CALVING GROUND SURVEYS OF THE AHIAK HERD OF BARREN GROUND CARIBOU JUNE 2006-2008

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ABSTRACT

We conducted three aerial systematic transect surveys of the Ahiak calving ground in June 2006, June 2007 and June 2008. On transect, we counted 5633 cows and 1723 calves, 4431 cows and 2508 calves, and 1709 cows and 598 calves, in June 2006, June 2007 and June 2008. Survey coverage was 4.5% in June 2006, 4.6% in June 2007 and 6.7% in June 2008. The density of total adult caribou observed on transect from June 2006-2008 was 3.1, 3.0 and 1.1 caribou/km^2, respectively. We mapped the annual calving areas near peak of calving based on the distribution of breeding cows observed during the annual systematic transect surveys conducted June 2006-08. From 2006-2008, the Ahiak annual calving area near peak of calving was located 60km west of the Ellice River and extended eastward to Chantrey Inlet including the Adelaide Peninsula and was roughly bounded to the north by the Queen Maud Gulf and to the south by 67º N. Highest densities of breeding cows were observed around the Perry River and on the east side of the Adelaide Peninsula. There was greater than 50% overlap in the annual calving grounds from June 2006-08; the distribution of breeding cows used in all three years was located between the Ellice River and Chantrey Inlet (including the Adelaide Peninsula) and extended ~40-50 km and ~20-30 km inland along the western and eastern portions, respectively. Annual variation in the distribution of annual calving grounds may be attributed to both late and early spring conditions. There is evidence that the low density of breeding cows observed in June 2008 may be due to low pregnancy rates. Except for June 2006 where weather conditions were ideal during the transect survey, weather conditions in June 2007 and 2008 were persistently bad with low ceilings, snowstorms, high winds and coastal fog.

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INTRODUCTION

Relatively little has been reported for the Ahiak herd of barren ground caribou except for the report by Gunn et al. (2000) that laid out the justification for identifying it as a separate herd. This paper also identified the calving area of the Ahiak herd and demonstrated overlap between the Ahiak, Beverly and Bathurst herds during the non-calving periods. Because barren ground caribou herds are defined as groups of animals that consistently calve in a distinct and traditional location (Thomas 1969, Skoog 1968), it is important to understand the location of calving grounds as a basis for managing mainland barren ground caribou.

The Ahiak herd was recognized as a separate herd in the 1980s and transect surveys were conducted on the pre-calving distribution in May1983 and 1995 (Buckland et al. 2000, Heard et al. 1987). Surveys of the distribution of the Ahiak calving ground were initiated in 1986, 1996 and 2002 (Gunn et al. 2000, Gunn and D'Hont 2003). These surveys either focussed on a portion on the Ahiak calving area or did not use a systematic approach. Conseqently, no systematic survey of the entire Ahiak calving distribution had been completed to date.

A systematic transect survey of the distribution of the breeding cows on the Ahiak calving ground was initiated in June 2006 to gain a better understanding the annual calving area near or at the peak of calving. This work was also continued in June 2007 and 2008 as part of a GNWT wide initiative to map the annual calving areas of all the mainland barren ground caribou herds in the Northwest Territories and Nunavut at the same time. Our objectives for the surveys were:

1. Systematically delineate the spatial distribution of breeding females on the annual calving ground of the Ahiak barren ground caribou herd close to or near the peak of calving,
2. Determine the relative density of breeding cows on the annual calving ground of the Ahiak barren ground caribou herd close to or near the peak of calving, and
3. Predict and map annual calving areas of the Ahiak barren ground caribou close to or near the peak of calving.

In this paper, we report the results of three systematic transect surveys of the Ahiak calving ground conducted June 2006, June 2007 and June 2008. The purpose of these surveys was to map the distribution and relative density of breeding cows on the Ahiak calving ground. This data was used to predict and map the distribution of breeding cows and calves on the Ahiak calving ground using a interpolation technique called kriging. These prediction maps were used to define the annual calving areas at the peak of calving and to provide information of the commonalities and annual variations in the distribution and relative densities of breeding cows. The results of this report will help guide future work on the Ahiak barren ground caribou herd, such as the feasibility of conducting a population estimate of the number of breeding females on the Ahiak calving ground.

METHODS

Study Area

We delineated the survey area based on the distribution of satellite collar data from 1996-2005 and previous aerial surveys in June 1986, 1996 and 2002 (Gunn and D'Hont 2002, Gunn et al. 2000, Gunn and Fournier 2000 and Gunn et al. 1997). The study area was bounded by Bathurst Inlet to the west, Chantrey Inlet to the east, and Queen Maud Gulf to the north, while the south end of the transects extended to 66º 16'N.

Systematic Transect Survey

A systematic strip transect survey method was used to delineate the spatial distribution of calving caribou and determine relative patterns of caribou density. A Cessna-337 aircraft was used to conduct the systematic transect survey in 2006, while a Heliocourier aircraft was used in June 2007 and 2008. Survey altitude was 120 m above ground level (agl), survey speed was approximately 160 km/hour and the total strip transect width was 0.8 km (0.4 km strip width for each observer). The survey was based out of Miramar Hope Bay Limited's Boston exploration camp at Spyder Lake, NU (67º 39.5' N / 106º 23.24'W) and the community of Gjoa Haven, NU.

Wooden dowels taped onto the wing struts were used to mark the outer boundary of the transect strip width on each side of the aircraft. The methodology outlined by Norton-Griffins (1978) was used to determine the position of the dowels on the strut that would define a 0.4 km strip width on each side of the plane at an altitude of 120 m agl. Observers calibrated the outer boundary of their strip markers, while the plane flew at survey altitude on an axis perpendicular axis to markers that defined the distance of the strip width (0.4 km) on the ground.

A landscape-level 10 km survey grid was applied to the survey area; transects corresponded to the north-south grid lines. The individual 10 km x 10 km grid cells were sequentially numbered with a transect number (ascending from west to east) and a grid cell number (ascending from south to north). For example, the grid cell with the label 1-1 was located at the south end of transect 1 (Figure XX – 10 km grid over survey area). The 10 km survey grid for the delineation of the Ahiak herd was a continuation of grid that covered the known calving distribution of the Bathurst herd since the mid-1990s (Gunn et al. 2005).

The survey area was stratified into three survey blocks to ensure that the entire survey area was covered as close to peak calving as possible (Figure 1). Stratification was based on results from previous surveys during the calving period (Gunn et al. 2000, Gunn and D'Hont 2003) and information on the past distribution of collared Ahiak cows during the calving period (GNWT unpublished data). The western block extended from the east side of Bathurst Inlet to just west of the Ellice River, the middle block approximately covered the area from the Ellice River east to the Simpson River and eastern block covered east of Simpson River to Chantrey Inlet. Based on previous information, it was estimated that the density of breeding cows would be highest in the central block and lower on the western and eastern blocks. As a result, the central block was flown at 10-km transect spacing, while the western and eastern blocks were flown at 20-km transect spacing.

Survey crews were comprised of the pilot and an observer and an observer/recorder seated in the back of the aircraft (Heliocourier or Cessna 337) (Appendix I). Observers estimated the numbers of caribou seen both on and off transect and wherever possible also classified caribou observed. We estimated the size of larger groups by estimating blocks of caribou by the 10s, 50s and 100s. Caribou were classified as cows with hard antlers, calves, antlerless cows, yearlings, and bulls based on body size and whether antlers were either light coloured and polished or in velvet. Observers called their observations to the navigator who recorded them as well as a waypoint number along with the transect segment label. When large numbers of caribou were encountered (density > 10 caribou/km^2) the observers used tape recorders to record caribou observations. The observers were also equipped with binoculars to help ensure that counts and classifications were done accurately. If an observer had difficulty counting or classifying a group of caribou, the pilot flew to the group and then flew in a tight circle around the group so that it could be accurately counted and classified. The pilot then flew the aircraft back to the point where we broke off the transect line and resumed surveying.

The observer/recorder created a GPS waypoint for each group of caribou observed and recorded the waypoint number, the number and classes of caribou observed at each site, and whether the observation was on or off transect. At the end of each day the waypoint files were downloaded to the laptop computer. The files were then imported into a Microsoft Excel spread sheet and the waypoint coordinate data (number, latitude and longitude coordinates, date and time) were appended to the observation data. We used the GPS to create a track file so that the transects flown could be accurately recorded (location recorded every 10 seconds). The track files were down loaded to the laptop computer at the end of each flight.

The criteria to end transects were based on the assumption that we were close to the peak of calving. On the north end of transects, we used the criterion of no antlered cows or calves within a 10 km segment and for the southern ends, we used the criteria of low density of cows with hard antler (< 5 cows with hard antler/segment) or presence of a calf. However, the southern criteria was modified to no more than one calf observed, as several lone cows with calves were observed in southern segments with no other caribou observed. The western boundary of the survey was determined by the absence of breeding caribou along one entire transect, while the eastern boundary was Chantrey Inlet.

The areas were surveyed at or near the peak of calving. Survey crew were equipped with laptop computers with OziExplorer (OziExplorer GPS Mapping Software), a digital map of the survey area, and a digital data file of the waypoints for the ends of each transect installed. Each day OziExplorer was used to download the waypoints for the ends of each transect from the laptop to the GPS of the aircraft. The pilot used these waypoints to navigate to the start and end points of each transect.

Defining and Mapping the Annual Calving Areas

a. Modelling the distribution of caribou on the calving grounds
The Ahiak calving ground distribution was modeled using a geostatistical approach called kriging using the Geostatistical Analyst extension in ArcGIS 9.1 based on the results from the annual systematic reconnaissance surveys flown June 2006, June 2007 and June 2008.

The ordinary kriging prediction map method in ArcGIS 9.1 was used to model the distribution of breeding cows and calves on the calving grounds near peak of calving. We used a heuristic approach to select the best-fit semivariogram model (circular, spherical, tetraspherical, pentaspherical, exponential, gaussian, rational quadratic, hole effect, K-Bessel, J-Bessel, stable). Kriging as a predictor does not require that data have a normal distribution (Johnston et al. 2003). When considering only predictors that are formed from weighted averages, kriging is the best unbiased predictor of whether or not your data is normally distributed (Johnston et al. 2003). Ordinary kriging has remarkable flexibility as it can use either semivariograms or covariances, it can use transformations and remove trend, and can allow for measurement error (Johnston et al. 2003).

Kriging was carried out using the estimated breeding cow and calf density values (number of cows or calves per km^2) at the centroids of the 10 km transect segments; transect segments that were not flown were coded as “9999”. We used a second order trend removal for all models. Lag size was set at one-third of the largest distance between the data points divided by the number of lags (lag number was set at 12). This consideration was based on a rule of thumb; which states that the lag size times the number of lags should be less than one half of the largest distance in the database (Sarangi et al. 2006; Sarangi et al. 2005; Johnston et al. 2003). The corresponding sill, nugget, and range values were observed for the different model types. The presence of isotropy and anisotropy in the data were observed in the variogram fitting (Sarangi et al. 2006; Sarangi et al. 2005). We used a search neighborhood of 5 data points, with a minimum of 2 included, and an 8 sector circular neighborhood.

Generally, the best model was selected as the one that had the standardized mean nearest to zero, the smallest root-mean-square prediction error, the average standard error nearest the root-mean-square prediction error, and the root-mean-square standardized prediction error nearest to one (Johnston et al. 2003).

We used a cell size of 1000 m to create the output raster, as once the semivariogram is estimated (i.e., the best model), a smaller cell size can be used in creating the actual output raster (ESRI 2007). The output raster was then reclassified into the following density classes (calves or breeding cows per km^2): cells with density values of $\leq$0.125 cow or calf per km^2 were given a value of 0, low density cells were labeled as cow/calf densities ≥ 0.125 and < 1.0, while medium density cells were labeled as cow/calf densities ≥1.0 and < 10.0 caribou/km^2 and high density cells were labeled as cow/calf densities > 10.0 caribou/km^2. We applied a spatial mask to limit these analyses to the boundaries of the survey area.

The models from the kriging analysis were also compared to the relative density class of breeding cows and calves observed for each 10 km transect segment, as well as collar cow data during the survey period. The density classes of caribou observed for each 10 km transect segment were labeled as none (transect segment flown but no caribou observed), low (< 1.0 caribou/km^2), medium (1.0 – 9.9 caribou/km^2) and high (> 10 caribou/km^2).

b. Overlap in annual calving areas

The values for cells in the raster layer that fell within the 2006 calving area were reclassified as 1, with the values for the remaining cells set at 0. Similarly the values for cells that fell within the 2007 and 2008 calving areas were reclassified as 20 and 300, respectively, with the values for the remaining cells set at 0. We summed the values for these three raster layers using raster calculator in Spatial Analyst and created a new raster layer. The cell values in the new layer indicated the years when cells were included in the annual calving areas as follows:

- cell value 1 = in calving area in 2006,
- cell value 20 = in calving area in 2007,
- cell value 21 = in calving area in 2006 and 2007,
- cell value 300 = in calving area in 2008,
- cell value 301 = in calving area in 2006 and 2008,
- cell value 320 = in calving area in 2007 and 2008, and
- cell value 321 = in calving area in 2006, 2007, and 2008.

The resulting classification was mapped to show the years in which different portions of the combined calving area were used.

The values for cells in the raster layers that fell within the calving area during 2006, 2007, and 2008 were reclassified as 1, with the values for the remaining cells set at 0 for each layer. We summed the values for these three raster layers using the raster calculator in Spatial Analyst and created a new raster layer. The cell values in the new raster layer indicated the number of times a cell was included in the annual calving areas during the 3 year period 2006 to 2008 as follows:

- cell value 1 = in calving area 1 of 3 years,
- cell value 2 = in calving area 2 of 3 years, and
- cell value 3 = in calving area 3 of 3 years.

The resulting classification was mapped to show the number of years in which different portions of the combined calving area were used.

RESULTS

Systematic Transect Surveys

a. June 2006

From 13 – 16 June 2006, we flew 21.5 hours on survey and 14.9 hours off survey based out of Miramar Hope Bay Limited's Boston exploration camp at Spyder Lake and Gjoa Haven, NU Table 1, Figure 2).

Weather conditions in June 2006 were ideal with clear skies, calm winds and warm temperatures (Appendix II). We encountered a bit of fog along the coast at the north end of some transect segment, but otherwise visibility was greater than 15 nautical miles. Snow cover ranged from 0-20%, with most areas free of snow.

We counted a total of 5633 cows (4321 cows with hard antlers) and 1723 calves (40% of hard antlered cows with calves) and 188 bulls, 45 yearlings and 171 unknown caribou on transect; 11688 caribou were observed off transect. Breeding cows (cows with calves and/or cows with hard antler) were primarily observed in a broad band from the coast inland 50-60 km along the Queen Maud Gulf from the Ellice River to Chantrey and to the entire Adelaide Peninsula (Figure 3-6). The main high-density cluster of breeding cows was located 20-30 km inland of the coast at the Perry River and extended approximately 60 km eastward to the Armark River (McTavish Point on the Queen Maud Gulf). Small high density clusters of breeding cows were also found west of the Perry River, 10 km inland along the Kaleet River and on the eastern arm of the Adelaide Peninsula that were intermixed with breeding cows at medium-density. The entire Adelaide Peninsula was populated with breeding cows at low density. Most notable was the number of non-breeding caribou intermixed with breeding cows; yearlings and bulls were commonly observed within the distribution of calving cows. Yearlings and bulls were also found along the south edge of the cow distribution. One lone cow/calf pair were also observed at the southern edge of the Ahiak calving ground at transect segment 53-9; however, it is not uncommon to have a low number of cows that do not reach their respective calving ground.

We counted 181 muskoxen and 18 calves in 23 groups on transect and 120 in 20 groups off transect with 1 calf, and 8 wolves in 3 groups on transect and 3 wolves in 2 groups off transect. No grizzly bears were seen in June 2006. Muskoxen were distributed throughout the survey area, while wolves were primarily seen around the Ellice River and McNaughton Lake (Figure 7).

b. June 2007

From 14 – 18 June 2007, we flew 21.0 hours on survey and 16.3 hours off survey based out of Miramar Hope Bay Limited's Boston exploration camp at Spyder Lake and Gjoa Haven, NU (Table 1, Figure 8).

Weather conditions in June 2007 were drastically different than June 2006. We experienced persistently bad weather throughout the survey consisting of very low ceilings (~500 agl), snow showers, sub-freezing temperatures, freezing rain, mist and high winds (Appendix I). Due to reduced visibility, we only counted caribou observed on transect. Spring conditions in Nunavut were much later than normal according to Gjoa Haven and Baker Lake residents, while spring conditions in the eastern NWT appeared to be normal. Lakes within the survey area were still frozen during the survey; however, snow cover was less than 20% near the coast and increased to 70% at the south end of transects.

We observed a total of 4431 cows (3377 cows with hard antlers) and 2508 calves (74% of hard antlered cows with calves) and 382 bulls, and 1157 yearlings on transect. The distribution of cows was more dispersed and at lower density than in June 2006 (Figures 9-12). The majority of breeding cows were observed east of the Ellice River and extended to Chantrey Inlet. A few dispersed groups of breeding cows were observed west of the Ellice River at low densities, with few calves seen in this area. A high density pocket of breeding cows was observed west of the Perry River approximately 50 km north of MacAlpine Lake, as well as 4 individual high density transect segments north and east of this pocket, including one area on the east side of the Adelaide Peninsula. Bulls were primarily seen west of the Ellice River, while yearlings were seen within the entire breeding cow distribution.

We counted 106 muskoxen with 10 calves and 5 wolves on transect. Most the animal were seen on the Adelaide Peninsula.

c. June 2008

From 13 – 18 June 2008, we flew 24.5 hours on survey and 7.5 hours off survey based out of Miramar Hope Bay Limited's Boston exploration camp at Spyder Lake and Gjoa Haven, NU (Table 1, Figure 13).

As in June 2007, we experienced consistently bad weather conditions in June 2008 that consisted of very low ceilings (~500 agl), snow showers, sub-freezing temperatures, mist and high winds (Appendix I). Due to reduced visibility, we only counted caribou observed on transect. Spring conditions were late in the western portion of the survey area with 30% snow cover near the coast increasing to 100% inland; however the amount of lake ice was reduced from June 2007. Spring conditions in Nunavut were normal according to Gjoa Haven and Baker Lake residents, while spring conditions in the eastern NWT appeared to be later than normal.

We classified 1709 cows (732 cows with hard antlers) and 598 calves (82% of hard antlered cows with calves); and 1144 non-breeders (750 yearlings, 36 bulls, 309 non-antlered cows and yearlings, 40 bulls and yearlings, and 9 unknown) on transect during this survey and 1073 cows (346 cows with hard antlers) and 238 calves (69% of breeding cows with calves); and 735 non-breeders (320 yearlings, 57 bulls, 290 non-antlered cows and yearlings, 63 bulls and yearlings, and 5 unknown) off transect during this survey.

Cows were dispersed over a larger area in June 2008 compared to the previous two years and at lower density (Figures 14-17). Most notably, a south tail of breeding cows was observed along the Ellice River, which appeared to represent the late movement of cows onto the Ahiak calving ground. As a result, more breeding cows and calves were seen west and along the Ellice River at low densities. Overall cow and breeding cow density was located just west of the Ellice River and extended east to Chantrey Inlet. The south edge of this distribution extended further inland along the western portion, but tapered to the east. The south distribution of breeding cows east of Simpson River was much further north than June 2006 and June 2007 and only extended 30 km inland. No areas with high cow or breeding cow density were observed. Medium density pockets of breeding cows were observed between the Ellice and Perry Rivers, and the Perry and Simpson Rivers, as well as few isolated transect segments on the Adelaide Peninsula. Considerably fewer cows were seen in June 2008 compared to June 2006 and 2007, especially the number of cows with hard antlers.

We counted 124 muskoxen and 6 calves in 15 groups on transect and 149 muskoxen with 20 calves in 13 groups off transect, 5 wolves in 4 groups on transect and 3 wolves in 1 group off transect, one grizzly bear on transect, one fox both one and off transect and 2 seals in 2 groups off transect. Muskoxen were distributed throughout the survey area, while wolves were seen around the Ellice, Perry and Back Rivers and the grizzly bear was observed along the coast between the Ellice and Perry Rivers (Figure 18).

Mapping the Annual Calving Areas

a. Ordinary kriging prediction maps for breeding cows and calves

We fitted models of breeding cows and calves based on the annual systematic reconnaissance transect survey conducted June 2006-08. In the models selected, the standardized mean was near zero, they had the smallest root-mean-square prediction error, the difference between the average standard error and the root-mean-square prediction error was near zero, and the root-mean-square standardized prediction error was near one (Johnston et al. 2003).

The ordinary kriging prediction maps of the distribution of breeding cows observed on transect during June 2006, 2007, and 2008 are given in Figures 19-22, respectively. We also created a prediction map of the distribution of all cows observed on transect in June 2008, as there were relatively fewer breeding cows in relation to non-breeding cows. The cross-validation results for these models are given in Tables 2-3. The cow densities at the centroids for each model were overlain on the corresponding prediction maps for 2006, 2007 and 2008 (Figure 23-26).

The ordinary kriging prediction maps of the distribution of calves observed on transect during June 2006, 2007, and 2008 are given in Figures 27-29, respectively. The cross-validation results for these models are given in Table 4. The calf densities at the centroids for each model were overlain on the corresponding prediction maps for 2006, 2007, and 2008 (Figure 30-32).

A visual examination of cow and calf densities at the centroids overlain on the corresponding prediction maps indicates that the models reasonably fit the data when generalized to a 10-km grid. The prediction maps, however, did not capture the isolated observations of lone hard antlered cows or cow/calf pairs that occurred at the outer distribution of cows and calves seen during the transect surveys. For example, the prediction map for the 2008 breeding cow distribution did not encompass low density centroids observed at the south end of eastern transects (Figure 25). Kriging uses a geostatisical interpolation technique to create a map of continuous caribou densities using the densities values summarized for each transect segment. These outlying transect segments had a very low density value (0.125 caribou/km^2), which when surrounded by densities values equal to zero resulted in a prediction density surface value of < 0.125 caribou/km^2. The estimated occurrence of cows and calves was based on a predicted density value of ≥ 0.125 caribou/km^2, which corresponds to the density value of 1 caribou per 10 km transect segment using a 0.8 km transect strip width. The prediction maps also generalized the density of transect segments, especially for transect centroids that had isolated values. For example, the three centriods with high calf density observed in June 2006 were averaged over a larger area at medium density (Figure 30).

The prediction maps of the distribution of breeding cows observed on transect during the June 2006-08 transect surveys were used to define the annual Ahiak calving grounds at the peak calving (Figure 33-35). The approximate size of the 2006, 2007 and 2008 calving areas at peak of calving were 25379 km^2, 23929 km^2 and 23696 km^2, respectively.

b. Distribution of GPS and Collared Cows

Locations of GPS and satellite-collared cows during the calving period were overlain on the prediction maps for breeding cows generated for 2006, 2007, and 2008 (Figures 36-39).

i. June 2006

Overall, the distribution of 17 cows fitted with satellite and GPS collars overlapped the distribution of breeding cows observed during the aerial systematic transect survey conducted 13-16 June 2006 (Figure 36). Eight of the collared cows were within the high density area centered on the Perry River, 6 collared cows were distributed throughout the medium density area and 1 was in the low density area west of the Ellice River. The majority of the collars (n=12) within the breeding cow distribution were centered on the Perry River, with one west of the Ellice River and four were scattered east of the Simpson River to Chantrey Inlet. Two collared cows located outside of the breeding cow distribution were non-breeding cows based on blood serum progesterone levels collected in March 2006.

ii. June 2007

Most of the 19 cows fitted with satellite and GPS collars were found within the distribution of breeding cows observed during the aerial systematic tranect survey conducted 14-18 June 2008 (Figure 37). Twelve of the collared cows were within the medium and high density areas and four were within areas of low cow density. The majority of collared cows within the breeding cow distribution were located between the Ellice and Simpson Rivers; one cow was west of the Ellice River, while one other collared cow was on an island in the Sherman Basin on the Adelaide Peninsula. Two collared cows were location outside of the breeding cow density and most likely represent non-breeding cows, as they both exhibited late movement towards the Ahiak calving area.

iii. June 2008

Thirty GPS collars were deployed on the late winter distribution of Ahiak and Beverly cows in April 2008. Based on blood serum progesterone levels, the majority of these cows were not pregnant (GNWT unpublished data). Due to the large number of known non-breeding collared cows, the collared cow data was broken into known non-breeder, and known and assumed breeding cows. The locations of known and assumed breeding cows and non-breeding cows were overlain on the prediction map for breeding cows generated for June 2008 (Figures 38-39).

Overall, the distribution of 24 collared cows assumed to be breeders overlapped the distribution of breeding cows observed during the aerial systematic reconnaissance survey 13-17 June 2008 (Figure 38). All 24 cows were located within the distribution of breeding cows. However, four of these collared cows were at the edge of the breeding cow distribution. All four were known to be pregnant and are reflective of a southern tail of breeding cows observed along the Ellice River during the survey, which appeared to represent the late movement of cows onto the Ahiak calving ground. The majority of collared cows were situated between the Ellice and Perry Rivers with only three collars east of the Perry River; no collared cows were located on the Adelaide Peninsula in June 2008.

Just over half of the 18 collared cows known to be non-breeders overlapped the distribution of breeding cows observed during the aerial systematic reconnaissance survey 13-17 June 2008 (Figure 39); however, most of these collared cows were at the southern extent of the breeding cow distribution. Of the collared cows located outside of the breeding cow distribution, most of these animals reached the Ahiak calving area by 25 June 2008. However, four collared cows never did arrive at the Ahiak calving area; one reached the Beverly calving area, one moved eastward towards the Beverly calving area, while the other two moved northeast towards the Ahiak calving ground. Most of these non-breeder moved onto the Ahiak calving ground northward along the Ellice River where we observed a southern tail of breeding cows during the transect survey.

c. Overlap in annual calving areas

The combined calving area used by the Ahiak herd near peak of calving in June 2006, June 2007 and June 2008 and the years when different portions of this area were used is shown in Figure 40. The combined calving area for all three years was 31008 km^2 (Table 5). Approximately 54 percent of this area was used in all years (Table 5). This area was largely east of the Ellice River, south of the Queen Maud Gulf and west of Chantrey Inlet; the south boundary was approximately 67º N at the western edge and tapered northwards to the shore south of Sherman Basin at the eastern edge. An additional 11 percent was used only in 2006 and 2007 and was south of the eastern portion of the 2006-2008 common area. Approximately 7 percent of the combined area was used only in 2006 and was primarily west of the Ellice River. Similarly, approximately 6 percent of the combined area was used only in 2007 and was south of the eastern portion of the 2006-08 common area. The proportion of the combined area only used in 2008 was 8% and was found south common area along the Ellice River and at the north end of the Adelaide Peninsula. Approximately 9% of the combined area was used in 2006 and 2008 and was located west of the Ellice River. Lastly, 5% of the combined area was used in 2007 and 2008 and was located south and north of the 2006-08 common area centred on the Perry River.

The combined area used by Ahiak herd during calving in 2006, 2007 and 2008 and the number of years that different portions of this area was used is shown in Figure 41. Again the combined calving area was 31008 km^2 (Table 6). Approximately 54 percent of this area was used 3 of the 3 survey years, 26 percent during 2 of the 3 survey years, and 20 percent was in 1 of the 3 survey years.

These data indicate that the distribution of the annual calving area did vary from year to year, but there was greater than 50% overlap each year. The common area used in all three years was largely east of the Ellice River, south of the Queen Maud Gulf and west of Chantrey Inlet; the south boundary was approximately 67º N at the western edge and tapered northwards to the shore south of Sherman Basin at the eastern edge. West of the Ellice River there was considerable variation in the use of this area during June 2006-08. This distribution extended furthest west in 2006 and was furthest south in 2008. The southern extension west of the Ellice River in 2008 reflects the late movement of breeding cows towards the calving area. In 2006, movement of cows onto the calving area was early and cows may have had more time to move into this area than in other years. There was also considerable variation in the southern boundary for the eastern portion of the combined calving area. The southern boundary extended further south in 2006 and 2007 than in 2008. The reason for this difference is not apparent, as 2006 and 2007 represent both early and late spring conditions, respectively. Spring conditions in 2008 along the eastern portion of the Ahiak calving area were also early and the distribution of cows was considerably further north.

DISCUSSION

The transect surveys conducted annually from June 2006-2008 were the first to systematically survey the entire calving distribution of the Ahiak herd of barren ground caribou since 1986 (Gunn et al. 2000). The systematic transect surveys were completed near the peak of calving and the annual calving area mapped in this report and the information presented in this section only refers to the distribution of breeding cows near the peak of calving.

From 2006-2008, the Ahiak annual calving ground was located 60km west of the Ellice River and extended eastward to Chantrey Inlet. The north boundary was essentially the Queen Maud Gulf including the Adelaide Peninsula except for the portion west of the Perry River where the boundary was inland of the coast at approximately 67.8º N. The south boundary of the western section centred on the Ellice River was ~66.8º N, the middle section between the Ellice and Simpson Rivers was ~67.1º N and the section east of the Simpson River was ~67.3º N. The combined area of the annual calving grounds from June 2006-2008 was 31008 km^2, and currently represents the largest calving area of mainland barren ground caribou herds in the NT and NU. This area was similar to the area mapped in 1996 (Gunn et al. 2000) except that Gunn et al. did not cover the Adelaide Peninsula or a large area south of the peninsula, and observations of a spaghetti survey of the Ahiak calving ground in 2002 (Gunn and D'Hont 2002).

As documented for other barren ground caribou herds, there was annual variation in the distribution of breeding cows. The largest annual calving ground occurred in June 2006 (25379 km2) and had the most western boundary. The 2007 and 2008 annual calving areas were very similar in size (23939 km^2 and 23696 km^2, respectively). The southern boundary of the 2006 and 2007 annual calving areas extended further south along the eastern section than for 2008. Similarly, the south boundary along the Ellice River extended much further south in 2008 than in either 2006 or 2007. Although, we observed variation in the annual calving areas, there was considerable overlap (54%) between the three years (16696 km^2). The area of breeding cows represented in all three years extended from the Ellice River eastward to Chantrey Inlet including Adelaide Peninsula; the south boundary was 67.1º N at the western edge and tapered northward to the south shore of Sherman Basin on the Adelaide Peninsula.

The reasons for changes in distribution of the annual calving areas are not clear. The annual calving area had the most western distribution during a year with very early spring conditions; this may indicate that cows reached the calving area early, and had time to mill around and increase their calving distribution. Late spring conditions in June 2007 may have delayed movement of cows onto the eastern section of the Ahiak calving ground resulting in a more southerly distribution in 2007; however, the same distribution was observed in June 2006 when spring conditions were early over the entire calving distribution. The Ahiak calving area is so large that the distribution of cows observed may be a result of differing weather and late winter and/or spring conditions experienced in the western Nunavut versus the eastern NT. For example, in June 2008, spring conditions were early in the western NU and late in the eastern NT; correspondingly, the eastern distribution of cows on the Ahiak calving ground was the farthest north observed during the 3 years, while the southern boundary of the west distribution was the furthest south recorded during the 3 years.

The intent of these annual transect surveys was to map the distribution and relative density of caribou observed on the annual Ahiak calving area near peak of calving and not to obtain a population estimate. Coverage in 2006-2008 was only 4.5, 4.6 and 6.7%, respectively. Density of adult caribou observed on transect in June 2006-08 was 3.1, 3.0 and 1.1 caribou/km^2, respectively. The highest densities of breeding were observed centred on the Perry River in 2006, just south and east of the Perry River in 2007 and on the eastern portion of the Adelaide Peninsula in 2006 and 2007. Cows were distributed at medium density from the Ellice River eastward to Chantrey Inlet and extended southward ~50-70km inland along the western section to ~20-40 km inland along the eastern section. Low densities of breeding cows were observed primarily west of the Ellice River, the northern portion of the Adelaide Peninsula and the south extent of the calving distribution. The exception to this pattern occurred in June 2008 when we saw considerably fewer cows during the transect survey. Although late spring conditions in June 2008 may have resulted in fewer calves on the western section, it is most likely more probable that the fewer cows observed was due to low pregnancy rates. Based on blood serum progesterone values collected from cows on the late Ahiak winter range, 57% of the cows were not pregnant. Similarly, we observed more non-breeding cows on the Ahiak calving ground in 2008 than breeders. Non-breeding cows most likely do not exhibit the same urgency to migrate toward a calving ground especially when the majority of cows are not pregnant. Accordingly, the movement of non-breeding cows (Figure 39) was delayed in reaching the calving area in 2008. For all three surveys, the ratio of calves to cows observed indicated that the transect surveys were conducted near or at peak of calving. On average, peak of calving was estimated to be approximately 14 June, as most cow:calf ratios observed were greater than 50% during the surveys.

The GPS and satellite collared cow data from June 2006-08 suggest that location of collared cows were good indicators of where the majority of breeding cows in a herd were located during the calving period assuming that the majority of the collared cows were pregnant. However, the Ahiak calving area is distributed over a large area, and therefore, the collar locations may not be representative of areas with low densities of breeding cows. The collar data from June 2008 also demonstrates that it is important to understand the breeding status of collared cows during the calving period to accurately map the distribution of breeding cows.

Very few of the collared cows that were captured on winter range in the NT were located on the Adelaide Peninsula in a given year (only 2 of 60) even though there were areas of medium to high densities of breeding cows each year. It is important to understand the origin of caribou that calve on the eastern portion of the Ahiak calving area. Nine collars were deployed on cows located around the Meadowbank gold mine (~50 km north of Baker Lake, NU) the first week of May 2008 (GNU unpublished data). Two of these collared cows were located on the eastern portion of the Ahiak calving ground in June 2008, while another three were south of the 2008 calving distribution, but had reached the Ahiak calving area by the end of June (Figure 42). Likewise, there was one collared satellite Ahiak cow (captured on winter range in the NT) that wintered near Bake Lake one year and returned to the Ahiak calving area during the subsequent calving period. Lastly, it is important to understand the level of exchange that may occur between the surrounding calving grounds. For 28 pairs of consecutive years of GPS calving locations between 2006-2008, 7 cows have switched calving grounds between the Ahiak and Beverly calving grounds (n=5), the Ahiak and Bathurst calving grounds (n=1) and the Ahiak calving ground and the Boothia Peninsula (n=1) (GNWT unpublished data). One GPS cow that calved on the Ahiak calving ground in June 2006, subsequently calved on the Bathurst calving ground in June 2007 and 2008. We have also documented exchange of collared cows between the Beverly and Ahiak calving grounds (Johnson and Williams XXXX). Interestingly, one GPS collared cow located on the Ahiak calving ground on June 2006 and 2007, calved just south of Simpson Lakes on the Boothia Peninsula in June 2008 (Figure 43); calving caribou were observed in this area in 1985 (Gunn and Ashevak 1990). Four of the nine collars deployed on cows north of Baker Lake in May 2008 were also located on the southern portion of the Boothia Peninsula (Figure 44). In light of this preliminary data, we need a better understanding of the level of interaction between the northeast mainland herds.

Weather conditions observed during the transect surveys in June 2006-2008 were varied. With the exception of 2006 where survey conditions were ideal, weather conditions in June 2007-2008 were persistently bad with very low ceilings (~500 agl), high winds, fog along the coast, reduced visibility from snow and rainstorms and freezing rain. Bad weather reduced visibility and was a source of bias, as animals were easily missed. Similarly, patchy snow conditions in June were also a source of bias, as it was hard to spot caribou against a mottled background especially at medium to low densities. Heard et al. (1987) purposely conducted pre-calving surveys in May rather than in June, as weather conditions in June made aerial surveys risky or impossible. They felt that weather conditions in May were generally good and that caribou were easily observed against a uniform white background. Logistically, other than Cambridge Bay and Gjoa Haven, NU there are few alternative locations with airstrips (mineral exploration camps) to base survey work along the Queen Maud Gulf. Likewise within and surrounding the Ahiak calving area there are almost no suitable areas for off-strip landings except for lakes.

In summary, the Ahiak is a large calving area that extends from approximately 60 km west of the Ellice River eastward to Chantrey Inlet including the Adelaide Peninsula and is roughly bounded to the north by the Queen Maud Gulf and to the south by 67º N. Highest densities of breeding cows were observed around the Perry River and on the east side of the Adelaide Peninsula. The distribution of breeding cows used in all three years was located between the Ellice River and Chantrey Inlet (including the Adelaide Peninsula) and extended ~40-50 km and ~20-30 km inland along the western and eastern portions, respectively. A population estimate of the Ahiak herd during the calving period will be logistically challenging due to the remoteness of the area, the limited off-strip landing spots and the bad weather conditions that are typical in June along the Arctic coast. Our results, also demonstrate that it is important to understand the pregnancy rates of cows prior to conducting a population estimate, as it could have significant effects on the number of cows on the calving area in a given year. Lastly, it is important to have a better understanding of the origin of cows that are found on the eastern distribution of the Ahiak calving area, namely the Adelaide Peninsula and the relationship of these animals to surrounding northeast mainland herds.

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Table 1:Times on and off survey, June 2006, June 2007 and June 2008.

Date	**On survey (hours)**	**Off survey (hours)**	**Radio-tracking (hours)**
June 2006	21.517	14.933	0.000
June 2007	21.033	16.25	1.025
June 2008	24.500	7.233	0.633

Table 2: Cross-validation results for ordinary kriging prediction maps generated for density distribution data obtained for breeding cows on the calving grounds of the Ahiak barren-ground caribou herd during June 2006, 2007 and 2008.

Year	**2006**	**2007**	**2008**
Class of caribou	Hard antlered cows	Hard antlered cows	Hard antlered cows
Number of points	256	256	344
Kriging method[a]	OKPM	OKPM	OKPM
Order of trend removal	second	second	second
Semivariogram model	Circular	Tetraspherical	Circular
Major range	14191	19796	35767
Anisotropy	no	no	no
Partial sill	40.086	15.256	0.099789
Nugget	35.511	1.0323	0.12334
Lag size	4028	4028	4028
Number of lags	12	12	12
Neighbours to include	5	5	5
Minimum number of neighbours included	2	2	2
Search neighbourhood[b]	8SC	8SC	8SC
Prediction Errors:			
Root-mean-square (1)	6.858	3.062	0.3944
Average standard error (2)	8.563	3.794	0.4209
(1) minus (2)	-1.705	-0.732	-0.0265
Mean standardize	0.001453	0.01226	-0.002418
Root-Mean-Square Standardized	0.8122	0.8333	0.9456

[a]Ordinary kriging prediction map.
[b]8 sector circular.

Table 3: Cross-validation results for ordinary kriging prediction maps generated for density distribution data obtained for cows on the calving grounds of the Ahiak barren-ground caribou herd during June 2008.

Year	**2008**
Class of caribou	Total cows
Number of points	344
Kriging method[a]	OKPM
Order of trend removal	second
Semivariogram model	Circular
Major range	37037
Anisotropy	no
Partial sill	0.14214
Nugget	0.45846
Lag size	4028
Number of lags	12
Neighbours to include	5
Minimum number of neighbours included	2
Search neighbourhood[b]	8SC
Prediction Errors:	
Root-mean-square (1)	0.7112
Average standard error (2)	0.747
(1) minus (2)	-0.0358
Mean standardize	-0.002032
Root-Mean-Square Standardized	0.9564

[a]Ordinary kriging prediction map.
[b]8 sector circular.

Table 4: Cross-validation results for ordinary kriging prediction maps generated for density distribution data obtained for calves on the calving grounds of the Ahiak barren-ground caribou herd during 2006, 2007 and 2008.

Year	**2006**	**2007**	**2008**
Class of caribou	calves	calves	calves
Number of points	256	256	344
Kriging method[a]	OKPM	OKPM	OKPM
Order of trend removal	second	second	second
Semivariogram model	Pentaspherical	Rotational quadratic	Spherical
Major range	21368	26364	26616
Anisotropy	no	no	no
Partial sill	16.317	11.906	0.08558
Nugget	0	0.52127	0.09501
Lag size	4028	4028	4028
Number of lags	12	12	12
Neighbours to include	5	5	5
Minimum number of neighbours included	2	2	2
Search neighbourhood[b]	8SC	8SC	8SC
Prediction Errors:			
Root-mean-square (1)	3.069	2.628	0.3996
Average standard error (2)	3.766	3.271	0.401
(1) minus (2)	-0.697	-0.643	-0.0014
Mean standardize	0.01199	0.01171	0.001662
Root-Mean-Square Standardized	0.8429	0.8227	0.9978

[a]Ordinary kriging prediction map.
[b]8 sector circular.

Table 5: Years in which different portions of the combine calving area were used.

Years	Amount of combined calving area used km^2	percent
2006	2123	6.8
2007	1870	6.0
2006, 2007	3546	11.4
2008	2391	7.8
2006, 2008	2776	9.0
2007, 2008	1606	5.2
2006, 2007, 2008	16696	53.8
Total area	31008	100.0

Table 6: Number of years in which different portions of the combined calving area were used.

No. of years	Amount of combined calving area used km^2	percent
1 of 3 years	6384	20.6
2 of 3 years	7928	25.6
3 of 3 years	16696	53.8
Total area	31008	100.0

APPENDIX I

SURVEY CREWS USED FOR THE SYSTEMATIC TRANSECT SURVEYS CONDUCTED JUNE 2006, JUNE 2007 AND JUNE 2008

Year	Aircraft	Pilot	Navigator	Observer Right Side	Observer Left Side
June 2006	C-337	Mitchell Macgillivary	Deborah Johnson	Damian Matomiak	Judy Williams
June 2007	Heliocourier	Perry Linton	**	Deborah Johnson	John Nagy
June 2008	Heliocourier	Perry Linton	Jan Adamczweski	Deborah Johnson	Judy Williams

** Due to space constraints in the aircraft there was no navigator in 2007. Each observer wrote down their own observations within a transect segment that was called out by the pilot. No waypoints for individual observations were collected.

APPENDIX II

Summary of Weather Conditions encountered during the Systematic Transect Surveys June 2006, June 2007 and June 2008