Estimates of breeding females from the 2015 Bluenose East calving ground survey.

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This document presents estimates of caribou on Bluenose East core calving ground areas based on the photo and visual surveys conducted during the 2015 Bathurst and Bluenose East calving ground surveys. The main objective of this report is to provide an update on estimates for the Bluenose East herd from the 2015 calving ground survey needed for discussion of conservation strategies. Future reports will provide more details on field methods and analyses.

Methods

Reconnaissance surveys of the Bluenose East calving ground area occurred from June 2nd to June 4th with the core area being surveyed on June 4th. Based on reconnaissance results a single photo stratum was delineated with 3 additional visual strata (Figure 1).
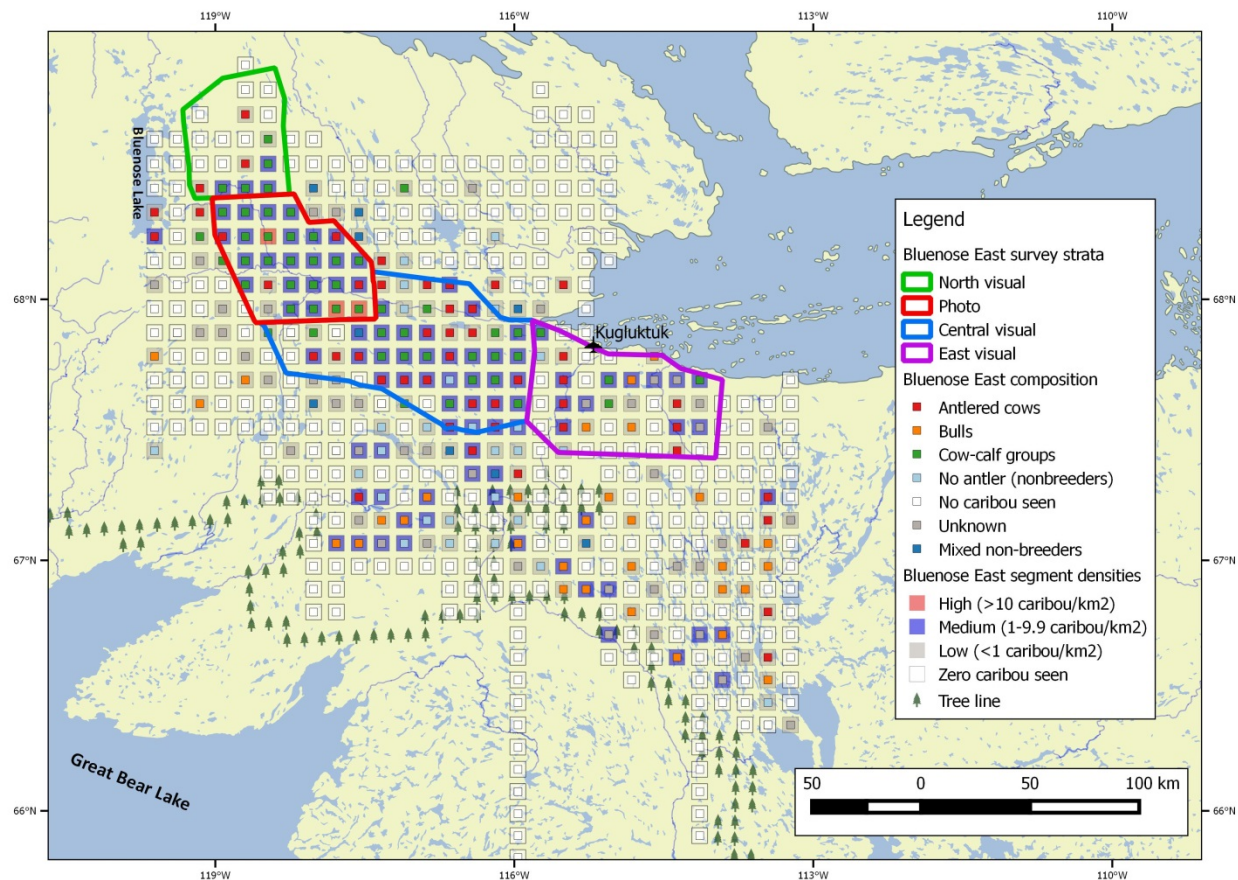
Figure 1 A summary of segment densities (caribou per km^2) from the reconnaissance survey of the Bluenose Calving ground 2015 survey.

A closer view of the strata and associated segment densities shows that only 3 segments had densities of over 10 caribou per km^2 (Figure 2).
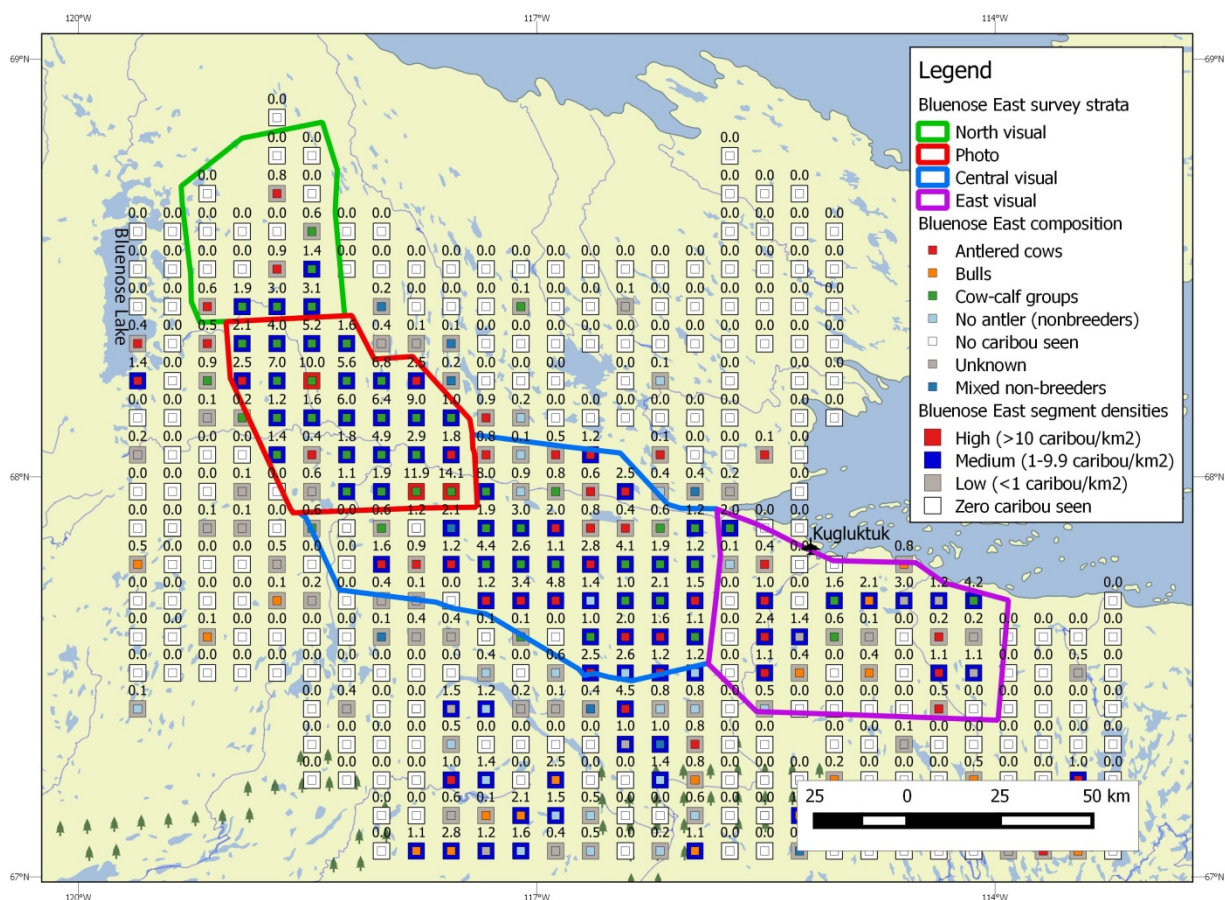
Figure 2:   Reconnaissance segment density (caribou per km^2) and composition with survey strata overlaid for the core Bluenose East calving ground.

The dimensions of the strata are given in Table 1.   The photo plane was able to fly at a higher altitude (GSD 7) which resulted in a large strip width and higher level of coverage for the photo stratum.   One of the visual survey planes flew at a lower survey altitude which created variation in strip width and subsequent survey area and coverage.

Table 1: Dimensions of strata and transects for the 2015 Bluenose East survey

Strata	Area (km^2)	Transects			
		Number	Strip width (km)	Area sampled (km^2)	coverage
Photo	2682.1	25	1.15	1486.6	0.55
North	1889.2	10	0.8	377.6	0.20
Central	4586.8	33	0.65-0.8[A]	902.98	0.20
East	3430.9	14	0.65-0.8	401.13	0.12

A

The photo and visual surveys occurred on June 5th, the day after the reconnaissance of the core calving ground area.   Composition surveys to estimate breeding females in each stratum occurred on June 5th and 6th.   Figure 3 displays movements of collared female caribou from June 4th to June 5th.   Of the caribou contained within strata

during the reconnaissance, all but 1 caribou stayed within the strata on June 5th. The 2 caribou outside of strata did not have significant densities associated with them as shown by the reconnaissance survey results (Figure 1).
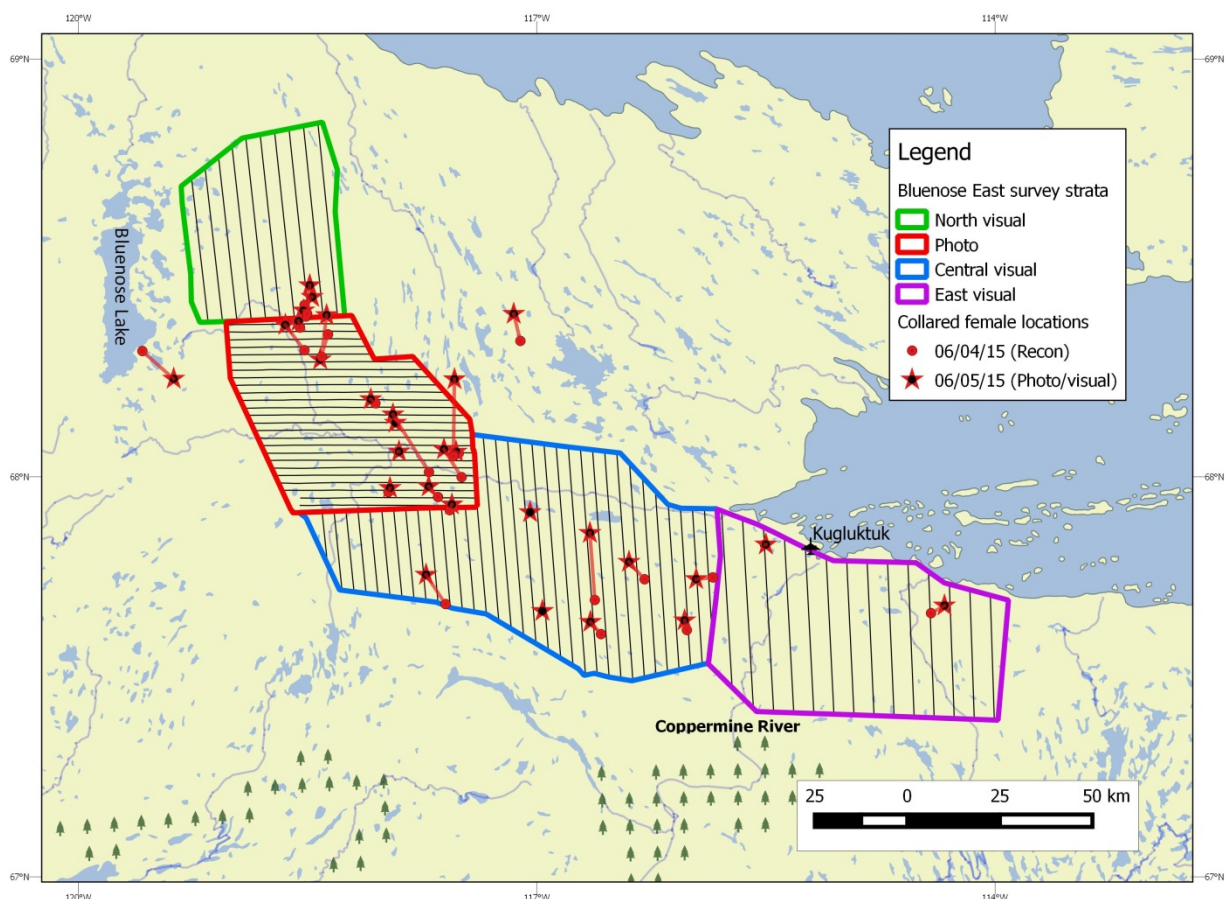

Figure 3: Transect layout of the photo and visual strata. Also shown are the locations of collared females during the primary reconnaissance survey (June 4th) and photo/visual survey (June 5th). Red lines connect the locations for June 4th and 5th for individual caribou.

For visual surveys, the majority of observations were for groups of 7 or less caribou (Figure 4).   There were 15 observations of over 20 caribou (out of 967 observations total) suggesting that any potential counting bias of larger group sizes was minimal. In most cases, caribou were seen by both observers suggesting that sightability bias was minimal.   Double observer analyses estimated that sightability was high during the survey due to low snow cover and minimal cloud cover.
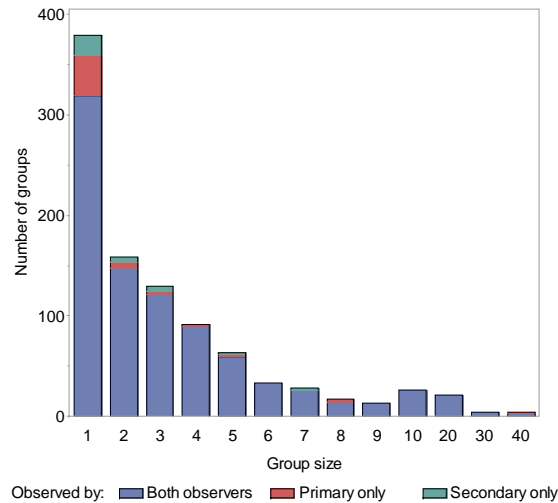
Figure 4: Distribution of group sizes from pooled visual surveys as categorized by double observer outcome

During post-processing of the data it was discovered that one of the visual survey planes was flying below the standard survey altitude which resulted in a smaller strip width. This plane surveyed a portion of the East and Central strata.   If uncorrected, this could potentially bias estimates since caribou the areas that this plane surveyed would have a lower chance of being sampled given the smaller strip widths.   To mitigate this issue, a method was used that estimated population size by equally weighting densities of caribou on each transect line regardless of strip width.   More precisely, population size within a stratum is usually estimated as the product of the total area of the stratum (A) and the mean density ($\overline{D}$) of caribou observed within the strata ($\widehat{N} = \overline{D}A$) where density is estimated as the sum of all caribou counted on transect divided by the total area of transect sampling ($\overline{D}$=caribou counted/total transect area).   An equivalent estimate of mean density can be derived by first estimating transect-specific densities of caribou ($\widehat{D}_i = caribou_i/area_i$) were $caribou_i$ is the number of caribou counted in each transect and $area_i$ is the transect area (as estimated by transect length X strip width).   Each transect density is then weighted by the relative length of each transect line (w_i) to estimate mean density ($\overline{D}$) for the stratum.   More exactly, $\overline{D} = \sum_i^n \widehat{D}_i w_i / \sum_i^n w_i$ where the weight (w_i) is the ratio of the length of transect line (l_i) i to the mean length of all transect lines ($w_i = l_i/\overline{l_i}$.) and n is the total number of transects sampled. Using this weighting term accommodates for different lengths of transect lines within the stratum therefore ensuring that each transect line contributed to the estimate in proportion to its length. Population size is then estimated using the standard formula ($\widehat{N} = \overline{D}A$). This procedure was used in unison with the double observer method to estimate population size. Bootstrap methods were used to estimate standard errors of estimates.

 Table 2 provides estimates of caribou on the calving ground strata, proportion breeding caribou and the resulting estimate of breeding females.   The proportion breeding females was relatively low especially for the Central stratum which reduced the breeding female estimates.   Total estimates were very precise as indexed by the coefficient of variation. The total   estimate of breeding females is 17,396 (CI=15,088-19,704).

Table 2: Estimates of total caribou on the calving ground, proportions of breeding females (from composition surveys) and the resulting estimates of breeding females.

Strata	Caribou Counted	Total caribou on calving ground				Proportion Breeding Females			Breeding Females		
		Density	N	SE(N)	CV	Proportion	SE	CV	N	SE(N)	CV
Photo	10,068	6.77	18,164.9	817.8	4.5%	0.657	0.027	4.1%	11,934	727.5	6.1%
North	496	1.31	2,481.9	710.9	28.6%	0.833	0.039	4.7%	2,067	599.9	29.0%
Central	2,120	2.42	11,098.6	1305.5	11.8%	0.273	0.026	9.5%	3,030	458.6	15.1%
East	699	1.83	6,295.4	1285.4	20.4%	0.058	0.045	77.6%	365	292.8	80.2%
Total			38,040.8	2128.6	5.6%				17,396	1088.6	6.3%

A comparison of the preliminary breeding female estimate with estimates from the 2010 survey (Adamczewski et al. 2014) and 2013 survey (Boulanger et al. 2014) shows a continued and possibly accelerating decline of breeding cows in the Bluenose East herd (Figure 5).
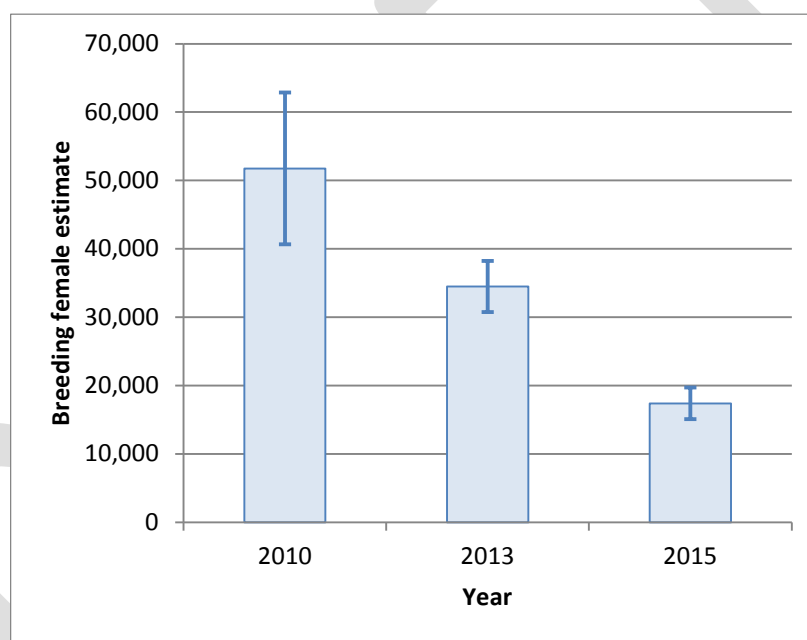
Figure 5: Comparison of 2015 breeding female estimate with estimates from the 2013 and 2010 calving ground surveys.

The breeding female estimate will be sensitive to yearly variation in pregnancy rates, in particular, the lower pregnancy rate (as indexed by the proportion on non-breeding adult females) observed in 2015. Another comparison can be gained from estimates of adult females which includes both breeding and non-breeding females (as determined by composition surveys on the calving ground) (Figure 6).
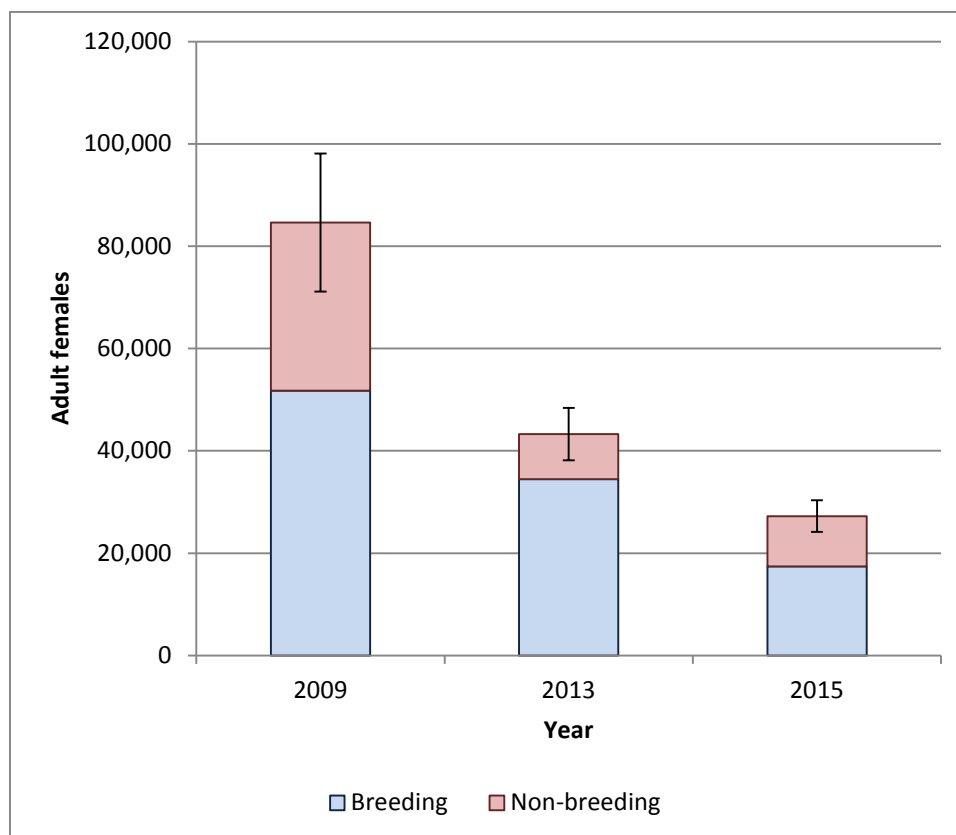
Figure 6: Comparison of 2015 estimate of adult females with estimates from the 2013 and 2010 calving ground surveys.

Extrapolated herd size estimates

Fall composition surveys were conducted on October 28 and 30, 2015.   Overall, 69 groups were observed amounting to 4,867 adult caribou. Of these, 1,107 were bulls and 2,774 were cows which resulted in proportion cow and bull cow ratios as listed in Table 3. Bootstrapping was used to obtain standard error and confidence limits.   The bull-cow ratio and proportion cows were similar for surveys conducted in 2009, 2013, and 2015.

Table 3: Estimates of the proportion of cows and bull cow ratio for the Bluenose East caribou herd from fall composition surveys.

Year	Proportion of Cows	SE	Confidence Limit		Bull-Cow Ratio	SE	Confidence Limit	
2009	0.700	0.008	0.684	0.716	0.429	0.017	0.396	0.463
2013	0.701	0.009	0.685	0.720	0.426	0.019	0.389	0.461
2015	0.706	0.014	0.678	0.734	0.417	0.029	0.367	0.479

In terms of extrapolated estimates of herd size, if the proportion cows from 2015 is used with a fixed pregnancy rate (0.72, CV=10%) then the overall herd size estimate is 34,223 1.5+ year old caribou (SE=4095.4, CV=12.0%, CI=25,541-42,904).   The assumption of a fixed pregnancy rate for 2015 is questionable given the lower observed relative number of breeding females (Figure 8).   This estimate is lower than the number of caribou estimated on the core calving ground (Table 2).

An alternative extrapolated herd size estimate was developed as a means to explore the effect of variable pregnancy rates as part of the 2014 Qamanirjuaq caribou herd survey (Mitch Campbell, Government of Nunavut,

and John Boulanger IER, in prep). This estimator first uses data from the composition surveys to estimate total proportion of adult females, and adult females in each of the survey stratum. The estimate of total adult females (as displayed in Figure 8) is then divided by the proportion adult females (cows) in the herd from fall composition surveys (Table 3). Using this approach, the fixed pregnancy rate is eliminated from the estimate procedure. For the Bluenose East herd in 2015, the estimate of total adult females in the core calving area was 27,246 (SE=1478.0, CV=5.4%, CI=24,172-30,320). The resulting estimate of herd size (27,246 divided by 0.706 from Table 3) is 38,592 (SE=2232.8, CV=5.8%, CI=33,859-43,325) 1.5+ year old caribou. This estimate assumes that all adult female caribou (breeders and non-breeders) as classified in composition surveys occurred within the core calving area as delineated by the survey strata (Figure 1). It does not make any assumptions about the distribution of yearling or bull caribou. The distribution of female collared caribou observed in 2015 suggests that this assumption may be reasonable given that all 24 of 26 collared females were contained within the survey strata (Figure 1). This estimate is roughly equivalent to the estimate of caribou on the calving ground (Table 1). Note that the extrapolated estimate will not contain yearlings (calves of 2014) whereas the estimate of total caribou on the calving ground will contain yearlings. Therefore, extrapolated estimates and estimates of total caribou on the calving ground are not directly comparable.

A comparison of estimates using the pregnancy-based and adult female-based methods reveals relative similarity between the two methods (Figure 7). In 2010 and 2015 the female-based methods was higher than the pregnancy-based methods whereas in 2013 it was lower. In 2010 and 2015 there was a higher proportion of non-breeding females on the calving ground (Figure 5) which may have indicated a lower pregnancy rate than the assumed mean level of 0.72 which resulted in the pregnancy-based estimate being lower. In contrast, the proportion of non-breeders was lower in 2013 which potentially indicated a pregnancy rate that was closer or higher than the mean level. Regardless, confidence limits from the 2 methods overlap in all years and therefore differences in estimates could also be due to statistical uncertainty.
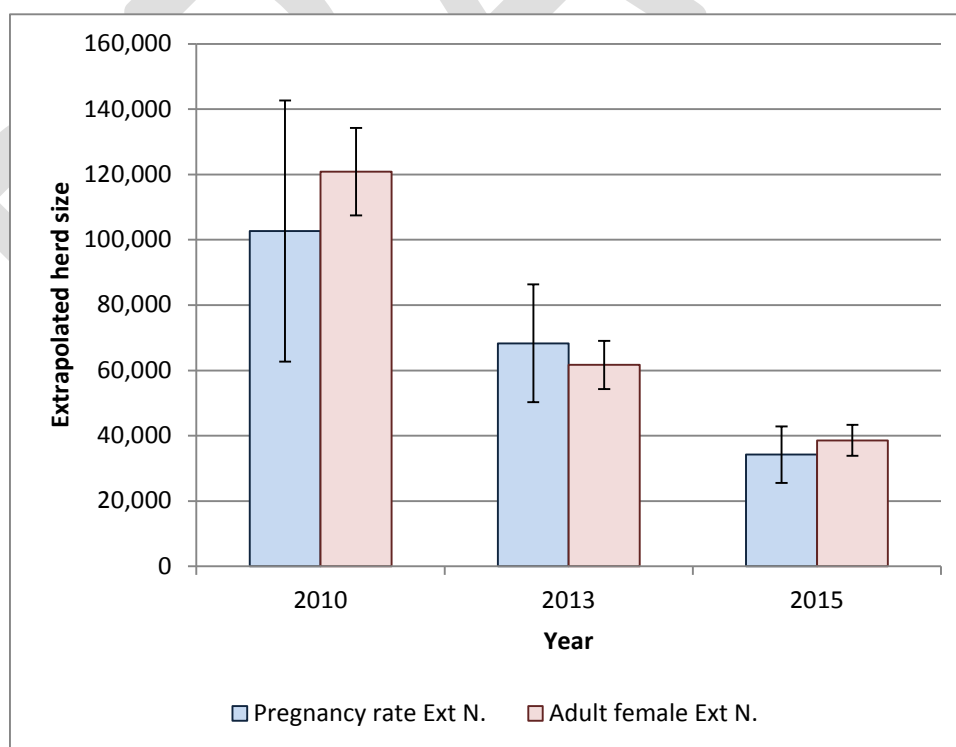

Figure 7: Estimates of extrapolated herd size for 2010, 2013, and 2015 calving ground surveys using pregnancy-based and adult female-based methods.

Discussion

Overall the coverage of the survey area, minimal movements of collared caribou in the time period between reconnaissance and visual/photo surveys indicate that the survey was reasonably efficient in estimating caribou on the calving ground. Therefore, the lower estimates cannot be attributed to survey or sampling issues.

There were isolated pockets of potential breeders (i.e. antlered females identified from fixed wing aircraft on the reconnaissance survey) that were not in strata area (Figure 2). In all cases, the segment densities around these caribou were low and it is possible that some of these "antlered females" were non-breeders. Given this, it can be assumed that the survey area encompassed the majority of breeding caribou in the Bluenose East herd.

The double observer analysis did not increase survey estimates appreciably which was due to ideal sighting conditions on the survey area. Future write-ups will provide more details on the double observer analysis.

Note that the likely lower pregnancy rate in 2015 will also reduce the estimate of breeding females. The proportion of adult females breeding was lower in 2015 compared to 2013 and 2010. From composition surveys the proportion adult females that were breeding was 65% in 2010, 82% in 2013, and 65% in 2015. Most notable was the lower proportion breeders in the Central Stratum. For example, 814 females were observed during composition surveys on the Central Stratum of which 316 (39%) were breeders and 498 (61%) were non-breeders. As a result, the estimate of breeding caribou in this stratum was reduced substantially. An OLS model based analysis will provide further inference on overall population trend while taking into account variable pregnancy rates. In addition, trend analyses based on adult females rather than breeding females will be explored.

Literature cited

Adamczewski, J., J. Boulanger, B. Croft, H. Sayine-Crawford, T. Davison, and B. Tracz. 2014. Post-calving photo surveys and extrapolated calving photo surveys for barren-ground caribou: a comparison from the Bluenose-East herd in June and July 2010 Environment and Natural Resources, Government of Northwest Territories.

Boulanger, J., B. Croft, and J. Adamczewski. 2014. An estimate of breeding females and analyses of demographics for the Bluenose East herd of barren ground caribou: 2013 calving ground photographic survey. Department of Environment and Natural Resources, Government of Northwest Territories, File Report No. 143.