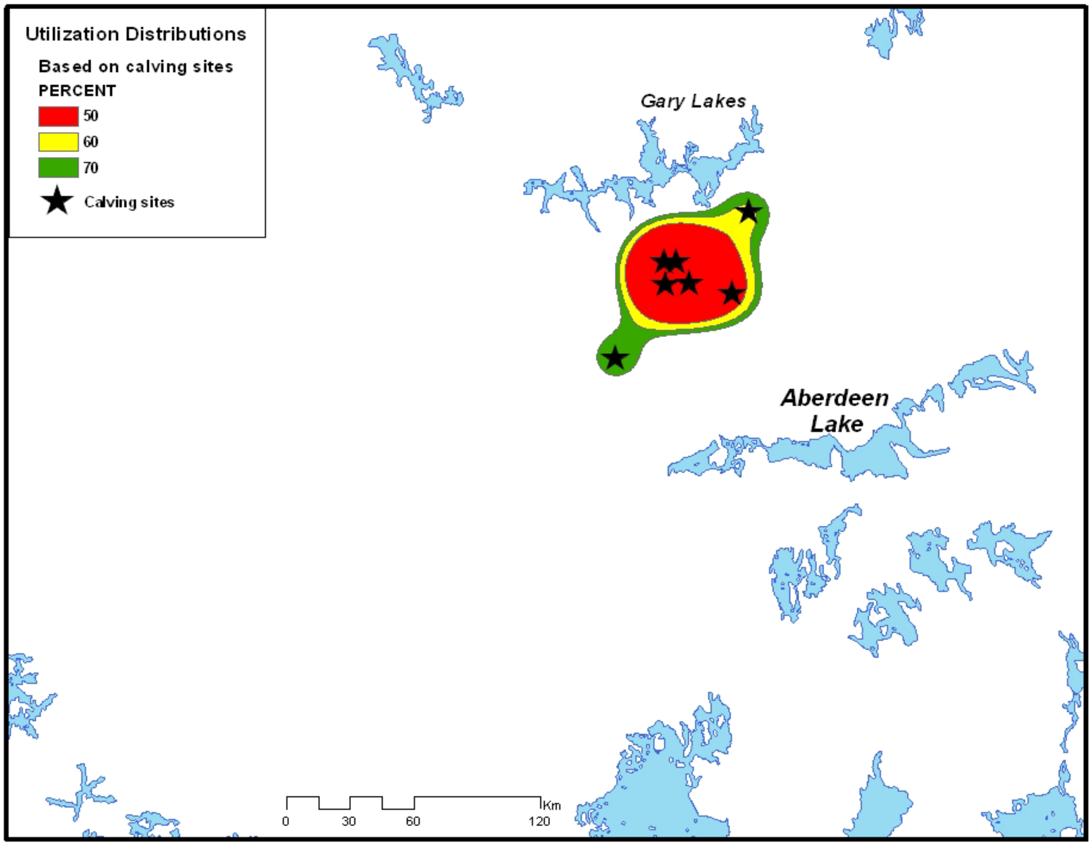


Fig. 3-6. The southern or "traditional" calving ground of the migratory Beverly barren-ground caribou herd. Utilization distributions are based on 7 calving sites estimated by examining the movement rates of satellite collared cows during the calving period, 1995-2009.



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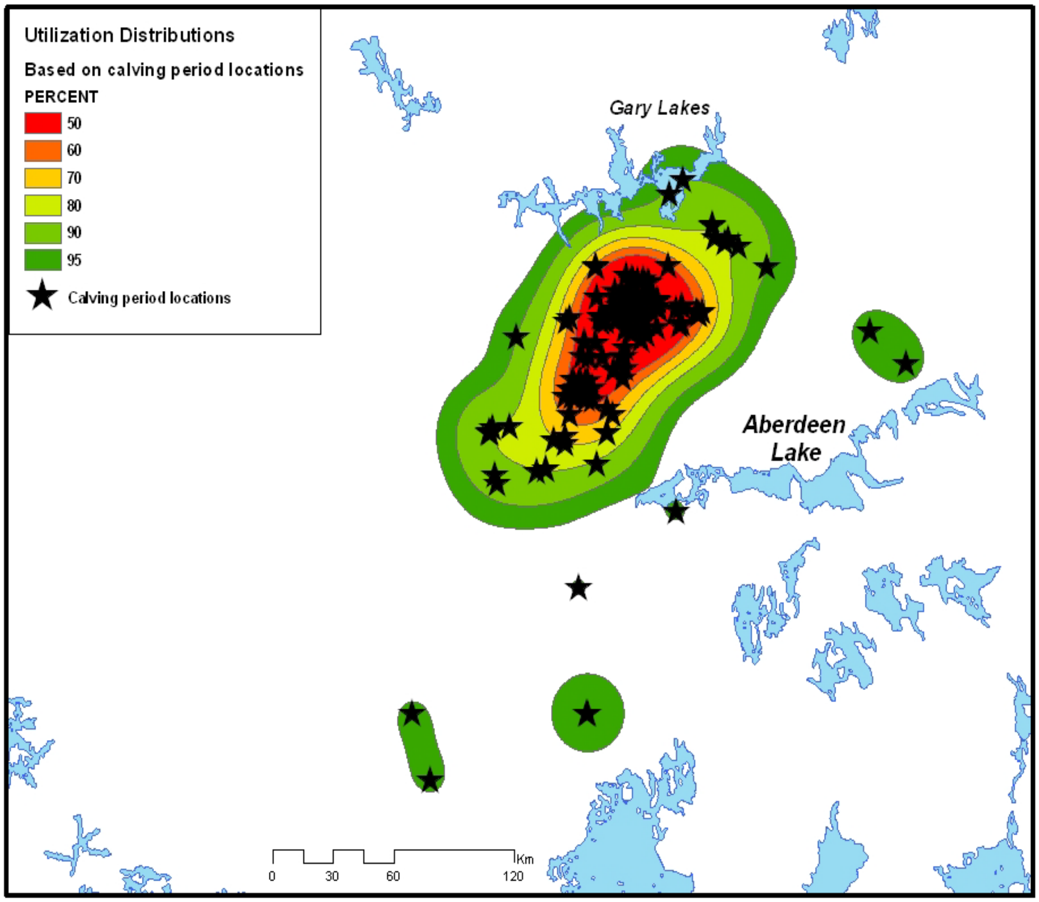
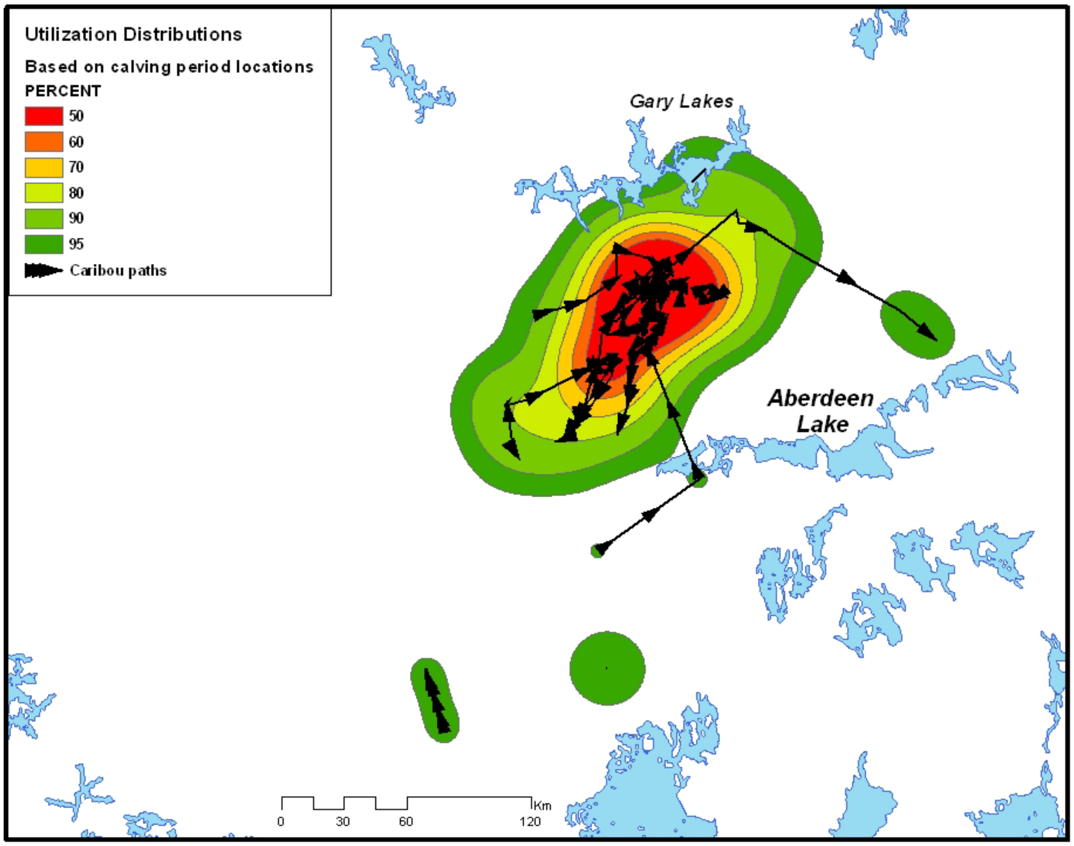


Fig. 3-8. The southern or “traditional” calving ground of the migratory Beverly barren-ground caribou herd. Utilization distributions and caribou paths are based on 167 locations obtained during 20 annual calving ground use events for satellite collared cows during 6-18 June (mean calving date 12 June ±1.96×3.177 STDEV), 1995-2009.



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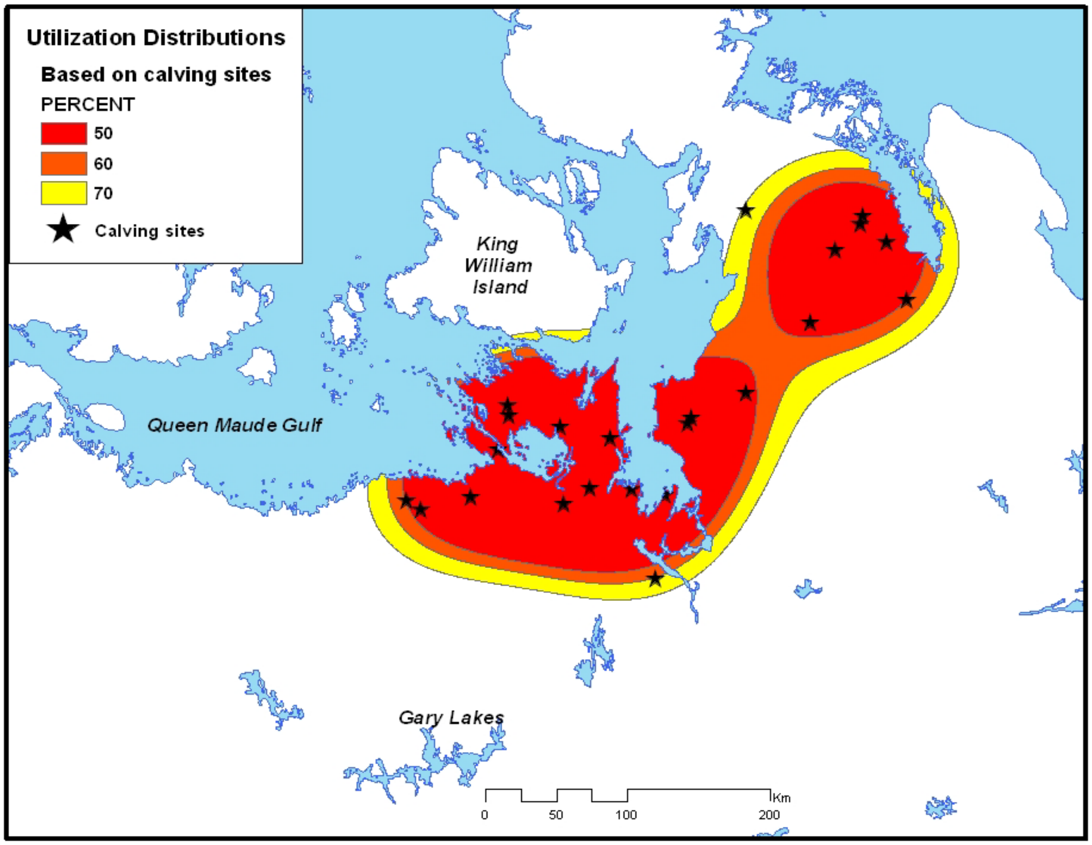

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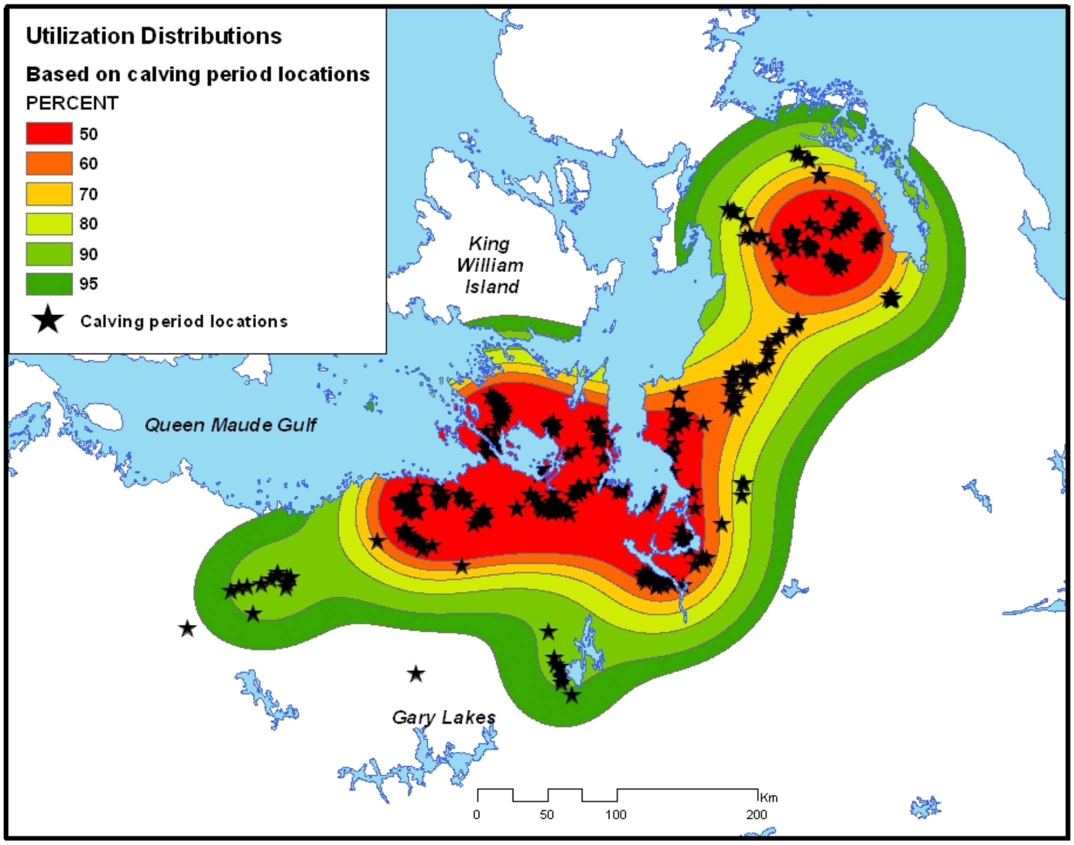
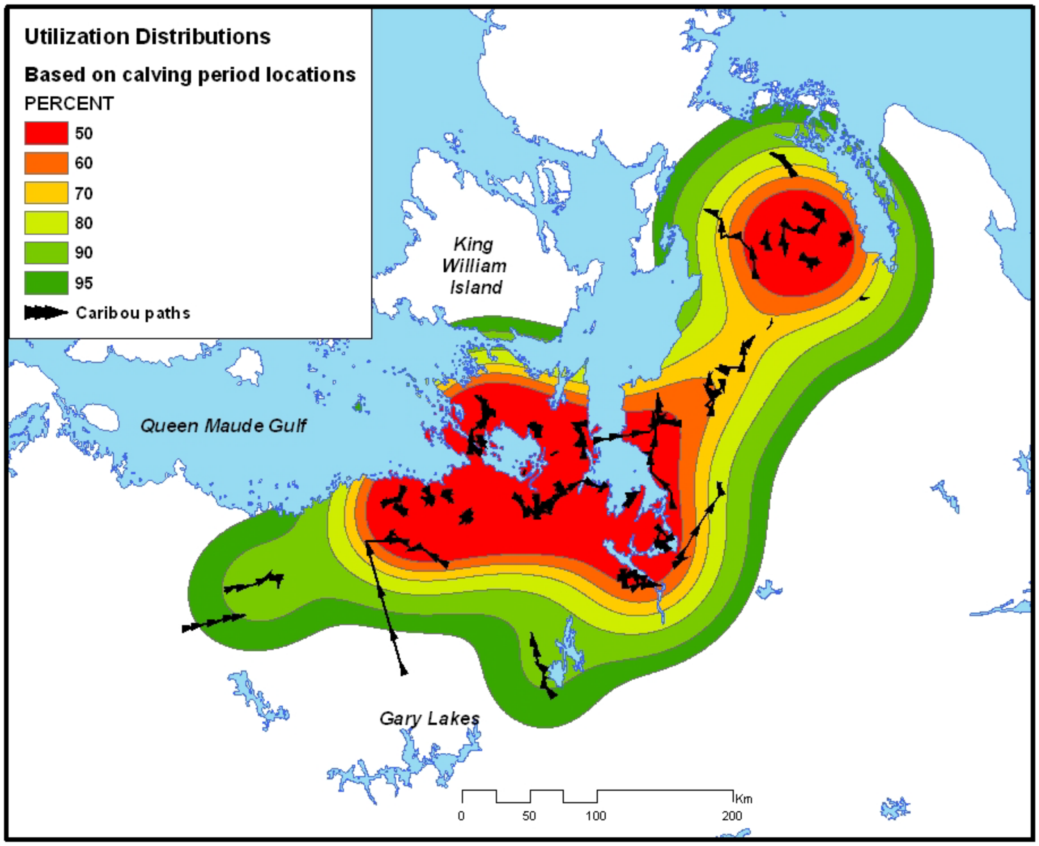


Fig. 3-11. The calving ground of the tundra-wintering Queen Maud Gulf barren-ground caribou herd. Utilization distributions and caribou paths are based on 425 locations obtained during 44 annual calving ground use events for satellite collared cows during 10-21 June (mean calving date 15 June ±1.96×2.865 STDEV), 2002-2010.



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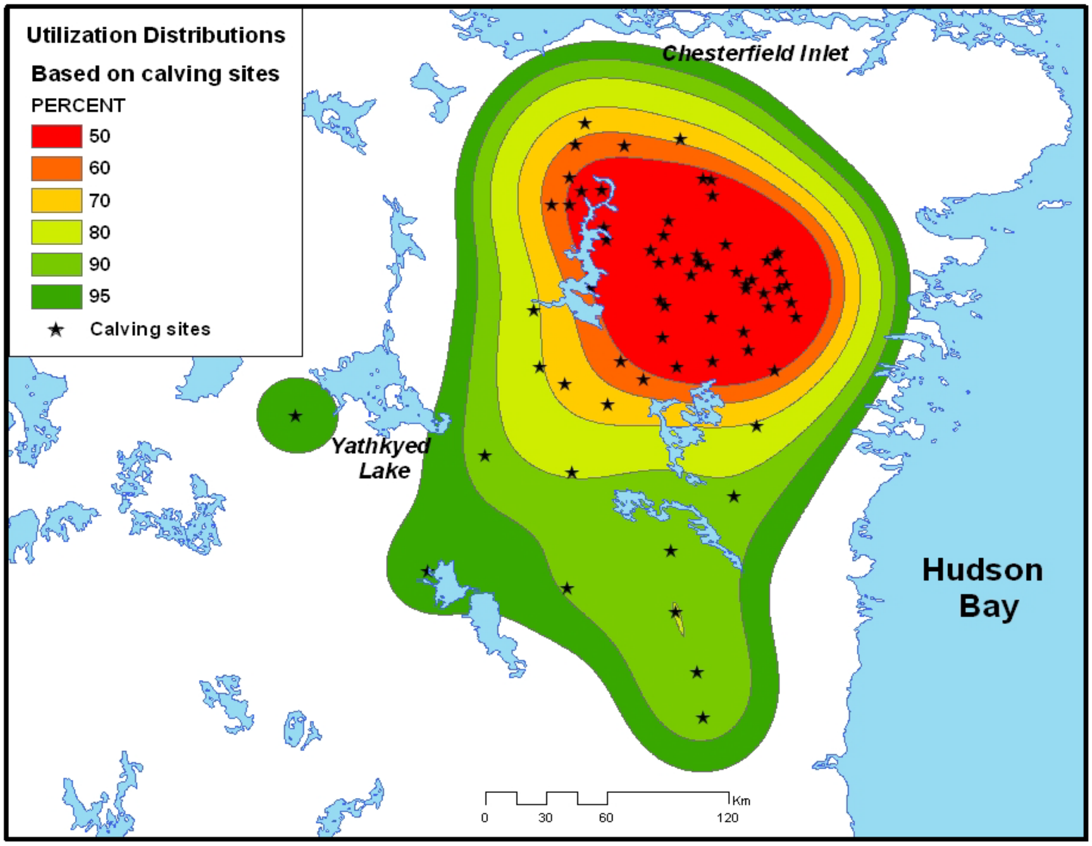

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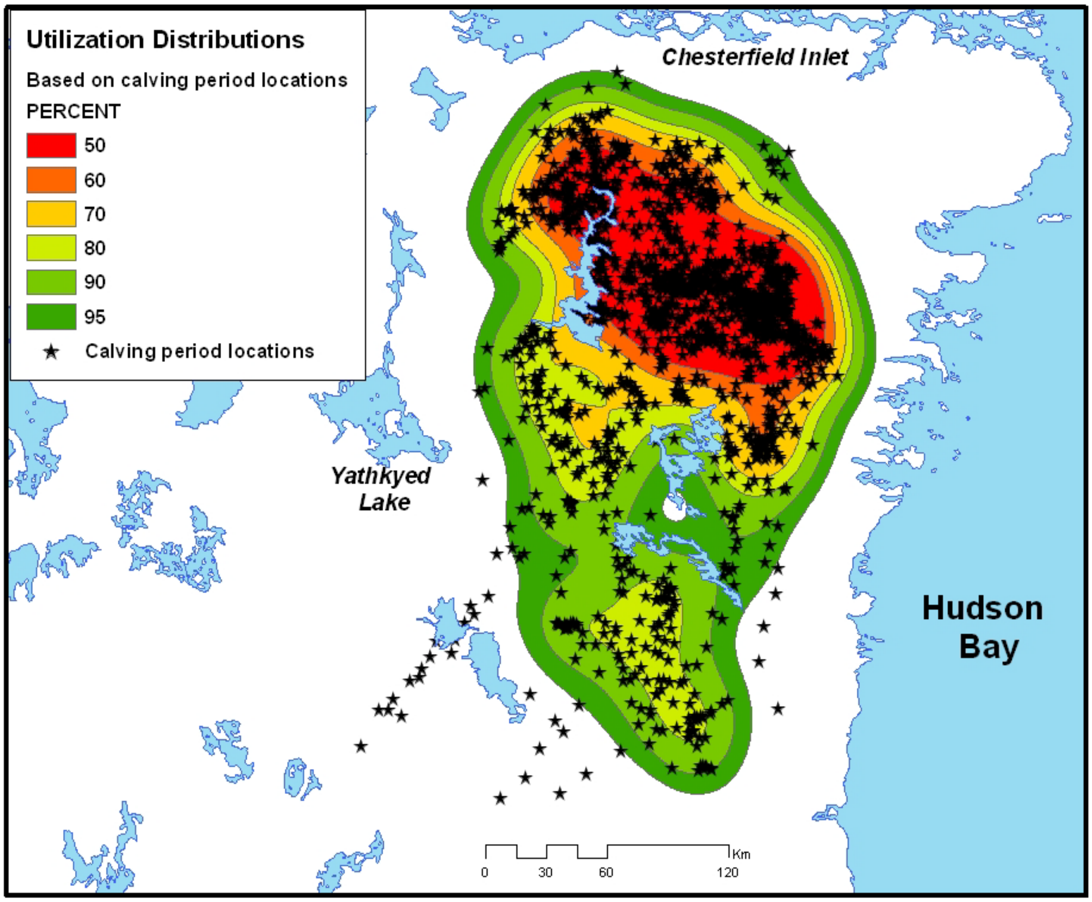

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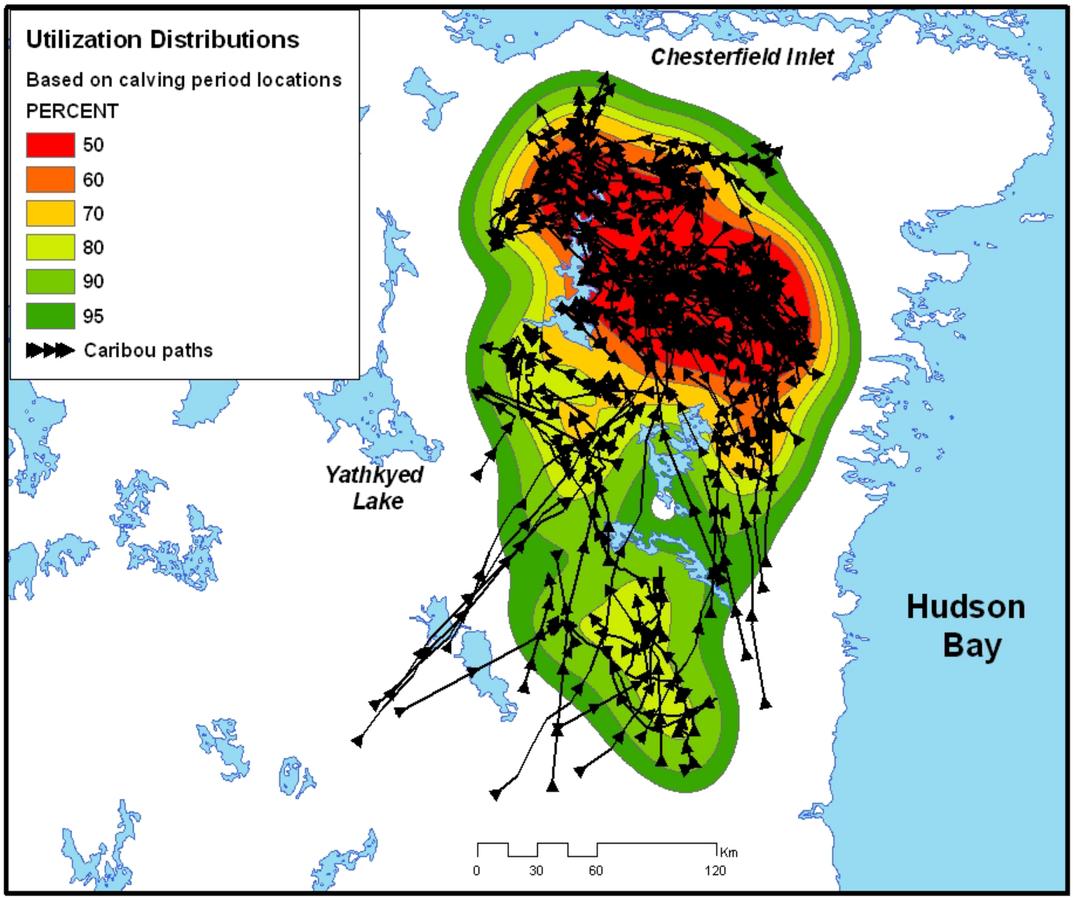

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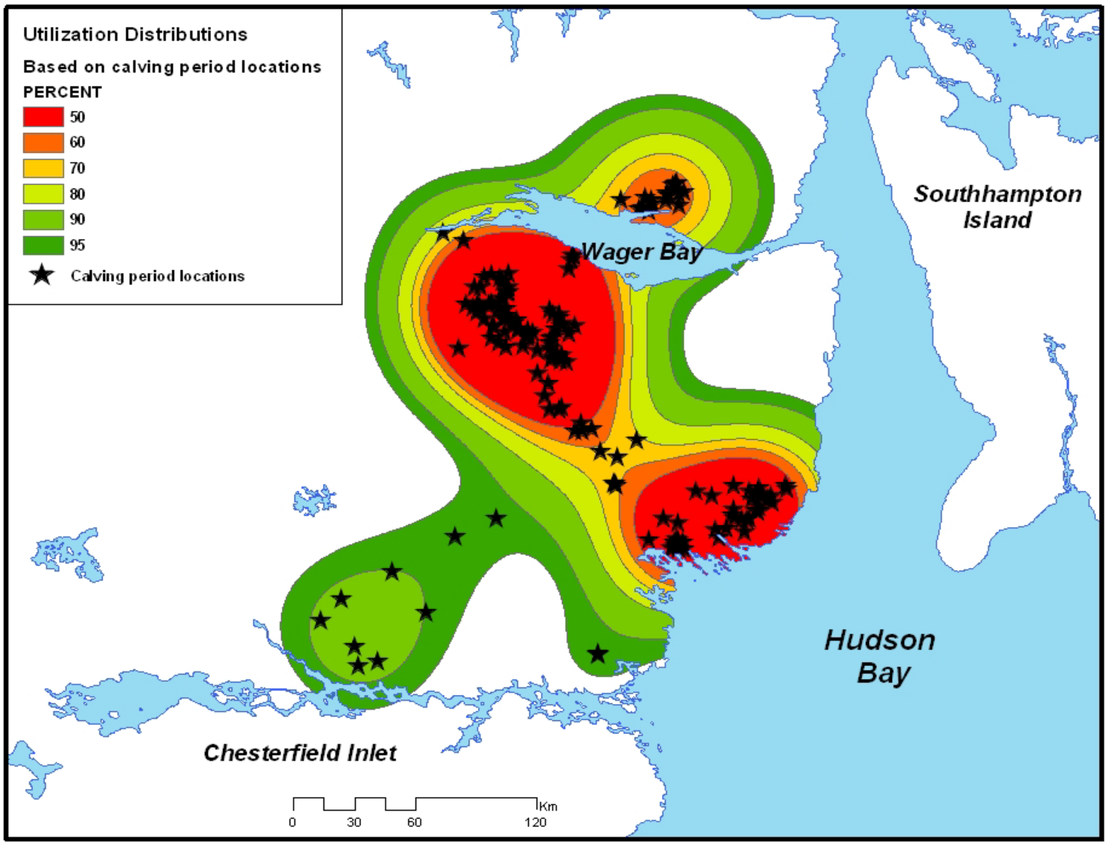

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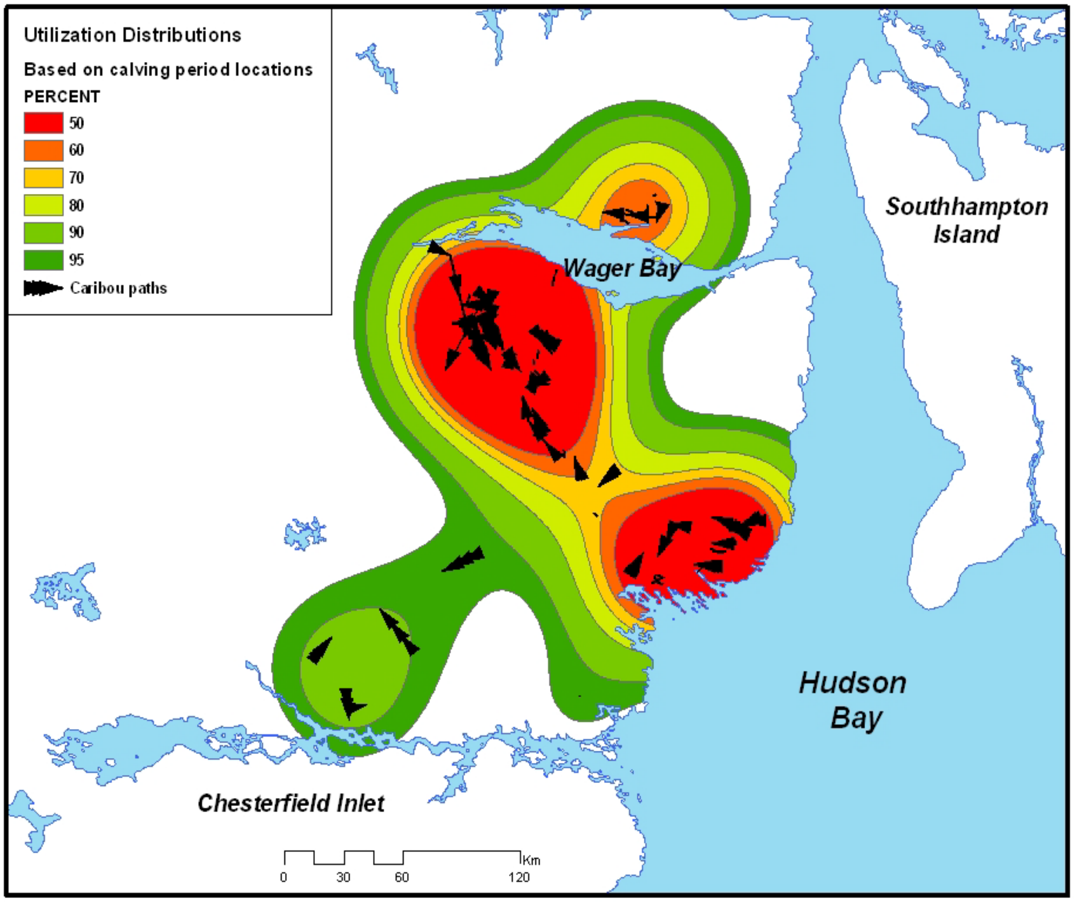

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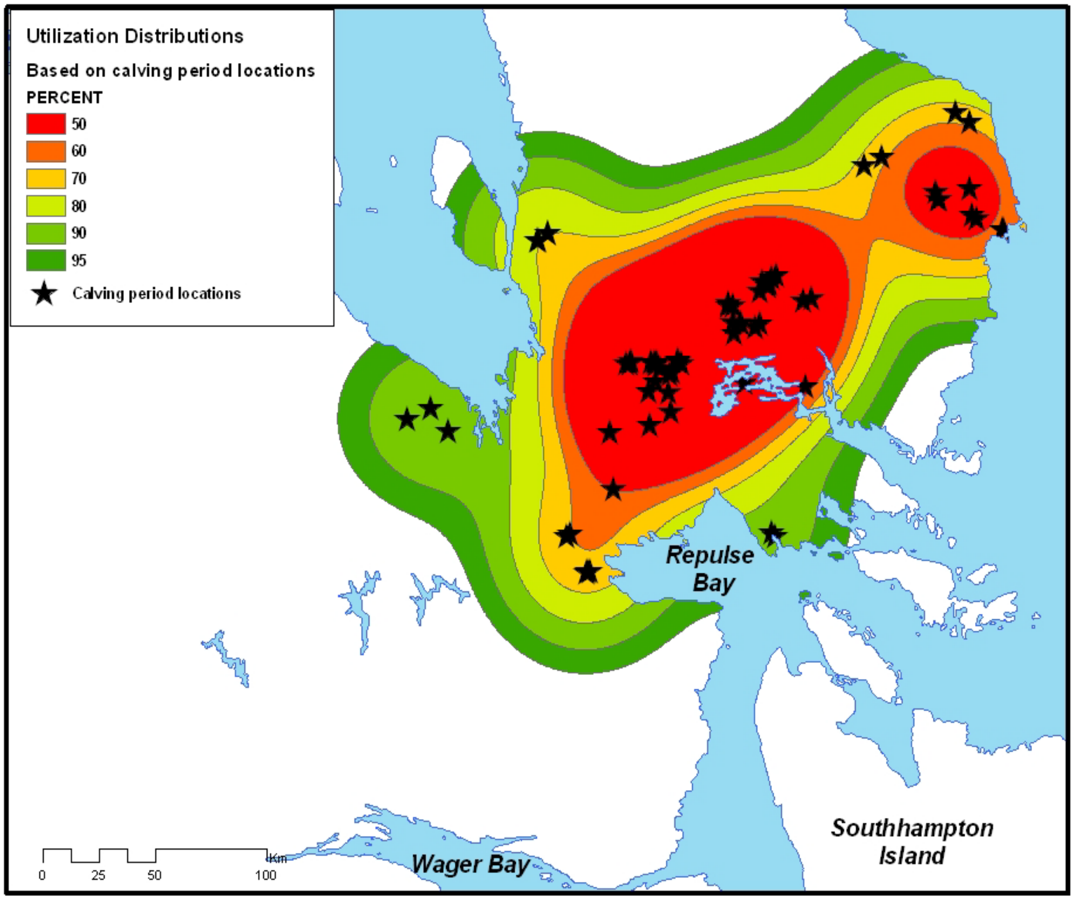

Fig. 3-18. The calving ground of the tundra-wintering Wager Bay barren-ground caribou herd. Utilization distributions and caribou paths are based on 65 locations obtained during 26 annual calving ground use events for satellite collared cows during 10-21 June (mean calving date 15 June ±1.96×2.865 STDEV), 2000-2010.

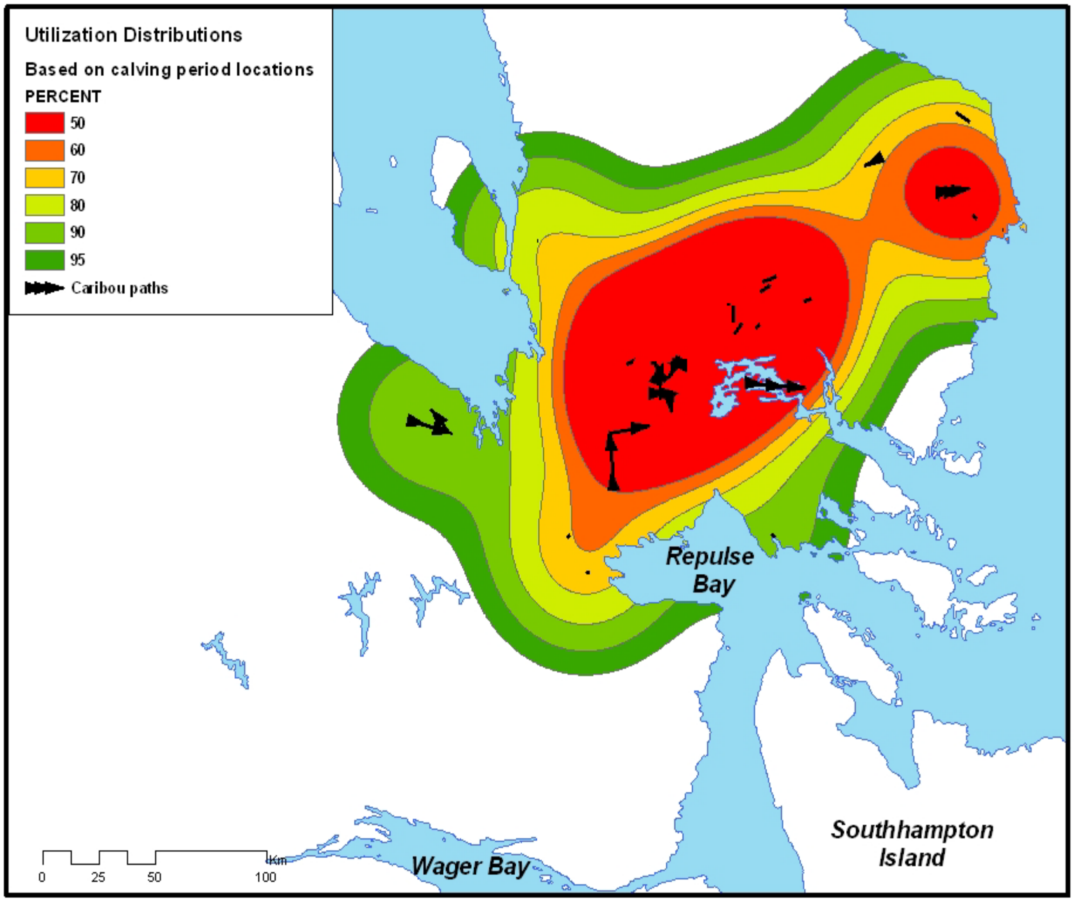

Fig. 3-19. Paths of Bathurst, Beverly, and Queen Maud Gulf cows during April in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), and the 1996 survey area (Gunn et al. 2000).

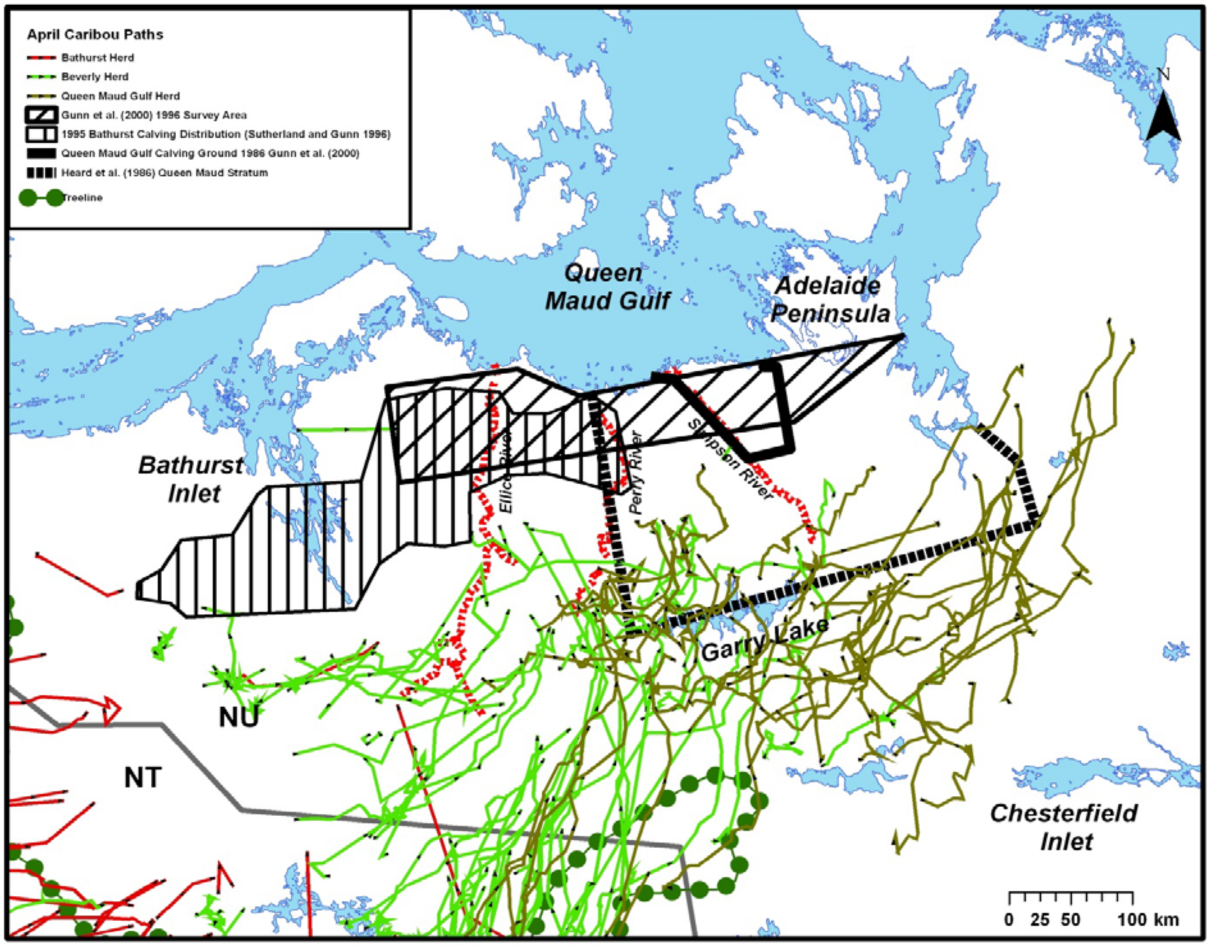

Fig. 3-20. Paths of Bathurst, Beverly, and Queen Maud Gulf cows during May in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), and the 1996 survey area (Gunn et al. 2000).

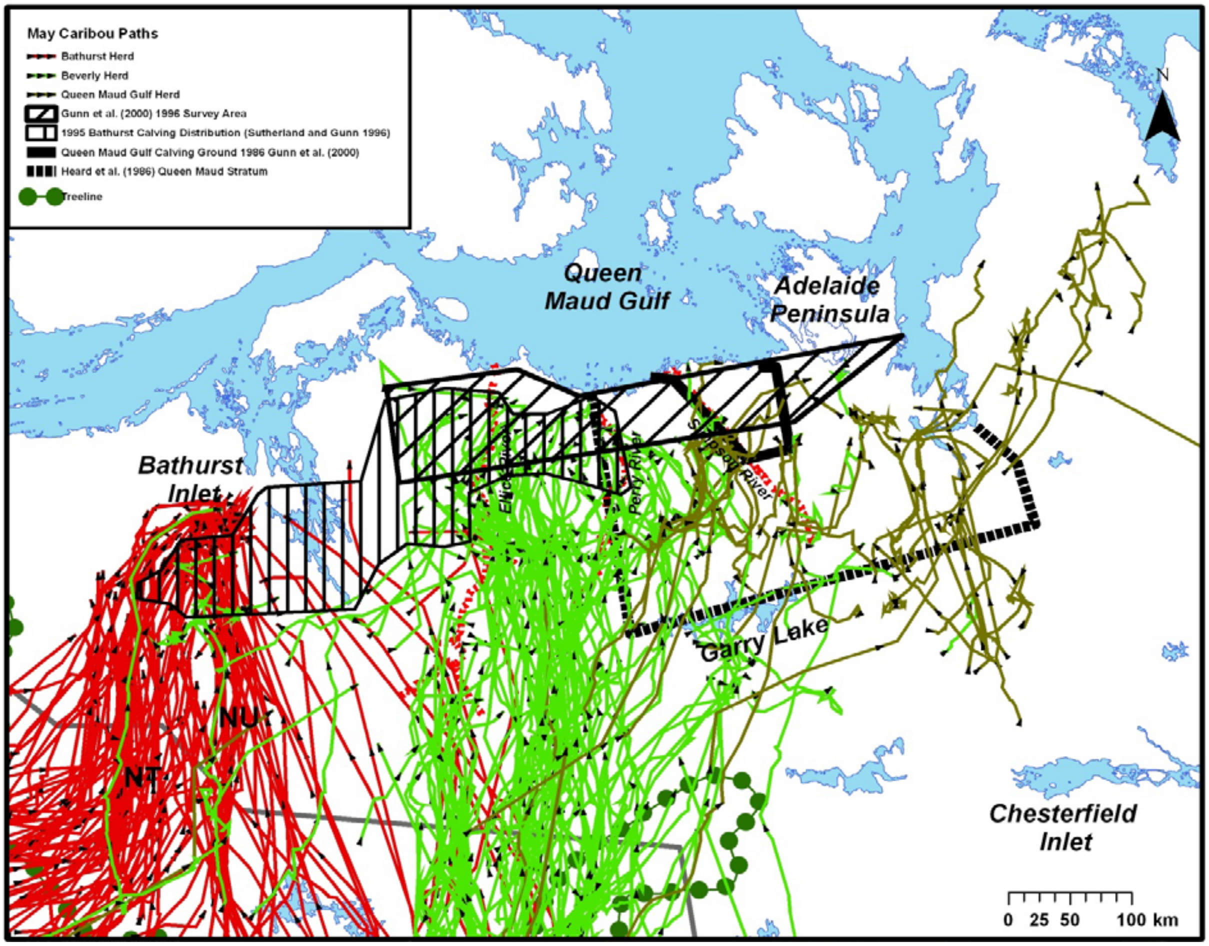

Fig. 3-21. Paths of Bathurst, Beverly, and Queen Maud Gulf cows during calving in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), and the 1996 survey area (Gunn et al. 2000).

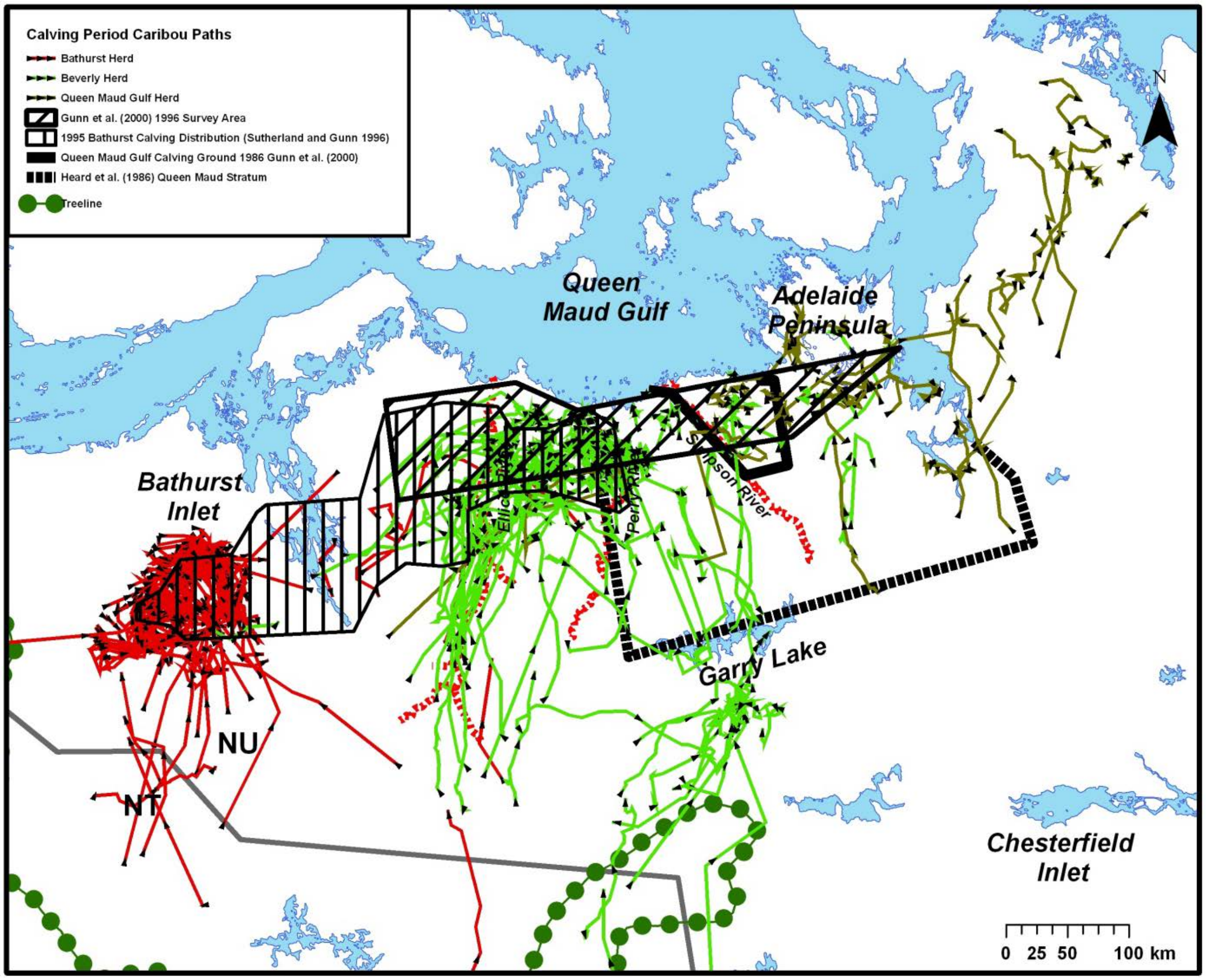

Fig. 3-22. Distribution of locations obtained during 4 to 24 June 1996 and 1997 for the five cows collared during the spring/spring migration period in April 1996 by Gunn et al. (2000) in relationship to the 1983 and 1995 survey stratum 7 (Heard et al. 1986, Buckland et al. 2000), the 1986 Queen Maud Gulf calving ground (Gunn et al. 2000), the 1995 Bathurst calving distribution (Sutherland and Gunn 1996), and the 1996 survey area (Gunn et al. 2000).

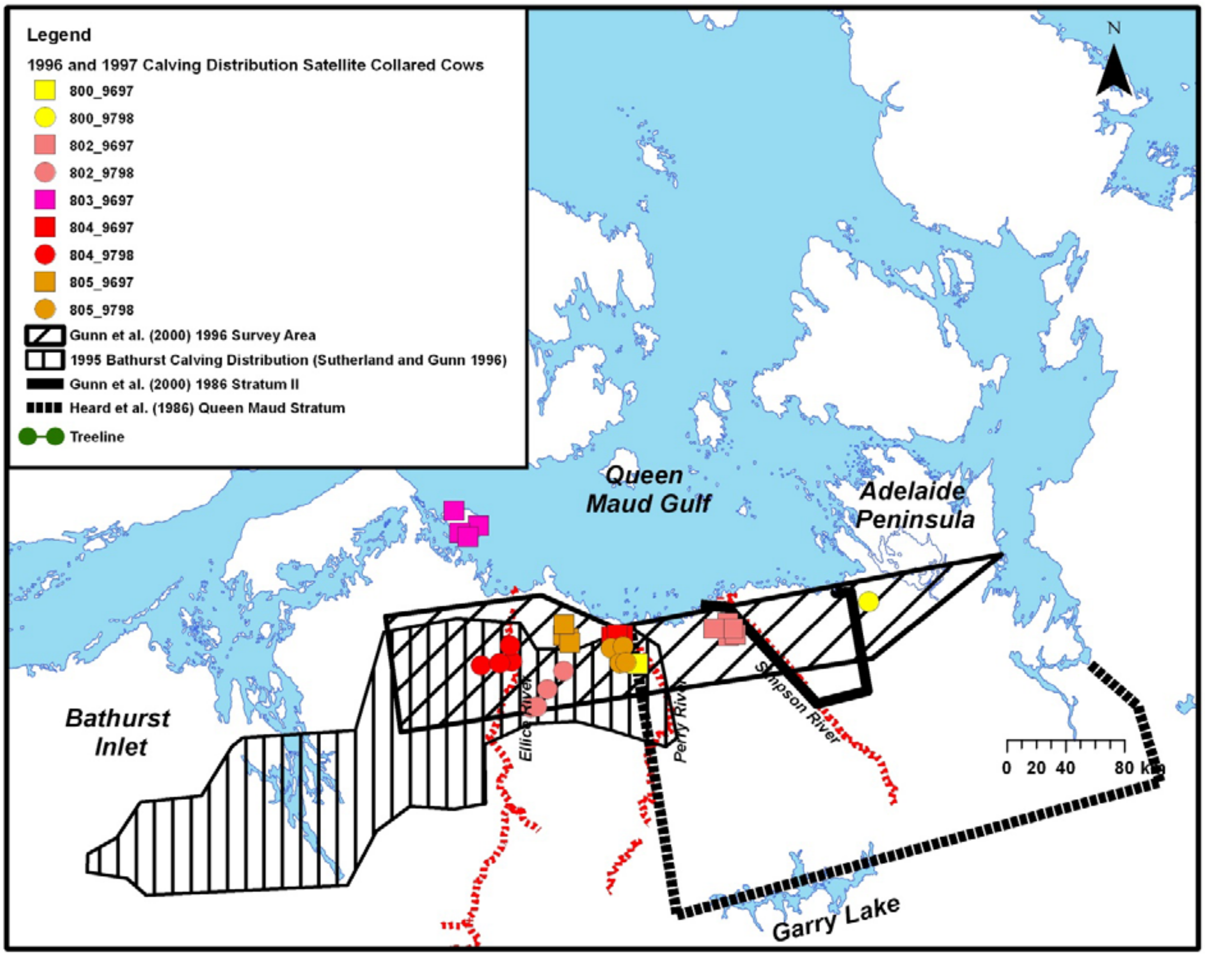

Fig. 3-23. Distribution of locations obtained during 4 to 24 June 1996 and 1997 for the five cows collared during the spring/spring migration period in April 1996 by Gunn et al. (2000) in relationship to the 50-95% calving utilization distributions (UD) for the Beverly herd and the 95% UD for the Queen Maud Gulf herd. UD's based on locations obtained during the calving period.

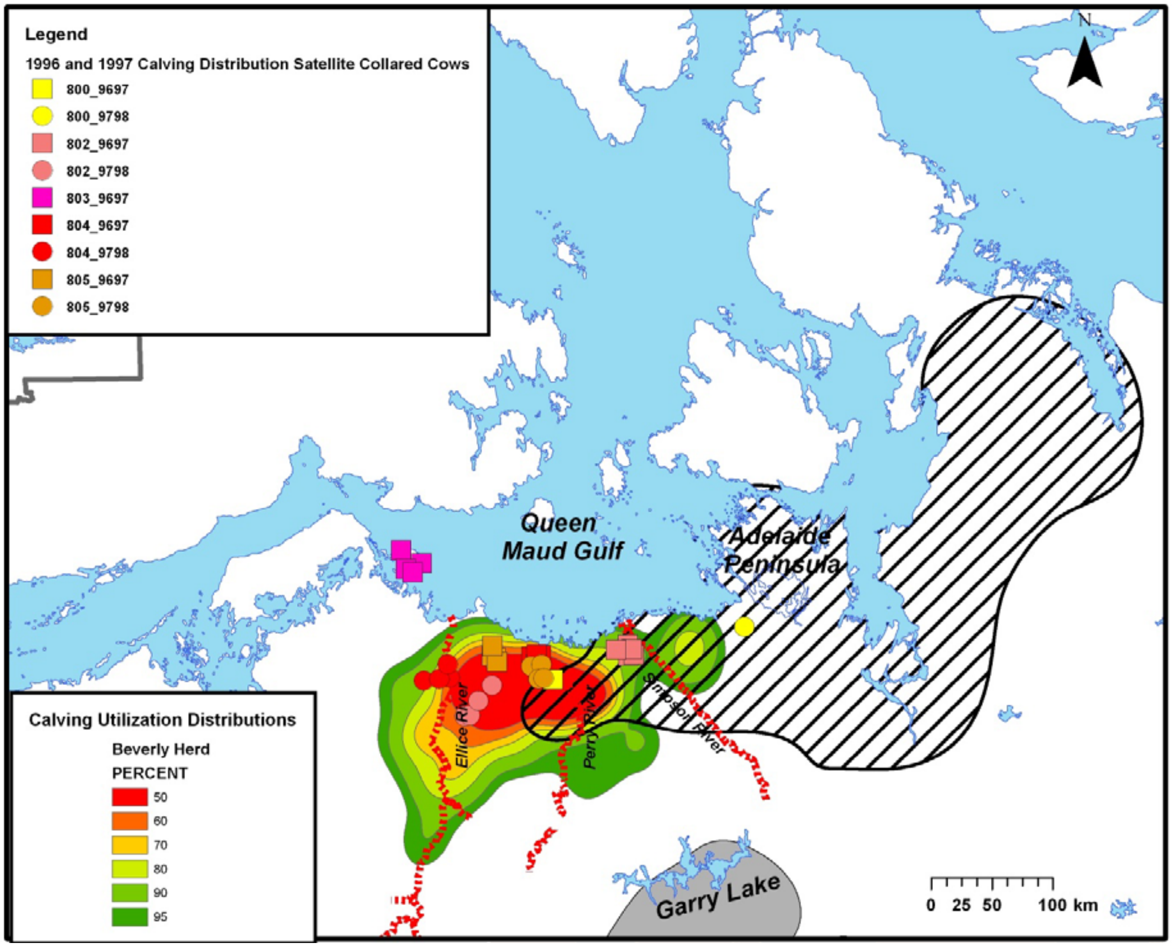

Fig. 3-24. Distribution of locations obtained during 4 to 24 June 1996 and 1997 for the five cows collared during the spring/spring migration period in April 1996 by Gunn et al. (2000) in relationship to the 50-95% calving utilization distributions (UD) for the Queen Maud Gulf herd and the 95% UD for the Beverly herd. UD's based on locations obtained during the calving period.

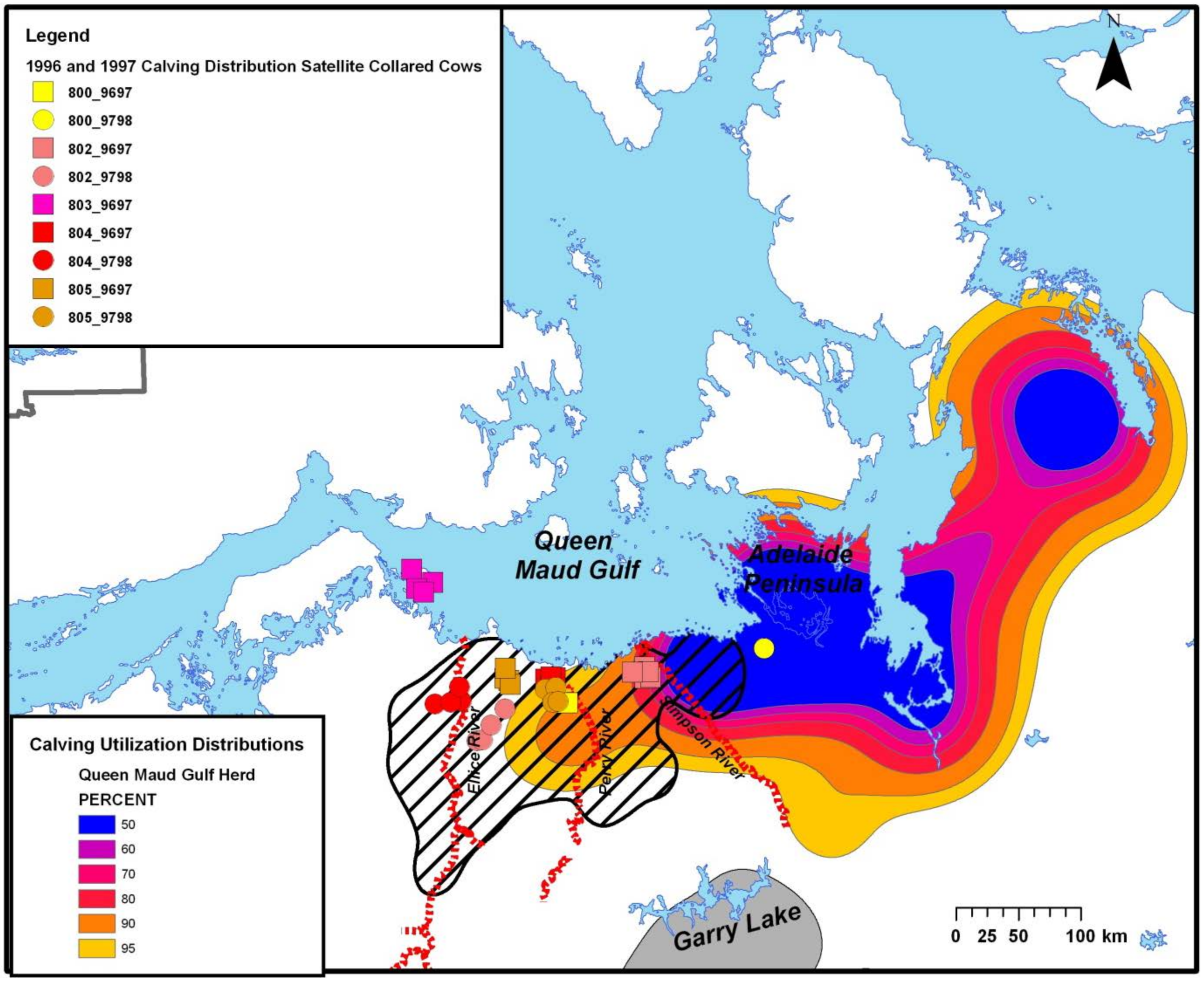

Fig. 3-25. Distribution of capture sites and spring/spring migration to peak of calving paths of cows assigned by fuzzy clustering to the Beverly herd shown in relationship to the Beverly-north and Beverly-south calving grounds and the extent of the Beverly winter range described by Gunn (1989).

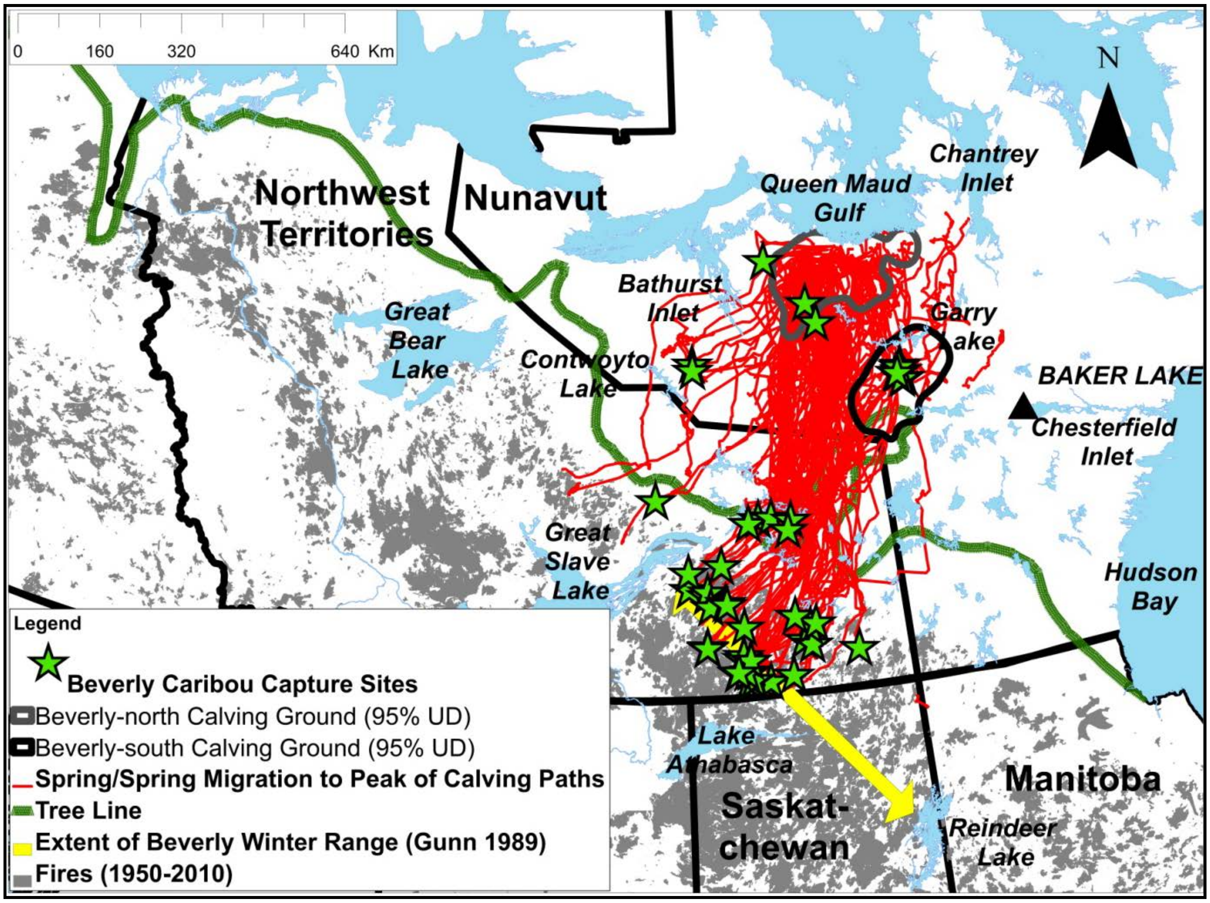

Fig. 3-26. Distribution of capture sites and spring/spring migration to peak of calving paths of cows assigned by fuzzy clustering to the Queen Maud Gulf herd shown in relationship to the Queen Maud Gulf calving ground, the 1983 and 1995 Queen Maud survey stratum, and the extent of the Beverly winter range.

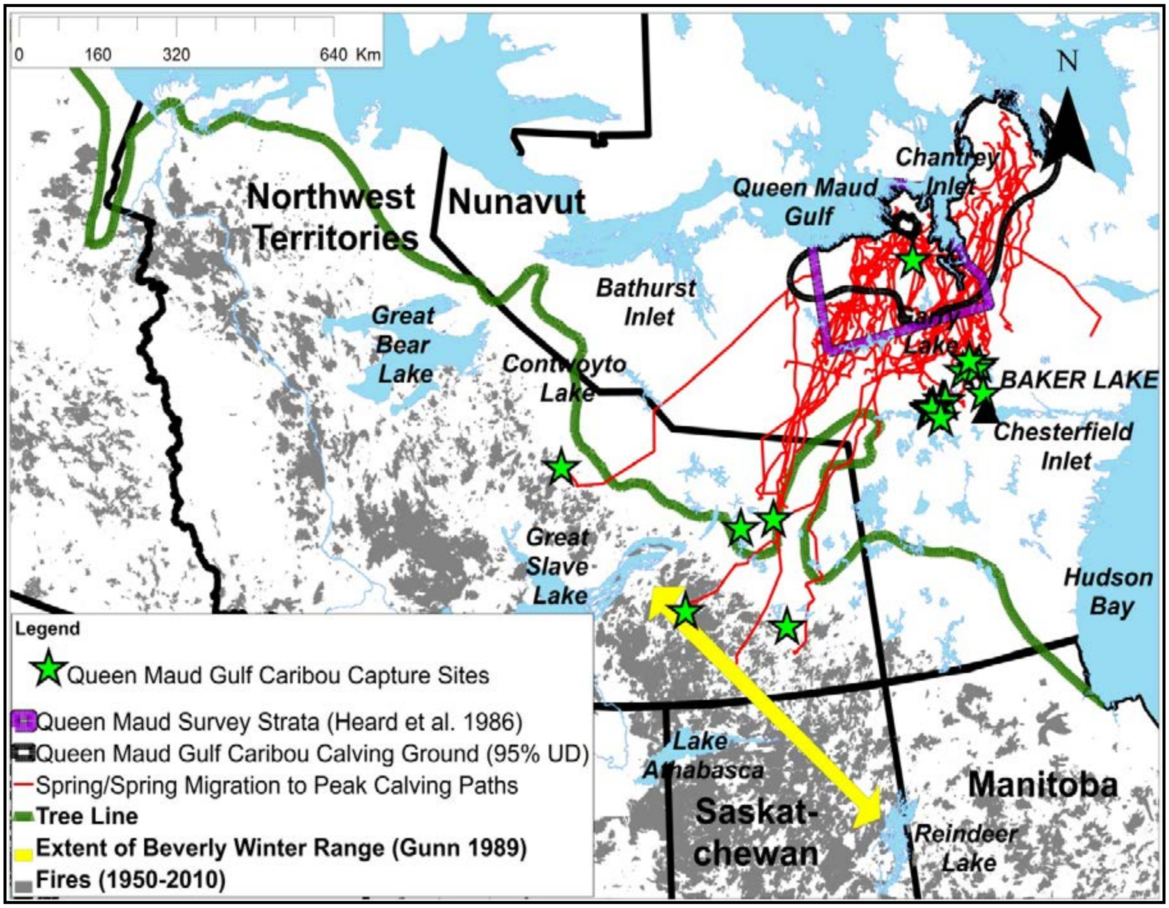

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Table 3-1. Number of cows for which locations were obtained during the calving period and used to generate 50-95% utilizations distributions for each migratory and tundra-wintering subpopulation calving ground on mainland Nunavut by satellite tracking in years 1993-2010.

	Number of cows by satellite tracking year																		
Calving ground	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Beverly-south			2	2	1				1	1	1	1	3	3		4	1		20
Beverly-north				3	3				4	4	2	1	5	12	15	29	24	20	122
Qamanirjuaq	4	4	4	5	2	8	7	6	7	6	6	11	7	23	14	26	11	11	162
Queen Maud Gulf										1	1	1	1	2	2	10	9	17	44
Lorillard						2	8	10	6	10	12	10	3	2					63
Wager Bay								4	4	2	8	6	1	1					26
Total	4	4	6	10	6	10	15	20	22	24	30	30	20	43	31	69	45	48	437

Section 4: Similarity of ranges used by Beverly, Qamanirjuaq, Queen Maud Gulf, Lorillard, and Wager Bay barren-ground caribou

Methods

We calculated Dice's (1945) coincidence index to measure the similarity of home ranges (Metsaranta and Mallory 2007) used by cows assigned to each herd by fuzzy clustering. We sub-sampled the satellite location data for each cow to a 5-day interval and included cows with ≥1 full year of data. We generated minimum convex polygons (MCPs) for each cow, clipped these to the coastline, and measured the area of each MCP using Hawth's Tools (Beyer 2007). We merged the MCP shapefiles for each herd using ACCRU Tools (Nielsen 2010) and intersected the merged shapefiles among cows within and pairwise between all herds separately to measure the areas of overlap of MCPs for cows within and between herds using ArcMap 9.3. We calculated Dice's (1945) similarity coincidence index (DCI) as:

Coincidence index = $2h/(a+b)$,

where h is the area of overlap between the MCPs of caribou A and B, and a and b are the areas of the MCPs of caribou A and B, respectively. The total number of possible intersections for within and between herd comparisons was ([n×(n-1)] ÷2) and (n1×n2), respectively, with n1 and n2 being equal to the number of cows in herd 1 and 2, respectively.

We grouped DCIs into five categories of percent MCP overlap including ≤0.2, >0.2-<0.4, ≥0.4-<0.6, ≥0.6-<0.80, and ≥0.8 that indicated slight, fair, moderate, substantial, and almost perfect overlap, respectively, based on Landis and Koch (1977). We calculated the proportion of DCIs that fell within each overlap category for comparison. Because caribou in some herds were tracked over 18 years, a high proportion of DCIs in the substantial to almost perfect overlap categories indicated a high degree of herd range fidelity.

Results

Within herd overlap among MCPs was highest for migratory Beverly and Qamanirjuaq caribou with 78 and 77% of DCIs indicating substantial to almost perfect overlap, respectively

(Table 4-1, Fig. 4-1). Values for substantial to perfect overlap among MCPs for tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay caribou were 34%, 46%, and 10%, respectively, with the majority of DCIs indicating moderate (Queen Maud Gulf and Lorillard) and fair (Wager Bay) overlap among MCPs (Table 4-1, Fig. 4-1).

Overlap among MCPs of migratory Beverly and Qamanirjuaq caribou was slight with 92% of DCIs indicating ≤20% overlap. Similarly, overlap among MCPs for migratory Beverly and tundra-wintering Lorillard and Wager Bay caribou was slight with 84 and 88% of DCIs indicating ≤20% overlap (Table 4-1, Fig. 4-1). Overlap among MCPs for Beverly and Queen Maud Gulf caribou was variable, with 43 and 49% of DCIs indicating slight overlap (≤20%) and fair to moderate overlap (>20% to <60%), respectively (Table 4-1, Fig. 4-1). Between herd overlap among MCPs for tundra-wintering caribou was also variable, but most DCIs (52-60%) indicated slight overlap (≤20%)(Table 4-1, Fig. 4-1). There was slight overlap among MCPs for migratory Qamanirjuaq and all tundra-wintering caribou with 97-100% of DCIs indicating ≤20% overlap (Table 4-1, Fig. 4-1).

Conclusions

The Beverly, Qamanirjuaq, Queen Maud Gulf, Lorillard, and Wager Bay herds occupy distinct areas within NU and NT. There is a high degree similarity among home ranges of cows within the Beverly and Qamanirjuaq herds; this was not the case for Queen Maud Gulf, Lorillard, and Wager Bay caribou. These results indicate that the migratory Beverly and Qamanirjuaq caribou are behaviourally different from Queen Maud Gulf, Lorillard, and Wager Bay caribou. Home range similarity was fair-moderate for most cows in the robust Beverly herd and distinct Queen Maude Gulf herd indicating that some Queen Maud Gulf cows used some of the same areas as some Beverly cows during the year. Because data for the Qamanirjuaq herd were obtained over 18 years (1993-2011) these results also indicate that these caribou exhibited a high degree of range fidelity during this period.

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Fig. 4-1. Distribution of Dice's (1945) coincidence indices (DCIs) by categories of overlap among minimum convex polygons for cows within and between migratory Beverly and Qamanirjuaq and tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay barren-ground caribou. DCIs of ≤0.2, >0.2-<0.4, ≥0.4-<0.6, ≥0.6-<0.80, and ≥0.8 indicated slight, fair, moderate, substantial, and almost perfect overlap, respectively.

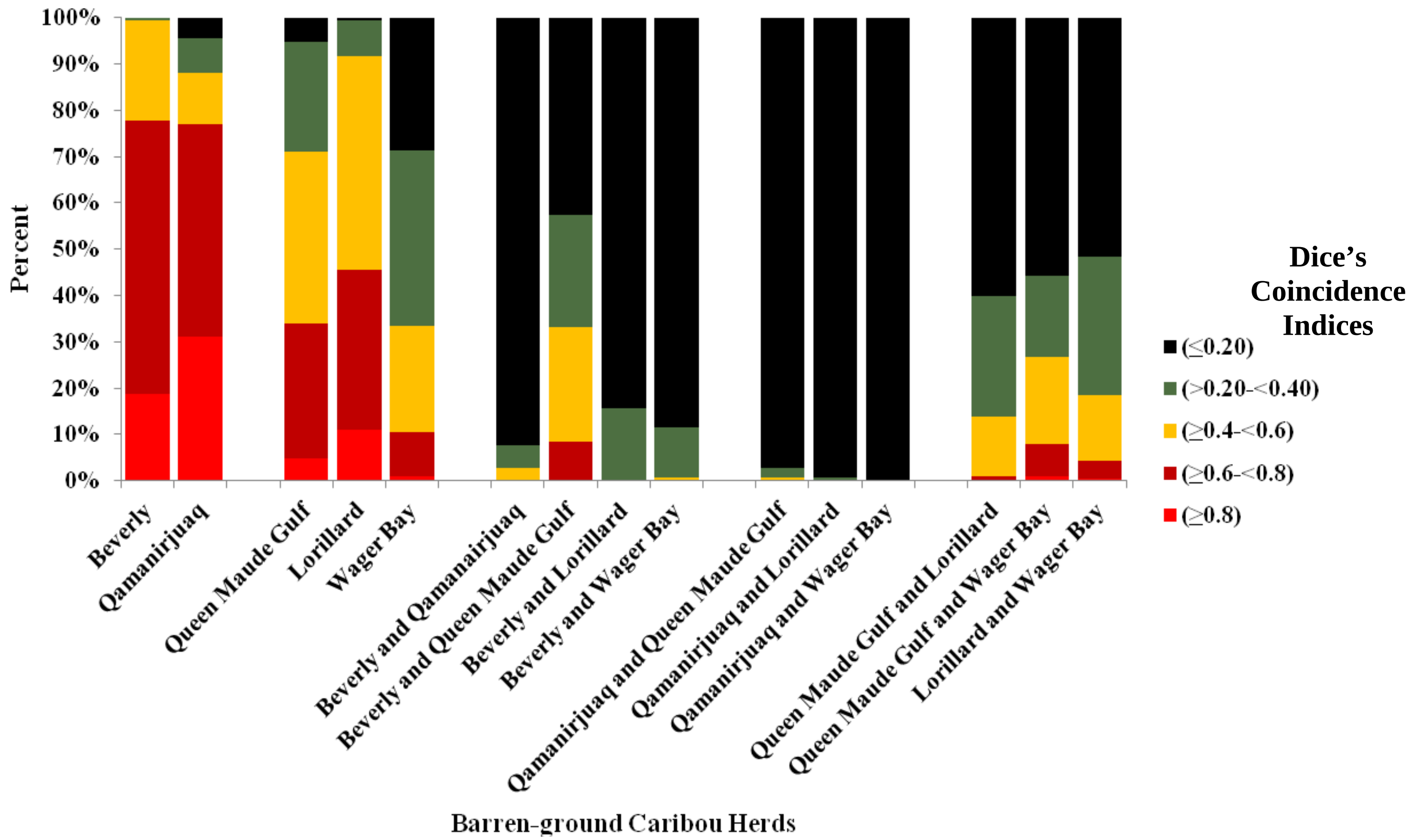

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Table 4-1. Distribution of Dice's coincidence indices (DCIs) by categories of overlap among minimum convex polygons of cows within and between migratory Beverly and Qamanirjuaq and tundra-wintering Queen Maud Gulf, Lorillard, and Wager Bay barren-ground caribou.

	Categories of Overlap Among Minimum Convex Polygons (Range of Dice's Coincidence Indices)				
Herds	slight (≤0.2)	fair (>0.2-<0.4)	moderate (≥0.4-<0.6)	substantial (≥0.6-<0.8)	almost perfect (≥0.8)
Within herd comparisons:					
Beverly	0.00	0.00	0.22	0.59	0.19
Qamanirjuaq	0.04	0.07	0.11	0.46	0.31
Queen Maud Gulf	0.05	0.24	0.37	0.29	0.05
Lorillard	0.01	0.08	0.46	0.35	0.11
Wager Bay	0.29	0.38	0.23	0.10	0.01
Between herd comparisons:					
Beverly and Qamanirjuaq	0.92	0.05	0.03	0.00	0.00
Beverly and Queen Maud Gulf	0.43	0.24	0.25	0.08	0.00
Beverly and Lorillard	0.84	0.16	0.00	0.00	0.00
Beverly and Wager Bay	0.88	0.11	0.01	0.00	0.00
Qamanirjuaq and Queen Maud Gulf	0.97	0.02	0.01	0.00	0.00
Qamanirjuaq and Lorillard	0.99	0.01	0.00	0.00	0.00
Qamanirjuaq and Wager Bay	1.00	0.00	0.00	0.00	0.00
Queen Maud Gulf and Lorillard	0.60	0.26	0.13	0.01	0.00
Queen Maud Gulf and Wager Bay	0.56	0.18	0.19	0.07	0.01
Lorillard and Wager Bay	0.52	0.30	0.14	0.04	0.00

Section 5: Activity periods of Queen Maud Gulf, Beverly, and Qamanirjuaq caribou

Methods

We used log10 transformed daily travel rates (km/day) with inter-location intervals of ≤2 days for cows assigned to each herd by fuzzy clustering, analysis of variance (ANOVA), and Tukey's honestly significant difference (HSD) pair-wise comparisons to identify 5-day periods with significantly different movement rates for each herd. These data gave the start and end dates for each activity period. Because Tukey's HSD pair-wise comparisons are limited to comparisons among 50 groups, we subdivided the data into three overlapping 50 5-day periods for analysis including 1 January-6 September (period 1), 25 April-30 December (period 2), and 28 August-5 May (period 3). We defined the main calving period as the mean calving date ±1.96STDEV and back dated 229 days to estimate the main breeding period (Mcewan and Whitehead 1972, Bergerud 1975, Rowell and Shipka 2009). We used the activity periods identified by Russell et al. (1993) for Porcupine caribou and Nagy (2011) for barren-ground caribou in the NT and NU to validate our analyses.

Results

Daily travel rates for Queen Maud Gulf caribou varied significantly in period 1 (ANOVA $F_{49,8250}=29.076$, $P<0.001$, Appendix 5-A), period 2 (ANOVA $F_{49,7711}=28.724$, $P<0.001$, Appendix 5-B), and period 3 (ANOVA $F_{49,8322}=36.699$, $P<0.001$, Appendix 5-C). These analyses revealed 13 activity periods for Queen Maud Gulf caribou (Table 5-1). Similarly, daily travel rates for Beverly caribou varied significantly in period 1 (ANOVA $F_{49,25520}=234.741$, $P<0.001$, Appendix 5-D), period 2 (ANOVA $F_{49,26576}=123.295$, $P<0.001$, Appendix 5-E), and period 3 (ANOVA $F_{49,24243}=126.732$, $P<0.001$, Appendix 5-F). These analyses revealed 14 activity periods for Beverly caribou. Daily travel rates for Qamanirjuaq caribou varied significantly in period 1 (ANOVA $F_{49,17410}=147.940$, $P<0.001$, Appendix 5-G), period 2 (ANOVA $F_{49,17615}=69.528$, $P<0.001$, Appendix 5-H), and period 3 (ANOVA $F_{49,16164}=93.931$, $P<0.001$, Appendix 5-I). These analyses revealed 11 activity periods for Qamanirjuaq caribou. Differences between activity periods identified by Nagy (2011) are due to a larger sample size of location data for Queen Maud Gulf caribou and use of higher resolution location data for all three herds, i.e., ≤2 days compared to ≤5 days used by Nagy (2011).

Daily travel rates for Queen Maud Gulf caribou did not vary significantly during mid to late winter (26 December to 30 March, Appendix 5-C)(95 days, Table 5-1). In comparison, daily travel rates decreased progressively and significantly during early to late winter for Beverly (21 November-9 April, Appendix 5-F)(140 days, Table 5-2) and Qamanirjuaq caribou (26 November-9 April, Appendix 5-I)(135 days, Table 5-3).

Daily travel rates for Queen Maud Gulf caribou did not vary significantly during spring (31 March to 24 May, Appendix 5-A)(55 days, Table 5-1). This period is comparable to the spring-spring migration period for migratory barren-ground caribou. During the spring-spring migration period daily travel rates increased progressively and significantly for Beverly (10 April to 30 May, Appendix 5-D)(51 days, Table 5-2) and Qamanirjuaq caribou (10 April to 3 June, Appendix 5-G)(55 days, Table 5-3). Daily travel rates of Queen Maud Gulf caribou spiked during the pre-calving period (10 days between 25 May-3 June, Appendix 5-A and 5-B); this may be similar to the spike in movement rates exhibited by boreal caribou just before they calve (Nagy 2011).

Conclusions

The activity periods that we identified for the tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq caribou were consistent with those described for barren-ground caribou by Nagy (2011) and Russell et al. (1993). There were similarities among activity periods for tundra-wintering and migratory caribou however there were notable differences, i.e. during the mid-late winter and spring-spring migration periods indicating that the tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq caribou were behaviourally different.

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Table 5-1. Activity periods of tundra-wintering Queen Maud Gulf barren-ground caribou.

Activity Period No.	Activity Period	Start and End Dates		Number of Days	Percent of Year
1	pre-calving	25-May	09-Jun	16	4
2	calving	10-Jun	21-Jun	12	3
3	post-calving	22-Jun	08-Jul	17	5
4	early summer	09-Jul	28-Jul	20	5
5	mid summer	29-Jul	07-Aug	10	3
6	late summer	08-Aug	06-Sep	30	8
7	early fall	07-Sep	26-Sep	20	5
8	pre-breeding	27-Sep	23-Oct	27	7
9	breeding	24-Oct	04-Nov	12	3
10	post-breeding	05-Nov	20-Nov	16	4
11	early winter	21-Nov	25-Dec	35	10
12	mid/late winter	26-Dec	30-Mar	95	26
13	spring	31-Mar	24-May	55	15

Table 5-2. Activity periods of migratory Beverly barren-ground caribou.

Activity Period No.	Activity Period	Start and End Dates		Number of Days	Percent of Year
1	pre-calving	31-May	05-Jun	6	2
2	calving	06-Jun	20-Jun	15	4
3	post-calving	21-Jun	08-Jul	18	5
4	early summer	09-Jul	02-Aug	25	7
5	mid summer	03-Aug	17-Aug	15	4
6	late summer	18-Aug	11-Sep	25	7
7	early fall	12-Sep	26-Sep	15	4
8	pre-breeding	27-Sep	19-Oct	23	6
9	breeding	20-Oct	01-Nov	13	4
10	post-breeding	02-Nov	20-Nov	19	5
11	early winter	21-Nov	31-Dec	41	11
12	mid winter	01-Jan	24-Feb	55	15
13	late winter	25-Feb	09-Apr	44	12
14	spring, spring migration	10-Apr	30-May	51	14

Table 5-3. Activity periods of migratory Qamanirjuaq barren-ground caribou.

Activity Period No.	Activity Period	Start and End Dates		Number of Days	Percent of Year
1	calving	04-Jun	20-Jun	17	5
2	post-calving	21-Jun	03-Jul	13	4
3	early summer	04-Jul	07-Aug	35	10
4	mid summer	08-Aug	22-Aug	15	4
5	late summer	23-Aug	21-Sep	30	8
6	fall, pre-breeding	22-Sep	17-Oct	26	7
7	breeding	18-Oct	03-Nov	17	5
8	post-breeding	04-Nov	25-Nov	22	6
9	early winter	26-Nov	25-Jan	61	17
10	mid/late winter	26-Jan	09-Apr	74	20
11	spring, spring migration	10-Apr	03-Jun	55	15

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Appendix 5-A. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 1 January-6 September.

Start Date 5-day Interval		Tukey's HSD subset for alpha = 0.05																						Activity Period[1]
	n	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	
1-Jan	188		0.47	0.47	0.47	0.47	0.47																	12
6-Jan	184		0.49	0.49	0.49	0.49	0.49	0.49	0.49															12
11-Jan	187	0.39	0.39	0.39	0.39																			12
16-Jan	182		0.48	0.48	0.48	0.48	0.48																	12
21-Jan	189		0.47	0.47	0.47	0.47	0.47																	12
26-Jan	179	0.41	0.41	0.41	0.41	0.41																		12
31-Jan	185	0.37	0.37	0.37																				12
5-Feb	182		0.49	0.49	0.49	0.49	0.49																	12
10-Feb	188	0.41	0.41	0.41	0.41	0.41																		12
15-Feb	182		0.50	0.50	0.50	0.50	0.50	0.50	0.50															12
20-Feb	177		0.47	0.47	0.47	0.47	0.47																	12
25-Feb	144		0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51													12
1-Mar	178		0.49	0.49	0.49	0.49	0.49	0.49																12
6-Mar	181		0.49	0.49	0.49	0.49	0.49	0.49	0.49															12
11-Mar	192		0.48	0.48	0.48	0.48	0.48																	12
16-Mar	187				0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57										12
21-Mar	187	0.46	0.46	0.46	0.46	0.46																		12
26-Mar	177					0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60									12
31-Mar	182												0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75				13
5-Apr	191											0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72					13
10-Apr	174						0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67								13
15-Apr	177											0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72					13
20-Apr	181													0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77			13
25-Apr	157														0.78	0.78	0.78	0.78	0.78	0.78	0.78			13
30-Apr	141							0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69							13
5-May	143														0.78	0.78	0.78	0.78	0.78	0.78	0.78			13
10-May	132															0.81	0.81	0.81	0.81	0.81	0.81	0.81		13
15-May	144									0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71						13
20-May	141										0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72					13

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-A. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 1 January-6 September. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																						Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	
25-May	121																	0.90	0.90	0.90	0.90	0.90	0.90	1
30-May	133																		0.92	0.92	0.92	0.92	0.92	1
4-Jun	150														0.78	0.78	0.78	0.78	0.78	0.78	0.78			1
9-Jun	152		0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54												2
14-Jun	149	0.26																						2
19-Jun	143	0.34	0.34																					2
24-Jun	154				0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58									3
29-Jun	158											0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72					3
4-Jul	169															0.82	0.82	0.82	0.82	0.82	0.82	0.82		3
9-Jul	175																			0.95	0.95	0.95	0.95	4
14-Jul	170																					1.01	1.01	4
19-Jul	167																						1.08	4
24-Jul	173																				0.96	0.96	0.96	4
29-Jul	175																0.89	0.89	0.89	0.89	0.89	0.89	0.89	5
3-Aug	174															0.86	0.86	0.86	0.86	0.86	0.86	0.86		5
8-Aug	179								0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69							6
13-Aug	166										0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71						6
18-Aug	146				0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59									6
23-Aug	149		0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51														6
28-Aug	143	0.42	0.42	0.42	0.42	0.42																		6
2-Sep	122			0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56											6

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-B. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 25 April-31 December.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																			Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	
25-Apr	157							0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78					13
30-Apr	141				0.69	0.69	0.69	0.69	0.69	0.69	0.69										13
5-May	143							0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78						13
10-May	132								0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81				13
15-May	144				0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71									13
20-May	141					0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72								13
25-May	121											0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90		1
30-May	133												0.92	0.92	0.92	0.92	0.92	0.92	0.92		1
4-Jun	150							0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78					1
9-Jun	152		0.54	0.54	0.54	0.54															2
14-Jun	149	0.26																			2
19-Jun	143	0.34	0.34																		2
24-Jun	154			0.58	0.58	0.58	0.58	0.58													3
29-Jun	158					0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72								3
4-Jul	169								0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82				3
9-Jul	175													0.95	0.95	0.95	0.95	0.95	0.95	0.95	4
14-Jul	170																1.01	1.01	1.01	1.01	4
19-Jul	167																		1.08	1.08	4
24-Jul	173													0.96	0.96	0.96	0.96	0.96	0.96	0.96	4
29-Jul	175										0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89		5
3-Aug	174									0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86			5
8-Aug	179				0.69	0.69	0.69	0.69	0.69	0.69	0.69										6
13-Aug	166				0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71									6
18-Aug	146			0.59	0.59	0.59	0.59	0.59													6
23-Aug	149		0.51	0.51	0.51																6
28-Aug	143	0.42	0.42	0.42																	6
2-Sep	122			0.56	0.56	0.56	0.56														6
7-Sep	142					0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72								7

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-B. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 25 April-31 December. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																			Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	
12-Sep	146							0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78					7
17-Sep	132				0.67	0.67	0.67	0.67	0.67	0.67											7
22-Sep	140						0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76							7
27-Sep	135																1.00	1.00	1.00	1.00	8
2-Oct-	136																	1.04	1.04	1.04	8
7-Oct	132																1.01	1.01	1.01	1.01	8
12-Oct	130																			1.15	8
17-Oct	135																	1.04	1.04	1.04	8
22-Oct	129														0.98	0.98	0.98	0.98	0.98	0.98	9
27-Oct	126																1.01	1.01	1.01	1.01	9
1-Nov	133															0.99	0.99	0.99	0.99	0.99	9
6-Nov	137													0.97	0.97	0.97	0.97	0.97	0.97	0.97	10
11-Nov	138														0.97	0.97	0.97	0.97	0.97	0.97	10
16-Nov	154													0.93	0.93	0.93	0.93	0.93	0.93		10
21-Nov	201							0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79					11
26-Nov	185							0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78					11
1-Dec	203								0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83				11
6-Dec	203								0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81				11
11-Dec	194			0.59	0.59	0.59	0.59	0.59													11
16-Dec	195				0.63	0.63	0.63	0.63	0.63												11
21-Dec	181			0.58	0.58	0.58	0.58	0.58													11
26-Dec	228			0.55	0.55	0.55															12

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-C. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 28 August-4 May.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																		Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	
28-Aug	143	0.42	0.42	0.42																6
2-Sep	122	0.56	0.56	0.56	0.56	0.56	0.56	0.56												6
7-Sep	142							0.72	0.72	0.72	0.72	0.72	0.72							7
12-Sep	146									0.78	0.78	0.78	0.78	0.78	0.78					7
17-Sep	132					0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67							7
22-Sep	140								0.76	0.76	0.76	0.76	0.76	0.76						7
27-Sep	135															1.00	1.00	1.00	1.00	8
2-Oct	136																	1.04	1.04	8
7-Oct	132																1.01	1.01	1.01	8
12-Oct	130																		1.15	8
17-Oct	135																	1.04	1.04	8
22-Oct	129															0.98	0.98	0.98	0.98	9
27-Oct	126																1.01	1.01	1.01	9
1-Nov	133															0.99	0.99	0.99	0.99	9
6-Nov	137														0.97	0.97	0.97	0.97	0.97	10
11-Nov	138														0.97	0.97	0.97	0.97	0.97	10
16-Nov	154													0.93	0.93	0.93	0.93	0.93		10
21-Nov	201										0.79	0.79	0.79	0.79	0.79					11
26-Nov	185									0.78	0.78	0.78	0.78	0.78	0.78					11
1-Dec	203												0.83	0.83	0.83	0.83	0.83			11
6-Dec	203											0.81	0.81	0.81	0.81	0.81				11
11-Dec	194			0.59	0.59	0.59	0.59	0.59	0.59	0.59										11
16-Dec	195				0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63								11
21-Dec	181		0.58	0.58	0.58	0.58	0.58	0.58	0.58											11
26-Dec	228	0.55	0.55	0.55	0.55	0.55	0.55	0.55												12
1-Jan	188	0.47	0.47	0.47	0.47															12
6-Jan	184	0.49	0.49	0.49	0.49	0.49														12
11-Jan	187	0.39	0.39																	12

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-C. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf barren-ground caribou for 50 5-day periods between 28 August-4 May. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																		Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	
16-Jan	182	0.48	0.48	0.48	0.48	0.48														12
21-Jan	189	0.47	0.47	0.47	0.47															12
26-Jan	179	0.41	0.41	0.41																12
31-Jan	185	0.37																		12
5-Feb	182	0.49	0.49	0.49	0.49	0.49														12
10-Feb	188	0.41	0.41	0.41																12
15-Feb	182	0.50	0.50	0.50	0.50	0.50	0.50													12
20-Feb	177	0.47	0.47	0.47	0.47															12
25-Feb	144	0.51	0.51	0.51	0.51	0.51	0.51													12
1-Mar	178	0.49	0.49	0.49	0.49	0.49														12
6-Mar	181	0.49	0.49	0.49	0.49	0.49														12
11-Mar	192	0.48	0.48	0.48	0.48	0.48														12
16-Mar	187		0.57	0.57	0.57	0.57	0.57	0.57	0.57											12
21-Mar	187	0.46	0.46	0.46	0.46															12
26-Mar	177			0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60									12
31-Mar	182								0.75	0.75	0.75	0.75	0.75	0.75						13
5-Apr	191							0.72	0.72	0.72	0.72	0.72	0.72							13
10-Apr	174					0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67							13
15-Apr	177							0.72	0.72	0.72	0.72	0.72	0.72							13
20-Apr	181								0.77	0.77	0.77	0.77	0.77	0.77						13
25-Apr	157									0.78	0.78	0.78	0.78	0.78	0.78					13
30-Apr	141						0.69	0.69	0.69	0.69	0.69	0.69	0.69							13

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6= late summer, 7=early fall, 8=pre=breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid/late summer, 13=spring

Appendix 5-D. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 1 January-6 September.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																		Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	
1-Jan	421				0.40	0.40	0.40													12
6-Jan	426				0.39	0.39	0.39													12
11-Jan	432				0.37	0.37	0.37													12
16-Jan	424					0.43	0.43													12
21-Jan	419					0.44	0.44													12
26-Jan	420		0.32	0.32	0.32	0.32														12
31-Jan	423					0.41	0.41													12
5-Feb	424		0.32	0.32	0.32	0.32														12
10-Feb	429			0.33	0.33	0.33														12
15-Feb	437	0.28	0.28	0.28	0.28															12
20-Feb	428			0.33	0.33	0.33														12
25-Feb	364	0.29	0.29	0.29	0.29															13
1-Mar	430	0.29	0.29	0.29	0.29															13
6-Mar	440	0.24	0.24	0.24																13
11-Mar	493	0.20	0.20																	13
16-Mar	488	0.22	0.22	0.22																13
21-Mar	483	0.23	0.23	0.23																13
26-Mar	470	0.22	0.22	0.22																13
31-Mar	515	0.17																		13
5-Apr	569	0.16																		13
10-Apr	547				0.38	0.38	0.38													14
15-Apr	550							0.60	0.60											14
20-Apr	556									0.78	0.78									14
25-Apr	505								0.67	0.67										14
30-Apr	513											0.90	0.90	0.90						14
5-May	534												0.93	0.93	0.93					14
10-May	547												0.93	0.93	0.93					14
15-May	546													0.99	0.99					14

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-D. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 1 January-6 September. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																		Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	
20-May	506													1.02	1.02	1.02				14
25-May	488														1.05	1.05	1.05			14
30-May	530												0.94	0.94	0.94					14
4-Jun	524										0.84	0.84	0.84							1,2
9-Jun	556						0.50	0.50												1,2
14-Jun	555			0.33	0.33	0.33														1,2
19-Jun	559				0.39	0.39	0.39													1,2
24-Jun	524							0.62	0.62											3
29-Jun	547											0.91	0.91	0.91						3
4-Jul	613													1.01	1.01					3
9-Jul	615																1.14	1.14		4
14-Jul	617																	1.20	1.20	4
19-Jul	583																		1.32	4
24-Jul	595																	1.24	1.24	4
29-Jul	593															1.14	1.14	1.14		4
3-Aug	617											0.90	0.90	0.90						5
8-Aug	621									0.79	0.79	0.79								5
13-Aug	587								0.66	0.66										5
18-Aug	529								0.64											6
23-Aug	535							0.60	0.60											6
28-Aug	523							0.60	0.60											6
2-Sep	520								0.63											6

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-E. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 25 April-31 December.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	
28-Aug	523								0.60	0.60	0.60							6
2-Sep	520									0.63	0.63							6
7-Sep	521										0.69	0.69						6
12-Sep	507												0.83	0.83	0.83	0.83		7
17-Sep	512													0.86	0.86	0.86	0.86	7
22-Sep	525													0.87	0.87	0.87	0.87	7
27-Sep	468															0.92	0.92	8
2-Oct	517																0.98	8
7-Oct	521														0.91	0.91	0.91	8
12-Oct	517														0.91	0.91	0.91	8
17-Oct	504													0.88	0.88	0.88	0.88	9
22-Oct	513															0.92	0.92	9
27-Oct	505															0.95	0.95	9
1-Nov	509													0.89	0.89	0.89	0.89	10
6-Nov	498													0.88	0.88	0.88	0.88	10
11-Nov	507												0.83	0.83	0.83	0.83		10
16-Nov	501											0.79	0.79	0.79	0.79			10
21-Nov	514										0.72	0.72	0.72					11
26-Nov	503										0.71	0.71	0.71					11
1-Dec	497										0.71	0.71	0.71					11
6-Dec	484										0.70	0.70	0.70					11
11-Dec	484										0.71	0.71	0.71					11
16-Dec	485							0.54	0.54	0.54								11
21-Dec	490								0.59	0.59	0.59							11
26-Dec	562						0.49	0.49	0.49									11
1-Jan	421			0.40	0.40	0.40	0.40											12
6-Jan	426			0.39	0.39	0.39	0.39											12
11-Jan	432			0.37	0.37	0.37	0.37											12
16-Jan	424					0.43	0.43	0.43										12

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-E. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 25 April-31 December. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																			Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	
12-Sep	507									0.83	0.83										7
17-Sep	512									0.86	0.86	0.86									7
22-Sep	525									0.87	0.87	0.87	0.87								7
27-Sep	468										0.92	0.92	0.92	0.92	0.92	0.92					8
2-Oct	517												0.98	0.98	0.98	0.98	0.98				8
7-Oct	521										0.91	0.91	0.91	0.91	0.91	0.91					8
12-Oct	517										0.91	0.91	0.91	0.91	0.91	0.91					8
17-Oct	504									0.88	0.88	0.88	0.88								9
22-Oct	513										0.92	0.92	0.92	0.92	0.92	0.92					9
27-Oct	505											0.95	0.95	0.95	0.95	0.95	0.95				9
1-Nov	509									0.89	0.89	0.89	0.89	0.89							10
6-Nov	498									0.88	0.88	0.88	0.88	0.88							10
11-Nov	507									0.83	0.83										10
16-Nov	501								0.79	0.79											10
21-Nov	514							0.72	0.72												11
26-Nov	503						0.71	0.71	0.71												11
1-Dec	497							0.71	0.71												11
6-Dec	484					0.70	0.70	0.70	0.70												11
11-Dec	484							0.71	0.71												11
16-Dec	485			0.54	0.54																11
21-Dec	490			0.59	0.59	0.59															11
26-Dec	562		0.49	0.49																	11

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-F. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 28 August-4 May.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	
28-Aug	523								0.60	0.60	0.60							6
2-Sep	520									0.63	0.63							6
7-Sep	521										0.69	0.69						6
12-Sep	507												0.83	0.83	0.83	0.83		7
17-Sep	512													0.86	0.86	0.86	0.86	7
22-Sep	525													0.87	0.87	0.87	0.87	7
27-Sep	468															0.92	0.92	8
2-Oct	517																0.98	8
7-Oct	521														0.91	0.91	0.91	8
12-Oct	517														0.91	0.91	0.91	8
17-Oct	504													0.88	0.88	0.88	0.88	9
22-Oct	513															0.92	0.92	9
27-Oct	505															0.95	0.95	9
1-Nov	509													0.89	0.89	0.89	0.89	10
6-Nov	498													0.88	0.88	0.88	0.88	10
11-Nov	507												0.83	0.83	0.83	0.83		10
16-Nov	501											0.79	0.79	0.79	0.79			10
21-Nov	514										0.72	0.72	0.72					11
26-Nov	503										0.71	0.71	0.71					11
1-Dec	497										0.71	0.71	0.71					11
6-Dec	484										0.70	0.70	0.70					11
11-Dec	484										0.71	0.71	0.71					11
16-Dec	485							0.54	0.54	0.54								11
21-Dec	490								0.59	0.59	0.59							11
26-Dec	562						0.49	0.49	0.49									11
1-Jan	421			0.40	0.40	0.40	0.40											12
6-Jan	426			0.39	0.39	0.39	0.39											12
11-Jan	432			0.37	0.37	0.37	0.37											12
16-Jan	424					0.43	0.43	0.43										12

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-F. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Beverly barren-ground caribou for 50 5-day periods between 28 August-4 May. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	
21-Jan	419					0.44	0.44	0.44										12
26-Jan	420		0.32	0.32	0.32	0.32												12
31-Jan	423				0.41	0.41	0.41	0.41										12
5-Feb	424		0.32	0.32	0.32	0.32												12
10-Feb	429		0.33	0.33	0.33	0.33												12
15-Feb	437	0.28	0.28	0.28														12
20-Feb	428		0.33	0.33	0.33	0.33												12
25-Feb	364	0.29	0.29	0.29	0.29													13
1-Mar	430	0.29	0.29	0.29	0.29													13
6-Mar	440	0.24	0.24															13
11-Mar	493	0.20	0.20															13
16-Mar	488	0.22	0.22															13
21-Mar	483	0.23	0.23															13
26-Mar	470	0.22	0.22															13
31-Mar	515	0.17																13
5-Apr	569	0.16																13
10-Apr	547			0.38	0.38	0.38	0.38											14
15-Apr	550								0.60	0.60	0.60							14
20-Apr	556											0.78	0.78	0.78				14
25-Apr	505										0.67	0.67						14
30-Apr	513													0.90	0.90	0.90	0.90	14

[1]Activity periods: 1=pre-calving, 2=calving, 3=post-calving, 4=early summer, 5=mid summer, 6=late summer, 7=early fall, 8=pre-breeding, 9=breeding, 10=post-breeding, 11=early winter, 12=mid winter, 13=late winter, 14=spring, spring migration

Appendix 5-G. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 1 January-6 September.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																					Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	
1-Jan	288						0.48	0.48	0.48	0.48													9
6-Jan	311					0.47	0.47	0.47	0.47	0.47													9
11-Jan	302				0.44	0.44	0.44	0.44	0.44														9
16-Jan	291							0.49	0.49	0.49													9
21-Jan	316						0.48	0.48	0.48	0.48													9
26-Jan	303	0.28	0.28	0.28																			10
31-Jan	308		0.32	0.32	0.32	0.32																	10
5-Feb	298			0.36	0.36	0.36	0.36	0.36															10
10-Feb	298	0.30	0.30	0.30	0.30																		10
15-Feb	295			0.36	0.36	0.36	0.36	0.36															10
20-Feb	311	0.16																					10
25-Feb	231	0.17	0.17																				10
1-Mar	338	0.17	0.17																				10
6-Mar	327	0.25	0.25	0.25																			10
11-Mar	347		0.32	0.32	0.32	0.32																	10
16-Mar	357		0.32	0.32	0.32	0.32																	10
21-Mar	354	0.29	0.29	0.29	0.29																		10
26-Mar	336			0.35	0.35	0.35	0.35	0.35															10
31-Mar	353	0.31	0.31	0.31	0.31	0.31																	10
5-Apr	381	0.26	0.26	0.26																			10
10-Apr	352			0.33	0.33	0.33	0.33																11
15-Apr	318								0.54	0.54	0.54												11
20-Apr	327								0.52	0.52													11
25-Apr	353									0.61	0.61	0.61	0.61										11
30-Apr	345											0.71	0.71	0.71	0.71								11
5-May	326												0.72	0.72	0.72								11
10-May	356													0.79	0.79	0.79							11
15-May	400														0.85	0.85	0.85	0.85					11

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Appendix 5-G. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 1 January-6 September. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																					Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	
20-May	393															0.90	0.90	0.90					11
25-May	352															0.92	0.92	0.92					11
30-May	354															0.89	0.89	0.89					11
4-Jun	418															0.91	0.91	0.91					1
9-Jun	455								0.56	0.56	0.56	0.56											1
14-Jun	479								0.56	0.56	0.56	0.56											1
19-Jun	471										0.68	0.68	0.68	0.68									1,2
24-Jun	440														0.85	0.85	0.85	0.85					2
29-Jun	389																	0.99	0.99	0.99			2
4-Jul	388																			1.13	1.13	1.13	3
9-Jul	399																				1.19	1.19	3
14-Jul	382																				1.23	1.23	3
19-Jul	384																				1.22	1.22	3
24-Jul	378																					1.28	3
29-Jul	344																					1.26	3
3-Aug	301																				1.23	1.23	3
8-Aug	332																		1.09	1.09	1.09		4
13-Aug	364																0.97	0.97	0.97				4
18-Aug	335													0.82	0.82	0.82	0.82						4
23-Aug	348										0.68	0.68	0.68	0.68									5
28-Aug	338											0.71	0.71	0.71	0.71								5
2-Sep	299											0.70	0.70	0.70	0.70								5

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Appendix 5-H. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 25 April-31 December.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																									Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	
25-Apr	353	0.61	0.61	0.61	0.61																						11
30-Apr	345			0.71	0.71	0.71	0.71	0.71																			11
5-May	326				0.72	0.72	0.72	0.72	0.72	0.72																	11
10-May	356						0.79	0.79	0.79	0.79	0.79	0.79	0.79														11
15-May	400								0.85	0.85	0.85	0.85	0.85	0.85	0.85												11
20-May	393											0.90	0.90	0.90	0.90	0.90	0.90	0.90									11
25-May	352												0.92	0.92	0.92	0.92	0.92	0.92									11
30-May	354											0.89	0.89	0.89	0.89	0.89	0.89	0.89									11
4-Jun	418												0.91	0.91	0.91	0.91	0.91	0.91									1
9-Jun	455	0.56	0.56																								1
14-Jun	479	0.56	0.56																								1
19-Jun	471		0.68	0.68	0.68	0.68	0.68	0.68																			1,2
24-Jun	440								0.85	0.85	0.85	0.85	0.85	0.85	0.85												2
29-Jun	389															0.99	0.99	0.99	0.99	0.99							2
4-Jul	388																				1.13	1.13	1.13	1.13	1.13		3
9-Jul	399																					1.19	1.19	1.19	1.19	1.19	3
14-Jul	382																							1.23	1.23	1.23	3
19-Jul	384																					1.22	1.22	1.22	1.22	1.22	3
24-Jul	378																									1.28	3
29-Jul	344																								1.26	1.26	3
3-Aug	301																						1.23	1.23	1.23	1.23	3
8-Aug	332																		1.09	1.09	1.09	1.09	1.09				4
13-Aug	364														0.97	0.97	0.97	0.97	0.97								4
18-Aug	335							0.82	0.82	0.82	0.82	0.82	0.82	0.82													4
23-Aug	348		0.68	0.68	0.68	0.68	0.68	0.68																			5
28-Aug	338			0.71	0.71	0.71	0.71	0.71																			5
2-Sep	299			0.70	0.70	0.70	0.70	0.70																			5
7-Sep	359		0.67	0.67	0.67	0.67	0.67																				5
12-Sep	331				0.74	0.74	0.74	0.74	0.74	0.74	0.74																5

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Appendix 5-H. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 25 April-31 December.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																									Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	
17-Sep	285						0.79	0.79	0.79	0.79	0.79	0.79	0.79														5
22-Sep	366									0.86	0.86	0.86	0.86	0.86	0.86	0.86											6
27-Sep	347										0.87	0.87	0.87	0.87	0.87	0.87											6
2-Oct	354										0.86	0.86	0.86	0.86	0.86	0.86											6
7-Oct	353													0.93	0.93	0.93	0.93	0.93									6
12-Oct	340																1.02	1.02	1.02	1.02	1.02						6
17-Oct	348														0.96	0.96	0.96	0.96	0.96								7
22-Oct	356													0.95	0.95	0.95	0.95	0.95	0.95								7
27-Oct	315																1.02	1.02	1.02	1.02	1.02						7
1-Nov	324																		1.09	1.09	1.09	1.09					7
6-Nov	329																			1.12	1.12	1.12	1.12	1.12			8
11-Nov	342																	1.03	1.03	1.03	1.03						8
16-Nov	360													0.95	0.95	0.95	0.95	0.95									8
21-Nov	333											0.89	0.89	0.89	0.89	0.89	0.89										8
26-Nov	320				0.74	0.74	0.74	0.74	0.74	0.74	0.74																9
1-Dec	321	0.66	0.66	0.66	0.66	0.66	0.66																				9
6-Dec	315			0.71	0.71	0.71	0.71	0.71	0.71																		9
11-Dec	310					0.77	0.77	0.77	0.77	0.77	0.77	0.77															9
16-Dec	259	0.57	0.57	0.57																							9
21-Dec	228	0.65	0.65	0.65	0.65	0.65																					9
26-Dec	347	0.53																									9

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Appendix 5-I. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 28 August-4 May.

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																								Activity Period[1]
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	
28-Aug	338													0.71	0.71	0.71	0.71	0.71								5
2-Sep	299													0.70	0.70	0.70	0.70									5
7-Sep	359												0.67	0.67	0.67	0.67										5
12-Sep	331														0.74	0.74	0.74	0.74	0.74							5
17-Sep	285															0.79	0.79	0.79	0.79	0.79						5
22-Sep	366																0.86	0.86	0.86	0.86	0.86					6
27-Sep	347																	0.87	0.87	0.87	0.87	0.87	0.87			6
2-Oct	354																0.86	0.86	0.86	0.86	0.86	0.86				6
7-Oct	353																			0.93	0.93	0.93	0.93	0.93		6
12-Oct	340																				1.02	1.02	1.02	1.02	1.02	6
17-Oct	348																				0.96	0.96	0.96	0.96	0.96	7
22-Oct	356																			0.95	0.95	0.95	0.95	0.95		7
27-Oct	315																					1.02	1.02	1.02	1.02	7
1-Nov	324																							1.09	1.09	7
6-Nov	329																								1.12	8
11-Nov	342																						1.03	1.03	1.03	8
16-Nov	360																			0.95	0.95	0.95	0.95	0.95		8
21-Nov	333																		0.89	0.89	0.89	0.89	0.89			8
26-Nov	320														0.74	0.74	0.74	0.74	0.74							9
1-Dec	321												0.66	0.66	0.66	0.66										9
6-Dec	315													0.71	0.71	0.71	0.71	0.71								9
11-Dec	310														0.77	0.77	0.77	0.77	0.77							9
16-Dec	259									0.57	0.57	0.57	0.57	0.57												9
21-Dec	228											0.65	0.65	0.65	0.65	0.65										9
26-Dec	347									0.53	0.53	0.53	0.53													9
1-Jan	288						0.48	0.48	0.48	0.48	0.48	0.48														9
6-Jan	311					0.47	0.47	0.47	0.47	0.47	0.47															9
11-Jan	302				0.44	0.44	0.44	0.44	0.44	0.44																9
16-Jan	291							0.49	0.49	0.49	0.49	0.49														9

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Appendix 5-I. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) multiple comparisons of log10 transformed daily travel rates (km/day) of migratory Qamanirjuaq barren-ground caribou for 50 5-day periods between 28 August-4 May. (Continued)

Start Date 5-day Interval	n	Tukey's HSD subset for alpha = 0.05																								Activity Period[1]
21-Jan	316						0.48	0.48	0.48	0.48	0.48	0.48														9
26-Jan	303	0.28	0.28	0.28	0.28																					10
31-Jan	308	0.32	0.32	0.32	0.32	0.32																				10
5-Feb	298			0.36	0.36	0.36	0.36	0.36	0.36																	10
10-Feb	298	0.30	0.30	0.30	0.30																					10
15-Feb	295			0.36	0.36	0.36	0.36	0.36	0.36																	10
20-Feb	311	0.16																								10
25-Feb	231	0.17	0.17																							10
1-Mar	338	0.17	0.17																							10
6-Mar	327	0.25	0.25	0.25																						10
11-Mar	347		0.32	0.32	0.32	0.32	0.32																			10
16-Mar	357	0.32	0.32	0.32	0.32	0.32																				10
21-Mar	354	0.29	0.29	0.29	0.29																					10
26-Mar	336			0.35	0.35	0.35	0.35	0.35																		10
31-Mar	353	0.31	0.31	0.31	0.31	0.31																				10
5-Apr	381	0.26	0.26	0.26																						10
10-Apr	352		0.33	0.33	0.33	0.33	0.33	0.33																		11
15-Apr	318									0.54	0.54	0.54	0.54													11
20-Apr	327								0.52	0.52	0.52	0.52	0.52													11
25-Apr	353										0.61	0.61	0.61	0.61	0.61											11
30-Apr	345													0.71	0.71	0.71	0.71	0.71								11

[1]Activity periods: 1=calving, 2=post-calving, 3=early summer, 4=mid summer, 5=late summer, 6=fall, pre-breeding, 7=breeding, 8=post-breeding, 9=early winter, 10=mid/late winter, 11=spring, spring migration

Section 6: Comparison of Queen Maud Gulf vs Beverly and Queen Maud Gulf vs Qamanirjuaq barren-ground caribou travel rates

Methods

We calculated the direct line distance between (km) each sequential pair of locations, the inter-location time interval (days), and average daily travel rate (km per day) for each caribou and used a log10 transformation to normalize the data. We selected daily travel rates with inter-location intervals of ≤2 days for each cow. We subdivided the daily travel rate data for these herds into nine overlapping 16 5-day periods (1 Jan-16 Mar, 10 Feb-25 Apr, 21 Mar-4 Jun, 30 Apr-14 Jul, 9 Jun- 23 Aug, 19 Jul-2 Oct, 28 Aug-11 Nov, 7 Oct-21 Dec, and 16 Dec-31 Jan) and used analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) pair-wise comparisons to identify 5-day periods when the travel rates of tundra-wintering Queen Maud Gulf cows were significantly different from those of the migratory Beverly and Qamanirjuaq herds.

We divided the mean log10 daily travel rates for each 5-day period for Queen Maud Gulf by those for Beverly and Qamanirjuaq caribou and graphed these to show the relative differences between movement rates of tundra-wintering and migratory caribou. We also graphed the mean actual and log10 transformed daily travel rates (±95% CI) by 5-day periods for each herd to show i) the periods when travel rates of Queen Maud Gulf caribou were significantly different from those of Beverly and Qamanirjuaq caribou and ii) the daily travel rates during each activity period for Queen Maud Gulf, Beverly, and Qamanirjuaq caribou.

Results

Daily travel rates for Queen Maud Gulf, Beverly, and Qamanirjuaq caribou varied significantly among the nine overlapping 16 5-day periods 21 January-25 Feb (ANOVA $F_{47,14672}$=11.193, P<0.001, Appendix 6-A), 1 March-5 April (ANOVA $F_{47,15784}$=36.833, P<0.001, Appendix 6-B), 10 April-15 May (ANOVA $F_{47,16583}$=96.724, P<0.001, Appendix 6-C), 20 May-24 June (ANOVA $F_{47,17448}$=20.390, P<0.001, Appendix 6-D), 29 June-3 August (ANOVA

$F_{47,17986}$=162.868, P<0.001, Appendix 6-E), 8 August-12 September (ANOVA $F_{47,16595}$=85.454, P<0.001, Appendix 6-F), and 17 September-22 October (ANOVA $F_{47,15661}$=34.350, P<0.001, Appendix 6-G), 27 October-1 December (ANOVA $F_{47,15713}$=36.632, P<0.001, Appendix 6-H), and 6 December-16 January (ANOVA $F_{47,15387}$=35.897, P<0.001, Appendix 6-I).

The daily movement rates of Queen Maud Gulf caribou were significantly different from those of Beverly and Qamanirjuaq caribou during four periods including: 1) 70 days between 5 February and 14 April, 2) 35 days between 29 June and 2 August, 3) 15 days between 23 August and 6 September, and 4) 15 days between 27 September and 11 October (Table 6-1, Fig. 6-1, 6-2, and 6-3). The most pronounce differences occurred during period 1 (mid and late winter) when the mean daily movement rates of Queen Maud Gulf caribou were 50-350% greater than those for Beverly and/or Qamanirjuaq caribou (Fig. 6-1).

The mean log10 transformed daily travel rates for each 5-day period and the start and end dates of each activity period (Tables 5-1, 5-2, and 5-3) for Beverly, Qamanirjuaq, and Queen Maud Gulf caribou are shown in Fig. 6-4, 6-5, and 6-6, respectively. Fig.6-4 and 6-5 illustrate the progressive and significant early to late winter decline and the progressive and significant spring, spring migration increase in mean daily travel rates that are characteristic of migratory caribou (Nagy 2011). Tundra-wintering Queen Maud Gulf caribou did not exhibit this change in mean daily travel rates during the early winter to spring periods (Fig. 6-6).

Conclusions

Travel rates of tundra-wintering Queen Maud Gulf caribou were significantly different from those of migratory Beverly and Qamanirjuaq caribou for four periods during the year. Most notably, those of the Queen Maud Gulf cows were significantly higher than those of Beverly and Qamanirjuaq cows during 5-February-14 April (mid to late winter, 65 days). These results further indicate that cows in the migratory Beverly and Qamanirjuaq herds behave differently from those in the tundra-wintering Queen Maud Gulf herd.

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Fig. 6-1. Percent differences in mean log10 daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou. Mean log10 daily travel rates of Queen Maud Gulf caribou were divided by those for Beverly and Qamanirjuaq caribou. Values >0 on the y-axis (percent difference) indicate that movement rates for Queen Maud Gulf caribou were greater than those for Beverly and/or Qamanirjuaq caribou. Values <0 on the *y*-axis indicate that movement rates for Queen Maud Gulf caribou were less than those for Beverly and/or Qamanirjuaq caribou.

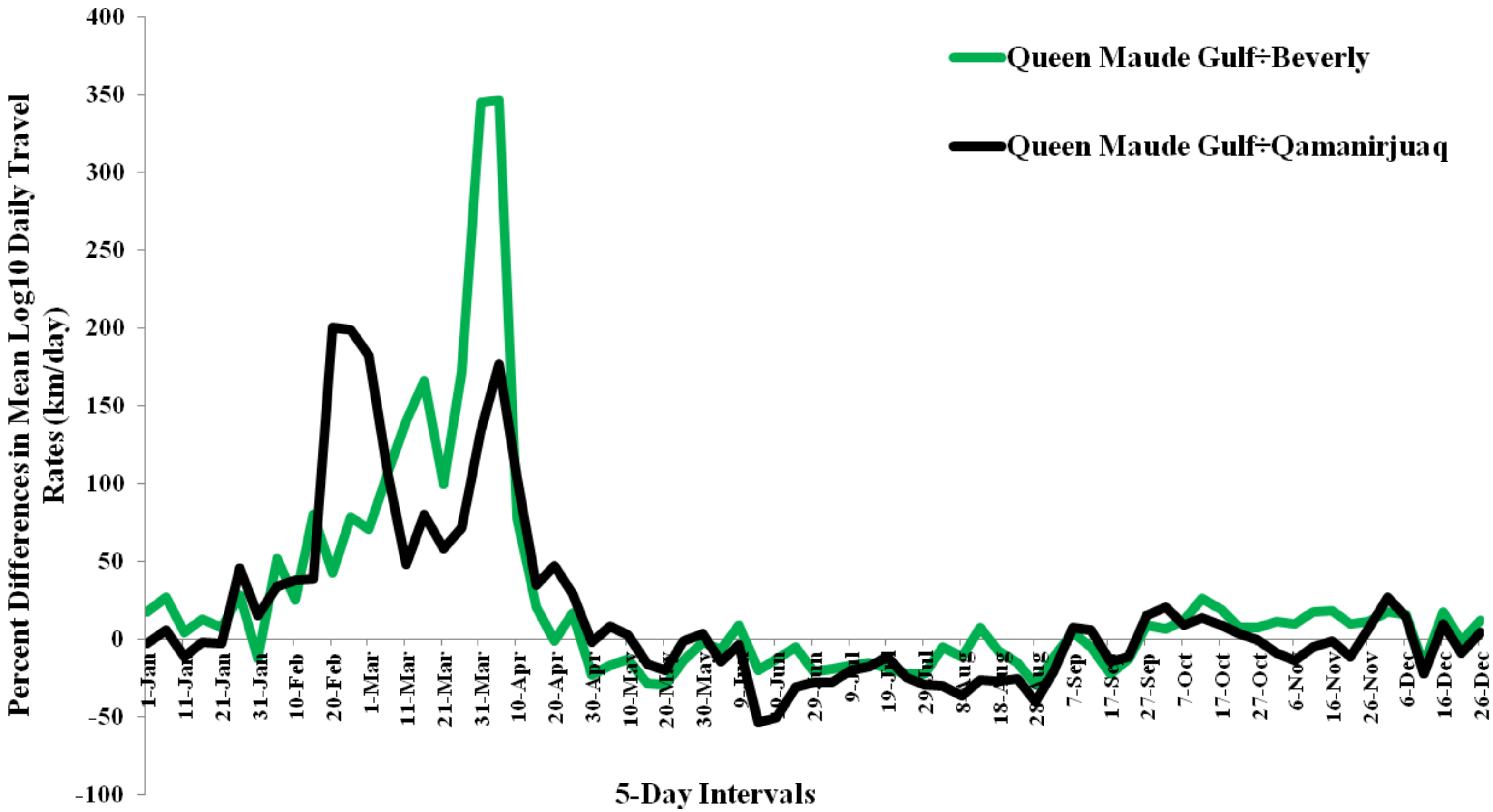
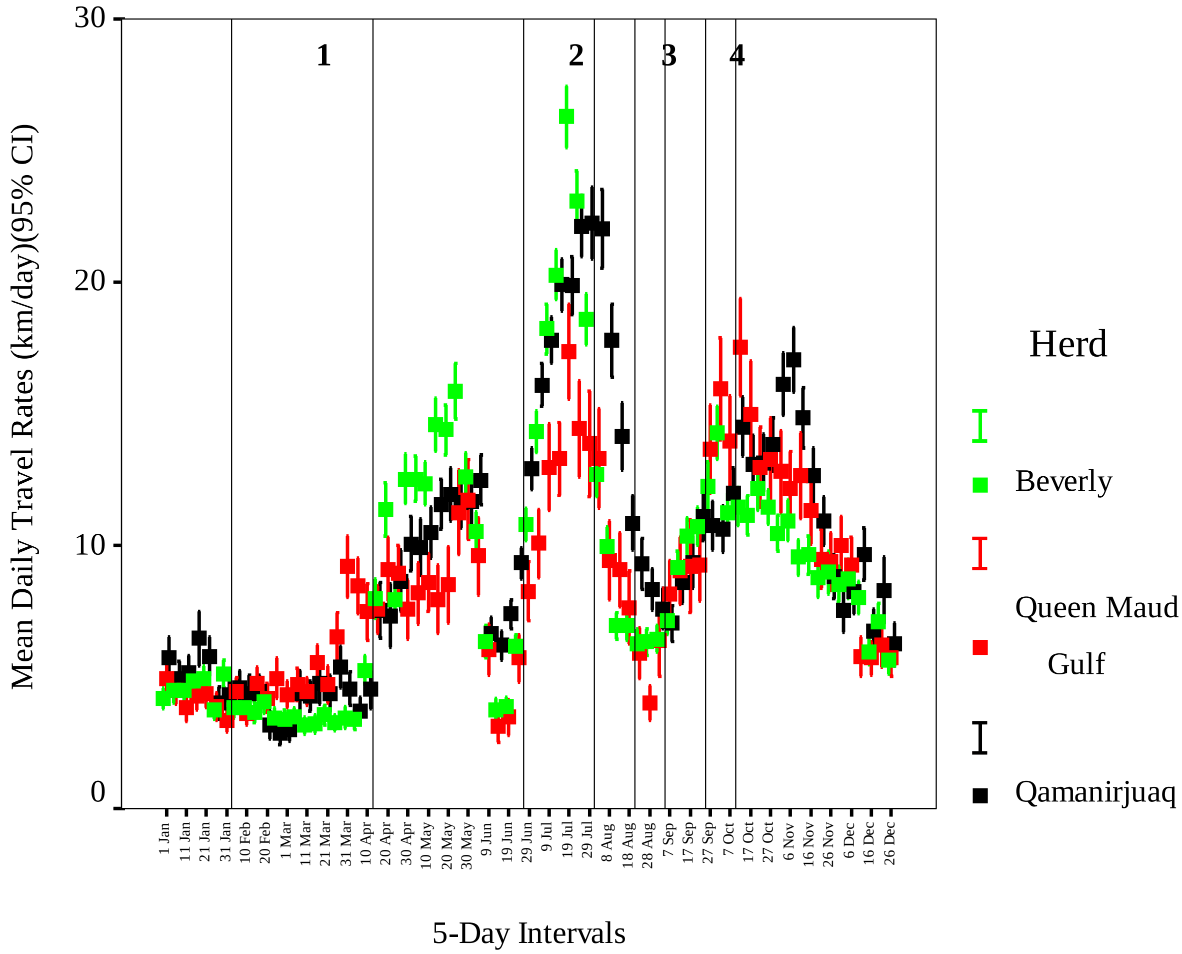


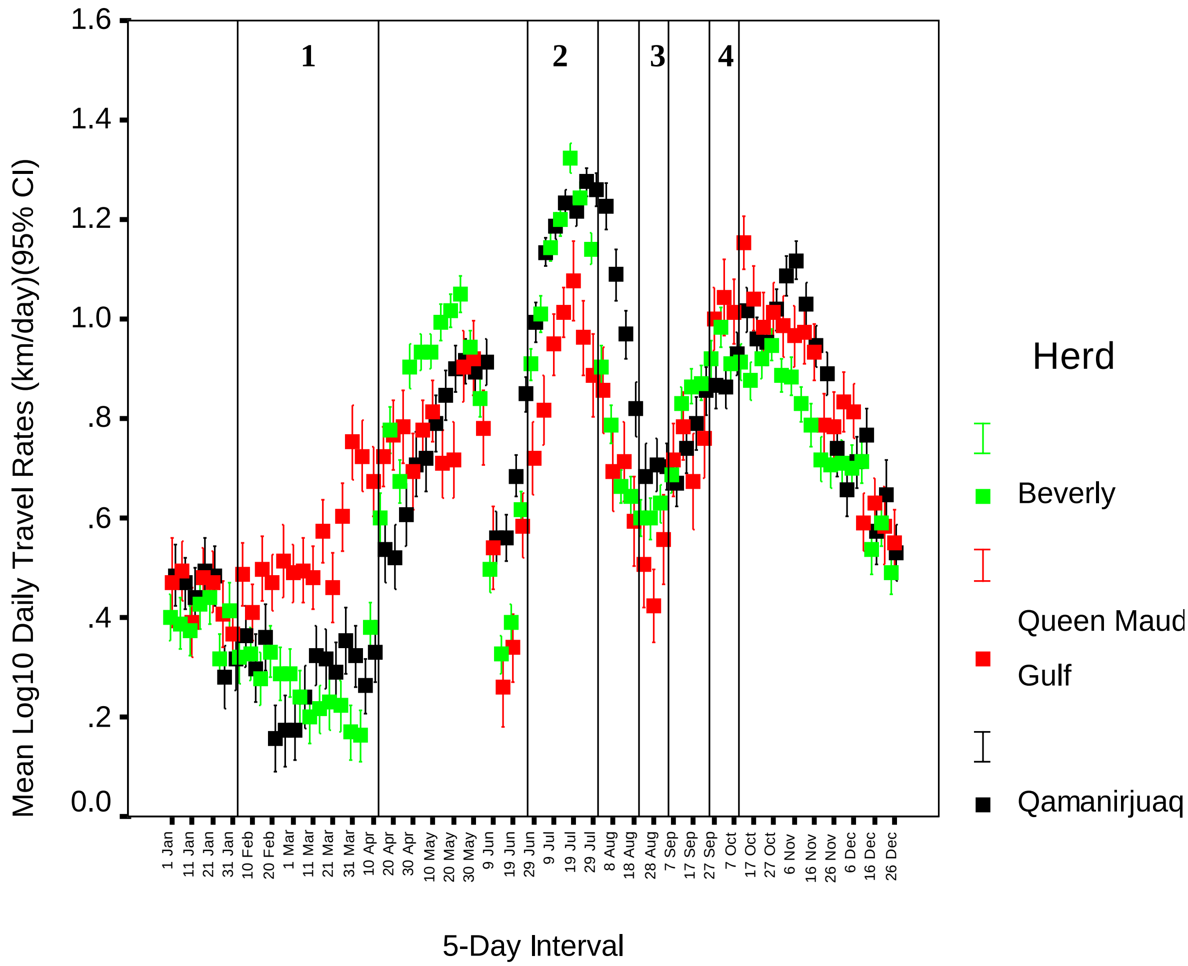
Fig. 6-2. Comparison of mean daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou. Periods when the daily travel rates of the Queen Maud Gulf were significantly different from those of the Beverly and Qamanirjuaq herds are shown.



Periods 1 and 4: daily travel rates of Queen Maud Gulf caribou were significantly greater than those of the Beverly and Qamanirjuaq herds.

Periods 2 and 3: daily travel rates of Queen Maud Gulf caribou were significantly lower than those of the Beverly and Qamanirjuaq herds.

Fig. 6-3. Comparison of mean log10 daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou. Periods when the daily travel rates of the Queen Maud Gulf were significantly different from those of the Beverly and Qamanirjuaq herds are shown.



Periods 1 and 4: daily travel rates of Queen Maud Gulf caribou were significantly greater than those of the Beverly and Qamanirjuaq herds.

Periods 2 and 3: daily travel rates of Queen Maud Gulf caribou were significantly lower than those of the Beverly and Qamanirjuaq herds.

Fig. 6-4. Mean log10 daily travel rates (km/day) by activity period for the migratory Beverly barren-ground caribou herd. Note the progressive decline in daily travel rates during early to late winter and a progressive increase in movement rates during the spring migration period.

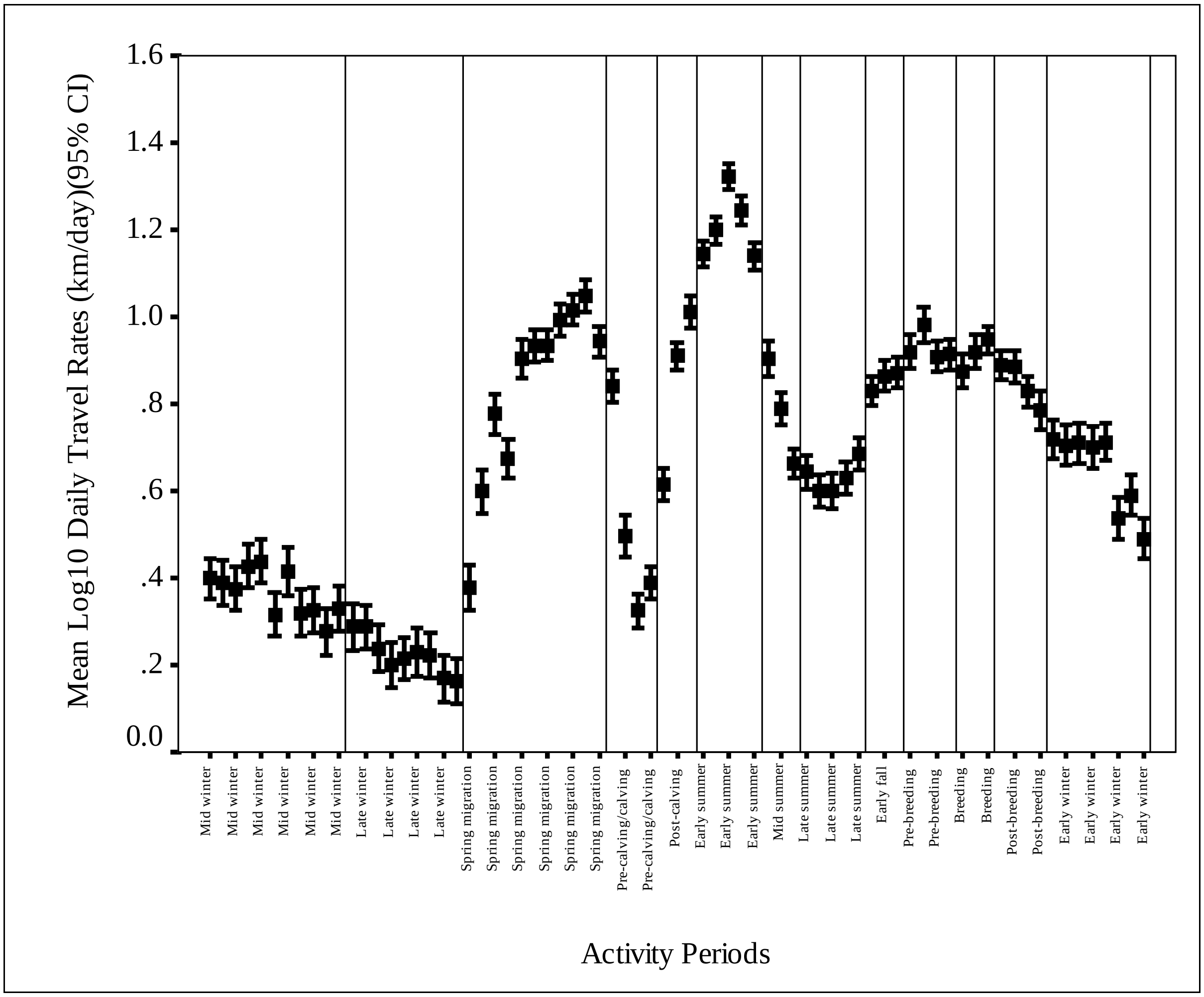


Fig. 6-5. Mean log10 daily travel rates (km/day) by activity period for the migratory Qamanirjuaq barren-ground caribou herd. Note the progressive decline in daily travel rates during early to late winter and a progressive increase in movement rates during the spring migration period.

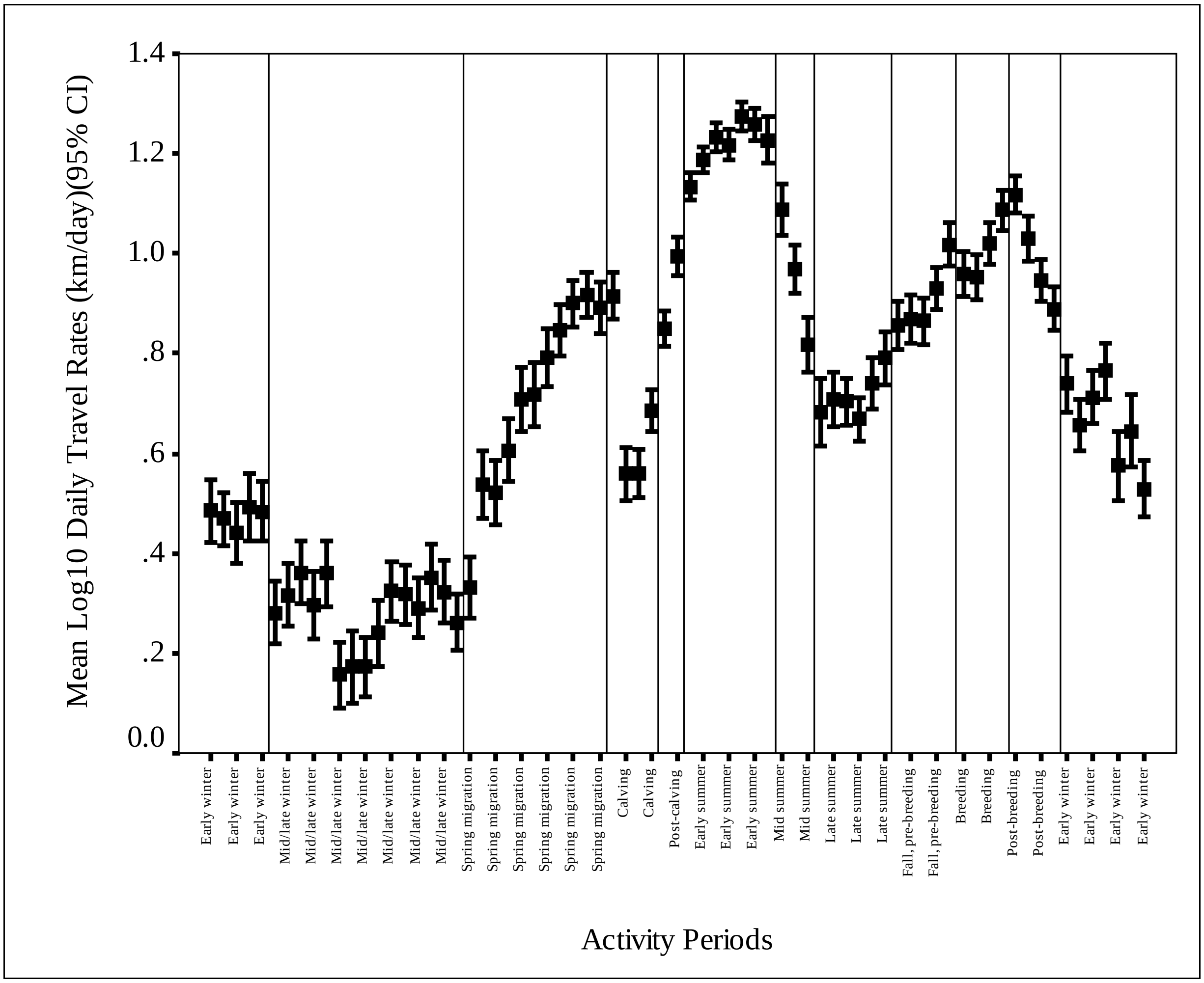


Fig. 6-6. Mean log10 daily travel rates (km/day) by activity period for the migratory Queen Maud Gulf barren-ground caribou herd. Note the lack of progressive decline in daily travel rates during early to late winter and a lack of a progressive increase in movement rates during the spring period. Daily travel rates were not significantly different during 26 Dec-30 Mar and from 31 Mar-24 May. Note the lack of daily travel rates indicative of a distinct spring migration.

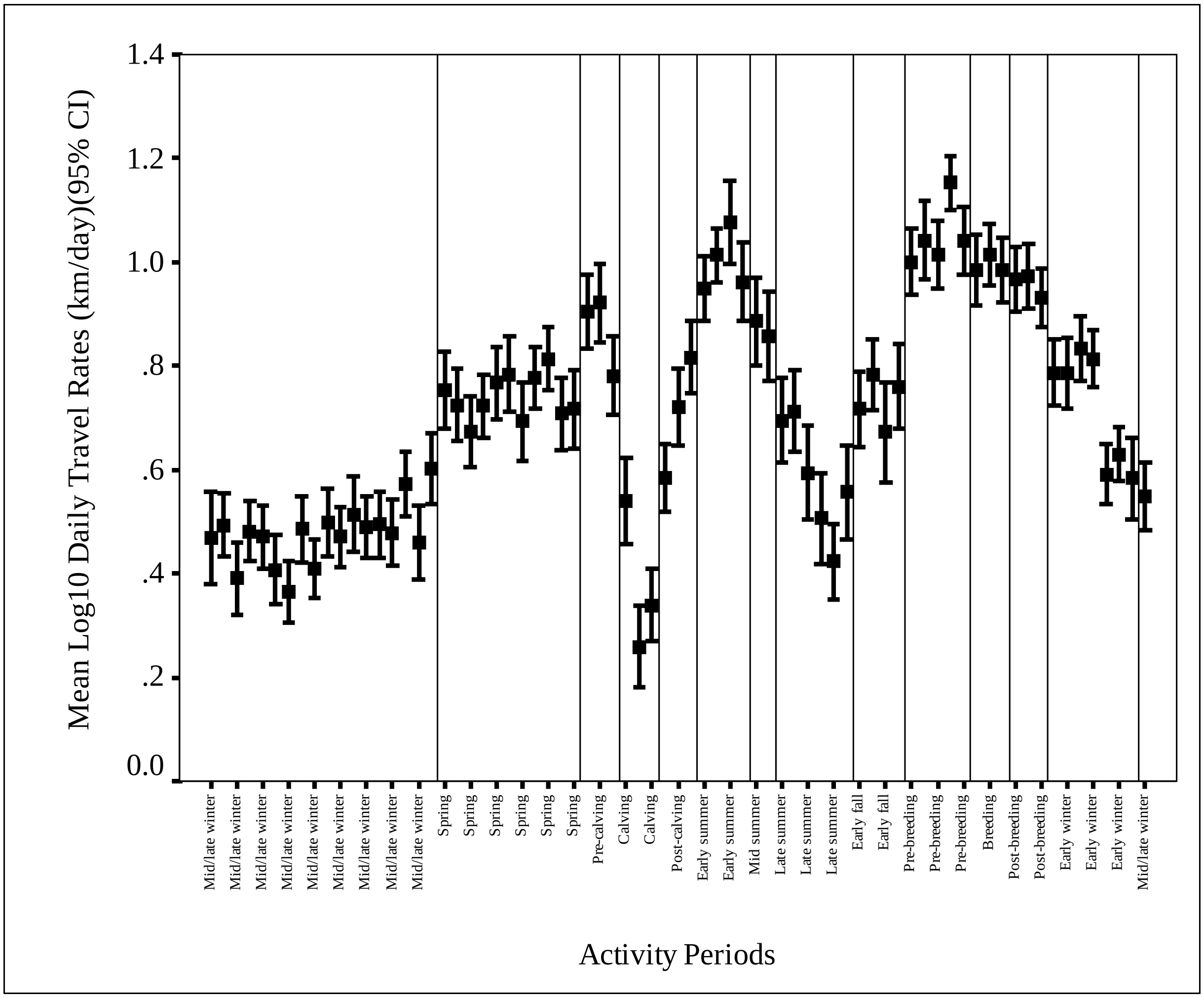


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Table 6-1. Mean daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou. Analyses of variance (ANOVA) and Tukey’s honestly significant difference (HSD) statistical tests were used to compare daily travel rates among herds during each of 73 5-day periods during 1 January-31 December.

First day of 5-day period	Beverly herd					Queen Maud Gulf herd					Qamanirjuaq herd					Significant Differences ($P<0.05$)
	Mean	STDEV	Min	Max	N	Mean	STDEV	Min	Max	N	Mean	STDEV	Min	Max	N	
1-Jan	4.2	4.2	0.1	26.3	421	4.9	4.2	0.0	22.4	188	5.7	6.9	0.1	42.3	288	QM=QA>BV
6-Jan	4.5	5.1	0.0	39.6	426	4.5	3.6	0.1	21.6	184	5.0	5.6	0.1	36.2	311	QM=QA>BV
11-Jan	4.5	5.4	0.0	39.8	432	3.8	3.7	0.0	24.0	187	5.1	5.8	0.1	37.8	302	QM=BV=QA
16-Jan	4.8	5.3	0.1	38.6	424	4.3	3.8	0.2	23.4	182	6.5	9.0	0.0	90.9	291	QM=QA>BV
21-Jan	4.9	5.3	0.0	38.0	419	4.3	3.5	0.0	16.3	189	5.8	6.7	0.1	39.3	316	QM=BV=QA
26-Jan	3.7	3.8	0.0	25.2	420	3.9	3.5	0.0	22.6	179	4.0	5.5	0.0	34.9	303	QM>BV=QA
31-Jan	5.1	5.6	0.0	31.6	423	3.4	3.1	0.1	23.3	185	4.3	5.3	0.0	31.6	308	QM=BV>QA
5-Feb	**3.8**	4.1	0.0	24.8	424	**4.5**	3.7	0.1	24.5	182	**4.6**	5.7	0.0	33.6	298	QM>QA>BV
10-Feb	**3.8**	4.1	0.0	30.2	429	**3.6**	3.0	0.1	18.5	188	**4.4**	6.1	0.0	55.5	298	QM>BV=QA
15-Feb	**3.6**	4.2	0.0	27.6	437	**4.8**	4.3	0.0	21.0	182	**4.5**	5.2	0.0	38.9	295	QM>QA>BV
20-Feb	**4.1**	5.0	0.0	40.7	428	**4.2**	3.8	0.2	21.1	177	**3.2**	4.9	0.0	42.2	311	QM>BV=QA
25-Feb	**3.4**	3.9	0.0	34.7	364	**5.0**	4.6	0.1	23.3	144	**2.9**	3.4	0.0	21.7	231	QM>BV=QA
1-Mar	**3.4**	3.8	0.0	29.0	430	**4.3**	3.5	0.1	18.3	178	**3.0**	3.7	0.0	21.7	338	QM>BV=QA
6-Mar	**3.5**	4.0	0.0	26.8	440	**4.7**	4.2	0.1	28.0	181	**4.7**	9.6	0.0	67.9	327	QM>BV=QA
11-Mar	**3.2**	3.6	0.0	28.9	493	**4.4**	3.7	0.0	25.3	192	**4.3**	5.4	0.0	34.6	347	QM>BV=QA
16-Mar	**3.2**	3.9	0.0	38.1	488	**5.5**	4.7	0.0	24.9	187	**4.8**	7.7	0.0	56.1	357	QM>BV=QA
21-Mar	**3.6**	4.2	0.0	41.5	483	**4.7**	4.9	0.1	37.9	187	**4.4**	6.8	0.0	60.2	354	QM>BV=QA
26-Mar	**3.3**	3.5	0.0	20.6	470	**6.5**	6.4	0.2	35.8	177	**5.4**	7.4	0.0	47.3	336	QM>QA>BV
31-Mar	**3.5**	5.0	0.0	36.7	515	**9.2**	8.1	0.1	41.1	182	**4.6**	6.2	0.0	50.0	353	QM>BV=QA
5-Apr	**3.4**	4.9	0.0	46.4	569	**8.4**	7.4	0.0	42.2	191	**3.7**	5.1	0.1	33.1	381	QM>BV=QA
10-Apr	**5.2**	6.9	0.0	57.9	547	**7.5**	7.2	0.2	44.0	174	**4.5**	6.9	0.0	75.2	352	QM>BV>QA
15-Apr	8.0	8.8	0.0	52.4	550	7.6	6.1	0.1	28.3	177	7.5	9.5	0.0	70.7	318	QM=BV>QA
20-Apr	11.4	12.0	0.1	76.6	556	9.1	8.2	0.0	48.1	181	7.3	11.1	0.0	77.9	327	QM=BV>QA
25-Apr	7.9	7.6	0.0	49.3	505	9.0	6.6	0.0	29.2	157	8.6	11.1	0.0	73.7	353	QM>BV=QA
30-Apr	12.5	10.9	0.0	84.8	513	7.6	6.8	0.0	39.6	141	10.1	9.8	0.0	49.2	345	QM=QA<BV
5-May	12.5	10.0	0.0	54.1	534	8.2	7.0	0.7	55.3	143	9.9	10.0	0.1	67.7	326	QA<QM<BV
10-May	12.4	9.8	0.1	62.9	547	8.6	6.4	0.4	39.2	132	10.5	9.3	0.0	52.4	356	QM=QA<BV
15-May	14.6	12.0	0.1	69.8	546	7.9	7.8	0.3	42.6	144	11.6	9.7	0.0	55.9	400	QA<QM<BV
20-May	14.4	10.8	0.3	59.2	506	8.5	8.8	0.3	50.2	141	11.9	10.1	0.0	87.0	393	QM<QA<BV
25-May	15.9	11.8	0.2	71.5	488	11.2	8.9	0.3	42.8	121	11.6	9.5	0.0	64.6	352	QM=QA<BV
30-May	12.6	10.7	0.3	66.6	530	11.7	8.8	0.1	61.2	133	11.7	9.6	0.0	62.5	354	QM=BV=QA
4-Jun	10.5	9.0	0.1	67.1	524	9.6	9.1	0.2	56.1	150	12.5	9.8	0.0	63.4	418	QM<BV=QA
9-Jun	6.4	7.5	0.0	52.3	556	6.0	6.0	0.1	26.8	152	6.6	7.0	0.0	39.2	455	QM=BV=QA
14-Jun	3.8	5.2	0.0	41.4	555	3.1	3.6	0.0	28.5	149	6.2	6.1	0.0	36.4	479	QM=BV<QA
19-Jun	3.9	4.2	0.0	36.1	559	3.5	4.2	0.2	28.0	143	7.4	6.2	0.1	49.9	471	QM=BV<QA
24-Jun	6.2	5.4	0.0	33.3	524	5.7	5.6	0.2	35.7	154	9.3	6.4	0.1	54.8	440	QM=BV<QA

Table 6-1. Mean daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou. Analyses of variance (ANOVA) and Tukey's honestly significant difference (HSD) statistical tests were used to compare daily travel rates among herds during each of 73 5-day periods during 1 January-31 December. (continued)

First day of 5-day period	Beverly herd					Queen Maud Gulf herd					Qamanirjuaq herd					Significant Differences (*P*<0.05)
	Mean	STDEV	Min	Max	N	Mean	STDEV	Min	Max	N	Mean	STDEV	Min	Max	N	
29-Jun	**10.8**	7.3	0.2	46.8	547	**8.3**	7.2	0.2	41.1	158	**12.9**	7.9	0.0	53.4	389	QM<BV<QA
4-Jul	**14.3**	10.1	0.0	63.0	613	**10.1**	8.6	0.1	44.0	169	**16.1**	8.3	0.3	52.3	388	QM<BV<QA
9-Jul	**18.2**	12.1	0.3	73.9	615	**13.0**	11.0	0.7	67.2	175	**17.8**	8.9	0.4	58.1	399	QM<BV<QA
14-Jul	**20.3**	11.9	0.0	74.0	617	**13.3**	9.1	0.9	59.2	170	**19.9**	9.9	0.4	58.5	382	QM<BV=QA
19-Jul	**26.3**	14.4	0.1	87.0	583	**17.4**	11.9	0.0	54.3	167	**19.9**	10.9	0.3	58.6	384	QM<BV=QA
24-Jul	**23.1**	13.8	0.0	83.4	595	**14.4**	12.2	0.1	73.5	173	**22.1**	11.5	0.0	77.4	378	QM<BV=QA
29-Jul	**18.6**	12.2	0.3	67.4	593	**13.9**	13.4	0.2	78.6	175	**22.2**	13.0	0.4	74.7	344	QM<BV<QA
3-Aug	12.7	10.6	0.0	75.3	617	13.3	12.6	0.1	58.9	174	22.0	13.2	0.0	66.6	301	QM=BV<QA
8-Aug	10.0	9.7	0.1	79.8	621	9.4	10.3	0.2	65.1	179	17.8	12.9	0.1	81.6	332	QM<BV<QA
13-Aug	6.9	6.4	0.1	57.9	587	9.1	9.1	0.1	54.3	166	14.2	12.4	0.0	96.1	364	QM=BV<QA
18-Aug	7.0	6.4	0.0	39.1	529	7.6	8.5	0.1	43.9	146	10.8	9.7	0.0	56.3	335	QM=BV<QA
23-Aug	**6.3**	6.4	0.1	45.8	535	**5.9**	6.0	0.1	26.9	149	**9.3**	9.1	0.0	49.8	348	QM<BV=QA
28-Aug	**6.3**	6.0	0.0	35.4	523	**4.0**	4.0	0.0	23.4	143	**8.3**	7.4	0.0	47.5	338	QM<BV=QA
2-Sep	**6.4**	6.0	0.0	55.0	520	**6.4**	7.4	0.1	49.4	122	**7.6**	6.7	0.3	33.1	299	QM<BV=QA
7-Sep	7.1	6.1	0.0	37.9	521	8.1	7.8	0.4	41.8	142	7.0	6.5	0.2	46.7	359	QM=BV=QA
12-Sep	9.2	6.9	0.2	46.8	507	9.0	7.8	0.2	39.1	146	8.6	7.4	0.0	38.6	331	QM=BV>QA
17-Sep	10.3	8.1	0.1	51.6	512	9.2	10.2	0.1	50.7	132	9.4	8.4	0.1	63.9	285	QM<BV=QA
22-Sep	10.7	8.6	0.1	56.4	525	9.2	8.1	0.1	41.6	140	11.1	9.1	0.2	47.9	366	QM=QA<BV
27-Sep	**12.2**	10.5	0.1	64.9	468	**13.6**	9.9	0.6	46.3	135	**10.7**	8.7	0.0	77.0	347	QM>BV>QA
2-Oct	**14.3**	11.7	0.0	67.3	517	**15.9**	11.4	0.1	62.9	136	**10.6**	8.4	0.1	61.8	354	QM>BV>QA
7-Oct	**11.2**	8.7	0.0	62.3	521	**14.0**	9.9	0.3	48.9	132	**12.0**	9.1	0.3	52.4	353	QM>BV=QA
12-Oct	11.5	8.6	0.0	51.0	517	17.5	10.6	1.7	51.3	130	14.5	10.5	0.2	59.5	340	QM=QA>BV
17-Oct	11.1	8.6	0.1	44.3	504	15.0	11.8	0.6	85.0	135	13.1	10.1	0.0	85.5	348	QM>BV=QA
22-Oct	12.2	9.6	0.0	49.6	513	13.0	8.7	0.5	46.6	129	13.1	10.7	0.3	74.2	356	QM=BV=QA
27-Oct	11.5	7.6	0.0	62.9	505	13.2	8.9	0.7	59.3	126	13.8	9.2	0.2	63.9	315	QM=QA>BV
1-Nov	10.5	7.9	0.1	54.8	509	12.8	9.1	0.3	41.0	133	16.1	11.0	0.3	64.1	324	QM=BV<QA
6-Nov	10.9	8.7	0.0	58.5	498	12.2	8.3	0.3	50.1	137	17.0	11.5	0.1	69.7	329	QM=BV<QA
11-Nov	9.5	7.7	0.0	59.7	507	12.7	9.7	0.3	46.9	138	14.8	10.9	0.0	55.4	342	BV<QM<QA
16-Nov	9.6	8.5	0.0	60.0	501	11.3	8.1	0.4	42.9	154	12.6	10.4	0.1	67.1	360	QM=QA>BV
21-Nov	8.8	8.6	0.0	48.5	514	9.5	8.2	0.3	39.3	201	10.9	8.5	0.1	52.7	333	QM=BV<QA
26-Nov	9.0	9.4	0.1	97.1	503	9.4	7.7	0.1	34.9	185	8.8	7.6	0.0	44.3	320	QM=BV=QA
1-Dec	8.5	7.7	0.0	48.8	497	10.0	7.9	0.2	36.7	203	7.5	7.8	0.0	51.5	321	QM=BV>QA
6-Dec	8.7	8.5	0.0	51.8	484	9.2	7.8	0.1	48.7	203	8.2	7.4	0.1	36.5	315	QM>BV=QA
11-Dec	8.0	6.8	0.1	36.1	484	5.8	5.2	0.2	31.9	194	9.7	8.8	0.1	52.2	310	QM<BV=QA
16-Dec	6.0	5.7	0.0	38.2	485	5.7	4.4	0.3	34.2	195	6.8	6.6	0.0	34.8	259	QM=BV=QA
21-Dec	7.1	7.7	0.1	44.3	490	6.2	5.6	0.0	28.6	181	8.3	9.6	0.0	58.2	228	QM=BV<QA
26-Dec	5.6	6.1	0.0	58.6	562	5.7	5.3	0.0	30.7	228	6.2	7.6	0.0	56.7	347	QM=BV=QA

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Appendix 6-A. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 21 January-25 February. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	Herd	n	Tukey's HSD subset for alpha = 0.05											Significant differences
			a	b	c	d	e	f	g	h	i	j	k	
21-Jan	BV	419											0.44	
21-Jan	QM	189											0.47	QM=BV=QA
21-Jan	QA	316											0.48	
26-Jan	BV	420	0.32											
26-Jan	QM	179											0.41	QM>BV=QA
26-Jan	QA	303	0.28											
31-Jan	BV	423											0.41	
31-Jan	QM	185										0.37		QM=BV>QA
31-Jan	QA	308	0.32											
5-Feb	BV	424	0.32											
5-Feb	QM	182											0.49	QM>QA>BV
5-Feb	QA	298										0.36		
10-Feb	BV	429	0.33											
10-Feb	QM	188											0.41	QM>BV=QA
10-Feb	QA	298	0.30											
15-Feb	BV	437	0.28											
15-Feb	QM	182											0.50	QM>=QA>BV
15-Feb	QA	295										0.36		
20-Feb	BV	428	0.33											
20-Feb	QM	177											0.47	QM>BV=QA
20-Feb	QA	311	0.16											
25-Feb	BV	364	0.29											
25-Feb	QM	144											0.51	QM>BV=QA
25-Feb	QA	231	0.17											

Appendix 6-B. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 1 March-5 April. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	**Herd**	**n**	**Tukey's HSD subset for alpha = 0.05**																	**Significant differences**
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	
1-Mar	BV	430	0.29																	
1-Mar	QM	178											0.49							QM>BV=QA
1-Mar	QA	338	0.17																	
6-Mar	BV	440	0.24																	
6-Mar	QM	181											0.49							QM>BV=QA
6-Mar	QA	323	0.24																	
11-Mar	BV	493	0.20																	
11-Mar	QM	192											0.48							QM>BV=QA
11-Mar	QA	347	0.32																	
16-Mar	BV	488	0.22																	
16-Mar	QM	187																0.57		QM>BV=QA
16-Mar	QA	357	0.32																	
21-Mar	BV	483	0.23																	
21-Mar	QM	187											0.46							QM>BV=QA
21-Mar	QA	354	0.29																	
26-Mar	BV	470	0.22																	
26-Mar	QM	177																	0.60	QM>QA>BV
26-Mar	QA	336											0.35							
31-Mar	BV	515	0.17																	
31-Mar	QM	182																	0.75	QM>BV=QA
31-Mar	QA	352	0.32																	
5-Apr	BV	569	0.16																	
5-Apr	QM	191																	0.72	QM>BV=QA
5-Apr	QA	381	0.26																	

Appendix 6-C. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 10 April-15 May. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	**Herd**	**n**	**Tukey's HSD subset for alpha = 0.05**																				**Significant differences**
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	**t**	
10-Apr	BV	547				0.38																	
10-Apr	QM	174									0.67												QM>BV>QA
10-Apr	QA	352	0.33																				
15-Apr	BV	550									0.60												
15-Apr	QM	177									0.72												QM=BV>QA
15-Apr	QA	318								0.54													
20-Apr	BV	556																	0.78				
20-Apr	QM	181																	0.77				QM=BV>QA
20-Apr	QA	327				0.52																	
25-Apr	BV	505									0.67												
25-Apr	QM	157																	0.78				QM>BV=QA
25-Apr	QA	353									0.61												
30-Apr	BV	513																				0.90	
30-Apr	QM	141									0.69												QM=QA<BV
30-Apr	QA	345									0.71												
5-May	BV	534																				0.93	
5-May	QM	143																	0.78				QA<QM<BV
5-May	QA	326									0.72												
10-May	BV	547																				0.93	
10-May	QM	132																	0.81				QM=QA<BV
10-May	QA	356																	0.79				
15-May	BV	546																				0.99	
15-May	QM	144									0.71												QM<QA<BV
15-May	QA	400																	0.85				

Appendix 6-D. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 20 May-24 June. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	**Herd**	**n**	**Tukey's HSD subset for alpha = 0.05**																			**Significant differences**
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	
20-May	BV	506																	1.02			QM<QA<BV
20-May	QM	141							0.72													
20-May	QA	393														0.90						
25-May	BV	488																	1.05			QM=QA<BV
25-May	QM	121														0.90						
25-May	QA	352														0.92						
30-May	BV	530														0.94						QM=BV=QA
30-May	QM	133														0.92						
30-May	QA	354														0.89						
4-Jun	BV	524														0.84						QM<BV=QA
4-Jun	QM	150							0.78													
4-Jun	QA	418														0.91						
9-Jun	BV	556			0.50																	QM=BV=QA
9-Jun	QM	152			0.54																	
9-Jun	QA	455			0.56																	
14-Jun	BV	555	0.33																			QM=BV<QA
14-Jun	QM	149	0.26																			
14-Jun	QA	479			0.56																	
19-Jun	BV	559	0.39																			QM=BV<QA
19-Jun	QM	143	0.34																			
19-Jun	QA	471							0.68													
24-Jun	BV	524			0.62																	QM=BV<QA
24-Jun	QM	154			0.58																	
24-Jun	QA	**440**														**0.85**						

Appendix 6-E. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 29 June-3 August. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	Herd	n	Tukey's HSD subset for alpha = 0.05																				Significant differences
			a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	
29-Jun	BV	547											0.91										
29-Jun	QM	158							0.72														QM<BV<QA
29-Jun	QA	389														0.99							
4-Jul	BV	613														1.01							
4-Jul	QM	169											0.82										QM<BV<QA
4-Jul	QA	388																			1.13		
9-Jul	BV	615																			1.14		
9-Jul	QM	175											0.95										QM<BV<QA
9-Jul	QA	399																				1.19	
14-Jul	BV	617																				1.20	
14-Jul	QM	170														1.01							QM<BV=QA
14-Jul	QA	382																				1.23	
19-Jul	BV	583																				1.32	
19-Jul	QM	167														1.08							QM<BV=QA
19-Jul	QA	384																				1.22	
24-Jul	BV	595																				1.24	
24-Jul	QM	173											0.96			0.96							QM<BV=QA
24-Jul	QA	378																				1.28	
29-Jul	BV	593																			1.14		
29-Jul	QM	175											0.89										QM<BV=QA
29-Jul	QA	344																				1.26	
3-Aug	BV	617											0.90										
3-Aug	QM	174											0.86										QM=BV<QA
3-Aug	QA	301																				1.23	

Appendix 6-F. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 8 August-12 September. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	Herd	n	Tukey's HSD subset for alpha = 0.05																								Significant differences
			a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	
8-Aug	BV	621													0.79												
8-Aug	QM	179				0.69																					QM<BV<QA
8-Aug	QA	332																					1.09				
13-Aug	BV	587				0.66																					
13-Aug	QM	166				0.71																					QM=BV<QA
13-Aug	QA	364																		0.97							
18-Aug	BV	529				0.64																					
18-Aug	QM	146				0.59																					QM=BV<QA
18-Aug	QA	335													0.82												
23-Aug	BV	535				0.60																					
23-Aug	QM	149	0.51																								QM<BV=QA
23-Aug	QA	348				0.68																					
28-Aug	BV	523				0.60																					
28-Aug	QM	143	0.42																								QM<BV=QA
28-Aug	QA	338				0.71																					
2-Sep	BV	520				0.63																					
2-Sep	QM	122	0.56																								QM<BV=QA
2-Sep	QA	299				0.70																					
7-Sep	BV	521				0.69																					
7-Sep	QM	142				0.72																					QM=BV=QA
7-Sep	QA	359				0.67																					
12-Sep	BV	507													0.83												
12-Sep	QM	146													0.78												QM=BV>QA
12-Sep	QA	331				0.74																					

Appendix 6-G. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 17 September-22 October. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	**Herd**	**n**	**Tukey's HSD subset for alpha = 0.05**																					**Significant differences**
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	**t**	**u**	
17-Sep	BV	512								0.86														
17-Sep	QM	132		0.67																				QM<BV=QA
17-Sep	QA	285								0.79														
22-Sep	BV	525																0.87						
22-Sep	QM	140								0.76														QM=QA<BV
22-Sep	QA	366								0.86														
27-Sep	BV	468																0.92						
27-Sep	QM	135																					1.00	QM>BV>QA
27-Sep	QA	347								0.87														
2-Oct	BV	517																0.98						
2-Oct	QM	136																					1.04	QM>BV>QA
2-Oct	QA	354								0.86														
7-Oct	BV	521																0.91						
7-Oct	QM	132																					1.01	QM>BV=QA
7-Oct	QA	353																0.93						
12-Oct	BV	517																0.91						
12-Oct	QM	130																					1.15	QM=QA>BV
12-Oct	QA	340																					1.02	
17-Oct	BV	504																0.88						
17-Oct	QM	135																					1.04	QM>BV=QA
17-Oct	QA	348																0.96						
22-Oct	BV	513																0.92						
22-Oct	QM	129																0.98						QM=BV=QA
22-Oct	QA	356																0.95						

Appendix 6-H. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 27 October-1 December. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	Herd	n	Tukey's HSD subset for alpha = 0.05																Significant differences
			a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	
27-Oct	BV	505												0.95					
27-Oct	QM	126																1.01	QM=QA>BV
27-Oct	QA	315																1.02	
1-Nov	BV	509												0.89					
1-Nov	QM	133												0.99					QM=BV<QA
1-Nov	QA	324																1.09	
6-Nov	BV	498												0.88					
6-Nov	QM	137												0.97					QM=BV<QA
6-Nov	QA	329																1.12	
11-Nov	BV	507						0.83											
11-Nov	QM	138												0.97					BV<QM<QA
11-Nov	QA	342																1.03	
16-Nov	BV	501						0.79											
16-Nov	QM	154												0.93					QM=BV<QA
16-Nov	QA	360												0.95					
21-Nov	BV	514						0.72											
21-Nov	QM	201						0.79											QM=BV<QA
21-Nov	QA	333												0.89					
26-Nov	BV	503						0.71											
26-Nov	QM	185						0.78											QM=BV=QA
26-Nov	QA	320						0.74											
1-Dec	BV	497						0.71											
1-Dec	QM	203						0.83											QM=BV>QA
1-Dec	QA	321	0.66																

Appendix 6-I. Analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) comparisons of log10 transformed daily travel rates (km/day) of tundra-wintering Queen Maud Gulf and migratory Beverly and Qamanirjuaq barren-ground caribou for each 5-day period during 6 December-16 January. Although we compared travel rates for 16 5-day periods, we excluded the first and last 4 5-day periods when interpreting the results of Tukey's HSD pairwise comparisons.

Start Date 5-Day Interval	Herd	n	Tukey's HSD subset for alpha = 0.05																			Significant differences
			a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	
6-Dec	BV	484															0.70					
6-Dec	QM	203																			0.81	QM>BV=QA
6-Dec	QA	315															0.71					
11-Dec	BV	484															0.71					
11-Dec	QM	194								0.59												QM<BV=QA
11-Dec	QA	310															0.77					
16-Dec	BV	485								0.54												
16-Dec	QM	195								0.63												QM=BV=QA
16-Dec	QA	259								0.57												
21-Dec	BV	490								0.59												
21-Dec	QM	181								0.58												QM=BV<QA
21-Dec	QA	228															0.65					
26-Dec	BV	562								0.49												
26-Dec	QM	228								0.55												QM=BV=QA
26-Dec	QA	347								0.53												
1-Jan	BV	421	0.40																			
1-Jan	QM	188								0.47												QM=QA>BV
1-Jan	QA	288								0.48												
6-Jan	BV	426	0.39																			
6-Jan	QM	184								0.49												QM=QA<BV
6-Jan	QA	311								0.47												
11-Jan	BV	432	0.37																			
11-Jan	QM	187	0.39																			QM=BV=QA
11-Jan	QA	302	0.44																			
16-Jan	BV	424	0.43																			QM=QA>BV

16-Jan	QM	182								0.48												
16-Jan	QA	291								0.49												