JUNE 2025 CALVING GROUND SURVEY AND 2025 POPULATION MODELLING OF THE BLUENOSE-EAST BARREN-GROUND CARIBOU HERD

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For review—contents may change in future drafts, including updates on collar data and enhanced demographic analyses.

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ABSTRACT

This report describes the methods and results of a calving ground survey of the Bluenose-East barren-ground caribou herd conducted June 3-15, 2025, west of Kugluktuk, Nunavut. It updates abundance estimates of the herd from the calving ground survey results and integrated population models. A calving ground survey of the Bathurst herd was completed at the same time and is reported on separately.

The Bluenose-East herd calving ground abundance survey was conducted using a stratified strip-transect survey covering approximately 17,000 km^2. Caribou observations from reconnaissance flights were used to delineate and stratify the survey area into areas of similar densities and composition. Caribou were then counted in stratified blocks using methods best suited for each block (i.e., stratum). Visual survey flights were used in lower density blocks surrounding the higher-density core area. A modified distance sampling method and data recorder observations were used to improve visual sightability estimates. These methods provided comparable results to methods used since 2011, but offered improvements, and therefore were used to estimate the abundance of caribou in visual strata. In the higher density central blocks, caribou were counted from stereoscopic images derived from high-resolution photos taken by a photo plane. A helicopter-based composition survey immediately following the abundance survey was used to estimate the proportion of caribou in each stratum. Abundance estimates were then derived for breeding females, non-breeding females, yearlings, and bulls, and for the abundance of 1+ year old caribou in the survey area.

The main objective of the calving ground survey was to estimate the number of adult females and the number of breeding females on the calving ground in June. The estimate of Bluenose-East adult females in June was 19,312 (95% CI 17,611-21,117) and the estimate of breeding females was 17,261 (95% CI 15,652-19,035). The proportion of adult females that were breeding was 0.90 (95% CI 0.89-0.92). The number of total adult caribou at least one year old on the calving ground (including yearlings and bulls) was estimated to be 34,577 (95% CI 32,218 – 37,111). The survey occurred close to peak calving with excellent visibility for the visual surveys and aerial photos, and good survey coverage of visual and photo strata. These coverage levels resulted in low coefficients of variation of 0.095 for adult females, 0.100 for breeding females and 0.033 for 1+ year old caribou on the calving ground.

A herd estimate of 2+ year old caribou was estimated after the 2025 fall composition survey, using the mean adult sex ratio from the 2024 and 2025 fall composition surveys to represent the proportion of bulls in the herd. The extrapolated 2025 herd estimate is 28,759 2+ year old caribou (95% CI 25,997-31,816). This survey-based 2025 herd estimate is lower than the 2023 estimate of 39,525 (95% CI 33,021-47,310) and higher than the 2021 estimate of 23,202 (95% CI 19,247-27,971).

Integrated population modelling is a tool that provides more information about herd trends than calving ground surveys alone and puts survey data in context with other data collected on a herd. Results suggest a model-based 2025 herd estimate of 30,088 (95% CI 26,488 – 33,812), similar to the calving ground survey results. Model results also suggested that the recent trend for the Bluenose-East herd is best represented as a slower increase since 2021, and not a rapid increase 2021-2023 followed by decline from 2023-2025. This agreed with similar modelling completed after the 2023 survey which suggested that the most likely rate of increase from 2021-2023 was lower than the 2023 calving ground survey suggested.

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INTRODUCTION

The Bluenose-East barren-ground caribou use habitat that extends from the Bluenose Lake area west of Kugluktuk, Nunavut, around Great Bear Lake to the east and down into the boreal forest north of Great Slave Lake (Figure 1). The calving ground has stretched from south of Kugluktuk northwest to Bluenose Lake with more recent calving areas occurring west and northwest of Kugluktuk (Figure 2).

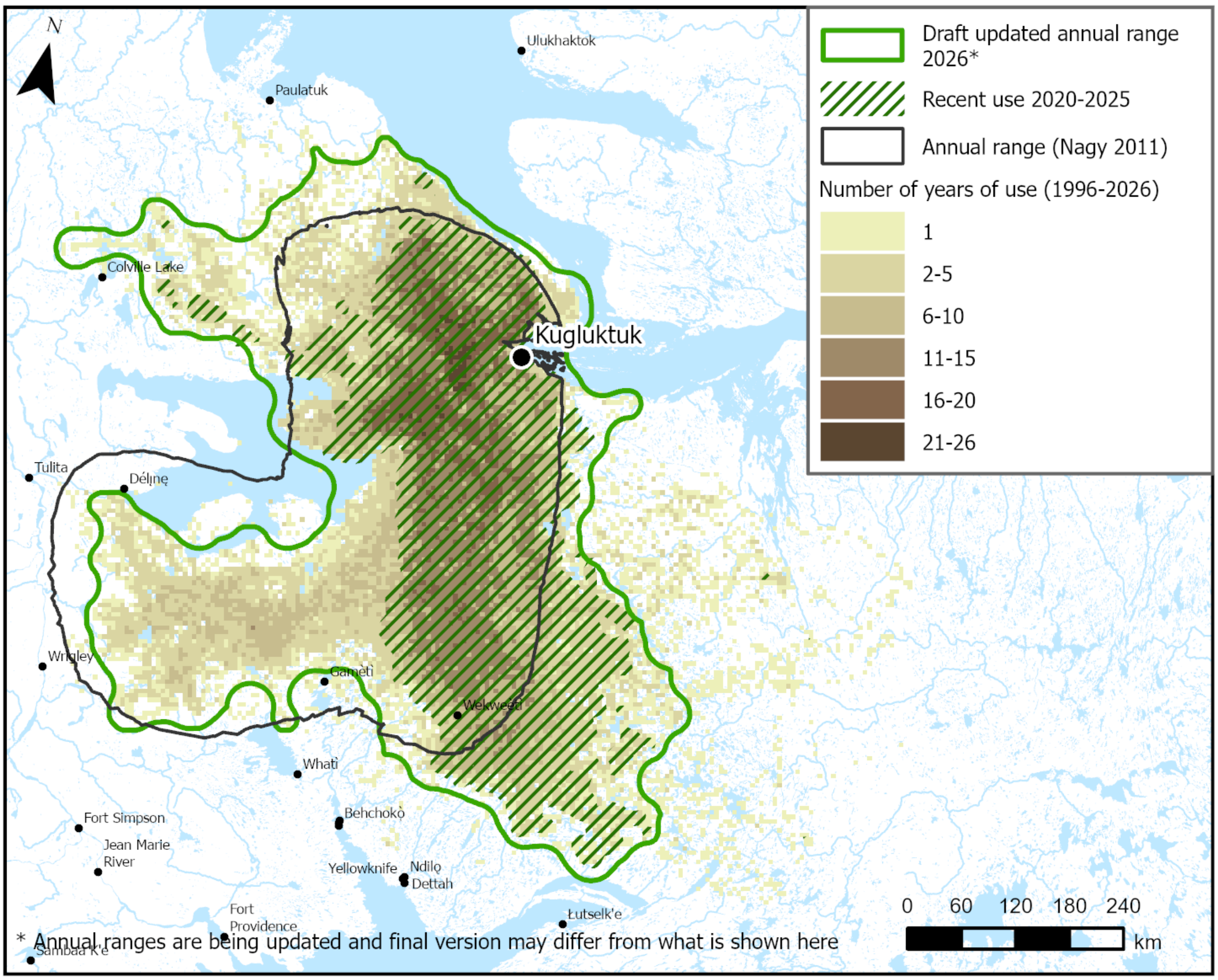

Figure 1. Annual range use by Bluenose-East barren-ground caribou, based on locations of collared caribou 2005-2025. Annual range boundary (Nagy 2011) used by ECC in previous documents is shown in black. The draft updated annual range is shown in dark green with density of use (i.e. number of unique years of use by collared caribou) shown in the background yellow-brown shading. Dark green hatching shows the range used by collared caribou in the last five years (2020 - 2025).

In recent years, Bluenose-East caribou have shifted their annual range use eastward. Collared Bluenose-East caribou have not used winter range areas south of Great Bear Lake since 2016 (previously used in most winters since 2005) and have shifted to using winter habitat farther east and south (Figure 1). In the past five years the calving locations of collared cows have shifted north and been west and northwest of Kugluktuk (Figure 2).

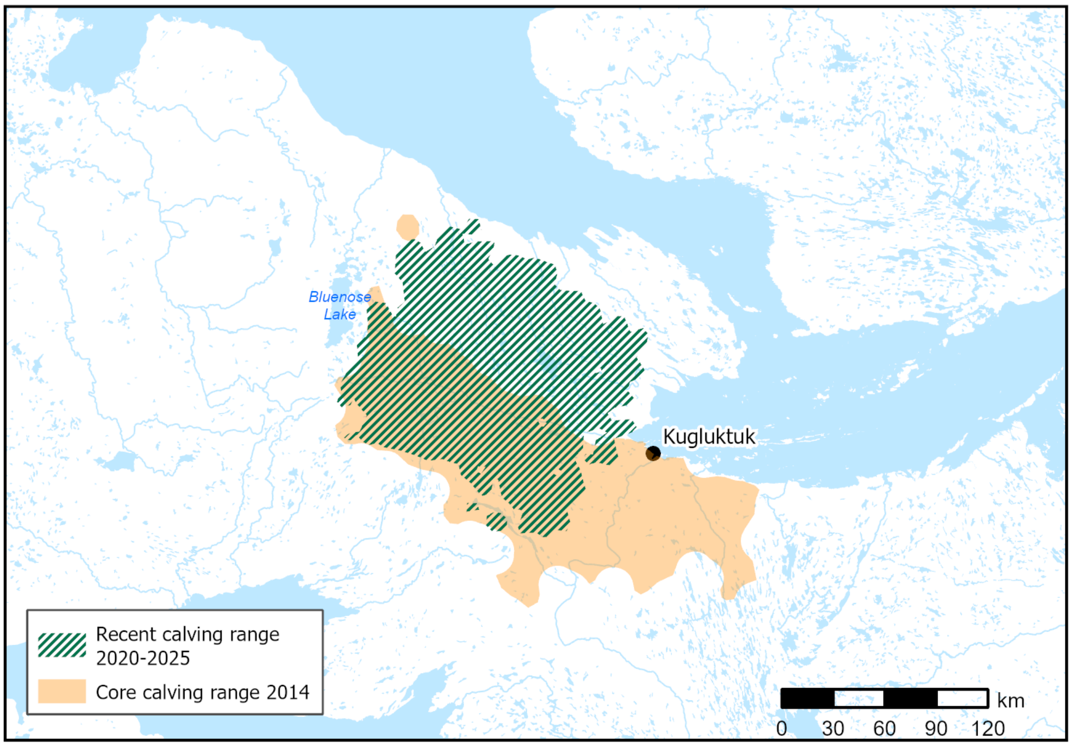

Figure 2. Calving ranges used by the Bluenose-East barren-ground caribou herd as mapped from collar data since 2005. The orange outlines the area used by adult females during the calving season from 2005-2012 (published in 2014 in the NWT Species and Habitat Viewer) and the green hatching shows areas used in the past 5 years (2020-2025).

Barren-ground caribou north of Great Bear Lake were managed as the Bluenose herd from the late 1960s (Thomas 1969) to the 1990s, when GPS collars in the early 2000s and analysis of caribou movements showed three separate calving grounds with different seasonal ranges in use by the "Bluenose" caribou herd (Nagy et al. 2025). This led to the designation of 3 herds (Cape Bathurst, Bluenose-West, and Bluenose-East), with the Bluenose-East herd's calving ground east of Bluenose Lake and summer and winter ranges east and south of Great Bear Lake (Davidson 2016). From 2000 to 2010, post-calving surveys were used to estimate the abundance of these herds including the Bluenose-East herd (Patterson et al. 2004, Adamczewski et al. 2009, Boulanger et al 2018). These surveys relied on caribou gathering in large, tightly aggregated groups (to reduce insect harassment), which were photographed from fixed-wing aircraft and counted from photos. The unpredictability of these aggregation patterns motivated a change in survey methods to June calving ground surveys used to estimate the abundance of other large migratory barren-ground caribou herds (Bathurst, Beverly, Qamanirjuaq). To establish comparability between survey methodologies both survey methods were used to estimate the Bluenose-East herd abundance in 2010, with similar results (Adamczewski et al. 2017).

Calving ground survey results indicate the Bluenose-East herd declined from about 120,000 caribou in 2010 (Adamczewski et al. 2017) to about 20,000 caribou in 2018 (Boulanger et al. 2019). The herd was stable between 2018 and 2021, and saw a large increase with the 2023 estimate of 39,525 (95% CI 33,021-47,310) (Figure 3). However, integrated population modelling combining survey results with other demographic data from the Bluenose-East herd indicated that the herd had increased since 2021 but suggested that the 2023 population estimates were higher than would be expected based on the other demographic data (Boulanger et al. 2024).

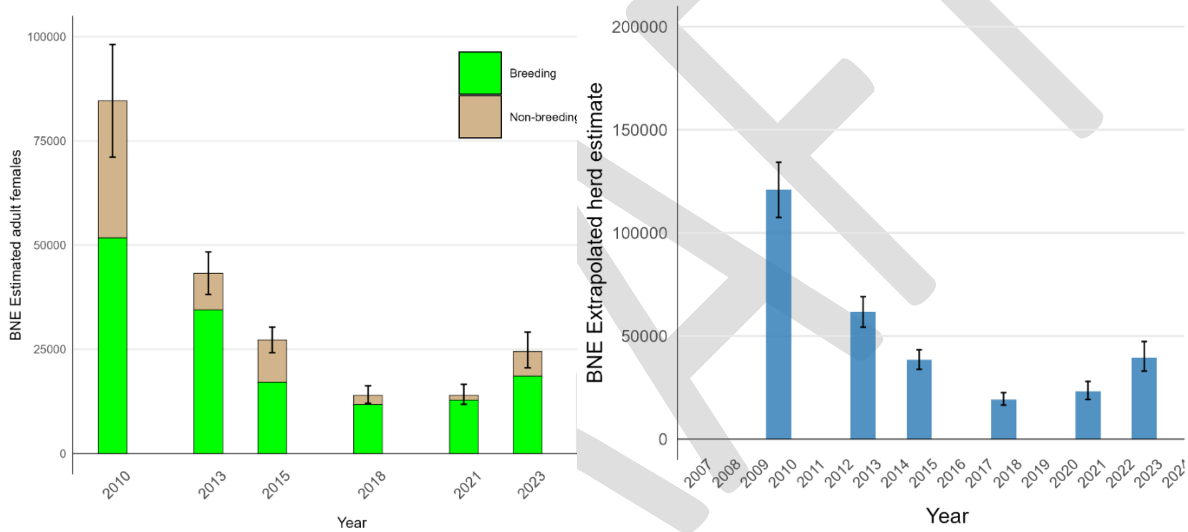

Figure 3. (a) Trends in Bluenose-East adult females, by breeding status, estimated on calving ground surveys 2010-2023 and (b) trends in Bluenose-East herd size estimated from calving ground surveys and fall composition surveys, 2010-2023.

Since 2010, calving ground surveys have occurred at 2- or 3-year intervals. In response to the Bluenose-East herd's decline in abundance between 2010 and 2018, more intensive monitoring of the Bluenose-East herd, including a 2-year calving ground survey interval, was proposed by Government of Northwest Territories (GNWT) and the Tłı̨chǫ Government (GNWT and TG 2019) and supported by the Wek'èezhìı Renewable Resources Board in 2019 (WRRB; WRRB 2019). In response to herd increases observed from 2018-2023 the calving ground surveys returned to a 3-year interval (starting after the 2025 survey) (WRRB 2025).

METHODS

Overview

Barren-ground caribou calving ground surveys are designed to estimate the number of adult females and breeding females gathered on the calving ground (before 2014 breeding females were the primary field estimate, see Campbell et al. 2015). Adult female barren-ground caribou migrate north in late April and May to aggregate on known calving grounds to give birth in a relatively concentrated time period. Most females will reach the annual calving ground area by early June, with breeding females at the leading edge, while males and yearlings often remain on the southern edges of, or south of, the main annual calving area.

The main objective of barren-ground caribou calving ground surveys is to estimate the number of adult females and the number of breeding females on the calving ground in June. These survey results are combined with the results of one or more fall composition surveys to estimate the adult males in the population and derive an extrapolated estimate of herd abundance of 2+ year old caribou. Yearlings and bulls are estimated on the calving ground but do not inform the extrapolated herd estimate.

The calving ground field survey components are designed and coordinated based on incoming telemetry data, real-time survey results, changing weather conditions, and aircraft and logistic constraints. The reconnaissance and visual surveys occur onboard Cessna Caravan aircraft, the photo survey is conducted with cameras mounted on specialized photo planes, and the composition survey occurs onboard a helicopter (details of field methods follow the survey design section). All parts of the survey are ideally conducted close to or at peak calving (when approximately 50% breeding females have given birth) when caribou movements are lowest (see below for methodology).

1. ***Reconnaissance survey:*** The objective of the reconnaissance survey is to determine in real time the distribution and density of breeding cows within the broad calving ground area. The results of the reconnaissance survey inform the survey stratification for the photo and visual abundance survey components. The area covered by the reconnaissance survey focuses on where the herd's core calving area has been in the recent years based on historical telemetry (GPS collar) data and calving ground survey data while also incorporating the real time locations of satellite collared cows and their movements. Survey lines are flown spaced at 10-km apart, and caribou observations are summarized for each 10-km segment of each survey line.
2. ***Stratification***: Using caribou density and composition (presence or absence of breeding cows) data from the reconnaissance survey, the survey area is delineated into high- and low-density areas (called 'strata' or survey blocks) to be surveyed either by a photo or visual survey.

3. ***Abundance survey- Visual strata**:* The strata with lower densities of caribou are surveyed visually from aircraft. Two observers and a recorder on each side of the airplane work together to get an accurate count of the caribou along each survey flight line. Higher survey coverage, i.e., more transect flight lines, is allocated to visual strata with relatively higher densities of caribou.
4. ***Abundance survey - Photo strata:*** A photo plane takes high-resolution digital photographs of the delineated area with the highest density of caribou. These photos are later turned into 3D images and caribou are counted from the photos using specialized equipment. This approach provides reproducibility of counts and provides the most accurate count in high density areas that are more difficult to count visually.
5. ***Composition survey:*** Caribou are classified during a helicopter-based survey to understand what proportion of caribou in each stratum are breeding females, non-breeding females, yearlings, and bulls. This data is used to estimate how many of the caribou counted on the photo and visual surveys belong to each group. Cows are classified based on presence/absence of antlers and distended udder to inform the timing of peak calving for the herd, and if sufficient time has passed since peak calving, calf mortality.
6. ***Estimates of caribou on the calving ground:*** Results of the abundance survey are used to estimate the number of caribou in each stratum and results of the composition survey are then used to estimate the proportions of each of breeding females, non-breeding females, yearlings, and males in each stratum. Strata estimates are added together to obtain overall calving ground survey abundance estimates of the total 2+ year old adult females in the herd and the total breeding females in the herd, which are the primary objective of the calving ground survey.
7. **Herd estimate using fall composition data:** The number of adult male caribou in the herd is estimated after one or more fall sex ratio surveys and is added to the estimate of adult females based on the proportion of adult males to adult females during the rut, when both sexes are together.

Integrated population modelling: Data from the current and past calving ground surveys, as well as estimates of survival rate from bull and cow collars, estimates of productivity from spring and fall composition surveys, estimates of bull-cow ratios from fall surveys, and estimates of survival rates from collared bulls and cows are used in a population model to provide further inference on population trend and overall herd demography.

Barren-ground caribou telemetry program: Global positioning system (GPS) collars provide location data that is key to conducting reliable surveys, tracking seasonal movements and ranges, and monitoring adult survival and fidelity to calving grounds. Collars have been deployed on the Bluenose-East herd since 2005. In 2019 collar numbers increased from 50 collars (30 cows and 20 bulls) to 70 collars (50 cows and 20 bulls) in the Bluenose-East herd (GNWT and TG 2019, WRRB 2019). Collars are typically deployed onto caribou in late winter in line with the NWT Standard

Operating Procedures for the Capture, Handling and Release of Caribou and are programmed to release from the caribou after 3-4 years. Collar deployments target areas with known collared caribou and newly collared cows are assigned to a herd in June based on where they calve (if they switch calving grounds from one year to the next their herd assignment is changed accordingly). In the past 5 years the average number of collared Bluenose-East caribou at the start of the monitoring year (June 1) has been 58 cows (range: 54-61) and 18 bulls (range: 16-20).

Calving ground survey design

Reconnaissance survey design

Timing and geographical scope of the reconnaissance survey is critical to the successful completion of the survey and confidence in resulting estimates. Movement and location data from collared caribou and survey data from past years were used to help plan the reconnaissance survey to ensure that it included known areas of recent concentrated calving. To identify core areas used for calving since 2018, we mapped annual 50% and 95% kernel density estimates from collared Bluenose-East female caribou locations recorded during 1–7 June for each year from 2018 -2024 and overlaid these distributions with the core photographic survey strata delineated in 2018, 2021, and 2023.

Preliminary reconnaissance flight routes using a grid of pre-established 10-km spaced survey transects were developed based on the calving area used in recent years and the aircrafts' flight durations. These routes were refined before and during the survey using current locations of collared females and weather constraints. Routes were designed to provide coverage of areas of known or expected caribou use while extending into adjacent areas to delineate the outer extent of the distribution.

Movement and location data from collared caribou were used to monitor the timing and routes of spring migration and arrival and locations on the calving ground. An automated R-script generated a report using the latest telemetry data to plot migration paths and summarize the movement rates of individuals and the mean movement rates of caribou travelling to each of the Bluenose-East, Bathurst and Beverly herds. These were compared to same-period movements in recent years. To include newly collared caribou (unassigned to a herd) and to account for caribou travelling to a different calving ground than previously used, we used polygons delineating buffered areas around each calving ground to summarize movement rates specific to each calving ground. Once a collared animal entered a polygon, its data was summarized in that group. Plots identified the mean movement rate of all female caribou in each polygon and the mean threshold of < 5 km/hour/day. While caribou calving is gregarious and likely motivates cows with earlier-born newborn calves to continue moving to remain with a mobile group, a herd-based mean movement rate of <5 km/hour has been shown to be associated with peak calving of the herd.

Calving ground surveys are completed as close to peak calving as logistics allow, when caribou movement rates are relatively stable and there will be less movement between the reconnaissance, abundance and composition survey components. Survey timing must also balance the need to complete the abundance and composition surveys, considering weather, and demands of surveying two calving grounds in one season (Bluenose-East and Bathurst).

Data from the reconnaissance survey was summarized and analyzed daily to be used to design the abundance survey. The reconnaissance data was first summarized by 10-km segments of the survey grid. Caribou observations within each 10-km segment were mapped by caribou density (10 km transect * 0.8 km transect width)/(number of caribou)). Densities of caribou/km^2 were classified by categories used in previous surveys: 0 (zero), <1 (low), 1.1-4.9 (medium-low), 5-9.9 (medium-high), and ≥10 (high) caribou/km^2. The 400 m strip width, in contrast to the 600m, was used for mapping density because sightability declines with distance (Boulanger and Campbell 2024, and latter analyses in this report.). Caribou were also mapped by presence/absence of breeding females or calves, using composition data from the 600 m strip width. Observations of caribou groups were also mapped using circles graduated by group size (not summarized by transect) as confirmation.

Abundance survey design

The main objective of the abundance survey is to obtain a precise and accurate estimate of adult females and of breeding females on the calving ground. Data from the reconnaissance survey is used to design the abundance survey. Precision is achieved by delineating areas (strata) of similar densities and composition (mostly breeding or mostly non-breeding caribou) in which caribou will be counted and for which estimates will be generated.

Initial survey strata were created as polygons in QGIS based on the mapped reconnaissance data. The number of caribou in each proposed survey strata, as well as variance, was then estimated from the on-transect (400 m strip width) caribou observations from the reconnaissance data using Jolly's 1969 strip-transect estimator (Jolly 1969). Areas with higher densities of caribou were assigned to be photo survey strata and areas with lower caribou densities were assigned as visual survey strata.

Allocation of effort

After stratification, the number of transects assigned to each stratum were based on optimizing the precision of estimates with logistic constraints. Logistically, the abundance survey should be flown in a relatively short time (one or two days) to minimize caribou movement between blocks during the survey, while considering that each survey aircraft has a fixed flight distance before it must return to an airstrip to refuel.

From a statistical perspective, the optimal allocation of survey effort was based on sampling theory (Heard 1987, Thompson 1992, Krebs 1998), where the stratum that had the highest abundance and variance should receive the highest amount of survey effort to achieve the most precise estimate. In calving ground abundance surveys, the number of survey lines available for each stratum (due to aircraft and time constraints) are often marginal to obtain an adequate estimate of variance. The optimal allocation of transects across strata was therefore proposed based on both (a) caribou densities in each stratum, under the likely assumption that the variance of density is proportional to density, and on (b) estimates of standard error (variance) around (a). An 'optimal allocation of transects' algorithm used reconnaissance survey estimates of density, abundance, and the precision (SE) for each stratum for allocation. It then considered total kilometers available to survey on transect, the baseline (long-width) of strata, and the average transect width for a stratum, and using these data, estimated the optimal number of (abundance-based and variance-based) transects for each stratum.

The optimally allocated transects were then adjusted based on considerations of at least 10 transects per stratum (a requirement for valid estimation of variance (Buckland et al 2001)) and based on likelihood of breeding females in the survey strata (to improve precision of breeding female estimates). The general target for survey coverage was at least 15% for visual strata with coverage also dictated by how aggregated caribou are on the stratum (which is considered by the allocation algorithm) (Boulanger 2020). Logistical factors such as transit distance to survey strata were considered in final allocation of lines. To meet the objective of completing the visual survey in a single or two days of flying, lines were potentially reduced for survey strata that had longer transit times. In general, adjustments stayed close to the allocated number of transects to ensure the most precise survey estimate given the resources available.

After the number of transects for each block was assigned, the first transect in each block was placed randomly along a line running parallel to the longest axis of the block, and the remaining transects were placed at equal intervals throughout the block to achieve the determined coverage. Placing transects perpendicularly to the longest side of the polygon maximized the number of transects, relative to flight time, to reduce variance. Total transect distances were tallied and cross-checked with total kilometers available for on-transect flying. The dssd package in R (Marshall 2021) provided an estimate of distance flown for a given strata including transiting between survey lines. Lines were adjusted further to ensure that the total distance flown across all transects including transits between lines was within the total kilometers available. Transect orientations within strata, transect shape files, and coverage estimates were generated and cross-validated using the dssd R package (Marshall 2021).

For the visual survey blocks, we estimated the total number of kilometers each of the Caravans could fly on survey transects, accounting for the transit between Kugluktuk (our refueling base) and the survey area, over 1.5 days (surveying with two aircraft on day 1 and one aircraft on day 2); addressing plans to survey the Bathurst calving ground and our anticipated weather window. The upper limit of distance available to allocate to visual survey transects was set at 3000 km after accounting for anticipated ferry flights between strata and Kugluktuk.

To allocate effort across the photo survey blocks, we similarly estimated the flight time available to each photo aircraft before refueling, accounting for transit times between Kugluktuk and the survey area. The coverage of the photo plane related to the survey height above ground, with more ground area covered by photos taken at higher altitudes than lower altitudes, and lower resolution photos taken at higher altitudes than lower altitudes. Ground sample distance (GSD) is the size of one pixel on the ground; at GSD8 (8 cm GSD) each pixel represents an 8 cm x 8 cm area. The Vexcel Ultracam Eagle 4.1 (UCE4) camera used in 2025 had an image frame of 28,110 x 18,060 pixels. We considered photos taken up to GSD8 (i.e. up to 6,283 agl) to be suitable for detecting caribou and that the number of photos available, based on flight planning and the available budget and cost per photo, was approximately 3000.

For the photo strata, 1100 km of on-transect km were available based on the estimated distance that the 2 photo survey planes could fly within strata areas with one flight each. An allocation algorithm (as used for the visual survey strata) suggested the optimal sampling effort (i.e. number of transects or flight lines in each stratum) based on the available km of flight lines and the abundance and precision (SE) of the reconnaissance survey estimates.

Composition survey design

The composition survey was timed to occur as close as possible to the abundance survey to ensure minimal movement of caribou between strata (i.e. caribou counted in the abundance survey would be the same caribou classified in the composition survey). Survey effort was allocated to ensure composition data was obtained across each strata with more effort (i.e., groups classified) in higher-density strata while also classifying a target sample of 30 groups spread across each low-density stratum.

Classification of cows on the calving ground provides insight into the timing of calving. Pregnant cows retain their hard antlers until they give birth, unlike non-pregnant cows that drop their antlers earlier and either have no antlers or new antler growth in June (Whitten 1995). The udder of a pregnant cow becomes distended with milk, is visible prior to calving and remains visible while the newborn calf is nursing (Whitten 1995). This makes it possible to compare the proportions of breeding cows that have (a) not yet calved, (b) that are close in time to the birthing event, or (c) that are post-calving and have dropped their antlers (Figure 4). We considered (a) hard antler but no visible udder (not yet distended) to indicate being before calving event; (b) hard antler and distended udder and/or calf to indicate still close to birthing event; and (c) cow with calf and/or distended udder but no hard antler (antlers dropped after calving) to be farther after the calving event. We compared the proportion of these groups to provide insight into timing of the composition survey relative to peak calving of the herd (when most breeding cows have birthed).

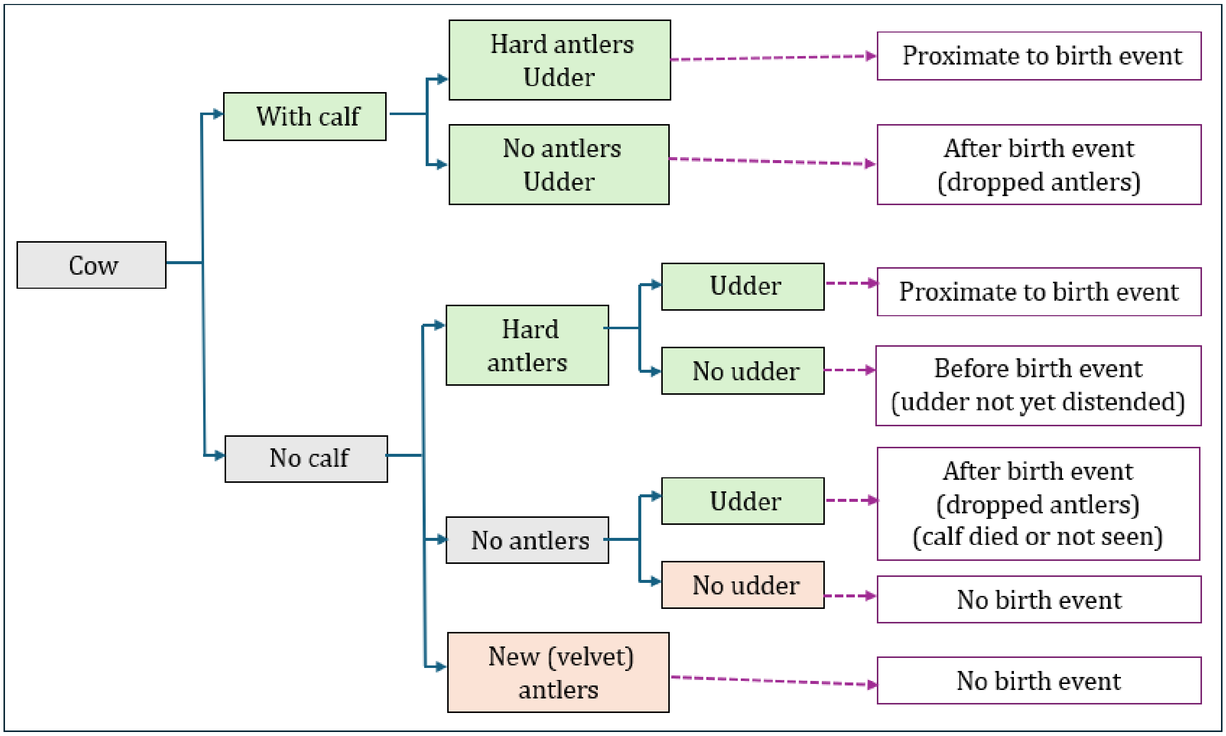

Figure 4. Classification criteria for cows during the June composition survey, with green-shaded boxes classified as breeding females and orange-shaded boxes classified as non-breeding females. Udder observation refers to a visibly distended udder in a cow that has given birth or is about to. Hard antlers (usually white) are from the previous year and retained until calving by pregnant females and are distinct from new velvet-covered antler growth. The inferred time of calving event relative to observed criteria is noted in the right-side column.

Survey field methods

Reconnaissance and visual survey

Aircraft setup and data collection

The visual and reconnaissance surveys were both flown at 160 km/h and 120 m above ground. Two Cessna 208 Caravan aircraft were used for each survey. Both aircraft had radar altimeter to ensure that altitude above ground remained constant. To allow observers to identify the survey strip widths (distance bins) in which observations occurred, survey transects and bin widths were marked on the wing struts using coloured electrical tape, with streamers (rope and freely-spinning end pieces) attached to help delineate each strip width. As in previous surveys, Norton-Griffiths's (1978) formula was used to determine the locations and distances on the wing strut that would correspond to the correct ground distances, as viewed by the observer (Figure 5). Survey strip widths (bins) that equate to equal coverage on the ground (200 m wide) are thinner when farther from the aircraft, from the observer's perspective. Figure 6 shows a training diagram used to orient observers to the new method.

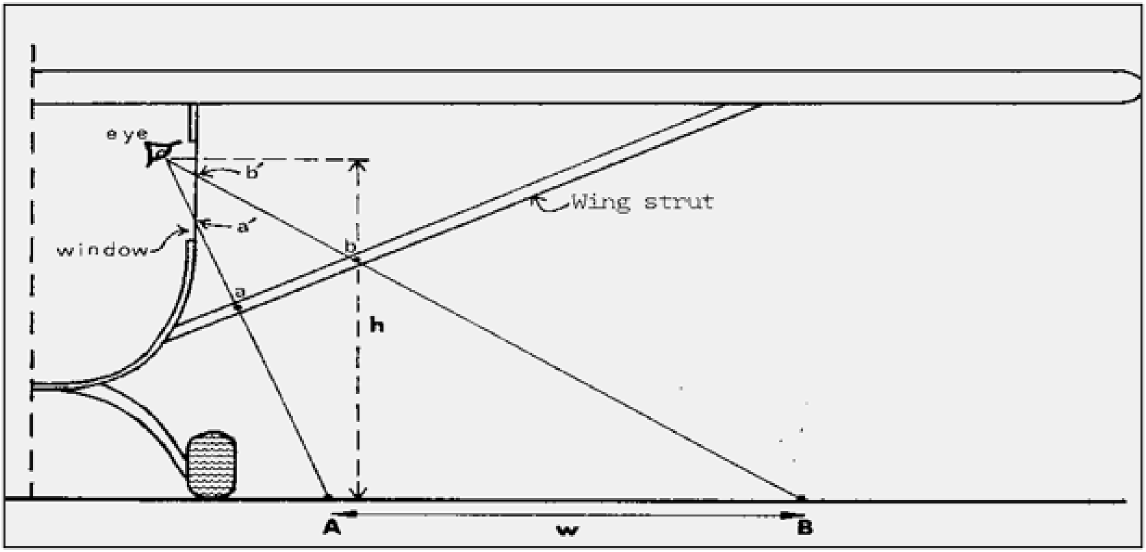

Figure 5. Schematic diagram of aircraft configuration for strip width sampling using w=W*(h/H) where W is the strip width, H is the flight height, h is the observer's eye height above the ground when the plane is on the ground, a marks the location of the strut that lines up with A on the ground as the near edge of the strip, and w is the distance on the ground calculated to position the wing strut markers. The wing strut markers are placed at b when the observer has lined up the b location on the wing strut with B on the ground. The location of b is marked with a piece of tape on the inside of the window so that observers can confirm they are lined up correctly with the distance markers.

Although the standing height of observers varied by > 6 inches, the sitting height (measured from seat to eye) of observers only varied by 1-2". Cushions were provided so that observers with a shorter 'sitting height' would have the same viewing height as observers with a taller 'sitting height'.

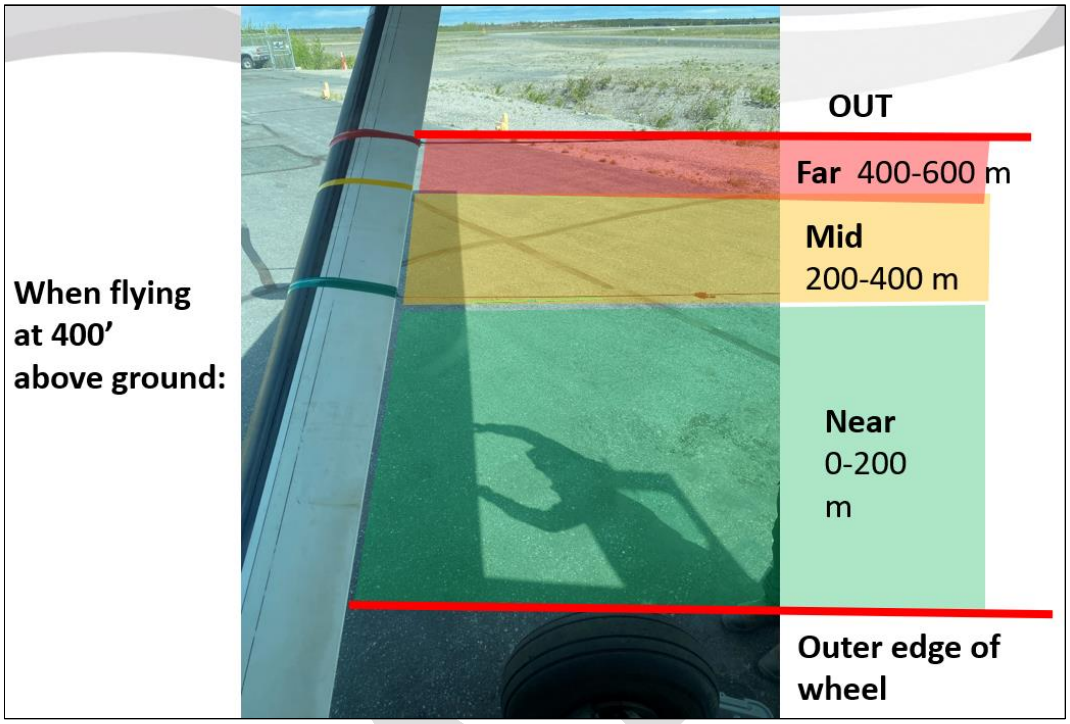

Figure 6. An annotated photo shows how strip widths are marked on the wing strut with coloured tape and streamers, and which ground area corresponds to each survey bin when the aircraft is 400’ (120 m) above the ground. Survey bins that are farther from the aircraft appear thinner to the observer than survey bins closer to the aircraft.

Survey observations were collected using a Microsoft Surface Pro 10 with 5G tablet and Observation Collector (OC) software initially created for the 2011 Beverly survey (Campbell et al. 2012) and maintained by Caslys Consulting Ltd. The OC software was modified for the 2026 surveys to incorporate distance bins and data recorder observations. The touch-screen tablets recorded the names and positions of survey team members and aircraft for each survey session and recorded georeferenced survey observations and a lower-resolution flight track. Each caribou and incidental wildlife observation was linked to a GPS waypoint and survey transect. The data recorder also recorded percent snow cover and percent cloud cover. Percent snow and cloud cover could be entered with any caribou group observation (selecting from 0, 5, 10, 25, 50, 75 or 100%, or entering a value from 1-100%) or as a georeferenced observation independent of a wildlife observation. Percent snow and cloud cover values were applied to each subsequent caribou observation until a new value was entered by the data recorder (i.e. if there was 0% snow across an entire flight track it did not need to be recorded with each observation). The updated OC interface is shown in Supplementary Figure A-1. Garmin 276CX GPS units were used to collect a higher-resolution flight track.

Observer methods

The reconnaissance and visual surveys rely on a large survey team, with 2 data recorders and 4 observers in each of two survey aircraft. Observers participated from communities across the Bluenose-East and Bathurst caribou range and from the Wek'èezhìi Renewable Resource Board. Two aircraft were used to shorten the survey time to take advantage of suitable weather and reduce the chance of over- or under counting caribou that moved during the survey. This was important as both the Bluenose-East and Bathurst calving grounds were to be surveyed out of Kugluktuk during the peak calving period.

Calving ground surveys have primarily been strip transect surveys (Jolly 1969), with a double observer method to estimate sightability used in NWT and Nunavut calving ground surveys since 2011 (Campbell et al. 2012). In this survey we further adapted these methods to introduce a modified distance sampling method, as suggested following Nunavut's 2023 Beverly calving ground survey (Appendix C in Campbell et al. 2025). These methods require observers to indicate which distance bin the observed caribou were in. The modified distance-sampling bins were delineated at 0-200 m, 200-400 m, 400-600 m, and "outside". The primary strip transect was 400 m on each side of the aircraft (800 m total), consistent with previous strip transect surveys. We were prepared to use the primary strip transect for the abundance survey (where observers would only indicate if caribou observations were "on" or "outside" the transect) if the distance bins proved to be challenging, but observers readily adapted to the three bins. Data from the two inside bins were combined to represent primary strip transect observations.

Each side of the aircraft had a front (primary) and rear (secondary) observer and a data recorder, who also acted as a third observer when time permitted (Figure 7). Front and rear observers switched places between flights. Both data recorders were positioned behind the observers in the rear of the aircraft (instead of a navigator-data recorder sitting in the front right seat next to the pilot) and actively recorded any caribou groups missed by the primary and secondary observers. When weather permitted each plane completed two flights with a break to refuel in between. On some days an additional observer or data recorder flew in one of the additional seats for training purposes. When on survey transects, the left and ride side of the aircraft used separate communication systems that allowed them to communicate within their group without hearing the observations from the other side of the aircraft.

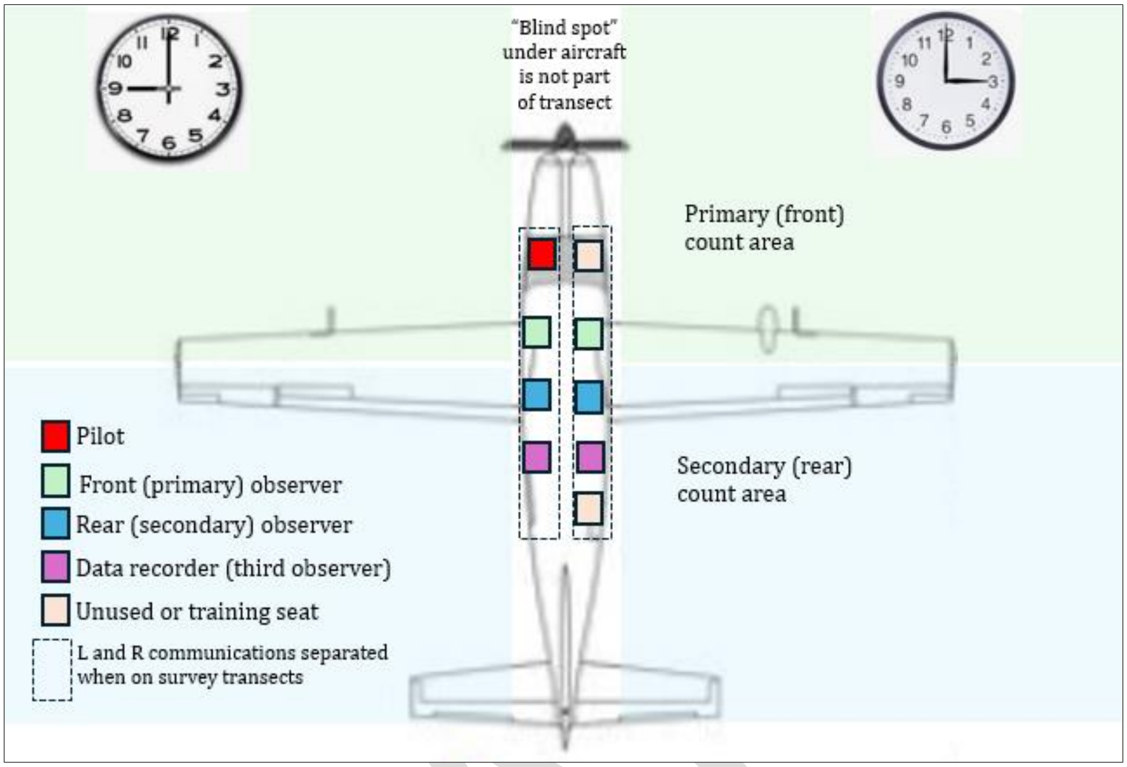

Figure 7. Observer and recorder positions for double observer method used in the Cessna 208 Caravan aircraft for the June 2025 Bluenose-East calving ground survey. Distance sampling bins are not shown here. Data recorders acting as a third observer when time permitted was new for the 2025 surveys.

The sample unit for these surveys was the observed group of caribou, regardless of size. Sightings of individual caribou that were influenced by seeing other caribou were considered a group. For the double-observer method, six basic steps were followed: (1) the front observer called out all groups of caribou (number of individuals and which distance bin) seen before they passed the front observer's position using an approximate dividing line between the front and rear observer perpendicular to the aircraft. Using a clock face as reference, this included caribou groups between 9 and 12 o'clock for the left side front observers and between 12 and 3 o'clock for the right side front observers. (2) After the caribou passed behind this viewing area, the rear observer noted whether they had seen those same groups and if they had observed any additional groups. The rear observer waited to call out caribou until the group observed passed the dividing line (9 'clock or 3 o'clock). (3) When needed, the observers and data recorder discussed the group count to confirm they were calling the same or different group. (4) The data recorder noted whether an observation was seen by the "Front [only]", "Rear [only]" or "Both" observers. (5) New for this survey: If the data recorder saw any caribou groups not noted by either observer, they were recorded as seen by "Recorder". (6) Front and rear observers switched places between flights.

During the reconnaissance survey observers also noted, where possible, if they had observed cows with hard antlers or calves (or were certain of their absence), or bulls/yearlings. With survey flight speeds of 160 km/h in the aircraft it was not always possible to determine these features and aircraft did not divert from planned transect lines to investigate caribou groups. However, recording this information, when available, helped to delineate areas with and without breeding females, which informed the stratification of the abundance survey.

The focus of observations differed between the reconnaissance and visual (abundance) surveys. The objective of the reconnaissance survey was to delineate the calving ground survey area based on the presence of breeding female caribou, and to stratify the survey area for the abundance survey. Therefore, more focus was placed on collecting information about breeding status, and on training new observers on the double-observer technique and estimating group sizes of caribou. On both survey types, georeferenced observations of other large mammals and birds (e.g. wolves, grizzly bears, muskox, moose, wolverine, eagles) were also recorded.

During the visual abundance survey, more focus was placed on detecting and counting caribou as accurately as possible, and sex and breeding status were not recorded.

Photo survey

Two aircraft, a Piper Malibu Jetprop PA-46T and a Piper Navajo PA-31, were used for the photo survey. The Piper Malibu Jetprop PA-46T used jet fuel and the Piper Navajo PA-31 used aviation gas. Drummed aviation gas was transported to Kugluktuk ahead of the survey to support the Navajo aircraft.

Each aircraft was equipped with a Vexcel Ultracam Eagle 4.1 (UCE4) camera with an image frame of 28,110 x 18,060 pixels, which captured a 35 – 40% larger footprint and higher-resolution photos than previous digital cameras used for calving ground surveys. The camera system was mounted in a gyro-stabilized mount with an airborne GPS and inertial measurement systems to allow for precise GPS navigation of survey flight lines and photos and could store up to 7,300 photos. A 60% forward overlap of photos was maintained for stereo coverage with no lateral overlap. After the survey team completed the stratification for the abundance survey and assigned transects to the photo strata, weather conditions were evaluated for what altitude the transects could be flown to obtain sufficient coverage. The final planned transects were emailed to the photo aircraft support team in Okotoks, Alberta for verification and creation of files for the flight management system that were sent to the pilots to navigate and operate the camera.

Composition survey

During the composition survey caribou were classified as cows, calves (< 1 month old), yearlings (approximately 1 year old), small (young) bulls, and large (mature) bulls. Young and mature bulls were differentiated by body size and antler size; young bulls and non-breeding cows were differentiated by presence/absence of a vulva patch. Cows were further classified based on presence/absence of hard antlers and presence/absence of a visible distended udder. Cows with any of a calf, hard antlers, or distended udder were considered breeding cows (i.e., had a calf, were about to calve, or very recently lost a calf). Cows lacking any of these criteria were considered non-breeders (Figure 4).

Caribou were classified from an A-Star helicopter using image-stabilizing binoculars (Canon 10 x 42L IS WP). Aerial classification was conducted in a way to minimize stress to caribou groups with the helicopter remaining as far away as possible while allowing observers to identify features and classify caribou. Caribou typically moved at a walking or trotting pace. If caribou began to run faster than a trot or a birthing event was observed or suspected, the classification was suspended and the helicopter moved away from the group. The crew also landed to classify larger groups but were unable to determine presence/absence of visible udders and of calves in flat terrain with bedded cows and calves. A Microsoft Surface Pro 10 with 5G tablet and Observation Collector software for composition survey data was used to record survey data and collected a georeferenced location for each group of classified caribou. The composition survey software interface is shown in Supplementary Figure A-2. A Garmin 276CX GPS recorded a detailed flight path.

To reduce ferry times and support mid-day refueling in the survey area, the helicopter moved 8 45-gallon drums of jet fuel from Kugluktuk to a central location on the calving ground at the start of the survey, and returned the empty drums to Kugluktuk at the end of the survey.

Survey data analysis

Visual survey data analysis

Data screening (visual survey)

Caribou observations from the visual survey were filtered to only include observations within strata boundaries by intersecting GPS coordinates of each sighting with the strata area and excluding those occurring outside the boundary. Photo and visual strata boundaries were revised during post-processing of data sets so that all available photo transect data was included in the photo strata (see section below). Where this contacted the adjacent visual strata boundary, visual survey observations were filtered out of transect counts if they occurred outside of the revised stratum boundary.

After filtering the visual survey data, the main strata attributes and caribou observed on-transect within each stratum were summarized for both the 400 m strip width (800 m transect) and the 600 m strip width (1200 m transect).

Overview of visual survey methods

For aerial transect surveys using human observers, sightability is a known bias where observers do not perfectly detect every animal within the survey area due to many factors including ground cover (i.e. patchy snow), an observer's ability to spot caribou, and distance of groups from the aircraft. Methods to conduct surveys and to estimate sightability (or detection) continue to be reviewed and updated to improve the robustness of estimates, while maintaining the ability to compare estimates to previous survey estimates. Prior to 2011, calving ground visual surveys used a 0-400 m survey strip width on each side of the aircraft, with the assumption that all caribou in the survey area were detected (Jolly 1969). Since 2011 (Campbell et al. 2012), NWT and Nunavut calving ground surveys have used a 400 m strip transect combined with a double observer mark-recapture modelling effort to estimate sightability in visual strata. In 2025, we modified the visual survey methods to incorporate distance sampling, and to include observations from the data recorder as a third observer on each side of the aircraft. An analysis of these abundance modelling frameworks, including previously-used methods (strip transect and double observer) as well as distance sampling and an approach that combines distance sampling and double observer methods (MRDS) were explored. This comparison of analytical frameworks is described in detail in Boulanger et al. 2026. Based on that analysis, it was judged that using data from all three observers and the distance sampling method, using 3 distance bins across a 600 m strip transect, produced the most robust estimates for the visual strata. These distance sampling analytical methods are described below, with more detail on this and other methods provided in Boulanger et al. 2026.

Distance sampling

Analysis of previous caribou surveys (Boulanger and Campbell 2025) and simulation analyses suggested that it was feasible to employ reduced distance sampling methods to improve caribou survey estimates. Unlike previous strip transect and double observer methods, distance sampling utilizes information from the change in sightability of caribou at further distances from the survey aircraft. Studies have suggested that it provides a more robust methodology to confront detection variation in visual surveys in comparison to strip transect and double observer methods (Laake et al 2008a, 2008b, Laake and Collier (2024)).

The potential robustness of distance sampling methods compared to double observer methods is due to the associated assumptions with each method. For distance sampling, estimates will likely be robust to variation in detection probabilities if detection probabilities in the immediate vicinity of the aircraft are 1 (all caribou are observed at distance = 0) (Buckland et al 2001, Rexstad et al 2023).

In contrast, double observer methods assume that all caribou groups have equal probabilities of being sighted. This assumption can be relaxed using covariates (i.e. group size) and robust estimates produced if covariates (i.e. group size) can model the observed variation. However, the ability of two dependent observers to model variation is limited especially at further distances from the survey aircraft (Laake et al 2008b). The dependent double observer method does not allow the use of data recorder observations.

In Nunavut spring and fall caribou surveys, distance sampling methods have been used where caribou observations are assigned to one of five distance bins across a 1500m survey strip

(Campbell et al. 2012). Results from these caribou surveys estimated that detection probability declines with distance within the 400m survey strip as well as across the entire 1500m survey strip (Boulanger and Campbell 2025). We established 3 distance bins of 0-200m, 200-400m, and 400-600m instead of 5, for two reasons: 1) expected higher densities of caribou would increase demands on observers to call and reconcile groups, and 2) results from Nunavut surveys suggested a decline in detection probability occurs across 3 - 200m bins. The nearest two bins of 0-200m and 200-400m allowed us to analyze data that was consistent with previous calving ground surveys that used a 400m strip transect width.

Calving ground surveys for the Bluenose-East and Bathurst herds in June 2025 were based out of Kugluktuk by the same survey crews and aircraft. To maximize sample sizes for detection and probability modelling, reconnaissance and visual data from both surveys were used to maximize samples sizes. The largest group of caribou that occurred in th e Bluenose-East and Bathurst visual survey strata was 35 so data from the reconnaissance survey was restricted to groups of 35 caribou or less.

Distance sampling estimates were derived by fitting a detection function to the 3 survey bins under the assumption that sightability will decrease with distance from the survey plane (Buckland et al. 1993, Thomas et al. 2009). The main detection functions considered were half-normal, hazard rate, and uniform. The covariates used are shown in Table 2.

Table 2. Covariates used to model variation in sightability for distance and dependent double observer pair analysis.

Covariate	Acronym	Description
Observer pair	obs	each unique observer pair
Group size	size	size of caribou group observed
	logsize	Natural log of group size
Herd	herd	Calving ground being surveyed
Phase	Phase	Reconnaissance or visual
Strata	strata	Visual survey strata (reconnaissance pooled)
Distance	distance	Distance bin where group observed
Snow cover	snow	Percent cover (continuous)
Cloud cover	cloud	Percent cover (continuous)

The fit of candidate models within each of the methods above was evaluated using the Akaike Information Criterion corrected for small sample size (AIC_c). The model with the lowest AIC_c score was considered the most parsimonious, thus minimizing estimate bias and optimizing precision (Burnham and Anderson 1998). The difference in AIC_c values between the most supported model and other models (ΔAIC_c) was also used to evaluate the fit of models when their AIC_c scores were close. In general, any models with a ΔAIC_c score of less than 2 between them were considered to have equivalent statistical support. Overall model fit was also assessed using goodness of fit tests

(Buckland et al. 1993, Buckland et al. 2004) as well as graphical comparison of detection functions with histograms of frequencies of observations from the survey. Details of the distance sampling analysis are given in Appendix B.

Analyses of visual survey data were conducted in program *R* (R Development Core Team 2009) with plots being produced using the *ggplot* (Wickham 2009) R package with GIS analyses conducted in QGIS (QGIS Foundation 2020) and the *sf* (simple features) (Pebesma 2018) R package. In addition, the *AICmodavg* (Mazerolle 2016), *lubridate* (Grolemund and Wickham 2011), and *ddply* (Wickham 2011) R packages were used in the analysis.

Photo survey data analysis

Photo counting

Processing of the aerial photographs and counting of caribou were completed by Greenlink Forestry Inc. (Edmonton, Alberta). Photos collected along the straight-line transects were processed using AGPS (camera position) and IMU (camera orientation and movement) data to establish the location and orientation of each image. The photos were then geographically aligned and corrected, and DATEM 3D files and single-image orthophotos were created from the 6–8 cm GSD RGBN imagery. Adjacent photographs were paired to create 3D views with at least 60% overlap. An ArcMap template was used to help prevent duplicate counting and to calculate caribou numbers for each photograph. Photo interpreters calibrate their search image by locating and viewing caribou, and then start at the top right of each photo (using the overlaid template) and search through the imagery in an S pattern. A consistent scale (zoom level) is maintained, but the DATEM software provides a zoom window in a corner of the screen to help review details as needed. Each identified caribou and other wildlife are marked with a georeferenced point. Caribou counts were summarized by photograph and transect, and cloud-obscured areas were estimated for each transect. Detailed methods are included in Supplementary Information (Appendix A).

Photo survey data screening

For photo transects, the transect width was the area photographed by the photo plane. The ground coverage of each photo varied slightly due to the height of the aircraft as it followed elevation changes across the survey area to maintain a consistent height above ground. A consistent strip width for each photo transect was determined using samples of the strip width of 3 georeferenced photos per photo transect. The mean strip width for each photo transect was measured from each georeferenced transect flight line and overlaid with the georeferenced caribou counts. Any georeferenced caribou counted outside of that strip width on each photo (i.e. "off transect") were filtered out.

The large strip width achieved by the new UCE4 camera also resulted in photo coverage outside of the photo strata when the flight line was close to a strata boundary or the corner of a strata was not a 90° angle. When this occurred the extent of the photographed area was usually trimmed based on strata boundaries (Supplementary Figure A-3). During post-processing of data sets the southern end of the PhotoSouth stratum was extended to include the full width of the southernmost photo transect line (prioritizing available photo survey data over visual survey data in that area). Visual survey observations that occurred in the revised photo strata were used for mark-recapture modelling (if 35 or less caribou) but were not included in visual estimates.

After filtering the data from the photo strata, the main strata attributes and caribou detected in each stratum were summarized.

Photo sightability correction factor

Overall photo sightability was tested by having 200 photos re-counted by a second independent photo interpreter and comparing the results of the 2 independent counts. The sampling design and results for estimating photo sightability are described in Appendix C.

Counts from observer 1 (n_1) and observer 2 (n_2) were compared for each cross-validated photo. As detailed in Appendix C these analyses did not detect a sufficient number of caribou detected by single counters to warrant further analysis of the data using more complex methods to estimate detection probabilities. Given this outcome, the ratio of n_1/n_2 was used as an estimate of photo sightability assuming that observer 2 detected all the caribou detected by observer 1, and any additional caribou were only observed by more experienced observer 2. A bootstrap approach (Manly 1997), which used individual photos as a sample unit, was used to estimate standard error and percentile-based confidence limits. The correction factor was then applied to the photo strata estimates.

Composition survey data analysis

Data was downloaded and overlaid with survey strata boundaries to assign observations to strata. Observations that occurred outside of survey strata were not included in analyses. The proportion of breeding females, total adult females, yearlings, and bulls was then estimated for each stratum of the abundance survey, and the proportion of breeding cows/cows, calves/cows and calves/breeding cows were also calculated for each stratum. Bootstrap resampling methods (Manly 1997) were used to estimate standard errors and percentile-based confidence limits for each proportion.

Estimates of caribou on calving ground

The Jolly 2 strip transect estimator (Jolly 1969) was used to estimate the number of caribou in each survey stratum based on the on-transect caribou density estimates obtained for the visual and photo strata using the above methods. The proportion of breeding females, total adult females, yearlings, and bulls estimated for each stratum from the composition survey was applied to those estimates to derive the number of caribou in each category (breeding females, non-breeding females, yearlings, and males) for each stratum. Those estimates were added together to obtain calving ground survey estimates of the total 1+ year old adult caribou on the calving ground, the total 2+ year old adult females on the calving ground (i.e. not including female yearlings) and the total breeding females on the calving ground. We estimated the total bulls on the calving ground, although this is only a portion of the bulls in the herd (not all bulls migrate as far north as the calving ground and survey area). The delta method ($SE_{AF} = \sqrt{N_{AF}^2 * (CV_{pf}^2 + CV_N^2)}$) was used to obtain standard error estimates for each category where CV_{pf} was the CV of the composition proportion estimated and CV_N was the coefficient of variation for the abundance estimate for a given stratum.

Estimates from the photo and visual strata were added to obtain an overall estimate of 1+ year old caribou on the calving ground. Variance for the overall estimate was based on the sum of the variance of each stratum estimate with the standard error of the overall estimate being the square root of the sum of strata variances. Log-normal confidence limits were then estimated for the overall estimate. Log-normal confidence limits, which are asymmetrical, take into account the skewed distribution of abundance estimates (Buckland et al 2001).

Extrapolated estimates of herd size

Extrapolated herd estimates are derived from the estimate of total adult females on the calving ground and the proportion of adult males to adult females in the herd during the rut, when both sexes are together, as estimated in one or more fall sex ratio surveys.

As for the previous two Bluenose-East calving ground surveys (Boulanger et al. 2022, 2024), the mean of the sex ratios estimated in the fall before and after the calving ground survey was used to derive the 2025 Bluenose-East herd estimate.

The actual estimator uses the estimate of total adult females on the calving ground divided by the proportion of adult females in the herd (sex ratio) from the 2024 and 2025 fall composition surveys. This process is equivalent to adding the estimated population of bulls to the adult female estimate.

Telemetry and demographic data for the Bluenose-East herd

We evaluated 2025 collared caribou movements and locations in relation to the 2025 survey area and fidelity of female caribou to the Bluenose-East calving ground in recent years.

We also reviewed demographic data from other field surveys of the Bluenose-East herd including fall composition surveys, late winter composition surveys, previous calving ground surveys, and annual survival rates of collared cows and bulls. As with previous Bluenose-East calving ground surveys since 2018 (Boulanger et al. 2019, 2022, 2024), this data was used in demographic modelling to integrate the calving ground survey estimates with other field data (see below).

Annual survival rates for collared cows and bulls were estimated for the June-May biological year, using monthly survival rates based on the number of active collars and mortalities documented each month and accounting for the staggered entry and censoring of individuals in the data set

(Pollock et al. 1989). These survival estimates can change slightly over time when new information is received from confirming presumed mortalities or collar failures at stationary collar sites.

Integrated population models (below) evaluated whether the calving ground survey results were consistent with other survey data, and by considering multiple sources of data on the Bluenose-East herd, provide more informed population trends.

Integrated population modelling of demographic data

Integrated Population Models (IPMs) provide a way to estimate the herd trend (and other parameters, e.g., calf survival) using all these pieces of information. We used a Bayesian state space IPM (Buckland et al. 2004, Kery and Schaub 2011, Schaub and Kery 2022) based upon the original (OLS) model (White and Lubow 2002) developed for the Bathurst barren-ground caribou herd (Boulanger et al. 2011) to further explore demographic trends for the Bluenose-East herd.

The IPM is a stage-based model that divides caribou into three age-classes, with survival rates determining the proportion of each age class that makes it into the next age class (Figure 8). The life history model is based upon a "caribou year" that starts in June when calves are born and ends at the end of May when caribou have arrived or are close to arriving on the calving ground. A "twoling" age class was considered with the assumption that two-year old caribou were not breeding (at ~16 months old during the fall rut and 24 months old on the calving ground). There is insufficient data to estimate yearling survival and therefore it is set to equal adult female survival. Twoling survival is also set to equal adult female survival.

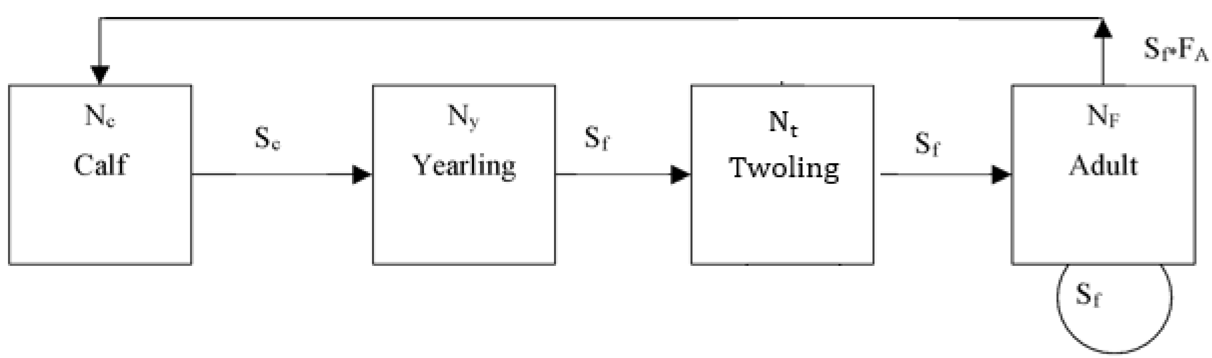

Figure 8. The stage matrix life history diagram for the caribou demographic model used for Bluenose-East barren-ground caribou herd in 2025. This diagram pertains to the female segment of the population. Nodes are population sizes of calves (N_c), yearlings (N_y), "twolings" (two-year-old cows, N_t) and adult females (N_F). Each node is connected by survival rates of calves (S_c), yearlings (S_f), twolings (S_f) and adult females (S_f). Adult females reproduce dependent on fecundity (F_A) and whether a pregnant female survives to produce a calf (S_f). The male life history diagram was similar, but with no reproductive nodes.

Field estimates are observed data collected from collared caribou and surveys that are used to inform the IPM. The breeding and adult female estimates in June, calf-cow ratios in October and March, bull-cow ratios in October, estimates of the proportion of breeding females in June, and adult cow and bull survival rates from collared caribou were used to estimate the most likely survival, abundance, and fecundity values that would result in the observed trends in all the demographic indicators for the Bluenose-East herd.

Estimated harvest values were also included. For harvest levels, we used reported values but allowed variation around these values to reflect levels of uncertainty. The IPM used information from the collar survival rates, herd size (and related trend), as well as productivity to estimate harvest for bulls and cows. Harvest was assumed to occur in January and was additive to natural mortality.

Models used in this analysis do not estimate emigration or immigration into or out of the Bluenose-East herd under the assumption that movement into equals movement out of the Bluenose-East herd. We provide a summary of emigration and immigration based on collars to allow further evaluation of the assumption of equal immigration and emigration. More advanced emigration and immigration models will be run in the future.

Random effect models were used to model yearly variation in demographic parameters. A random effect model can be conceptualized as sampling a distribution of values with a mean central value. In the context of the demographic analysis, it basically assumes a mean value of a demographic parameter (i.e. adult survival rate) with annual yearly variation.

This work was in collaboration with a Bayesian statistician (Joe Thorley-Poisson Consulting; Thorley 2017, Ramey et al. 2018, Thorley and Boulanger 2019). Details on the IPM approach are in Appendix D. All results are reported with the mean and 95% credible intervals.

RESULTS

Survey overview

The June 2025 survey was based out of Kugluktuk, Nunavut, from June 3 – 15, 2025. The survey team included observers from several Indigenous Governments and Indigenous organizations: the Kugluktuk Hunters and Trappers Organization, Délı̨nę Renewable Resources Council, Tłı̨chǫ Government, Wek'éezhìi Renewable Resources Board, North Slave Métis Alliance, Northwest Territories Métis Nation, Yellowknives Dene First Nation, and Łutsël K'é Dene First Nation.

Survey conditions and daily flying

Spring conditions were delayed in 2025, and caribou migrated north to their calving grounds later than in recent years, with timing of migration more similar to 2018-2020 (Supplementary Figure A-4). Once it warmed up, snow melted rapidly on the calving grounds, leading to excellent visibility of caribou on the calving grounds (Supplementary Figure A-5).

Weather was generally good for survey conditions (i.e. clear skies and snow-free ground conditions). We did not fly due to weather on 1.5 days near the start of the survey (June 5 - 6), but during this time caribou movement rates on the calving ground were above what is considered peak of calving (mean < 5 km/day) and continued to decrease, which is optimal for survey timing. The reconnaissance survey was completed on June 6 (one aircraft in afternoon when weather improved) and June 7 (both aircraft). The photo survey was completed on June 8 and the visual survey was completed on June 8 (two aircraft) and 9 (one aircraft). The composition survey occurred on June 10-14. The survey timing corresponded to low mean herd movement rates associated with the peak calving period (Figure 9).

The photo plane was able to take unobstructed photos at a high altitude (GSD 8) over the calving ground, providing excellent coverage of the areas with the most caribou. The timing of the surveys corresponded to low mean herd movement rates associated with the peak calving period (Figure 9 below).

A summary of daily flying by aircraft and weather conditions for the duration of the calving ground survey is shown below in Table 3. Additional details on aircraft flight hours are included in Supplementary Table A-1. Daily weather conditions for the Bluenose-East abundance survey are in Supplementary Table A-2.

Table 3. Summary of daily flying and weather conditions for the duration of the 2025 Bluenose-East calving ground survey. Each black 'X' indicates a single aircraft flying a component of the Bluenose-East survey. The 2025 Bluenose-East and Bathurst calving ground surveys were completed by the same survey team out of Kugluktuk, therefore an aircraft flying a component of the Bathurst survey is indicated by a grey 'B'.

2025 Survey activity	June 3	June 4	June 5	June 6	June 7	June 8	June 9	June 10	June 11	June 12	June 13	June 14
Reconnaissance	Transit to Kugluktuk	BB	No flying - poor weather	X	XX		B		BB			
Visual abundance				Poor weather in AM		XX	X	BB				
Photo abundance						XX		B	B			
Composition								X	X B	X B	X B	X

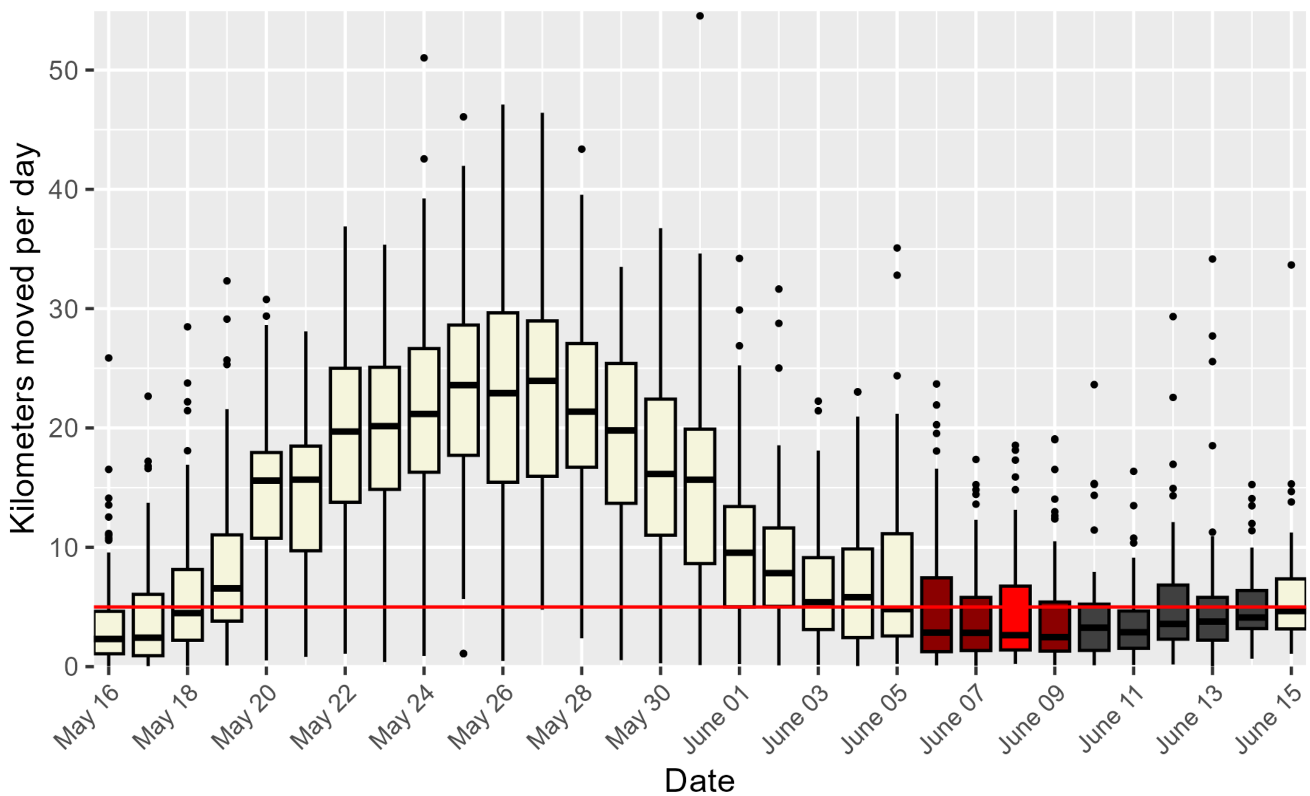

Figure 9. Mean daily movement rates (km/day) of collared Bluenose-East females. The red line indicates a mean herd movement rate of 5 km/day, used as a general reference for movement rates associated with peak calving. Dates when survey components were conducted are shaded dark red (reconnaissance and visual surveys), bright red (photo survey), and grey (composition survey). For Bluenose-East, on June 8 both the visual survey and photo survey were conducted.

Reconnaissance survey

The reconnaissance survey was conducted for the Bluenose-East on June 6 and 7, 2025. The data was visually summarized to inform the stratification of the abundance survey. Figure 10 shows the relative sizes of caribou groups observed on-transect on survey flight lines and the locations of collared caribou on June 7 when most of the reconnaissance survey occurred. Figure 11 shows the density of caribou observed on transect summarized by transect segments and segments in which breeding caribou were noted. Figure A-6 provides more detail on the composition data recorded during the reconnaissance survey.

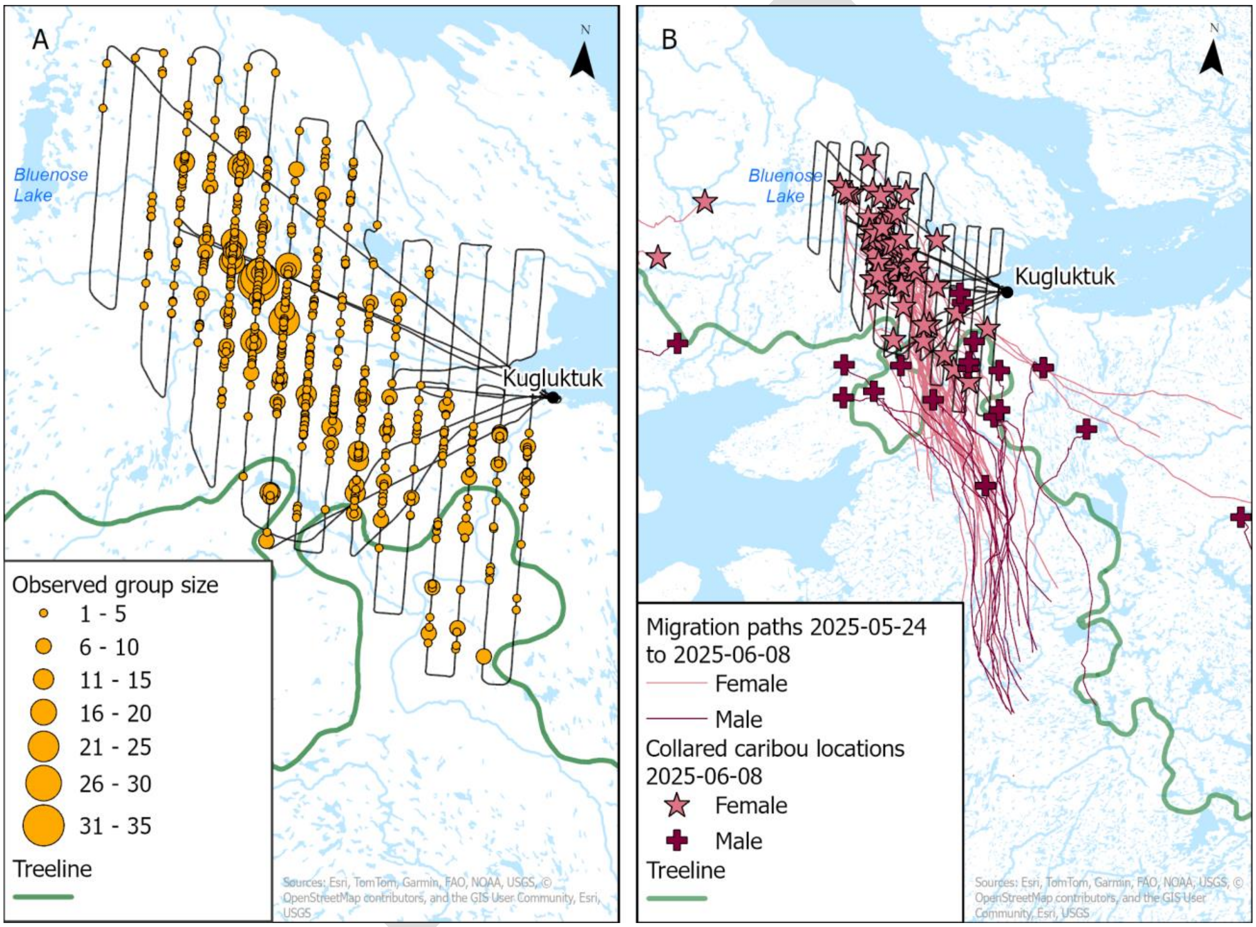

Figure 10. A) On-transect (400 m strip width) caribou groups observed during the June 6 and 7, 2025 Bluenose-East calving ground reconnaissance survey, and B) locations of collared cows (stars) and bulls (crosses) on June 7, 2025, with migration paths from May 24 to June 8 shown.

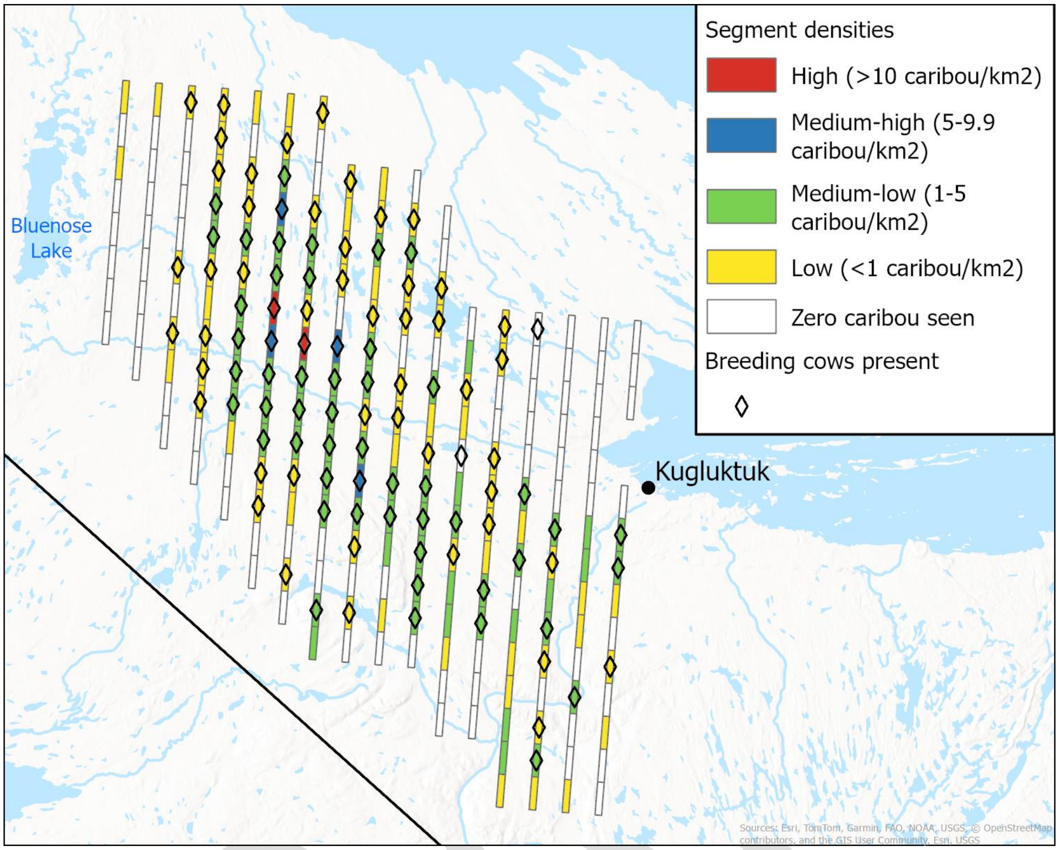

Figure 11. Segment densities of caribou observed on-transect (400 m strip width) during the June 6 and 7, 2025 Bluenose-East calving ground reconnaissance survey. Diamonds indicate segments where at least one breeding caribou (calf and/or cow with hard antler) was noted during the reconnaissance survey.

Stratification for the abundance survey

Delineating strata

Initial survey blocks drawn based on the reconnaissance data are shown in Figure 12.

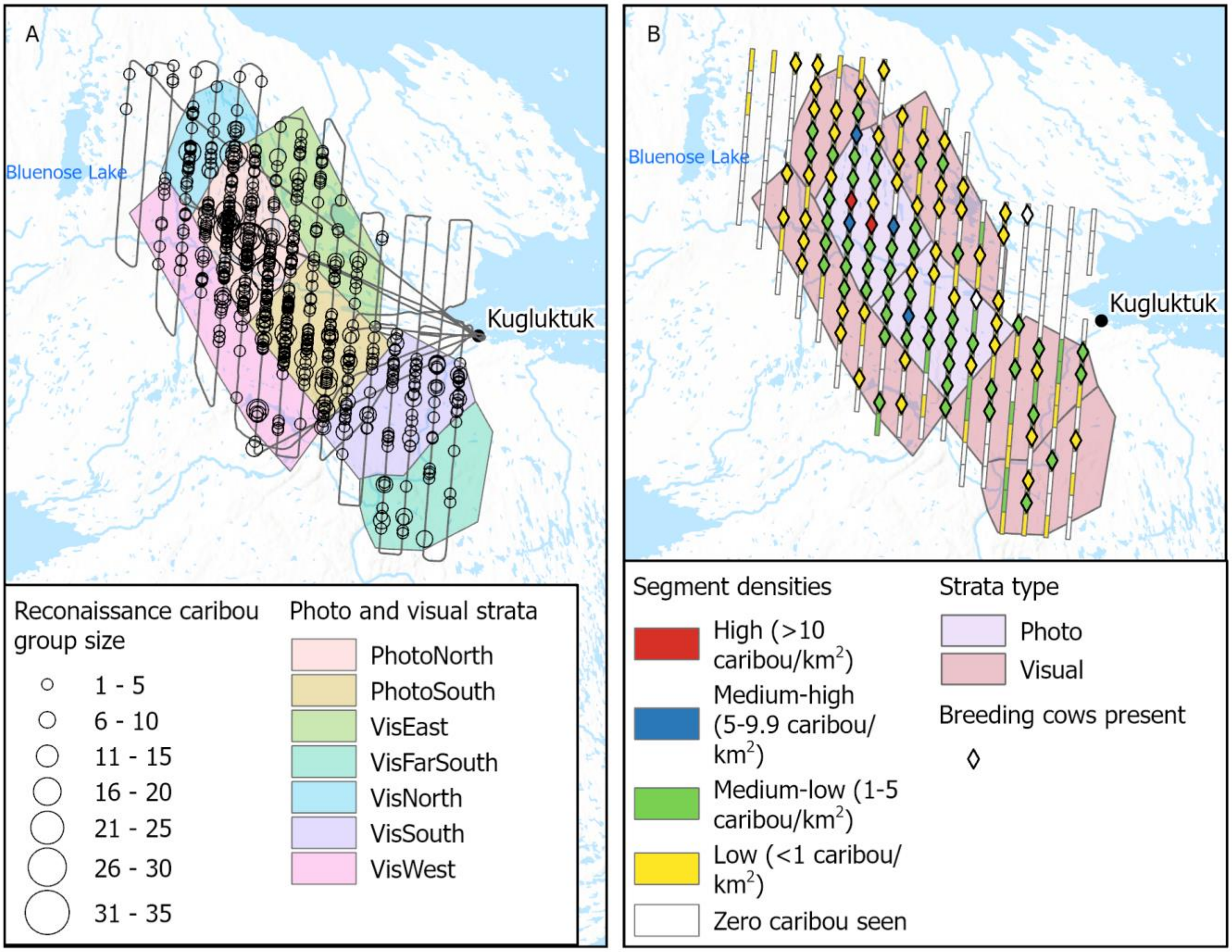

Figure 12. Abundance survey strata drawn based on reconnaissance survey data. Panel a) overlays the strata with the caribou groups observed on the 400 m strip width transect during the reconnaissance survey, mapped by group size. Panel b) overlays the strata with the on-transect density of caribou in each transect segment and indicates segments where at least one breeding caribou was observed (diamonds) within the 600 m strip width transect.

Allocating effort to visual strata

The optimal numbers of transects per visual stratum based on estimate density and variance (standard error) of each stratum as well as the adjusted number of allocated transects is shown in Table 4. For strata that had few transects (e.g. VisNorth) allocation based on abundance was considered more than based on standard error. Adjustments were within or near the range of transects suggested by the initial allocation. A reduction of transects within VisWest was made to allow flying as much of this stratum (along with other priority visual strata) as possible on the first survey day. VisFarSouth, (lower priority due to lower numbers of breeding caribou) was adjusted slightly upward given the closer proximity of this strata and extra time available on the 2nd survey day. VisNorth, which likely had higher densities of breeders, was adjusted to the upper level of the allocation. Strata coverage was between 0.18 and 0.34 at the 600m strip width which was used for the ultimate visual estimates (after comparison of methods). Total kilometers flown including transiting between transects in each stratum (but not including ferries from Kugluktuk) amounted to 3,017 km.

Table 4: Transect allocation results for Bluenose-East visual strata. The area of each stratum and the estimated density and coefficient of variation from reconnaissance surveys is given. The optimal number of allocated transects based on the standard error (SE), and estimated abundance from reconnaissance surveys, the adjusted number of transects, and associated coverage using the adjusted number using a 400m and 600m strip width is given.

Strata	Area (km²)	Reconaissance survey estimates		Allocated number of transects		Adjusted number of transects	Coverage	
		Density (caribou/km²)	CV	SE-based	N-based		400m	600m
VisFarSouth	2,334	0.49	0.31	12.9	11.2	14	0.15	0.22
VisNorth	1,403	0.82	0.24	8.7	16.6	15	0.23	0.34
VisSouth	2,667	1.09	0.19	16.8	21.3	18	0.21	0.31
VisWest	3,292	0.69	0.29	42.8	28.0	25	0.15	0.23
VisEast	2,532	0.54	0.20	14.5	17.9	14	0.12	0.18

Allocating effort to photo strata

The abundance survey stratification identified 2 blocks with higher densities of caribou that would be surveyed with the photo plane.

Based on the allocation algorithm, baseline width, average transect length of each stratum, and flight logistics, 18 flight lines were allocated to the north stratum (PhotoNorth) and 10 flight lines were allocated to the south stratum (PhotoSouth) using both the abundance- and variance- based methods, and were not manually adjusted (Table 5).

Table 5: Reconnaissance-based estimates and transect line allocation for Bluenose-East photo strata. Area of each strata is given along with reconnaissance-based estimates of abundance (N), SE of abundance (SE), coefficient of variation of N (cvN)and density of the stratum (calculated by N/Area). Optimal sampling effort (number of transect lines) was estimated based on abundance/density (N-based) and variance within stratum (SE-based).

Strata	Area (km²)	Recon estimates				Allocated transect lines (no adjustments made)	
		N	SE	cvN	Density of Strata	N-based	SE-based
PhotoNorth	2264	8550	1307.1	0.18	3.6	18.5	18.1
PhotoSouth	2296	4741	853.2	0.18	2.0	9.6	10.0

Sampling coverage that could be obtained using the number of allocated flight lines was evaluated by comparing the ground coverage of the new UCE4 camera at various Ground Sampling Distance (GSD) associated with altitudes above ground level (Figure 13). A GSD of 5 to 8 would result in 3000 or fewer photos taken with coverage levels of 0.45 at GSD 5 to 0.69 at GSD 8 for the PhotoNorth stratum and 0.25 at GSD 5 to 0.39 at GSD 8 for the PhotoSouth stratum. These coverage levels were acceptable in terms of achieving precise survey estimates. Survey weather looked favorable so the main flight plan was developed for GSD8.

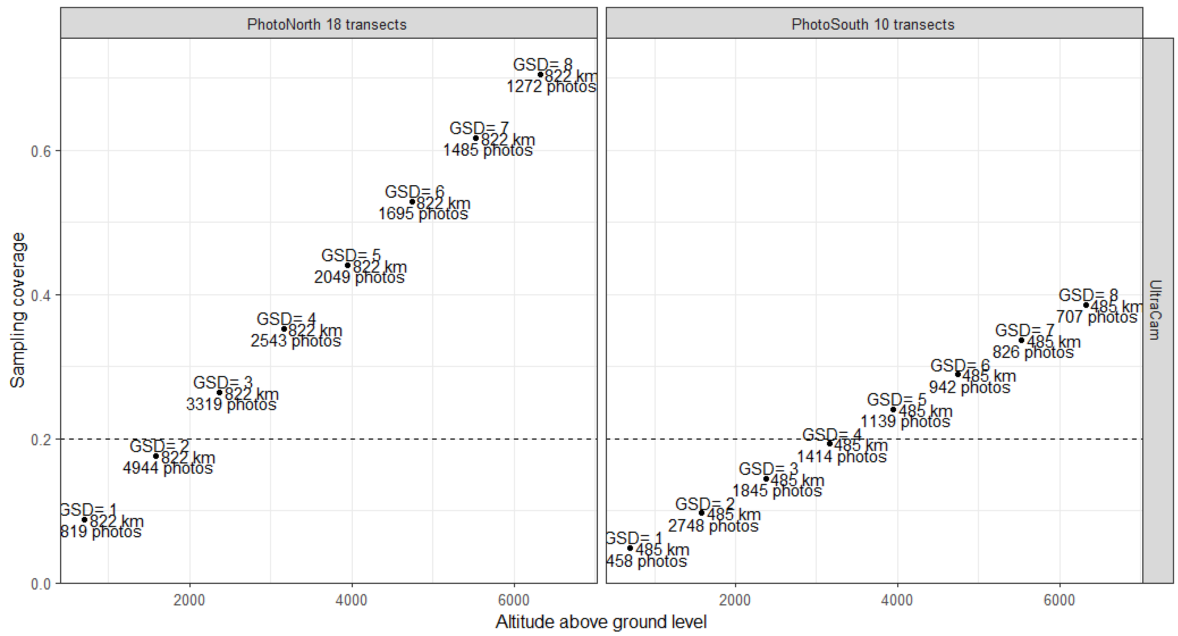

Figure 13: Sampling coverage for two potential photo strata given the area of each stratum, the number of transects flown, and the image frame size of the Vexcel Ultracam Eagle 4.1 camera, at different altitudes of the survey aircraft that provided GSD values of 1cm to 8 cm. At GSD=8 each pixel in the photo would represent an 8cm x 8 cm area on the ground.

Final abundance survey design

The resulting abundance survey design is shown in Figure 14. The transect flight lines planned for each stratum and the collared cow locations from June 8 when the photo survey and first day of visual survey occurred are also shown.

Of 61 collared adult females within the Bluenose-East calving range in June 2025, 29 were in the PhotoNorth stratum with the rest spread through the PhotoSouth and visual strata (Table 6, Figure 14), except one adult female (collared in 2025) that was located along the Coppermine River southeast of the survey area, and one female (on Bluenose-West calving ground in 2024) located northwest of the survey area.

Table 6. Number of collared adult females in each stratum of the 2025 Bluenose-East abundance survey.

	PhotoNorth	PhotoSouth	VisEast	VisFarSouth	VisNorth	VisSouth	VisWest
Collared adult females	29	12	4	2	5	4	3

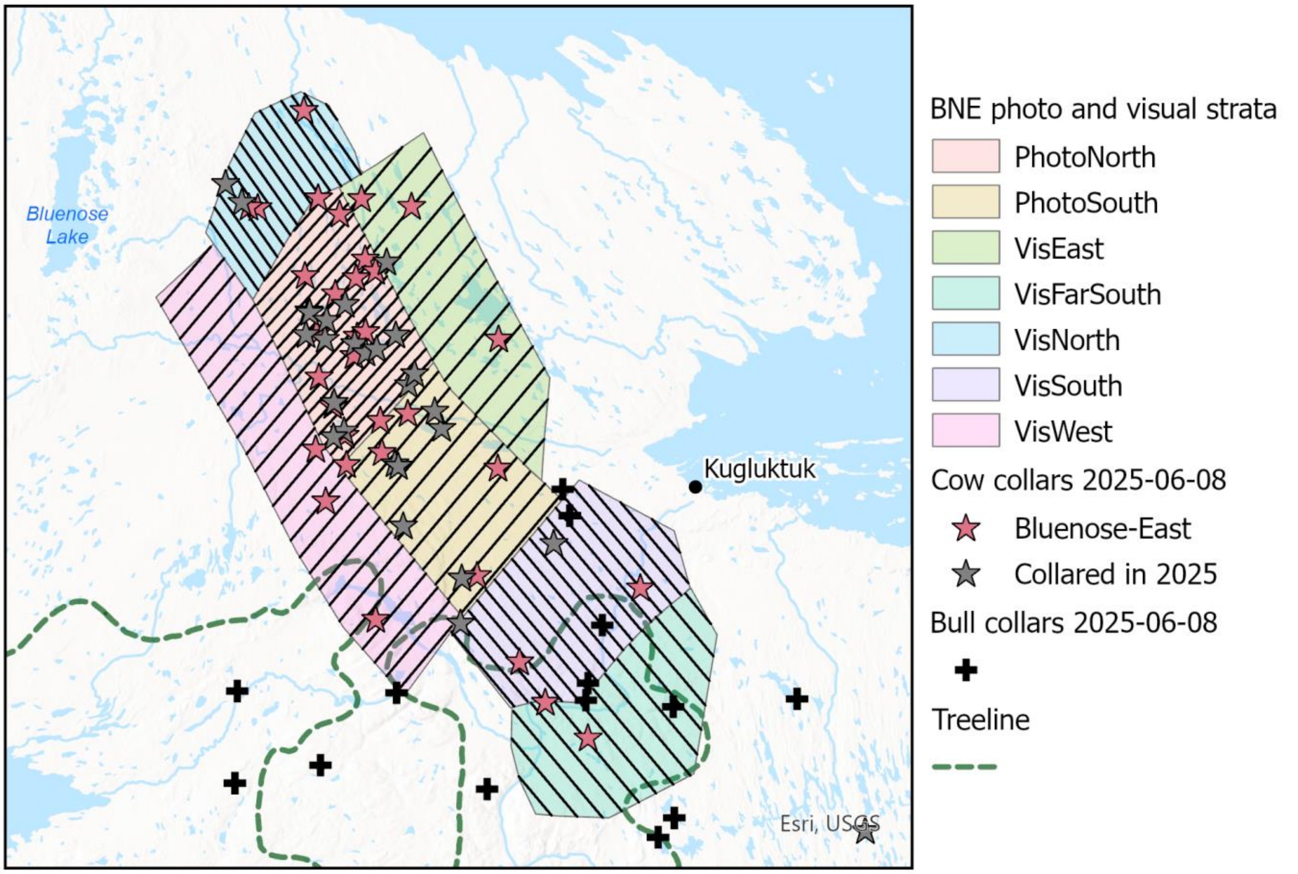

Figure 14. Final layout of the 2025 Bluenose-East calving ground abundance survey. The transect flight lines planned for each stratum are shown along with locations of collared female (stars) and male (crosses) caribou on June 8 when the photo survey and day 1 of the visual survey occurred. Red stars indicate collared cows that were on the Bluenose-East calving ground in 2024, and grey stars indicate cows that were newly collared in March 2025 (no known calving ground history). There were no collared caribou that used a different calving ground in 2024 than the Bluenose-East calving ground in 2025.

Visual survey

The visual survey was completed on June 8 (two aircraft) and 9 (one aircraft). Caribou groups observed on-transect during the visual survey are shown in Figure 15.

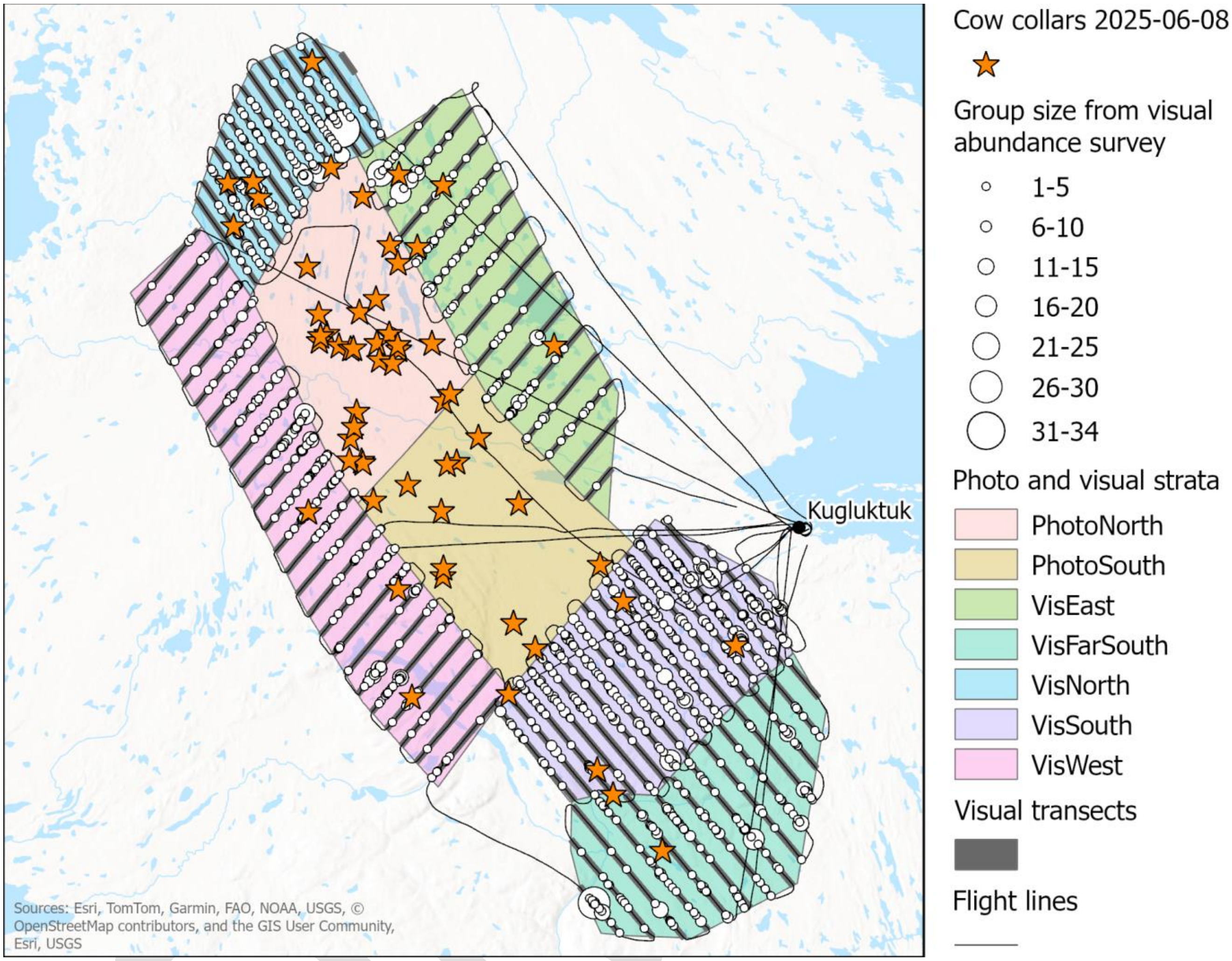

Figure 15. Caribou groups observed on-transect (400 m strip width) on the visual survey strata of the calving ground abundance survey on June 8 and 9, 2025. Locations of collared cows on June 8 are shown as orange stars.

Visual strata data

After filtering the visual survey data, the on-transect caribou detected in each stratum and main strata attributes were summarized (Table 7). Coverage at 600m strip width was moderate at 18-35%. Coverage at 400m strip width was 12-23%.

Table 7: Summary of visual survey strata, transects, and post-data filtering caribou observations on Bluenose-East visual strata for the 2025 calving ground survey.

Strata	Area (km²)	transects	Ave transect (km)	Coverage (strip)		Caribou observed on transect	
				400m	600m	400m	600m
Bluenose-East							
VisEast	2515.19	14	26.6	0.12	0.18	253	410
VisFarSouth	2366.84	14	30.5	0.14	0.22	441	604
VisNorth	1408.44	15	27.0	0.23	0.35	298	487
VisSouth	2670.11	18	38.5	0.21	0.31	1006	1434
VisWest	3312.14	25	25.5	0.15	0.23	499	706
Total						2497	3641

Visual strata on-transect densities

Transect densities across the visual strata (400 mm strip) ranged from 0 to 3.9 caribou/km^2, except one transect with 6.5 caribou/km^2 in the VisFarSouth strata (Figure 16), where only bulls and yearlings were observed during the composition survey (see Figure 20). The density of caribou on each visual transect is in Supplementary Table A-3. A 2023 comparison of visual survey transects flown directly over photo lines for 15 transects on the Bluenose-East calving ground showed that visual and photo counts were similar for caribou densities < 5 caribou/km^2, suggesting that these transects were suitable for visual surveys (Boulanger et al. 2024). The Boulanger et al (2024) analysis was limited in terms of sample size. Previous calving ground surveys had put a threshold limit of densities less than 10 caribou/km^2 for visual counts.

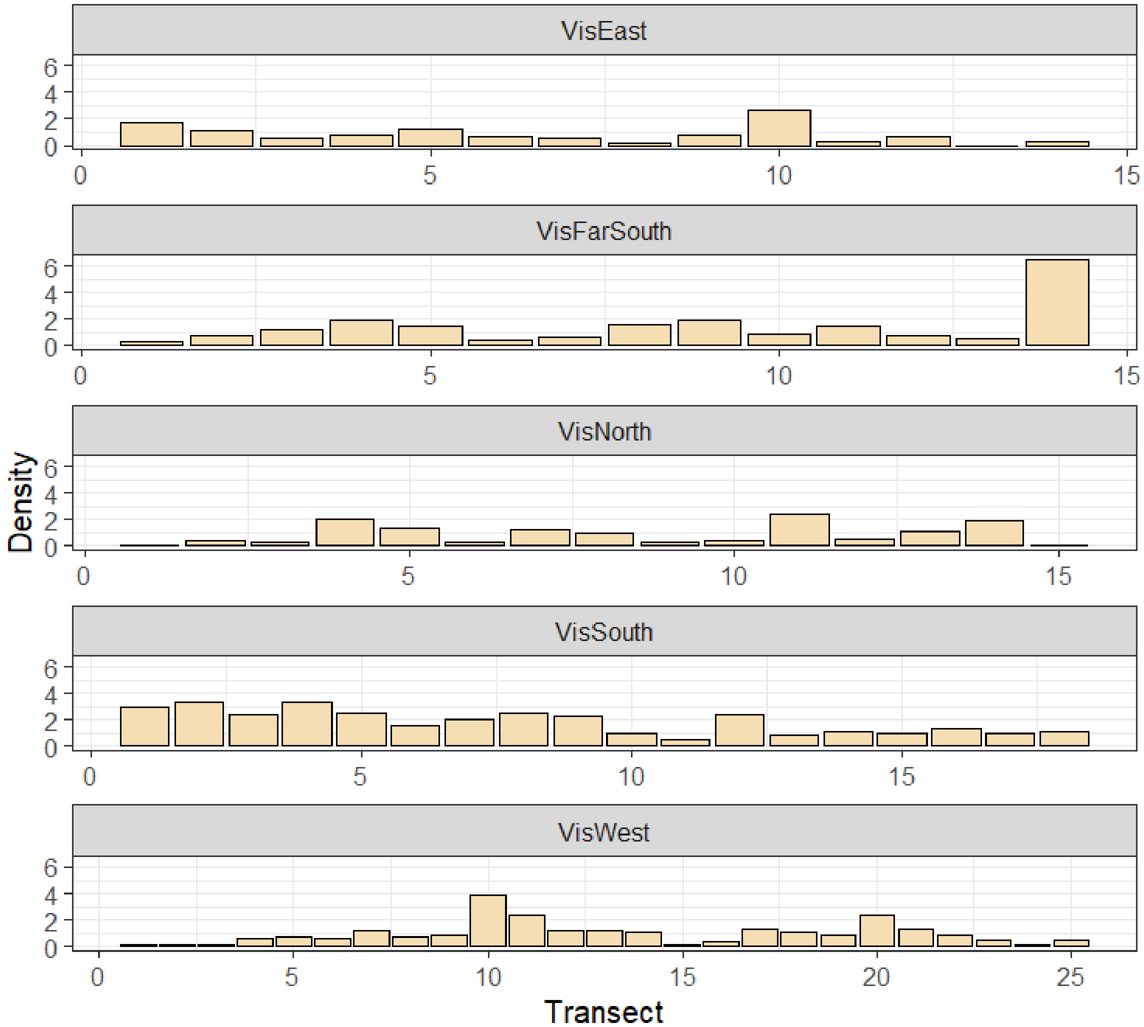

Figure 16: Relative densities on visual transects for Bluenose-East visual surveys based on a 400m strip width.

Photo survey

The photo survey was flown by both aircraft on June 8 with 1,987 photos taken at GSD8 on the Bluenose-East photo strata flight lines. The final photo transect coverage and caribou observations from the photo survey are shown in Figure 17. Figure C-1 in Appendix C shows the summarized caribou counts per photo. Cloud cover and snow cover were 0 in all photos.

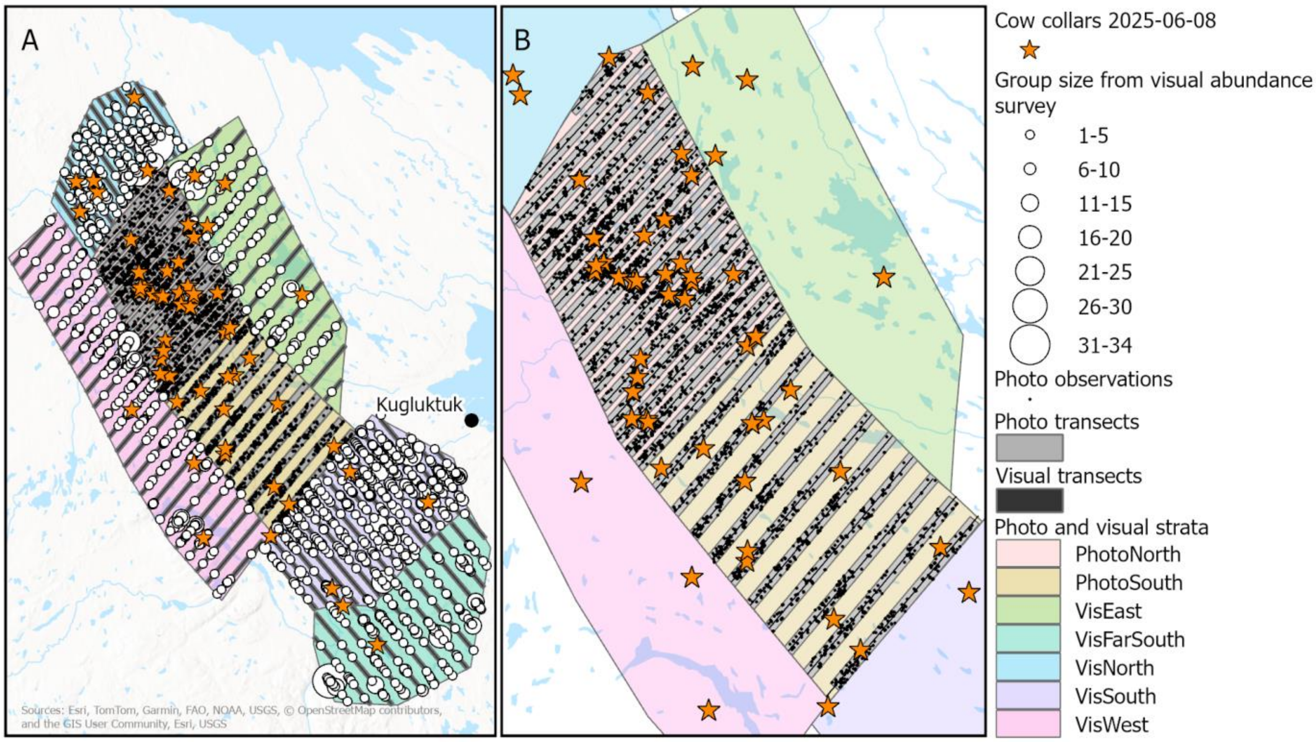

Figure 17. Caribou groups observed on-transect on the visual survey strata and caribou observed on-transect on the photo strata of the calving ground abundance survey on June 8 and 9, 2025. Panel B) provides a closer view of the photo strata. Locations of collared cows on June 8 are shown as orange stars.

Photo strata data

The mean strip width as calculated across all transects in each stratum was 2250 m for the PhotoNorth stratum and 2200 m for the PhotoSouth stratum, very close to the assumed width of ground coverage of 2249 m for photos taken at GSD8 at 6,283 agl.

After filtering the photo data, the main strata attributes and caribou detected in each stratum were summarized in Table 8. See Supplementary Table A-4 for transect width and length, caribou counted and caribou density for individual photo transects.

Table 8. Summary of strata, transects, and caribou counts on Bluenose-East photo strata for the 2025 calving ground survey. Strip width is the mean georeferenced strip width for each strata.

Strata	Area (km^2)	Number of transects	Mean transect length (km)	Total transect km	Strip width (km)	Proportion ground coverage	Caribou counted
PhotoNorth	2294.5	18	39.5	710.7	2.25	0.69	8059
PhotoSouth	2333.6	10	42.1	420.5	2.20	0.40	2833

Photo strata on-transect densities

Transect densities in the photo strata were highest in the central region of the PhotoNorth stratum (Figure 18), exceeding 4 caribou/km^2 on transects 5-14 as well as northernmost transect 1 and transect 17 near the southern end of the block. Transect densities in the PhotoSouth stratum were homogenous and moderate, between 2 and 4 caribou/km^2 (Figure 18).

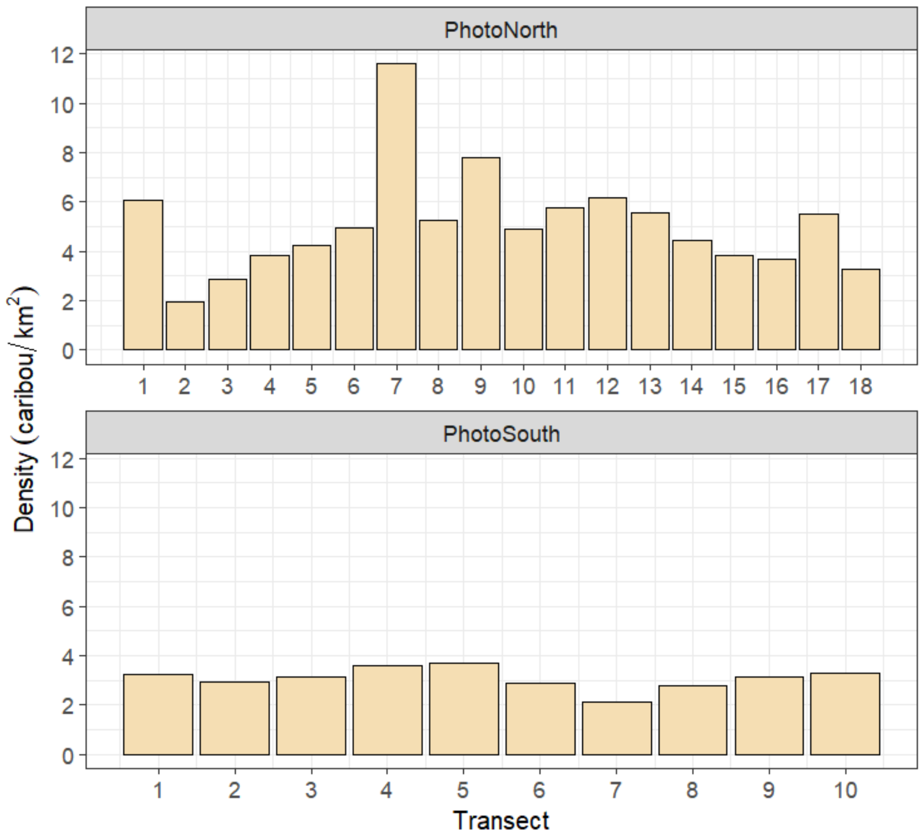

Figure 18: Transect densities on photo strata.

Composition survey

The composition survey was flown on June 10-14, 2025. Survey flight lines, locations of classified caribou groups and incidental observations are shown in Figure 19. One golden eagle, 10 grizzly bears, 3 moose, 3 wolves, and 61 muskoxen were also observed during the composition survey.

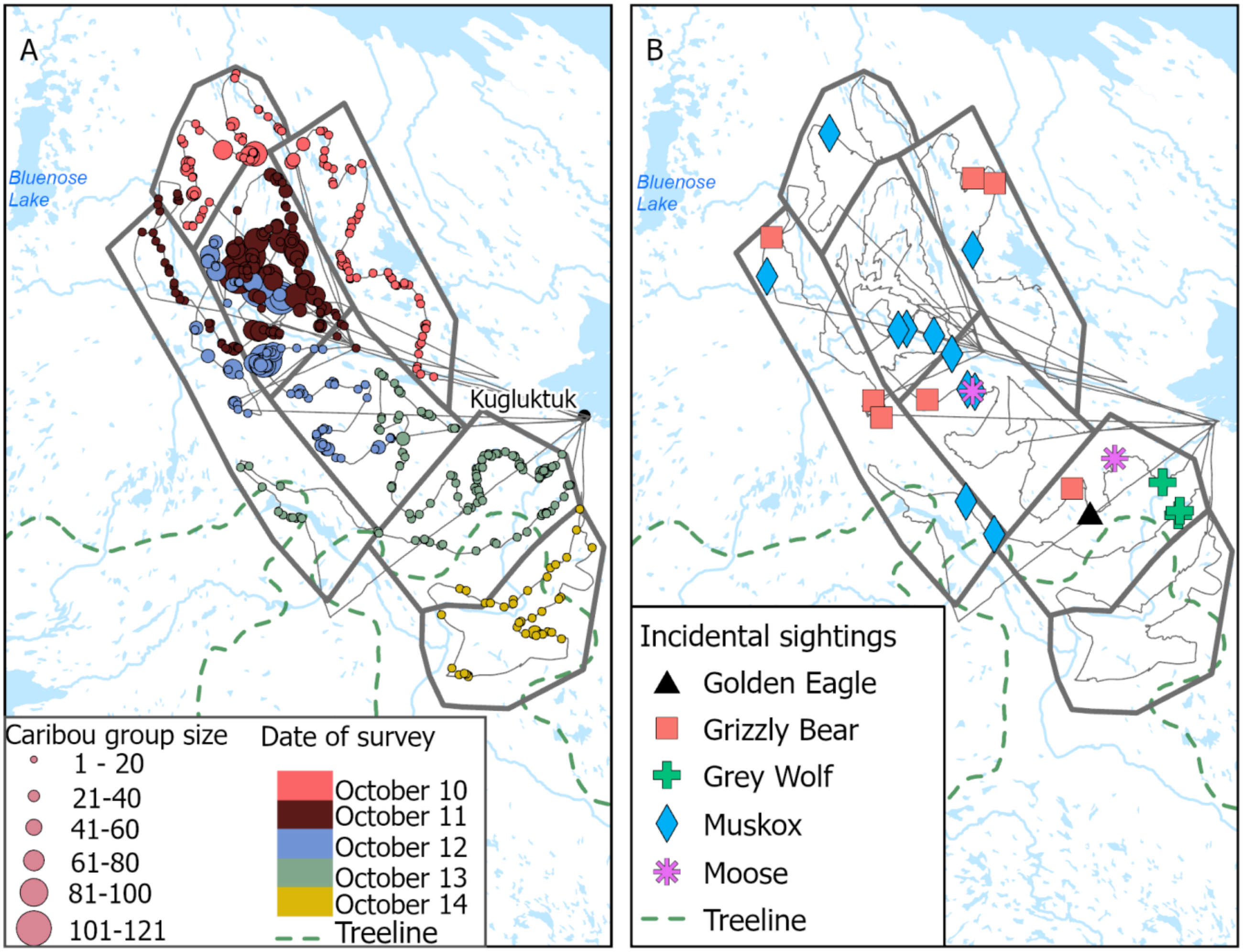

Figure 19. 2025 Bluenose-East calving ground composition survey (a) survey flight lines and observations of classified caribou groups by survey date, relative to abundance survey strata boundaries outlined in grey, and (b) locations of incidental observations relative to abundance survey strata boundaries outlined in grey.

In total, 4,423 1+ year old caribou and 2219 calves were classified in 477 groups. The number of breeding cows, non-breeding cows, calves, bulls, and yearlings classified in each stratum is shown in Table 9.

Table 9. Summary of 2025 Bluenose-East calving ground composition survey data. The number of groups classified, breeding cows (cows with antler and/or udder), non-breeding cows (cows with no antler or udder), cows total (breeding + non-breeding cows), calves, bulls, yearlings, and total 1+year old caribou (excluding calves) is given.

strata	groups	Breeding cows	Non-Breeding cows	Cows total	Calves	Bulls	Yearlings	Total 1+ year old Caribou
PhotoNorth	123	1643	168	1811	1465	18	297	2126
PhotoSouth	71	217	41	258	177	58	235	551
VisEast	59	204	18	222	174	2	29	253
VisFarSouth	36	3	1	4	2	119	87	210
VisNorth	50	288	9	297	251	0	23	320
VisSouth	88	20	8	30	14	352	249	631
VisWest	50	159	25	184	136	29	119	332
Totals	**477**	**2534**	**270**	**2806**	**2219**	**578**	**1039**	**4423**

The spatial distribution of caribou classified as breeding cows, non-breeding cows, calves, bulls, and yearlings is shown in Figure 20. The composition of each caribou group classified illustrated as a pie chart is shown in Supplementary Figure A-7 for comparison with previous survey reports.

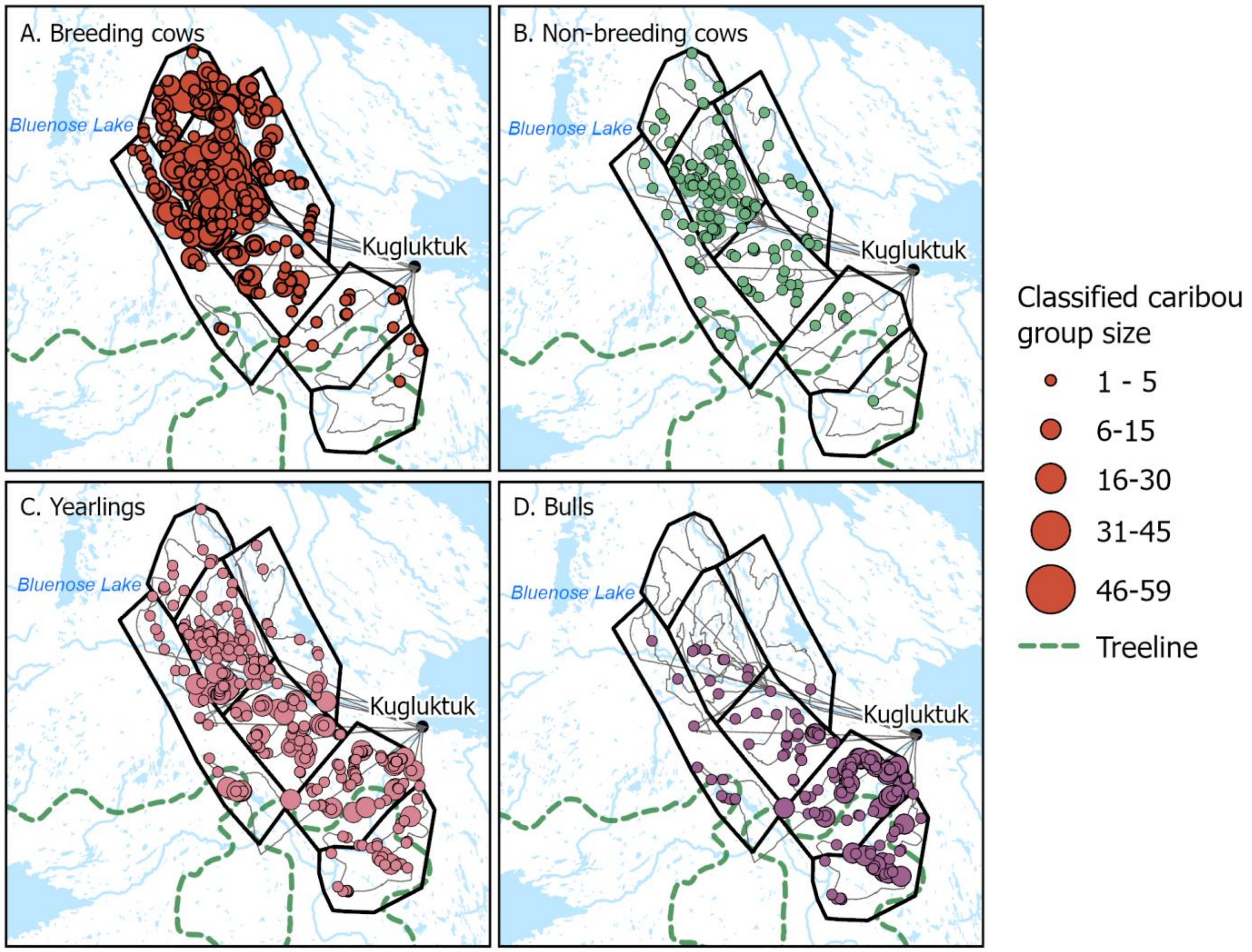

Figure 20. Locations of caribou classified as (a) breeding females, (b) non-breeding females, (c) yearlings and (d) bulls during the 2025 Bluenose-East calving ground composition survey. Circle size represents the number of caribou with that classification in the group with larger circles representing more caribou; size of graduated circles are consistent across each map.

More detailed composition of breeding females to inform the timing of the calving ground survey relative to calving events, is shown in Table 10. Overall, the composition survey observations suggested that the survey occurred very close to peak calving. Overall, pregnant cows that had not yet calved (having antlers and no distended udder) comprised 4.7% (n=119) of breeding cows and cows that were close in time to their calving event (having antlers and distended udder) were 41.4% (n=1050) of breeding cows. Cows that had calved and dropped antlers (no antlers, with distended udder) were 53.9% (n=1365) of breeding cows. In the strata with > 20 breeding cows (i.e. excluding VisSouth and VisFarSouth), the Vis East and VisNorth strata had the highest proportion of breeding females before or near calving (74% and 63% respectively) whereas in the PhotoNorth, PhotoSouth and VisWest strata > 50% of breeding caribou had already calved and dropped their antlers.

Table 10: Summary of breeding adult female caribou by strata. The proportion of breeding cows that were classified before they gave birth (ANU; hard antler but udder not yet distended), close in time to giving birth (AU; udder distended, hard antlers not yet dropped) and after calving (ANU; udder distended, antlers dropped) are given. The proportion was the count of each class divided by total breeding cows in each stratum. Also given are sample sizes for each class along with total breeding cows counted in the strata. The primary dates on which sampling occurred is given. Proportions within strata of greater than 0.50 are shown in bold, where strata sample size > 20.

Strata	June Dates	Proportion of each group			Sample sizes of breeding cow classes			
	Sampled[1]	pANU	pAU	pNAU	ANU	AU	NAU	Total
PhotoNorth	11,12[2]	0.045	0.371	**0.584**	74	610	959	1643
PhotoSouth	12,13[3]	0.046	0.290	**0.664**	10	63	144	217
VisEast	10	0.054	**0.686**	0.260	11	140	53	204
VisFarSouth	14	0.000	1.000	0.000	0	3	0	3
VisNorth	10,11[4]	0.042	**0.590**	0.368	12	170	106	288
Vis South	13[6]	0.150	0.300	0.550	3	6	11	20
VisWest	11,12,13	0.057	0.365	**0.579**	9	58	92	159
All Strata					119	1050	1365	2534

[1] Footnotes indicate when few caribou were classified on an additional date: [2] One of 122 groups in the Photo North Stratum was classified on June 10. [3] Four of 67 groups in the Photo South stratum were classified June 11. [4] Five groups were classified on June 11 and 45 groups classified on June 10. [5] Three of 88 groups in the VisSouth stratum were classified on June 14.

The composition proportions within each strata (proportion of breeding females, total adult females, yearlings, and bulls, and the proportion of breeding cows/cows, calves/cows and calves/breeding cows) are shown in Supplementary Table A-5. The composition of the overall estimate of 1+ year old caribou on the calving ground was calculated following the abundance calculations and is shown in that section below.

Abundance survey estimates

Visual strata estimate: Distance sampling method

Overall plots of observations by distance demonstrate a decline in the frequencies of detection with successive distance bins. The proportion of double observer detection types were roughly proportional for each distance bin (Figure 21).

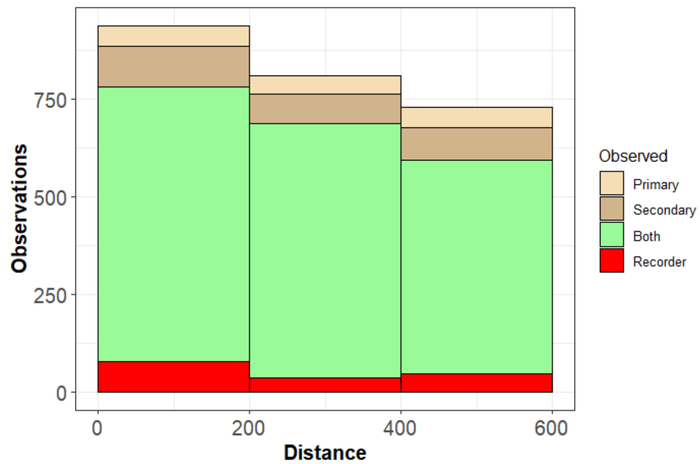

Figure 21: Pooled distance detection frequencies for visual and reconnaissance surveys. Sub-bars indicate whether the caribou group was observed by the primary, secondary or both observers, or only by the data recorder.

A decline in detection frequency with successive distance bins was seen across herds and survey phases. Detection frequencies for distance bins varied when comparing across strata and observer pairs, likely due to group sizes, observers used in each strata, and lower sample sizes within some strata. Group size also influenced the shape of distance detection frequencies, with decline by distance bin most notable for single caribou observations, and similar detection frequency across all distance bins for groups of 6-35 caribou (Figure 22).

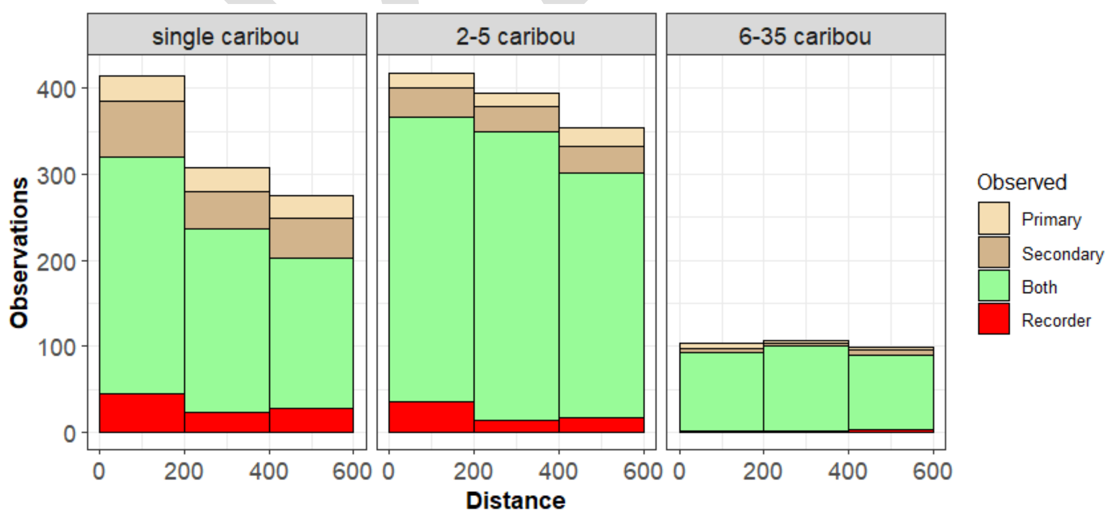

Figure 22: Detection frequencies a function of ranges of group size. Sub-bars indicate whether the caribou group was observed by the primary, secondary or both observers, or only by the data recorder.

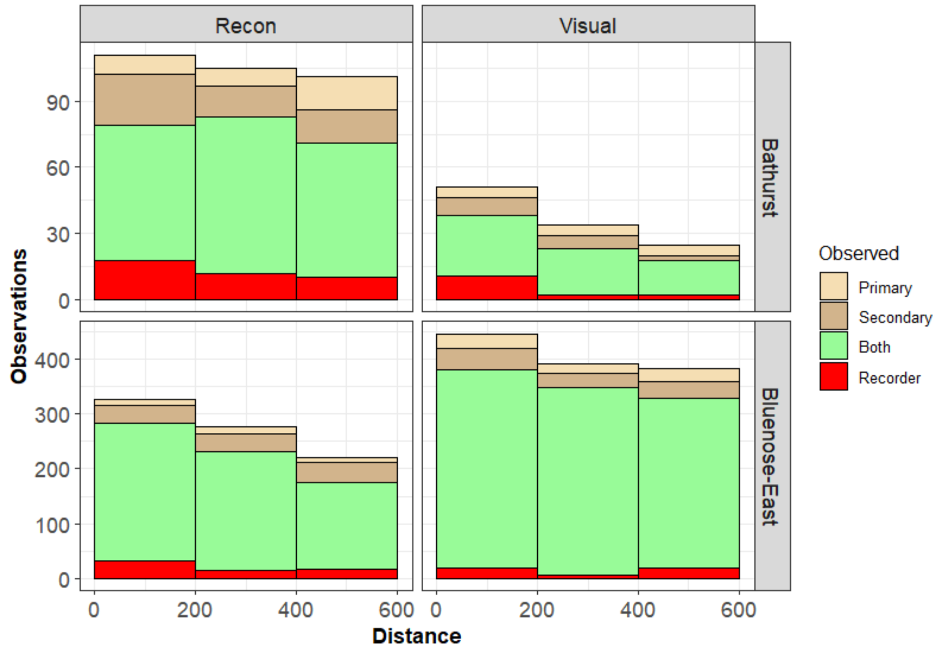

Figure 23: Detection frequencies for distance bins for visual and reconnaissance phases by herd. Sub-bars indicate whether the caribou group was observed by the primary, secondary or both observers, or only by the data recorder. Note different y-axis scales.

Distance sampling models were fit to the resulting data sets (Appendix B) demonstrating variation in amount of change in detection probability as a function of herd * phase, observer pairs, and group size.

A plot of detection functions with various covariates demonstrates fit of the model to various sources of variation (Figure 24). For herd * phase detection functions for Bathurst recon and Bluenose-East visual had reduced slopes compared to Bathurst visual and Bluenose-East recon as also suggested by frequency plots (Figure 23). The slope of detection functions was reduced with increasing group size as suggested by detection frequencies (Figure 22). The slopes of observer pair functions also varied with detection function.

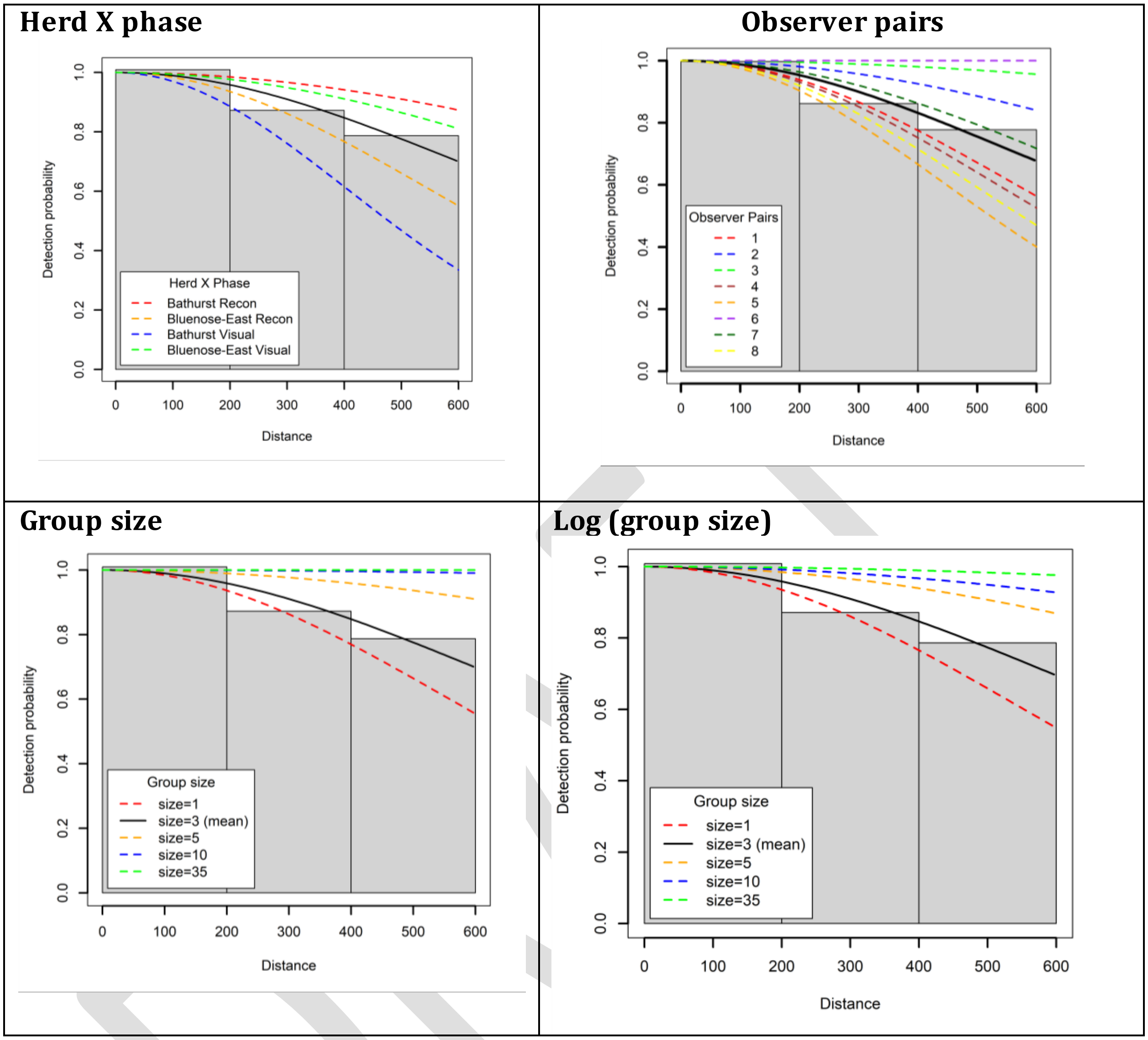

Figure 24: Predictions of model 1 (Appendix B, Table B-1) for each covariate in the model. The black line in each plot is the mean intercept detection function. Group size and log of group size (model 2) are also shown for comparison.

The distance sampling method (using 600 m strip and including data recorder observations) was used for the visual strata estimates for the Bluenose-East herd with an estimate of 15,260 (95% CI 13,536 – 17,204) 1+year caribou in the visual strata. The coefficient of variation was 0.06.

Photo strata

Photo sightability results

The 200 photos selected for recount was 10% of the 1987 photos (after data filtering) across both Bluenose-East and Bathurst calving ground surveys. When counts from observer 1 (n_1) and observer 2 (n_2) were compared for each cross-validated photo, in all cases observer 2 counts were higher than observer 1. Given this outcome, more complex methods were not suitable and the ratio of n_1/n_2 was used as an estimate of photo sightability assuming that observer 2 detected all the caribou detected by observer 1, and any additional caribou were only observed by observer 2.

The resulting photo sightability estimates, based on the ratio of photo counts between observers, were 0.974 and 0.978 for the PhotoNorth and PhotoSouth strata (Table 12). A bootstrap approach, which used individual photos as a sample unit, was used to estimate standard error and percentile-based confidence limits.

Table 12: Photo sightability estimates based on ratio of counts from first (n_1) and second (n_2) photo counter for the Bluenose-East herd.

Strata	n_1	n_2	n_1/n_2	SE	Conf. Limit		CV
PhotoNorth	2193	2252	0.974	0.005	0.962	0.984	0.006
PhotoSouth	311	318	0.978	0.009	0.959	0.994	0.009

Photo strata estimate

Photo-sightability corrected estimates were derived by dividing the strip-transect estimates from the photo strata by the estimated photo sightability which resulted in slightly increased estimates (Table 13).

Table 13: Strip-transect photo estimates and photo-sightability corrected estimates for Bluenose-East survey strata

	Photo estimate			Photo sightability		Photo sightability corrected estimate		
strata	N	SE	CV	p	CV	N	SE	CV
PhotoNorth	11,674	655.3	0.056	0.974	0.006	11,985	676.2	0.056
PhotoSouth	7,172	260.5	0.036	0.978	0.009	7,333	274.4	0.037
Totals	**18,845**	**705.2**	**0.037**			**19,318**	**729.8**	**0.038**

Calving ground abundance estimates

Estimates of 1+ year old caribou in the survey area

The visual strata estimates were added to the photo strata estimates to obtain an estimate of 1+ year old caribou (i.e., including yearlings) within the survey area. The overall abundance estimate of 34, 577 1+ year old caribou was very precise with a CV of 3.3% (Table 14).

Table 14: Total estimates of 1+ year old caribou on the Bluenose-East calving ground

Strata	N	SE	95% Conf. Limit		CV
PhotoNorth	11,985	676.2	10,641	13,499	0.056
PhotoSouth	7,333	274.4	6,738	7,981	0.037
VisEast	2,491	253.4	1,971	3,149	0.102
VisFarSouth	3,034	506.0	2,060	4,470	0.167
VisNorth	1,490	228.2	1,053	2,109	0.153
VisSouth	4,987	465.1	4,061	6,124	0.093
VisWest	3,257	385.5	2,529	4,193	0.118
Total	**34,577**	**1126.9**	**32,218**	**37,111**	**0.033**

Composition of estimates in each stratum

The estimates for each class of 1+ year old caribou (breeding females, non-breeding females, yearlings and bulls) in each stratum based on the strata abundance estimates (Table 14, above) and the composition data, are shown in Table 15.

Table 15: Total estimates of each group in the Bluenose-East calving ground survey by strata . The coefficient of variation (CV=SE/N) is given for each estimate. Also given is the proportion of the total number of caribou (34,577) of each group (i.e. Nbulls/34,577).

Strata	Caribou 1+yr		Breeding females		Non-breeding females		Bulls		Yearlings	
	N	CV	N	CV	N	CV	N	CV	N	CV
PhotoNorth	11,985	0.056	9,262	0.062	947	0.129	101	0.335	1674	0.115
PhotoSouth	7,333	0.037	2,888	0.106	546	0.190	772	0.237	3128	0.085
VisEast	2,491	0.102	2,009	0.122	177	0.320	20	0.927	286	0.403
VisFarSouth	3,034	0.167	43	0.668	14	1.052	1719	0.186	1257	0.200
VisNorth	1,490	0.153	1,341	0.156	42	0.338	0		107	0.354
VisSouth	4,987	0.093	174	0.322	63	0.426	2782	0.108	1968	0.120
VisWest	3,257	0.118	1,560	0.180	245	0.276	284	0.381	1167	0.198
Total	**34,577**	**0.033**	**17,277**	**0.099**	**2,034**	**0.200**	**5678**	**0.170**	**9587**	**0.139**
Proportion of N	1.0		0.500		0.059		0.164		0.277	

The proportion of each class of 1+ year old caribou and of breeding cows/cows, calves/cows, and calves/breeding cows, pooled across all survey strata, is shown in Table 16.

Table 16: Composition proportions pooled across all survey strata

strata	proportion	SE	Conf. Limit		CV
Cows/all 1+ caribou	0.634	0.022	0.587	0.676	0.035
Breeding cows/all 1+ caribou	0.573	0.022	0.529	0.614	0.039
Non-breeding cows/all 1+ caribou	0.061	0.005	0.051	0.072	0.088
Bulls/all 1+ caribou	0.131	0.013	0.107	0.159	0.102
Yearlings/all 1+ caribou	0.235	0.014	0.208	0.262	0.058
Breeding cows/cows	0.904	0.009	0.886	0.920	0.010
Calves/cows	0.791	0.013	0.763	0.815	0.017
Calves/breeding cows	0.875	0.010	0.856	0.893	0.011

Estimates of adult females and breeding females in the survey area

The overall estimate was 19,312 adult female caribou and was very precise with a CV of 0.095 (Table 17). The proportion of adult females was highest (> 0.85) in the Photo North, VisEast, and VisNorth strata. The proportion of adult females was moderate (0.468 – 0.544) in the PhotoSouth and VisWest strata, and low (<0.05) in the VisSouth and VisFarSouth strata.

Table 17: Adult female estimates based upon initial abundance estimates and composition surveys on Bluenose-East calving ground June 2025.

Strata	Caribou (1+ year old)		Prop. Adult Females		Adult Females				
	N	**CV_N**	**pf**	**CV_{pf}**	**N_{AF}**	**SE_{AF}**	**95% Conf. Limit**		**CV**
PhotoNorth	11,985	0.056	0.852	0.018	10,209	603.9	9,012	11,565	0.059
PhotoSouth	7,333	0.037	0.468	0.092	3,434	342.2	2,742	4,300	0.100
VisEast	2,491	0.102	0.877	0.058	2,186	255.5	1,671	2,861	0.117
VisFarSouth	3,034	0.167	0.019	0.530	58	32.1	17	194	0.554
VisNorth	1,490	0.153	0.928	0.025	1,383	214.5	973	1,966	0.155
VisSouth	4,987	0.093	0.048	0.263	237	66.2	129	434	0.279
VisWest	3,257	0.118	0.554	0.130	1,805	317.0	1,242	2,623	0.176
Total	**34,577**	**0.033**			**19,312**	**836.0**	**17,611**	**21,177**	**0.095**

For breeding females, the resulting estimate was 17,261 breeding adult female caribou; precision of this estimate was similarly high with a CV of 0.100 (Table 18).

Table 18: Breeding females estimates based upon initial abundance estimates and composition surveys on Bluenose-East calving ground June 2025

Strata	**Caribou (1+ year old)**		**Prop. Breeding Females**		**Breeding Females**				
	N	**CV**	**p_{bf}**	**CV**	**N**	**SE**	**Conf. Limit**		**CV**
PhotoNorth	11,985	0.056	0.773	0.027	9,262	579.0	8,119	10,567	0.063
PhotoSouth	7,333	0.037	0.394	0.104	2,888	319.8	2,250	3,707	0.111
VisEast	2,491	0.102	0.806	0.069	2,009	247.3	1,514	2,667	0.123
VisFarSouth	3,034	0.167	0.014	0.611	43	27.4	11	169	0.638
VisNorth	1,490	0.153	0.900	0.027	1,341	208.7	942	1,908	0.156
VisSouth	4,987	0.093	0.032	0.313	158	51.7	78	319	0.327
VisWest	3,257	0.118	0.479	0.143	1,560	289.0	1,052	2,313	0.185
Total	**34,577**	**0.033**			**17,261**	**793.2**	**15,652**	**19,035**	**0.100**

The estimates of non-breeding cows, bulls, and yearlings based on abundance estimates and composition surveys on the Bluenose-East calving ground June 2025 are shown in Supplementary Table A-6, in addition to the estimates of breeding cows.

Comparison of estimates of adult females and breeding females 2010-2025

The number of adult females and breeding females estimated from Bluenose-East calving ground surveys since 2010 is shown in Figure 25. Fewer adult females were estimated in 2025 (19,312) compared to the 2023 survey (24,466 (95% CI 20,550-29,129); Boulanger et al. 2024); however, estimates are higher than the 2018 (13,988 (95% CI=12,042-16,249); Boulanger et al. 2019) and 2021 surveys (13,991 (95% CI 11,805-16,585); Boulanger et al. 2022).

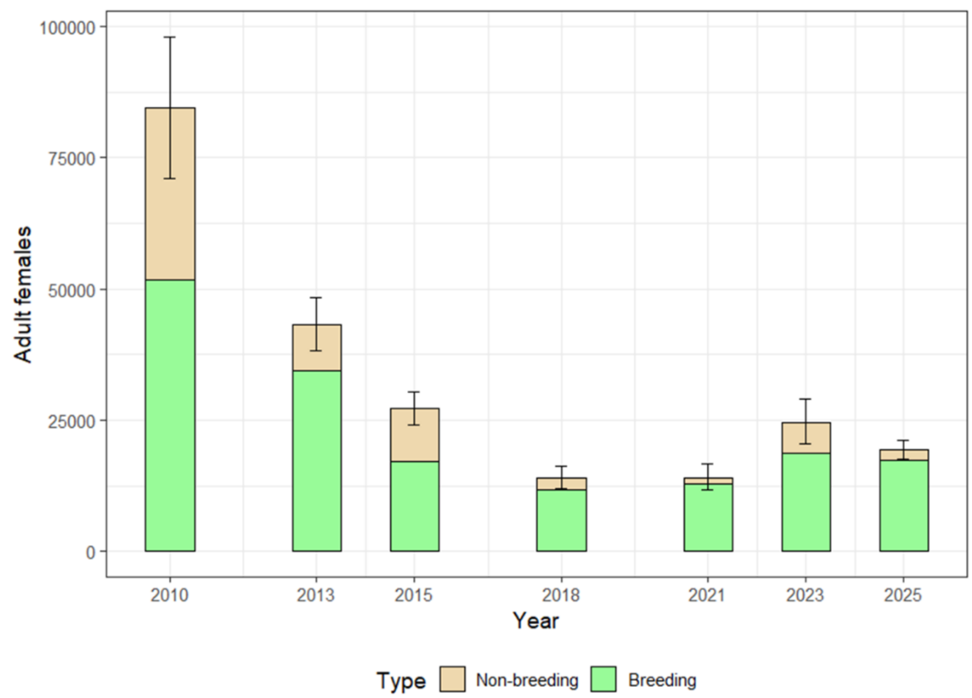

Figure 25: Trends in adult female estimates by breeding status from 2010-2025 Bluenose-East calving ground abundance surveys.

Extrapolated herd estimate

Fall composition survey

The 2024 and 2025 fall composition survey results (Adamczewski et al. 2026, Kelly et al. in prep), used in the calculations to extrapolate a herd estimate from the 2025 calving ground survey, are summarised in Table 19. Both the 2024 and 2025 fall composition surveys were judged to be well-timed during the rut season as sparring behaviour, males closely following females and mating events were observed across the survey areas. Spatial coverage of the herd, in both years, was adequate to good, with some areas of fewer collars not sampled due to weather and logistics.

Table 19. Sex ratio and proportion of cows resulting from the 2024 and 2025 Bluenose-East fall composition surveys. SE is the standard error, CI_low and CI_high are the lower and upper 95% confidence limits, and CV is the coefficient of variation.

Year	Ratio	Formula	Estimate	SE	CI_low	CI_high	CV
2024	Bull-cow ratio	bulls/cows	0.621	0.032	0.556	0.683	0.051
2024	Proportion cows	cows/(bulls+cows)	0.617	0.012	0.594	0.643	0.019
2025	Bull cow ratio	bulls/cows	0.38	0.03	0.33	0.43	0.07
2025	Proportion cows	cows/(bulls+cows)	0.73	0.01	0.70	0.75	0.02

The 2025 bull cow ratio was lower than ratios observed on fall surveys from 2020 to 2024 (2020 (63.3), 2021 (68.7), 2022 (64.8), 2023 (58.2), 2024 (62.1)) and comparable to ratios observed from 2015-2019 (2015 (41.7), 2016 (37.2), 2017 (43.7), 2018 (38.0), 2019 (35.3)) (Figure 26).

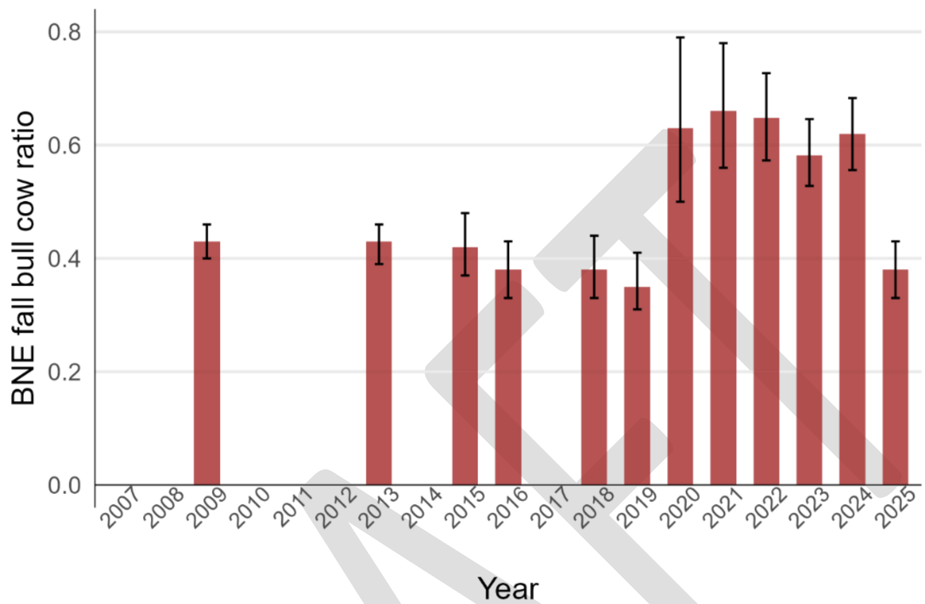

Figure 26. Summary of Bluenose-East bull cow ratios 2009-2025 estimated from fall composition surveys during the rut when females and males are together.

The herd estimate extrapolated from fall surveys is sensitive to variation in the fall data and given the large year-to-year change between the 2024 and 2025 sex ratios, further information about the coverage of each survey is provided.

The 2025 fall classification of Bluenose-East caribou occurred on October 22-24, 2025, with 48 female and 13 male Bluenose-East caribou collared at that time. The spatial coverage of the 2025 survey relative to concurrent collar locations is shown in Figure 27. 3,903 caribou (2886 adults) in 98 groups were classified with a bull cow ratio of 0.38 (SE 0.03, 95% CI 0.33-0.43) (Kelly et al. 2026 in prep). Most of the 2025 sample was classified on October 24 (83%, 3236 caribou) in the area north of the Dease Arm of Great Bear Lake where caribou were closely aggregated in a large group containing 75% (36 of 48) of the female collars and 54% (7 of 13) of the male collars. On October 23 caribou were classified around Point Lake where 4 female and 2 male collars were present. There were 5 female and 2 male collars west of Point Lake and 3 female and 2 male collars west of Napaktulik Lake; these areas were not sampled due to weather. There were 2 cows north of Great Bear Lake that had calved west of the calving ground in June 2025 and were not included in the Bluenose-East collar numbers. Overall, 49 of 61 collared Bluenose-East caribou (80%) were in areas surveyed.

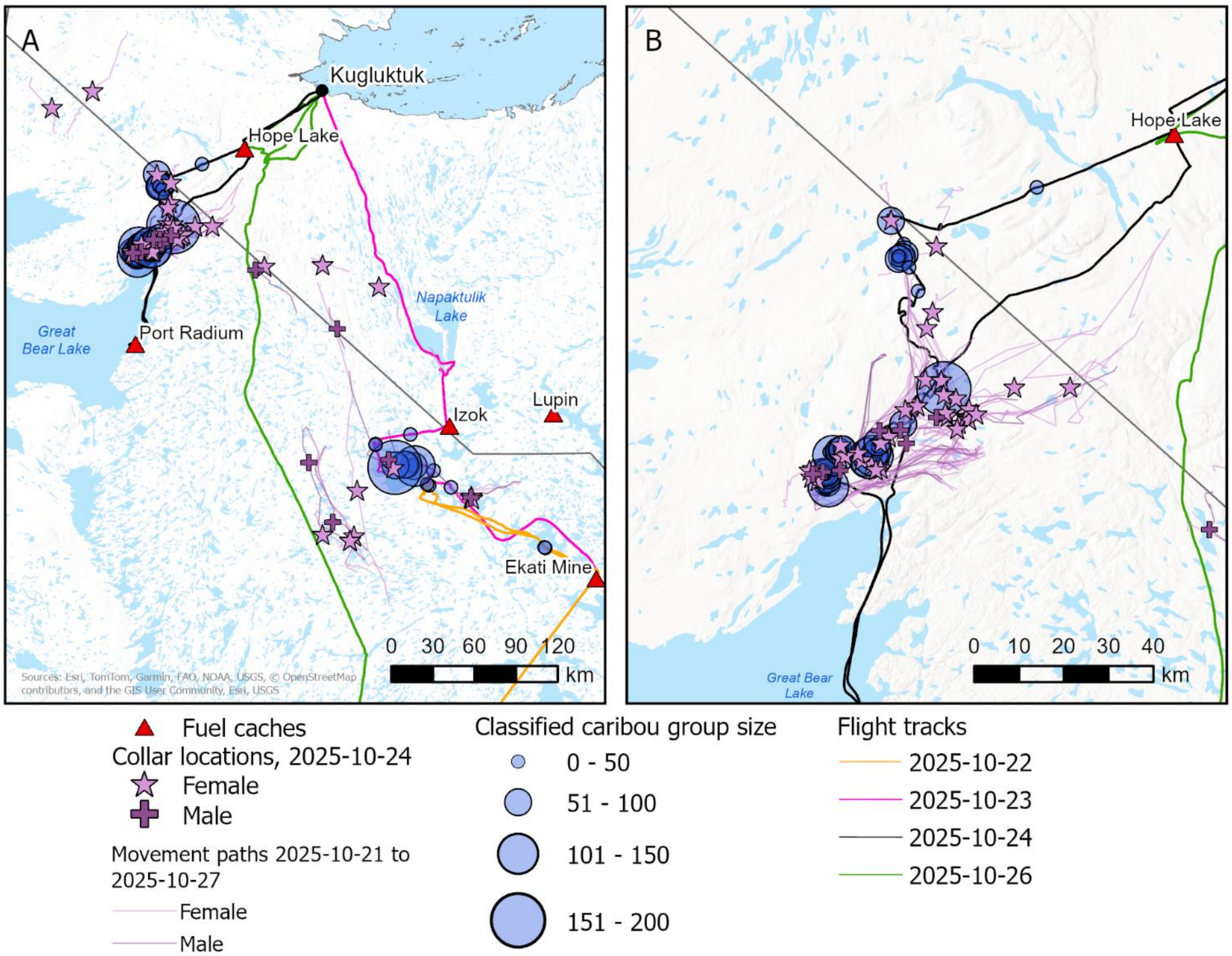

Figure 27. Locations of classified caribou groups, collared Bluenose-East caribou, and survey flightlines for the 2025 fall composition survey completed October 22-24, 2025. Panel (a) shows the range of all collared Bluenose-East caribou on those dates and panel (b) zooms into the areas where caribou were classified October 24.

The 2024 fall classification survey for Bluenose-East caribou occurred on October 23 and 25, 2024. The spatial coverage of the 2024 survey relative to the concurrent collar locations is shown in Figure 28. 3,218 caribou (2,886 adults) in 130 groups were classified with a bull: cow ratio of 62.1 (SE 3.2, 95% CI 55.6 – 68.3) (Adamczewski et al. 2026). Most of the 2024 sample was classified on October 23 (78%; 2,358 caribou) between Wekweètì and Point Lake where collars occurred in two broadly clustered areas. The survey route over the eastern part of this area provided good sampling coverage. The western survey route near Rawalpindi Lake partially sampled the collars in that area. The area north of Point Lake was surveyed on October 25 with good sampling coverage. Seven Bluenose-East collared caribou (5 females, 2 males) were north of the Dease Arm of Great Bear Lake and not surveyed in 2024, and an additional 2 cow collars between Izok Camp and Napaktulik Lake were outside of sampling areas. Overall, 52 of 68 collared Bluenose-East caribou (76%) were in areas surveyed (Adamczewski et al. 2026).

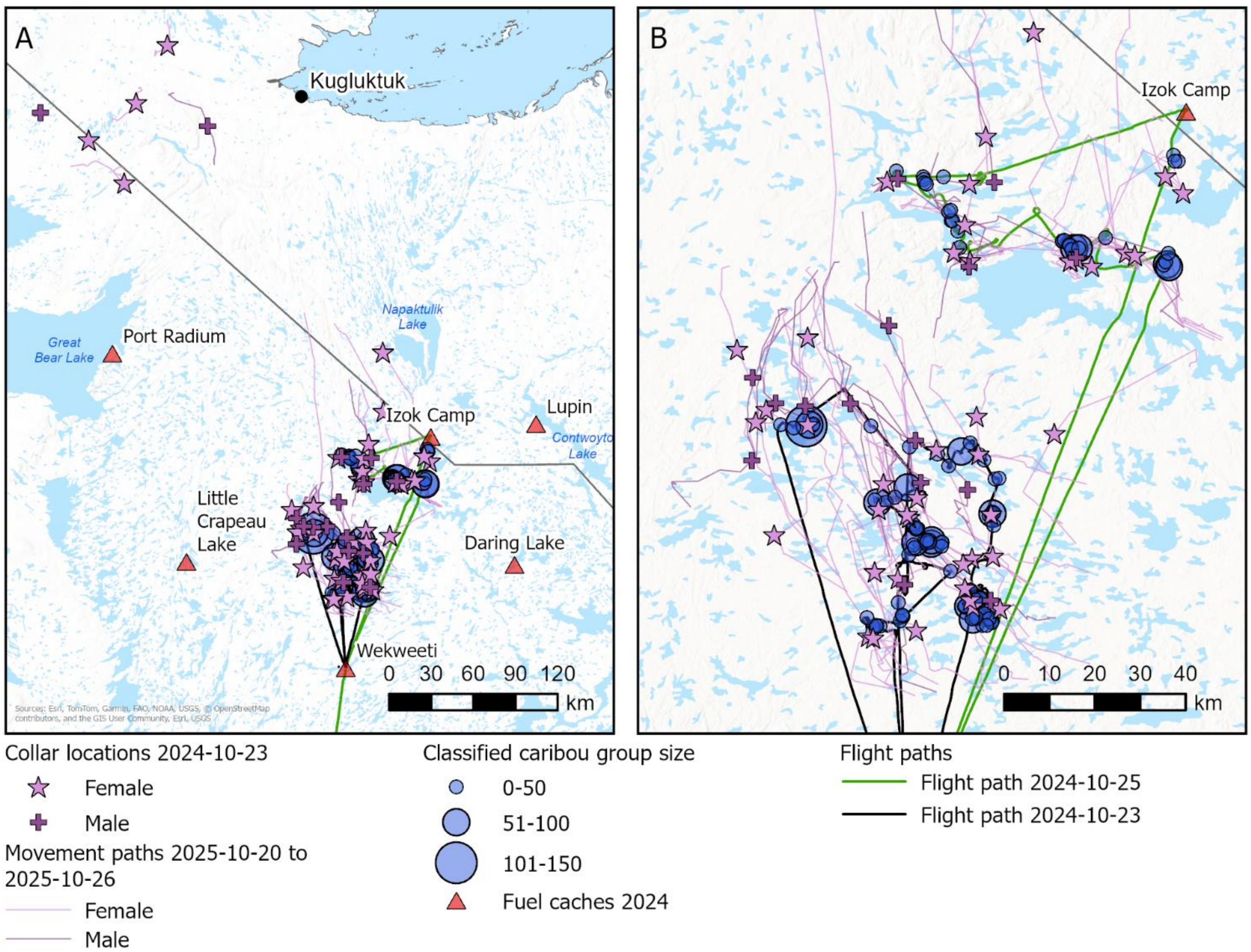

Figure 28. Locations of classified caribou groups, collared Bluenose-East caribou, and survey flightlines for the 2024 fall composition survey completed October 23 and 25, 2024. Panel (a) shows the range of all collared Bluenose-East caribou on those dates and panel (b) zooms into the areas where caribou were classified Oct 23 and 25.

Herd estimate

Based on the mean of the 2024 and 2025 fall composition ratios, the resulting 2025 Bluenose-East herd estimate is 28,759 2+ year old caribou (95% CI 25,997-31,816). Using just the 2025 sex ratio estimate would provide a smaller extrapolated herd size (because fewer bulls are 'added' to the adult female estimate); using just the 2024 sex ratio estimate would provide a larger extrapolated herd size. These derived estimates are provided along with the primary estimate using the mean of the two surveys in Table 20. The difference between the estimates derived from the 2024 and 2025 sex ratios demonstrates the sensitivity of extrapolated abundance to annual variation in fall sex ratios, whether arising from true changes in herd composition or from or sampling adequacy. Using the mean of multiple surveys reduces the influence of any single-year estimate on the final herd estimate.

Table 20. Extrapolated herd estimates using the calving ground survey adult female estimate of 19,312 (SE=836.0). The extrapolated herd estimate is the estimate of adult (2+) year old caribou in the herd (not including yearlings).

Year of data	Fall composition survey		Extrapolated herd estimate (2+ year old caribou)				
	Proportion cows	SE	N	SE	Conf. Limit		CV
2025	0.726	0.013	26,601	1246.2	24,075	29,392	0.047
2024	0.617	0.012	31,300	1485.5	28,291	34,629	0.047
Mean 2024 & 2025	**0.672**	**0.013**	**28,759**	**1363.9**	**25,997**	**31,816**	**0.047**

The 2025 extrapolated herd estimate is shown in comparison to previous herd estimates in Figure 29. The 2025 estimate is lower than the 2023 estimate of 39,525 (95% CI 33,021-47,310) (Boulanger et al. 2024) and higher than the 2021 estimate of 23,202 (95% CI 19,247-27,971) (Boulanger et al. 2022).

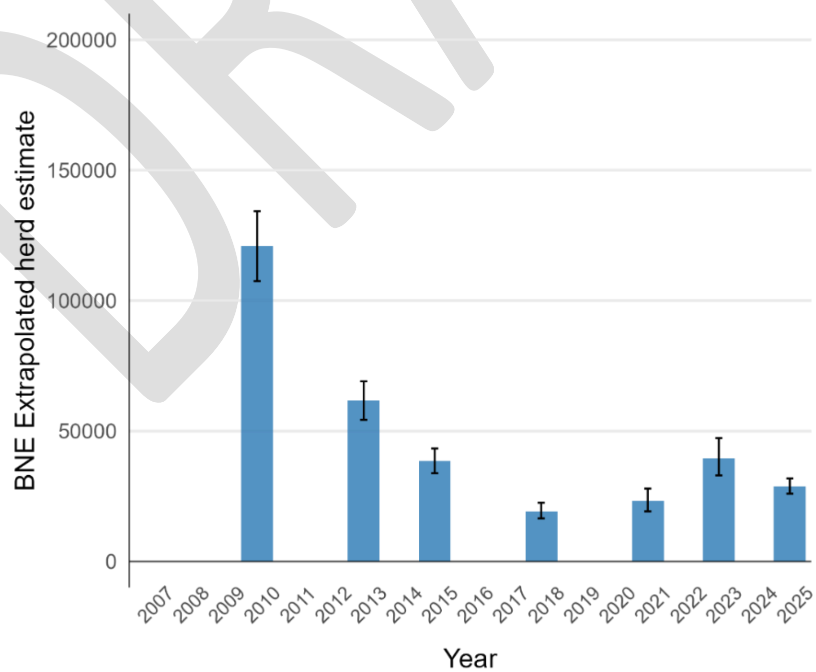

Figure 29. Extrapolated herd estimates for the Bluenose-East herd 2010-2025.

Combining survey results with other demographic data

Analysis of collar data

An assumption of calving ground surveys is that all the adult females (and particularly the breeding females), will be within the area delineated for the abundance survey, so the calving ground estimate will include all of the females that have been in that herd in recent years, and can be compared to previous calving ground-based estimates to inform the trend of herd abundance. We reviewed calving ground use in consecutive years by collared cows to evaluate whether this assumption was met.

During the 2025 calving ground survey, there were 61 collared cows on the Bluenose-East calving ground. Of the 38 collared females on the Bluenose-East calving ground the previous calving season (2024) and still tracked in June 2025, 34 returned to the Bluenose-East calving ground in June 2025. Two of the 38 collared cows were located west of Bluenose Lake (south of Bluenose-West calving ground) in June. 2025 after wintering with the Bluenose-West herd north of Great Bear Lake. One collared cow on the Bluenose-East calving ground in 2024 (collared in 2024) went to the Beverly calving ground in 2025, and a collared cow that was on the Bathurst calving ground in 2023 and the Bluenose-East calving ground in 2024 went back to the Bathurst calving ground in 2025. 23 cows newly-collared in 2025 went to the Bluenose-East calving ground and there was one cow collared in 2025 that was in between the Bluenose-East and Bathurst calving ground and remained unassigned. Figure 30 shows migration pathways of collared cows from April 1, 2025, to June 15, 2025.

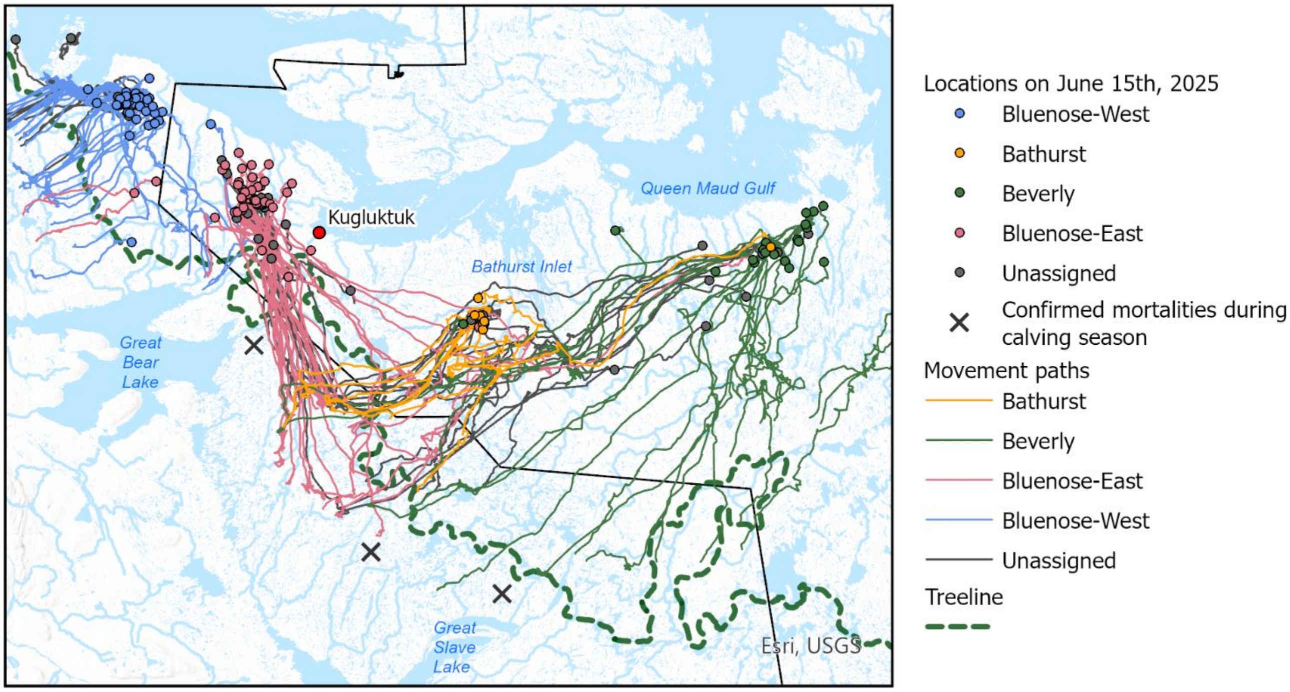

Figure 30. Movement paths of collared caribou from April 10, 2025, to June 15, 2025. Movement paths are coloured by calving ground use in 2024, for collars deployed before June 2024, and by calving ground use in 2025 for collars deployed within the previous year. This identifies the caribou that are known to have used a different calving ground in 2024 and 2025.

Movements between calving grounds

We further considered movements of adult females among neighboring calving grounds (Bluenose-West, Bluenose-East, Bathurst, and Beverly herds) since 2018. A plot of caribou locations on approximately June 10th for caribou that occurred on calving grounds for more than 1 year shows fidelity as well as movement of caribou between the calving grounds (Figure 31). One notable trend is movement of some cows from the Bathurst calving ground to the Beverly calving grounds in 5 of the last 7 years (2018-2024) and to Bluenose-East in 2024. In 4 of the previous 6 years (2018-2023), 18-27% of Bathurst collars moved to Beverly calving ground (3 of 11 (27%) in 2018, 3 of 17 (18%) in 2019, 0 in 2020, 6 of 34(18%) in 2021, 0 in 2022, and 4 of 21 (19%) in 2023), but no collared Bathurst cows moved to the Bluenose-East calving ground. In 2024, 18% (3 of 17) known collared Bathurst cows moved to the Beverly calving ground and 12% (2 of 17) moved to the Bluenose-East calving ground. In addition, some movement from the Bluenose-East calving ground to the Bluenose-West, Bathurst, and Beverly is indicated from 2023-2025.

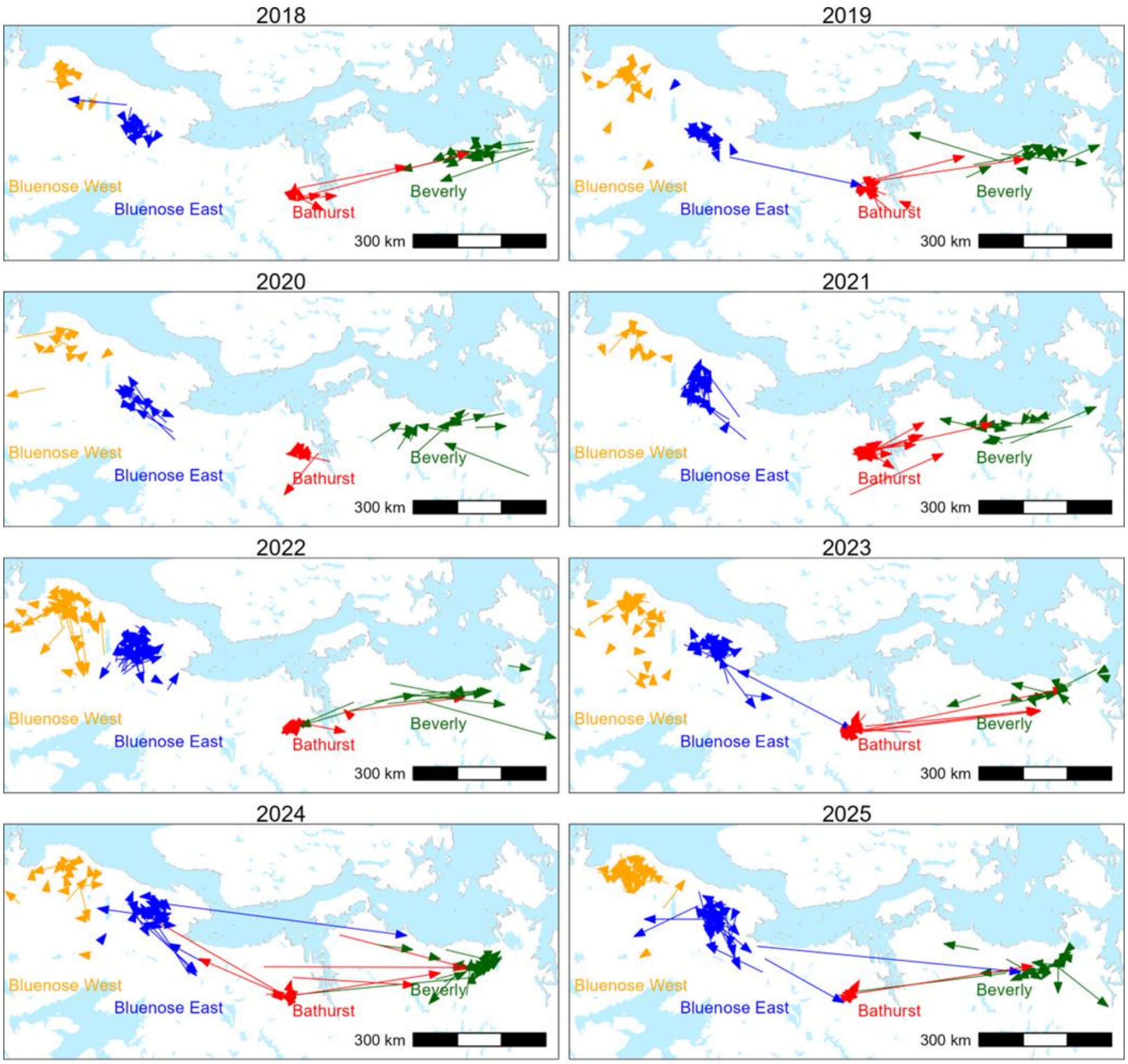

Figure 31: Locations of caribou on June 10 for previous (tail of arrow) and current (arrow) year for caribou that occurred on calving grounds for more than 1 year. Color of arrow indicates calving ground from the previous year.

Figure 32 summarizes frequencies of fidelity and movement associated with the use of the Bluenose-East calving ground by collared adult females. The column for the herd displays levels of fidelity (caribou returning to the calving ground from the previous year) with movement into or out of the calving ground also indicated. For example, in 2025 for the Bluenose-East herd, 34 caribou returned to the calving ground from the previous year, 1 moved to the Bathurst, and 1 moved to the Beverly. Two cows were west of Bluenose-Lake during the calving period (considered to have moved to Bluenose-West in Figure 32), though subsequent movements of these cows showed them to be separate from the main Bluenose-West herd so could be considered "grey zone" caribou.

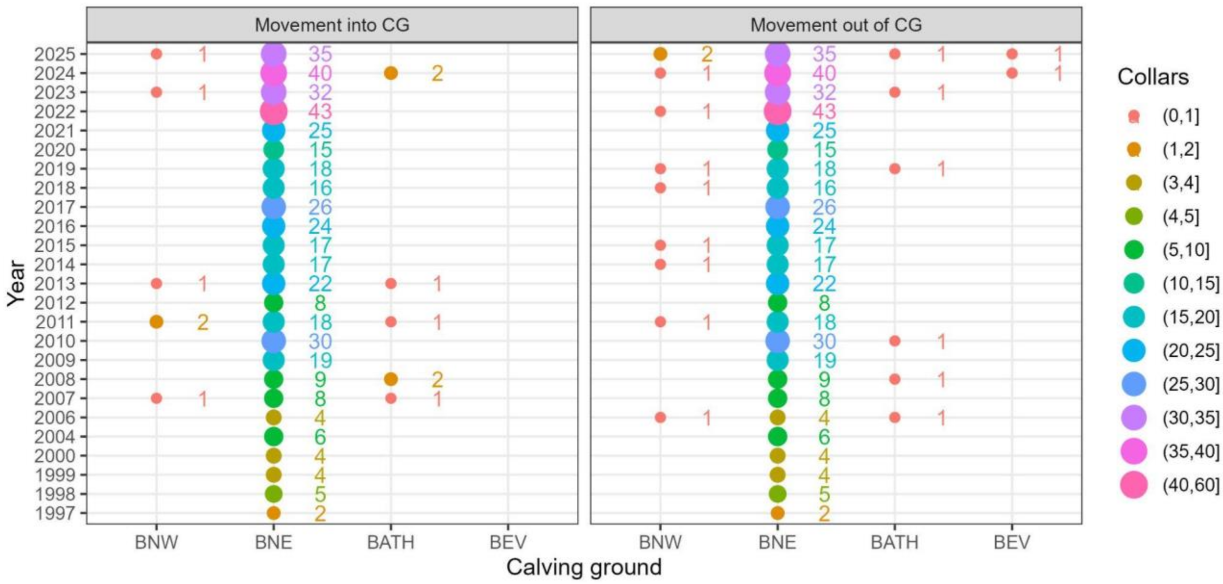

Figure 32. Frequency of collared adult female caribou returning to and moving in/out of the Bluenose-East barren-ground caribou herd calving ground. The left panel shows how many collared adult females returned to the Bluenose-East calving ground (BNE column) or moved to this calving ground after using a different calving ground the previous year (BNW = Bluenose-West; BNE = Bluenose-East; BATH = Bathurst, BEV = Beverly). The right panel shows where caribou calved the year after calving on the Bluenose-East calving ground (returning or moving to a different calving area). Only collared female caribou with >1 years of calving season data are included.

Demographic data 2010-2025 for the Bluenose-East herd

Composition surveys in June, in years with calving ground surveys, provide information on the proportion of breeding females to non-breeding females on the calving ground, which is related to pregnancy rates from the previous fall. The proportion of breeding females on the calving ground in 2025 was high (0.90; 95% CI 0.88-0.92; Figure 33a).

Composition surveys in the fall provide calf:cow ratios, which are an index of calf survival from calving until ~4.5 months old, and similar surveys in late winter provide an index of calf survival from calving until ~9 months old. Fall calf:cow ratios were 0.49 (95% CI 0.46–0.52) in 2024 and 0.49 (95% CI 0.45–0.52) in 2025, and have been consistently above 49 calves:100 cows in annual surveys since 2020 (Figure 33b). Late winter calf:cow ratios have been above 40 calves:100 cows since 2020, and was 0.48 (95% CI 0.46 – 0.50) in 2024 (no survey in 2025; Figure 33c). These ratios are indicative of very good calf survival during this time period. On average, these indicators for breeding caribou and calf survival have been consistently higher from 2020 to 2025 than during the declining phase between 2010 and 2018 (Figure 33).

Fall composition surveys also provide a ratio of adult males to adult females when both sexes are together for the breeding season. Bull:cow ratios were higher (0.58–0.69) from 2020 to 2024. Bull:cow ratios were 0.62 (95% CI 0.56–0.68) in 2024 and were lower in 2025 at 0.38 (95% CI

0.33–0.43; Figure 33d). Higher bull:cow ratios were observed in the 1980s when herds were large and increasing (average ratio of 0.66 across six fall composition surveys [Gunn et al. 1997]), and lower bull:cow ratios (0.31–0.38) were observed in 2006-2009 when the Bathurst herd was declining (Nishi et al. 2014). The bull:cow ratio in 2025 suggests lower survival of bulls in 2024-2025, but these surveys should be evaluated as a trend over time as the coverage of a single survey can miss groups with more or fewer bulls (or calves); therefore, less certainty can be applied to a single year of data. To help account for this uncertainty, the mean 2024 and 2025 fall bull:cow ratio values were used to extrapolate the 2025 herd estimate.

Field estimates from June calving ground surveys since 2010 are included in Appendix E.

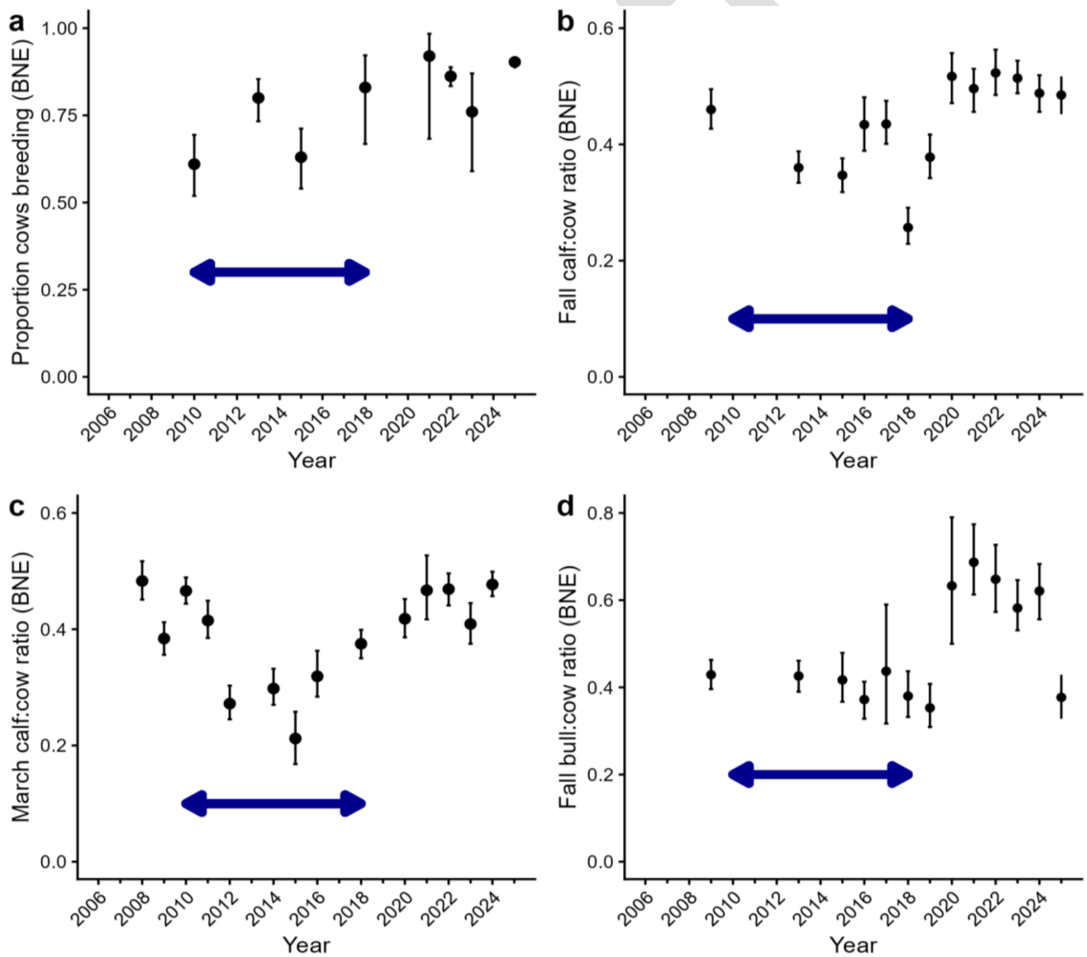

Figure 33. Trends in demographic parameters for the Bluenose-East barren-ground caribou herd: (a) proportion of females on the calving ground that are breeding vs. not breeding, based on June calving ground surveys; (b) fall calf:cow ratios as an index of summer/fall calf survival; (c) late winter calf:cow ratios as an indicator of calf survival to ~9 months old; (d) bull:cows ratios based on fall composition surveys to determine the adult sex ratio of the herd during the rut season. The horizontal blue arrow indicates the 2010-2018 period when the Bluenose-East caribou herd was declining.

Collar-based survival estimates of adult (a) bulls and (b) cows in the Bluenose-East herd are shown in Figure 34.

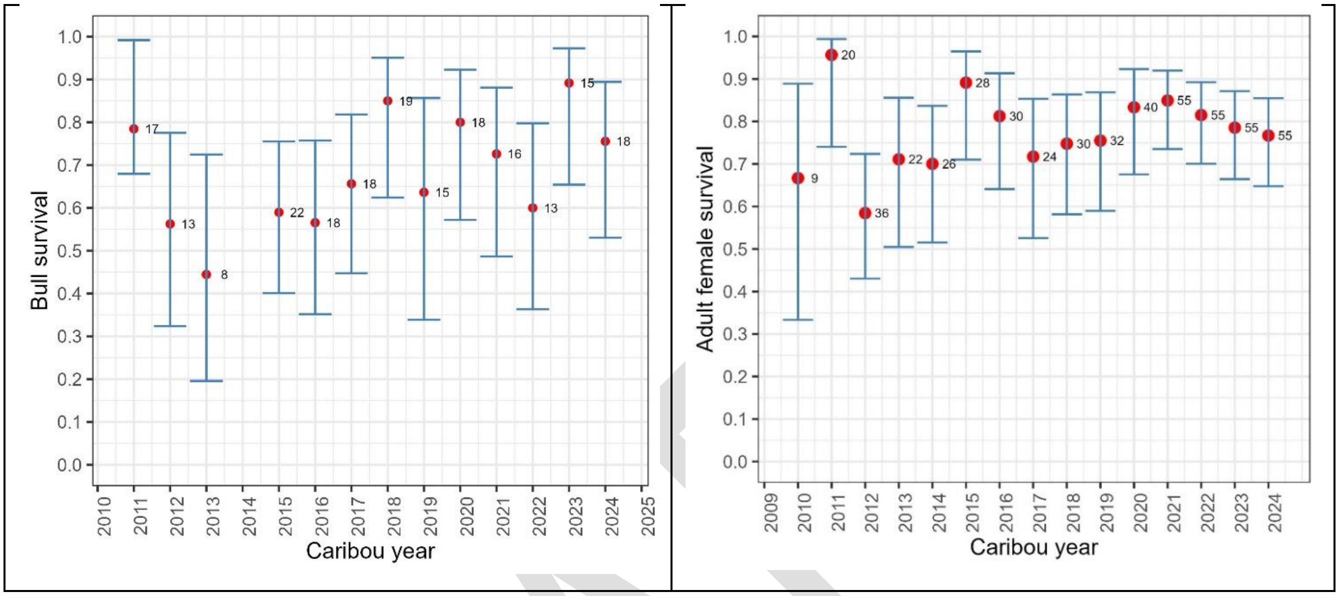

Figure 34. Collar-based survival estimates of adult (a) bulls and (b) cows in the Bluenose-East herd. Sample sizes of the mean number of collars monitored monthly are given next to each data point. The caribou year is June to May so 2024 refers to June 2024 - May 2025.

Integrated population model

Fit of Base Integrated Population Model

The IPM (Appendix D) was fitted to the demographic data to assess overall demographic trend in the Bluenose-East herd. Figure 35 displays the IPM and the main demographic indicators by showing the modelled values (blue line with hashed 95% confidence limits) relative to the observed field estimates (red points with confidence limits as vertical bars). In general, the modelled estimates visually fit the field estimates reasonably well (Figure 35).

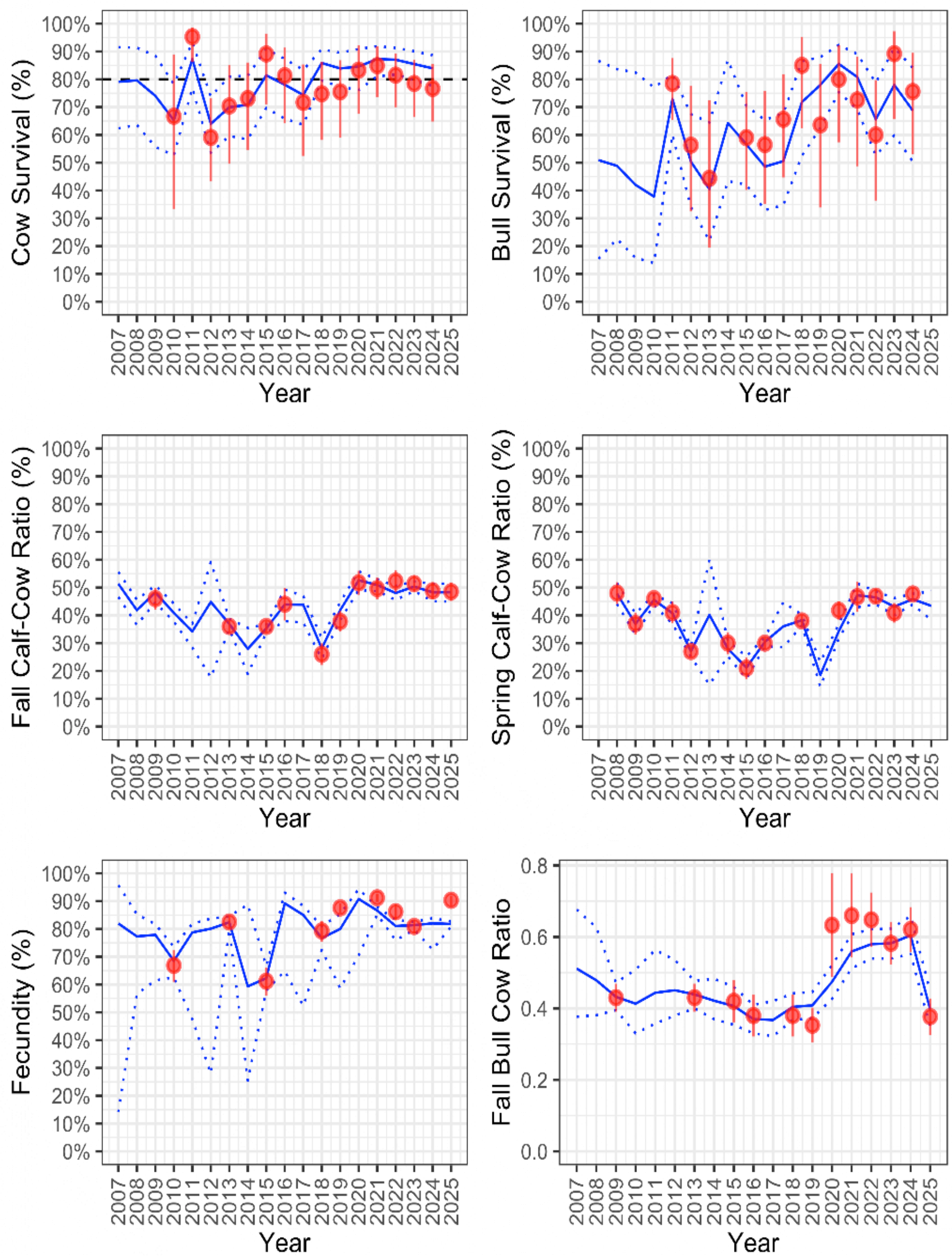

Figure 35. IPM predictions (blue line with 95% hashed credible intervals) in comparison to observed field estimates (red dots with 95% credible interval) for the base Bluenose-East barren-ground caribou herd IPM.

Adult female and male survival

Figure 36 shows the adult female and male survival estimates included in the IPM. IPM estimates of survival are higher than observed collar-based estimates for adult females for 6 of the past 8 years, suggesting a potential negative bias in collar survival rates as suggested by other studies (Haskell and Ballard 2007, Rasiulis et al. 2014). Causes of negative bias could be uncertainty in determination of collar fate, premature collar release (assumed to be mortality), or other factors. The higher IPM survival estimates may also be due to the assumption that the Bluenose-East herd is a closed population with no immigration; if immigration is occurring, it is likely that adult survival estimates would be lowered. The IPM estimate of adult cow survival for the 2024-25 caribou year is 0.84 (CI=0.78-0.89) compared to the field estimate of 0.77 (CI=0.65-0.85).

IPM bull survival estimates follow collar-based estimates with all IPM estimates being within the confidence limits of field estimates. IPM estimates will also be influenced by bull-cow ratios and are likely more robust than collar-based estimates which are based on lower sample sizes of collars (i.e. <20 bulls monitored in most years). The IPM estimate of bull survival for the 2024-25 caribou year is 0.69 (CI=0.50-0.84) in comparison to the field estimate of 0.76 (CI=0.53-0.89).

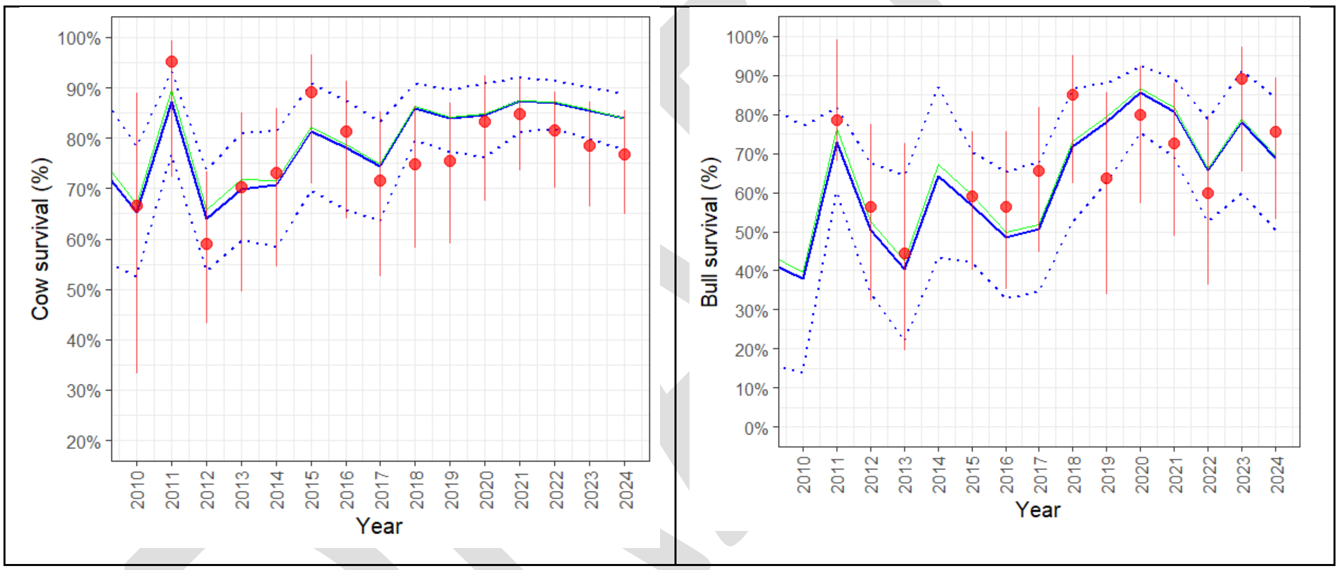

Figure 36: Estimates of adult cow and bull survival from IPM (blue line with hashed 95% credible intervals) compare with field estimates (red points with 95% confidence limits). The green line shows "natural survival" with harvest mortality removed. Since harvest was low the difference between the two estimates is negligible. The caribou year is June to May the following year (i.e., 2024 refers to the June 2024-May 2025 period).

An additional factor influencing survival is harvest. The observed collar-based survival estimates include harvest mortality because it is difficult to discern exact mortality caused from collars and there are usually insufficient sample sizes of collars to separate harvest mortality from natural mortality. The IPM used estimates of harvest (Figure 37) to also estimate "natural survival" with harvest mortality removed (Figure 38). Levels of harvest were relatively low compared to the abundance of bulls and cows and therefore there is minimal difference between observed and natural survival rates (Figure 38).

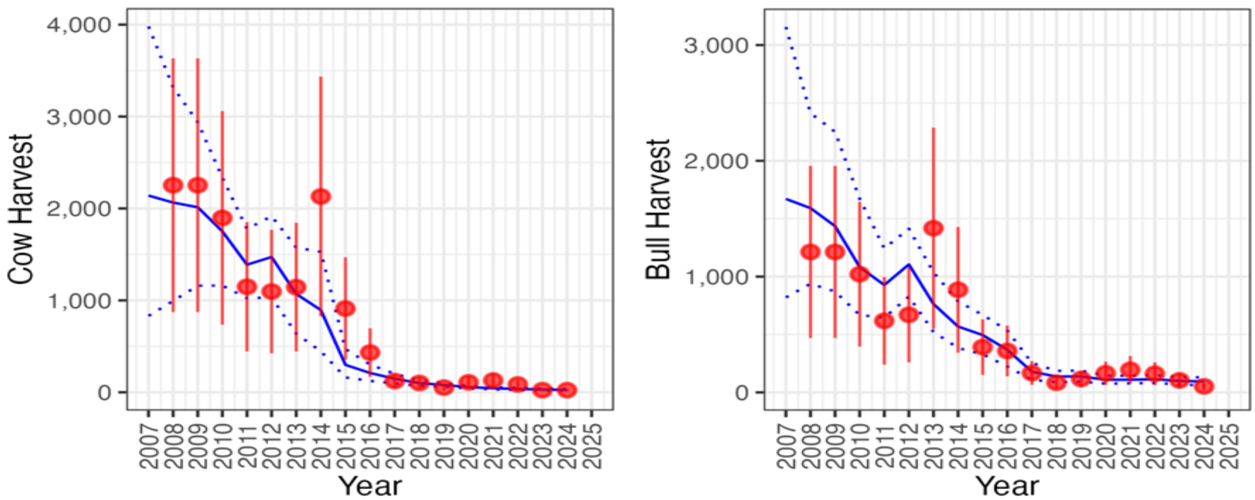

Figure 37. Estimated harvest of cows and bulls.

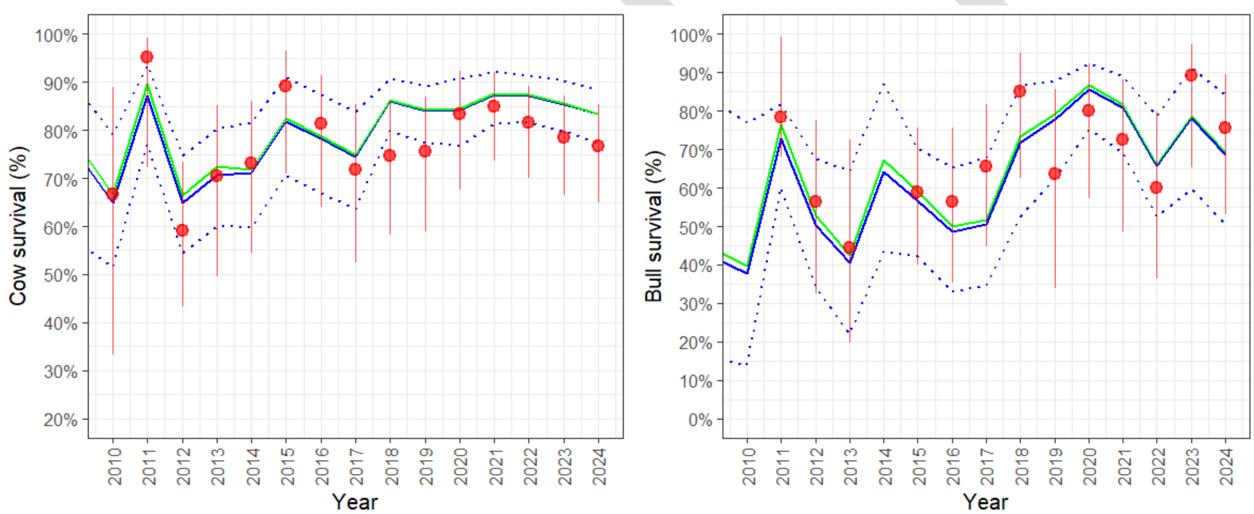

Figure 38. Estimates of adult cow and bull survival from IPM (blue line with hashed 95% credible intervals) compare with field estimates (red points with 95% confidence limits). The green line shows "natural survival" with harvest mortality removed. Since harvest was low the difference between the two estimates is negligible.

Productivity

Estimates of fecundity, derived calf survival, and productivity suggest higher productivity (estimated as fecundity X calf survival) from 2019-20 to 2024-25 caribou years (Figure 39). The IPM fecundity estimate was lower than the observed fecundity estimate of 89% (observed as proportion of adult females breeding on the calving ground) in 2025 (Figure 39).

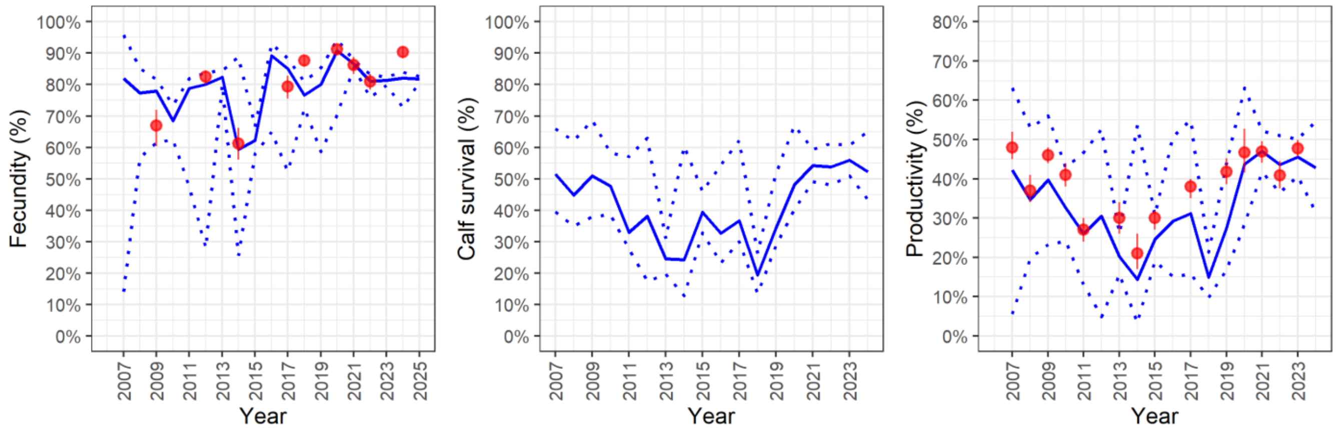

Figure 39: Fecundity, calf survival (derived) and productivity (calf survival X fecundity). Also shown are spring calf-cow ratios which are proportional to productivity. The exact fit of IPM predictions to calf-cow ratios is shown in previous figures. IPM estimates are depicted as a blue line with hashed 95% credible intervals and field estimates as red points with 95% confidence limits. The caribou year is June to May the following year (i.e., 2024 refers to the June 2024-May 2025 period).

Abundance estimates

The model was also fit to estimates for breeding female and adult female abundance, and adult herd abundance. Overall the IPM parameter estimates for breeding females, and adult females follow the observed field estimates, with the exception of the IPM not predicting higher abundance estimates in 2023 for herd size and adult females (Figure 40).

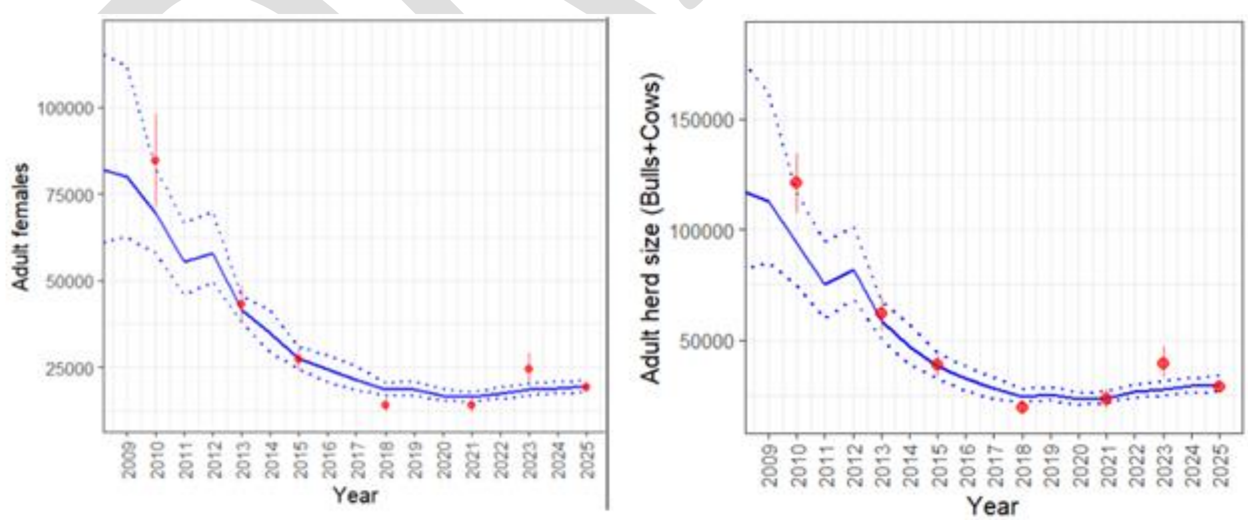

Figure 40. Estimates of the trend in (a) number of adult females and (b) total adult caribou in the Bluenose-East barren-ground caribou herd from the IPM (blue line) compared to the survey estimates (red dots).

A closer-up view of the model to recent data suggests better fit to the breeding cow data in comparison to the adult cow data (Figure 41). Fit in this context is determined by whether the credible intervals of the IPM intersect 95% confidence limits of field estimates. In this case, all estimates for breeding females intersect whereas 2 of 4 adult female estimates intersect. Most notable is that for breeding cows, the 2023 field estimate intersects the mean IPM estimate whereas the 2023 adult female estimate is above the 2023 IPM prediction. The same general pattern occurred for the 2023 Beverly IPM analysis (Campbell et al. 2025) with better model agreement between breeding female IPM and field estimates.

One potential reason for this is that the breeding females may constitute the core older aged caribou in the herd and may show higher calving ground fidelity than non-breeding females or than younger caribou. The adult female age class includes younger (two-year-old) cows that are often non-breeders. We speculate this class of non-breeding cows may show less fidelity to calving grounds, including to core breeding areas, compared to adult cows. Because younger cows are not collared, we have little inference on the distribution and movements of these two-year-old cows relative to calving grounds. This "twoling" class may create a higher degree of variance in adult female estimates given that they can represent 20% of the adults in a given year, dependent on productivity levels (Figure 41). We note that the variation in "twoling" cows could be positive (immigration of twolings from other herds) or negative (emigration of "twolings" to other herds) and therefore could create increases or decreases in estimates of adult females.

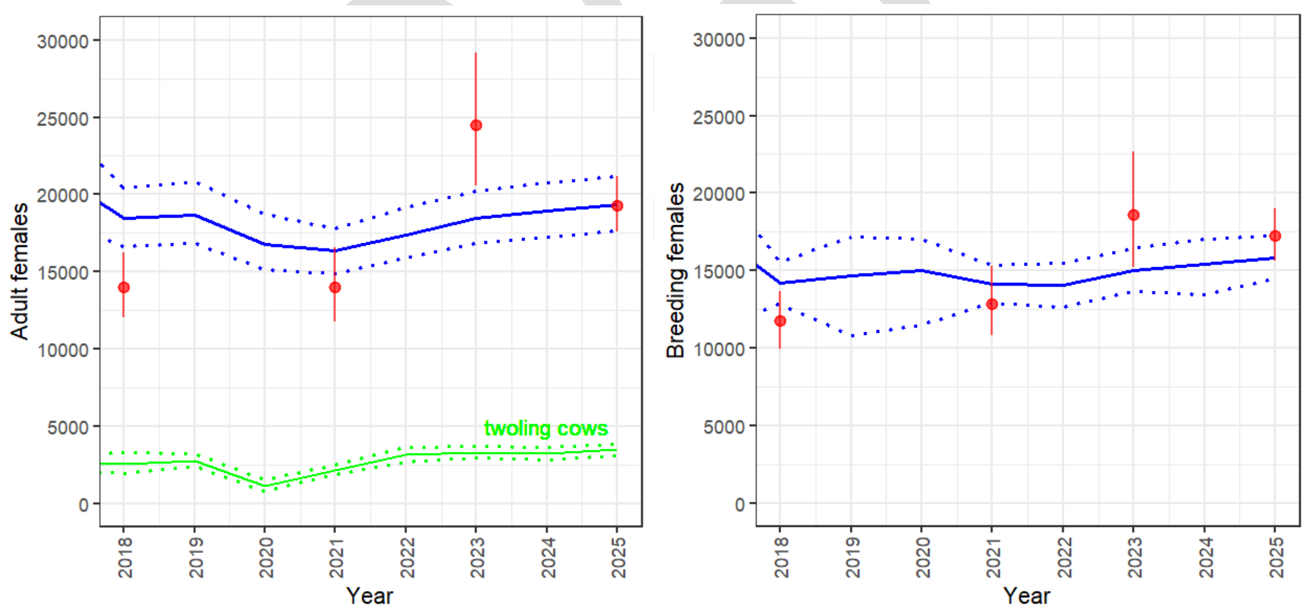

Figure 41: The number of adult females estimated to be two years old on the calving ground ("twoling" cows) are shown as a green line with hashed 95% credible intervals. The estimate of adult females (blue line) includes these "twoling" cows so the green line provides reference to the proportion of adult cows assumed to be two years old on the calving ground. Field estimates are shown as red points with 95% confidence limits.

Overall trend

Overall IPM estimates of trend of adult females suggest an increasing trend with an increase starting in 2021 ranging from 1.01 to 1.06. The 3-year geometric mean of adult female λ up to the 2024-25 caribou year was 1.035 (CI 1.0-1.07). The geometric mean of herd (adult males + adult females) λ from 2021 to 2025 was 1.05 with the geometric mean from 2023-2025 being 1.04. These estimates of trend are within the range suggested by comparisons of observed field estimates from 2021 to 2025 (Figure 42).

The IPM results incorporating observed field data as of 2025 suggest that the Bluenose-East herd is increasing at an approximately 5% rate (CI 2-8%) per year since 2021. This rate coincides to rates derived from the ratio of 2021 and 2025 adult female and herd size estimates (i.e., if there was a constant rate of increase between the 2021 and 2025 estimates). IPM estimates also suggest that the best estimate of trend is using the ratio of 2021 and 2025 estimates compared to the ratio of 2023 to 2025 estimates which would suggest a decline. Past IPM analyses after the 2023 survey estimate (Boulanger et al. 2024) considered a variety of hypotheses regarding the potential increase from 2021 to 2023 with the general conclusion of an increase from 2021-2023 with an annual rate (λ) ranging from 3 to 11% (rather than the 32% from field estimates (Boulanger et al. 2024)). Results from the 2025 survey further affirm this range of increase (estimate of 5% (CI 2-8%) per year for adult females).

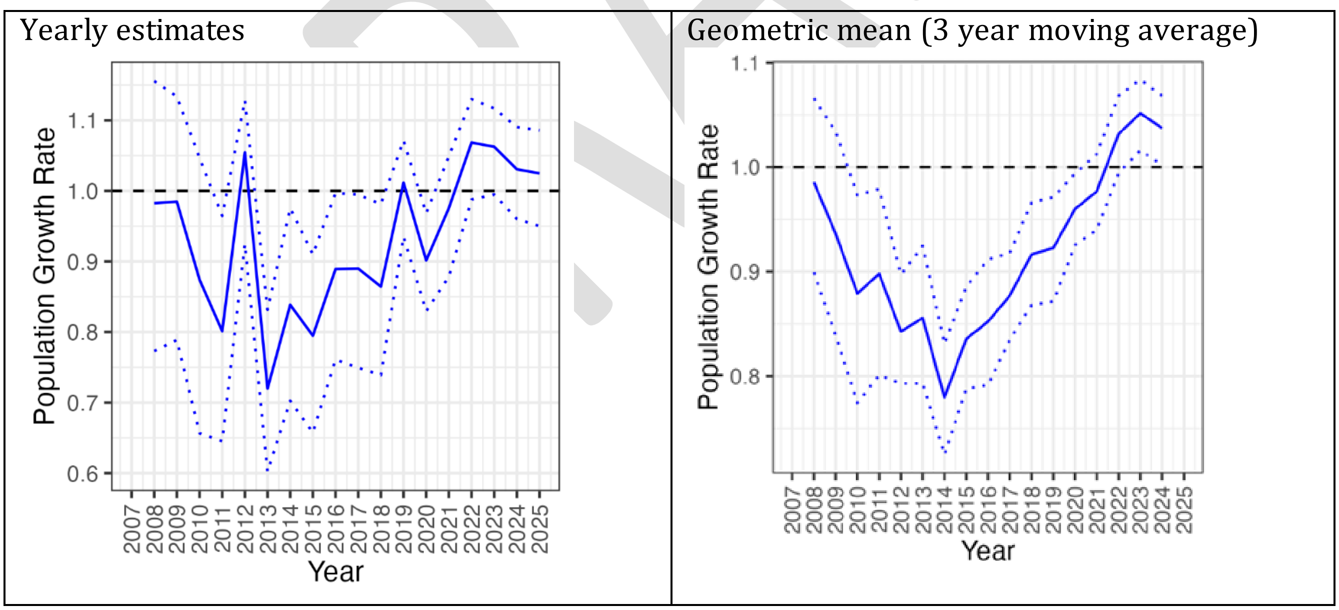

Figure 42: Population growth rate for adult females.

DISCUSSION

Interpreting the 2025 survey results

Visual survey method changes

Visual survey estimates have improved over time from using single observers and a 400 m strip transect on each side of the aircraft (where perfect sightability is assumed), to using double observers on each side of the aircraft and mark-recapture analysis to estimate sightability of caribou on-transect. In the 2025 survey we built on the recommendations in Boulanger and Campbell 2025 to add a distance sampling component with 3 distance bins and further introduced using the data recorder as a third observer on each side of the aircraft. Abundance estimates from the visual strata were calculated using each of these methods and compared in Boulanger et al. 2026. The estimates generated from each method for the Bluenose-East herd were not significantly different from each other, as shown in Figure 43 (Figure 14 in Boulanger et al. (2026)) below. The visual strata estimate used in 2025 (from distance sampling and with the data recorder observations) was 6.5% higher (1,022 more caribou) than the 'original' strip transect method (400 m strip, 2 observers, no sightability correction) and was 5.7% higher (913 caribou) than the double observer (mark-recapture) method used from 2011-2023.

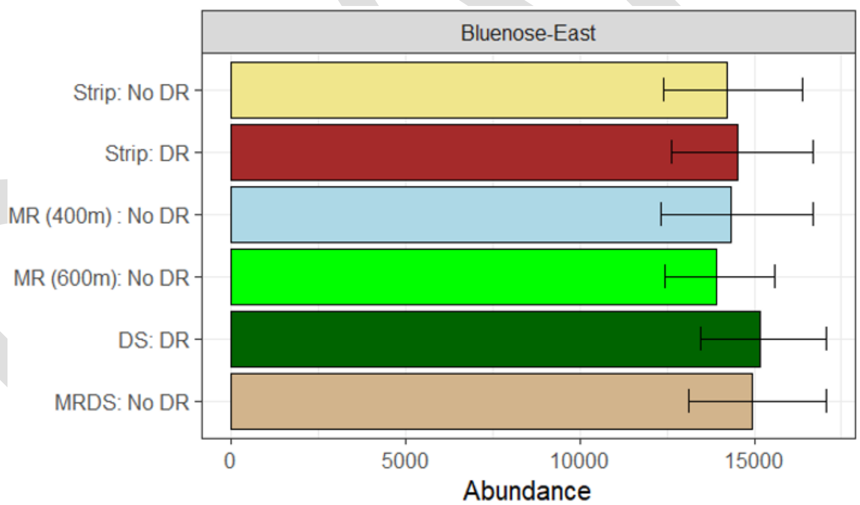

Figure 43. Comparison of visual strata estimates for the Bluenose-East calving ground survey, using different data set formulations and estimation methods. The methods used are: Strip transect, 400 m strip, 2 observers (Strip: No DR); Strip transect, 400 m strip, including data recorder observations (Strip: DR); Double observer (mark-recapture), 400 m strip, 2 observers (MR (400m): No DR); Double observer (mark-recapture), 600 m strip, 2 observers (MR (400m): No DR); Distance sampling including data recorder observations (DS:DR); and MRDS (mark-recapture/distance sampling), 2 observers (MRDS: No DR). Figure is from Boulanger et al. 2026 (Figure 14).

Although the 2025 visual estimate was generated with 'new' analytical methods, the estimate is not significantly different than estimates generated using the previous methods. This supports the comparison of trends across calving ground surveys.

These changes to field and analysis methods have improved our understanding of factors that influence visual detections of caribou. Adding a third observer (data recorder) on each side of the aircraft showed that the mark-recapture method did not adequately estimate the number of caribou 'missed' by observers; i.e., the third observer saw more 'missed' caribou than were modelled. We strongly recommend use of the data recorder as a third observer on future calving ground surveys. The conditions of the 2025 survey provided excellent conditions for detecting caribou (bare ground and good light), and some methods may perform better in estimating sightability in poor conditions (e.g. patchy background conditions). Repeating the comparison of results from the different analytical methods during the next calving ground surveys will provide additional insights into their performance.

Photo survey strata

The proportion of adult females was low in the south stratum (0.47 adult females, with 0.21 of the total 1+ caribou estimate in the stratum) and relatively low in the PhotoNorth stratum (0.85 adult females, with 0.35 of the total 1+ caribou estimate in that stratum), in comparison to the 2023 single photo strata that had a proportion adult females of 0.92. Proportions of adult females in stratum will vary by how adult females are distributed in a given year and how strata were drawn around groups of adult females. In 2023, caribou arrived relatively early on the calving ground and were in a relatively homogenous cluster compared to 2025 and previous years when they were distributed in a more drawn out north to south gradient.

Lower proportions in strata with higher overall abundance in this case drive the adult female estimate relatively lower. The collared cows were concentrated in the PhotoNorth stratum and the northern portion of the PhotoSouth stratum; however, the delineation of the PhotoSouth stratum was motivated by observations of breeding caribou in this area during the reconnaissance survey. We tested whether there was a north/south gradient in the proportion of adult females in the PhotoSouth stratum by dividing it in half with composition and abundance estimated derived for each portion. Estimates from this post-stratification exercise changed little (<1%) due to the relatively homogenous density of caribou across this stratum. 0.43 of caribou in the PhotoSouth stratum were classified as yearlings.

Composition survey timing in relation to neonate mortality

The 2025 composition survey occurred very close to peak calving. In this case the data does not support using the composition data to estimate calf mortality, as some breeding cows were clearly still pregnant (udder not yet distended), and for cows with antlers and udder observed, we could not confirm if absence of a calf meant the calf had not yet been born or the calf died shortly after birth. For cows with no antlers (post-birth event) and a visible udder, if data was recorded to link presence/absence of a calf with each cow, then calf mortality could be estimated for this group. However, classification data is recorded by group and does not pair calves and cows within the group. It would be challenging to pair all cows with their calf (or lack of calf) in larger groups where a group of calves (e.g. 3-5) may occur in proximity to a group of (e.g. 3-5) cows. In other years when the June composition survey clearly occurs post-peak calving, it may be more reasonable to estimate an early calf mortality range; e.g. in the 2021 Bathurst calving ground survey the ratio of breeding cows that had dropped their antlers to breeding cows that had not dropped their antlers was 6:1 (Adamczewski et al. 2022). Similarly, when the composition survey occurs close to peak of calving and some breeding cows are still pregnant, using a calves/cows or a calves/breeding cows ratio to estimate calf loss is not a reliable way to estimate calf mortality (Whitten 1995). However, these ratios were reported for 2025 for consistency with previous surveys.

Herd abundance estimates from fall composition surveys

Herd abundance estimates rely heavily on data (the ratio of bulls to cows in the herd) from fall composition surveys. In the case of a large year-to-year change in sex ratio, whether a single ratio or mean ratio is used has a big influence on the extrapolated herd estimate (Table 19). Calving ground surveys to estimate the adult females are designed using a reconnaissance survey to delineate the abundance survey area, which provides confidence that the survey will encompass the females in the herd. In fall composition surveys, the survey design is to sample caribou across the herd's distribution on the landscape during the rut when females and males are together. Field planning relies on collared caribou to represent areas of use and on classifying caribou associated with, and in areas surrounding, collared animals of the herd (i.e. no collars from neighbouring herds). However, composition surveys do not census the entire herd and coverage of collared animals can be variable due to flight and fuel restrictions, weather, and caribou movements. Collared animals can also over- or underrepresent some areas used by the herd, and the sexual segregation of adult caribou (i.e. the bull cow ratio) can vary across the range. Therefore year-to-year changes in ratios can result from measurement error related to sampling coverage, from true changes in the sex ratio/composition of the herd, or a combination of both. For these reasons, considering multiple data points and trends over time is more robust than using a single data point (e.g. multiple fall composition surveys, and/or survey ratios alongside collar survival rates and other data).

A main challenge of fall composition ratios is obtaining a representative sample of all bulls and cows in years when caribou are less aggregated. The bull-cow ratio in 2025 was lower than previous years which could result from lower bull survival relative to cows, lower productivity, or lower fidelity of bulls or cows to the Bluenose-East herd, or it could result from sampling locations. Each of the fall sex ratios may be biased due to sampling locations relative to the herd's distribution. Using the mean of the two fall sex ratios provides a conservative approach to estimating abundance, recognizing that fall composition surveys in subsequent years will provide additional data to inform the magnitude of change in the herd sex ratio over this time period.

Herd abundance estimates - movement among neighboring herds

Comparing estimates of breeding females, adult females, or total herd size derived from multiple calving ground surveys assumes that there is no immigration or emigration out of the herd between surveys. There is, however, some movement of collared caribou across herds (i.e., subpopulations of barren-ground caribou). In the past ten years the average number of collared adult females on the Bluenose-East calving ground in June has been 28 (range 15-43). At least 15 collars are needed to detect emigration rates of less than 10% (Boulanger et al 2024), but even with more collars it is difficult to estimate what proportion of the herd may be moving based on relatively small collar sample sizes.

Collared cows have shown relatively high fidelity to the Bluenose-East calving ground over time (with the herd's annual calving ground location shifting farther north over time), but higher movement rates have been observed between neighbouring herds (Bluenose-East, Bathurst, and Beverly) in recent years, consistent with recent winters of high overlapping range use of multiple herds. Of 38 collars known to have calved on the Bluenose-East calving ground in 2024, 34 returned to the Bluenose-East calving ground in 2025, with two occurring to the west of Bluenose Lake (south of Bluenose-West calving ground), one occurred on the Beverly calving ground and one returning to the Bathurst calving ground where it was in 2023. Herd abundance estimates are likely affected to some extent by movement among calving grounds.

The current challenge to IPMs is modelling potential movement between adult females on calving grounds due to overlap on winter ranges (Adamczewski et al. 2019, Adamczewski et al. 2022, Boulanger et al. 2024, Campbell et al. 2025). Movement models have been developed for the Bathurst and Beverly herds that mainly consider directional movement of caribou from the Bathurst to Beverly herd (Boulanger et al 2024) or bi-directional movement between the Beverly and Ahiak herd (Campbell et al 2025). Development of a multi-herd IPM provides a potential way to model the demography and movements of herds therefore sharing information on demography and the effect of movement between herds of demography.

The integrated population models in this report do not estimate emigration or immigration into or out of the Bluenose-East herd; the model assumes that movement into equals movement out of the Bluenose-East herd. In recent years emigration from the BNE has increased (approximately 10% in 2024). The summary of emigration and immigration based on collars in this report allows for evaluation of the assumption of equal immigration and emigration in the population model.

Integrated population modeling (IPM) outcomes

IPMs incorporate data from multiple sources (fall and late winter composition surveys, calving ground surveys, and collar-based survival rates) which can lead to a greater understanding of herd trends than single sources of data, i.e., calving ground surveys. In practice, direct comparisons of field estimates to obtain a trend often use estimates as a "true" value and do not consider the sampling error around that estimate. Moreover, when comparing results from one or two field surveys it can be difficult to separate out ecological variation from sampling error. IPMs do consider the precision of each estimate and that the true value of an estimate may be at the top or bottom (or outside of) of the variance around the observed estimate. The IPM approach has been applied across a full range of species worldwide (Schaub and Kery 2022). We suggest that IPMs provide a method to better understand overall dynamics of caribou herds by considering all sources of data available as opposed to single metrics (i.e. calving ground estimates).

The IPM analyses run after the 2023 calving ground survey suggested modelled herd estimates that were lower than the observed 2023 estimate, considering other data about the Bluenose-East herd (Figure 44). Extrapolating those model runs to 2025 suggests that the 2025 calving ground survey estimates are in line with the IPM predictions from 2023.

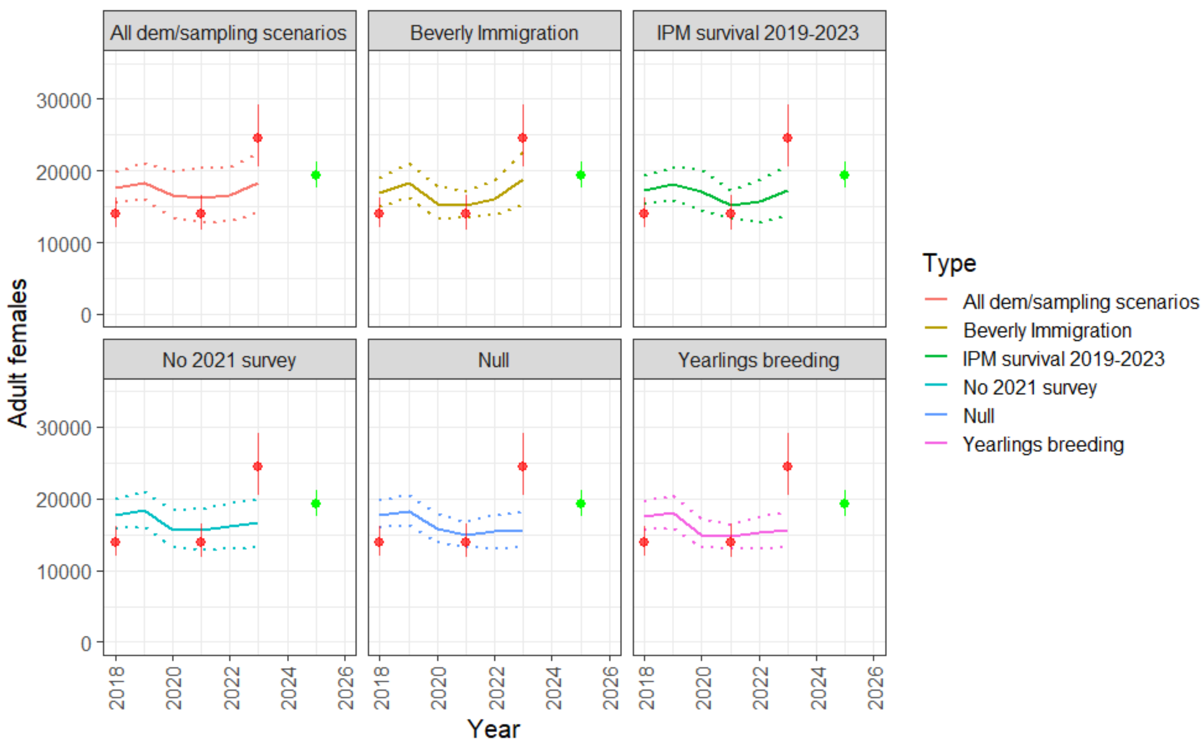

Figure 44: IPM model predictions of adult females in 2023 (Boulanger et al. 2024) with the 2025 estimate in green. See Boulanger et al. 2024 for description of scenarios run.

The 2025 integrated population modelling results suggest that the Bluenose-East herd is increasing at an approximate 5% rate per year since 2021. This rate is also suggested by field-based estimates of breeding females on calving ground surveys.

IPMs from across different herds and scenarios better match observed trends in breeding females compared to trends in total adults based on analyses in this report as well as the IPM developed for the Beverly herd (Campbell et al 2025). This could result from several factors, e.g., breeding females may represent older caribou showing higher fidelity than younger caribou; breeding females may show more fidelity to calving areas than non-breeding females; breeding females may be more readily classified whereas judgement is required to classify, based on body size, a smaller non-breeding adult female versus a female yearling, and classification error might occur in years with larger 1-year old females (yearlings) and/or smaller 2-year old females (adults) or due to observer differences. Breeding females appear to be a more stable cohort to track trends from calving ground surveys.

Herd status and trend

The Advisory Committee for Cooperation on Wildlife Management (ACCWM) has developed a *Taking Care of Caribou Management Plan for the Bluenose-East, Bluenose-West, and Cape Bathurst Herds* (ACCWM 2021) that provides overall guidance for management and monitoring of the Bluenose-East herd across land claim and treaty boundaries. At the ACCWM's 2026-2027 Annual Status Meeting held in November 2025, the committee reviewed community-based and scientific information to determine the status of the Bluenose-East herd. The Kugluktuk Angoniatit Association, Tłı̨chǫ Government, and Délı̨nę provided community information about the Bluenose-East caribou and their habitat during the previous year. Scientific information included the results of the 2025 Bluenose-East calving ground survey and other field surveys, and the 2025 population modelling presented in this report. This information supported the ACCWM's decision of the herd as "Yellow", representing intermediate and increasing numbers under the ACCWM's "traffic light" approach (ACCWM 2026).

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The rest of our survey team included Allicia Kelly, Judy Williams, Colin Modeste-Burgin, James Hodson, Stefan Goodman, Robin Abernethy, Karin Clark (GNWT-ECC), John Boulanger (Integrated Ecological Research) and Lisa Leclerc (Government of Nunavut).

We thank the survey pilots for the professionalism and excellent flying throughout the survey: Kyle Newhook (NorthWright Airways Caravan pilot), Dylan Davidson (Tintina Air Inc. Caravan pilot), Tyler Watt (Geodesy Group Inc. Jetprop pilot), Juniian Lin (Geodesy Group Inc. Navajo pilot), Aidan Millan-Smyth (Geodesy Group Inc. Navajo sensor operator), and Alex Buendia (Canadian Helicopters A-Star helicopter pilot).

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Figure 45: Photo of 2025 calving ground survey team members in Kugluktuk, NT. Back row L-R: Kyle Newhook, Colin Modeste-Burgin, Stefan Goodman, Jason Michael, Regan Adjun, Cheyenne Koyina, Darryl Bohnet, Karin Clark, James Hodson, Earl Evans, Roy Judas, Charlie Sangris, Dylan Davidson. Front row L-R: Amanda Weltman, Hughie Kenny, John Boulanger, Judy Williams, Allicia Kelly. Lisa Leclerc (Government of Nunavut) and Robin Abernethy (remote support) not pictured.

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APPENDICES

Appendix A. Supplementary Information for the 2025 Bluenose-East calving ground survey

Appendix B. Details on visual distance sampling analysis

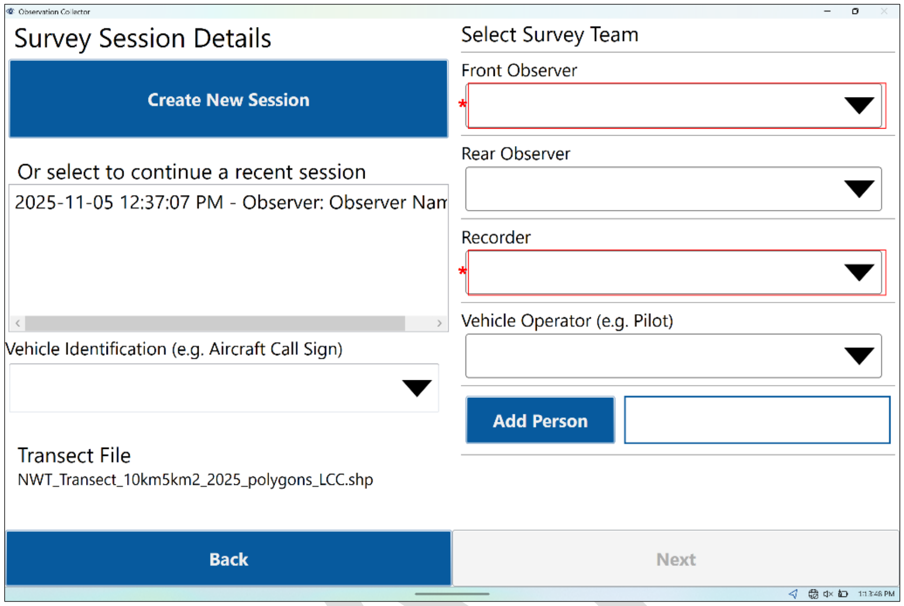
Appendix C: 2025 sightability assessment of photo interpreter counts

Appendix D. Details on the 2025 Integrated Population Model for the Bluenose-East herd

Appendix E. Field estimates from June calving ground surveys 2010 - 2025 and from fall and late winter surveys 2009 -2025 for the Bluenose-East herd of barren-ground caribou

Appendix A. Supplementary Information for the 2025 Bluenose-East calving ground survey

Supplementary Figures



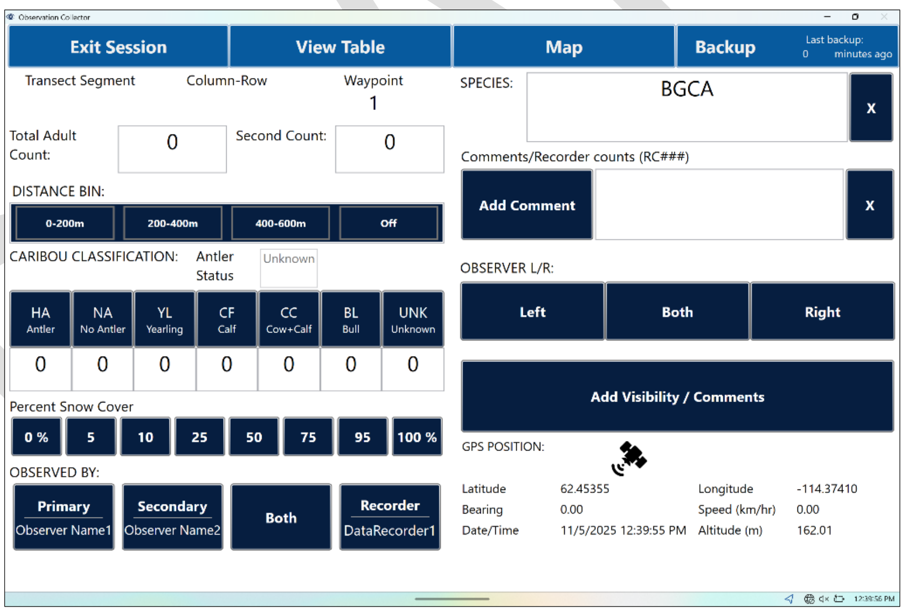


Figure A-1. Observation Collection software interface, modified in 2025 to incorporate distance bins and data recorder observations, used for reconnaissance and visual survey components of the 2025 Bluenose-East calving ground survey. Tablet touch-screen images show the survey session details page (top) and the primary data collection display (bottom). Entered names of observers, data recorder and pilot appeared in the relevant boxes during the survey sessions.

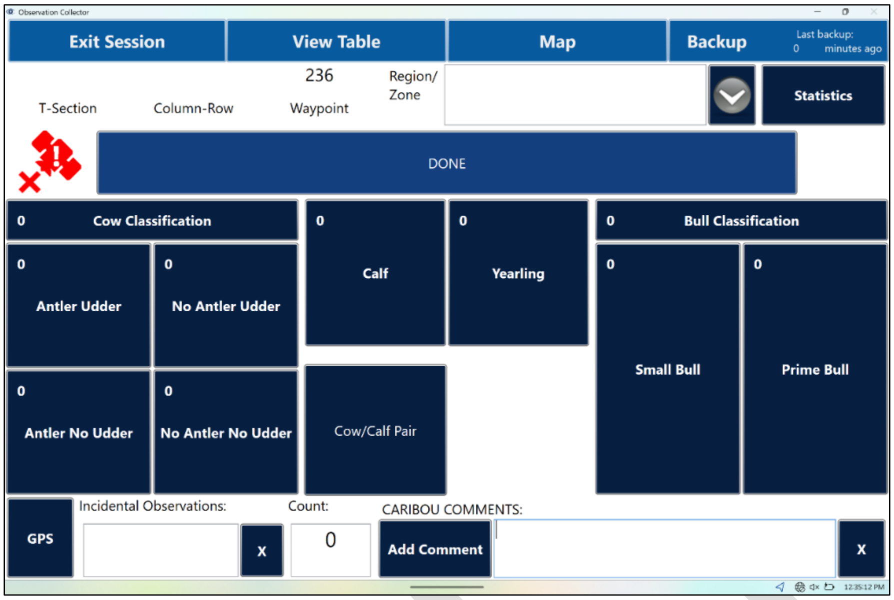


Figure A-2. Observation Collection software interface used for the June calving ground composition survey. Data entered as a "Cow/Calf Pair" was only used 2x; this added to the total cow and total calf count but did not allow for insight into the timing of calving related to antler loss.

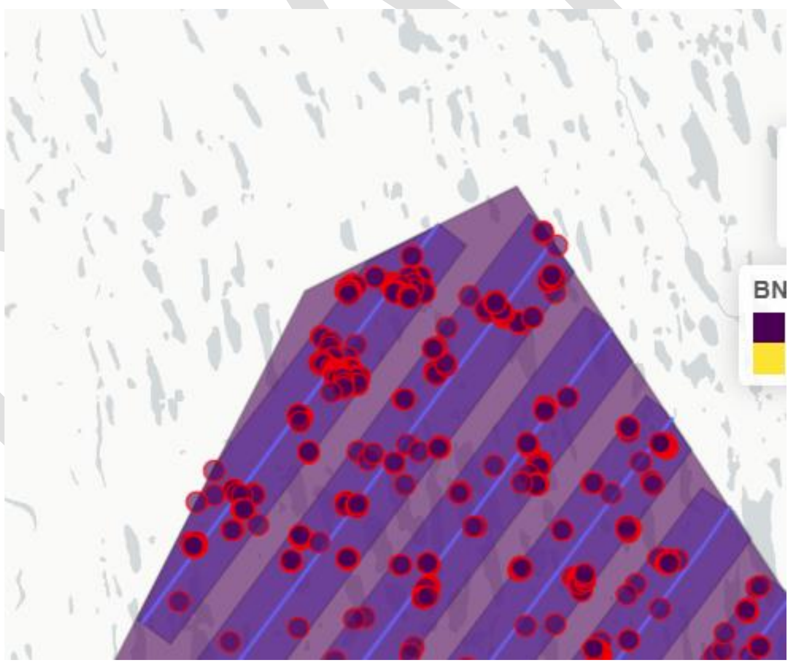


Figure A-3. The northern end of the PhotoNorth stratum illustrates how photo transect areas were clipped based on stratum boundaries. Photo transect areas are based on buffering each transect center line by the given strip width (based on mean photo width) and then trimming the edges based on stratum boundaries. Therefore they will be slightly less than transect length X strip width for some transects. The differences are greatest for transects that were on the edges.

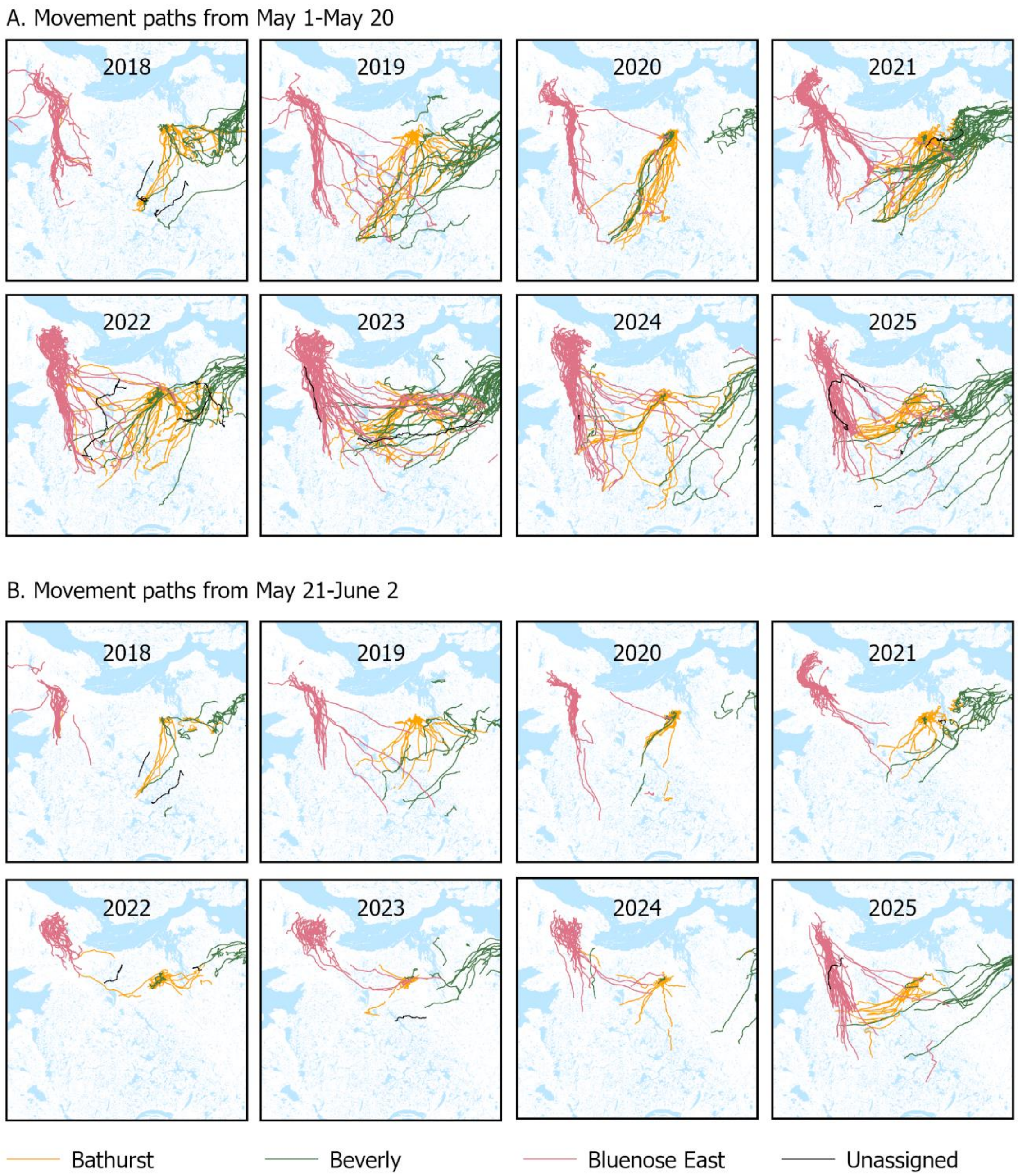


Figure A-4. Migration paths of collared caribou comparing 2018 to 2025. Series A shows movement paths from May 1-20; series B shows movement paths from May 21 -June 2. Migration paths are coloured to show herd assignment.

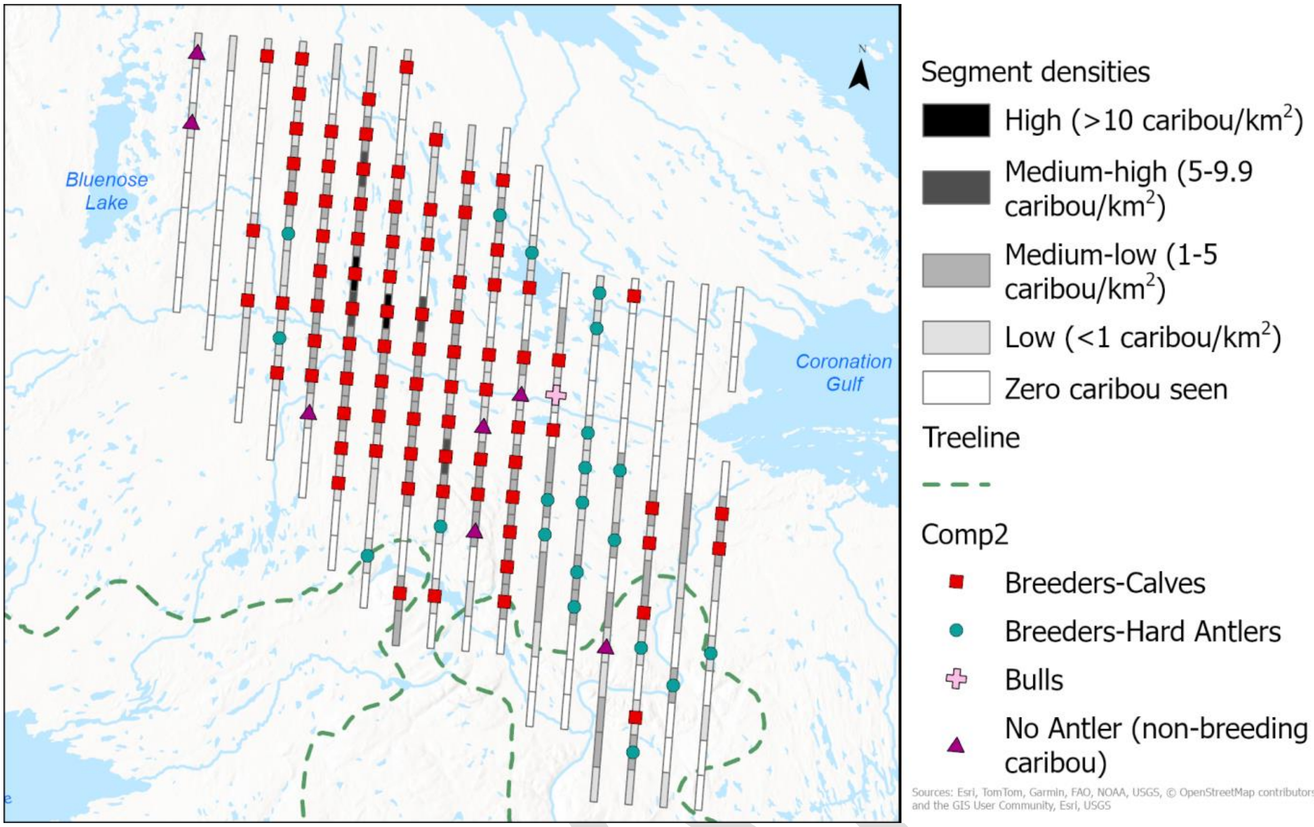


Figure A-6. Detailed composition information from the 2025 Bluenose-East calving ground reconnaissance survey where presence of calves, presence of hard-antlered caribou (i.e. breeding cow) and absence of hard-antler (absence of breeding females) was noted. Classification of “bull” indicates only bull caribou were observed in that segment.

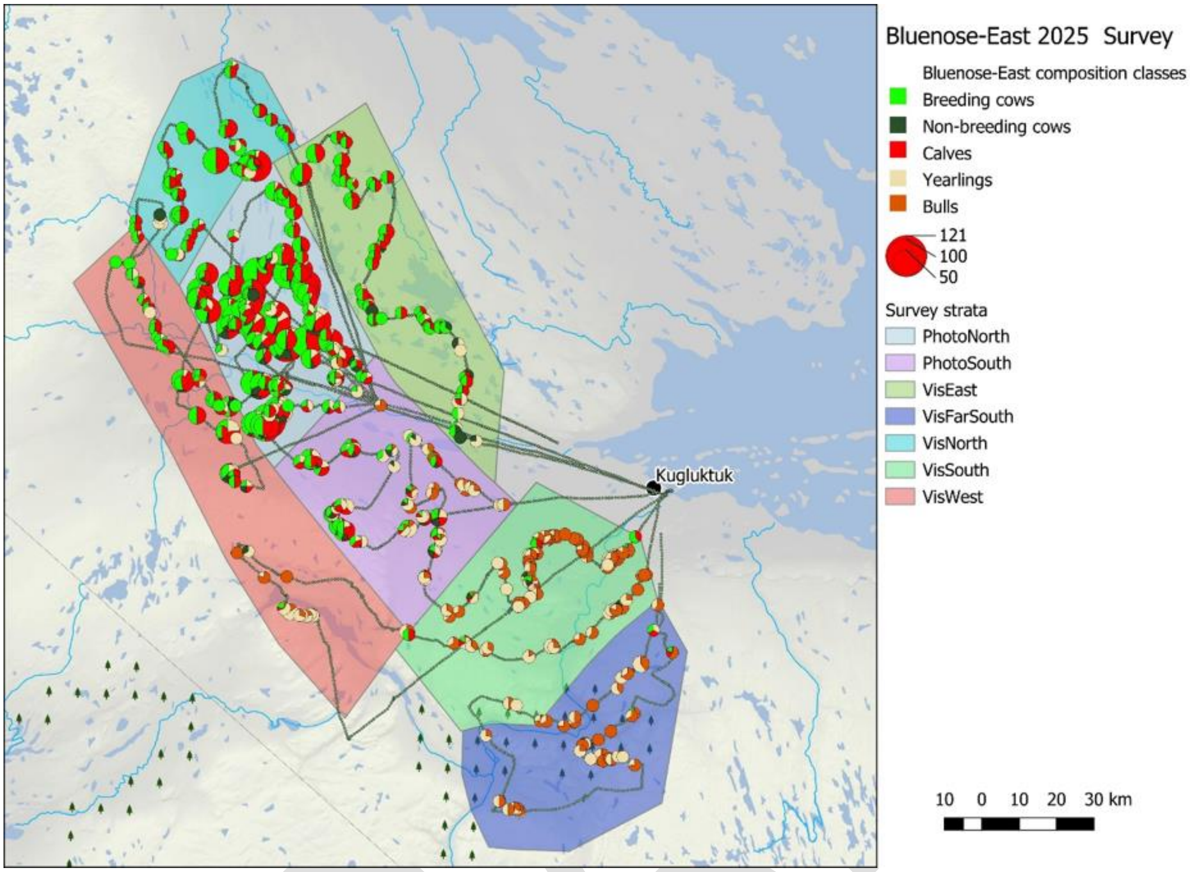


Figure A-7. Locations and composition of caribou groups classified during the June 2025 Bluenose-East calving ground composition survey. Pie charts show relative proportions of caribou classes identified in each group.

Supplementary Tables

Table A-1a. Summary of reconnaissance and visual survey flying on the June 2025 Bluenose-East calving ground survey. ‘Ferry’ refers to flying to and from the survey transects. ‘Transect’ refers to on-transect flying and includes travel between adjacent transects. Both GDLC and GJAS are Cessna 208 Caravan aircraft with GDLC contracted from NorthWright Air in Inuvik, NT and GJAS contracted from Tintina Air Inc. in Whitehorse, YT.

Date	Aircraft	Description		Reconnaissance		Visual	
			Position	Ferry (h)	Transect (h)	Ferry (h)	Transect (h)
03-Jun	GDLC	Yellowknife-Kugluktuk	2.2				
	GJAS	Yellowknife-Kugluktuk	2.2				
04-Jun	GDLC	Bathurst Recon					
	GJAS	Bathurst Recon					
05-Jun	GDLC	No Fly - Poor Weather					
	GJAS	No Fly - Poor Weather					
06-Jun	GDLC	BNE Recon		0.3	1.9		
	GJAS	Did Not Fly					
07-Jun	GDLC	BNE - Recon		2.2	5		
	GJAS	BNE - Recon		1.5	5.7		
08-Jun	GDLC	BNE - Visual				2.5	4.8
	GJAS	BNE - Visual				2.3	5.1
09-Jun	GDLC	BNE - Visual				1.6	3.9
		Total hours reconnaissance survey		4	12.6		
		Total hours visual survey				6.4	13.8

Table A-1b. Summary of composition survey flying on the June 2025 Bluenose-East calving ground survey. GBTB is an A-Star helicopter operated by Canadian Helicopters Ltd. Composition survey routes are shown in Figure 19.

Date	Aircraft	Survey Area	Position (h)	Fuel cache (h)	Survey (h)	Total
9-Jun	GBTB	YK-Kug, cache fuel	3.3	3.6		6.9
10-Jun	GBTB	VisEast, VisNorth			5.8	5.8
11-Jun	GBTB	PhotoNorth, visN, visW			7.4	7.4
12-Jun	GBTB	PhotoNorth, South, visW		1.3	5.2	6.5
13-Jun	GBTB	PhotoSouth, visS, visW			5.7	5.7
14-Jun	GBTB	VisFarSouth			2.7	2.7
15-Jun	GBTB	Kug – YK and stationary collar site investigations	8			8
			11.3	4.9	26.8	43

Table A-2. Daily field weather conditions during the 2025 Bluenose-East calving ground abundance survey.

Date	Field Observation	Daily Weather Forecast[1]	Survey Operation
3 Jun	No weather observations recorded	Transit forecast indicated scattered clouds along the Yellowknife-Kugluktuk route, with generally good flying conditions.	Both caravan aircraft positioned from Yellowknife to Kugluktuk
4 Jun	(-5˚C) High Overcast, slight wind - 3-5 Kt	Bluenose-East: overcast to broken cloud; ceiling near 600 ft AGL early; visibility >6 mi; isolated snow/rain showers before 08:00; ceilings improving through the morning.	(Bathurst 1st reconnaissance survey flown by both caravans)
5 Jun	(-2˚) Overcast, 1–3-mile visibility, low ceiling	Bluenose-East: overcast; ceiling near 500 ft AGL; showers/snow showers/drizzle possible; visibility occasionally 1-3 mi, with low cloud developing or worsening later.	No flying- poor weather
6 Jun	(-2˚C) overcast, low ceiling, Visibility 3-5 miles, 10-15 kt wind	Bluenose-East: overcast with frequent low stratiform cloud; local ceiling near 300 ft AGL; rain/snow showers, drizzle and mist; visibility occasionally 1-3 mi.	Bluenose-East reconnaissance (1 aircraft)
7 Jun	(-3˚C) High overcast, Visibility good >10 miles, 10-15kt wind	Bluenose-East: scattered cloud around 2,500 ft, visibility >6 mi and nil significant weather; patchy broken cloud possible before noon.	Bluenose-East reconnaissance (2 aircraft)
8 Jun	(-3˚C) Overcast, visibility good >10 miles, 5-10 kt wind	Bluenose-East: scattered to broken clouds, mainly high clouds with a few clouds near 3,000 ft; visibility >6 mi; nil significant weather.	Bluenose-East visual survey (2 aircraft); Bluenose-East photo survey (2 aircraft)
9 Jun	(-3˚C) High Overcast, visibility good, >10 miles, 5 -10 kt wind	Bluenose-East: overcast with ceilings near 1,500 ft; isolated light showers; visibility >6 mi; possible lower ceilings of roughly 500-800 ft near the north coast.	Bluenose-East visual survey (1 aircraft) (Bathurst recon #2 flown)

[1] Weather forecasts for the survey areas were provided daily by meteorological consultant Doug Charko.

Table A-3. Summary of visual strata including the transect length, transect area, number of caribou counted (400 m strip), and resulting density (caribou/transect area).

Strata	Transect number	Transect length (km)	Transect area (km^2)	Caribou counted	Density (caribou/km^2)
VisEast	1	23.58	18.86	31	1.64
VisEast	2	31.39	25.11	28	1.12
VisEast	3	31.10	24.88	12	0.48
VisEast	4	30.81	24.65	20	0.81
VisEast	5	30.52	24.42	30	1.23
VisEast	6	30.23	24.18	16	0.66
VisEast	7	29.95	23.96	13	0.54
VisEast	8	29.78	23.82	4	0.17
VisEast	9	29.52	23.62	19	0.80
VisEast	10	28.07	22.46	60	2.67
VisEast	11	26.09	20.87	6	0.29
VisEast	12	24.10	19.28	12	0.62
VisEast	13	18.38	14.70	0	0.00
VisEast	14	9.43	7.54	2	0.27
VisFarSouth	1	11.56	9.25	3	0.32
VisFarSouth	2	19.14	15.31	11	0.72
VisFarSouth	3	24.43	19.54	24	1.23
VisFarSouth	4	28.61	22.89	45	1.97
VisFarSouth	5	32.57	26.06	38	1.46
VisFarSouth	6	36.31	29.05	12	0.41
VisFarSouth	7	38.72	30.98	19	0.61
VisFarSouth	8	36.42	29.14	47	1.61
VisFarSouth	9	34.11	27.29	52	1.91
VisFarSouth	10	38.09	30.47	26	0.85
VisFarSouth	11	41.43	33.14	49	1.48
VisFarSouth	12	40.66	32.53	25	0.77
VisFarSouth	13	29.85	23.88	12	0.50
VisFarSouth	14	14.95	11.96	78	6.52
VisNorth	1	5.69	4.55	0	0.00
VisNorth	2	28.78	23.02	8	0.35
VisNorth	3	30.18	24.14	6	0.25
VisNorth	4	30.55	24.44	49	2.00
VisNorth	5	30.31	24.25	32	1.32
VisNorth	6	30.08	24.06	8	0.33
VisNorth	7	30.05	24.04	30	1.25
VisNorth	8	29.61	23.69	23	0.97
VisNorth	9	29.17	23.34	6	0.26

VisNorth	10	28.73	22.98	10	0.44
VisNorth	11	28.14	22.51	53	2.35
VisNorth	12	27.29	21.83	10	0.46
VisNorth	13	26.45	21.16	23	1.09
VisNorth	14	25.60	20.48	40	1.95
VisNorth	15	24.75	19.80	0	0.00
VisSouth	1	12.86	10.29	31	3.01
VisSouth	2	30.90	24.72	81	3.28
VisSouth	3	41.97	33.58	81	2.41
VisSouth	4	44.56	35.65	119	3.34
VisSouth	5	44.01	35.21	87	2.47
VisSouth	6	43.57	34.86	54	1.55
VisSouth	7	43.12	34.50	72	2.09
VisSouth	8	42.78	34.22	87	2.54
VisSouth	9	42.67	34.14	79	2.31
VisSouth	10	42.70	34.16	35	1.02
VisSouth	11	42.76	34.21	18	0.53
VisSouth	12	42.88	34.30	82	2.39
VisSouth	13	42.90	34.32	29	0.84
VisSouth	14	42.65	34.12	37	1.08
VisSouth	15	38.60	30.88	29	0.94
VisSouth	16	33.84	27.07	37	1.37
VisSouth	17	30.89	24.71	23	0.93
VisSouth	18	28.63	22.90	25	1.09
VisWest	1	22.64	18.11	2	0.11
VisWest	2	24.38	19.50	2	0.10
VisWest	3	24.91	19.93	4	0.20
VisWest	4	25.44	20.35	12	0.59
VisWest	5	25.59	20.47	15	0.73
VisWest	6	25.12	20.10	12	0.60
VisWest	7	24.66	19.73	24	1.22
VisWest	8	24.19	19.35	15	0.78
VisWest	9	23.72	18.98	17	0.90
VisWest	10	23.34	18.67	73	3.91
VisWest	11	23.20	18.56	44	2.37
VisWest	12	23.05	18.44	23	1.25
VisWest	13	22.91	18.33	22	1.20
VisWest	14	23.98	19.18	20	1.04
VisWest	15	25.03	20.02	4	0.20
VisWest	16	25.99	20.79	8	0.38
VisWest	17	26.69	21.35	29	1.36

VisWest	18	27.38	21.90	23	1.05
VisWest	19	28.09	22.47	20	0.89
VisWest	20	28.86	23.09	54	2.34
VisWest	21	29.07	23.26	32	1.38
VisWest	22	28.89	23.11	19	0.82
VisWest	23	28.72	22.98	12	0.52
VisWest	24	28.55	22.84	4	0.18
VisWest	25	24.31	19.45	9	0.46

Table A-4. Summary of photo strata including the transect length, estimated transect strip width, transect area, caribou counted on photos, and resulting density (caribou/transect area). Note that transect areas are based on photo transect polygons trimmed at the strata boundaries (see Figure A-6) and therefore are slightly lower than transect length X strip width. Caribou counted do not include the sightability correction applied before estimating strata abundances.

Strata	Transect number	Transect length (km)	Transect strip width (km)	Transect area (km^2)	Caribou counted	Density (caribou/km^2)
PhotoNorth	1	15.91	2.26	32.27	195	6.04
PhotoNorth	2	34.50	2.26	75.15	148	1.97
PhotoNorth	3	40.23	2.25	89.63	258	2.88
PhotoNorth	4	40.34	2.25	90.07	347	3.85
PhotoNorth	5	40.48	2.29	91.85	391	4.26
PhotoNorth	6	40.57	2.27	91.80	455	4.96
PhotoNorth	7	40.70	2.24	90.93	1054	11.59
PhotoNorth	8	40.84	2.31	94.32	497	5.27
PhotoNorth	9	41.04	2.24	91.62	715	7.80
PhotoNorth	10	41.22	2.24	92.30	452	4.90
PhotoNorth	11	41.41	2.20	90.81	523	5.76
PhotoNorth	12	41.63	2.23	92.33	571	6.18
PhotoNorth	13	41.82	2.21	92.11	512	5.56
PhotoNorth	14	42.05	2.26	94.68	422	4.46
PhotoNorth	15	42.27	2.25	94.88	361	3.80
PhotoNorth	16	42.45	2.25	95.01	347	3.65
PhotoNorth	17	41.88	2.23	93.08	511	5.49
PhotoNorth	18	41.31	2.21	91.17	300	3.29
PhotoSouth	1	41.11	2.15	88.10	284	3.22
PhotoSouth	2	40.51	2.17	87.54	257	2.94
PhotoSouth	3	40.93	2.16	88.23	278	3.15
PhotoSouth	4	41.48	2.19	90.60	324	3.58
PhotoSouth	5	42.05	2.23	93.44	343	3.67
PhotoSouth	6	42.53	2.18	92.65	267	2.88
PhotoSouth	7	43.03	2.21	94.86	201	2.12
PhotoSouth	8	43.59	2.20	95.96	265	2.76
PhotoSouth	9	43.59	2.24	97.77	308	3.15
PhotoSouth	10	41.70	2.25	92.66	306	3.30

Table A-5. Estimated proportions of groups within each stratum from the composition survey. The proportion of breeding females, non-breeding females, yearlings, and bulls estimated for each stratum is shown. The proportion of breeding cows/cows, calves/cows* and calves/breeding cows* is also calculated for each stratum. Also given is the bootstrap-based standard error (SE), percentile-based 95% confidence limits, and coefficient of variation (SE/estimate). "All 1+ caribou" refers to all 1+ year old caribou in the stratum (does not include calves).

Strata	Proportion	**Estimate**	**SE**	**95% CI**		**CV**
PhotoNorth	Breeding cows/all 1+ caribou	0.77	0.02	0.73	0.81	0.027
PhotoNorth	Cows/all 1+ caribou	0.85	0.02	0.82	0.88	0.018
PhotoNorth	breeding cows/cows	0.91	0.01	0.88	0.93	0.013
PhotoNorth	calves/cows	0.81	0.02	0.77	0.84	0.022
PhotoNorth	calves/breeding cows	0.89	0.01	0.87	0.91	0.014
PhotoNorth	Bulls/all 1+ caribou	0.01	0.00	0.00	0.01	0.328
PhotoNorth	Yearlings/all 1+ caribou	0.14	0.01	0.11	0.17	0.101
PhotoSouth	Breeding cows/all 1+ caribou	0.39	0.04	0.31	0.47	0.104
PhotoSouth	Cows/all 1+ caribou	0.47	0.04	0.38	0.55	0.092
PhotoSouth	breeding cows/cows	0.84	0.03	0.78	0.89	0.034
PhotoSouth	calves/cows	0.69	0.04	0.61	0.76	0.056
PhotoSouth	calves/breeding cows	0.82	0.03	0.75	0.87	0.041
PhotoSouth	Bulls/all 1+ caribou	0.11	0.02	0.06	0.16	0.234
PhotoSouth	Yearlings/all 1+ caribou	0.43	0.03	0.36	0.49	0.076
VisEast	Breeding cows/all 1+ caribou	0.81	0.06	0.69	0.90	0.069
VisEast	Cows/all 1+ caribou	0.88	0.05	0.78	0.96	0.058
VisEast	breeding cows/cows	0.92	0.03	0.86	0.96	0.028
VisEast	calves/cows	0.78	0.04	0.70	0.85	0.048
VisEast	calves/breeding cows	0.85	0.03	0.79	0.91	0.036
VisEast	Bulls/all 1+ caribou	0.01	0.01	0.00	0.02	0.936
VisEast	Yearlings/all 1+ caribou	0.11	0.04	0.04	0.21	0.390
VisFarSouth	Breeding cows/all 1+ caribou	0.01	0.01	0.00	0.03	0.611
VisFarSouth	Cows/all 1+ caribou	0.02	0.01	0.00	0.04	0.530
VisFarSouth	breeding cows/cows	0.75	0.26	0.00	1.00	0.345
VisFarSouth	calves/cows	0.50	0.29	0.00	1.00	0.574
VisFarSouth	calves/breeding cows	0.67	0.31	0.00	1.00	0.463
VisFarSouth	Bulls/all 1+ caribou	0.57	0.05	0.48	0.65	0.082
VisFarSouth	Yearlings/all 1+ caribou	0.41	0.05	0.33	0.50	0.110
VisNorth	Breeding cows/all 1+ caribou	0.90	0.02	0.85	0.94	0.027
VisNorth	Cows/all 1+ caribou	0.93	0.02	0.88	0.96	0.025
VisNorth	breeding cows/cows	0.97	0.01	0.95	0.99	0.010
VisNorth	calves/cows	0.85	0.03	0.77	0.90	0.037
VisNorth	calves/breeding cows	0.87	0.03	0.81	0.92	0.033
VisNorth	Bulls/all 1+ caribou	0.00				
VisNorth	Yearlings/all 1+ caribou	0.07	0.02	0.04	0.12	0.319

VisSouth	Breeding cows/all 1+ caribou	0.03	0.01	0.02	0.05	0.313
VisSouth	Cows/all 1+ caribou	0.05	0.01	0.03	0.08	0.263
VisSouth	breeding cows/cows	0.67	0.10	0.46	0.85	0.149
VisSouth	calves/cows	0.47	0.07	0.32	0.61	0.149
VisSouth	calves/breeding cows	0.70	0.15	0.46	1.08	0.221
VisSouth	Bulls/all 1+ caribou	0.56	0.03	0.50	0.61	0.054
VisSouth	Yearlings/all 1+ caribou	0.39	0.03	0.34	0.45	0.075
VisWest	Breeding cows/all 1+ caribou	0.48	0.07	0.34	0.60	0.143
VisWest	Cows/all 1+ caribou	0.55	0.07	0.41	0.69	0.130
VisWest	breeding cows/cows	0.86	0.03	0.80	0.93	0.038
VisWest	calves/cows	0.74	0.05	0.63	0.83	0.068
VisWest	calves/breeding cows	0.86	0.05	0.74	0.94	0.059
VisWest	Bulls/all 1+ caribou	0.09	0.03	0.04	0.16	0.362
VisWest	Yearlings/all 1+ caribou	0.36	0.06	0.26	0.47	0.158

Table A-6: Estimates of breeding cows, non-breeding cows, bulls and yearlings based on photo and visual surveys and composition surveys in survey strata.

Group	1+ yr old caribou		Proportion on strata		Estimate of Group				
Strata	N	CV.N	p(comp)	cv_comp	N	SE	Conf. Limit		CV
Breeding cows									
PhotoNorth	11,985	0.056	0.773	0.026	9,262	575.2	8,126	10,557	0.062
PhotoSouth	7,333	0.037	0.394	0.100	2,888	307.2	2,272	3,671	0.106
VisEast	2,491	0.102	0.806	0.068	2,009	245.9	1,516	2,662	0.122
VisFarSouth	3,034	0.167	0.014	0.641	43	28.7	10	178	0.668
VisNorth	1,490	0.153	0.900	0.027	1,341	208.6	942	1,908	0.156
VisSouth	4,987	0.093	0.035	0.309	174	56.0	87	348	0.322
VisWest	3,257	0.118	0.479	0.136	1,560	280.9	1,064	2,288	0.180
Total	**34,577**				**17,277**	**782.3**	**15,690**	**19,024**	**0.099**
Non-breeding cows									
PhotoNorth	11,985	0.056	0.079	0.116	947	121.9	723	1,241	0.129
PhotoSouth	7,333	0.037	0.074	0.187	546	103.9	356	837	0.190
VisEast	2,491	0.102	0.071	0.303	177	56.6	86	364	0.320
VisFarSouth	3,034	0.167	0.005	1.006	14	14.7	2	105	1.052
VisNorth	1,490	0.153	0.028	0.302	42	14.2	20	89	0.338
VisSouth	4,987	0.093	0.013	0.414	63	26.8	26	155	0.426
VisWest	3,257	0.118	0.075	0.249	245	67.6	137	438	0.276
Total	**34,577**				**2,034**	**186.0**	**1,670**	**2,478**	**0.200**
Bulls									
PhotoNorth	11,985	0.056	0.008	0.328	101	33.8	51	201	0.335
PhotoSouth	7,333	0.037	0.105	0.234	772	182.6	455	1,309	0.237
VisEast	2,491	0.102	0.008	0.936	20	18.5	3	123	0.927
VisFarSouth	3,034	0.167	0.567	0.082	1,719	319.9	1,117	2,647	0.186
VisNorth	1,490	0.153	0.000		0				
VisSouth	4,987	0.093	0.558	0.054	2,782	299.5	2,195	3,526	0.108
VisWest	3,257	0.118	0.087	0.362	284	108.2	129	625	0.381
Total	**34,577**				**5,678**	**488.5**	**4,669**	**6,905**	**0.170**
Yearlings									
PhotoNorth	11,985	0.056	0.140	0.101	1,674	193.1	1,313	2,134	0.115
PhotoSouth	7,333	0.037	0.426	0.076	3,128	265.8	2,582	3,790	0.085
VisEast	2,491	0.102	0.115	0.390	286	115.2	117	700	0.403
VisFarSouth	3,034	0.167	0.414	0.110	1,257	251.4	791	1,998	0.200
VisNorth	1,490	0.153	0.072	0.319	107	37.9	49	234	0.354
VisSouth	4,987	0.093	0.395	0.075	1,968	235.8	1,512	2,561	0.120

VisWest	3,257	0.118	0.358	0.158	1,167	230.8	767	1,776	0.198
Total	**34,577**				**9,587**	**542.9**	**8,448**	**10,880**	**0.139**

Photo processing and counting caribou on imagery

Processing of the aerial photos and counting of caribou on the aerial photos was completed by Greenlink Forestry Inc. (Edmonton, Alberta). Methods used were consistent with methods used for Bluenose-East calving ground surveys since 2015.

Photographs collected along the straight-line transects were processed using the associated AGPS (assisted global positioning system, i.e., camera position) and IMU (inertial measurement unit; i.e., camera orientation and movement) data to establish the geographic position and orientation of each image. The raw imagery was then processed for aerial triangulation and orthorectification, producing geographically referenced images and establishing the spatial relationships among photographs. DATEM softcopy three-dimensional (3D) files were created from the 6-8 cm GSD RGBN imagery, along with the single image orthophotos. with adjacent photographs along each transect paired to create stereoscopic (3D) views with a minimum of 60% forward overlap between paired images.

The digital aerial photographs were viewed in 3D on-screen in a MicroStation V8 or ArcMap environment. Areas meeting the 60% overlap criterion were identified and documented as the areas used for stereoscopic animal counting. An ArcMap template was created and draped digitally over the 3D imagery to define counting areas, prevent duplicate counting of caribou, and support calculation of the number of caribou per image. The footprint of each photograph was delineated as a GIS polygon and linked to its photo ID to document the location and spatial extent of the imagery used.

Caribou and other wildlife species were identified in the 3D imagery and recorded as a point shapefile. A team of photo interpreters used specialized software and glasses that allowed three-dimensional viewing of the images. Caribou were counted across the full extent of each photo and each counted caribou was marked with a georeferenced point.

Caribou counts were summarized by photo and transect line, and the proportion of ground obstructed by cloud cover was estimated for each transect line.

Appendix B. Details on visual distance sampling analysis

This appendix provides details on model selection for distance sampling analyses. This section is taken from Boulanger et al. (2026) which also provides details on other analyses on the 2025 visual data sets.

The DS data sets for modelling included all observations, including data recorder observations. Model selection focused initially on determining optimal detection functions with half-normal, hazard rate, and uniform detection functions considered (Table B-1). Of models considered, the hazard rate (Model 18) and half normal (Model 17) models both showed support with the difference in AICc values being 2 while the uniform detection functions which assume detection probabilities of 1 regardless of distance were not supported. For half normal and hazard rate, models were further considered with group size and log of group size covariates which were likely to influence detection function shape. The scale parameter for the hazard rate model had issues with convergence (scale parameter close to 0) which was likely due to roughly equal decrease in detection across all survey bins which made estimation of a shoulder area problematic. For this reason, the half-normal detection function with size as a covariate was used for subsequent model building (Model 9). Sensitivity of estimates to half normal and hazard rate was minimal with differences of <1% in estimates for Bluenose-East and Bathurst abundance estimates (Model 6 vs Model 9). A final model (Model 1) that allowed detection functions to vary by the group size, observer pair, and an interaction between survey phase and herd was most supported. A model with the log of group size was also supported (Model 2) with minimal difference in estimates. A strata-specific model (Model 4) was less supported suggesting that strata-specific variation could be explained by observer-specific, group size, and survey phase covariates. A model with covariates from Model 1 but with hazard rate as the detection function was slightly more supported than Model 1 but did not converge adequately which was likely due to lack of data to estimate the scale parameter (as discussed later). Abundance estimates were relatively stable for the Bluenose-East herd for each model. Estimates were less stable for the Bathurst herd with an increase when PhaseXHerd was a covariate in the model. This was likely due to the difference in detection histogram shape between the Bathurst recon and visual surveys (Figure 8).

Table B-1: Model selection results for distance sampling analysis. Detection functions (DSDF) are given (hn=half-normal, hr=hazard rate, un=uniform). Model selection criteria are AIC_c, the difference in AIC_c values between the *i*th and most supported model 1 (ΔAIC_c), Akaike weights (w_i), and number of parameters (K), and log-likelihood. Total visual estimates are also given for each herd.

No	DSDF	DS model	Model selection					BNE N		Bathurst N	
			AIC_c	ΔAIC_c	wi	K	LL	N	CV	N	CV
1	hn	size + Obs + Phase * Herd	5388.9	0	0.49	12	-2682.3	15165	0.058	458	0.157
2	hn	logsize + Obs + Phase * Herd	5389.2	0.25	0.43	12	-2682.5	15260	0.060	449	0.159
3	hn	size + Obs	5392.8	3.895	0.07	9	-2687.3	15276	0.058	390	0.143
4	hn	size + Strata	5399.3	10.37	0.00	9	-2690.6	15030	0.059	450	0.155
5	hn	size + Phase * Herd	5401.7	12.71	0.00	5	-2695.8	14797	0.059	455	0.158
6	hr	logsize	5403.2	14.25	0.00	3	-2698.6	15119	0.060	382	0.144
7	hr	logsize + Phase * Herd	5403.4	14.48	0.00	6	-2695.7	14833	0.060	486	0.227
8	hr	size	5403.6	14.63	0.00	3	-2698.8	15032	0.058	381	0.143
9	hn	size	5403.7	14.71	0.00	2	-2699.8	15094	0.058	380	0.143
10	hn	logsize	5403.8	14.86	0.00	2	-2699.9	15198	0.060	381	0.144
11	hn	logsize + snow	5404.0	15.03	0.00	3	-2699.0	15127	0.060	378	0.144
12	hn	logsize * Phase * Herd	5404.1	15.115	0.00	8	-2694.0	14572	0.060	445	0.169
13	hn	logsize + Phase	5405.0	16.04	0.00	3	-2699.5	15079	0.060	376	0.146
14	hn	logsize + cloud	5405.8	16.82	0.00	3	-2699.9	15227	0.060	380	0.145
15	hn	logsize * Phase	5406.0	17.05	0.00	4	-2699.0	14774	0.061	370	0.145
16	hn	logsize + Phase + Herd	5406.7	17.79	0.00	4	-2699.4	15050	0.060	387	0.151
17	hn	constant	5409.7	20.70	0.00	1	-2703.8	15893	0.060	387	0.149
18	hr	constant	5411.6	22.63	0.00	2	-2703.8	15858	0.066	386	0.151
19	un	constant	5431.5	42.59	0.00	0	-2715.8	14165	0.056	345	0.147

There were insufficient degrees of freedom to test goodness of fit for the fully parameterized model 1 with an overall chi-square value of 2.12. Goodness of fit to the base half normal (model 17), which had adequate degrees of freedom suggested reasonable fit (χ^2=2.1, df=1, p=0.14).

References

Boulanger, J., A. Kelly, R. Abernethy, and J. Hodson. 2026. Use of Distance and Double Observer Sampling Applied to Barren-Ground Caribou Calving Ground Visual Survey Estimates. DRAFT Manuscript Report, Environment and Climate Change, Government of the Northwest Territories, Yellowknife, NT.

Appendix C: 2025 sightability assessment of photo interpreter counts

We conducted an assessment of sightability on photos using similar methodologies as previous calving ground surveys (Adamczewski et al. 2019, Boulanger et al. 2019, Adamczewski et al. 2022, Boulanger et al. 2022).

In 2025 a new camera was used for the first time on calving ground surveys in aircraft contracted from Geodesy Group Inc. The Vexcel Ultracam Eagle 4.1 (UCE4) camera has an image frame of 28,110 x 18,060 pixels and captured a 35 – 40% larger footprint and higher-resolution photos than previous digital cameras used for calving ground surveys. One question of interest was whether newer photo camera technology affected sightability of caribou on photos. To assess this question as well as overall photo sightability was tested by selecting 200 photos for re-counting as was done in previous surveys. The Bluenose-East and Bathurst calving ground surveys were completed by the same team and aircraft out of Kugluktuk, NU. Therefore the 200 photos for recounted were distributed approximately evenly between the 3 photo strata (Bathurst, BNE North and BNE so uth) leading to 66 photos for the Bathurst stratum and 134 photos for the 2 BNE strata. The sightability cross validation (design and interpretation) was applied to both herds; however, this appendix only describes the sampling design and analysis of the Bluenose-East data.

The basic approach was to systematically select photos with more than 1 caribou identified and then have a 2nd photo interpreter re-detect and count caribou on the photos. Critical to this test was that the 2nd interpreter did not have knowledge of prior detection or counts on the photos. By doing this a 2 sample mark-recapture estimator (Seber 1982) could be applied to estimate sightability on photos and from this potentially correct counts on photos for sightability.

Sampling design

Sampling design to select photos for recounting used a combined systematic and random approach. The Bluenose-East and Bathust calving grounds were both surveyed in 2025 using the same aircraft, cameras, and photo counters, so the 200 photos selected for recount were distributed approximately evenly between the 3 photo strata (Bathurst, Bluenose-East PhotoNorth and Bluenose-East PhotoSouth). This worked out to 67 photos from the Bathurst stratum and 133 photos from the 2 Bluenose-East strata. To select specific images, five cross-validation transects with 10 km spacing were overlaid with the Bluenose-East photo strata, parallel with the long edge of the strata from a random starting point, and photos that intersected with or were most proximate to the cross-validation transects were randomly selected for the recount sample (Figure C-1). This resulted in 70 (5 cross-validation lines X 18 transects in the PhotoNorth stratum) and 40 (4 cross-validation lines X 10 transects in the PhotoSouth stratum) possible intersections (and selected photos) leading to 110 potential photo selections. Photos required a minimim of 1 caribou on the original photo count to be selected and this criteria was met for all 110 photos on the Bluenose-East photo strata cross-validation transects. The remaining 22 photos from Bluenose-East strata were selected by sampling the photos with the highest counts of caribou on remaining non-selected photos. The rational for inclusion of these photos is that they have the highest influence on overall counts. This provides a better estimate of potential counting bias. A plot of caribou photo counts revealed a band of higher density in the middle section of the North stratum with reasonable numbers in other areas (Figure C-1). Cloud and snow cover were 0 in all photos.

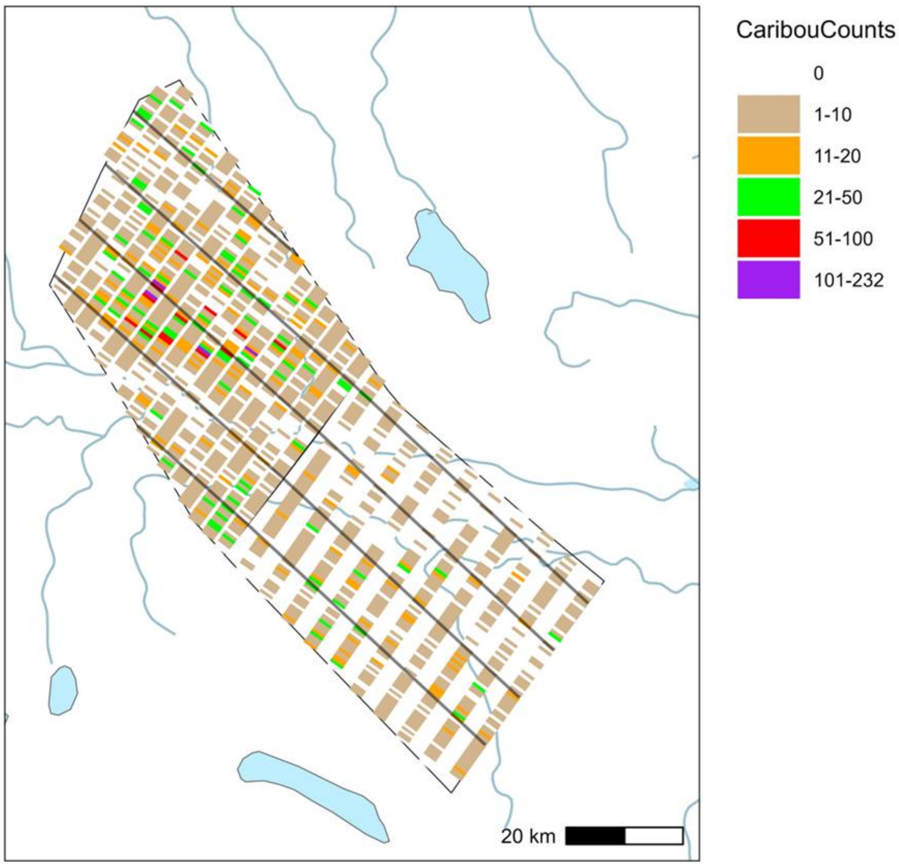


Figure C-1: Summaries of caribou counts on photos based on photo count polygons for Bluenose-Est herd with photo cross-validation lines shown (black lines).

Overall there were 1245 and 742 photos taken in the PhotoNorth and PhotoSouth strata, respectively. Table C-1 below shows binned frequencies of caribou counted on photos. Only the PhotoNorth stratum had photos with >50 caribou counted.

Table C-1. The number of photos for each stratum with ranges of caribou counted.

Caribou counted	PhotoNorth	PhotoSouth
0	344	227
1-10	702	454
11-20	111	46
21-50	71	15
51-100	13	0
101-232	4	0

Sampled photos

Photos in the proximity of a cross-validation transect that were selected are shown in Figure C-2. This equalled 111 selected photos (71 in PhotoNorth and 40 in PhotoSouth.

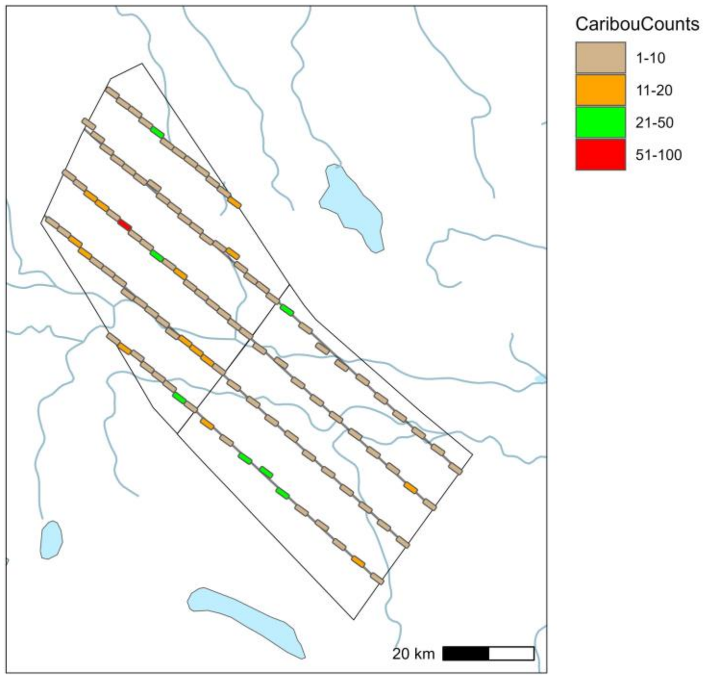


Figure C-2: Photos with at least 1 caribou selected for recounting based on proximity to cross-validation transect lines.

The remaining 22 photos selected based on photos with the highest count of caribou are shown in Fgure C-3. These photos had more than 45 caribou on the first count and occurred mainly in the central region of the PhotoNorth stratum (Figure C-3). The resulting data set had 133 photos to be counted.

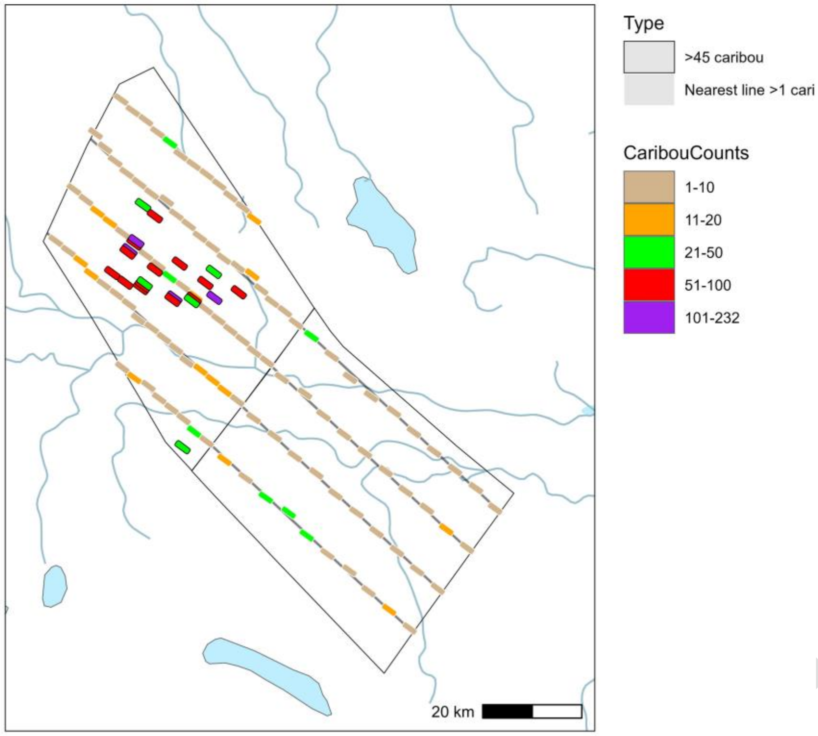


Figure C-3: Photos selected based on proximity to transect lines and photos selected based on highest counts of caribou(>45 caribou per photo).

In terms of distribution of all photos versus sampled photos, a graph of all the photos (with 0 count photos filtered out) shows a wider range of caribou counted on photos for the PhotoNorth stratum (Figure C-4).

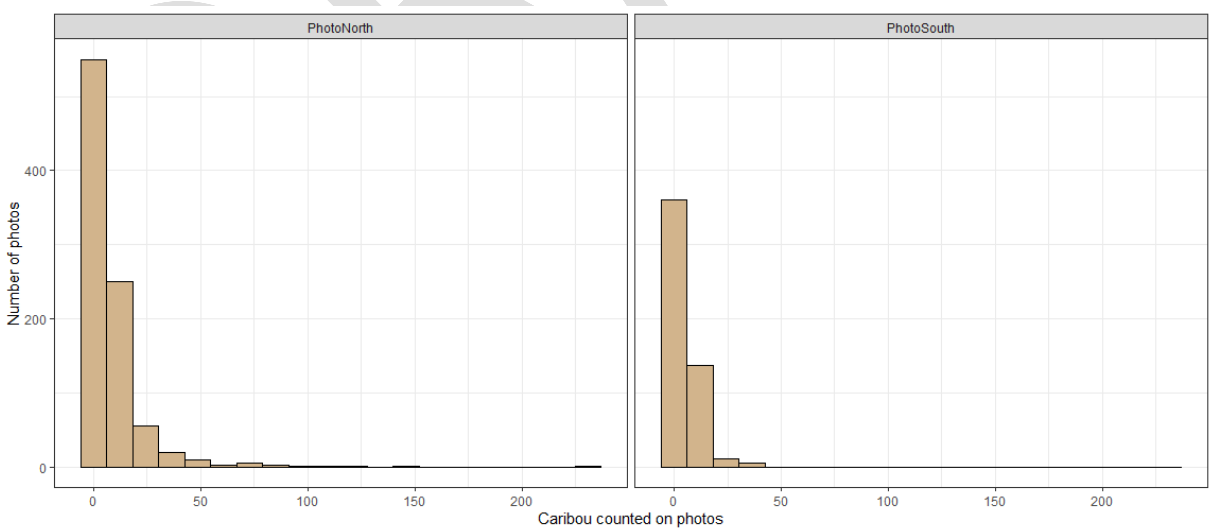


Figure C-4: Distribution of caribou counts on photos in each photo strata, with 0 count photos filtered out.

The distribution of photos in Figure C-4 reflects the distribution of counts of photos selected by using the neareast cross-validation line. Including the >45 caribou photos samples a higher proportion of higher count photos (Figure C-5).

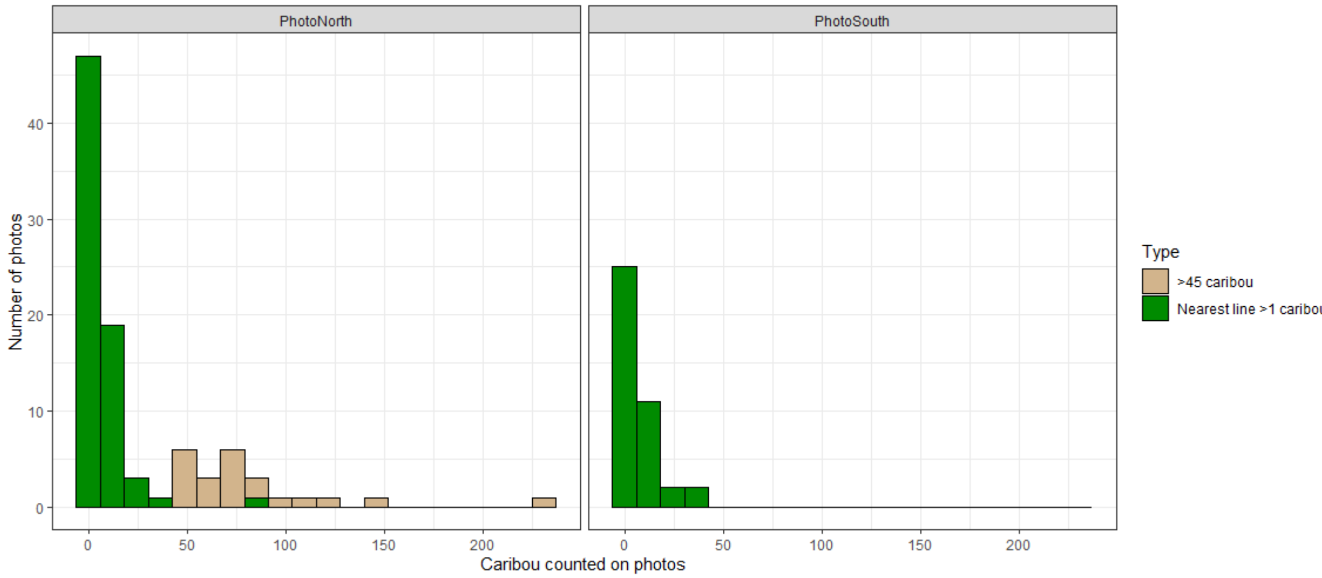


Figure C-5: Distribution of caribou counts on photos for sampled photos delineated by selection criteria including proximity to cross-validation line (green) and containing the highest caribou count (> 45 caribou), to reach total sample size of 133 photos.

Spatial analysis of counted caribou

In addition, the caribou counted by observers were reviewed by observing the locations of counted caribou by each observer on a photo. This was a new approach in 2025 to investigate the possibility of marking different caribou that totaled the same number of caribou per photo. One potential issue with comparing counts of observer 1 and observer 2 is that it is assumed that observer 1 and 2 count the same caribou and that any difference in counts is due to either observer 1 detecting new caribou or observer 2 detecting new caribou. From the context of mark-recapture, it is also possible that observers 1 and 2 count unique sets of caribou. More exactly, observer 1 would count/waypoint a set of caribou, observer 2 will count/waypoint a set of caribou, and of these caribou there will be ones that both observers counted, only observer 1 counted, and only observer 2 counted. Below is a list of potential counts of caribou from photos.

- n1-caribou waypoint by observer 1
- n2-caribou waypointed by observer 2
- m1-caribou waypointed by both observer 1 and 2
- m1a-caribou only waypointed by observer 1
- m2a-caribou only waypointed by observer 2

If observers 1 and 2 are counting unique sets of caribou, and the number of caribou that both detected can be determined, then this information can be used to model unique detection probabilities for the 2 observers allowing a robust estimate of detection probability for the primary observer 1 (who counted all the photos). To derive the quantities listed above, an algorithm was developed that determined the closest distance of waypointed caribou from observer 1 and 2 for each photograph to approximate potential "matched caribou". From the distances of "matched caribou", a "threshold distance" as determined by the 97.5th percentile of distances of closest observations of the 2 observers was calculated which identified potential unique caribou only sighted by observer 1 or 2. The "unique" caribou were then visually inspected and from this the quantities (n1,n2,m1a,m2a) could be estimated. This algorithm could not conclusively determine matches given more than 1 caribou may be within the threshold distance but could potentially identify unique caribou missed by either observer 1 or 2.

Of 133 photos recounted from the Bluenose-East photo strata, counts were identical in 102 of the photos with observer 2 counts being higher in 30 photos. Of the 30 photos, the mean difference was 1 caribou with only 16 photos having differences greater than 1. Overall, counts from the 2nd observer were 59 and 7 caribou higher than the first observer for the PhotoNorth and PhotoSouth strata, respectively (Table C-2; Figure C-6).

Table C-2: Tabulation of photos counted for Bluenose-East cross-validation.

Difference observer 2 and 1 counts	Number of photos
0	102
1	14
2	5
3	6
4	3
5	1
7	1

The main areas of difference occurred in the higher density photos in the North stratum (Figure C-6).

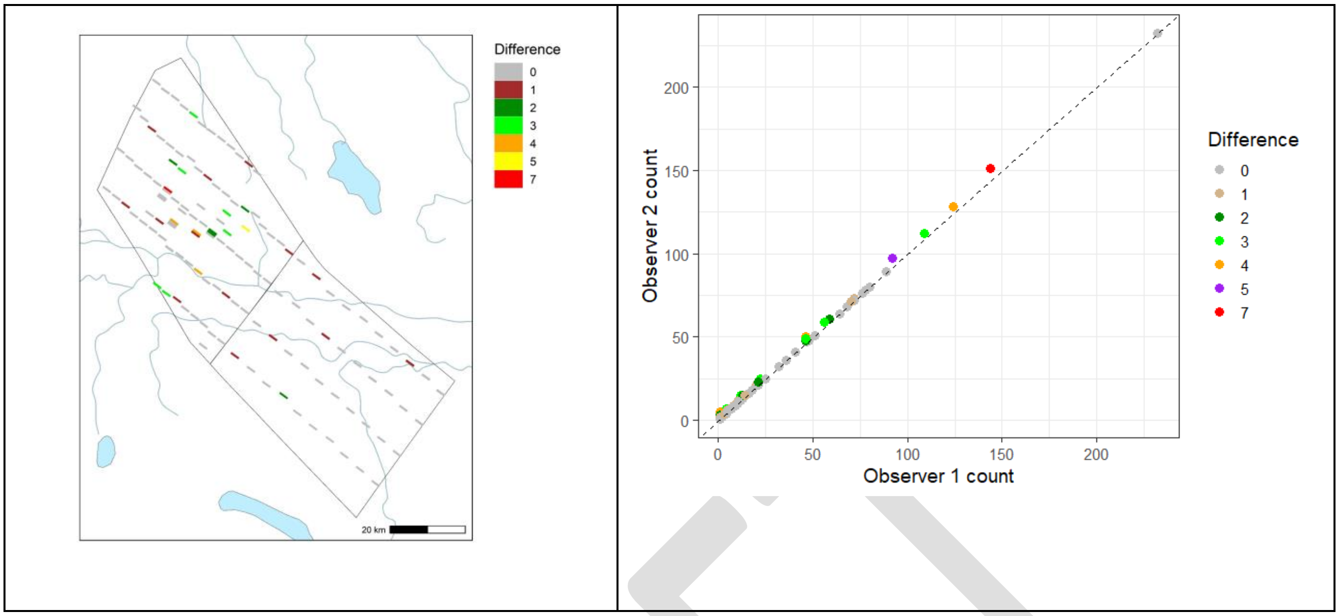


Figure C-6: Spatial distribution of photos recounted as coded by difference between observer 1 and observer 2 (left). A plot of observer 1 and 2 counts as coded by difference between observer 2 and 1 (right).

The GIS spatial analysis revealed that the mean difference between closest observations of observers 1 and 2 was 0.89 meters. The 95th percentile was 14 km with the 97nth percentile being 33 kilometers. Various threshold distances to determine unique observations were tried. Using the 33 km threshold resulted in 62 caribou detected by observer 2 but not observer 1 and 12 caribou detected by observer 1 and not observer 2.

One factor that was not considered in this comparison was whether the caribou was moving when the photo plane was overhead. In this case it was possible for a caribou to appear on 2 photos given that the photo overlap was 60% (to create a stereoscopic image) therefore appearing as 2 caribou when waypoints from observer 1 and 2 were both displayed. In this case, the caribou can be identified as duplicates by the photo interpreter closing one eye to see if the caribou appeared or disappeared on the image. The difference between successive photos was 7 seconds and in this case a caribou could appear up to 30 meters apart if moving at 15 km/hr (running) (Figure C-8).

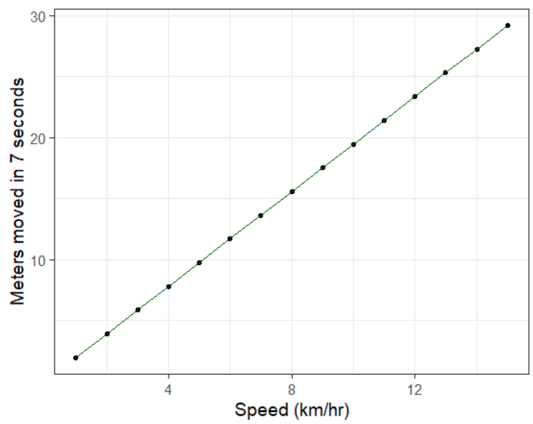


Figure C-8: Distance moved by a caribou within 7 seconds between photos (if moving).

To explore this further, photos with 12 pairings of waypointed caribou that were greater than 33 km were sent back to the photo-interpreter to determine if they were the same or unique caribou. In all cases, caribou that appeared to be unique were the same caribou. So in this case no caribou could be conclusively be determined to be only detected by the first observer. Similar patterns existed in other photographs. It was determined that without further information it was not possible to conclusively determine caribou only observed by observer 1 or 2.

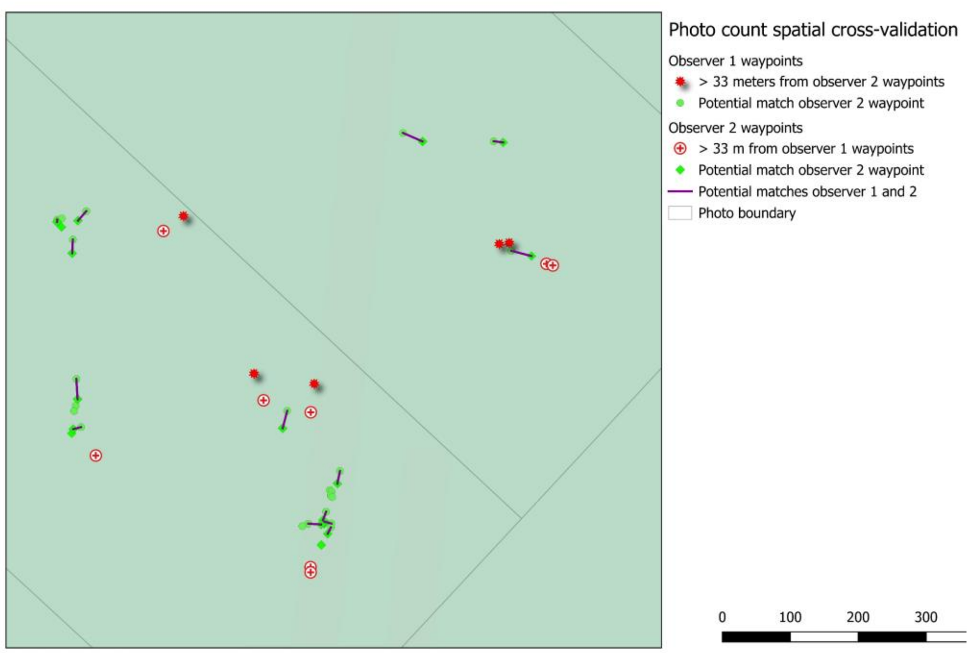


Figure C-9: Example of spatial cross-validation of Bluenose-East photos showing pairings of "matched" and "unique" caribou based upon a 33 km distance threshold between closest waypoints of observer 1 and 2.

Results

Counts from observer 1 (n_1) and observer 2 (n_2) were compared for each cross-validated photo and in all cases observer 2 counts were higher than observer 1. Given this outcome, the ratio of n_1/n_2 was used as an estimate of photo sightability assuming that observer 2 detected all of the caribou detected by observer 1, and any additional caribou were only observed by more experienced observer 2. A bootstrap approach (Manly 1997), which used individual photos as a sample unit, was used to estimate standard error and percentile-based confidence limits. The correction factor was then applied to the photo strata estimates.

We note that a mark-recapture approach if applied estimated photo sightability at 1 for the 2nd observer at 1 (since observer 1 did not detect any new caribou) and the estimate of photo sightability was equivalent to the ratio estimate for the first observer. A bootstrap approach, which used individual photos as a sample unit, was used to estimate standard error and percentile-based confidence limits. The resulting photo sightability estimates were 0.974 and 0.978 for the PhotoNorth and PhotoSouth strata (Table C-3).

Table C-3: Photo sightability estimates based on ratio of counts from first (n_1) and second (n_2) photo counter for the Bluenose-East herd.

Strata	n_1	n_2	n_1/n_2	SE	Conf. Limit		CV
PhotoNorth	2193	2252	0.974	0.005	0.962	0.984	0.006
PhotoSouth	311	318	0.978	0.009	0.959	0.994	0.009

Appendix D. Details on the 2025 Integrated Population Model for the Bluenose-East herd

Integrated Population Model analysis was performed in collaboration with Joe Thorley (www.poissonconsulting.ca). Details are given on the Bluenose-East base IPM model. Further information is available upon request to the authors.

Bluenose-East Integrated Population Model

Suggested citation: Thorley, J.L. and Boulanger, J. (2026) Bluenose-East Caribou Herd Population Analysis 2025. A Poisson Consulting Analysis Appendix in Kelly, A., J. Boulanger, J. Williams, R. Abernethy, J. Hodson, C. Modeste-Burgin, S. Goodman, E. McHugh, and K. Clark. 2026. June 2025 Calving Ground Survey and 2025 Population Modelling of the Bluenose-East Barren-ground Caribou Herd. Manuscript Report XXX, Environment and Climate Change, Government of the Northwest Territories, Yellowknife, NT.

Data Preparation

The estimates of key population statistics with SEs and lower and upper bounds were provided in the form of a csv spreadsheet and prepared for analysis using R version 4.5.1 (R Core Team 2024).

Statistical Analysis

Model parameters were estimated using Bayesian methods. The estimates were produced using JAGS (Plummer 2003). For additional information on Bayesian estimation the reader is referred to McElreath (2016).

Unless stated otherwise, the Bayesian analyses used weakly informative normal and half-normal prior distributions (Gelman et al. 2017). The posterior distributions were estimated from 1500 Markov Chain Monte Carlo (MCMC) samples thinned from the second halves of 3 chains (Kery and Schaub 2011, 38–40). Model convergence was confirmed by ensuring that the potential scale reduction factor $\hat{R} \leq 1.05$ (Kery and Schaub 2011, 40) and the effective sample size (Brooks et al. 2011) ESS ≥ 150 for each of the monitored parameters (Kery and Schaub 2011, 61).

The parameters are summarised in terms of the point estimate, lower and upper 95% credible limits (CLs) and the surprisal s-value (Greenland 2019). The estimate is the median (50th percentile) of the MCMC samples while the 95% CLs are the 2.5th and 97.5th percentiles. The s-value can be considered a test of directionality. More specifically it indicates how surprising (in bits) it would be to discover that the true value of the parameter is in the opposite direction to the estimate. An s-value (Chow and Greenland 2019) is the Shannon transform (-log to base 2) of the corresponding p-value (Kery and Schaub 2011; Greenland and Poole 2013). A surprisal value of 4.3 bits, which is equivalent to a p-value of 0.05 indicates that the surprise would be equivalent to throwing 4.3 heads in a row. The condition that non-essential explanatory variables have s-values ≥ 4.3 bits provides a useful model selection heuristic (Kery and Schaub 2011).

The sensitivity of the estimates to the choice of priors was examined by doubling the standard deviations of the normal priors and using the split $\hat{R}$ (after collapsing the chains) to compare the posterior distributions (Thorley and Andrusak 2017). A split $\hat{R} \leq 1.1$ was taken to indicate low sensitivity.

The results are displayed graphically in the main body of the report by plotting the modeled relationships between particular variables and the response(s) with the remaining variables held constant. In general, continuous and discrete fixed variables are held constant at their mean and first level values, respectively, while random variables are held constant at their typical values (expected values of the underlying hyperdistributions) (Kery and Schaub 2011, 77–82). When informative the influence of particular variables is expressed in terms of the effect size (i.e., percent or n-fold change in the response variable) with 95% credible intervals (CIs, Bradford et al. 2005). Data are indicated by points (with lower and upper bounds indicated by vertical bars) and estimates are indicated by solid lines (with CIs indicated by dotted lines).

The analyses were implemented using R version 4.5.1 (R Core Team 2024) and the **mbr** family of packages.

Model Descriptions

The data were analysed using a state-space population model (Newman et al. 2014).

The cow and bull harvest, fecundity, breeding cow abundance, cow survival, bull survival, fall bull cow, fall calf cow and spring calf cow ratio data complete with standard errors were analysed using a stage-based state-space population model similar to Boulanger et al. (2011). Key assumptions of the female stage-based state-space population model include*:*

- Calving occurs on the 11th of June (with a year running from calving to calving)
- Cow natural survival from calving to the following year varies continually and randomly by year.
- Bull natural survival from calving to the following year varies randomly by year.
- Cow and bull natural survival is constant throughout the year in any given year.
- Harvest of cows and bulls occurs on the 15th of January.
- Harvest rate varies by harvest period (the second harvest period occurs from 2001-2009) and continually by year by harvest period for cows and bull.
- Yearling survival to the following year is the same as cow natural survival.
- Calf survival varies between the summer and winter seasons and randomly by year.
- The calf sex ratio is 1:1.
- Fecundity varies randomly by year.
- Female yearlings are indistinguishable from cows in the fall and spring surveys.
- The uncertainty in the number of cows in the initial year is described by a positively truncated normal distribution with a mean of 75,000 and a standard deviation of 25,000.
- The number of bulls in the initial year relative to the number of cows is described by a beta distribution with an alpha of 11 and a beta of

- The number of calves in the initial year relative to the number of cows is described by a beta distribution with an alpha of 19 and a beta of 3.
- The number of yearlings in the initial year relative to the number of cows is described by a beta distribution with an alpha of 11 and a beta of 11.
- The number of two year old cows in the initial year relative to the number of cows is described by a beta distribution with an alpha of 3 and a beta of 19.
- The uncertainty in each data point is normally distributed with a standard deviation equal to the provided standard error.

Table D-1: IPM parameter descriptions. Model code is provided below.

Parameter	Description
`Annual`	The year as a integer starting at 1
`BreedingCowsSE[i]`	The standard error for `BreedingCows[i]`
`BreedingCows[i]`	The data point for the number of breeding cows in the `i`th year
`BreedingProportionSE[i]`	The standard error for `BreedingProportionSE[i]`
`BreedingProportion[i]`	The data point for the logistic proportion of cows breeding in the `i`th year
`BullSurvivalSE[i]`	The standard error for `BullSurvival[i]`
`BullSurvival[i]`	The data point for logistic bull survival from the `i-1`th year to the `i`th year
`CollarsFidelity[i]`	The total number of collared cows remaining with the herd in the spring of the `i`th year
`CollarsTotal[i]`	The total number of collared cows in the spring of the `i`th year
`CowSurvivalSE[i]`	The standard error for `CowSurvival[i]`
`CowSurvival[i]`	The data point for logistic cow survival from the `i-1`th year to the `i`th year
`FallBullCowSE[i]`	The standard error for `FallBullCow[i]`
`FallBullCow[i]`	The data point for the bull cow ratio in the fall of the `i`th year
`FallCalfCowSE[i]`	The standard error for `FallCalfCow[i]`
`FallCalfCow[i]`	The data point for the calf cow ratio in the fall of the `i`th year
`HarvestedBullsSE[i]`	The standard error for `HarvestedBulls[i]`
`HarvestedBulls[i]`	The data point for the number of bulls harvested in January of the `i`th year
`HarvestedCowsSE[i]`	The standard error for `HarvestedCows[i]`
`HarvestedCows[i]`	The data point for the number of cows harvested in January of the `i`th year
`SpringCalfCowSE[i]`	The standard error for `SpringCalfCow[i]`
`SpringCalfCow[i]`	The data point for the calf cow ratio in the spring of the `i`th year
`bBreedingCows1`	The number of breeding cows in the initial year
`bBullsCows1`	The bull to cow ratio in the initial year
`bFecundityAnnual[i]`	The random effect of the `i`th `Annual` on `bFecundity`
`bFecundity`	The log-odds probability of a cow breeding in a typical year
`bFidelityAnnual[i]`	The random effect of the `i`th `Annual` on `bFidelity`
`bFidelity[i]`	The log-odds probability of a cow remaining with the herd in a typical year in the `i`th `FidelityPeriod`
`bHarvestRateBullYear[i]`	The change in `bbHarvestRateBull` by year for the `i`th `HarvestPeriod`
`bHarvestRateBull[i]`	The log-odds probability of a bull being harvested in year 0 for the `i`th `HarvestPeriod`
`bHarvestRateCowYear[i]`	The change in `bbHarvestRateCow` by year for the `i`th `HarvestPeriod`

Parameter	Description
`bHarvestRateCow[i]`	The log-odds probability of a cow being harvested in year 0 for the `i`th `HarvestPeriod`
`bSurvivalBullAnnual[i]`	The random effect of the `i`th `Annual` on `bSurvivalBull`
`bSurvivalBull`	The log-odds bull survival in a typical year
`bSurvivalCalfAnnual[i]`	The random effect of the `i`th `Annual` on `bSurvivalCalfSummerAnnual` and `bSurvivalCalfWinterAnnual`
`bSurvivalCalfSummerAnnual`	The log-odds summer calf survival if extended for one year
`bSurvivalCalfWinterAnnual`	The log-odds winter calf survival if extended for one year
`bSurvivalCowAnnual[i]`	The random effect of the `i`th `Annual` on `bSurvivalCow`
`bSurvivalCow`	The log-odds cow (and yearling) survival in a typical year
`sFecundityAnnual`	The SD of `bFecundityAnnual`
`sFidelityAnnual`	The SD of `bFidelityAnnual`
`sSurvivalBullAnnual`	The SD of `bSurvivalBullAnnual`
`sSurvivalCalfAnnual`	The SD of `bSurvivalCalfAnnual`
`sSurvivalCowAnnual`	The SD of `bSurvivalCowAnnual`

Bluenose-East base code

```
model {
  bSurvivalCow ~ dnorm(0, 2^-2)
  bSurvivalBull ~ dnorm(0, 2^-2)
  bFecundityCow ~ dnorm(2, 2^-2)
  bFecundityTwolingCow <- -1000
  bSurvivalCalfSummerAnnual ~ dnorm(0, 2^-2)
  bSurvivalCalfWinterAnnual ~ dnorm(0, 2^-2)

  for(i in 1:nHarvestPeriodCow) {
    bHarvestRateCow[i] ~ dnorm(-5, 2^-2)
    bHarvestRateCowYear[i] ~ dnorm(0, 2^-2)
  }
  for(i in 1:nHarvestPeriodBull) {
    bHarvestRateBull[i] ~ dnorm(-5, 2^-2)
    bHarvestRateBullYear[i] ~ dnorm(0, 2^-2)
  }

  sSurvivalCowAnnual ~ dnorm(0, 1^-2) T(0,)
  sSurvivalBullAnnual ~ dnorm(0, 1^-2) T(0,)
  sSurvivalCalfAnnual ~ dnorm(0, 1^-2) T(0,)
  sFecundityAnnual ~ dnorm(0, 2^-2) T(0,)
  for(i in 1:nAnnual){
    bSurvivalCowAnnual[i] ~ dnorm(0, sSurvivalCowAnnual^-2)
    bSurvivalBullAnnual[i] ~ dnorm(0, sSurvivalBullAnnual^-2)
    bSurvivalCalfAnnual[i] ~ dnorm(0, sSurvivalCalfAnnual^-2)
    bFecundityAnnual[i] ~ dnorm(0, sFecundityAnnual^-2)

    logit(eSurvivalCow[i]) <- bSurvivalCow + bSurvivalCowAnnual[i]
    logit(eSurvivalBull[i]) <- bSurvivalBull + bSurvivalBullAnnual[i]
```

```
    logit(eFecundityCow[i]) <- bFecundityCow + bFecundityAnnual[i]
    logit(eFecundityTwolingCow[i]) <- bFecundityTwolingCow + bFecundityAnnual[i]
    logit(eSurvivalCalfSummerAnnual[i]) <- bSurvivalCalfSummerAnnual + bSurvivalCa
lfAnnual[i]
    logit(eSurvivalCalfWinterAnnual[i]) <- bSurvivalCalfWinterAnnual + bSurvivalCa
lfAnnual[i]
    logit(eHarvestRateCow[i]) <- bHarvestRateCow[HarvestPeriodCow[i]] + bHarvestRa
teCowYear[HarvestPeriodCow[i]] * i
    logit(eHarvestRateBull[i]) <- bHarvestRateBull[HarvestPeriodBull[i]] + bHarves
tRateBullYear[HarvestPeriodBull[i]] * i
  }
  bCows1 ~ dnorm(75000, 25000^-2) T(0,)
  bBullsCows1 ~ dbeta(11, 11)
  bCalvesCows1 ~ dbeta(19, 3)
  bYearlingsCows1 ~ dbeta(11, 11)
  bTwolingsCows1 ~ dbeta(3, 19)

  bCows[1] <- bCows1
  bBulls[1] <- bCows1 * bBullsCows1
  bCalves[1] <- bCows1 * bCalvesCows1
  bYearlings[1] <- bCows1 * bYearlingsCows1
  bTwolingCows[1] <- bCows1 * bTwolingsCows1
  bSpringCalfCow[1] <- bCalves[1] / (bCows[1] + bYearlings[1] / 2)

  for(i in 1:nAnnual) {
    eJuneToFallCor[i] <-  FallCalfCowDays[i] / 365

    eFallCows[i] <- bCows[i] * eSurvivalCow[i]^eJuneToFallCor[i]
    eFallBulls[i] <- bBulls[i] * eSurvivalBull[i]^eJuneToFallCor[i]
    eFallYearlings[i] <- bYearlings[i] * eSurvivalCow[i]^eJuneToFallCor[i]
    eFallCalves[i] <- bCalves[i] * eSurvivalCalfSummerAnnual[i]^eJuneToFallCor[i]

    bFallBullCow[i] <- (eFallBulls[i] + eFallYearlings[i]/2) / (eFallCows[i] + eFa
llYearlings[i]/2)
    bFallCalfCow[i] <- eFallCalves[i] / (eFallCows[i] + eFallYearlings[i]/2)
  }

  for(i in 2:nAnnual) {
    eFallToJanCor[i] <- (218 - FallCalfCowDays[i-1])/365
    eJanToSpringCor[i] <- (SpringCalfCowDays[i] - 218) / 365
    eSpringToJuneCor[i] <- (365 - SpringCalfCowDays[i]) / 365

    eJanCows[i] <- eFallCows[i-1] * eSurvivalCow[i-1]^eFallToJanCor[i]
    eJanBulls[i] <- eFallBulls[i-1] * eSurvivalBull[i-1]^eFallToJanCor[i]
    eJanYearlings[i] <- eFallYearlings[i-1] * eSurvivalCow[i-1]^eFallToJanCor[i]

    eSpringCows[i] <- eJanCows[i] * (1 - eHarvestRateCow[i]) * eSurvivalCow[i-1]^e
JanToSpringCor[i]
    eSpringBulls[i] <- eJanBulls[i] * (1 - eHarvestRateBull[i]) * eSurvivalBull[i-
```

```
1]^eJanToSpringCor[i]
    eSpringFemaleYearlings[i] <- eJanYearlings[i]/2 * eSurvivalCow[i-1]^eJanToSpri
ngCor[i]
    eSpringMaleYearlings[i] <- eJanYearlings[i]/2 * eSurvivalCow[i-1]^eJanToSpring
Cor[i]
    eSpringCalves[i] <- bCalves[i-1] * eSurvivalCalfSummerAnnual[i-1]^(154/365) *
eSurvivalCalfWinterAnnual[i-1]^((SpringCalfCowDays[i] - 154) / 365)

    bSpringCalfCow[i] <- eSpringCalves[i] / (eSpringCows[i] + eSpringFemaleYearlin
gs[i])

    bCows[i] <- (eSpringCows[i] + eSpringFemaleYearlings[i]) * eSurvivalCow[i-1]^e
SpringToJuneCor[i]
    bTwolingCows[i] <- eSpringFemaleYearlings[i] * eSurvivalCow[i-1]^eSpringToJune
Cor[i]
    bBulls[i] <- eSpringBulls[i] * eSurvivalBull[i-1]^eSpringToJuneCor[i] + eSprin
gMaleYearlings[i] * eSurvivalCow[i-1]^eSpringToJuneCor[i]
    bYearlings[i] <- eSpringCalves[i] * eSurvivalCalfWinterAnnual[i-1]^eSpringToJu
neCor[i]
    bCalves[i] <- (bCows[i] - bTwolingCows[i]) * eFecundityCow[i] + bTwolingCows[i
] * eFecundityTwolingCow[i]
  }

  for(i in 2:nAnnual) {
    HarvestedCows[i] ~ dnorm(eJanCows[i] * eHarvestRateCow[i], HarvestedCowsSE[i]^
-2)
    HarvestedBulls[i] ~ dnorm(eJanBulls[i] * eHarvestRateBull[i], HarvestedBullsSE
[i]^-2)
  }

  for(i in CowSurvivalAnnual) {
    CowSurvival[i] ~ dnorm(logit(eSurvivalCow[i]), CowSurvivalSE[i]^-2)
  }

  for(i in BullSurvivalAnnual) {
    BullSurvival[i] ~ dnorm(logit(eSurvivalBull[i]), BullSurvivalSE[i]^-2)
  }

  for(i in CowsAnnual) {
    eBreedingCows[i] <- (bCows[i] - bTwolingCows[i]) * eFecundityCow[i] + bTwoling
Cows[i] * eFecundityTwolingCow[i]
    BreedingCows[i] ~ dnorm(eBreedingCows[i], BreedingCowsSE[i]^-2)
    eBreedingProportion[i] <- min(eBreedingCows[i] / bCows[i], 0.99)
    BreedingProportion[i] ~ dnorm(logit(eBreedingProportion[i]), BreedingProportio
nSE[i]^-2)
  }

  for(i in FallBCAnnual) {
    FallBullCow[i] ~ dnorm(bFallBullCow[i], FallBullCowSE[i]^-2)
```

```
}

for(i in FallAnnual) {
  FallCalfCow[i] ~ dnorm(bFallCalfCow[i], FallCalfCowSE[i]^-2)
}

for(i in SpringAnnual) {
  SpringCalfCow[i] ~ dnorm(bSpringCalfCow[i], SpringCalfCowSE[i]^-2)
}
```

The baseline IPM model was run for the Bluenose-East herd. This model does not model emigration or immigration into or out of the Bluenose-East herd. It therefore provides mainly inference on demographic status under the assumption that movement into equal movement out of the Bluenose-East herd. More advanced emigration and immigration models will be run in the future.

IPM parameter estimates

Table D-2.: Bluenose-East IPM parameter estimates. Estimates are on the log or logistic scale. Confidence limits (lower and upper) are given along with s-values. An s “surprisal” value is the number of successive head flips of a coin that would create the given estimates. A s-value of 4.5 is equivalent to a p-value of 0.05.

term	estimate	lower	upper	svalue
bBullsCows1	4.723e-01	2.860e-01	6.853e-01	10.55
bCalvesCows1	8.820e-01	7.400e-01	9.697e-01	10.55
bCows1	8.440e+04	5.979e+04	1.147e+05	10.55
bFecundityCow	3.622	2.290	5.480	10.55
bHarvestRateBull[1]	-3.045	-3.874	-2.221	10.55
bHarvestRateBull[2]	-1.888	-3.400	-6.060e-01	6.464
bHarvestRateBullYear[1]	1.283e-03	-1.216e-01	1.097e-01	0.0213
bHarvestRateBullYear[2]	-1.562e-01	-2.433e-01	-6.531e-02	10.55
bHarvestRateCow[1]	-3.671	-4.758	-2.788	10.55
bHarvestRateCow[2]	-2.382	-3.666	-1.083	10.55
bHarvestRateCowYear[1]	8.373e-03	-1.707e-01	1.930e-01	0.09947
bHarvestRateCowYear[2]	-2.355e-01	-3.332e-01	-1.506e-01	10.55
bSurvivalBull	4.794e-01	5.790e-02	9.577e-01	5.422
bSurvivalCalfSummerAnnual	-1.049	-1.403	-7.057e-01	10.55
bSurvivalCalfWinterAnnual	3.700e-01	-3.272e-02	8.186e-01	3.757
bSurvivalCow	1.424	1.157	1.718	10.55
bTwolingsCows1	1.269e-01	2.910e-02	3.084e-01	10.55
bYearlingsCows1	4.823e-01	2.976e-01	6.873e-01	10.55
sFecundityAnnual	2.465	1.483	4.120	10.55
sSurvivalBullAnnual	8.796e-01	5.875e-01	1.387	10.55

term	estimate	lower	upper	svalue
sSurvivalCalfAnnual	6.025e-01	4.088e-01	9.244e-01	10.55
sSurvivalCowAnnual	5.511e-01	3.515e-01	8.765e-01	10.55

Table D-3. Model summary.

n	K	nchains	niters	nthin	ess	rhat	converged
19	22	3	500	100	171	1.03	TRUE

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Appendix E. Field estimates for the Bluenose-East herd of barren-ground caribou.

This appendix summarizes field estimates from June calving ground surveys 2010 - 2025 for the Bluenose-East herd of barren-ground caribou, and indicates the reference report, where applicable.

Table E-1. Field estimates of breeding females and total adult females from Bluenose-East calving ground surveys 2010-2025, and associated herd estimates extrapolated from calving ground and fall composition surveys. The standard error (SE), coefficient of variation (CV) and upper and lower 95% confidence limits (LCL and UCL) are provided.

Estimates of Bluenose-East breeding females from calving ground surveys

Year	Estimate	SE	CV	LCL	UCL	Citation
2010	51,757	4,836	9.3	40,665	62,849	Adamczewski et al. 2017
2013	34,472	1,898	5.5	30,109	38,836	Boulanger et al. 2014 FR143
2015	17,396	1,089	6.3	15,088	19,704	Boulanger et al 2016 MR260
2018	11,675	904	7.7	9,971	13,670	Boulanger et al. 2019 MR278
2021	12,863	1,043	13.0	10,816	15,298	Boulanger et al. 2022 MR325
2023	18,580	1,783	9.6	15,225	22,674	Boulanger et al. 2024 MR319
2025	17,261	793	0.1	15,652	19,035	This report

Extrapolated Bluenose-East herd population estimates (calving ground + fall composition surveys)

Year	Estimate	SE	CV	LCL	UCL	Citation[a]
2010	120,880	5,841	4.8	107,482	134,278	Adamczewski et al. 2017*
2013	68,295	7,847	11.5	50,255	86,336	Boulanger et al. 2014 FR143
2015	38,592	2,233	5.8	33,859	43,325	Boulanger et al 2016 MR260
2018	19,294	1,475	7.6	16,527	22,524	Boulanger et al 2019 MR278
2021	23,202	2,029	9.0	19,247	27,971	Boulanger et al 2022 MR325
2023	39,525	3,423	8.7	33,021	47,310	Boulanger et al. 2024 MR319
2025	28,759	1,364	0.5	25,997	31,816	This report

[a] MR and FR refer to numbered ECC Manuscript Reports and File Reports, respectively. The full citation for references are provided below.

*This estimate is preferred over earlier estimates in Adamczewski et al. 2014.

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