



OCTOBER 2020 FALL COMPOSITION SURVEYS OF BATHURST AND BLUENOSE-EAST BARREN-GROUND CARIBOU HERDS

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ABSTRACT

This report describes the results of fall composition surveys of the Bathurst and Bluenose-East barren-ground caribou herds conducted in October 2020. The main purpose of these surveys was to estimate the sex ratio in the two herds during the breeding season, and to estimate the proportion of females in the herd that were accompanied by a calf, as an index of calf mortality in the first four to five months of age.

The surveys were conducted between October 19 and 23 with a total of 15.4 hours flown. The survey crew of Dean Cluff, Jan Adamczewski, Colin Modeste-Burgin, and pilot Jordan Crook flew in an A-Star B2 helicopter operated by Acasta HeliFlight Inc. Survey flying was focused on flying to locations of female and male collared Bathurst or Bluenose-East caribou. Caribou were classified as cows, calves, young bulls and prime bulls using motion-stabilized binoculars from the front seat of the helicopter. Observations were recorded on tablet computers. Multiple observations of bulls fighting suggested that both surveys took place near the peak of the rut.

For the Bathurst herd, the survey resulted in an estimated ratio of 39.1 calves: 100 cows (95% Confidence Intervals [CI] 36.2-41.9), based on 1,843 caribou classified in 15 groups. Of the 38 collared cows and 12 collared bulls in the herd, 33 female and five male collared caribou (76% of total collars) were in areas surveyed. A further five female and seven male collared Bathurst caribou were far east of Contwoyto Lake and mixed with Beverly collared caribou, and out of our flying range. This suggests some caution in interpreting the results. The October bull:cow ratio was 64.1 bulls: 100 cows (95% CI 49.9-79.6).

For the Bluenose-East herd, the survey resulted in an estimated ratio of 51.7 calves: 100 cows (95% CI 47.2-55.7). Of the 32 collared females and 18 collared males in the Bluenose-East herd at the time of the surveys, 29 females and 17 males (92% of total collars) were in the vicinity of caribou groups surveyed. This suggested that a large proportion of the herd was in areas surveyed and the sample was representative of the herd. The October bull:cow ratio was 63.3 bulls: 100 cows (95% CI 50.0-79.0).

Overall, the calf:cow ratios in both herds in October were similar to the ratios found in July, suggesting that relatively little calf mortality occurred over this period. Ratios of 39 and 51 calves:100 cows indicate good recruitment in both herds for 2020. The bull:cow ratios were somewhat higher than has been recorded recently in the two herds, and may suggest that male survival rates have improved. Collar-based cow survival rates in both herds have improved in recent years. If these positive indicators continue, population trend may improve in the Bathurst and Bluenose-East herds.

In addition to the survey results, this report includes three appendices: (1) a group by group listing of caribou composition survey results, (2) a summary of some unusual fall 2020 movements of Bathurst and Beverly caribou and a brief review of how newly placed cow and bull collars have been assigned to herd, and (3) an analysis of bull fidelity to herd in the Bathurst, Bluenose-East and Beverly herds.

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INTRODUCTION

The Bathurst and Bluenose-East (BNE) caribou herds have calving grounds west of Bathurst Inlet (Bathurst) and west of Kugluktuk (BNE) in Nunavut (NU), with portions of the summer range in NU and the remainder of the ranges in the Northwest Territories (NWT) (Figure 1). Ranges of the neighbouring Bluenose-West and Beverly herds are also shown.

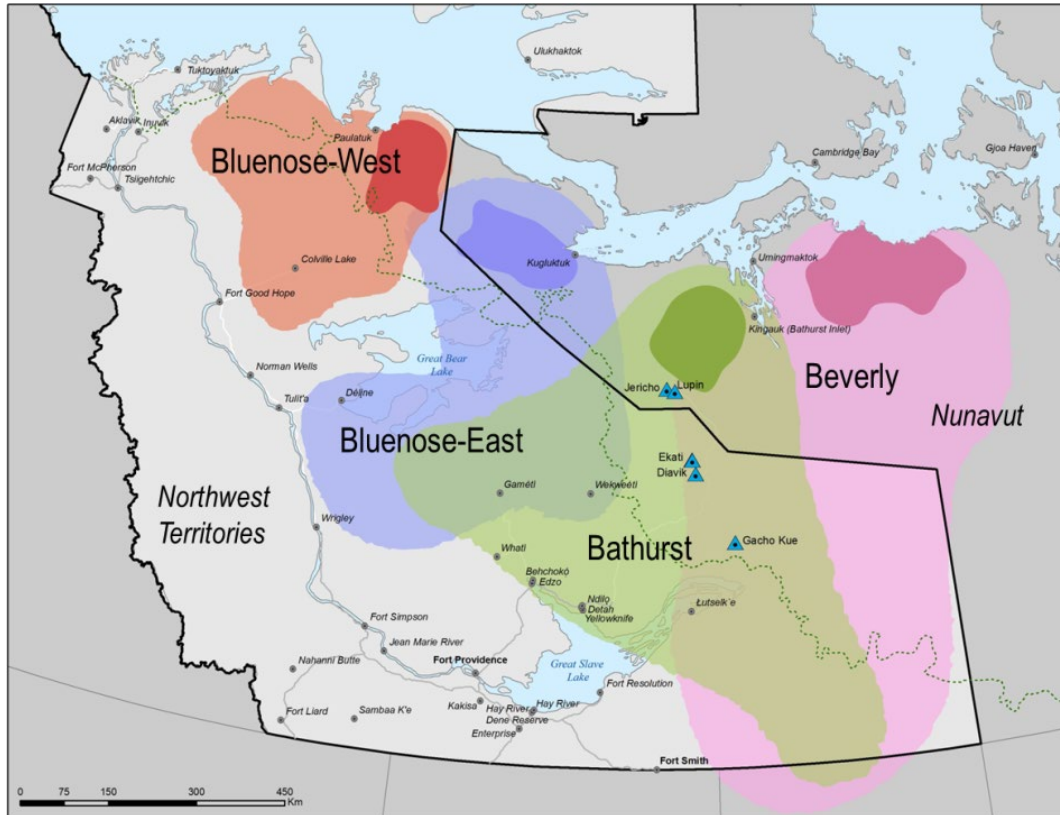


Figure 1. Annual ranges and calving grounds of the Bluenose-West, BNE, Bathurst, and Beverly¹ herds, based on accumulated radio collar locations of cows (Nagy et al. 2011). Other herd ranges west and east of these four herds were omitted for simplicity. The Diavik and Gahcho Kue mines were active in July 2020, the Ekati mine was in maintenance mode, the Jericho mine was closed, and the Lupin mine was closed with a small maintenance staff.

Population estimates for the Bathurst herd (Adamczewski et al. 2019) and BNE herd (Boulanger et al. 2019) in 2018 showed large declines from the previous estimates in 2015. In joint management proposals from the Tłı̄ch̄o Government and the Department of

¹ The Beverly herd described in this report is the herd defined by the Government of NU as calving in the central and western Queen Maud Gulf. This herd may not correspond exactly to the Beverly herd defined prior to 2009 with an inland calving ground south of Garry Lakes (Adamczewski et al. 2015).

Environment and Natural Resources (ENR) to the Wek'èezhì Renewable Resources Board (WRRB) in early 2019, increased monitoring proposed for the two herds included annual composition surveys of both herds in June, late October, and March/April (ENR and Tłıchǫ Government 2019a, b).

Composition surveys in the second half of October have been carried out for the Bathurst and BNE herds in multiple years since 2009-2010. At the peak of the breeding season, all sex and age classes of caribou are mixed in rutting aggregations, thus sampling across the herd's distribution can provide an estimate of the sex ratio (bulls: 100 cows). This is needed to generate an overall herd estimate from the estimated numbers of females on the calving grounds in June (e.g. Boulanger et al. 2019). In addition, a calf:cow ratio can be estimated which gives an index of calf mortality in the first four to five months.

METHODS

Locations of collared Bathurst (38 F, 12 M) and BNE (32 F, 18 M) caribou were monitored through the study period of October 19-23, 2020. The most recent locations were used to plan survey flying. Collared caribou were generally moving slowly southward during this period. In situations where the caribou were not where the last collar locations indicated, fresh trails in the snow heading southward led to caribou groups. Caribou were classified from the front of the helicopter using motion-stabilized binoculars. Caribou were identified as calves (based on small body size), cows (based on presence of a vulva patch), prime bulls (based on large body size and large antlers and absence of vulva patch) and young bulls (based on absence of vulva patch, smaller size and smaller antlers).

Trimble Yuma 2 tablet computers were used to record observations with a GPS waypoint taken for each observation. Garmin GPS model 276Cx units were used to plan flights and record flight lines. In addition to caribou, we also recorded observations and locations of other large mammals.

RESULTS

Survey Weather Conditions

Temperatures during the surveys were generally mild, varying between -4°C and -10°C. The larger lakes had mostly open water, including the observed portions of Great Bear Lake. Flying on October 19, 20, 21 and 23 was somewhat constrained by low cloud and snowfall, particularly in the vicinity of large lakes with open water. Snow cover was continuous in the areas surveyed but appeared to be limited in depth to a few centimeters (Figure 2).



Figure 2. Field conditions on Bathurst survey (bottom) October 20 and BNE survey (top) October 22, 2020. Snow cover was generally light. Photos: GNWT, J. Adamczewski, ENR.

Daily Flying and Survey Crew

A daily summary of flying hours and tasks for each day is shown in Table 1. The survey aircraft and three-person crew, pilot Jordan Cook, Jan Adamczewski and Dean Cluff, are shown in Figure 3. A fourth person, Colin Modeste-Burgin, manager of the Daring Lake research station, assisted with the Bathurst survey on October 20.

Table 1. Daily summary of flying hours and tasks accomplished on Bathurst and BNE October 2020 composition surveys. Flight from Yellowknife to Daring Lake October 19 is included with Bathurst survey as ferry flying. Flights from Daring Lake to Wekweètì October 21 and from Wekweètì to Yellowknife October 23 are included with BNE survey as ferry flying.

Date	Flying Hours and Tasks
October 19	Positioning flight to Daring Lake research station; 2.0 hours ferry flying.
October 20	Survey main Bathurst collar cluster – one large aggregation of a few thousand caribou; survey smaller numbers of Bathurst caribou east of main cluster; 3.0 hours surveying; caribou nearby so minimal ferry flying.
October 21	Positioning flight from Daring Lake to Wekweètì; no survey flying due to poor weather north of Wekweètì; 1.1 hours ferry flying.
October 22	Survey cluster of BNE collars north of Port Radium; survey BNE collars east of Port Radium; 4.7 hours surveying; 2.8 hrs. ferry flying.
October 23	Return to Yellowknife; 1.8 hours ferry flying.
	Bathurst survey: 5.0 hrs. total; 3.0 hrs. survey, 2.0 hrs. ferry.
	BNE survey: 10.4 hrs. total, 4.7 hrs. survey, 5.7 hrs. ferry.
	Total flying hours 15.4; survey 8.7 hrs.; 6.7 hrs. ferry



Figure 3. Survey crew on October 2020 Bathurst and BNE composition surveys, left to right: Dean Cluff, Jan Adamczewski, and pilot Jordan Crook. A fourth person, Colin Modeste-Burgin, was part of the Bathurst survey on October 20. Photo: GNWT/ENR.

Bathurst Survey

The Bathurst survey was flown on October 20 with the helicopter based at Daring Lake in the NWT, south of Contwoyto Lake. All caribou surveyed were relatively close to Daring Lake so ferry flying was minimal and no fuel caches were needed.

At the time of the Bathurst survey, there was one main cluster of Bathurst collared caribou (33F, 5M) west and south of Contwoyto Lake (Figure 4). There were 12 additional Bathurst collars (5F, 7M) east of Contwoyto Lake mixed with Beverly collared caribou. These collared caribou had moved well east of Contwoyto Lake in mid-October, just before the survey. At the time of the surveys they were out of reach of any helicopter bases or fuel caches.

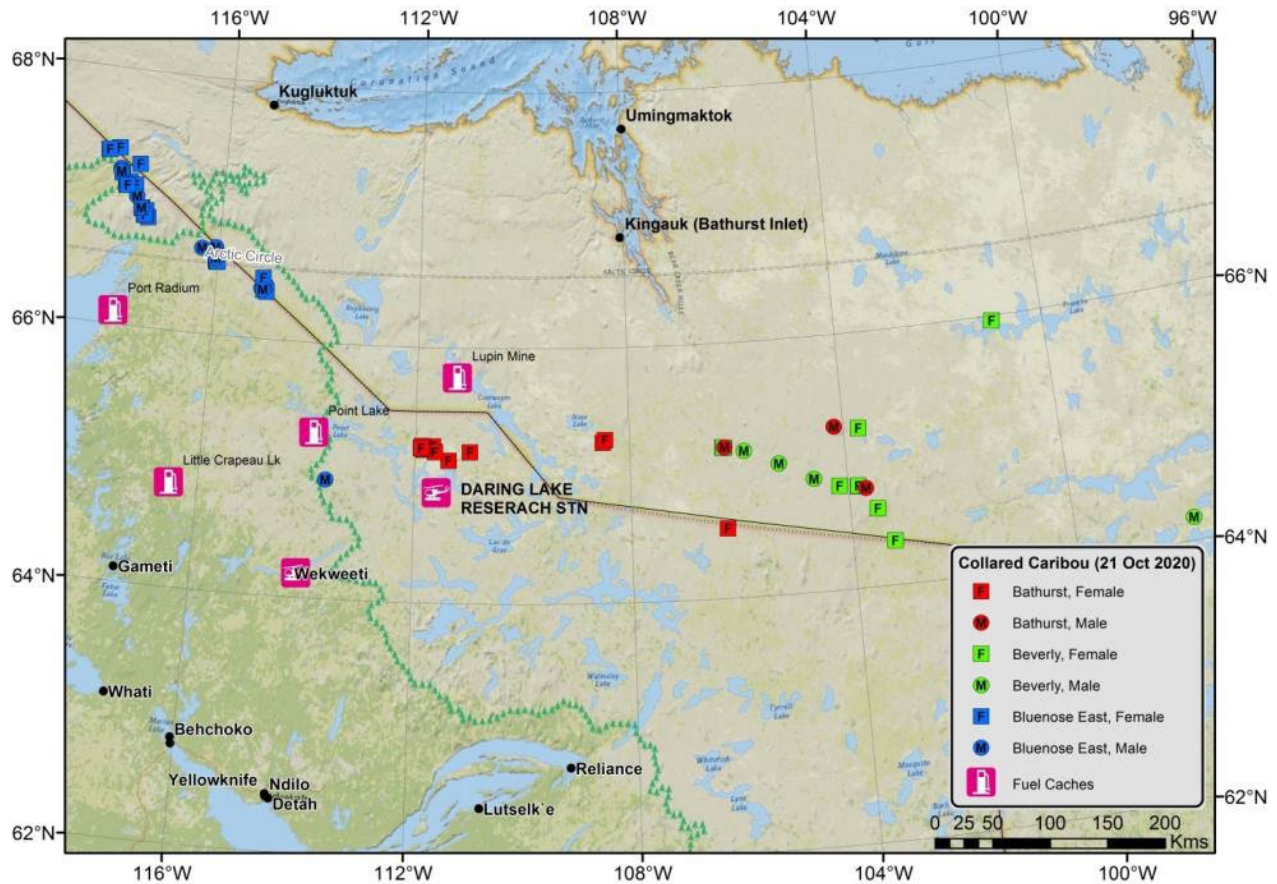


Figure 4. Locations of collared Bathurst, BNE and Beverly caribou on October 21, 2020. There were 38 collared Bathurst caribou just north of Daring Lake. East of Contwoyto Lake there were 12 additional Bathurst collars mixed with Beverly collars; these caribou were not surveyed. There were 50 BNE collars, with all but one north or east of Port Radium.

There was one large aggregation of caribou in the area of the main cluster of Bathurst collars north of Daring Lake (Figure 5). There appeared to be several thousand caribou in the area and this was likely the bulk of the herd (Figure 6). A second flight was made to classify smaller numbers of caribou associated with a few collared caribou east of the main group. The caribou surveyed in the Bathurst herd had 38 collars in the vicinity (Table 2), which likely represented about $\frac{3}{4}$ of the herd (38 of 50 collars), with the remainder of the collars and herd well east of Contwoyto Lake.

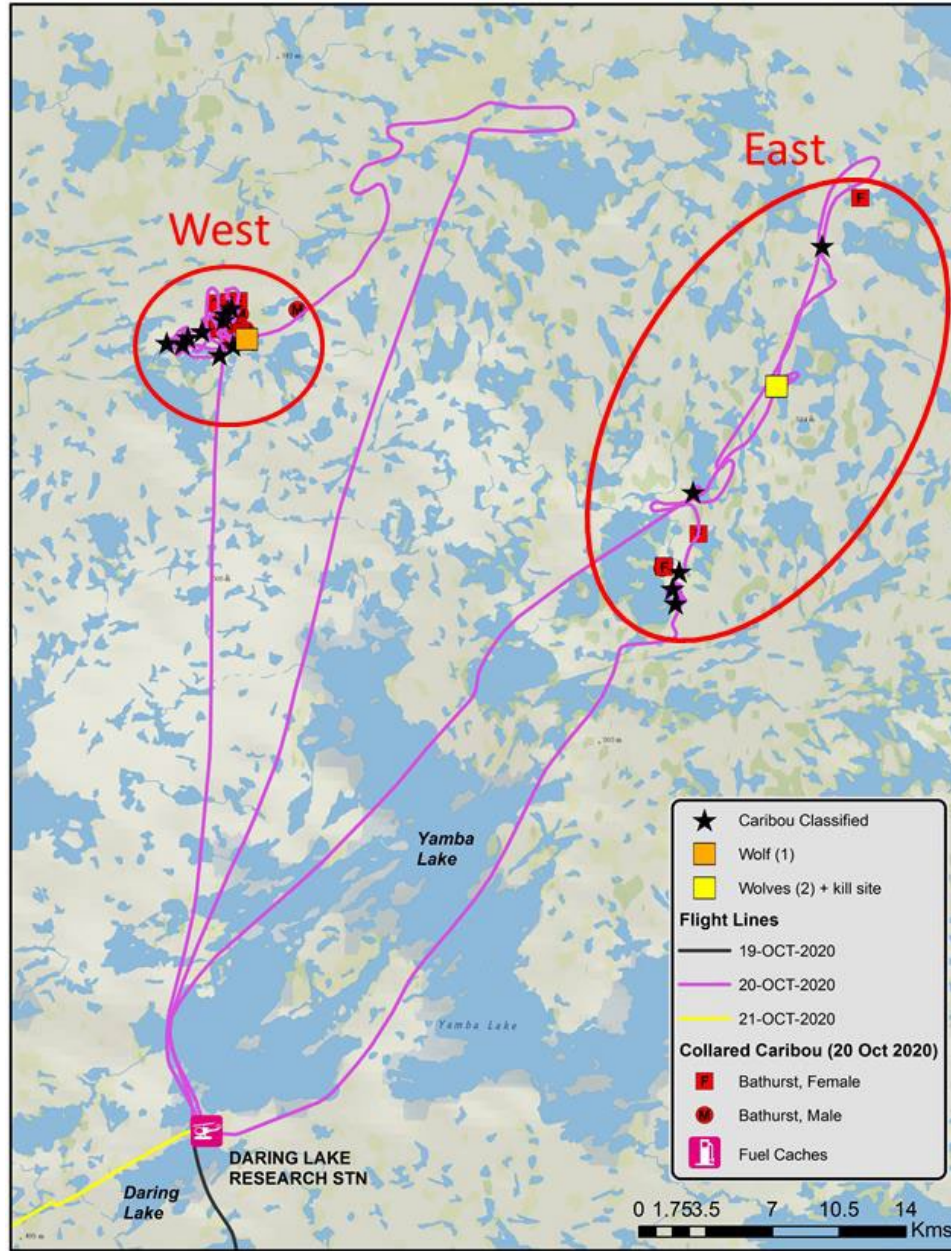


Figure 5. Flight lines, locations of caribou groups surveyed, collared caribou locations, and locations of wolves seen on Bathurst survey October 20, 2020. Caribou classified in the west and east areas were also analyzed separately to assess regional variation.



Figure 6. Part of a large rutting aggregation in the Bathurst herd, October 20, 2020. There appeared to be several thousand caribou in this area. Photo: GNWT/D. Cluff, ENR.

Table 2. Numbers of active collared cow and bull caribou from the Bathurst and BNE herds during October 2020 composition surveys, and numbers of collared caribou within surveyed areas.

	Bathurst			BNE		
	F	M	Total	F	M	Total
Total	38	12	50	32	18	50
In Areas Flown	33	5	38	29	17	46

Bluenose-East Survey

The BNE survey was flown on October 22, 2020 (Figure 7). Weather on this day was good, with some blue skies and high cloud ceilings; however, weather forecast for the following days was very poor, and thus the flying was concentrated in a single day. The flight north from the Port Radium fuel cache was initially north through the collared caribou to verify their locations relative to collars, and classification occurred on the southward flight through the collars and associated caribou. On some occasions we found that most of the

caribou were a few kilometers south of the mapped collar locations; following southward-pointing trails in the snow led to the caribou groups. After re-fueling at Port Radium, a second flight was made to classify caribou in two clusters of collars east of Port Radium.

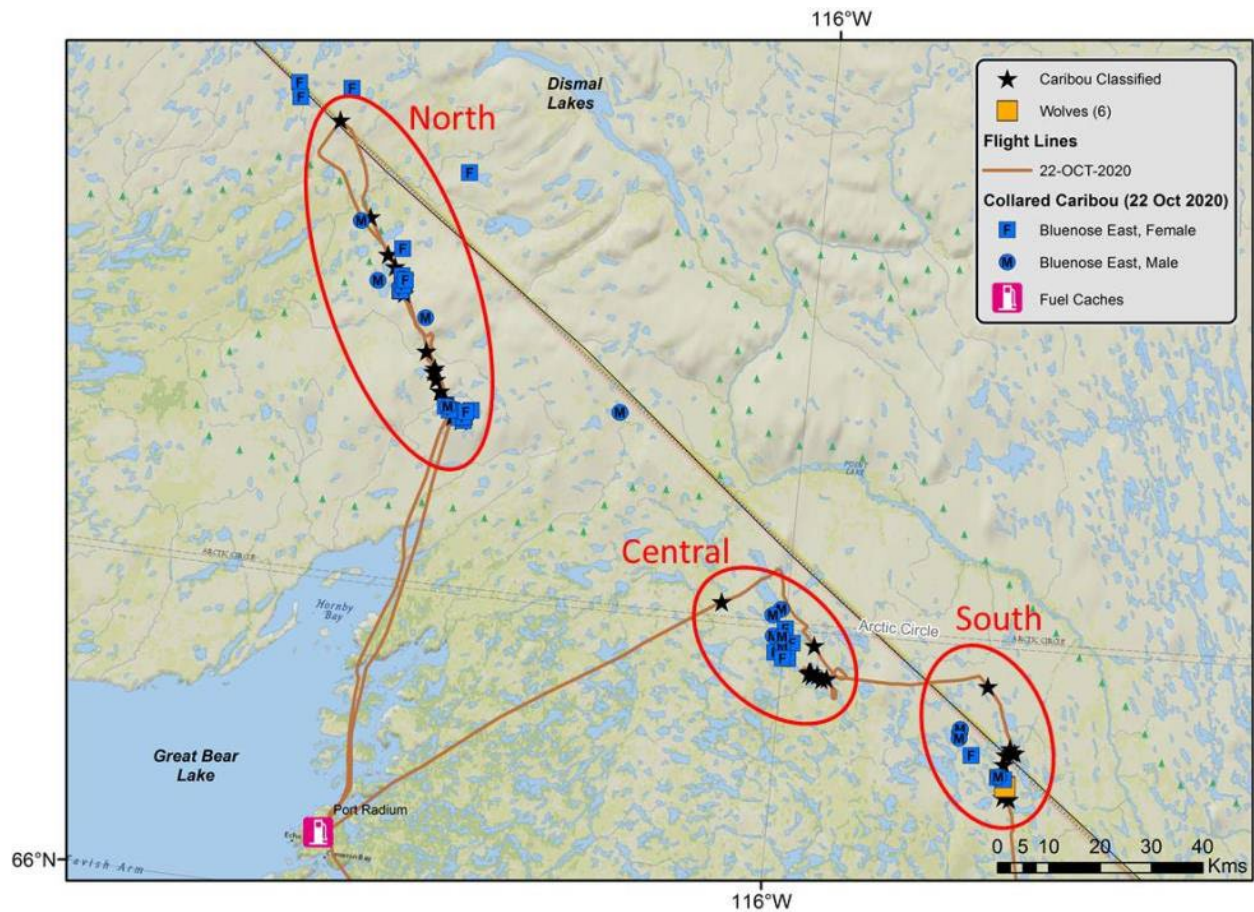


Figure 7. Flight lines, locations of caribou groups surveyed, collared caribou locations, and locations of wolves seen on BNE survey October 22, 2020. One pack of six wolves was seen on the survey and is shown on the map. North, central and south areas of survey results were also analyzed separately to assess regional variation. The helicopter was based at Wekweètì, not shown on the map.

Caribou Group Composition and Rutting Behaviour

There were multiple observations of prime bulls fighting during the Bathurst and BNE October 2020 surveys (Figure 8). We also saw many cases of prime bulls closely following cows. Groups of caribou consistently showed a mix of cows, calves, prime bulls and young bulls (e.g. Figure 9). These observations suggested that our surveys were timed close to the peak of the breeding season.



Figure 8. Two prime bulls in the Bathurst herd fighting on October 20, 2020 (top) and two prime bulls fighting in the BNE herd on October 22, 2020 (bottom). Photos: GNWT/D. Cluff, ENR.



Figure 9. A mixed group of caribou in the BNE herd, October 22, 2020. Cows, calves, young bulls and prime bulls are represented in this group. Photo: GNWT/D. Cluff, ENR.

Survey Results for Bathurst Herd

The survey of the Bathurst herd included 1,843 caribou in 15 groups (Table 3). Groups identified during the survey were more units of convenience than actual groups. The caribou classified in the main cluster of Bathurst collars (West area in Figure 5) were in actuality one large rutting aggregation and we estimated several thousand caribou in the area (Figure 6). Groups found in the East area were much smaller and included a number of more dispersed groups. Results should be considered with some caution given that 12 of 50 collars (24%) were east of Contwoyto Lake and not sampled during the survey. Survey results group-by-group for the Bathurst and BNE herds are in Appendix 1.

Table 3. Overall results and regional variation for the October 2020 Bathurst fall composition survey. East and West groups are as shown in Figure 5. SE = Standard Error; CIU = 95% Confidence Interval Upper; CIL = 95% Confidence Interval Lower.

Measurement	All Groups	West Area	East Area
# Caribou	1,843	1,312	531
# Cows	907	647	260
# Calves	355	263	92
# Young Bulls	335	243	92
# Prime Bulls	246	159	87
# Groups	15	10	5
Mean Group Size	122.9	131.2	106.2
Median Group Size	144	144	143
Calves: 100 Cows	39.1	40.6	35.4
SE Calves: 100 Cows	1.5	1.4	2.5
CIU & CIL Calf:Cow	41.9, 36.2	43.4, 37.7	40.2, 31.3
Bulls: 100 Cows	64.1	62.1	68.8
SE Bulls: 100 Cows	7.6	8.7	15.8
CIU & CIL Bull:Cow	79.6, 49.9	80.0, 45.9	103.2, 43.2

The overall Bathurst calf:cow ratio of 39.1 calves:100 cows (Table 3) mostly reflected results in the larger West area, where 71% of the caribou were classified. The calf:cow ratio in the East area was somewhat lower at 35.4 calves:100 cows.

The overall bull:cow ratio for the Bathurst herd was 64.1 bulls:100 cows, with a relatively high variance (SE of 8.7 and Upper and Lower 95% CI of 80.0 and 45.9). This may reflect in part substantial variation in bull:cow ratios among groups, and in part a relatively small number of groups. The bull:cow ratio was relatively similar between the West and East areas of the survey.

To provide context for the 2020 Bathurst fall composition survey, fall calf:cow and bull:cow ratios for the herd from 2006 to 2020 are shown in Figure 10.

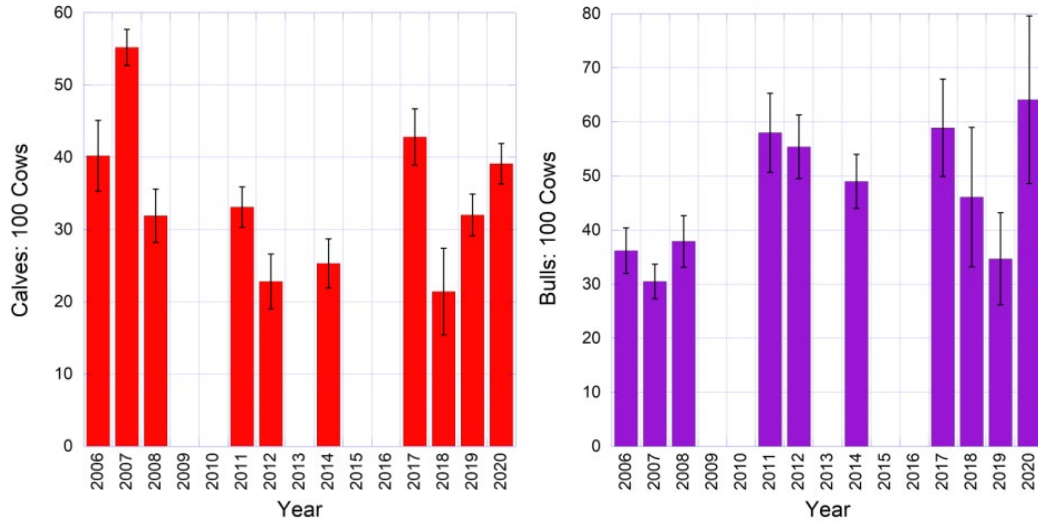


Figure 10. Fall calf:cow ratios (left) and bull:cow ratios (right) for the Bathurst herd 2006-2020.

The calf:cow ratios indicate substantial variation over this period and an increasing trend from 2018 to 2020. Bull:cow ratios also show substantial variation from 2006-2020, with relatively low bull:cow ratios 2006-2008 and generally better ratios since 2011. The 2020 bull:cow ratio was similar to the ratio of just below 60:100 in 2017.

Survey Results for Bluenose-East Herd

The survey of the BNE herd included 2,171 caribou in 39 groups (Table 4). Groups identified during the survey were more units of convenience than actual groups. The bulk of the observations were in the North area, which had the greatest number of collared caribou and the largest numbers of caribou seen.

Table 4. Overall results and regional variation for October 2020 BNE fall composition survey. North, Central and South groups are as shown in Figure 7.

Measurement	All Areas	North Area	Central Area	South Area
# Caribou	2,171	1,585	325	261
# Cows	1,010	775	142	93
# Calves	522	405	63	54
# Young Bulls	362	226	69	67
# Prime Bulls	277	179	51	47
# Groups	39	18	9	12
Mean Group Size	55.7	88.1	36.1	21.8
Median Group Size	33	74.8	18	18.5
Calves: 100 Cows	51.7	52.3	44.4	58.1
SE Calves: 100 Cows	2.2	2.6	4.6	5.3
CIU and CIL Calf:Cow	55.7, 47.2	57.2, 46.8	50.8, 32.8	70.7, 49.6
Bulls: 100 Cows	63.3	52.3	84.5	122.6
SE Bulls: 100 Cows	7.4	7.8	10.4	15.1
CIU and CIL Bull:Cow	79.0, 50.0	67.2, 37.0	102.7, 61.9	158.2, 97.5

The overall BNE calf:cow ratio of 51.7 calves:100 cows (Table 3) mostly reflected results in the North area (52.3), where 73% of the caribou were classified. Calf:cow ratios in the Central (44.4) and South areas (58.1) were somewhat lower and somewhat higher, respectively. Numbers of caribou surveyed in the Central (325 caribou) and South (261 caribou) areas were relatively low.

The overall bull:cow ratio for the Bathurst herd was 63.3 bulls:100 cows, with a relatively high variance (SE of 7.4 and Upper and Lower 95% CI of 79.0 and 50.0). The bull:cow ratio varied substantially between the North (52.3), Central (84.5) and South (122.6) areas.

To provide context for the 2020 BNE fall composition survey, fall calf:cow ratios and bull:cow ratios for the BNE herd from 2009 to 2020 are shown in Figure 11. The calf:cow ratios do not show a clear trend over this period; however, the ratio in October 2020 was the highest of the eight surveys conducted over this period. Bull:cow ratios between 2009 and 2019 were variable with a slight downward trend. The ratio recorded in October 2020 was higher than results observed in this herd between 2009 and 2019.

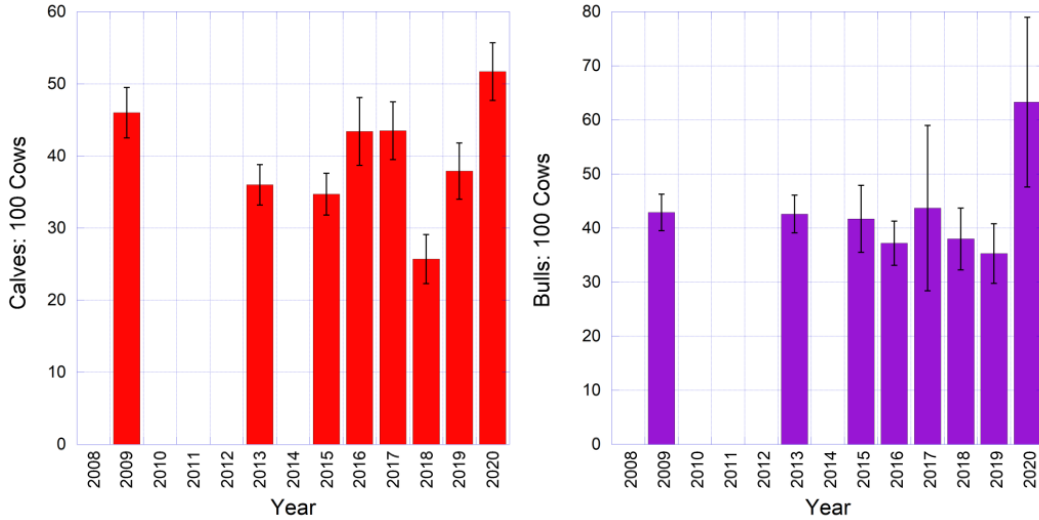


Figure 11. Fall calf:cow ratios (left) and bull:cow ratios (right) for the BNE herd 2009-2020.

Incidental Observations of Wildlife

Incidental sightings of wolves are listed in Table 5, and their locations are shown in Figures 5 and 7. There were no other incidental wildlife sightings. The pair of wolves seen on the Bathurst survey was at a fresh kill site where a prime bull caribou had been killed.

Table 5. Incidental sightings of wolves on the Bathurst and BNE October 2020 composition surveys.

Species	Bathurst Herd	Notes Bathurst	BNE Herd	Notes BNE
Wolf	3	1 single, 1 pair	6	1 pack

DISCUSSION

Fall Bull:Cow Ratios in the Bathurst and Bluenose-East Caribou Herds

The bull:cow ratios recorded in October 2020 for the Bathurst and BNE herds were higher than has been found in previous fall surveys for both herds in the last ten to twelve years. These ratios could be affected by a number of factors, which are reviewed briefly below.

- (1) Timing of the survey:** A survey at the peak of the rut is most likely to include all sex and age classes in the herd, while a survey well after the peak of the rut may result in lower bull:cow ratios if the rutting aggregations have started to break up and some of the bulls have begun to segregate away from the females as they begin winter. From this perspective, the October 2020 surveys appeared to be timed close to the peak of the rut, based on multiple observations of bulls fighting and bulls following cows closely. The peak of calving likely occurred about a week into June 2019 and 2020 (Adamczewski et al. 2019, 2020). Assuming a gestation of 230 days, this would mean a peak in breeding around October 19, close to the timing of the October 2020 surveys. In comparison, the fall 2019 surveys were carried out November 3-6 (Williams and Cluff 2019) and resulted in much lower bull:cow ratios. These surveys may have been two weeks or more past the peak of the rut, with the possibility of some of the males having separated from the females.
- (2) Spatial variation and adequacy of sampling:** Regional bull:cow ratios in the BNE survey varied widely, from 52.3:100 in the North area to 84.5:100 in the Central area and 122.6:100 in the South area. The latter two results could in part have resulted from relatively small sample numbers. Had one or the other of these smaller samples not been included, the overall bull:cow ratio would have been lower. This range of results underscores the importance of sampling across the range of the herd and sampling in proportion to relative numbers of caribou. We used the collared caribou in the herds in the vicinity of the survey flying as our primary measure of the herd's distribution and relative numbers in sampled areas. For the BNE herd, areas sampled included 46 of 50 collars in the herd and there was greater sampling in areas with more caribou. In this respect the survey should have been representative of the herd. For the Bathurst herd, 12 of 50 collars (24%) were in an area east of Contwoyto Lake in October 2020 that was not sampled. It is possible that including that portion of the herd could have altered the survey bull:cow ratio, thus these results should be used with some caution. We note that bull:cow ratios estimated for the Bathurst herd between 2006 and 2020 varied substantially year to year (Figure 10), although it seems unlikely that the true bull:cow ratio actually varied to this extent; this would suggest that adequacy of fall sampling has been somewhat variable.

(3) Misclassification of cows and bulls: Classification from a helicopter of caribou walking or running does not allow for extended observation of single animals. Cows and young bulls are often similar in body size and may be similar in their antlers. It is possible that cows and young bulls could occasionally be misclassified, particularly if the caribou did not have its tail lifted when classified. This could bias the results if smaller adults were consistently misclassified as cows or young bulls. However, prime bulls with large antlers are unmistakable and unlikely to be misclassified. Misclassification is unlikely to have affected more than a small percentage of the cows and young bulls in the surveys.

(4) A real increase in bull:cow ratios in both herds: It is possible that the Bathurst and BNE caribou herds have moved toward a stabilizing trend in recent years. Collar-based cow survival rates for the Bathurst herd have increased in the last four years and were above 90% in 2018 and 2019 (Boulanger unpublished). Collar-based cow survival rates for the BNE herd have averaged 85% for the last four years (Boulanger unpublished). While the sample numbers remain limited (25-30 cows on average), these rates are a significant improvement over previous years. Collar-based bull survival rates for the BNE herd also have increased from a range of 50-60% for 2012-2016 to 70-80% for 2017-2019 (Boulanger unpublished). The sample size of bull collars (15-20 bull collared on average each year) precludes solid determination of survival rates; however, a general upward trend is suggested. In contrast, Bathurst bull survival rates have ranged from 70 to 75% for 2016-2018 (Boulanger unpublished). The percentage of breeding females in June 2019 was 86% in the Bathurst herd and 87.5% in the BNE herd, the highest values recorded in more than ten years. Calf:cow ratios recorded in October 2020 of 39:100 in the Bathurst herd and 51:100 in the BNE herd are the highest recorded in recent years.

Improved bull:cow ratios in the Bathurst and BNE herds in 2020 may be a further indicator of improving demographics in the two herds. The last period of widespread growth in NWT mainland barren-ground caribou herds was in the early 1980s. The average bull:cow ratio recorded during six fall composition surveys during this period was 66 bulls:100 cows (in Gunn et al. 1997, p. 35). Given the challenges of adequately sampling the sex ratio in these herds and the spatial variation we documented in 2020, however, we suggest it would be essential to carry out further fall composition surveys of the two herds in 2021 to verify whether bull:cow ratios have increased as the 2020 surveys suggest. An ongoing Integrated Population model, as was used up to 2018 (Adamczewski et al 2019, Boulanger et al 2019)

as part of the calving survey analyses, will provide updated survival rates as well as bull trends based on composition surveys and other data sources.

A Comparison with Bull:Cow Ratios in the Western Arctic Herd, Alaska

The challenges of obtaining a bull:cow ratio fully representative of a migratory caribou herd numbering many thousands are not unique to surveys of the Bathurst and BNE herds. The following paragraph from Dau (2015) summarizes some of the challenges encountered in fall surveys of the western Arctic herd (WAH) in Alaska.

“Sexual segregation and our inability to sample the entire population during fall probably account for more annual variability in the estimated bull:cow ratio than actual changes in population composition (Figure 12). The low value of 38 bulls: 100 cows in 2001 were probably a result of spatial segregation and incomplete sampling of the entire herd rather than an actual short-term drop in the proportion of bulls in the population. Because of this measurement error, the bull:cow ratio reported here should be viewed with caution. We think these data probably reflect trends in bull:cow ratios reasonably accurately; however, the actual values could be higher or lower.”

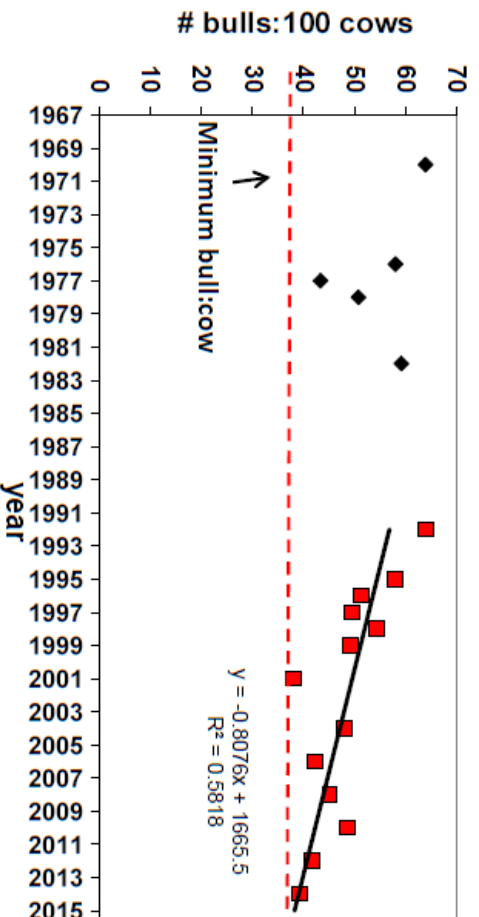


Figure 12. Fall bull:cow ratios, western Arctic caribou herd, 1976-2014. No trend line shown for 1970-1982 because yearly survey methods varied. (Originally Figure 27 in Dau 2015; figure caption as presented in that report).

The graph above is from Dau (2015) and shows bull:cow ratios in the WAH from the 1970s to 2014 (Figure 12). This herd was increasing in the 1980s and early 1990s, at high numbers of over 400,000 1993-2003, and has had a declining trend since about 2003. The overall range in bull:cow ratios in this herd has varied between 1991 and 2015 from a high of more than 60:100 1991, when the herd was still increasing, to a low of 38-40:100 in 2001 and 2014. The overall range in sex ratios is similar to the range reported for the

Bathurst and BNE herds 2006-2020, although somewhat lower ratios were recorded for the Bathurst herd 2006-2008 during a period of rapid decline.

Fall Calf:Cow Ratios in the Bathurst and Bluenose-East Caribou Herds

Fall calf:cow ratios of 39.1 calves:100 cows in the Bathurst herd and 51.7 calves:100 cows in the BNE herd are a generally positive sign for these herds; the BNE calf:cow ratio is the highest recorded in the fall for this herd since 2009 (Figure 11). Whether a calf:cow ratio is associated with a stable population depends in part on the cow survival rate (Crête et al. 1996, Boulanger et al. 2011, Boulanger and Adamczewski 2016). In population modeling summarized by Boulanger and Adamczewski (2016; Table 1), at a cow survival rate of 85%, fall calf:cow ratios needed to be 49-51 calves:100 cows and late-winter ratios needed to be 38-45 calves:100 cows for stability. At a higher cow survival rate of 90%, fall calf:cow ratios of 44 calves:100 cows and late-winter calf:cow ratios of 29 calves:100 cows were associated with stability (ibid.). At a low cow survival rate of 77%, it was essentially impossible for the herd to produce enough calves for a stable herd (ibid.). Recent collar-based cow survival estimates of about 85% in the BNE herd (Boulanger unpublished) and over 90% for the Bathurst herd (Boulanger unpublished) also suggest improving trends.

Calf:cow ratios were previously estimated in July 2020 for the Bathurst and BNE herds (Adamczewski et al. 2020). Composition surveys in July had not been previously flown for these herds; the purpose was to assess the extent of calf mortality in the first four to five weeks. In some caribou populations, calf mortality in the first month can be 50% (Bergerud 2000). The resulting Bathurst calf:cow ratio was 44.1 calves:100 cows, compared to 39.1:100 cows in October. For the BNE herd, the July survey resulted in an estimated ratio of 46.9 calves:100 cows, compared to 51.7 calves:100 cows in October. Overall, within the limitations of these surveys, these results would suggest that calf mortality in the two herds between mid-July and late October was limited, and the bulk of the calf mortality appeared to occur in the first four to five weeks in both herds in 2020.

Regional variation in calf:cow ratios for the BNE herd (North 52.3, Central 44.4, and South 58.1) was not as pronounced as variation in bull:cow ratios. Regional variation in the Bathurst herd (West 40.6, East 35.4) was of a similar magnitude. Some of this variation may be the result of relatively small sample numbers in some of the areas sampled. Nonetheless, this variation suggests that fall calf:cow ratios are variable within these herds. This again underscores the importance of representative sampling across the range of the herd, and greater sampling where caribou numbers are higher. As noted earlier, 12 of 50 Bathurst collars were far east of Contwoyto Lake in late October 2020 and mixed with Beverly collars (Appendix 2), and our fall survey did not sample this portion of the Bathurst herd. For the BNE herd, the presence of 46 of 50 total collars (92%) in surveyed areas, and greater sampling where caribou numbers were higher, suggests that the survey was

reasonably representative of the herd. The need for ample sample sizes of both bull and cow collars to ensure an adequate spatial sampling of composition groups is highlighted by the results of this survey.

ACKNOWLEDGEMENTS

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APPENDIX 1. Group-by-group Summary of October 2020 Fall Composition Surveys of Bathurst and BNE Caribou.

Bathurst Observations

Area	Date Time	Latitude	Longitude	Cows	Calves	Young Bulls	Prime Bulls	Bulls Total	Caribou Total	Incid Species
East	20-Oct-2020 3:26:33 PM	65.1218395	-111.07703	61	25	40	31	71	157	
East	20-Oct-2020 3:20:34 PM	65.1287181	-111.08106	96	29	19	20	39	164	
East	20-Oct-2020 3:14:59 PM	65.1368433	-111.07353	69	25	24	25	49	143	
East	20-Oct-2020 3:04:08 PM	65.2253372	-110.96724	0	0	0	0	0	0	2 wolves
East	20-Oct-2020 2:59:27 PM	65.2922945	-110.91824	33	13	9	11	20	66	
East	20-Oct-2020 2:47:28 PM	65.174628	-111.05944	1	0	0	0	0	1	
West	20-Oct-2020 12:56:25 PM	65.240041	-111.65637	110	49	24	20	44	203	
West	20-Oct-2020 12:50:01 PM	65.2397502	-111.63859	65	30	31	18	49	144	
West	20-Oct-2020 12:42:50 PM	65.2350296	-111.59648	12	7	4	2	6	25	
West	20-Oct-2020 12:40:54 PM	65.242898	-111.63248	106	43	64	36	100	249	
West	20-Oct-2020 12:32:39 PM	65.245996	-111.61706	38	13	13	15	28	79	
West	20-Oct-2020 12:27:43 PM	65.2396502	-111.58143	62	27	32	15	47	136	
West	20-Oct-2020 12:21:31 PM	65.2543261	-111.59151	65	24	32	23	55	144	
West	20-Oct-2020 12:15:00 PM	65.2516338	-111.59293	11	4	5	1	6	21	
West	20-Oct-2020 12:12:12 PM	65.2573276	-111.58427	80	27	23	14	37	144	
West	20-Oct-2020 12:06:45 PM	65.2421527	-111.56665	98	39	15	15	30	167	
West	20-Oct-2020 12:00:01 PM	65.2426634	-111.56608	0	0	0	0	0	0	1 wolf

Bluenose-East Observations

Area	Date	Time	Latitude	Longitude	Cows	Calves	Young Bulls	Prime Bulls	Bulls Total	Caribou Total	Incid Species
Central	22-Oct-20	14:21:16	66.58732	-116.28789	11	1	3	2	5	14	
Central	22-Oct-20	14:31:28	66.52650	-115.86340	5	3	2	2	4	10	
Central	22-Oct-20	14:40:12	66.47075	-115.79618	5	2	0	1	1	8	
Central	22-Oct-20	14:48:39	66.46846	-115.81869	41	22	23	21	44	84	
Central	22-Oct-20	14:51:57	66.47526	-115.83860	32	16	15	12	27	60	
Central	22-Oct-20	14:54:55	66.47413	-115.86206	20	7	7	3	10	30	
Central	22-Oct-20	14:55:52	66.47683	-115.87703	8	3	5	2	7	13	
Central	22-Oct-20	14:57:44	66.47959	-115.87402	16	7	8	5	13	28	
Central	22-Oct-20	14:58:46	66.48008	-115.86789	4	2	6	3	9	9	
South	22-Oct-20	15:11:19	66.48137	-115.08733	3	3	0	0	0	6	
South	22-Oct-20	15:17:38	66.36934	-114.96314	7	4	5	3	8	14	
South	22-Oct-20	15:19:25	66.36871	-114.94766	1	1	0	0	0	2	

Area	Date	Time	Latitude	Longitude	Cows	Calves	Young Bulls	Prime Bulls	Bulls Total	Caribou Total	Incid Species
South	22-Oct-20	15:20:32	66.37553	-114.96976	0	0	2	3	5	3	
South	22-Oct-20	15:21:36	66.36400	-114.98649	0	0	0	1	1	1	
South	22-Oct-20	15:24:16	66.34730	-114.99268	7	5	3	3	6	15	
South	22-Oct-20	15:27:05	66.30830	-114.97888	0	0	0	1	1	1	
South	22-Oct-20	15:30:00	66.30357	-114.97590	15	9	11	7	18	31	
South	22-Oct-20	15:31:50	66.29815	-114.97813	13	5	4	6	10	24	
South	22-Oct-20	15:34:18	66.29430	-114.97575	13	10	12	4	16	27	
South	22-Oct-20	15:37:47	66.28987	-114.98496	25	12	16	14	30	51	
South	22-Oct-20	15:41:01	66.28701	-114.95695	9	5	14	5	19	19	
North	22-Oct-20	11:27:25	67.34938	-118.23135	0	0	0	1	1	1	
North	22-Oct-20	11:38:03	67.18796	-118.03932	37	12	7	19	26	68	
North	22-Oct-20	11:41:16	67.12664	-117.93973	13	4	1	2	3	19	
North	22-Oct-20	11:43:50	67.10660	-117.90089	19	7	4	0	4	26	
North	22-Oct-20	11:45:56	67.09457	-117.87019	31	13	3	2	5	46	
North	22-Oct-20	11:50:18	67.09066	-117.85535	97	44	12	11	23	152	
North	22-Oct-20	11:54:57	67.07061	-117.86487	98	54	11	13	24	165	
North	22-Oct-20	11:58:24	67.06253	-117.84671	54	25	9	6	15	85	
North	22-Oct-20	12:27:06	66.89993	-117.63324	1	0	0	0	0	1	
North	22-Oct-20	12:27:56	66.88659	-117.60820	2	1	1	0	1	3	
North	22-Oct-20	12:37:14	66.88275	-117.60636	118	76	56	28	84	222	
North	22-Oct-20	12:40:25	66.85846	-117.56557	43	28	15	12	27	83	
North	22-Oct-20	12:47:29	66.86367	-117.54993	82	45	35	20	55	147	
North	22-Oct-20	12:53:53	66.85279	-117.52622	74	38	26	19	45	131	
North	22-Oct-20	12:18:00	66.96668	-117.71588	32	16	8	18	26	66	
North	22-Oct-20	12:19:51	66.93870	-117.66859	15	10	2	3	5	28	
North	22-Oct-20	12:21:02	66.93257	-117.67408	18	13	10	0	10	31	
North	22-Oct-20	12:25:29	66.91933	-117.65753	41	19	26	25	51	85	
South	22-Oct-20	15:27:05	66.3083	-114.97888	0	0	0	0	0	0	6 Wolves

APPENDIX 2. Unusual Fall 2020 Movements of Bathurst and Beverly Caribou and Assignment of Bull Collars to Herd: A Summary

Summary: In the fall of 2020, there was an unusual movement of some Bathurst collared bulls and cows with Beverly bulls and cows east of Contwoyto Lake. It appeared that part of the Bathurst herd was mixed with the Beverly herd during the rut in late October. As a result of these movements, ENR staff re-examined the way in which recently collared bulls are assigned to herd, including bull collars placed in March 2020 and assigned to herds in July 2020. This summary (Appendix 2) provides maps and related information on (1) the unusual collared caribou movements in fall 2020, and (2) assignment of collared bulls to herds. In addition, John Boulanger carried out some further analyses to assess the degree of fidelity of collared bulls to herds throughout the year, using data from 2015-2020 for the Bathurst, BNE and Beverly herds. His summary is included as Appendix 3.

1. Bathurst and Beverly Collared Caribou Movements in Fall 2020 East of Contwoyto Lake

Collars were placed on Bathurst and BNE caribou in winter 2020, primarily March. As in previous years, there was some overlap of the Bathurst herd with the BNE and Beverly herds in the winter, thus newly placed collars were not assigned to herd until June (cows) or at a point in the summer (bulls) when herds showed clear separation. In mid-July 2020, there was clear separation of the three herds (Figure 1) and the newly placed bull collars (in violet) were assigned to the three herds at that time. This approach was consistent with assignment of bull collars to the three herds in previous years. Newly placed cow collars were assigned to the three herds in June based on the calving grounds they were on, also consistent with previous years.

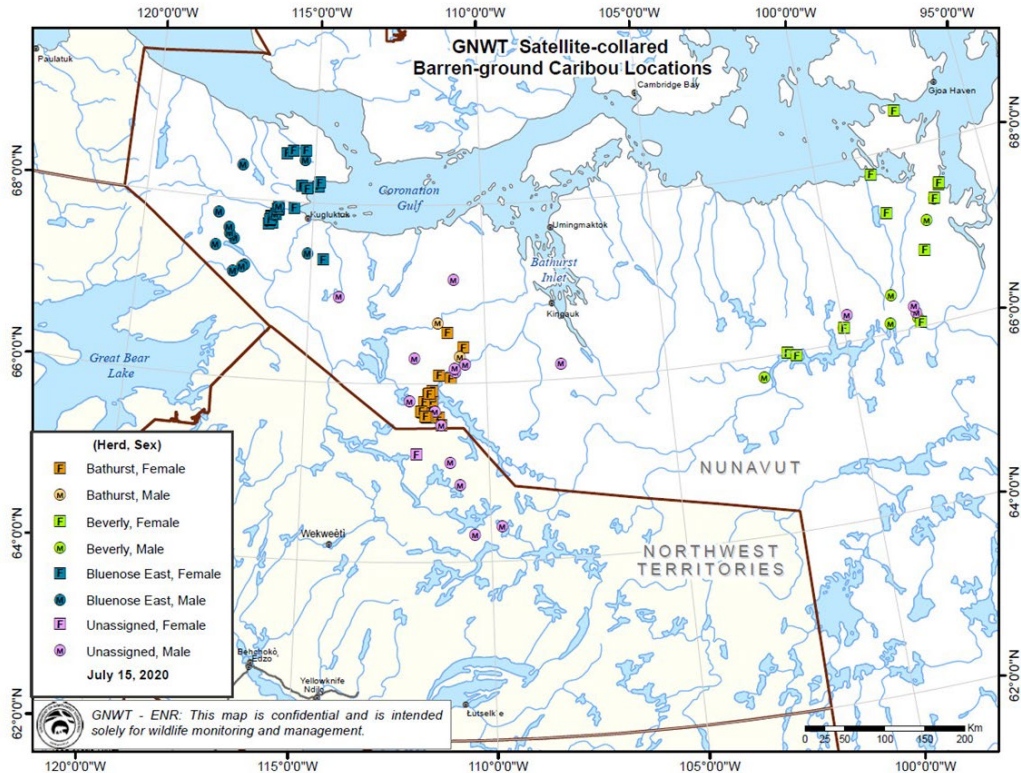


Figure 1. Locations of BNE, Bathurst and Beverly collared caribou on July 15, 2020. Newly placed bull collars are shown in violet.

By early October 2020, the distribution of collars in the three herds showed less separation (Figure 2). BNE collared caribou were still relatively separate from Bathurst caribou but there was a mixing of Bathurst and Beverly collars east of Contwoyto Lake. West of Contwoyto Lake, there were only Bathurst collars and this collar cluster included 33 cows and five bulls (total 38), likely representing about $\frac{3}{4}$ of the herd, based on the number of collars. East of Contwoyto Lake, there were 12 Bathurst collars (seven bulls, five cows) and these were mixed with Beverly cow and bull collars. As the breeding season approached (assumed peak of breeding about October 20), these collared Bathurst caribou and Beverly caribou showed some unusual movements, first to the east and then to the west and south (Figures 3-5).

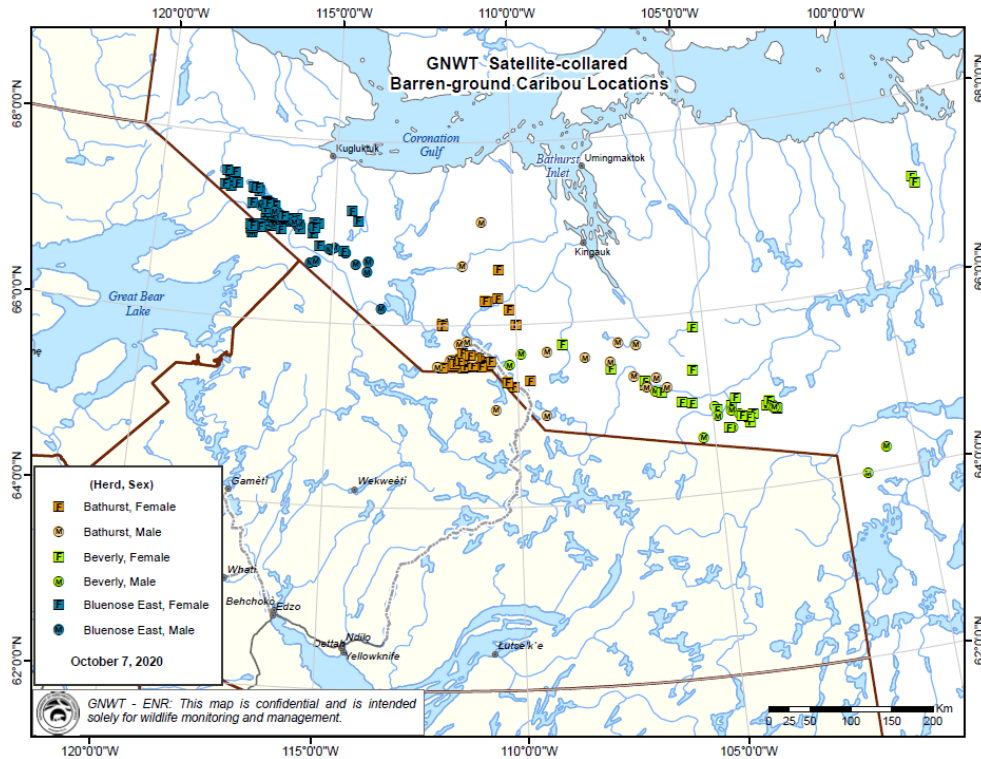


Figure 2. Locations of BNE, Bathurst and Beverly collared caribou on October 7, 2020.

Movements of collared Beverly bulls between the beginning of September and the beginning of November 2020 (Figure 3) show an eastward shift to about the middle of October, then a westward shift to the beginning of November to the north coast of Contwoyto Lake and a shift south by three of the bulls.

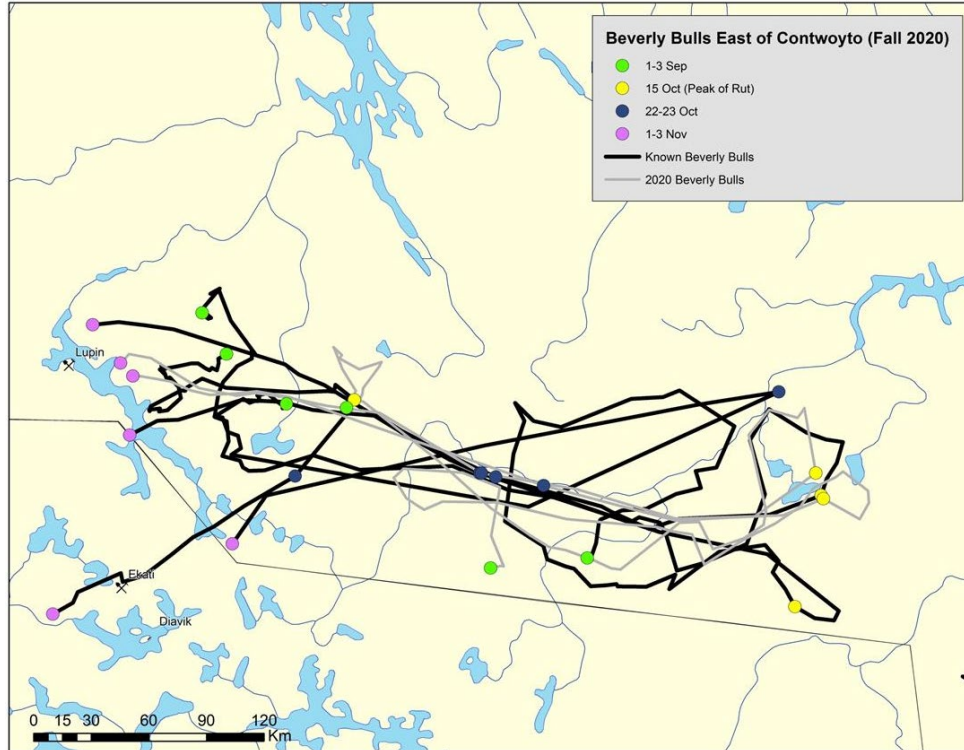


Figure 3. Movements from early September to early November 2020 of Beverly bull collars, east of Contwoyto Lake. Black lines are Beverly bulls from 2019 or earlier (known, n=5) and grey lines are bulls collared in 2020 (n=2). Green locations are September 1-3, yellow locations are October 15 and violet locations are November 1-3.

Movements of collared Bathurst bulls east of Contwoyto Lake between the beginning of September and the beginning of November 2020 (Figure 4) showed an eastward shift to about the middle of October, then a westward shift to the beginning of November. This was similar to the movements of Beverly bulls at this time. By November 3, two Bathurst bulls were south and west of Contwoyto Lake, while the rest were still east of Contwoyto Lake.

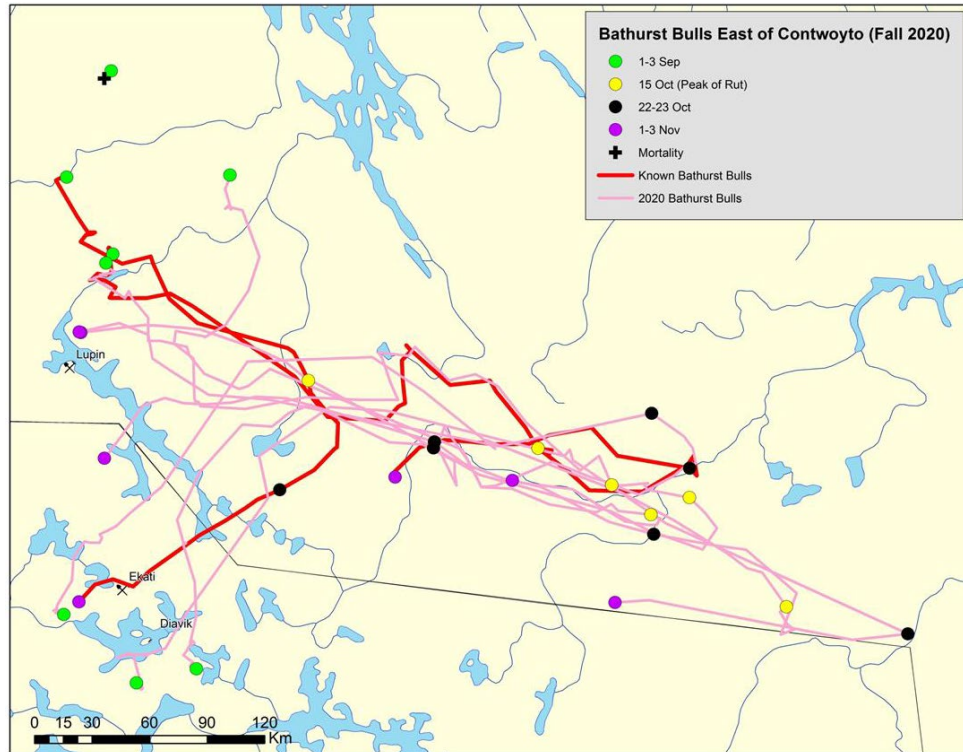


Figure 4. Movements from early September to early November 2020 of Bathurst bull collars, east of Contwoyto Lake. Red lines are Bathurst bulls from 2019 or earlier (n=2) and pink lines are bulls collared in 2020 (n=5). Green locations are September 1-3, yellow locations are October 15 and violet locations are November 1-3. Collared Bathurst caribou west/south of Contwoyto Lake (38 total; 33 cows, five bulls) are not shown for clarity.

Movements of collared Bathurst and Beverly cows east of Contwoyto Lake for the same period of early September to early November are shown in Figure 5. Six Beverly cows showed the same eastward shift September-October as a number of Beverly and Bathurst bulls, while another five Beverly cows moved south and east from the Bathurst Inlet area and one moved south from the Chantrey Inlet area. One known Bathurst cow and four Bathurst cows collared in 2020 that were east of Contwoyto Lake showed a partial eastward shift with Beverly collared cows and bulls in October, however all of these collared cows then moved west and south and most were near the main Bathurst collar cluster in early November.

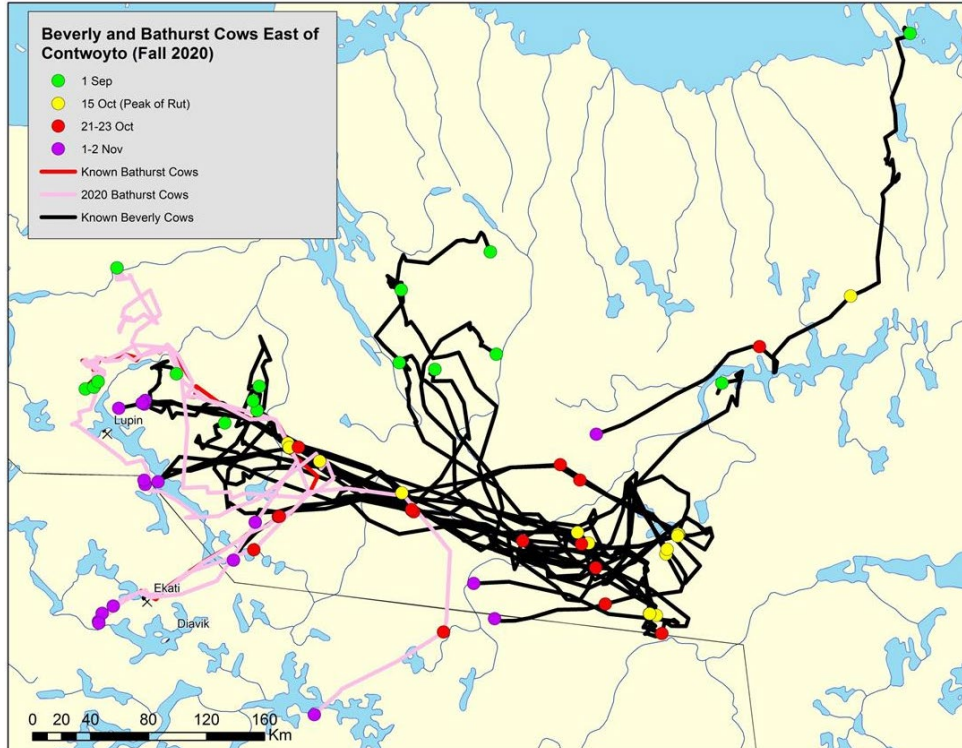


Figure 5. Movements from early September to early November 2020 of Bathurst and Beverly cow collars, east of Contwoyto Lake. The red line is a known Bathurst cow from 2019 or earlier ($n=1$) and pink lines are cows collared in 2020 ($n=4$). Black lines are known Beverly cows ($n=12$). Green locations are September 1-3, yellow locations are October 15 and violet locations are November 1-2. Collared Bathurst caribou west/south of Contwoyto Lake (38 total; 33 cows, five bulls) are not shown for clarity.

In total, the 12 Bathurst collared caribou east of Contwoyto Lake (one known Bathurst cow, four Bathurst cows collared in 2020, two known Bathurst bulls, five Bathurst bulls collared in 2020) all showed at least a partial eastward shift in October and were mixed with Beverly collared cows and bulls (likely representing many thousands of Beverly caribou based on equal distribution of population to collars) during the breeding season. Locations of collared Bathurst, Beverly and BNE caribou in early November (Figure 6) showed that these fall movements resulted in the BNE herd being relatively separate but dispersed over a large area, a cluster of the majority of collared Bathurst bulls and cows with one Beverly bull and one BNE bull, and a number of areas with primarily Beverly caribou and a few Bathurst cows and bulls mixed in. A map of collar locations from November 18, 2020 (Figure 7) shows that further movement has occurred and there may be a substantial mixing this winter of Bathurst, BNE and Beverly caribou.

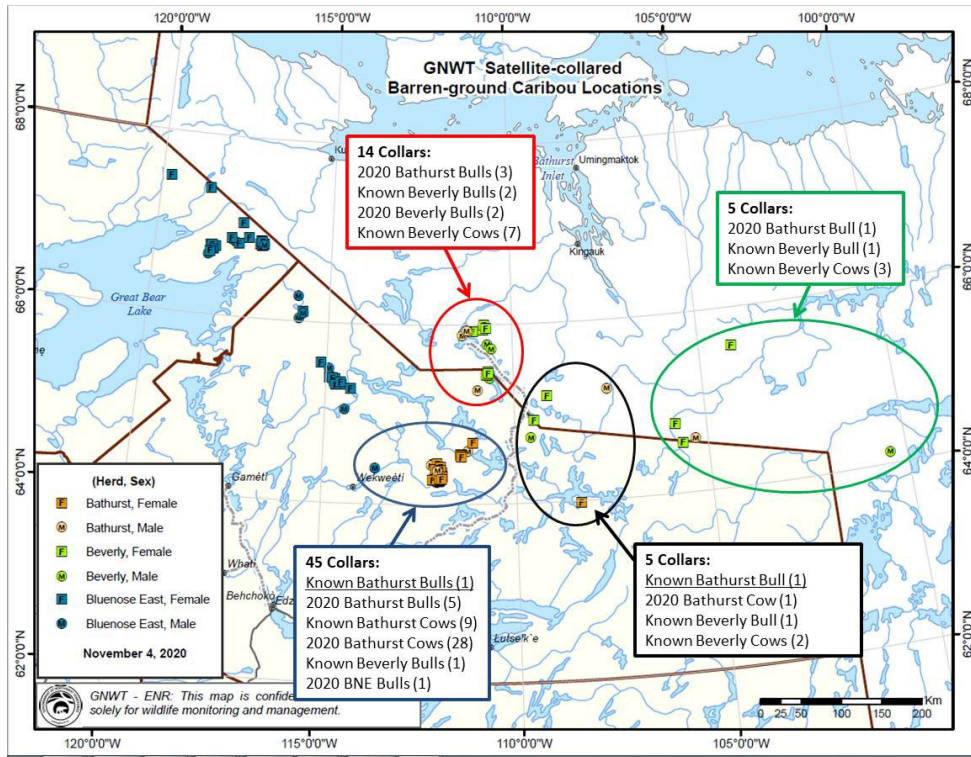


Figure 6. Collar locations of BNE, Bathurst and Beverly caribou on November 4, 2020. Three groupings of mixed Bathurst and Beverly collars are shown, as well as the main Bathurst collar cluster.

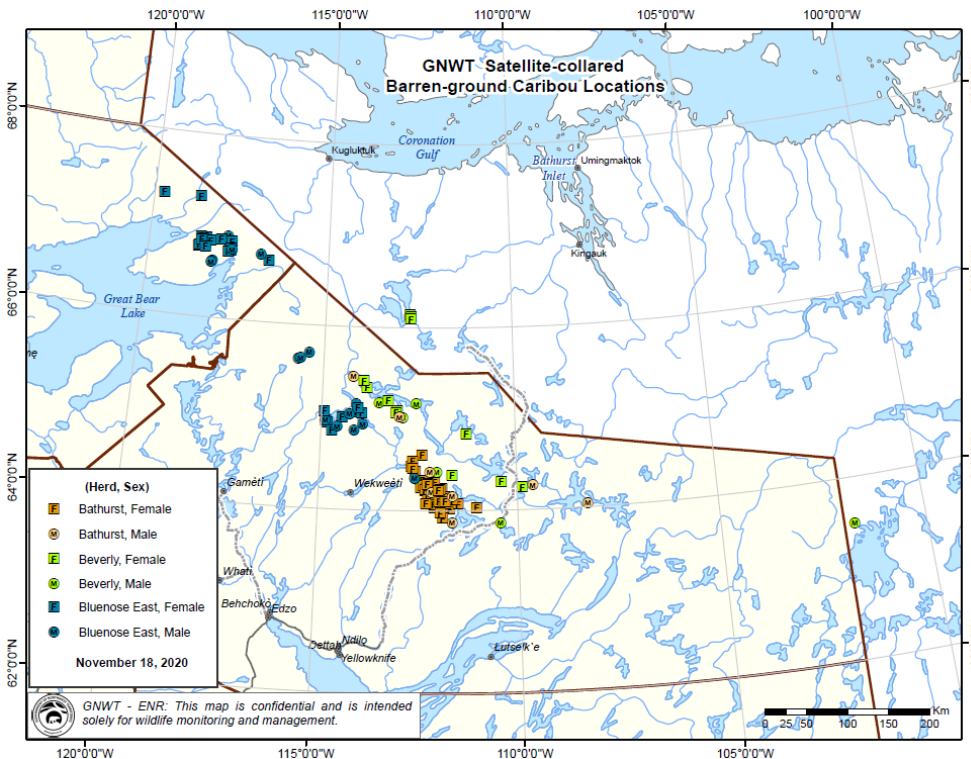


Figure 7. Collar locations of BNE, Bathurst and Beverly caribou on November 18, 2020.

A further section of this appendix includes maps showing how newly placed Bathurst, BNE and Beverly collars have been assigned in 2017, 2018, 2019 and 2020. In addition, Appendix 3 was written by J. Boulanger with an assessment of bull collar fidelity in these three herds over the last six years. Boulanger's analyses suggest that the fall collar movements in 2020 were unusual. It will be important to track the fates of these collars over time, and to consider whether there is a point where Bathurst collars should be re-assigned as Beverly. Their movements in June and July 2021 may show whether they are (a) Bathurst caribou that mixed during the rut with Beverly caribou, and potentially wintered with them but returned to Bathurst range in the spring, or (b) they have changed affiliation to the Beverly herd and move with that herd in the spring.

To provide a more complete picture of the movements of Bathurst collared caribou in fall 2020, a further two maps are included. These show the movements of 38 collared Bathurst caribou (33 cows, Figure 8) and five bulls (Figure 9) west and south of Contwoyto Lake in fall 2020, over the same time period as the collared caribou in Figures 3-5 that were east and north of Contwoyto Lake.

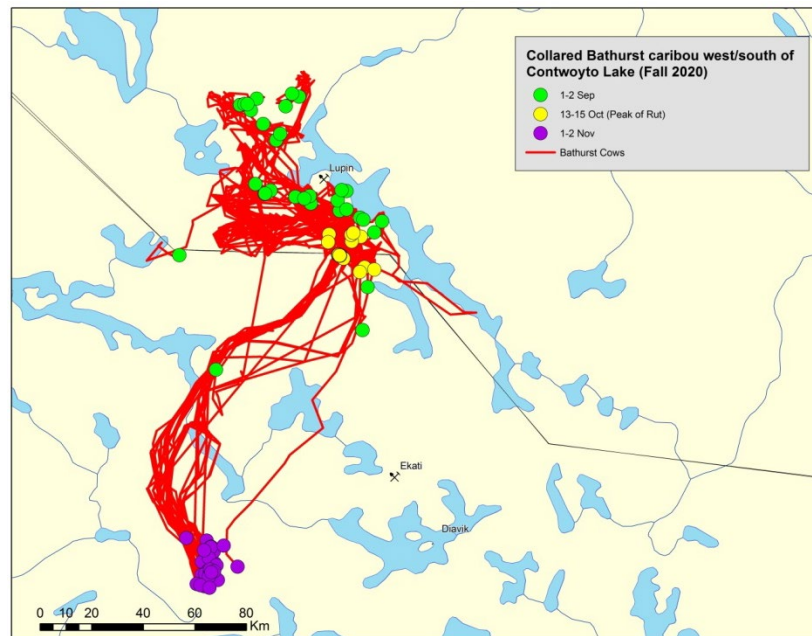


Figure 8. Movements from early September to early November 2020 of 33 Bathurst cow collars, west and south of Contwoyto Lake. Green locations are September 1-3, yellow locations are October 15 and violet locations are November 1-2. An additional five collared Bathurst cows north and east of Contwoyto Lake are not shown on this map; see Figure 5.

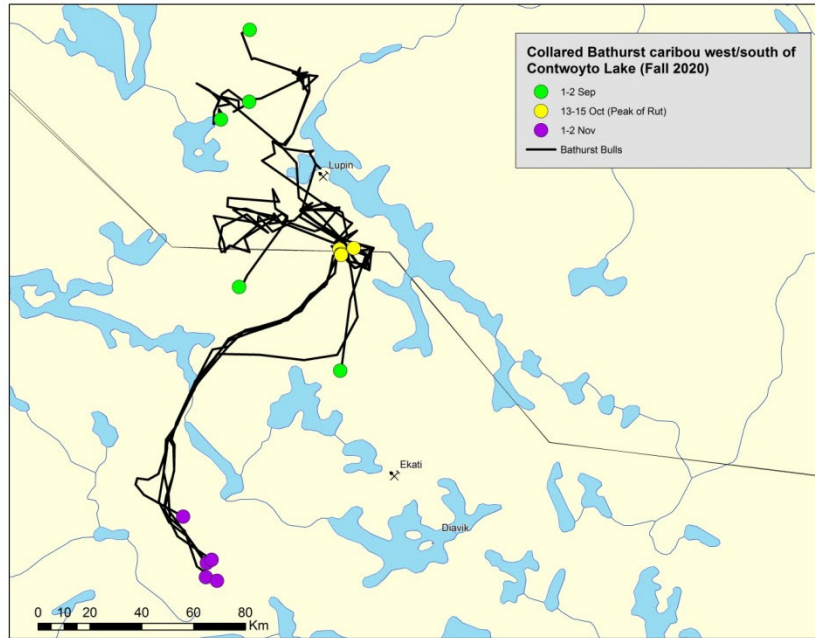


Figure 9. Movements from early September to early November 2020 of five Bathurst bull collars, west and south of Contwoyto Lake. Green locations are September 1-3, yellow locations are October 15 and violet locations are November 1-2. An additional seven collared Bathurst bulls north and east of Contwoyto Lake are not shown on this map; see Figure 4.

2. Assignment of Newly Collared Bathurst, Bluenose-East and Beverly Caribou, 2017-2020

Collar placements on caribou in the NWT occur most commonly in late winter, often March, although timing is somewhat variable. Existing collars for each of the herds (Bathurst, BNE and Beverly) in the North Slave region are generally used to guide placement of new collars. In some situations, a herd or part of the herd may winter separately from other herds, as indicated by an absence of collars from other herds nearby. In these cases, collars placed in those areas usually turn out reliably for that herd. In other winters, there may be some or extensive overlap between neighbouring herds. In these situations, collars targeted for one herd may turn out to be from the neighbouring herd, based on where they move to in the spring. As a general rule, newly placed cow collars (March) are assigned to a herd based on the calving ground they are found on in June. Exceptions occasionally occur, where a collared cow may be between calving grounds in June, or a cow may be south of the calving grounds in June; these are most likely non-pregnant cows that may move north somewhat later. These exceptions are rare.

Bull collars have generally been assigned to herd in the summer or fall at a point when the herds are most clearly separated spatially. In many cases, bulls can be assigned in June as they may be near the calving grounds of a herd and clearly associated with that calving ground. By the time of the July post-calving period, bull collars are usually at least partially mixed with cow collars, and separation between herds is fairly clear; see, for example Figure 1 with July 15, 2020 collar locations of Bathurst, BNE and Beverly herds. In this section, a series of maps is shown to demonstrate how and when newly placed bull collars have been assigned to herds in these three herds in 2017, 2018, 2019 and 2020 (Figures 10-13).

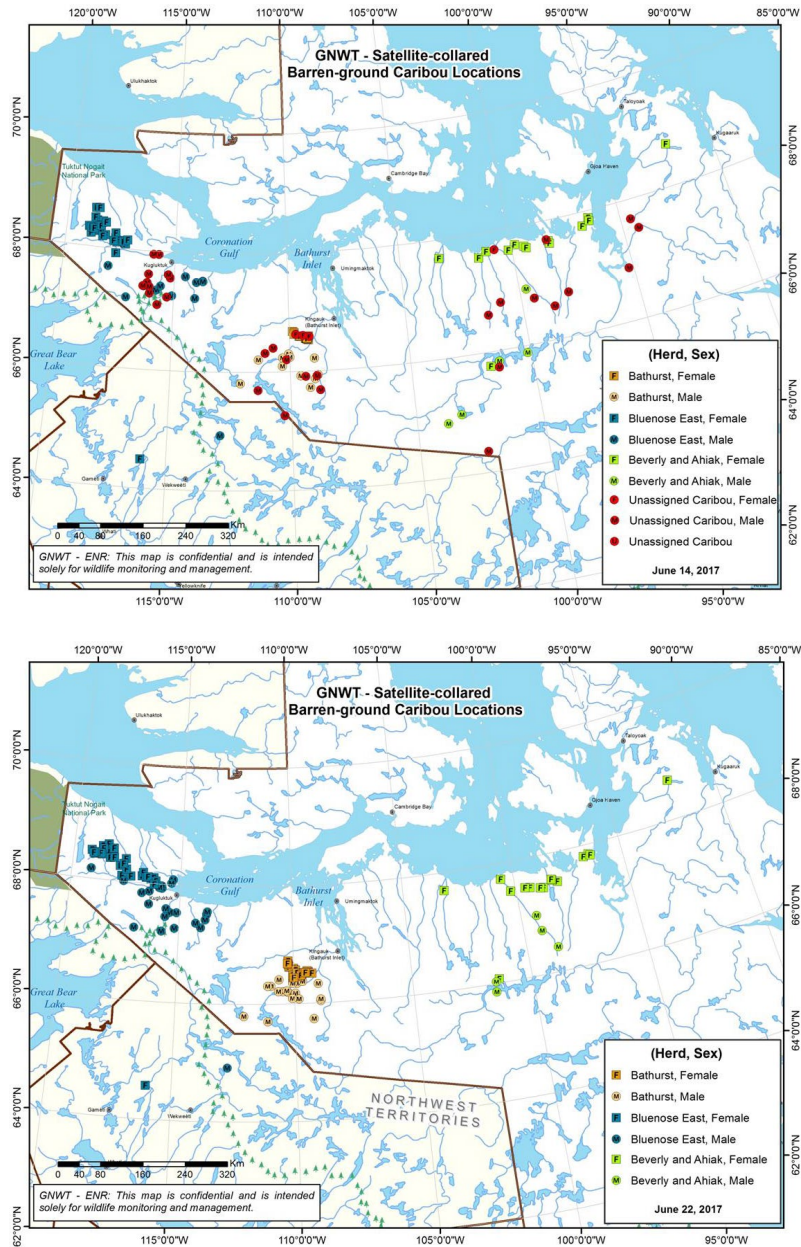


Figure 10. Locations of Bathurst, BNE and Beverly collared caribou on June 14 (top) and June 22 (bottom), 2017. On the June 14 map, cows and bulls collared in late winter that year are shown in red. As there was clear separation of the three herds at that time, newly collared cows and bulls were assigned to herds at that time, and the June 22 map shows collar locations with all collars assigned.

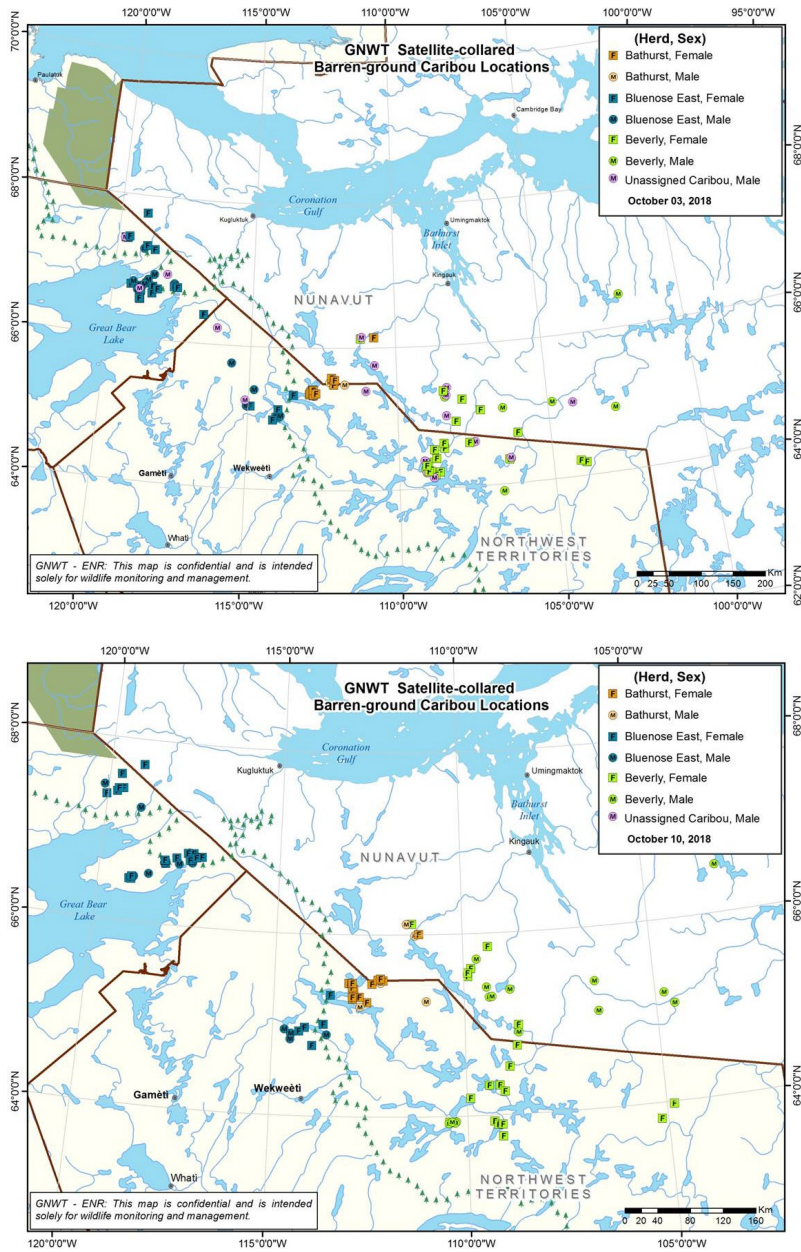


Figure 11. Locations of Bathurst, BNE and Beverly collared caribou on October 3 (top) and October 10 (bottom), 2018. On the October 3 map, bulls collared in late winter that year are shown in violet. Newly bulls were assigned to herds at that time, and the October 10 map shows collar locations with all collars assigned. Cows collared in 2018 were assigned to herd in June based on the calving ground they were on.

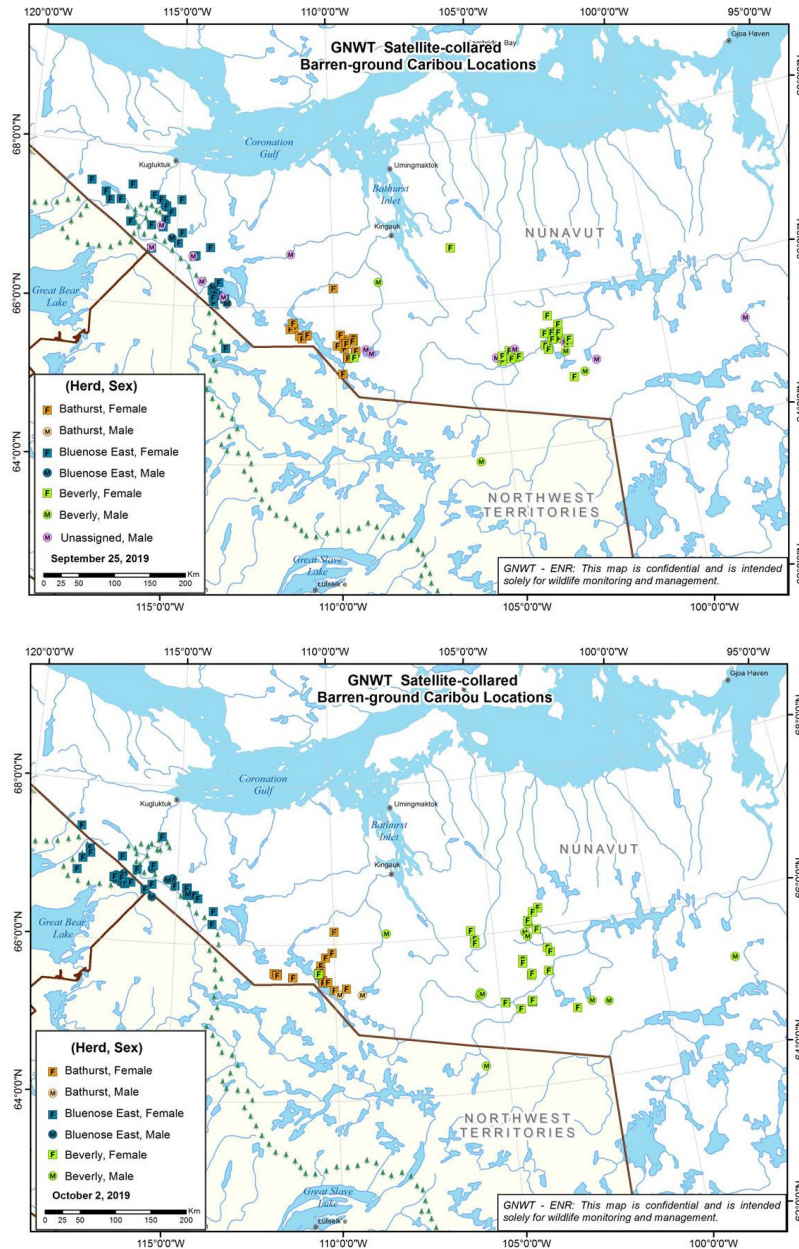


Figure 12. Locations of Bathurst, BNE and Beverly collared caribou on September 25 (top) and October 2 (bottom), 2019. On the September 25 map, bulls collared in late winter that year are shown in violet. Newly bulls were assigned to herds at that time; the October 2 map shows collar locations with all collars assigned. Cows collared in 2019 were assigned to herd in June based on the calving ground they were on.

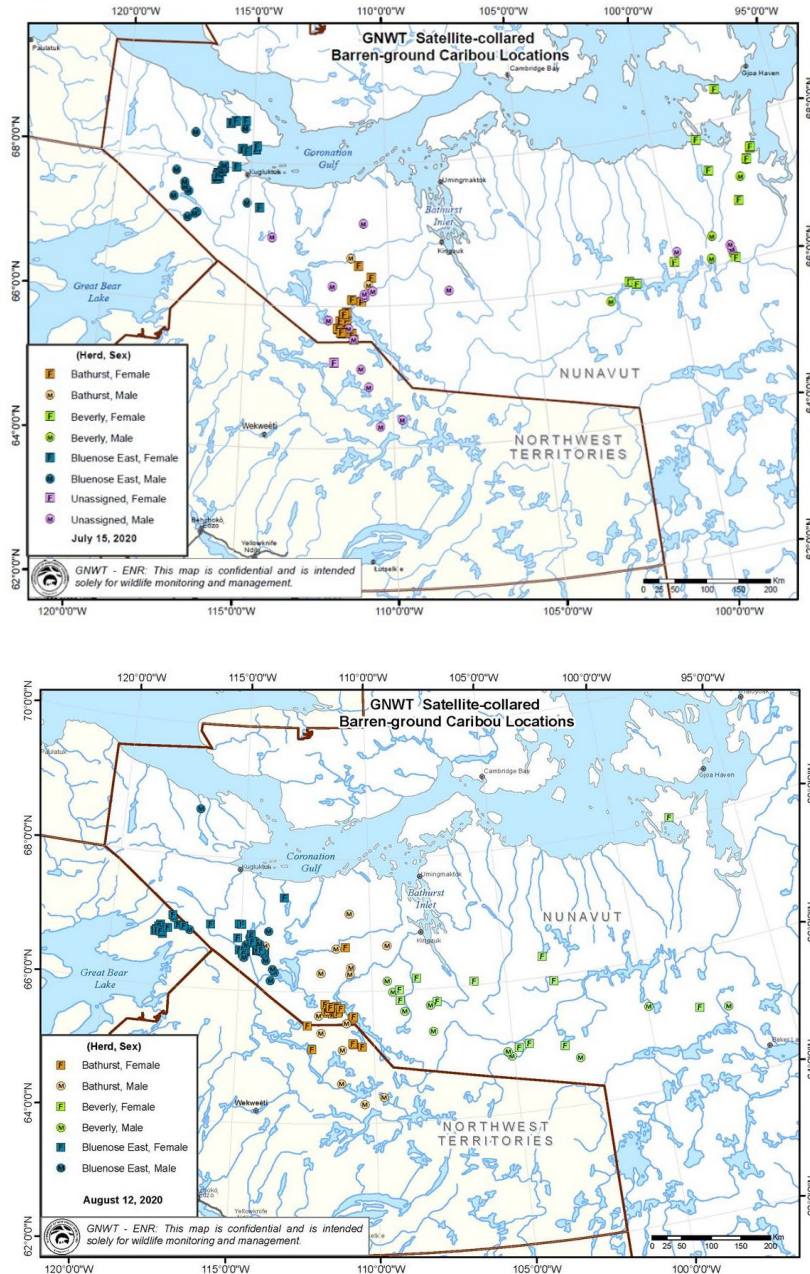


Figure 13. Locations of Bathurst, BNE and Beverly collared caribou on July 15 (top) and October 2 (bottom), 2020. On the July 15 map, bulls collared in late winter that year are shown in violet. They were assigned to the three herds at that time. Separation of herds was less pronounced in the fall. Cows collared in 2020 were assigned to herd in June based on the calving ground they were on.

Review of the assignment of newly collared bulls to herd in these four years shows that the timing of herd assignment has varied, and has been carried out at a time when the three herds appear to be well separated. In some years (e.g. 2017), separation of cow and bull collars between herds has been apparent as early as June. In 2020, the three herds were well separated in mid-July and newly collared bulls were assigned at that time

(Figure 13). Discussion with Tracy Davison, ENR regional biologist in Inuvik, NWT who works with the Tuktoyaktuk Peninsula, Cape Bathurst and Bluenose-West barren-ground caribou herds indicates that assignment of newly collared cows and bulls to these herds is done similarly. Cows are assigned during calving and bulls more commonly in July when these three herds are well separated.

Tracking of collars through late summer and into fall 2020 indicated that separation between Bathurst and Beverly collars (cows and bulls) decreased and overlap increased. This was documented in detail in Figures 2-6. By November 18 (Figure 7), there was mixing of Bathurst, BNE and Beverly collars.

APPENDIX 3. Bull Herd Fidelity Notes for Bathurst, Bluenose-East and Beverly Caribou Herds, 2015-2020

John Boulanger

Introduction

This brief set of notes details estimation of bull fidelity to herds in the Bathurst, BNE and Beverly herds 2015-2020. These assessments were triggered by some unusual movements of collared Bathurst caribou cows and bulls at the time of the rut in October 2020, when there appeared to be mixing of some Bathurst collared cows and bulls with Beverly collared cows and bulls.

The initial phase of the analysis involved exploring herd membership of bulls and fidelity of bulls to herds throughout the year. As described earlier in this report, newly placed bull collars are assigned to herd at a point in the summer or fall when the herds appear to be well separated spatially. However, this may or may not indicate herd affiliation throughout the year. In 2020, seven collared bulls (five collared in 2020 and two in previous years) and five collared cows (four collared in 2020 and one from previous years) from the Bathurst herd appeared to be mixed with collared cows and bulls from the Beverly herd during the breeding season in late October. A focus of this analysis was to assess fidelity of collared bulls from the three herds to their assigned herd and to collared cows from that herd. Collar data for each year from 2015-2020 for the three herds were used. Collar histories were compiled from bull collar records to reconcile fate data with location data.

Methods and Results

Assessment of Herd Membership and Fidelity of Bulls to Herds

Currently, herd membership of bulls is assigned at a point in the summer or fall when the herds appear to have good spatial separation, as described in earlier sections of this report. Newly placed cow collars are assigned to herd in June based on the calving ground they are on or near. Collars are placed in late winter (often March); at this time herds may be well separated (all collars from one herd in an area and no overlap with collars from another herd) or they may be partially or extensively mixed between neighbouring herds.

Membership of bulls in herds was checked by plotting locations of bulls in June and October which roughly correspond to calving and the rut. To explore bull fidelity and herd membership the distributions of bulls from each herd were compared, and the degree of overlap between herds, throughout the year using Minimum Convex Polygons (MCP) polygons (as has been done for overall herds previously). One question of interest was whether bulls from each herd were separated during rut periods and if this changed yearly for bulls that were collared more than one year. An additional question related to bull fidelity was whether bulls congregated with females from their herd through the year,

outside the usual rut period. Of particular interest were recent locations in 2020 where some collared cows and bulls from the Bathurst seemed to stray into the Beverly distribution during the rut; one objective of this analysis was assessing whether this overlap in the rut had occurred in previous years.

For the first phase, MCP polygons were fitted for monthly bull locations from the Bathurst, BNE, and Beverly herds (Figure 14). Bulls seemed to show a fair amount of overlap in most months with the exception of the period of June to October Segregation was greatest prior to 2017. Sample sizes for Bathurst bulls were low in October of 2019 (n=3 bulls), precluding interpretation.

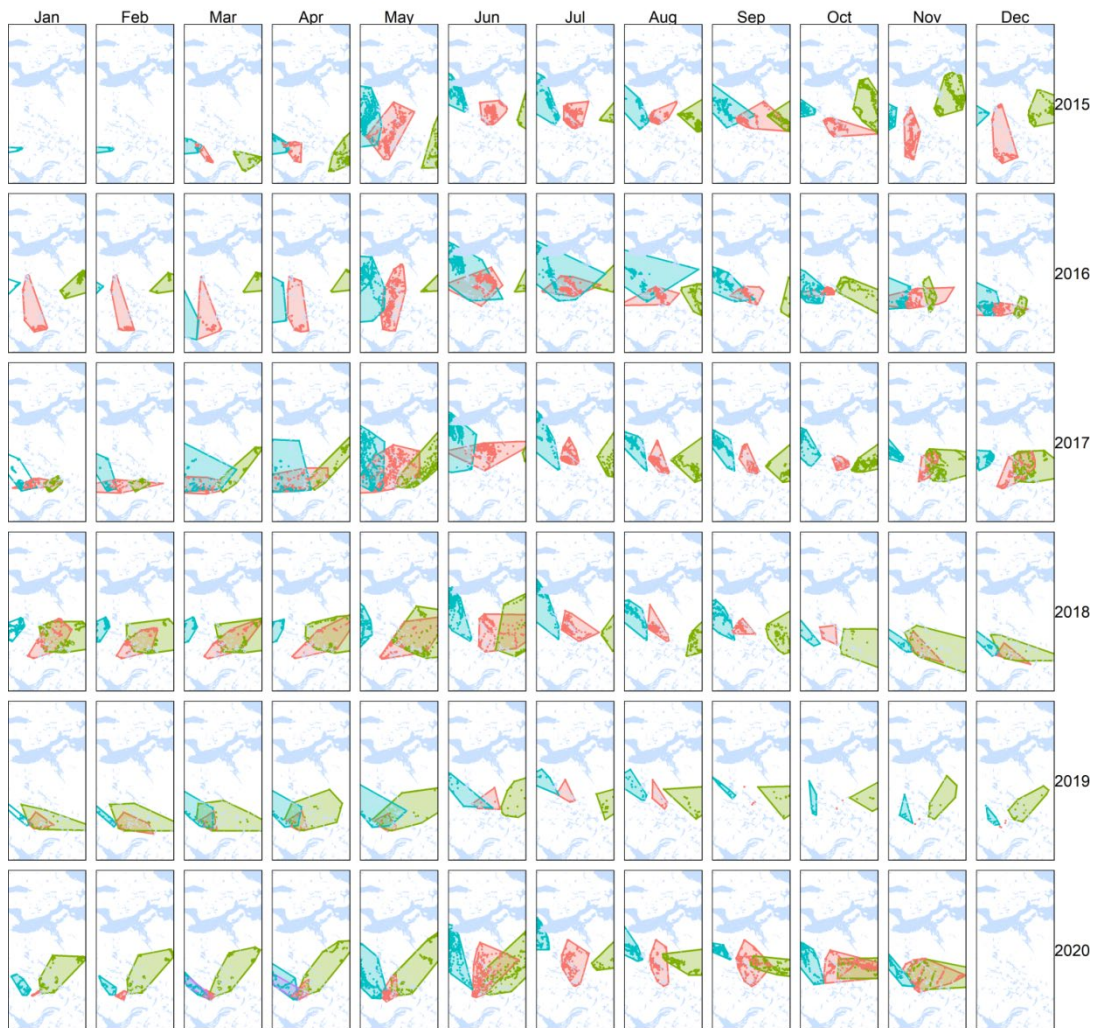


Figure 14. Overlap of bull locations by herd (red-Bathurst, green-Beverly, blue-BNE) by year and month. MCP polygons were also fitted to locations of bulls for each month.

A close-up of October (rut) locations demonstrates good separation of bulls from neighbouring herds (Figure 15), with the exception of 2020 where part of the Bathurst

herd overlapped with the Beverly distribution. The close up of June (calving) shows the overlap in June of 2020 was similar to previous years. Overlap of neighbouring herds in March on the winter range has been known for many years.

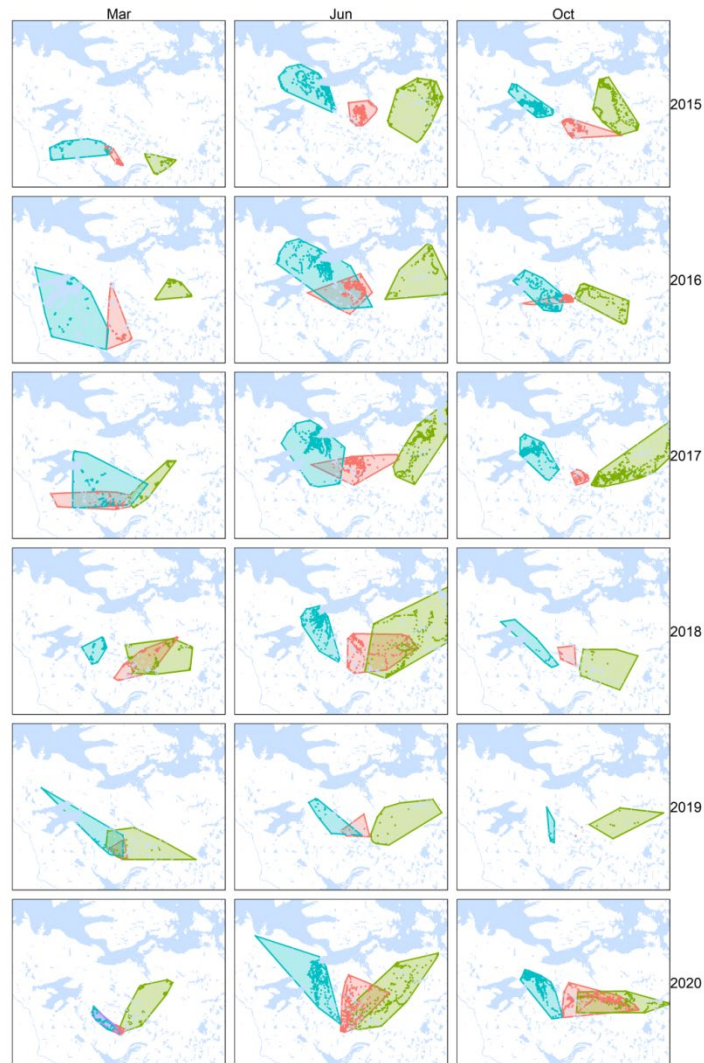


Figure 15. A close-up of March, June and October locations from Figure 2.

One question of interest was whether the movement during the rut of 2020 was due to new bulls not being classified in the correct herd or Bathurst bulls showing less fidelity to their normal rutting areas. Of the 16 bulls monitored, only two were not new deployments. These two bulls (Bathurst from 2019 or earlier) also strayed to the east suggesting that this movement could be due to low fidelity of bulls to the traditional rutting area. However, there were four newly collared Bathurst cows and one Bathurst cow collared in 2019 or earlier that also moved eastward at this time in October, as described earlier. Thus the apparent lack of fidelity during the rut of Bathurst caribou included five cows and seven bulls (all of the Bathurst collared caribou east of Contwoyto Lake), among them newly collared caribou but also cows and bulls that had been assigned in 2019 or earlier.

There was no overlap of any Bathurst collars with Beverly collars (cows or bulls) in July 2020, when newly placed bull collars were assigned. However from August to October 2020, overlap of Bathurst and Beverly collars east of Contwoyto Lake progressively increased (Figure 14). Considering the size disparity of the two herds (Beverly outnumbering Bathurst by at least 12:1), it is likely that the Bathurst caribou east of Contwoyto Lake, probably about $\frac{1}{4}$ of the herd based on collars, would have been increasingly mixed with much higher numbers of Beverly caribou as the rut began. West and south of Contwoyto Lake, there were only Bathurst collared cows and bulls (38 of 50 totals, likely about $\frac{3}{4}$ of the herd) and these caribou remained separate from Beverly caribou through the breeding season (Figures 2, 8 and 9). This portion of the Bathurst herd appeared to have a rutting area and period fully distinct from those of the two neighbouring herds.

In terms of demographic analysis as well as construction of mobile management zones, the main question becomes “what constitutes a herd” when bulls are included. Cows show strong fidelity to calving grounds and summer ranges, and one way to consider a herd in this context is the fidelity of Bathurst bulls to Bathurst cows throughout the year, particularly in the rut. To assess this, I overlaid bull locations on MCP polygons based on cows from the Bathurst, BNE and Beverly herds to assess if fidelity of bulls to cows of a given herd extends beyond the rut and whether some of the bull movements observed were due to bulls following cows. Below is a plot of the overlap of bull locations with the MCP polygons for cows (Figure 16). Of most interest are the orange polygons which are based on cow locations and the orange locations which are bull locations for the Bathurst herd.

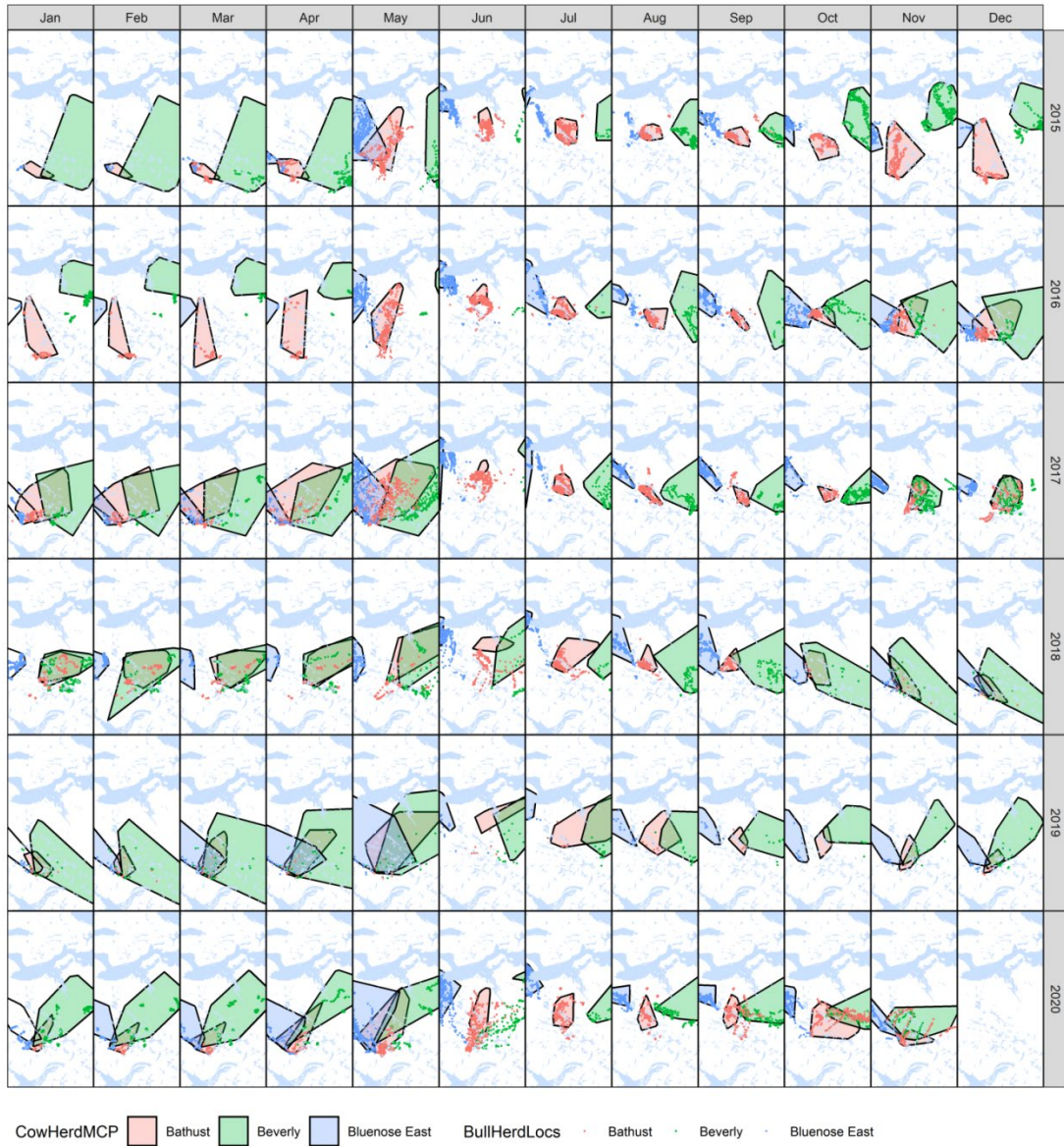


Figure 16. The correspondence of bull locations (points) for the Bathurst, BNE, and Beverly herds with MCP polygons derived from cow locations for each herd for each month and year.

A close-up of March (when collaring of new bulls usually occurs), June (calving) and October (rut) reveals that bull fidelity to cows of their herd was reasonably high in June and October up to 2017 after which fidelity was reduced (Figure 17).

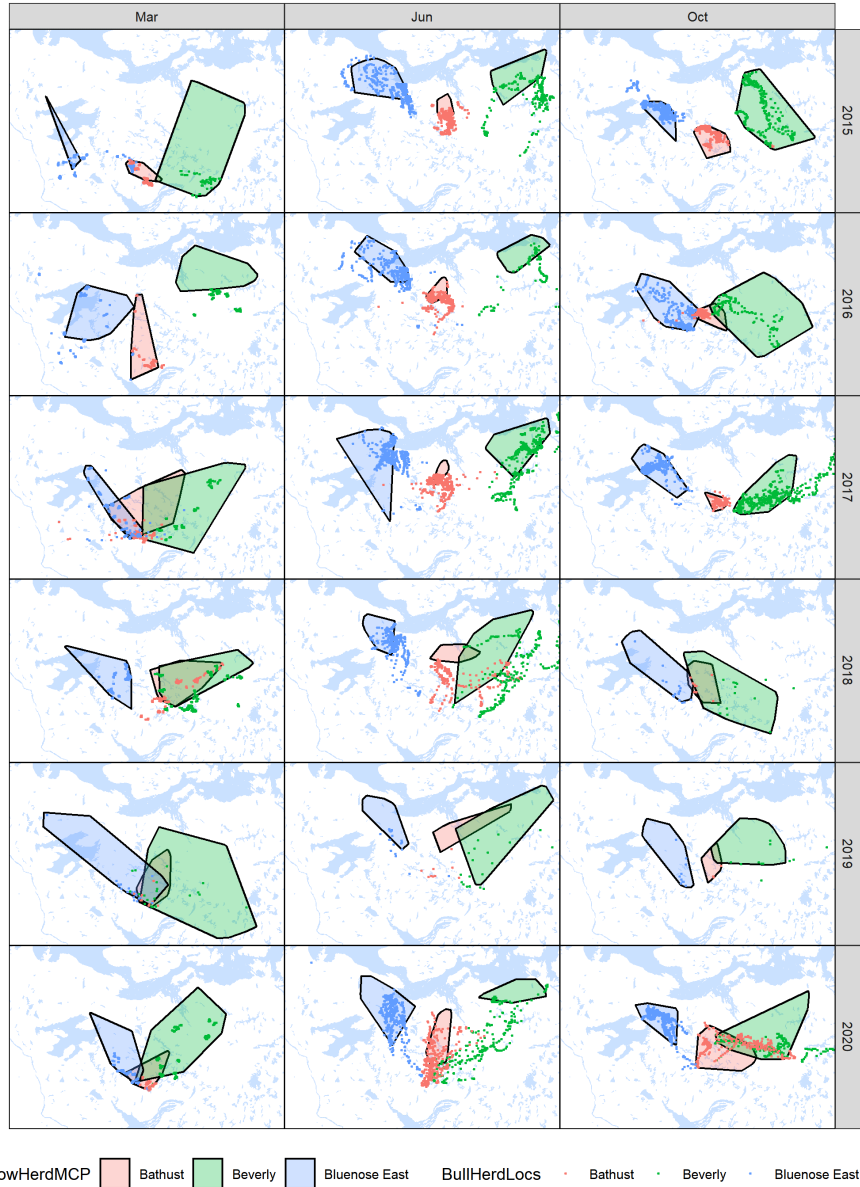


Figure 17. Comparison of cow MCP's and bulls from each herd (locations) for March, October, and June.

Most noteworthy is the large degree of overlap in both cows and bulls for the Beverly and Bathurst in 2018 and 2020 during the rut (Figure 18).

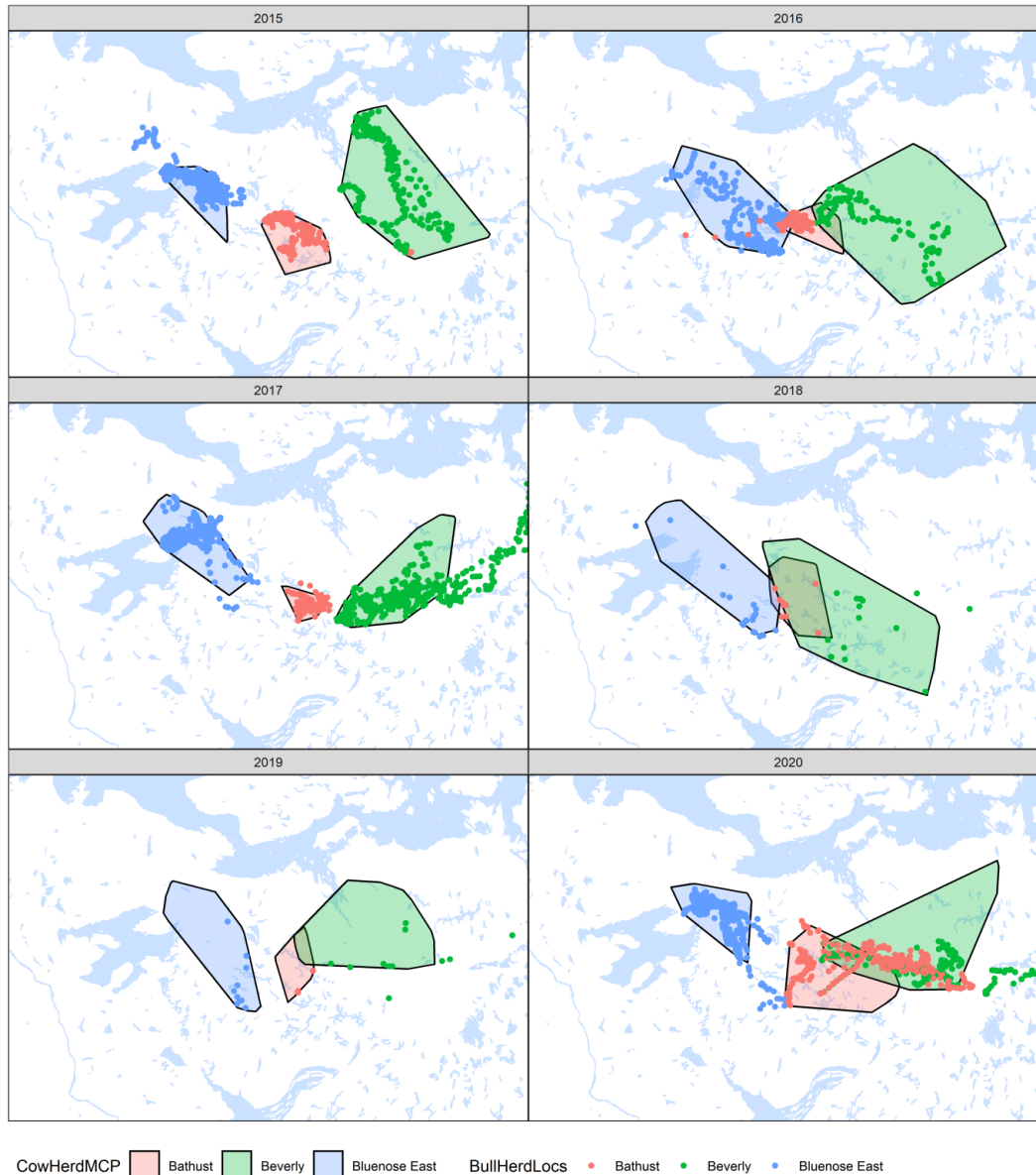


Figure 18. Fidelity of bulls (locations) to cows (MCP) for each herd for the rut.

A summary of overlap of Bathurst bulls with other herds is shown graphically in Figure 19. The main pattern shown is that the Bathurst bulls showed reasonable fidelity to cows especially during the rut up to 2018, even when there was overlap with the Bathurst and Beverly cows. Overall overlap of Bathurst bulls with Bathurst cows was low in 2020 with minimal increase in overlap in the rut. This general pattern also occurred in 2019; however, this comparison is challenged by only two bull collars for the Bathurst herd.

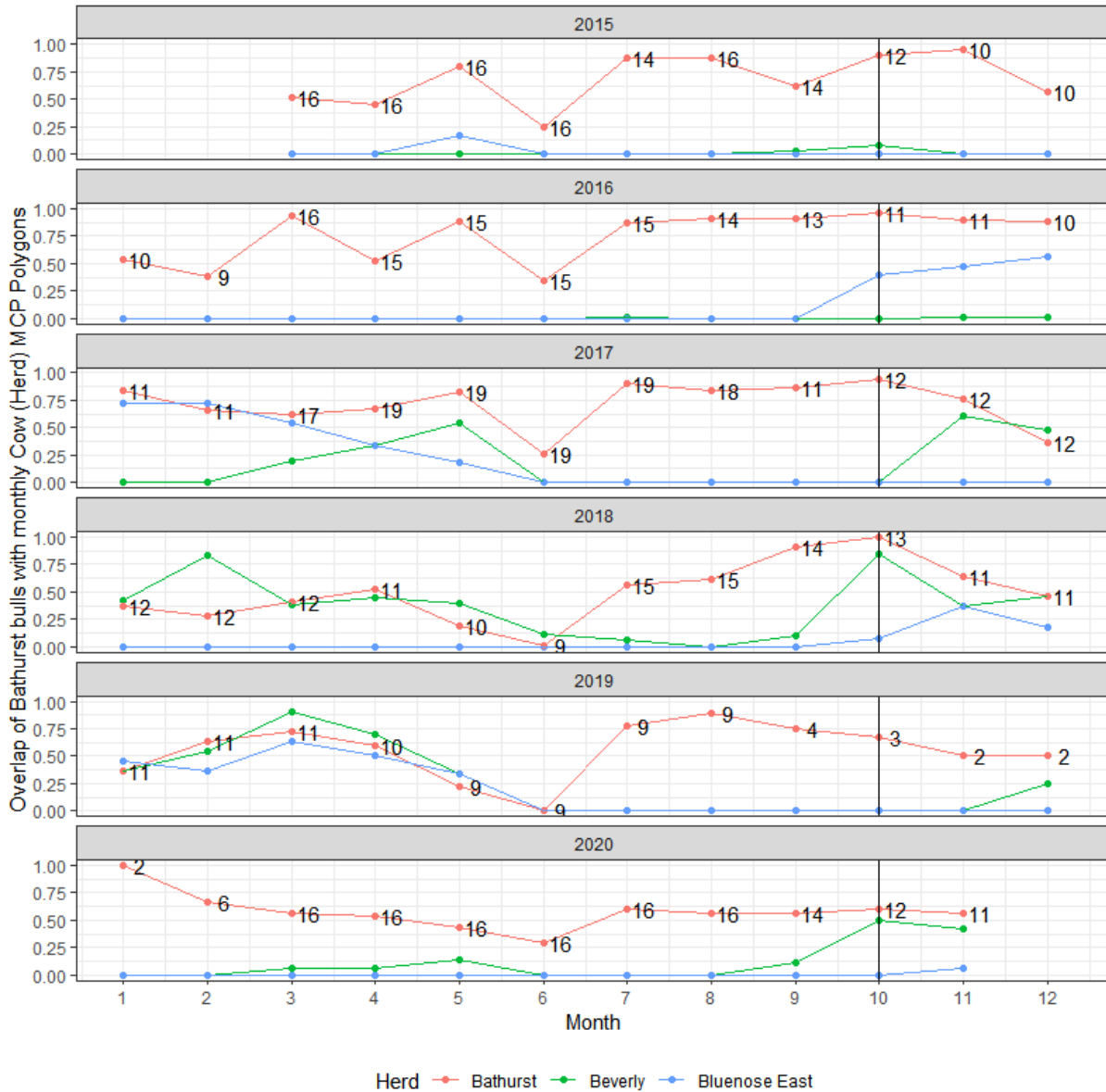


Figure 19. Overlap of Bathurst bulls with the polygons of cows from the Bathurst herd, Beverly herd, and BNE herd. Sample size of Bathurst bull collars is shown next to each Bathurst data point.

Individual estimates of overlap for the 2019 Bathurst bulls demonstrates that both bulls showed fidelity to Bathurst cows in 2019 (as indicated by overlap values of 1 from October/November 2019 to June 2020), however BGCA 19377 showed higher overlap with the Beverly cows starting in September 2020, whereas BGCA19336 maintained higher overlap with Bathurst cows (Figure 20).

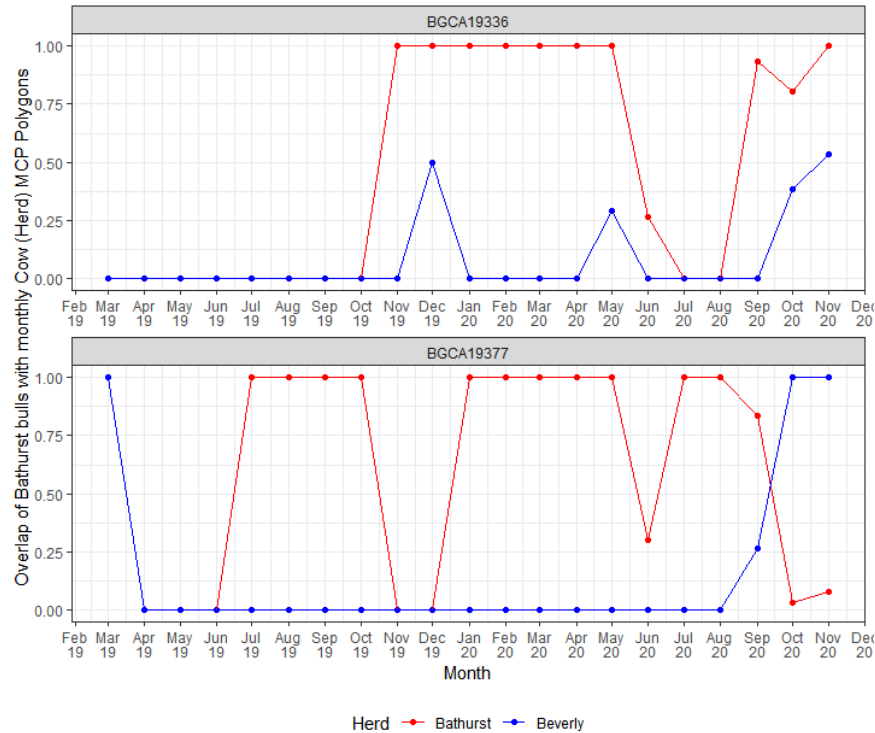


Figure 20. Overlap of Bathurst bulls with the polygons of cows from the Bathurst herd and Beverly herd for individual collared bulls monitored in 2019 and 2020

In contrast, bulls collared in 2020 mainly exhibited higher fidelity to Bathurst cows after August 2020, the few that shifted to the Beverly (BGCA20104, BGCA20108, BGCA20142, and BGCA20146) show similar patterns to BGCA19377, a known Bathurst bull from 2019 (Figure 21). The data from these five bull collars suggest they may have switched to the Beverly, however, it will be difficult to assess if this is permanent until later in the winter when it can be assessed if bull fidelity with Beverly cows continues to be higher than with Bathurst cows.

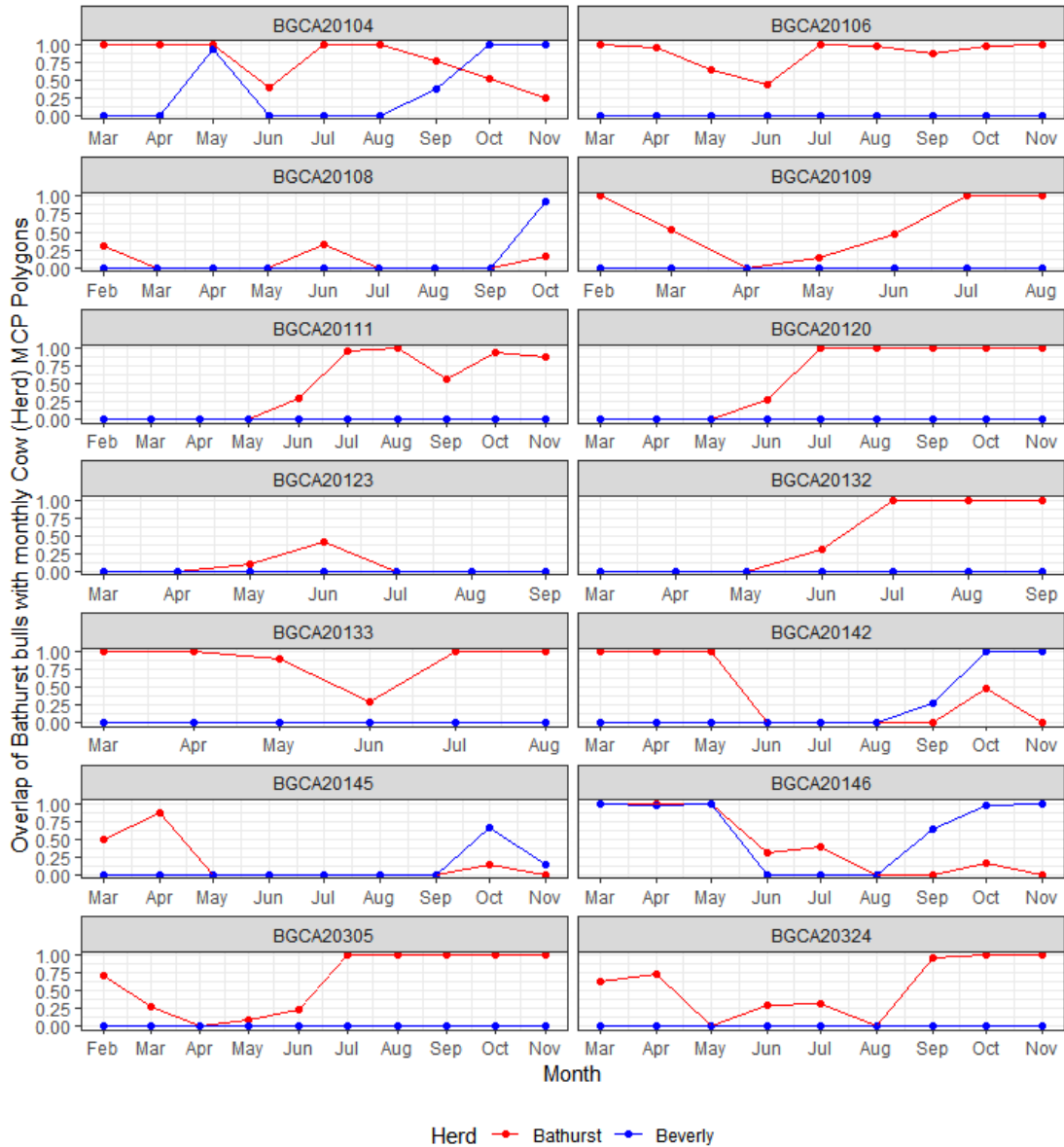


Figure 21. Overlap of Bathurst bulls with the polygons of cows from the Bathurst herd and Beverly herd for individual collared bulls collared in 2020.

Discussion

The general conclusion of the analysis of bull collar fidelity and herd membership was that in most years bulls from the Bathurst, BNE and Beverly herds seem to show reasonable fidelity to rutting areas in October but also a high degree of overlap with cows of their herds in other months of the year. However, the degree of overlap of Bathurst cows and bulls seems to have declined in the last two years. One challenge to assessing bull fidelity is the lower sample size of bull collars especially given that fact that bull collars often do not last as long due to the lower bull survival rates.

Continued tracking of the Bathurst bulls and cows that seem to have mingled with the Beverly herd during the rut in 2020 will provide an assessment of whether this was a transient event or a form of emigration. These 12 collared Bathurst caribou (or some of them) may return to traditional Bathurst calving grounds and summer ranges in 2021, or they may integrate fully with the Beverly herd and adopt all of its seasonal ranges, including calving and summer ranges. We note that assessing mixing of Beverly caribou with Bathurst and BNE caribou in fall 2020 and winter 2020-2021 is challenged in part by the low numbers of Beverly collars (12 cows, seven bulls in early November 2020) compared to the other two herds and given that the Beverly is by far the largest of the three herds.

Mixing of Bathurst and Beverly collared caribou in recent years during winter has been extensive (2018 and 2019) or more limited (2020). After two winters of extensive Bathurst-Beverly overlap in 2018 and 2019, there was evidence from collared Bathurst cows of emigration to the Beverly calving grounds in the Queen Maud Gulf (three of 11 known Bathurst cows in 2018, three of 17 known Bathurst cows in 2019; Adamczewski et al. 2019). After more limited winter overlap of Bathurst and Beverly caribou in 2020, there was no evidence from collared cows, at least, of further emigration in June 2020. It is not difficult to imagine, given the gregarious nature of caribou, that after several months of wintering with far more numerous Beverly caribou, some of the Bathurst cows would have been drawn along with the Beverly cow migration to their calving grounds. In June 2018 there was also limited evidence that Bathurst collared bulls showed a similar movement east and north into Beverly summer ranges (Adamczewski et al. 2019). There would have been a similar large disparity in numbers of Bathurst and Beverly bulls.

The unusual movements of 12 collared Bathurst caribou east of Contwoyto Lake in the fall followed a period in late summer (August-October) where there was increasing overlap with most of the Beverly collared caribou. As in spring 2018 and 2019, the numbers of Beverly caribou would have greatly out-numbered this portion of the Bathurst herd. The movement eastward in October of the bulk of the Beverly herd could have drawn the much smaller numbers of Bathurst caribou east of Contwoyto Lake along with them, in a manner analogous to the June northward migration in 2018 and 2019. The advent of the rut and associated breeding opportunities with thousands of Beverly might have made gregarious movement eastward that much more attractive to Bathurst cows and bulls. It is worth noting again that the main Bathurst cluster of collars west of Contwoyto Lake, likely representing about $\frac{3}{4}$ of the herd based on collars, had no Beverly collared caribou in their midst and their movements showed no eastward shift, rather a more traditional Bathurst rutting aggregation with a slow southward movement in late October.

The general method of assigning newly collared bulls to herds in June, July or later in the summer and fall seems to have worked well in earlier years when bulls showed reasonable

fidelity to cows in rutting areas. If this fidelity is reduced, as appeared for part of the Bathurst herd in 2020, then herd affiliation for bulls may need to be re-examined.

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