

2021 Report Update: Variability in Calving and Post-calving Areas of the Bluenose-East and Bathurst Caribou Herds



Prepared For

Kitikmeot Inuit Association

PO Box 360

Kugluktuk, NU X0E 0E0

Prepared By

EDI Environmental Dynamics Inc. and

Aurora Wildlife Research

Whitehorse, YT and Nelson, BC

Contact

Mike Setterington, Director/Sr. Biologist (EDI)

Kim Poole, Wildlife Research Biologist (AWR)

EDI Project

21Y0514

November 2021



Down to Earth Biology



EXECUTIVE SUMMARY

The Government of Nunavut Department of Environment (GN-DoE) provided the Nunavut Planning Commission (NPC) with maps for the 2016 Draft Nunavut Land Use Plans (DNLUP) representing seasonal areas of use by barren-ground caribou. Those maps combined collar data from 1993 to 2012 and retained barren (non-breeding) cows to determine calving areas. Retaining those data resulted in large areas mapped for calving and post-calving that do not reflect shifts in seasonal ranges over the past decade. Inuit Qaujimagajatuqangit (IQ) was not considered in the development of boundaries. The NPC's 2021 DNLUP included additions to the boundaries of some caribou-based protected polygons.

The Kitikmeot Inuit Association retained EDI Environmental Dynamics Inc. (EDI) and Aurora Wildlife Research in 2016 to provide a critical review of the caribou protected areas boundaries. This report is an update to the analyses and report completed in 2016. This report updates the 2016 analyses considering the 2021 DNLUP boundaries and additional caribou collar data collected since 2016.

At the request of the Kitikmeot Inuit Association (KitIA), we conducted analyses of collar data from the Bluenose-East and Bathurst caribou herds to determine the accuracy of the DNLUP boundaries to reflect annual variation in use by calving and post-calving caribou. We identified and removed barren cows from analyses, mapped annual calving and post-calving areas, and then compared these with the DNLUP maps.

Our analyses identified areas of concentrated annual use within the DNLUP calving and post-calving areas, with a degree of annual variability across years. Our conclusions:

- In any given year, varying portions of the DNLUP mapped areas were not used by calving or post-calving caribou. Collared caribou have not occupied some areas for a decade, and some areas have not been occupied at all.
- More recent caribou use areas (i.e., >2012) are not encompassed within the DNLUP polygons. For example, the DNLUP mapping does not accurately reflect current calving areas for the Bathurst herd, which has moved eastward. The Bluenose-East herd has moved to the northwest. Similar patterns were evident for the post-calving area for the Bluenose-East herd;
- We also identified areas within the DNLUP polygon southeast of Kugluktuk that showed minimal use by calving caribou, likely due to the inclusion of barren cows in the polygon development.

Caribou are adaptable in their use of areas due to changes in weather and forage availability and changes in herd size. Timing of calving can vary by days among years, affecting dates used to derive range boundaries. Boundaries of mapped seasonal areas also can vary considerably based on methods of analysis and the data used. Caribou calving areas used annually generally move within a larger bounded area over time; not all portions within this larger, historically used area are occupied by breeding cows in any one year or a series of years. Rather than treating seasonal ranges as static entities, the patterns observed suggest areas of concentrated annual use may change over time and thus should be re-examined regularly, and that use of mobile protection measures that account for yearly variability in use may be more appropriate for these herds in the Kitikmeot Region.



AUTHORSHIP

Team members from EDI Environmental Dynamics Inc. and Aurora Wildlife Research who contributed to preparing this report include:

Kelsey Russell (EDI), B.Sc. Lead Author (2016)

Kerman Bajina (EDI), M.Sc. Author and Spatial Analyses (2021)

Kim Poole (AWR), M.Sc., R.P.Bio. Lead Author and Senior Review (2016 and 2021)

Matt Power (EDI), A.Sc.T... GIS Analyses and Mapping (2016 and 2021)

Mike Setterington (EDI), M.Sc., R.P.Bio. Senior Review (2016 and 2021)

Suggested Citation:

EDI Environmental Dynamics Inc. and Aurora Wildlife Research. 2021. 2021 Report Update: Variability in Calving and Post-calving Areas of the Bluenose-East and Bathurst Caribou Herds. Prepared for the Kitikmeot Inuit Association. 26 pp.



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1 INTRODUCTION

At the request of the Kitikmeot Inuit Association (KitIA), EDI Environmental Dynamics Inc. (EDI) and Aurora Wildlife Research (AWR) were retained to provide background technical information and analyses to support KitIA's input into the 2021 Draft Nunavut Land Use Plan (DNLUP; NPC 2021); specifically, technical analysis of the caribou calving and post-calving area boundaries of the Bluenose-East and Bathurst caribou herds, and the utility of those boundaries for the protection of caribou. This report updates analyses conducted in 2016 (EDI Environmental Dynamics Inc. and Aurora Wildlife Research 2016).

The Government of Nunavut Department of Environment (GN-DoE) provided the Nunavut Planning Commission (NPC) with maps representing seasonal areas of use by barren-ground caribou obtained from collar data combined from 1993 to 2012. In the 2016 and 2021 DNLUPs, the proposed land use designations identify calving and post-calving areas, key access corridors, and freshwater crossings as Protected (2016) and Limited Use (2021) Areas, respectively, prohibiting exploration or development within these areas (NPC 2016, 2021). The calving and post-calving areas (also termed grounds) of both the Bathurst caribou herd (BAH) and the Bluenose-East caribou herd (BNE) occur within the Kitikmeot Region. With the approval of this draft plan, all development within the areas identified by the GN-DOE that delineate calving and post-calving would be prohibited. Our emphasis in this report is on analysis of the BNE herd, with more limited analysis for the BAH herd due to time constraints.

The KitIA would like to demonstrate to the NPC that there is sizeable inter-annual variability in the location of calving and post-calving areas over the longer term. Designating defined areas as Protected/Limited Use may not adequately protect caribou habitat.

1.1 TERMINOLOGY

Barren-ground caribou calving cows have two characteristics: first, the pregnant cows annually migrate to concentrate within a relatively small area typically used for calving in previous years; and second, most cows have their calves within a few days of each other during a distinctly defined calving period (Russell et al. 2002). When the cows are about to give birth, their daily movements slow down and once the calf is born, it takes a few days for the calf to bond with the cow and build enough strength to keep up easily. The cow's lactation peaks 7–10 days after the birth and by about three weeks after the birth, the calf has begun to independently forage but still needs the cow's milk for growth. Biologists have relied on those biological dates and characteristics of calving behaviour to define the areas used. However, methods to describe both the timing and areas used for calving have changed over time. Consequently, the terminology has varied, which can lead to confusion.

During a 2001 gathering of experts for a barren-ground caribou calving ground workshop, the consensus definition of a calving ground was:



“...the area occupied by the parturient [calving] barren-ground caribou from calf birth through the initiation of foraging by calves” (Russell et al. 2002).

This definition highlights the importance of the areas used by cows and calves up to three weeks after birth when the calves are particularly vulnerable (Russell et al. 2002). The three weeks is generally divided into a 7–10 day calving period, including the birth (characterized by low daily movement rate) and then a post-calving period until independent foraging is initiated at about three weeks of age (Russell et al. 2002).

In this report, we use terms to describe the calving and post-calving periods and areas. Several terms and definitions surrounding these periods have been used over the years, but in this report, we have minimized the terminology used. Maps of calving and post-calving areas produced for the NPC DNLUP were based mainly on date ranges provided by Nagy (2011) (Caslys Consulting Ltd. 2016). We also provide a tighter definition (peak calving) to more closely define the area used during and immediately after calving as determined by the lowest daily movement rates.

Calving occurs over a 7–10 day period, typically in early June, when almost all cows in the calving area give birth. When the cows are about to give birth, they reduce the daily rate of travel, and once the calf is born, the cows do not move much until their calf is strong enough to keep up with them. Calving is now measured from cows with satellite or GPS collars, which allow for measuring the daily rate of travel and examining spatial movements. The calving areas mapped by NPC in the DNLUP were derived from but are not identical to analysis conducted by Nagy (2011) who used daily movement rates for each herd to describe calving from caribou collared between 1993 and 2008. To align with these date ranges and for this report, the annual **calving area** is the area used by the calving cows during the dates used to develop the maps for the DNLUP (Caslys Consulting Ltd. 2016).

Peak of calving is when approximately 50% of cows calved in a given year and was initially based on observations of newborn calves and cows during aerial surveys. More recently, the movement rates of satellite and GPS-collared cows are used to determine the 7-day period of greatly reduced movement by each individual breeding cow associated with calving (Gunn et al. 2008). As used here, the **peak calving area** is the area used by calving cows during this 7-day period. This is a shorter period than used for mapping calving area in the DNLUP.

Post-calving is the time from when calves are about seven days old to when they are old enough to independently forage at about three weeks of age. The annual post-calving area is the area used by the cows after calving for about two weeks. Russell et al. (2002) described that “*Indicators of foraging may include the number of nursing bouts per day (from 30 down to 4 or 5 times), good calf locomotion, time spent foraging, and calf body size (herd-specific indicators should be established for each managed herd).*” The post-calving areas mapped in the DNLUP (which excludes areas overlapping with the calving areas), are based on Nagy’s (2011) analysis of daily movement rates from 1993–2008 collared caribou for all mainland Nunavut caribou herds, as updated with collar locations to 2012 (Caslys Consulting Ltd. 2016). For this report and to enable comparison between analysis methods, the annual **post-calving area** is the area used by cows during the dates used to develop the post-calving maps for the DNLUP (Caslys Consulting Ltd. 2016).



Concentrated area: The area of greatest overlap from multiple years of data is termed the “concentrated” area. We avoided the use of the term “core” since this often refers to a GIS-derived polygon that encompasses 50–80% of the collar locations under consideration (Formica et al. 2010; Johnson and Russell 2014), but in the case of DNLUP polygons, the maps produced use 95% utilization distribution boundaries (Caslys Consulting Ltd. 2016).

Additional terms that we use in this report include:

- **Fix:** A satellite or GPS location from a collared caribou;
- **Polygon:** A closed shape that delineates a static area on a map, generally generated using a GIS program;
- **Calving site:** The suspected or estimated location where the calf is born.



2 METHODS

We used BNE and BAH collar data provided by the Government of Northwest Territories, Environment and Natural Resources (GNWT-ENR; 1996 to 2021) to explore the variability in calving and post-calving areas over time and space, using different approaches to delineate seasonal ranges. Caribou location data from 1996 to 2005 (BNE) or 2007 (BAH) were derived solely from satellite collars that generally provided a collar location every 1 to 5 days with associated location error generally <150 metres (m), but ranging up to 1,000 m (Gunn et al. 2008). Use of satellite collars continued in a diminished manner to 2016, but beginning in 2006, GPS collars were increasingly deployed with resultant increased accuracy in locations (<20 m in most cases) and fix frequency. All caribou locations from 2017–2021 were derived from GPS collars.

Analysis of the data differed between herds. For the BNE herd, we provide an analysis of calving area and post-calving area to match date ranges used by the GN-DOE to develop maps for the DNLUP (NPC 2016, 2021) and analysis of peak calving area. For the BAH herd we updated analyses of peak calving area conducted up to 2007 from Gunn et al. (2008) and subsequently updated for an unpublished environmental assessment in the Kitikmeot Region (EDI Environmental Dynamics Inc. and Aurora Wildlife Research, unpubl. data).

2.1 IDENTIFYING CALVING COWS

Pregnant cows generally decreased their movements immediately before birth, with reduced movements in the days immediately following calving (Gunn and Russell 2008; Figure 1). Calving dates were estimated by determining the period of low movement rates combined with a spatial analysis of movement patterns (e.g., circular movement in a small area versus directional movement). If numerous low movements were observed for an individual within a likely calving period, generally the earliest date of decreased movement was chosen as the calving date (Nagy 2011).

To focus analyses on calving cows only for both calving and post-calving, the movement rates of collared female caribou were examined during the general calving period (mid-May to late June) to determine whether individuals calved. Distance between fix locations was determined for each individual daily (if there was more than one fix per day, these data were rarefied) and standardized by serial date. In their analysis, Gunn et al. (2008) identified two satellite collar fix locations over a 7-day period that demonstrated reduced movement rates during calving; however, due to the higher fix frequency of the GPS collars used post-2006, up to 21 locations (three fixes per day) were used per calving year. In addition, each collar was examined spatially during May and June using ArcMap and QGIS. This indicated the proximity of individual collared caribou to known calving areas around the general calving period. Ultimately, the movement of each cow was assessed using a dual approach: first, by assessing mean daily movement rates using a box-and-whisker plot, and second, by observing the animal's movement trajectories in a GIS.

Calving date analyses were based on individual movement rates and patterns. If individuals were found to be quite a distance away from known calving areas, the entire data set for that individual was examined to determine whether it calved in another calving area, if it was likely barren, or if it calved outside the known calving areas. Caribou removed from the databases had either obviously calved in neighbouring calving areas,



had limited collar data available during the calving period, were suspected to be barren, or were located a considerable distance from known calving areas (e.g., outliers; Appendix A, Appendix Table 3).

Our analysis assumes that the calving location and area used by calving females as determined from the collar data represents the overall distribution of breeding cows in the calving area. The temporal and spatial resolution of satellite collars (with fewer locations and greater location error) will be less than the resolution of GPS collars. Gunn et al. (2008) found reasonable agreement between caribou locations during peak calving as determined from satellite collars and areas of moderate to high-density caribou as observed during aerial surveys. This is illustrated from the 2015 aerial survey of the BNE calving area (Boulanger et al. 2016; Figure 2).

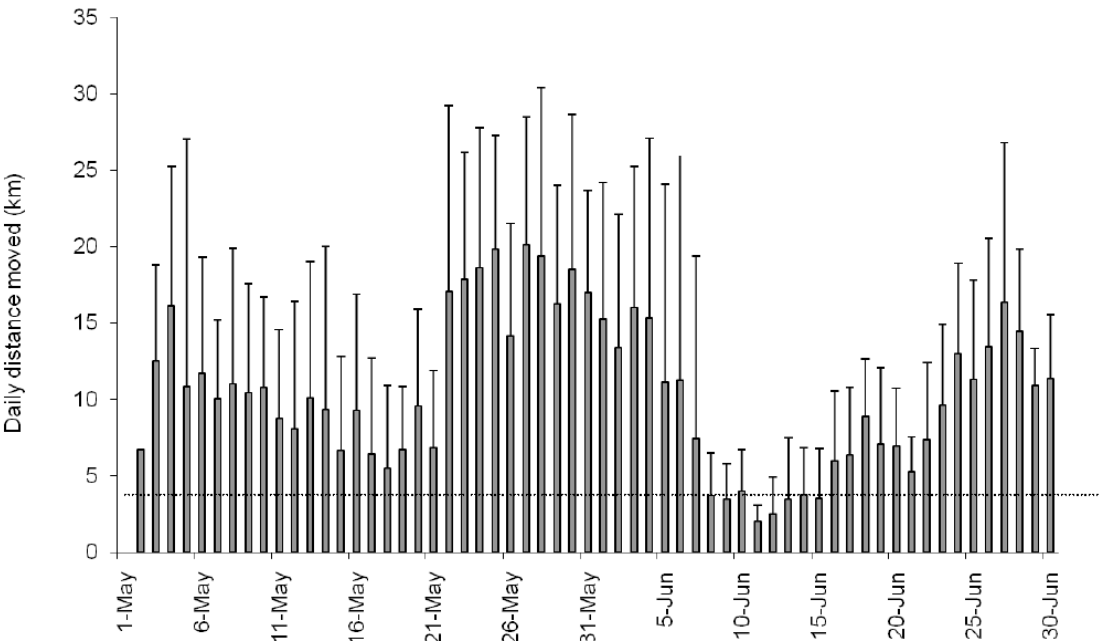


Figure 1. Mean daily movements (+ 1 SD) of barren-ground caribou by satellite collared Bathurst caribou during May and June 2009 (Nishi et al. 2014).

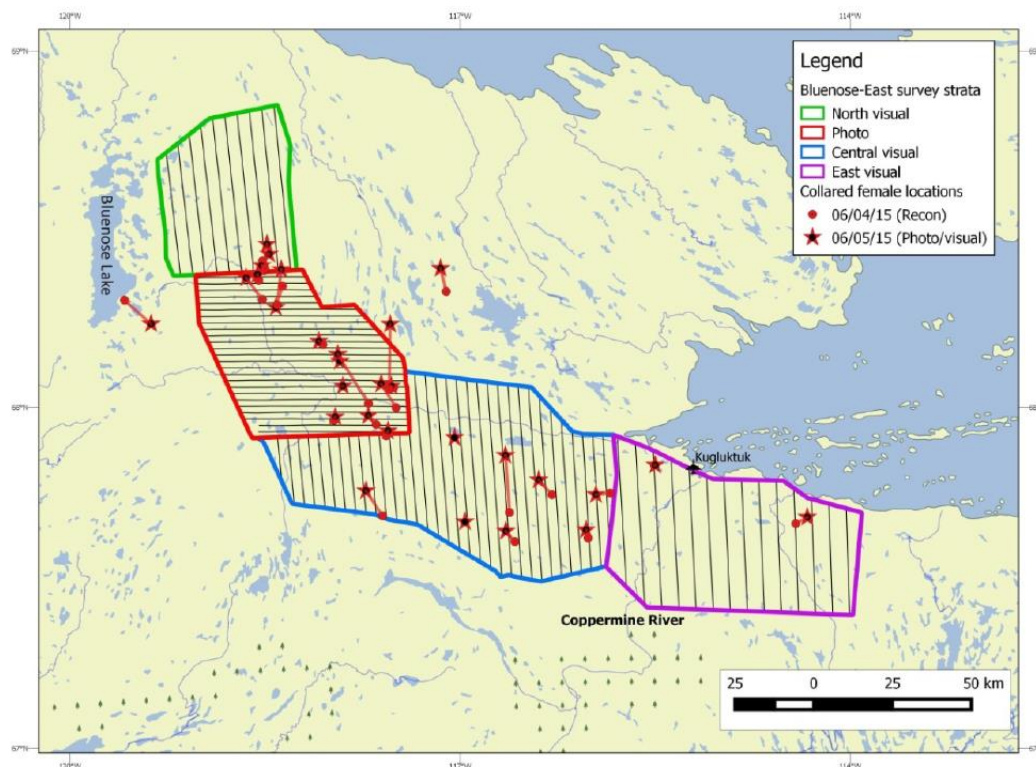


Figure 2. Caribou collar locations compared with the final stratification for the calving ground survey of the Bluenose-East caribou herd, June 2015 (Boulanger et al. 2016).

2.2 SEASONAL RANGES

Following the methods outlined by Caslys Consulting Ltd. (2016), we used the kernel density estimation (KDE) method of utilization distribution (UD) to develop polygons that represent the probability of use based on density values (Worton 1989) for each year of collar data. Analyses of data from 1996–2016 were conducted using Geospatial Modelling Environment (GME; Version 0.7.4.0); whereas, for this report update, analyses of data from 2017–2021 were conducted using ArcGIS (Version 10.8) because GME is no longer maintained or supported. The program used in the GN-DoE analyses was not provided in their methods report (Caslys Consulting Ltd. 2016). Other than the sample size of collared individuals, the most influential variable affecting polygon shape and size is the input search radius, also known as the bandwidth or smoothing parameter. As the search radius decreases, the prediction accuracy for the range boundary increases. As the search radius increases, the resulting range boundary becomes smoothed, representing a broader density of use. There are several ways to derive the search radius, and for the analysis conducted on behalf of the GN the GIS approach used two different methods (the reference search radius and least squares cross-validation), resulting in a range of search radii from 3 to 20 km. Based on both ecological (e.g., Boulanger et al. 2012) and logistical (the minimum distance that produced continuous range boundaries) justifications, the authors used an 11 km search radius (Caslys Consulting Ltd. 2016). It is unclear what dataset was used to derive these estimates (i.e., averaged across individual herds or all herds). Although it is generally not accepted to apply a bandwidth value to a dataset based on another dataset, we adopted this value for the sake of method



replication. Utilization distribution boundaries were derived for 50, 80, 90, 95, and 100% kernels density estimates. The 95% density class had to surround a higher density class (e.g., 50%, 80%, or 90%) to be included in the final range delineation. To connect these areas, which were often patchy, each individual polygon was buffered by 11 km, then all the buffered polygons were merged and dissolved (i.e., shared edges removed), and finally, a negative 11 km buffer was applied to restore it to the original 95% density class.

Calving and post-calving areas were determined for BNE caribou using the date ranges defined for the DNLUP (Caslys Consulting Ltd. 2016; NPC 2016): calving (28 May–20 June) and post-calving (21 June–3 July). Our analyses of the BNE data attempted to highlight variability when similar methods as used for the DNLUP are applied. The methods applied to this analysis were similar to the GN-DoE approach, except our input data extended to 2021. In addition, the calving and post-calving areas developed for NPC included all collared BNE cows (calving as well as non-calving), combined all years of collar data into a single analysis, and did not account for animals that switched herds (J. Shaw, pers. comm.; Caslys Consulting Ltd. 2016). Our analysis separated collar location by year, identified barren cows, and identified cows which switched herds. For some of the earlier years when satellite collars were used exclusively (1996–2005), sample sizes (number of individuals and locations) were too small to represent the herd's annual use of calving and post-calving areas. For these years, locations were grouped into two time periods: 1996–2000 and 2001–2005. Additionally, and following the methods outlined by Caslys Consulting Ltd. (2016), all collar data for these analyses were rarefied (i.e., sub-sampled) to provide only one location per day per collar.

Analysis of BAH herd data for 1996–2021 followed determination of peak calving areas using collar data (satellite collars only) conducted by Gunn et al. (2008). Our assessment focused on BAH data from 2008 to 2021, while following similar methods of Gunn et al. (2008) to maintain consistency across years. Peak calving areas were also determined for the BNE herd using collar data from 1996–2021.

Once the calving date was estimated for each animal (based on reduced movement rates and spatial localization), the date of peak of calving was calculated for each herd for each year (when 50% of cows calved that year, calculated as the median date among individuals). The 7-day period of reduced movement likely associated with calving (Gunn et al. 2008) was used to determine the peak calving area. Fix locations suggesting calving, plus six days, were selected and formed the basis of the peak calving polygon delineation. Since the number of fixes per caribou varied across years and between animals, locations were weighted to allow for equal representation of each collared caribou in building the polygon. Locations in each year were weighted according to the following formula (number of fix locations per caribou ranged from 1 to 21 [or more if hourly fixes were present for a short durations during peak-calving periods]):

$$\text{Weighted value} = \frac{1}{\# \text{ fix locations per Caribou ID}}$$

The collar locations were then used to calculate 90% fixed kernel peak calving area polygons. The area of peak calving was then calculated. Peak calving areas among years were merged to create the cumulative peak calving areas from 1996 to 2021.

We also evaluated inter-annual variability by determining the percent overlap of calving, post-calving, and peak calving areas (only peak calving areas for BAH) from one year to the next. This demonstrates the relative



amount of area that calving cows used in consecutive years. We also calculated the percent overlap of BNE calving and post-calving areas (not conducted for the BAH) with the polygons used in the DNLUP. For the post-calving areas, the DNLUP calving and post-calving polygons were merged to create a single area because the overlap of post-calving with calving area is unknown. To calculate overlap, the following formula was adapted from Gunn et al. (2008):

$$\text{Percent overlap} = \frac{(2 \times \text{area of polygon overlap (km}^2\text{)}) \times 100}{\text{Area of year 1 polygon} + \text{Area of year 2 polygon}}$$

2.3 CENTRES OF ACTIVITY DURING CALVING

We calculated the approximate annual centroid of BNE and BAH during calving to illustrate spatial changes over time. We determined the centroid (geographic centre of the polygon) of use during calving and peak calving each year for both BNE and BAH caribou (peak calving only for BAH; 1996–2000 and 2001–2005 were grouped for BNE due to low sample size). Calving centroids for the BAH herd from 1996 to 2007 were obtained using data from Gunn et al. (2008).



3 VARIABILITY IN CALVING AND POST-CALVING AREAS

The calving, peak calving, and post-calving areas of both the BNE and BAH herds demonstrated considerable spatial variability from 1996 to 2021, including both the location and size of the ranges (Maps 1–8; Table 1). Similarly, both herds demonstrated temporal variability in the timing of peak of calving over this period (Table 2).

Table 1. Size (km²) and inter-annual overlap (%) of the Bluenose-East calving, post-calving, and peak calving seasonal ranges, and the Bathurst peak calving area, 1996–2021.

Year	Bluenose-East						Bathurst	
	Calving (km ²)	Overlap (%)	Post-calving (km ²)	Overlap (%)	Peak calving (km ²)	Overlap (%)	Peak calving (km ²)	Overlap (%)
1996	10,050 (1996–2000)	-	15,681 (1996–2000)	-	5,761 (1996–2000)	-	614	-
1997							3,035	33
1998							2,005	38
1999							3,974	41
2000							3,900	38
2001	11,250 (2001–2005)	53 (2001–2005)	10,337 (2001–2005)	64 (2001–2005)	4,249 (2001–2005)	34 (2001–2005)	4,760	11
2002							2,345	49
2003							5,793	28
2004							1,611	34
2005							4,962	34
2006	6,497	53	6,631	15	3,056	37	1,316	38
2007	6,026	47	7,441	12	3,283	25	1,884	4
2008	9,349	47	11,214	40	4,568	28	2,703	61
2009	10,736	48	9,540	31	8,050	44	1,772	49
2010	11,692	53	15,549	76	8,442	46	1,899	37
2011	6,950	60	7,390	28	5,027	46	1,528	53
2012	14,822	59	11,466	43	8,333	55	1,981	52
2013	17,836	73	10,166	49	7,592	54	845	47
2014	11,515	65	12,271	91	6,729	49	1,452	58
2015	14,004	54	11,879	64	6,148	52	2,309	48
2016	11,827	68	10,892	66	6,963	56	923	33
2017	6,329	62	7,320	58	3,135	45	1,052	41
2018	8,104	44	8,153	50	4,202	34	1,549	29
2019	7,236	71	9,325	77	3,792	55	2,443	33
2020	9,156	70	10,821	67	5,548	42	2,090	57
2021	9,088	63	9,590	72	6,975	55	2,760	54
Cumulative size km ²	34,164	-	38,700	-	24,906	-	14,840	-



Year	Bluenose-East						Bathurst	
	Calving (km ²)	Overlap (%)	Post-calving (km ²)	Overlap (%)	Peak calving (km ²)	Overlap (%)	Peak calving (km ²)	Overlap (%)
Average overlap (%±SE)	-	58 (±2.2%)	-	53 (±5.4%)	-	45 (±2.4%)	-	40 (±2.7%)

Table 2. Median and range of peak of calving dates of the Bluenose-East and Bathurst caribou herds based on changes in movement rates and patterns from collar data (1996–2021).

Year	Bluenose-East		Bathurst	
	Median	Range	Median	Range
1996–2000	5 June	27 May–13 June	-	4–14 June ¹
2001–2005	3 June	1–20 June	-	8–14 June ¹
2006	3 June	28 May–7 June	-	8–14 June ¹
2007	3 June	2–15 June	-	8–14 June ¹
2008	3 June	4–9 June	10 June	3–15 June
2009	4 June	25 May–16 June	8 June	4–13 June
2010	4 June	27 May–11 June	5 June	3–8 June
2011	5 June	25 May–13 June	4 June	1–9 June
2012	4 June	25 May–13 June	4 June	31 May–8 June
2013	7 June	30 May–13 June	6 June	5–13 June
2014	6 June	28 May–14 June	4 June	27 May–9 June
2015	6 June	27 May–10 June	3 June	25 May–10 June
2016	2 June	29 May–10 June	1 June	28 May–6 June
2017	5 June	1 June–11 June	1 June	29 May–9 June
2018	8 June	3 June–13 June	7 June	3 June–11 June
2019	9 June	2 June–14 June	5 June	26 May–12 June
2020	10 June	5 June–14 June	5 June	29 May–14 June
2021	7 June	1 June–15 June	2 June	30 May–12 June

¹Gunn et al. (2008)

3.1 BLUENOSE-EAST CARIBOU

Before the mid-1990s, the Bluenose-East herd was part of a single herd known as the Bluenose herd, with calving spread at varying densities over a widely spaced area (Hawley et al. 1976). Reanalysis of the aerial survey and collar data showed that three distinct calving areas existed within the original Bluenose herd, leading to the recognition of three distinct calving areas: Bluenose-East, Bluenose-West, and Cape Bathurst (Nagy et al. 2005). The highest density of calving within the current range of the BNE herd from the mid-1960s to the early 1990s surrounded Bluenose Lake. After the mid-1990s, most recognized calving occurred



farther to the southeast within the Rae and Richardson rivers valleys west of Kugluktuk (Nagy 2009; this report).

From 1996 to 2012, the estimated peak of calving date ranged from 2–7 June, with a median date of 4 June (Table 2). Up to 2012, the area of greatest annual overlap of the BNE calving area remained largely west of Kugluktuk; however, beginning in 2013, median date of peak of calving shifted to 7 June (Table 2) and an area farther to the northwest experienced increasing use by collared calving females (Map 1 and Map 3). This is consistent with the 2015 survey report that described higher density strata in this area (Boulanger et al. 2016). Between 2017–2021, this area continued to experience greater use by collared calving females, again consistent with the higher density stratum observed further to the west during the 2018 survey (Boulanger et al. 2019). Our estimated median date of peak of calving was within 1 (one) day of peak dates estimated from collar data and visual observations during 2015, 2018 and 2021 calving ground surveys (Boulanger et al. 2016, 2019; J. Boulanger, pers. comm; Integrated Ecological Research 2021). From 1996–2021, there was a distinct area of considerable overlap in use, evident during both the broad calving (28 May–20 June) and peak calving periods (Map 2 and Map 4). Although the concentrated area of cumulative peak calving area is smaller (Table 1), it still captures the area immediately west of Kugluktuk as experiencing the most consistent use over the years, largely consistent with the central area of the DNLUP calving area polygon (Map 4). However, this cumulative peak calving area does not capture the general shift in calving areas to the west and northwest in recent years (Map 3).

The average inter-annual overlaps of calving and post-calving areas ($58 \pm 2.2\%$ and $55 \pm 6.2\%$, respectively; Table 1) for the BNE were larger than the overlap of annual peak calving areas, ($40 \pm 2.7\%$; Table 1). This suggests that the area used during peak calving is more variable year-to-year than the broader calving and post-calving areas.

Our estimated BNE post-calving area showed variability in areas used, with greater use of more southern areas during 2006–2012 (located mainly within the DNLUP designated calving area), and more use of northern areas from 2013–2021 (located primarily within the DNLUP post-calving area; Map 5). Post-calving use of areas north and northwest of Kugluktuk increased since the mid-2010s. On average, in any given year, our calving areas overlapped with $55 \pm 2.6\%$ (range = 40–78%) of the DNLUP calving area (Figure 3). The cumulative BNE post-calving area was larger than the calving and peak calving areas (Table 1); however, the area of greatest overlap covered much of the same area (Map 6). In our analyses, the area of the greatest cumulative use during post-calving was roughly centred between the DNLUP calving and post-calving area polygons (Map 6). On average, our post-calving areas overlapped with $46 \pm 2.4\%$ (range = 18–61%) of the DNLUP calving and post-calving area (merged) in any given year (Figure 3).

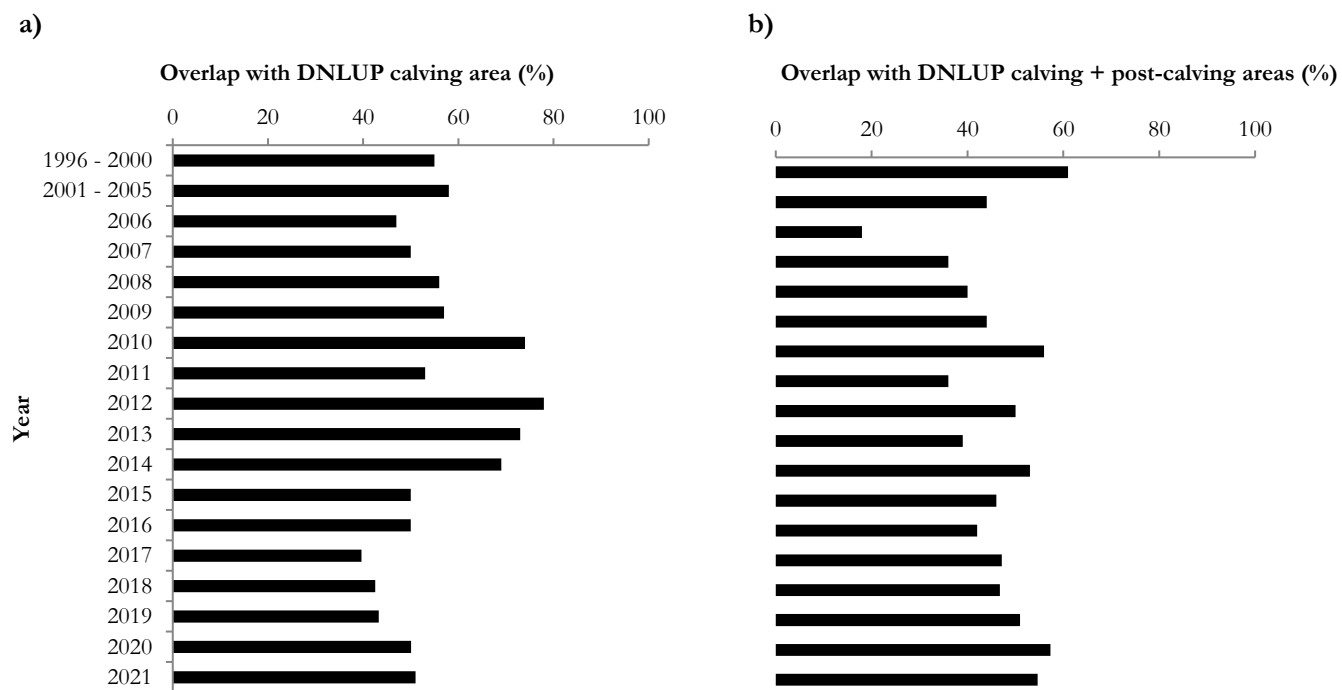
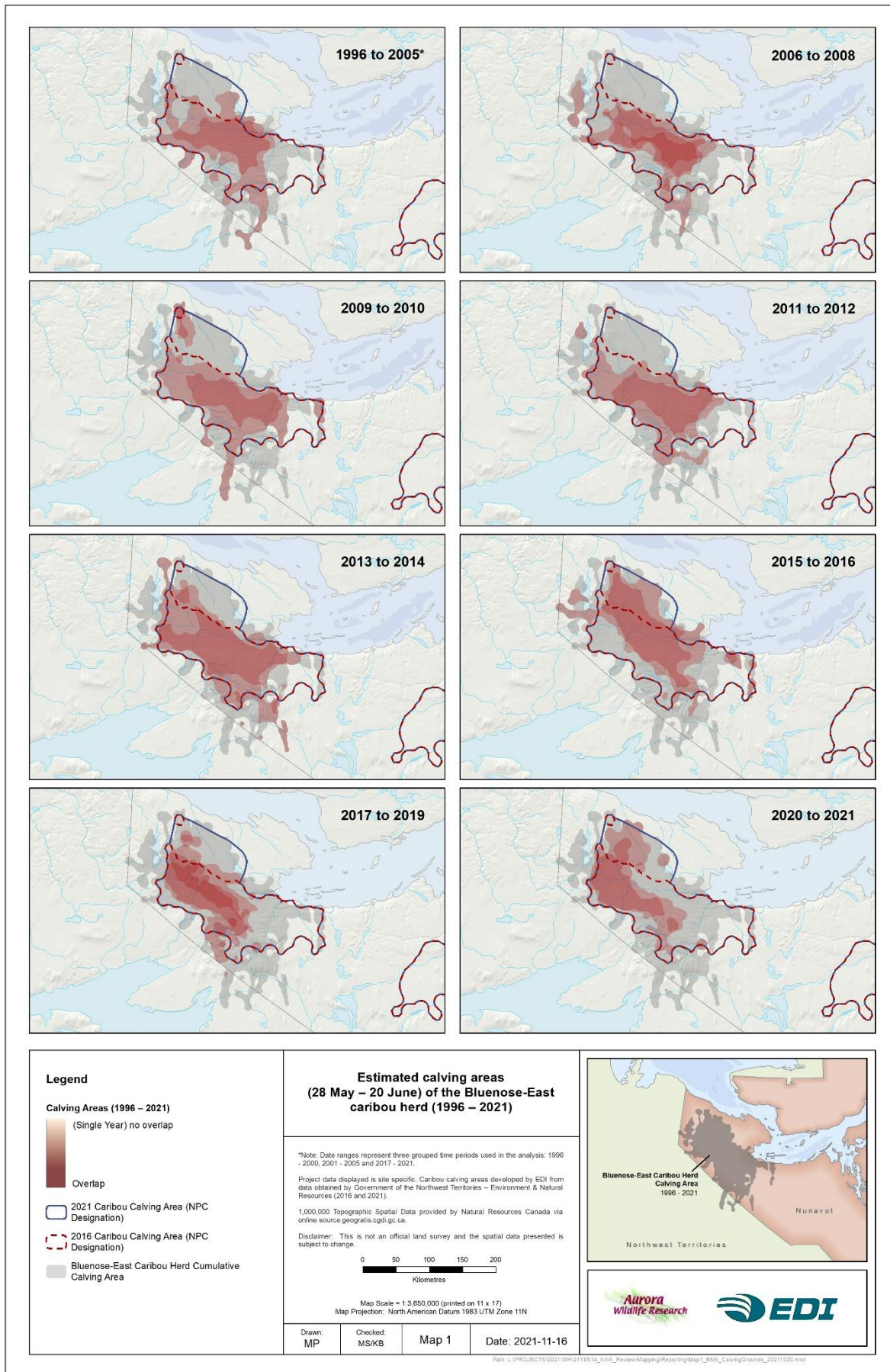
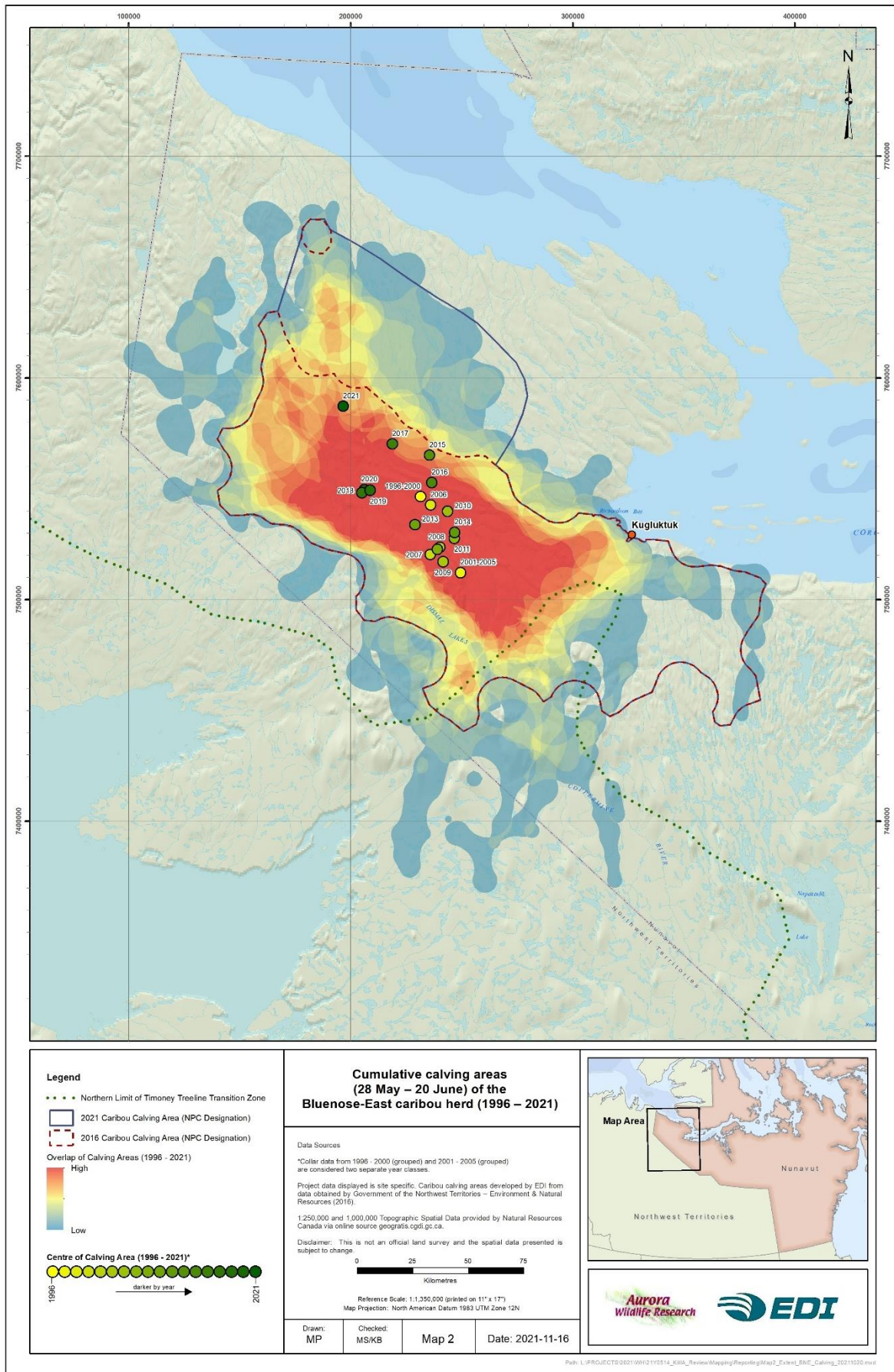
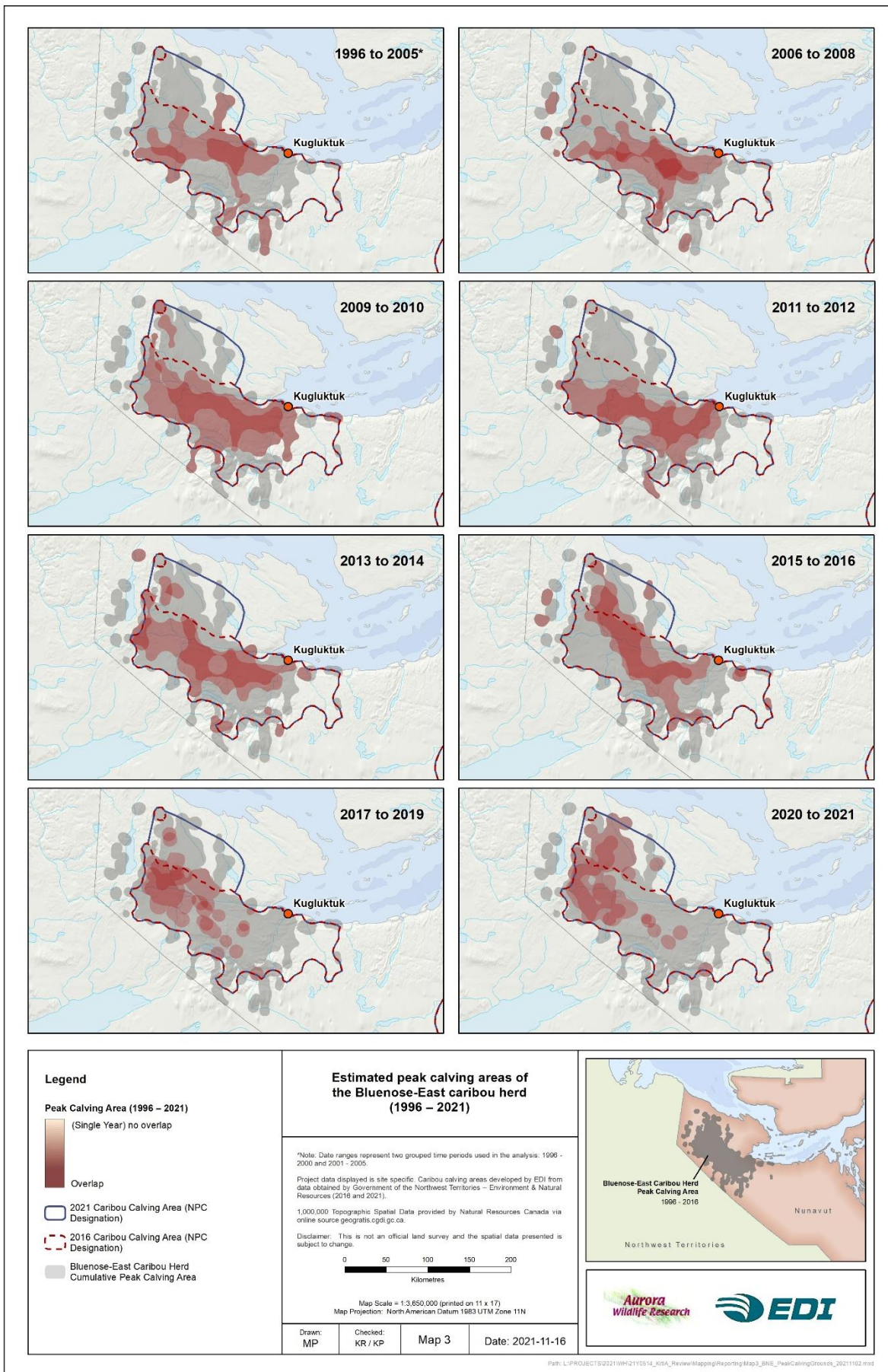
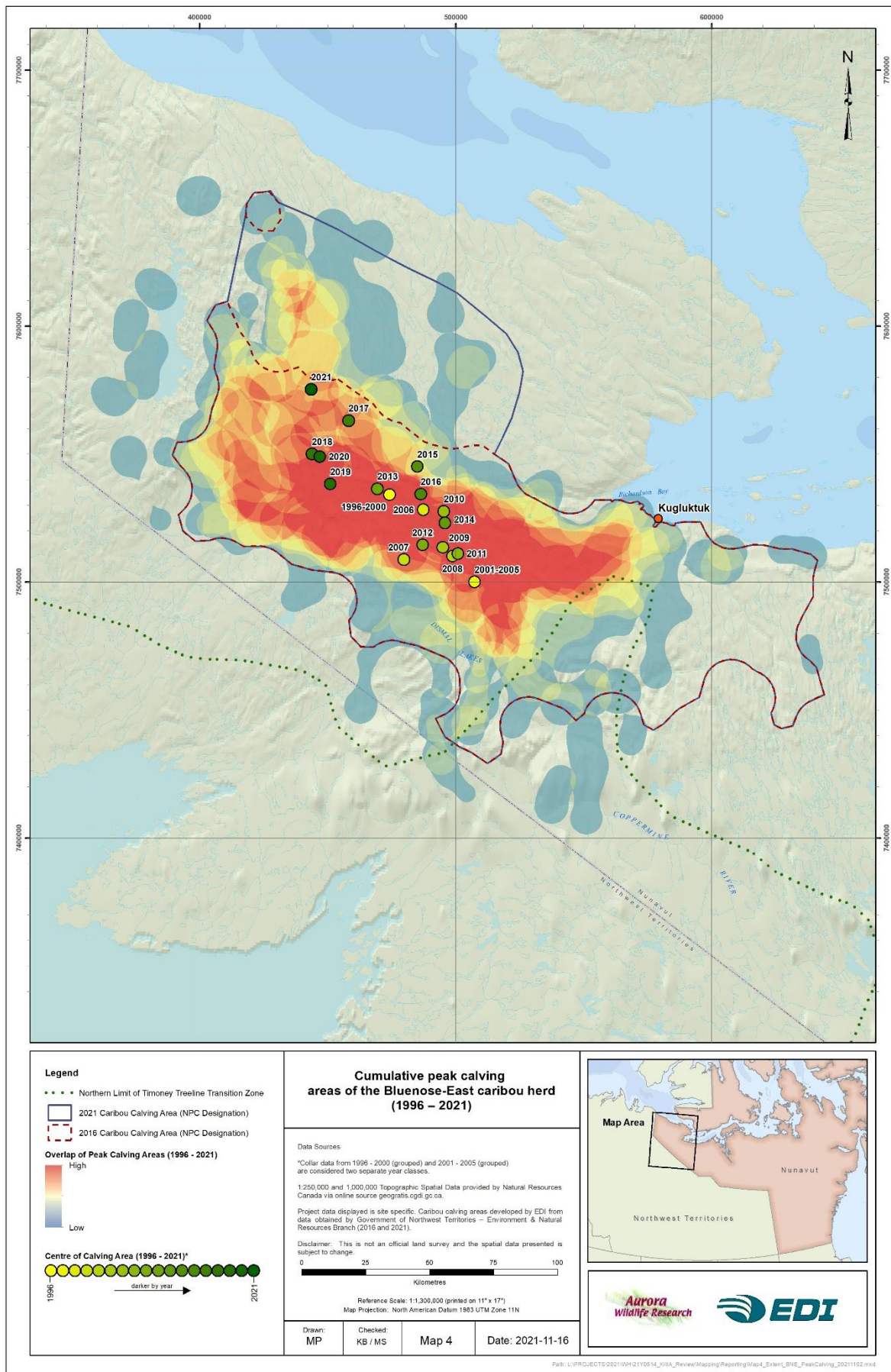


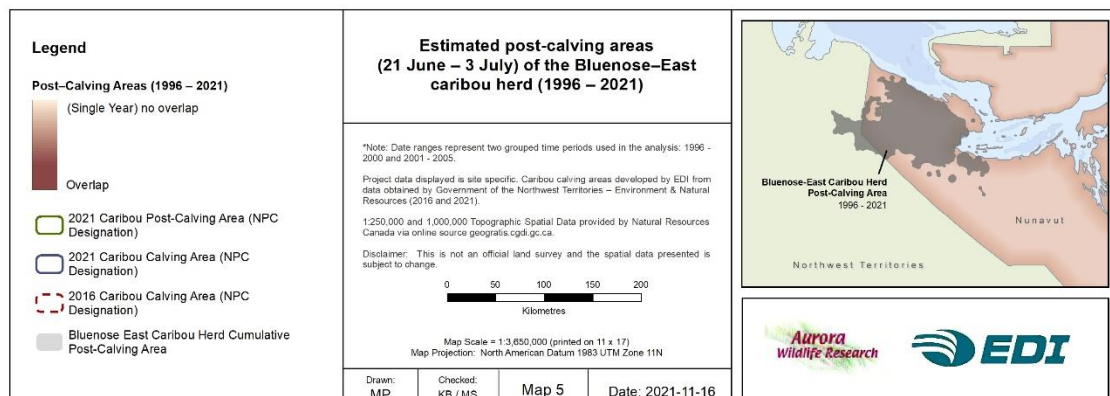
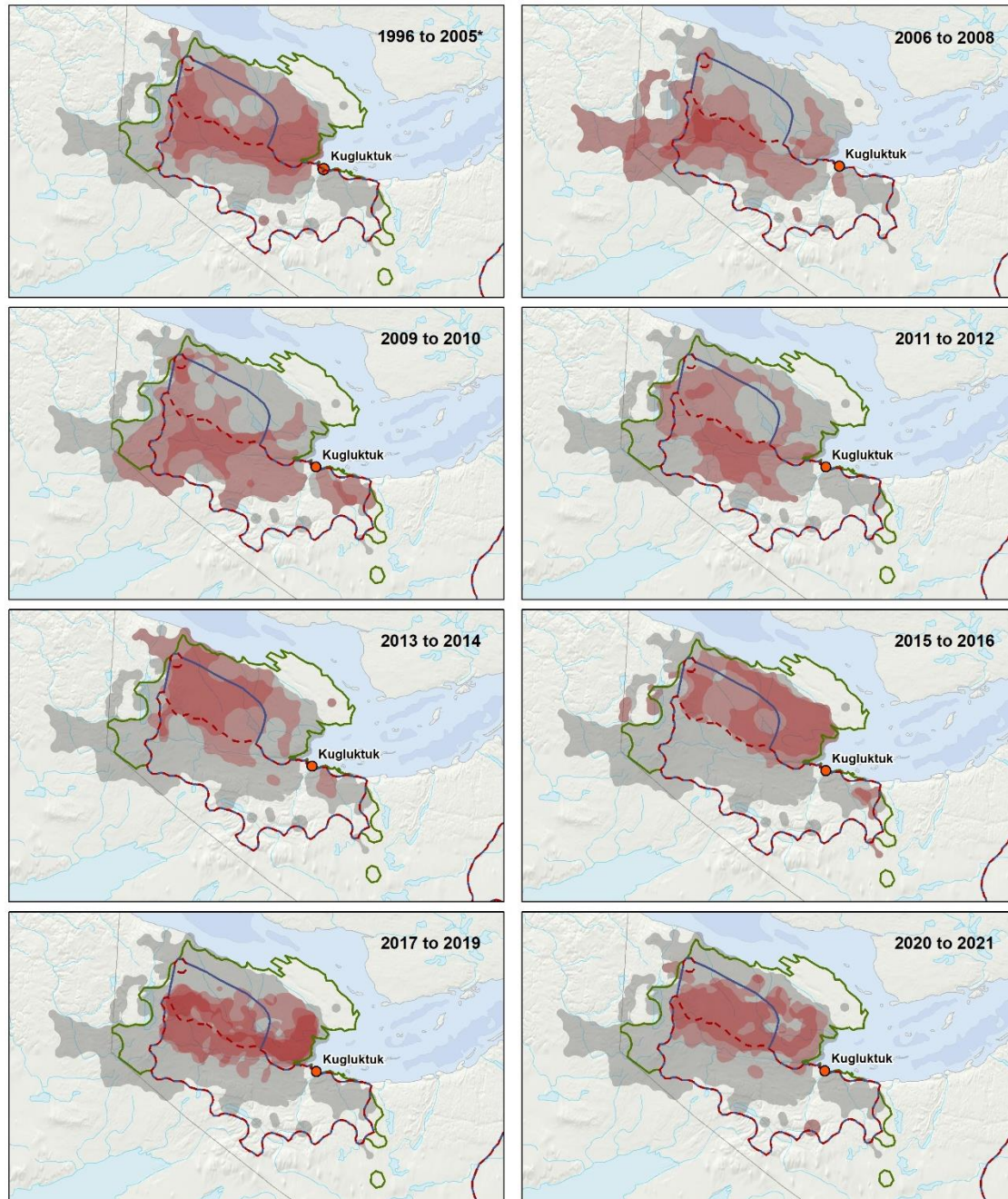
Figure 3. Overlap of Bluenose-East calving (a) and post-calving (b) areas with the 2016 (for 1996–2016) and 2021 (for 2017–2021) DNLUP-designated calving and post-calving areas.



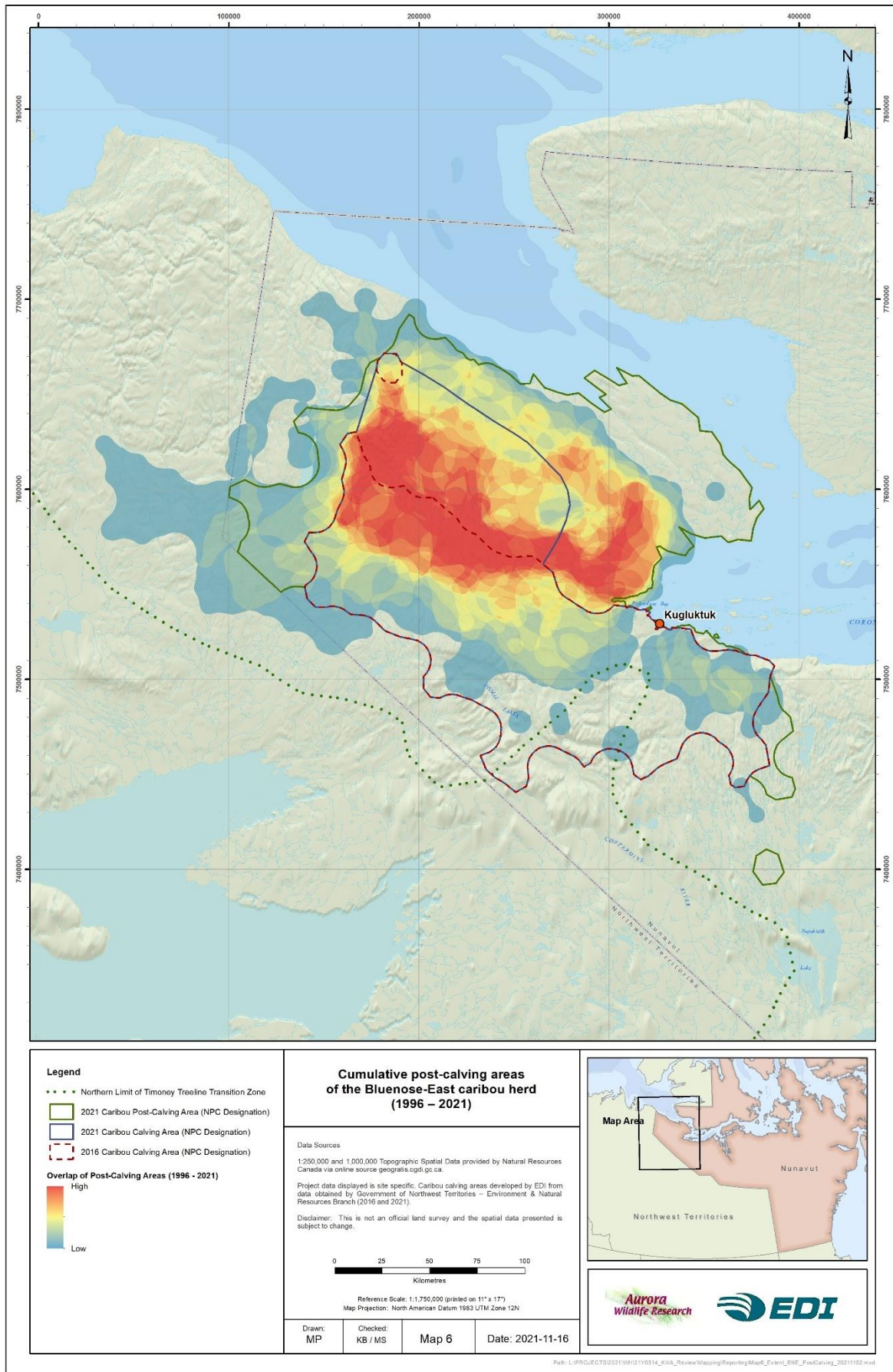








Path: L:\PROJECTS\2021\W1\21Y0514_KHA_Review\Mapping\Reporting\Map5_5NE_PostCalvingGrounds_20211103.mxd



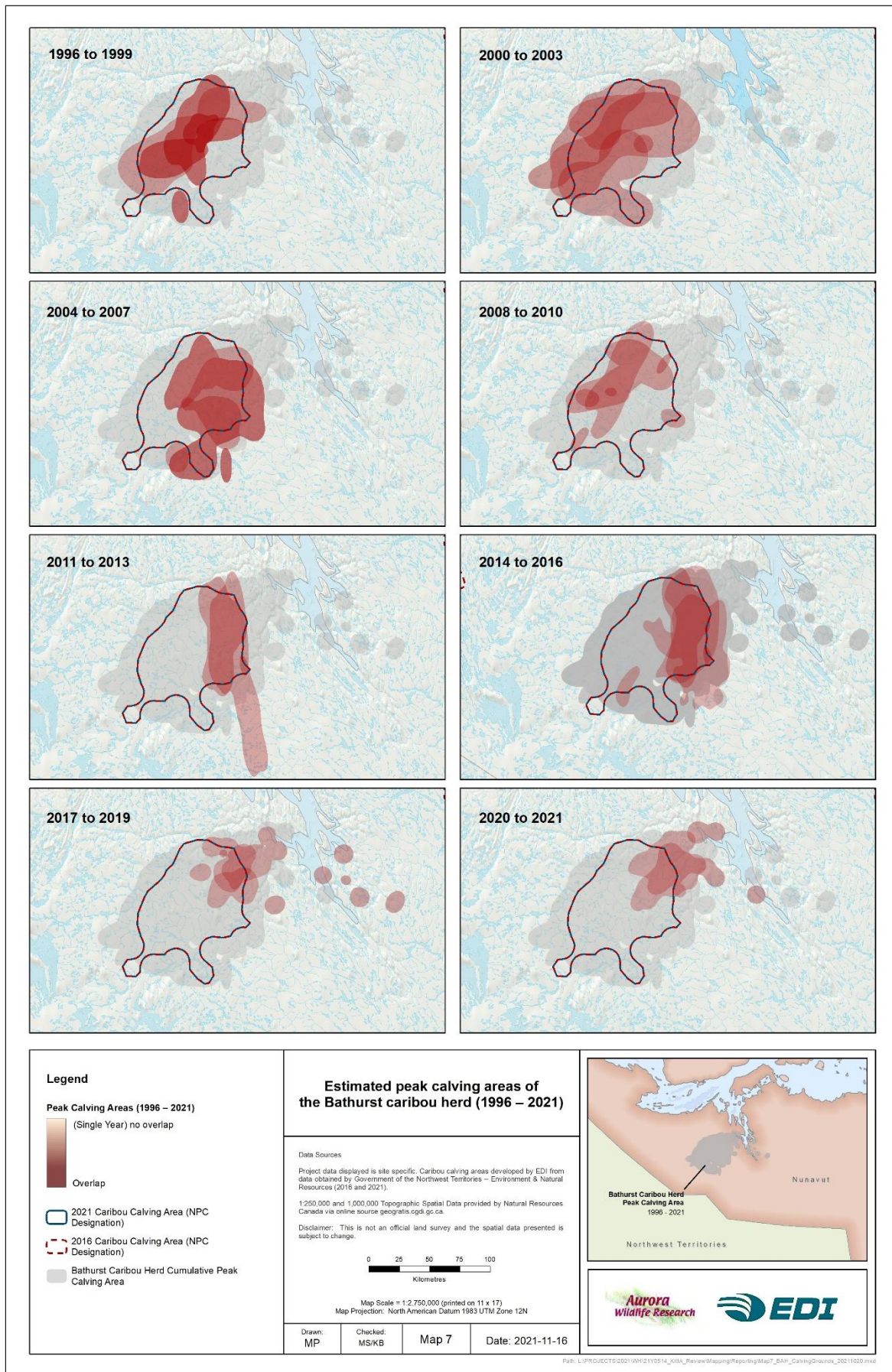


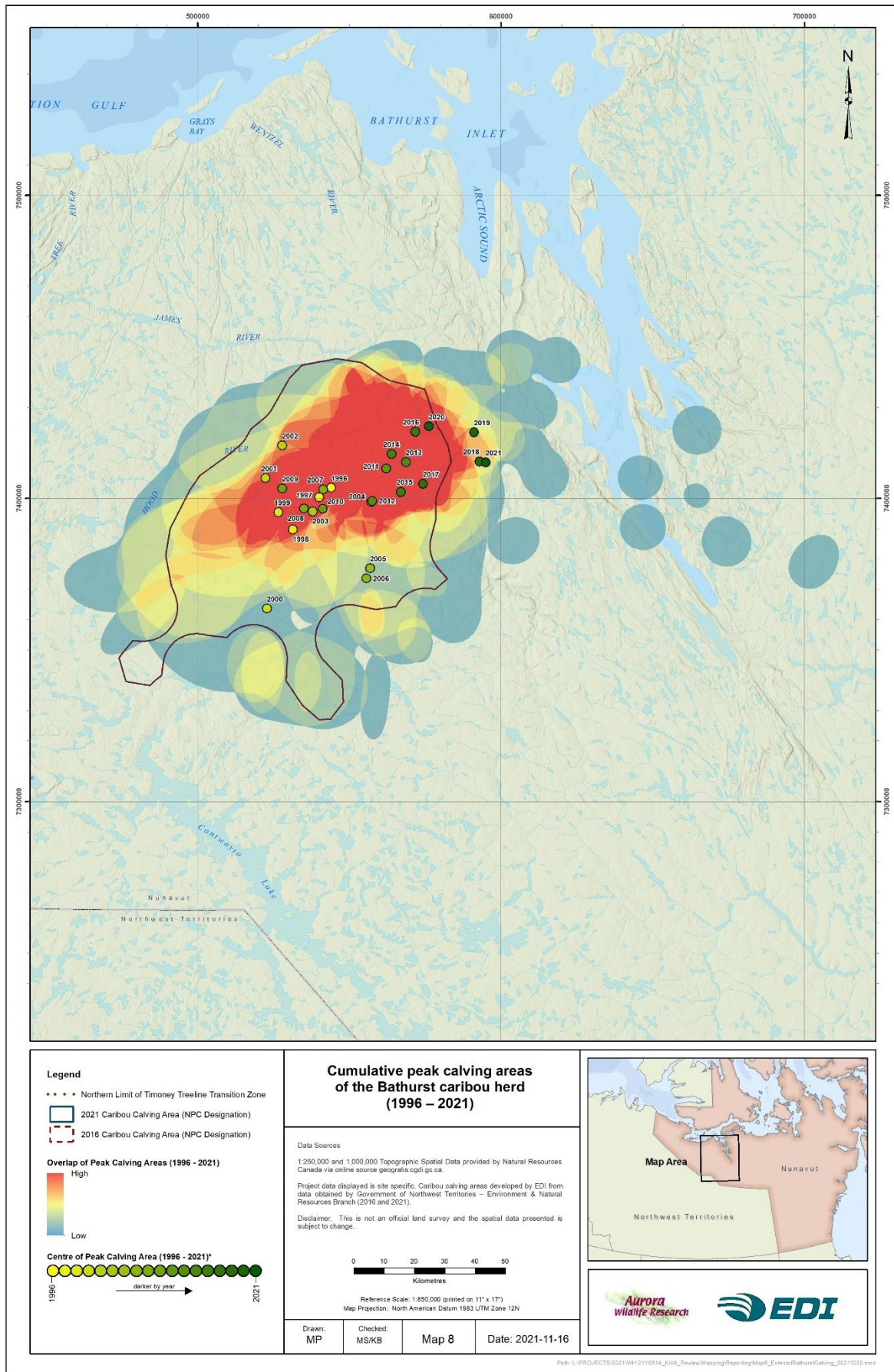
3.2 BATHURST CARIBOU

The GNWT began surveys of the Bathurst caribou herd's calving areas in 1965, largely in response to the increase of exploration and development activity in the vicinity of calving areas (Sutherland and Gunn 1996). In 1977 and 1979 caribou were observed calving west of Bathurst Inlet (Fleck and Gunn 1982); however, the majority of the herd calved east of Bathurst Inlet up to the mid-1980s, and between 1986 and 1996 calving area use had shifted to west of the inlet, roughly around the Hood and Burnside rivers (Sutherland and Gunn 1996). This shift in calving areas was also observed by Inuit knowledge holders (Hagialok 1998; Kapolak 1998; Akana 1998 in Thorpe et al. 2001). With the population peak in 1986, this shift was attributed to increased density of calving cows in the calving area (east of Bathurst Inlet), possibly leading to increased forage competition and risk of parasitism, ultimately causing a shift to calving areas in the west that were not as recently highly used (Gunn et al. 2013).

From 1966 to 1996, the Bathurst herd's peak of calving was estimated to occur throughout a five-day period between 3 and 15 June (Sutherland and Gunn 1996), with estimates of peak of calving as late as 18 June (Gunn et al. 2008). Since 1996 and into the late 2010s, the Bathurst calving area has remained west of Bathurst Inlet and centred around the Hood River (Gunn et al. 2008), with some year-to-year latitudinal variation between the Burnside and James rivers (Map 7). During 2018, 2019 and 2021, however, several BAH cows calved east of or at the southern end of Bathurst Inlet (Map 7). According to weekly maps distributed by GNWT-ENR (unpubl. data), approximately six cows that calved with the BAH herd in 2020 made long movements east of Bathurst Inlet in May and June 2021; however, the collar data for these individuals were not provided and we were unable to assess their herd fidelity. From 1996 to 2009, peak of calving was estimated to occur between 4 and 12 June (Nagy 2011), with cows arriving in the vicinity of the calving areas between 20 May and 5 June (Gunn and Poole 2010). From 2008–2016, the peak of calving date ranged from 1–10 June (Table 2). From 2017–2021, the peak of calving date ranged from 1–7 June (Table 2). Our estimated median peak of calving dates for the BAH herd correspond within 1 day of estimates derived from collar data combined with visual observations during 2015 and 2018 calving ground surveys (Boulanger et al. 2017, Adamczewski et al. 2019).

In most years, the BAH peak calving area used only a portion of the DNLUP areas for calving, and in some years extended beyond the mapped boundary (Map 7). Annually, there was a notable shift to the eastern edge of the area beginning in 2011, with some use of the areas just east of Bathurst Inlet in recent years. The concentrated peak calving areas show an area of greatest overlap centred in the central and northeast portions of the main BAH DNLUP polygon (Map 8). The average overlap of annual peak calving areas for the BAH herd from 1996 to 2007 was 32% ($\pm 4.0\%$) with no consistent directional shift (Gunn et al. 2008), and increased to an average of 49% ($\pm 3.1\%$) from 2008–2016 (Table 1), with an apparent directional shift to the east (Map 7). The average annual overlap was 40% ($\pm 2.7\%$) when considering all years of data (1996–2021).







4 IMPLICATIONS

Caribou movements and use of areas reflect adaptability to annual and longer-term changes in weather and forage availability (Bergerud et al. 2008). Caribou also adapt their use of areas as caribou herd size increases and decreases (Gunn et al. 2012). This adaptability of how and when caribou use areas, such as for calving and post-calving, creates uncertainties for mapping those areas for land use planning.

The timing of calving and subsequent dates for peak lactation and when the calf begins to forage independently determines the areas used as calving and post-calving areas. The timing of calving can vary by a few days each year, depending on the cow's body reserves and annual weather changes. For example, the range of median dates for the BAH herd calving was 10 days earlier in 2016 compared to 2008, while the BNE herd dates have varied by only a few days for the same period (Table 2). Median dates of calving for the BAH herd have remained relatively consistent from 2017–2021 compared to earlier, while median dates for the BNE herd appear to have become later. This means the timing used to define areas used for calving and post-calving can vary each year by a few days or can vary by a week or more over the longer term, so dates used to derive area boundaries have to account for the likely spread or trends in calving dates.

As well as the variability in calving dates, how caribou cows annually use the calving areas varies by year. Snow conditions during pre-calving migration may delay the cows. They may calve before reaching the calving area used in previous years (Gunn and Poole 2010). Additionally, cows do not necessarily use the identical area for calving year after year as their fidelity is to the other calving cows and the 'general' area rather than specific sites. The annual variation in the calving areas may show a directional shift which is currently apparent at a small scale for both herds in recent years (Maps 2, 4, 8). Based on our overlap analysis with the DNLUP polygons (Figure 3), the polygons never encompass 100% of the seasonal range use, leaving considerable used areas (up to 53% and 82% during calving and post-calving, respectively) outside the designated boundaries in any given year and further highlighting the rigidity of the DNLUP boundaries. Before collared cows were used to monitor the annual distribution of calving areas, monitoring was infrequent. Annual directional shifts were not detected, giving the impression of jumps in calving distribution. Caution is warranted in interpreting potential shifts in calving areas as we may have not yet seen all the possible variations in calving distribution, especially during severe declines (Gunn et al. 2012).

As well as the variability in the timing and use of peak calving areas, further uncertainty is that there are many ways to analyze and map the seasonal range use of caribou. The same dataset run using different assumptions about which cows to include (e.g., how to assign calving cows to a particular herd), and run through different statistical and GIS packages (i.e., ArcGIS vs. GME and R), can produce differing maps. For example, one key difference between the results of our calving analyses and the DNLUP designated calving area is the area to the east and southeast of Kugluktuk that was included in the DNLUP calving area polygon where we found limited to no use by calving cows (Map 1 and Map 3). Mapping of calving areas should not include barren cows, many of which often lag far behind pregnant cows during spring migration and often occur some distance from the calving areas during calving (Gunn et al. 2008). The area within the DNLUP calving polygon sparsely used by calving caribou to the southeast of Kugluktuk covers approximately 2,500 km² (Map 2). Using



calving date ranges based on precise terminology and definitions would facilitate a more accurate mapping of these seasonal ranges.

This report presents calving and post-calving areas for two mainland barren-ground caribou herds within the Kitikmeot Region. Treating these seasonal ranges as static entities can result in situations where some areas currently have low or no use as a calving area (e.g., for the BNE, southeast of Kugluktuk) and are unnecessarily protected from human activities. Still, other areas that have experienced increasing recent use may not be adequately protected (e.g., post-calving areas northwest of Kugluktuk for the BNE from 2013–2021) if protection from human presence is necessary. Our analyses also showed large areas within the cumulative maps that have been unused for many years. This use pattern would lend itself to the use of mobile protection measures as a more responsive way of managing disturbance to calving and post-calving caribou.

Although the concept of concentrated calving or post-calving areas certainly has merit, delineating and applying this area in land use planning must be more critically considered. Caribou calving areas used annually generally move within a larger bounded area over time; not all portions within this larger, historically used area are occupied by breeding cows in any one year or a series of years. Calving areas could then be mapped using all historical annual calving grounds (documented using all collar data and IQ) to document the all-encompassing historical distribution, which would give context to a second boundary of more recently used calving areas (e.g., using collar data over the past 5–10 years). Land use designations could be applied differently between the historical and recent coverages. Defined calving areas would be applied with mobile protection measures that account for annual variability in use (e.g., Poole and Gunn 2015). As a key component of the land use planning process, it should be understood that these areas of recent concentrated annual use may change over time within the historical calving range and thus should be re-examined regularly, at a minimum within 5-year intervals.



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APPENDICES



APPENDIX A SUMMARY OF COLLAR DATA USED IN THE ANALYSES



Appendix Table 1. The number of collared female Bluenose-East caribou (*with the number of locations*) used in the delineation of calving (28 May–20 June) and post-calving (21 June–3 July) seasonal ranges, 1996–2021.

Year	Satellite	GPS	Total	Total locations (rarefied)
1996	5	-	5	100
1997	5	-	5	120
1998	5	-	5	100
1999	4	-	4	96
2000	3	-	3	71
2001	0	-	0	0
2002	0	-	0	0
2003	3	-	3	12
2004	3	-	3	13
2005	8	-	8	134
2006	7 (106)	6 (141)	13	247
2007	9 (150)	3 (71)	12	221
2008	12 (215)	16 (384)	28	599
2009	23 (339)	18 (423)	41	762
2010	17 (396)	22 (527)	39	923
2011	7 (123)	15 (359)	22	482
2012	20 (480)	25 (587)	45	1,067
2013	10 (239)	16 (382)	26	621
2014	4 (94)	20 (427)	24	521
2015	4 (91)	28 (635)	32	726
2016	5 (111)	31 (705)	36	816
2017	-	27 (630)	27	630
2018	-	27 (640)	27	640
2019	-	25 (587)	25	587
2020	-	32 (768)	32	710
2021	-	54 (1293)	54	1,293



Appendix Table 2. The number of collared female Bathurst caribou (*with the number of locations*) used in the delineation peak calving ranges, 1996–2021.

Year ¹	Peak calving	
	Satellite	GPS
1996	9	-
1997	7	-
1998	2	-
1999	12	-
2000	11	-
2001	10	-
2002	11	-
2003	10	-
2004	5	-
2005	12	-
2006	14	-
2007	19	-
2008	12 (42)	-
2009	1 (7)	9 (58)
2010	2 (14)	13 (188)
2011		17 (355)
2012		18 (377)
2013		12 (238)
2014		17 (344)
2015		31 (707)
2016		19 (493)
2017		25 (524)
2018		12 (252)
2019		18 (377)
2020		26 (546)
2021		32 (793)

¹Data from 1996–2007 is derived from Gunn et al. (2008) and does not include the number of locations.



Appendix Table 3. Caribou and locations removed from (peak) calving and post-calving analyses.

Year	Caribou ID	Reason
<i>Bluenose-East caribou</i>		
2000	BE16565	Suspected non-breeder
2004	151	Removed one erroneous location (animal retained for analysis)
	159	Removed one erroneous location (animal retained for analysis)
2008	1015	Calved in BAH calving area
	1114	Data limited; could not determine breeding status
	1708	Calved in BAH calving area
2009	1019	Suspected non-breeder
	7051	Suspected non-breeder
	7053	Calved in BAH calving area
	7099	Suspected non-breeder
	BG209	Suspected non-breeder
	BG214	Suspected non-breeder
2010	210	Removed one erroneous location (animal retained for analysis)
	1023	Calved in BAH calving area
	1606	Suspected non-breeder
	7024	Suspected non-breeder
	7044	Suspected non-breeder /potential collar failure or mortality
	7062	Calved in BAH calving area
	7101	Suspected non-breeder
2011	7101	Suspected non-breeder
2012	1604	Suspected non-breeder
2016	BGCA12514	Calved in BNW calving area
	BGCA12515	Suspected non-breeder
	BGCA12517	Calved in BNW calving area
2017	BGCA15182	Suspected non-breeder
	BGCA15267	Calved in BAH rut area
	BGCA16130	Suspected non-breeder
	BGCA16132	Outliers removed
	BGCA17119	Suspected non-breeder
2018	BGCA15182	Calved in BNW calving area
	BGCA16125	Outliers removed
	BGCA18135	Suspected non-breeder
	BGCA18137	Suspected non-breeder
	BGCA18166	Outliers removed
2019	BGCA18133	Suspected non-breeder
	BGCA18135	Suspected non-breeder
	BGCA18155	Suspected non-breeder
	BGCA19124	Outliers removed (locations prior to calving)
	BGCA19303	Suspected non-breeder /potential collar failure or mortality



Year	Caribou ID	Reason
	BGCA19325	Suspected non-breeder
	BGCA19365	Suspected non-breeder
	BGCA19371	Outliers removed
2020	BGCA16132	Suspected non-breeder
	BGCA19300	Outliers removed (locations prior to calving)
	BGCA20141	Calved in BAH rut area
	BGCA20181	Suspected non-breeder
	BGCA20184	Suspected non-breeder
	BGCA20211	Outliers removed (locations prior to calving)
	BGCA20217	Outliers removed (locations prior to calving)
	BGCA20239	Outliers removed (locations prior to calving)
2021	BGCA20229	Suspected non-breeder
	BGCA20239	Suspected non-breeder
	BGCA21343	Suspected non-breeder /potential collar failure or mortality
	BGCA21716	Suspected non-breeder
	BGCA21723	Suspected non-breeder
<i>Bathurst caribou</i>		
1999 ¹	127	Outlier
2000 ¹	128	Outlier
2001 ¹	105	Outlier
	126	Outlier
	124	Outlier
2003 ¹	137	Outlier
2004 ¹	156	Outlier
2005 ¹	171	Suspected non-breeder
	184	Suspected non-breeder
	185	Suspected non-breeder
	191	Suspected non-breeder
	192	Suspected non-breeder
2009	BG209	Suspected non-breeder; located near BNE calving area
	BG212	Outlier
2010	BG225	Outlier
	BG233	Suspected non-breeder
	BG248	Suspected non-breeder
	BG249	Suspected non-breeder
2012	BG236	Suspected non-breeder /potential collar failure or mortality
	BGCA12489	Outlier
2013	BGCA12489	Suspected non-breeder
2014	BGCA12489	Suspected non-breeder
2016	BGCA16112	Data limited; could not determine breeding status
	BGCA16113	Data limited; could not determine breeding status



Year	Caribou ID	Reason
	BGCA16114	Data limited; could not determine breeding status
	BGCA16116	Data limited; could not determine breeding status
	BGCA16117	Data limited; could not determine breeding status
	BGCA16119	Data limited; could not determine breeding status
	BGCA16121	Data limited; could not determine breeding status
2017	BGCA14711	Suspected non-breeder
2018	BGCA15224a	Suspected non-breeder
	BGCA16119	Suspected mortality
	BGCA17102	Suspected non-breeder
	BGCA17131	Suspected non-breeder
	BGCA18116	Suspected non-breeder
	BGCA18129	Located near BNE calving area
2019	BGCA17102	Suspected mortality
	BGCA18147	Suspected non-breeder
	BGCA18148	Suspected non-breeder
	BGCA19130	Suspected non-breeder
	BGCA19366	Suspected non-breeder
	BGCA19376	Suspected non-breeder
	BGCA19378	Suspected non-breeder
2020	BGCA15224b	Suspected non-breeder
	BGCA19352	Suspected non-breeder
	BGCA19376	Suspected non-breeder
	BGCA19378	Suspected mortality
	BGCA19379	Suspected mortality
	BGCA20125	Suspected non-breeder
	BGCA20136	Suspected non-breeder
	BGCA20143	Suspected non-breeder
	BGCA20144	Suspected non-breeder
	BGCA20173	Suspected mortality; located near BAH rut area
2021	BGCA19130	Suspected mortality
	BGCA19358	Suspected non-breeder
	BGCA19366	Suspected non-breeder
	BGCA19376	Suspected non-breeder
	BGCA20128	Suspected non-breeder
	BGCA20136	Suspected non-breeder; several outliers
	BGCA21702	Suspected non-breeder

¹Outliers removed from 1996–2007 were determined by Gunn et al. (2008)

Note: All collared male caribou were removed from all databases