Calf Production and Adult Sex Ratio in the Bathurst and Bluenose East Herds of Barren-Ground Caribou 2006-2016

Part 2: Appendices - Composition Survey Maps

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2016

APPENDIX A
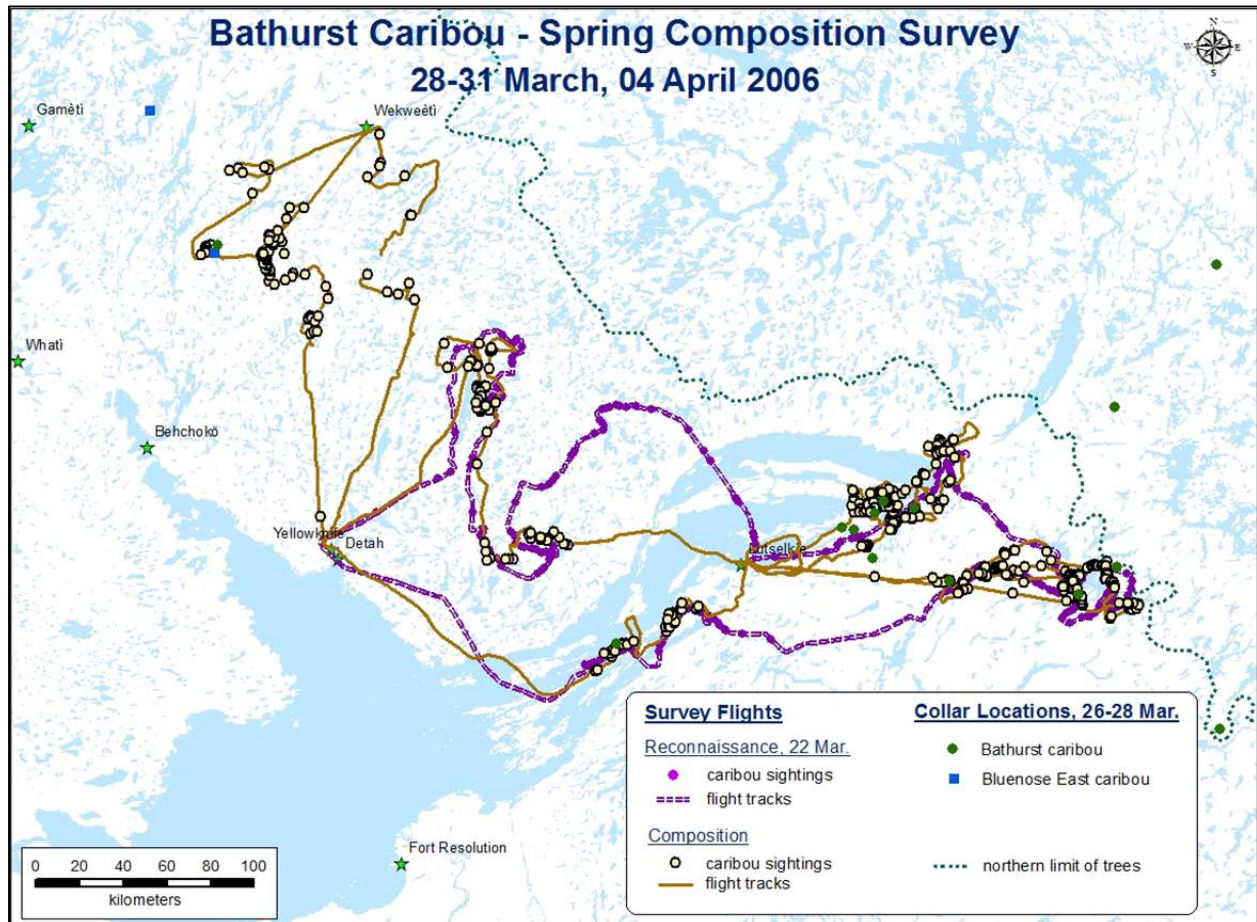
Spring 2006

Bathurst caribou

Figure A1. Spring composition survey of the Bathurst caribou herd on 28-31 March and 04 April 2006 showing flight lines, sightings, and locations of collared caribou. The reconnaissance survey occurred on 22 March. Total distance flown for the composition survey was 3,760 km over 31.4 hours. Collared caribou locations from the Bathurst herd (14 individuals) occurred from 26-28 March, Bluenose East herd (16 individuals) from 26-28 March, 04 April, and Ahiak herd (20 individuals) from 26-28 March 2006.
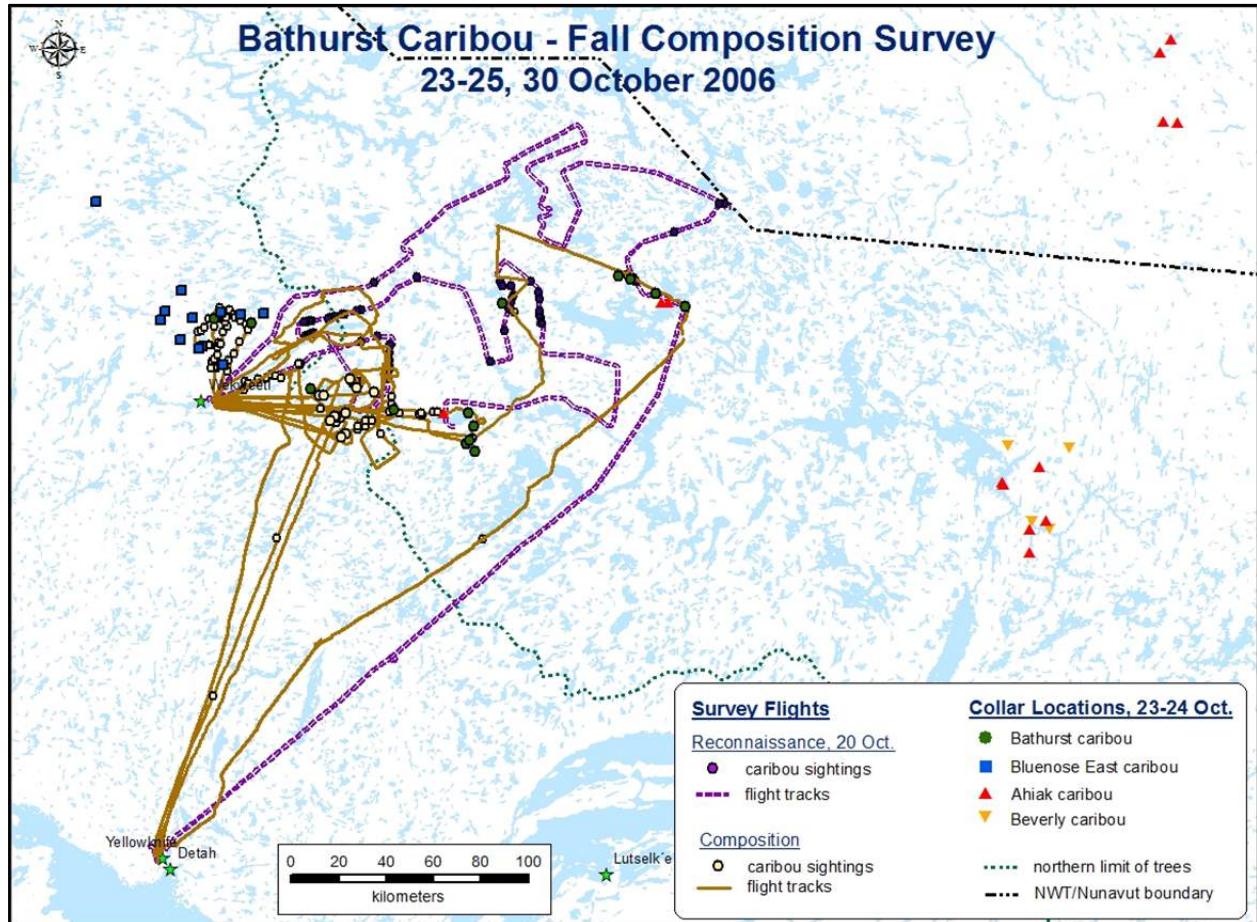
Fall 2006

Bathurst caribou

Figure A2. Fall composition survey of the Bathurst caribou herd on 23-25, 30 October 2006 showing flight lines, sightings, and locations of collared caribou. The reconnaissance survey occurred on 20 October. Total distance flown for the composition survey was 2,997 km over 24.5 hours. Collared caribou locations from the Bathurst herd (14 individuals) and the Bluenose East herd (12 individuals) occurred from 23-24 October, while the Ahiak herd (16 individuals) and Beverly herd (5 individuals) occurred on 24 October 2006.
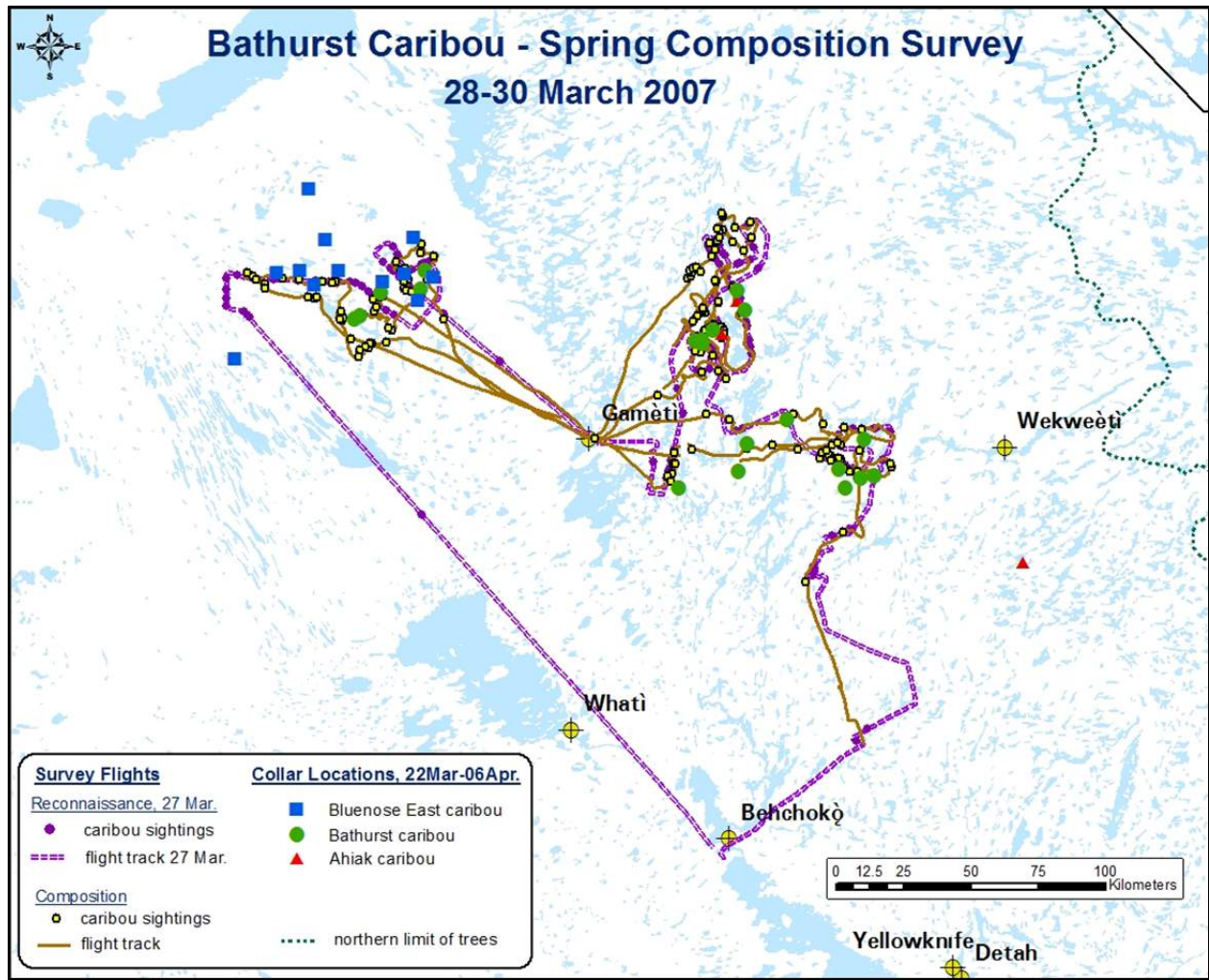
Spring 2007

Bathurst caribou

Figure A3. Spring composition survey of the Bathurst caribou herd on 28-30 March 2007 showing flight lines, sightings, and locations of collared caribou. The reconnaissance survey occurred on 27 March. Total distance flown for the composition survey was 2,011 km over 19.2 hours. Collared caribou locations from the Bathurst herd (21 individuals) occurred from 27-31 March, Bluenose East herd (14 individuals) from 22, 24, 27-31 March, 01-04 April, and Ahiak herd (16 individuals) from 27-31 March 2007.
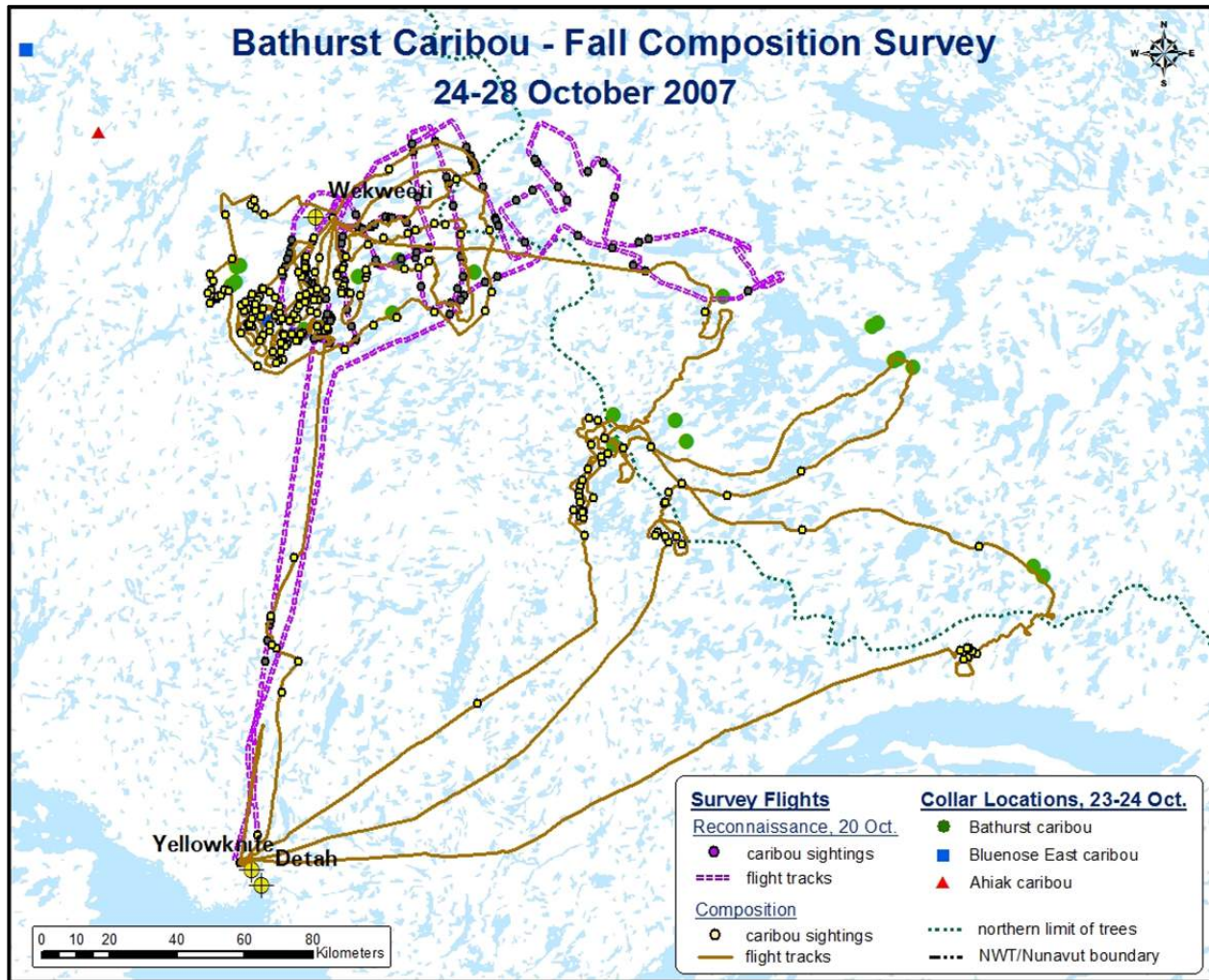
Fall 2007

Bathurst caribou

Figure A4. Fall composition survey of the Bathurst caribou herd on 24-26, 28 October 2007 showing flight lines, sightings, and locations of collared caribou. The reconnaissance survey occurred on 20 October. Total distance flown for the composition survey was 2,879 km over 21.0 hours. Collared caribou locations from the Bathurst herd (24 individuals) occurred from 23-24 October, Bluenose East herd (8 individuals) from 08 and 23-24 October, Ahiak herd (16 individuals) from 23-24 October, and Beverly herd (15 individuals) from 23-24 October 2007.
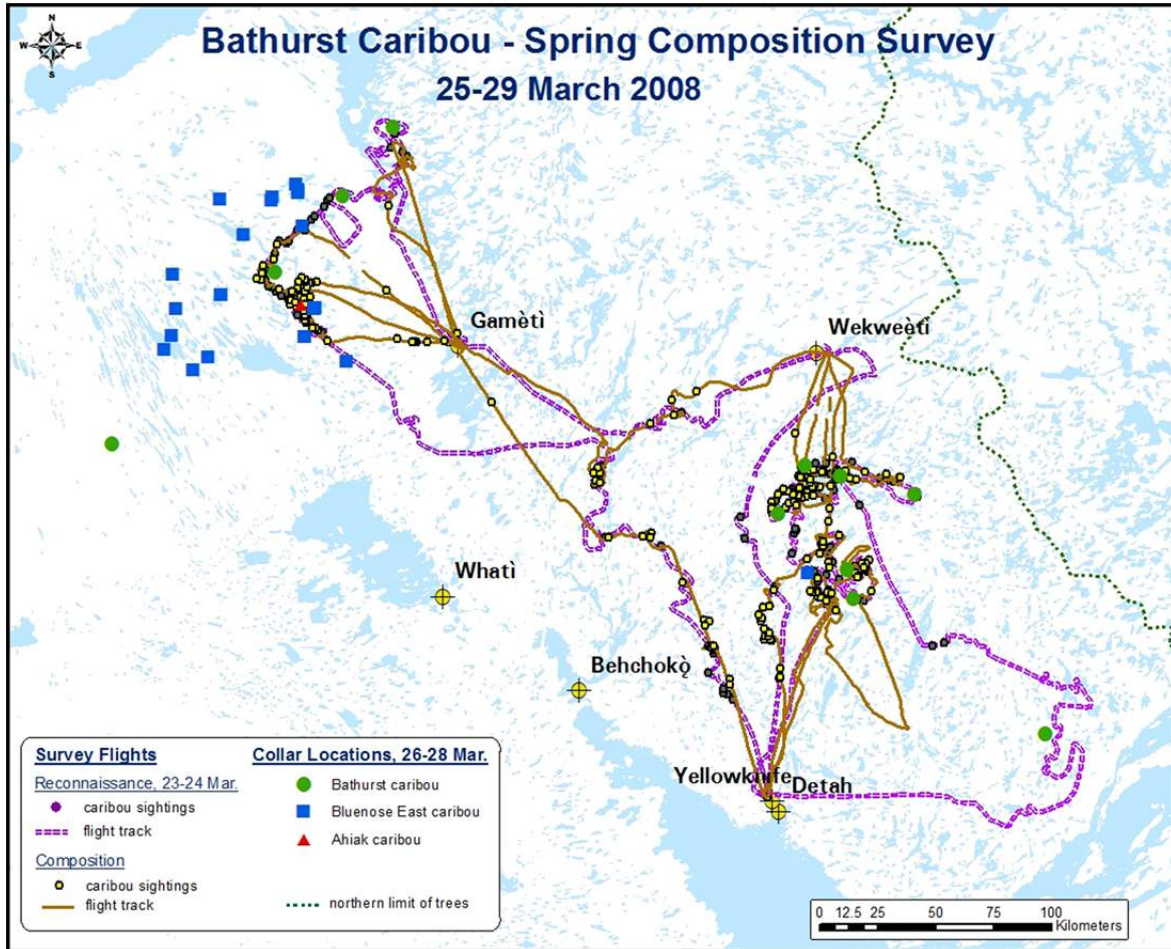
Spring 2008

Bathurst caribou

Figure A5. Spring composition survey of the Bathurst caribou herd on 25-29 March 2008 showing flight lines, sightings, and locations of collared caribou. The reconnaissance surveys occurred on 23-24 March. Total distance flown for the composition survey was 2,678 km in 23.0 hours. Collared caribou locations from the Bathurst herd (15 individuals) occurred on 26-28 March, Bluenose East herd (23 individuals) on 22, 26-28 March, and Ahiak herd (1 of 14 individuals in survey area) on 26-28 March 2008. The composition data from 28 March (west of Gameti) and the morning of 29 March (north of Gameti) was not included in the final results because of the spatial overlap of collared Bathurst caribou (green circles) with collared Bluenose East caribou (blue squares). Removing these tracks resulted in a total distance flown for the composition survey results as 1,970 km in 16.5 hours.
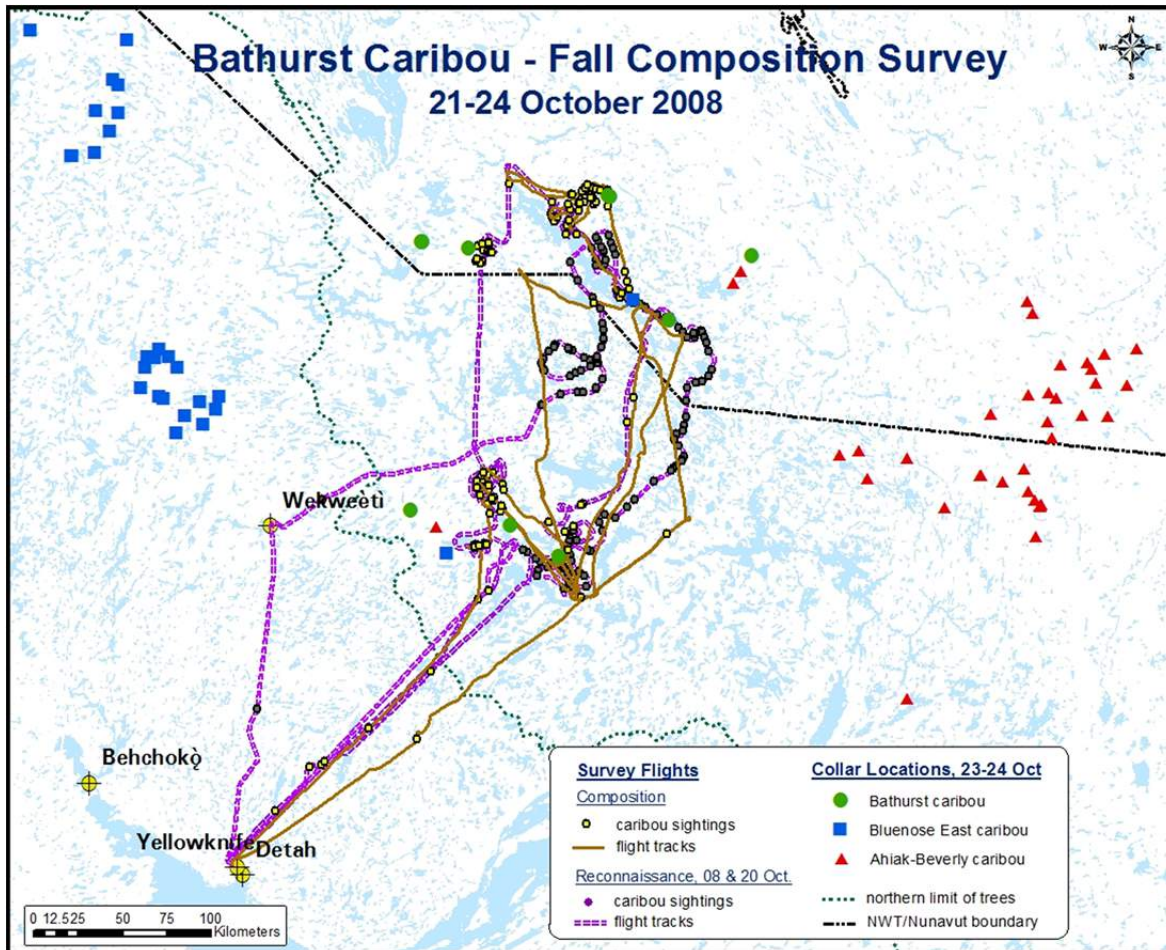
Fall 2008

Bathurst caribou

Figure A6. Fall composition survey of the Bathurst caribou herd on 21-24 October 2008 showing flight lines, sightings, and locations of collared caribou. The reconnaissance surveys occurred on 08 and 20 October. Total distance flown for the composition survey was 2,240 km over an estimated 15.3 hours. Collared caribou locations from the Bathurst herd (10 individuals) occurred from 23-24 October, Bluenose East herd (28 individuals) from 17 and 23-24 October, Ahiak/Beverly herd (46 individuals) from 23-24 October 2008.
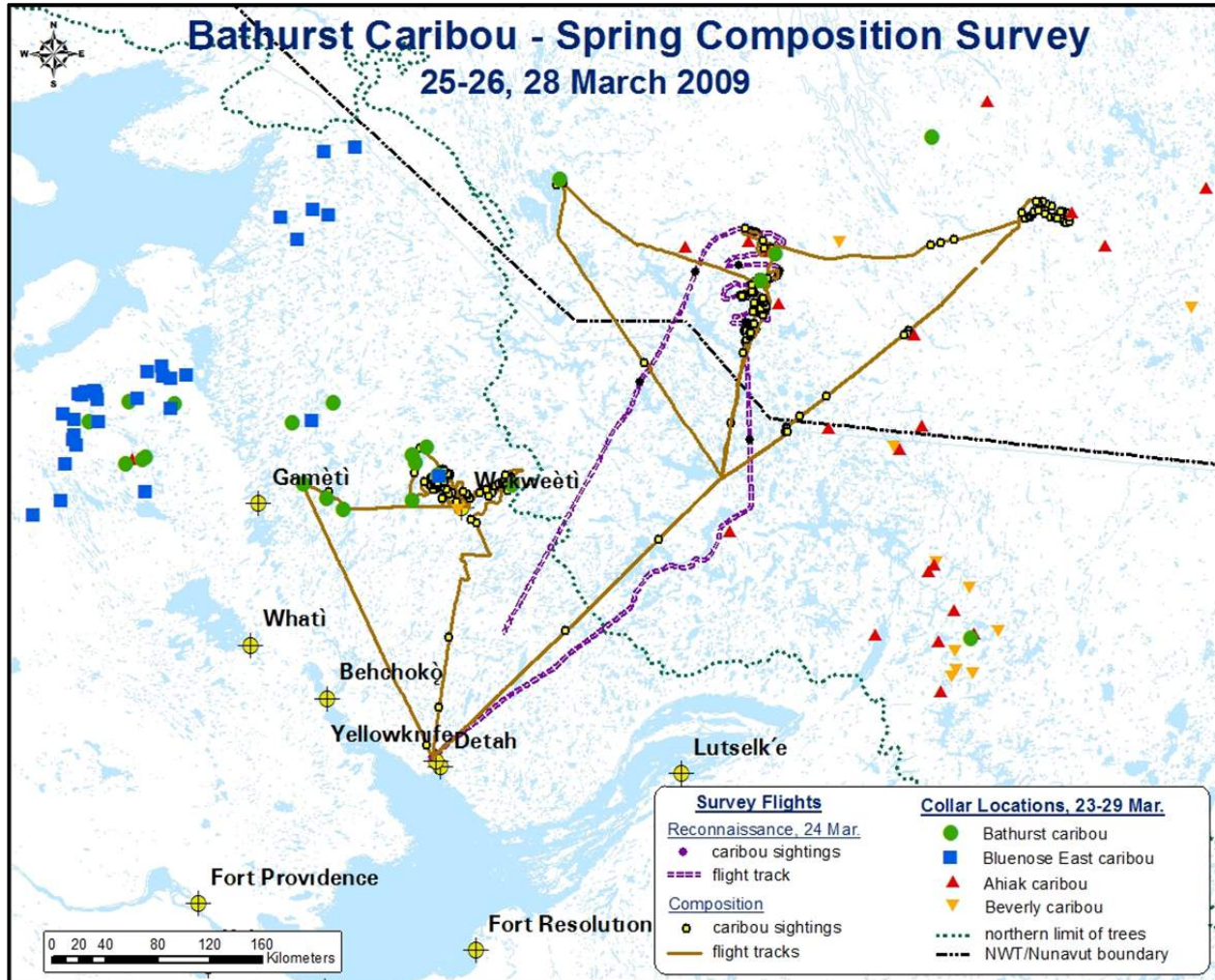
Appendix A

Spring 2009

Bathurst caribou

Figure A7. Spring composition survey of the Bathurst caribou herd on 25-26, 28 March 2009 showing flight lines, sightings, and locations of collared caribou. The reconnaissance survey occurred on 24 March. Total distance flown for the composition survey was 2,485 km in 22.9 hours. Collared caribou locations from the Bathurst herd (22 individuals) occurred from 23-24 March, Bluenose East herd (33 individuals) from 23-29 March, Ahiak herd (28 individuals) from 23-25 March and Beverly herd (14 individuals) from 25 March 2009.
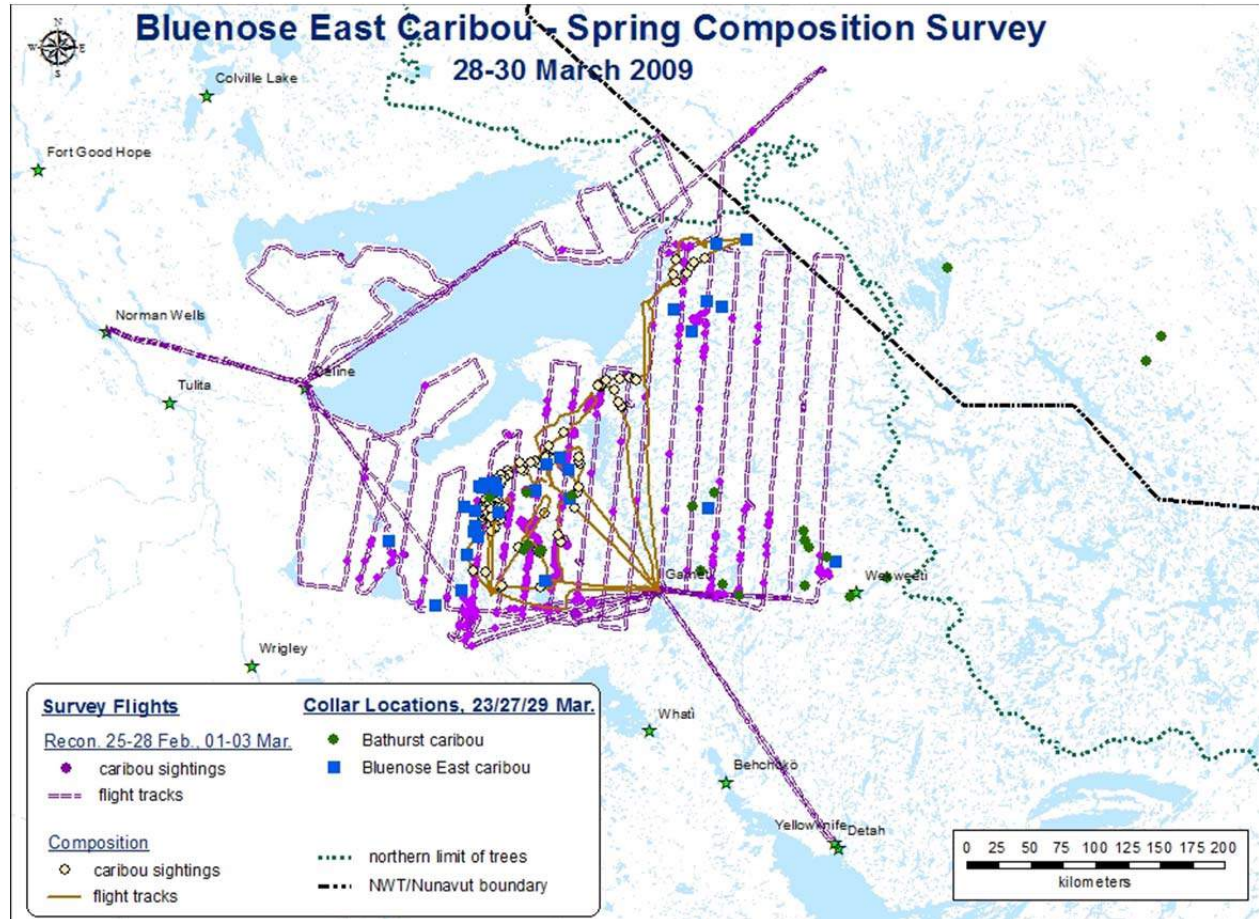
Bluenose East caribou

Figure A8. Spring composition survey of the Bluenose East caribou herd on 28-30 March 2009 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred from 25 February to 01 March, and 03-05 March. Collared caribou locations from the Bathurst herd (24 individuals) are shown from either 23 or 29 March, and the Bluenose East herd (31 individuals) from either 23, 27, or 29 March 2009. Total distance flown for the composition survey was 2,384 km over 17.5 hours.

Fall 2009

Bathurst caribou
No fall composition survey for Bathurst caribou herd in 2009.

Bluenose East caribou
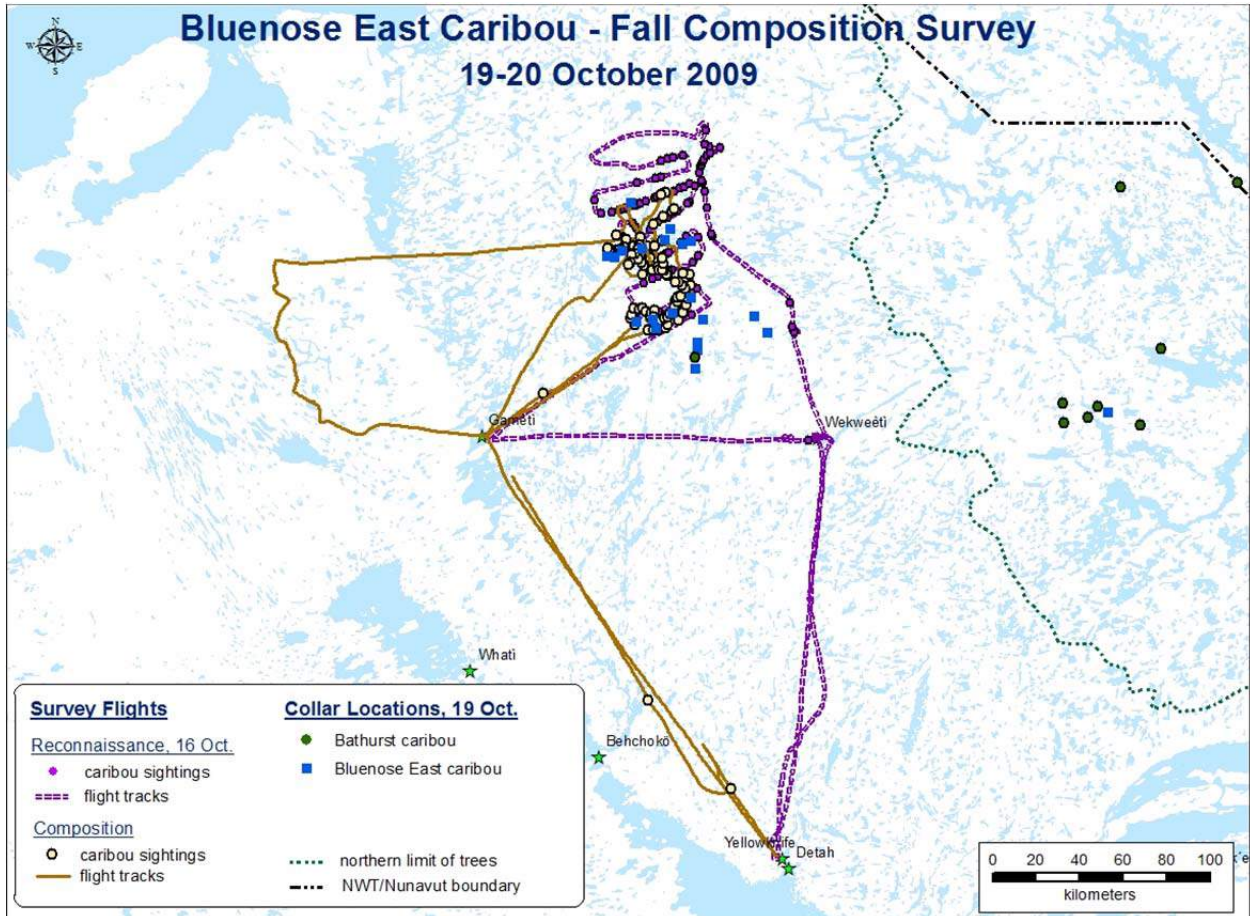

Figure A9. Fall composition survey of the Bluenose East caribou herd on 19-20 October 2009 showing flight lines and sightings of caribou. The reconnaissance survey occurred on 16 October 2009. Total distance flown for the composition survey was 1,693 km in 13.2 hours. Collared caribou locations from the Bluenose herd (22 individuals) and Bathurst herd (10 individuals) occurred on 19 October.

Spring 2010

Bathurst Caribou

Figure A10. Spring composition survey for the Bathurst caribou herd on 31 March and 03 April 2010 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 15-16, and 19 March. Total distance flown for the composition survey was 1,335 km in 10.8 hours. Collared caribou locations from the Bathurst herd (23 individuals) and Ahiak herd (23 individuals) occurred on 03 April, while Bluenose East herd (47 individuals) were from either 31 March, 01 April, or 03 April 2010.
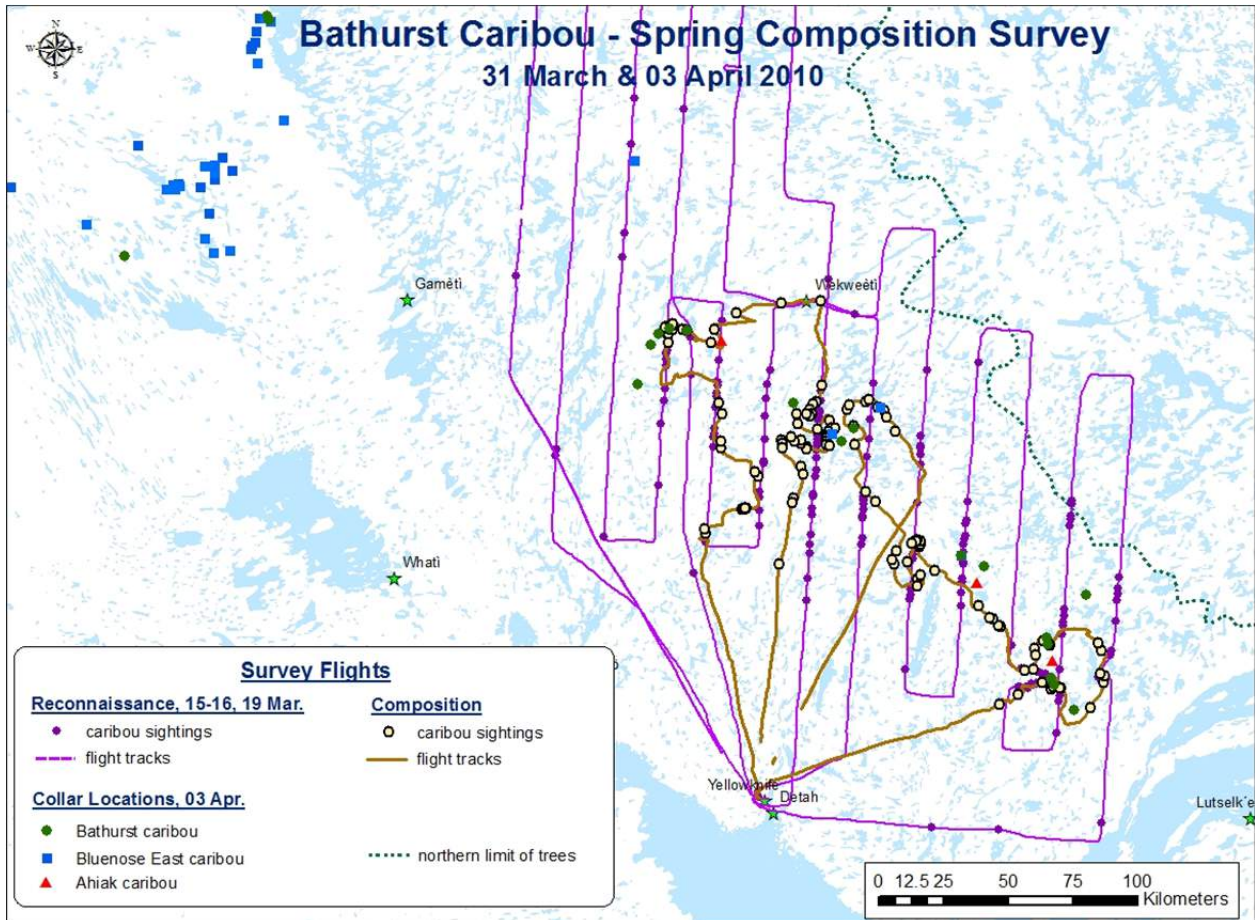
Bluenose East Caribou

Figure A11. Spring composition survey for the Bluenose East caribou herd on 06-07 April 2010 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 17-18 March. Total distance flown for the composition survey was 1,882 km in 13.9 hours. Collared caribou locations are shown from the Bluenose East herd (36 individuals) from 06 or 07 April, the Bathurst herd (21 individuals) from either 06 or 08 April, and the Beverly/Ahiak herd (3 individuals) from 06 April 2010.

Fall 2010

No surveys for either Bathurst caribou or Bluenose East caribou

Spring 2011

Bathurst caribou

Figure A12. Spring composition survey for the Bathurst caribou herd on 04-05 April 2011 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 01-02 April. Total distance flown for the composition survey was 1,895 km in 13.4 hours. Collared caribou locations from the Bathurst herd (14 individuals) are shown for 05 April, and Bluenose East herd (26 individuals) for either 03 or 06 April 2011.

Bluenose East caribou

Bluenose East Caribou - Spring Composition Survey
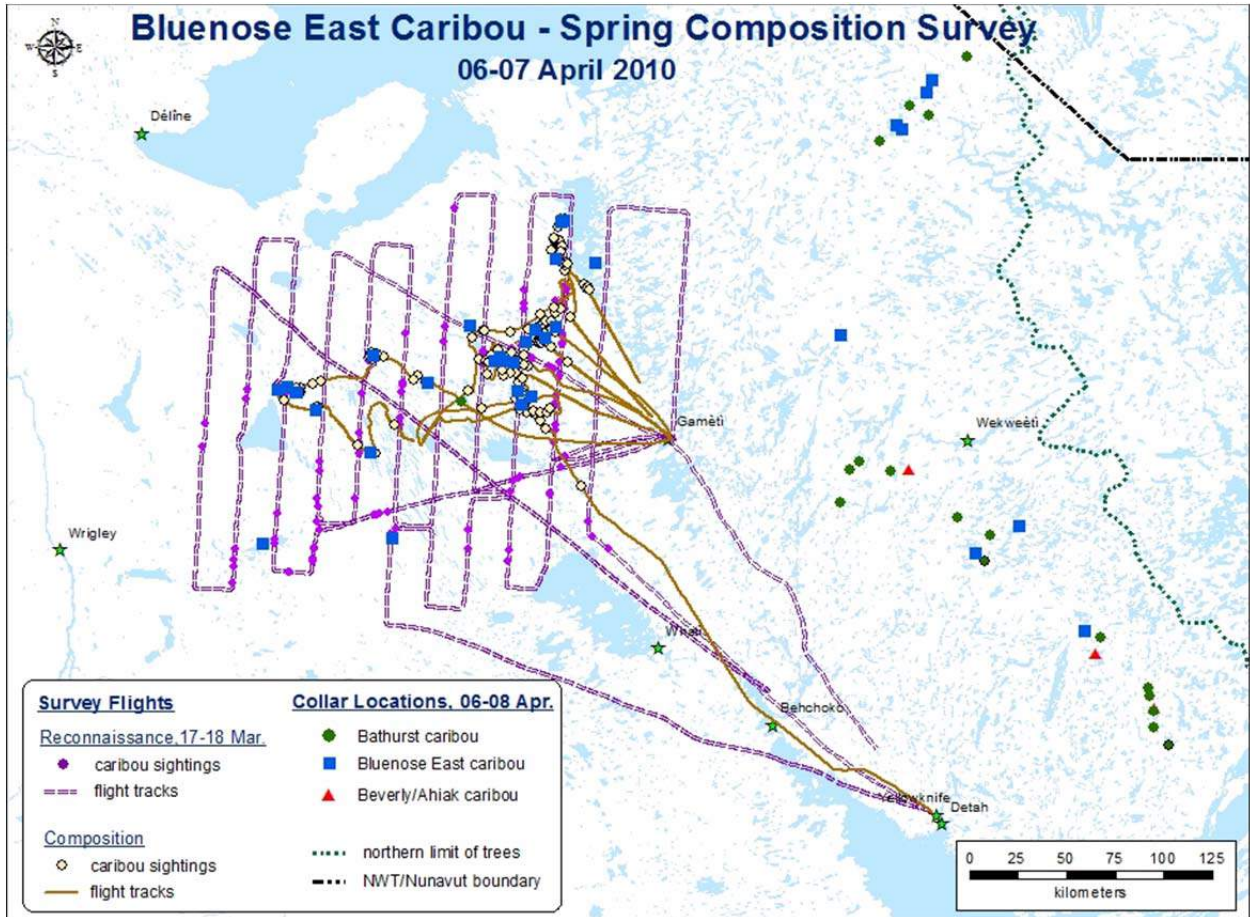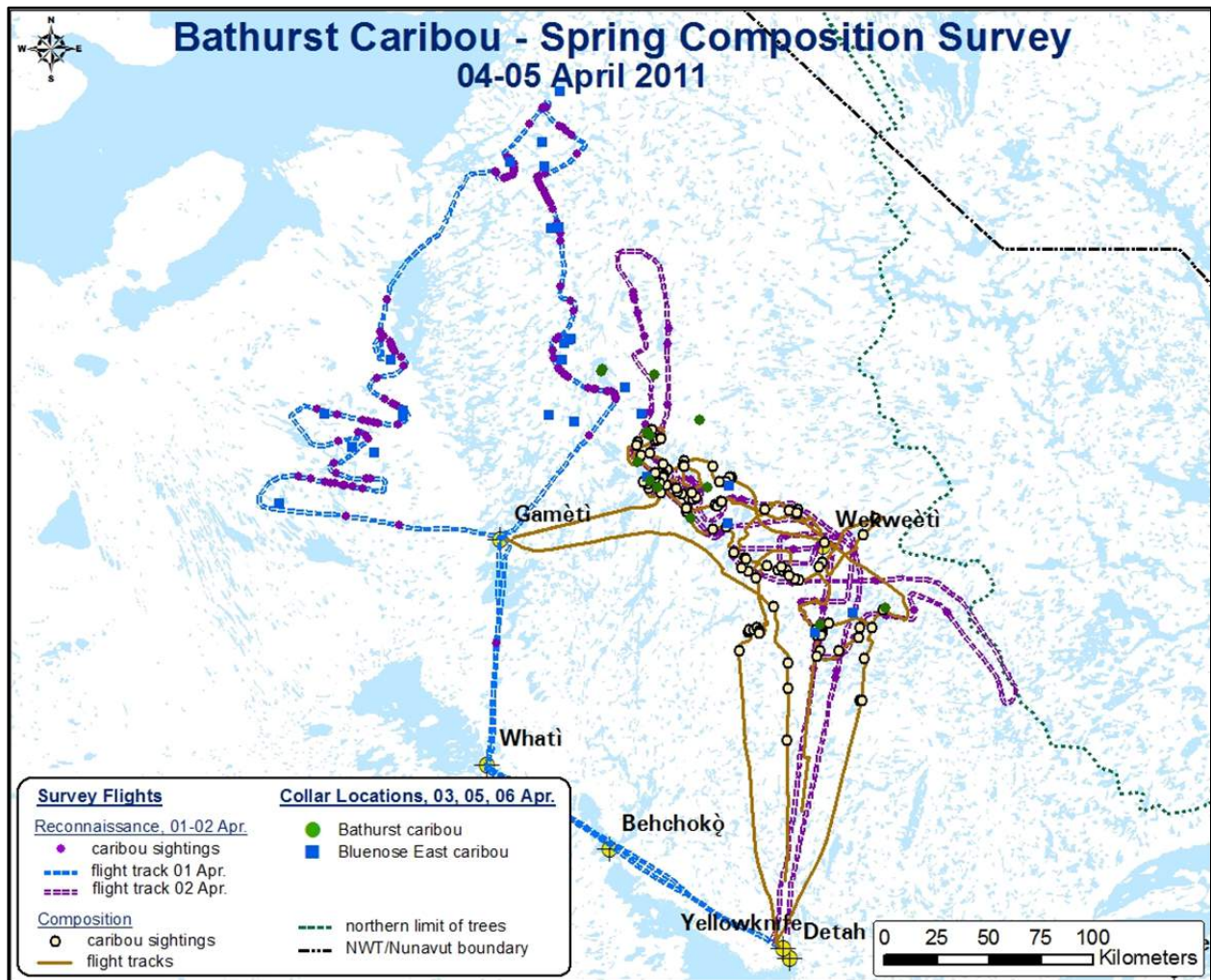**07-08 April 2011**

Figure A13. Spring composition survey for the Bluenose East caribou herd on 07-08 April 2011 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 01-02 April. Total distance flown for the composition survey was 1,310 km in 11.5 hours. Collared caribou locations from the Bathurst herd (18 individuals) are shown from either 07 or 08 April, and the Bluenose East herd (21 individuals) from 08 April 2011.

Fall 2011

Bathurst caribou
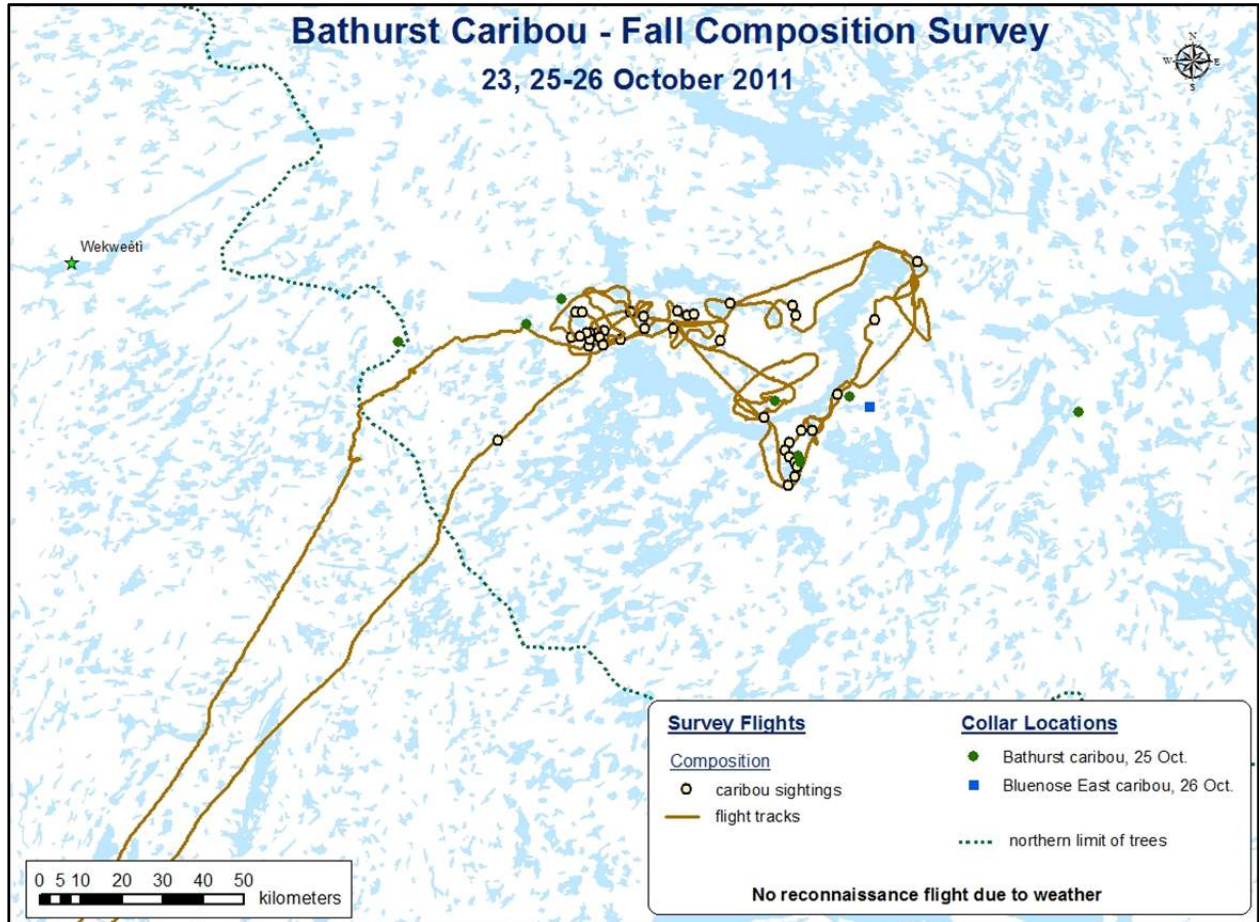
Figure A14. Fall composition survey for the Bathurst caribou herd on 23, 25-26 October 2011 showing flight lines, sightings, and locations of collared caribou. No reconnaissance survey occurred because of adverse weather. Total distance flown for the composition survey was 1,398 km in 9.8 hours.
Collared caribou locations from the Bathurst herd (10 individuals) are shown from 25 October, and the Bluenose East herd (8 individuals) from 26 October 2011.

Spring 2012
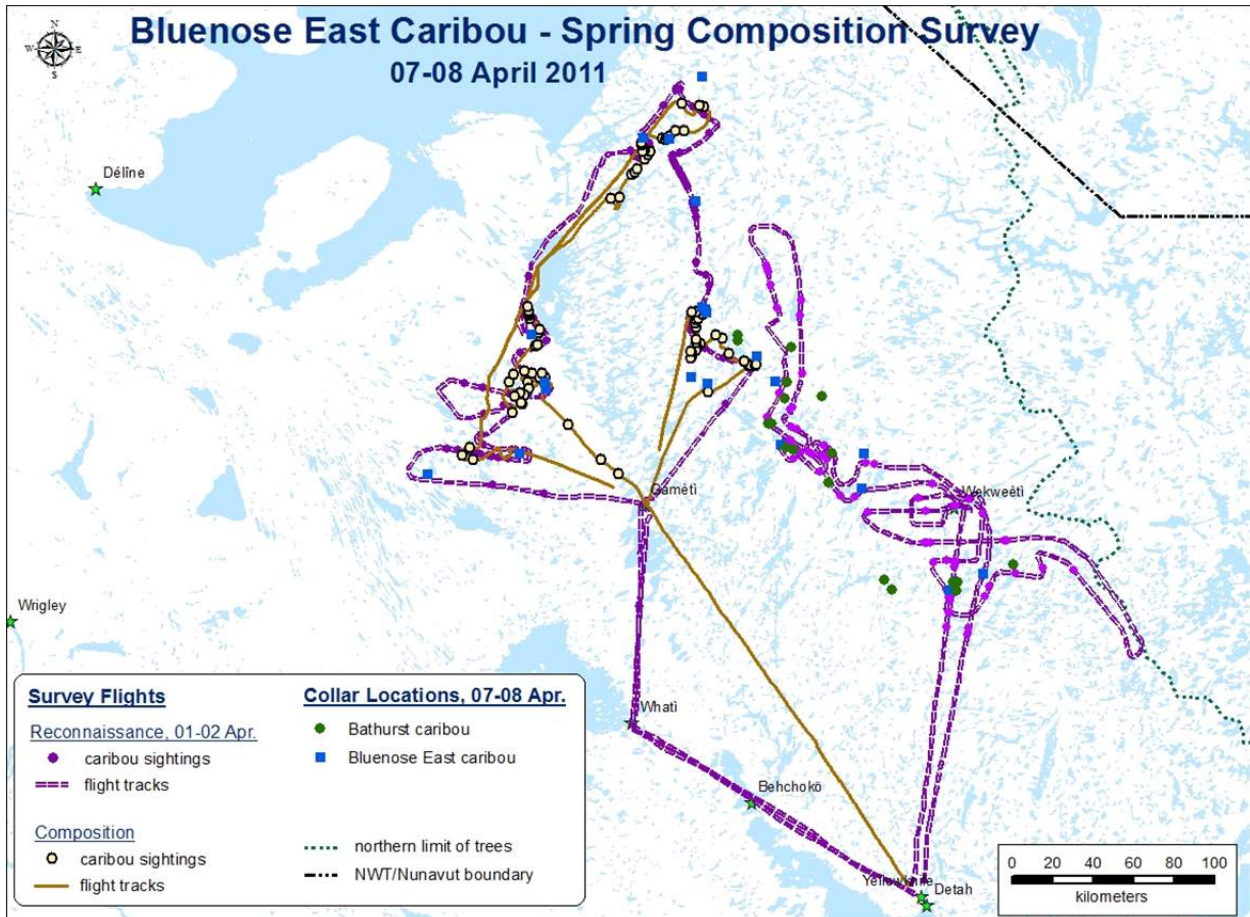
Bathurst caribou

Figure A15. Spring composition survey for the Bathurst caribou herd on 28 March and 02 April 2012 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 11, 13-14 March. Total distance flown for the composition survey was 1,553 km in 14.5 hours. Collared caribou locations from the Bathurst herd (23 individuals) are shown for either 28 March or 02 April, and Bluenose East herd (27 individuals) for 28 March 2012.

Bluenose East caribou

Figure A16. Spring composition survey for the Bluenose East caribou herd on 29 March 2012, showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred from 05-08 and 10 March. Total distance flown for the composition survey was 1,090 km in 8.0 hours. Collared caribou locations from the Bluenose East herd (65 individuals) and Bathurst herd (3 individuals) are shown for 29 March 2012.
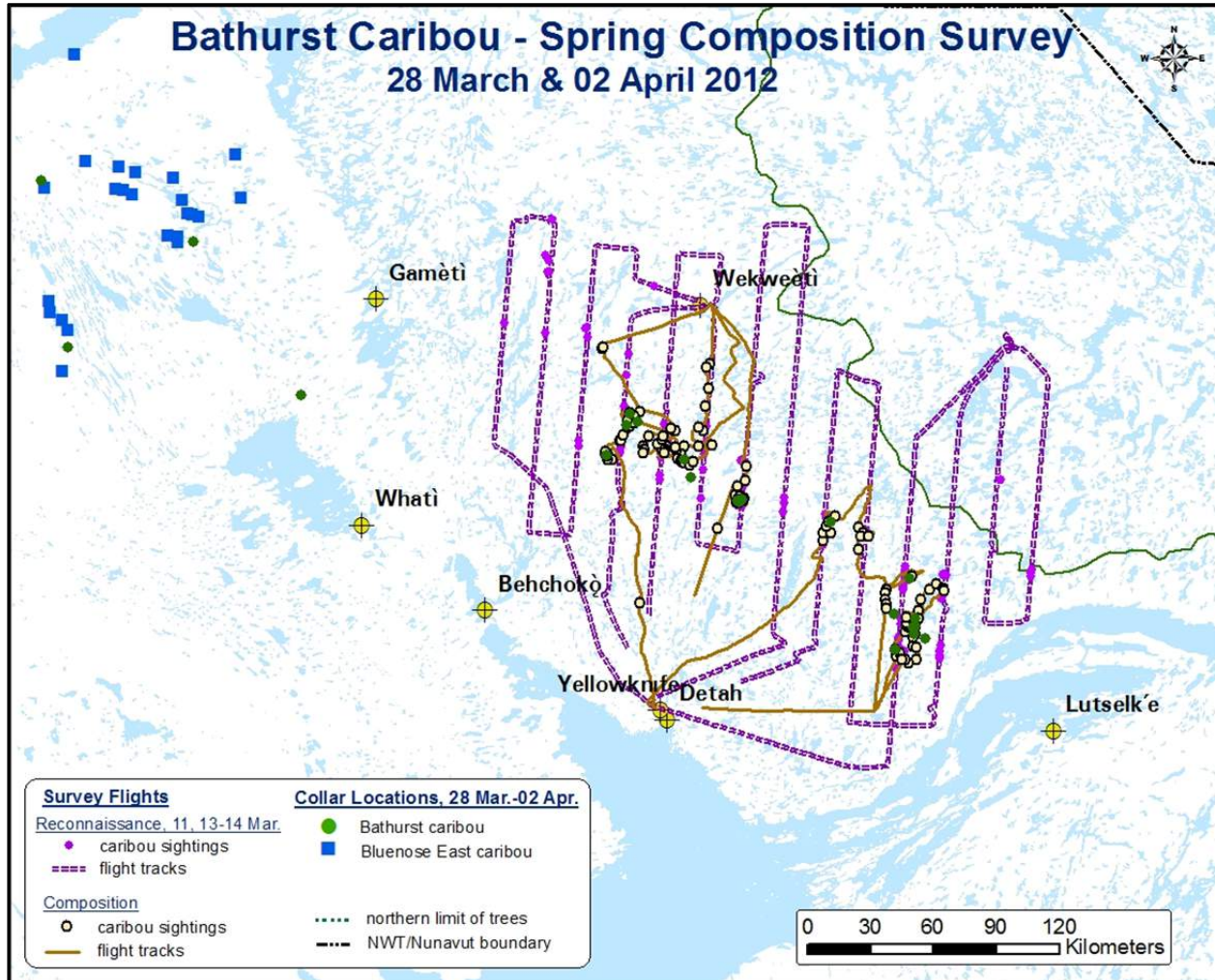
Fall 2012

Bathurst caribou

Figure A17. Fall composition survey for the Bathurst caribou herd on22-24 October 2012 showing flight lines, sightings, and locations of collared caribou. No reconnaissance survey occurred because of adverse weather. Total distance flown for the composition survey was 1,856 km in 15.6 hours. Collared caribou locations from the Bathurst herd (15 individuals) and Ahiak herd (21 individuals) are shown for 22 October 2012.

Spring 2013

- No composition surveys conducted: overlap between Bathurst & Bluenose East caribou

Fall 2013

Bluenose East caribou

Figure A18. Fall composition survey for the Bluenose East caribou herd on 20, 22-23 October 2013 showing flight lines, sightings, and locations of collared caribou. No reconnaissance survey occurred because of adverse weather. Total distance flown for the composition survey was 2,142 km in 16.2 hours. Collared caribou locations from the Bluenose East herd (28 individuals) and Bathurst herd (9 individuals) are shown for 22 October 2013.
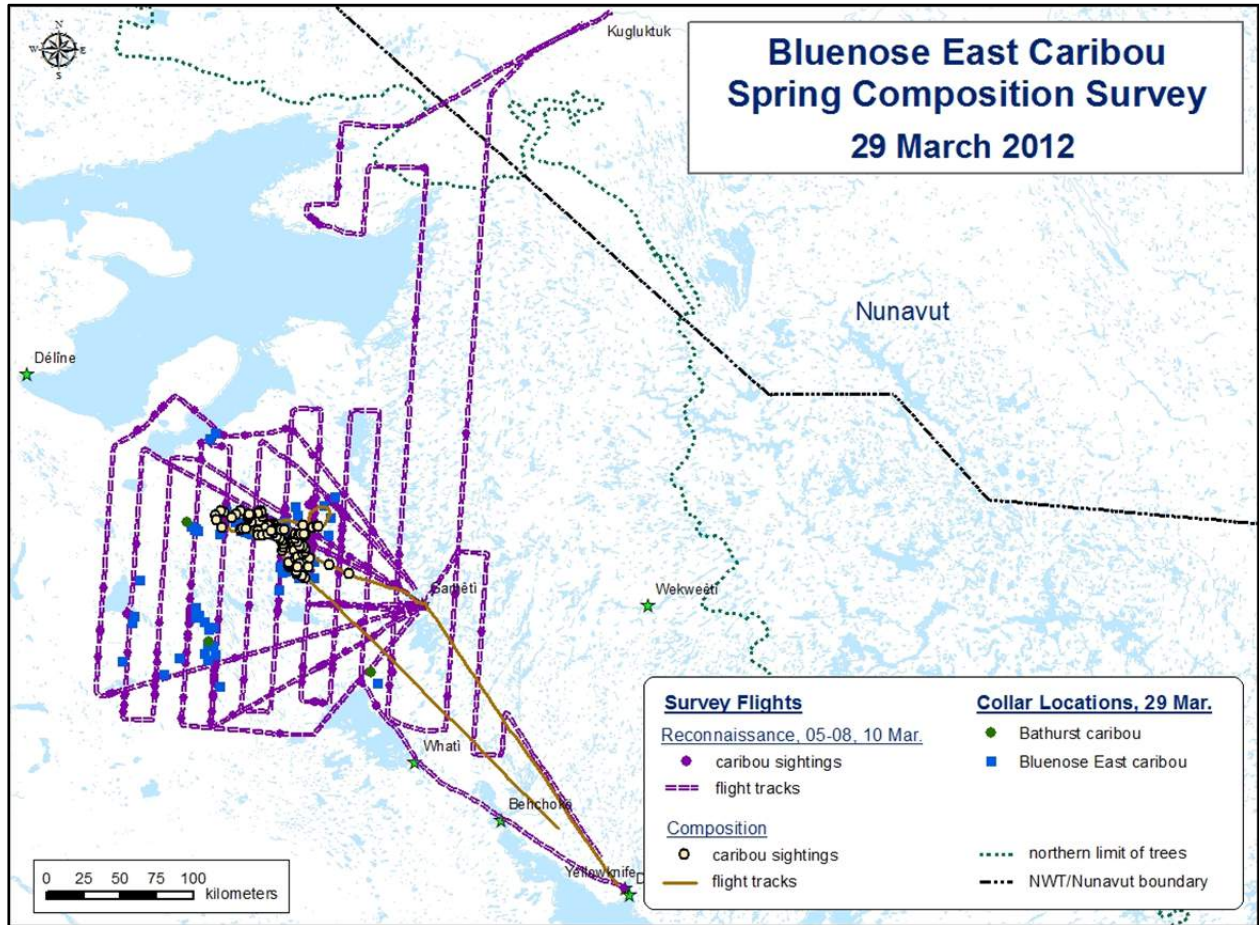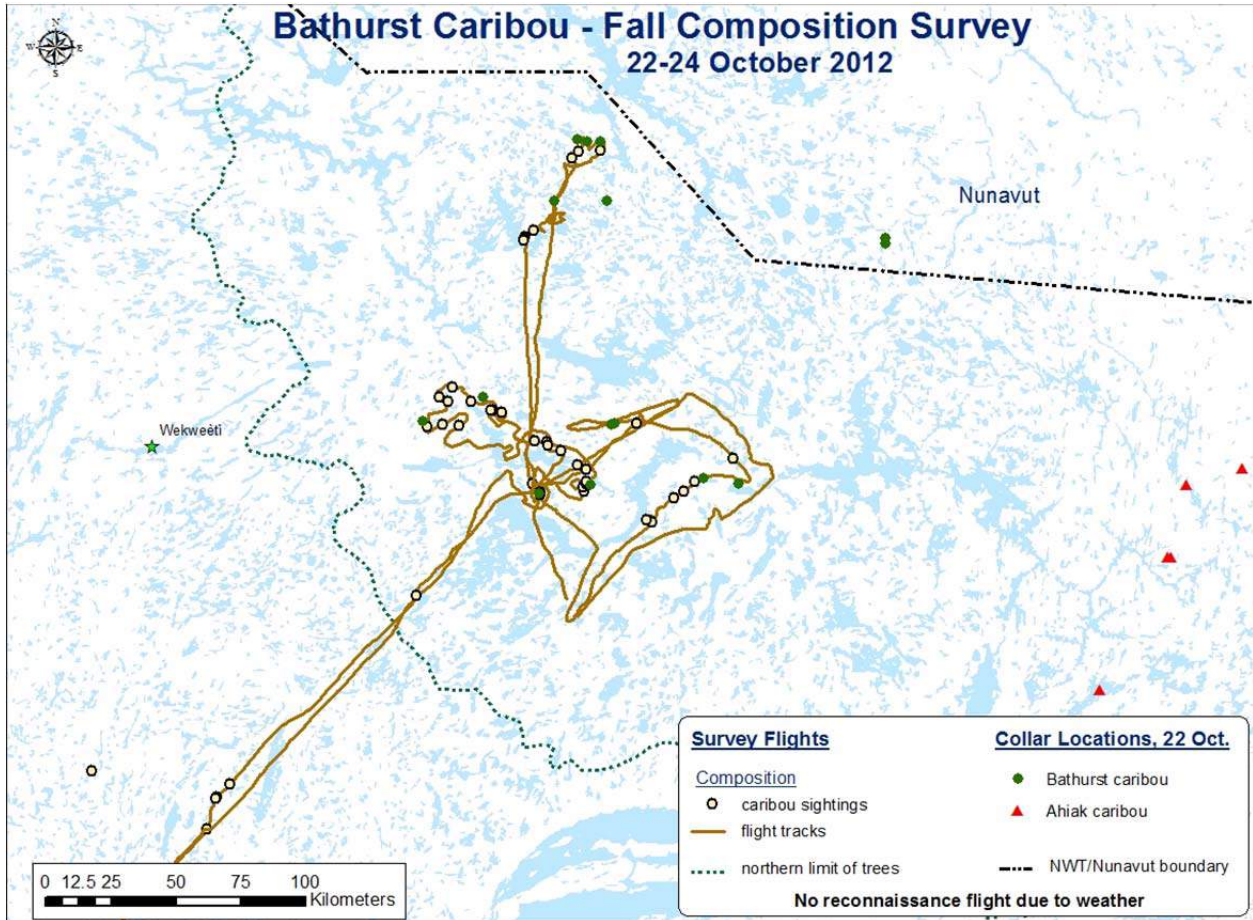
Spring 2014

Bathurst caribou

Figure A19. Spring composition survey for the Bathurst caribou herd on 10-12 March 2014 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 04-05, and 07 March. Total distance flown for the composition survey was 1,694 km in 15.7 hours. Collared caribou locations from the Bathurst (8 individuals), Bluenose East (17 individuals), Ahiak (6 individuals), and Beverly (2 individuals) herds, are shown for 12 March 2014.

Bluenose East caribou

Figure A20. Spring composition survey for the Bluenose East caribou herd on 12-13 March 2014 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 06 March. Total distance flown for the composition survey was 1,339 km in 13.1 hours. Collared caribou locations from the Bluenose East (17 individuals), Bathurst (7 individuals), and Ahiak (6 individuals) herds are shown for 12 March 2014.

Fall 2014

Bathurst caribou

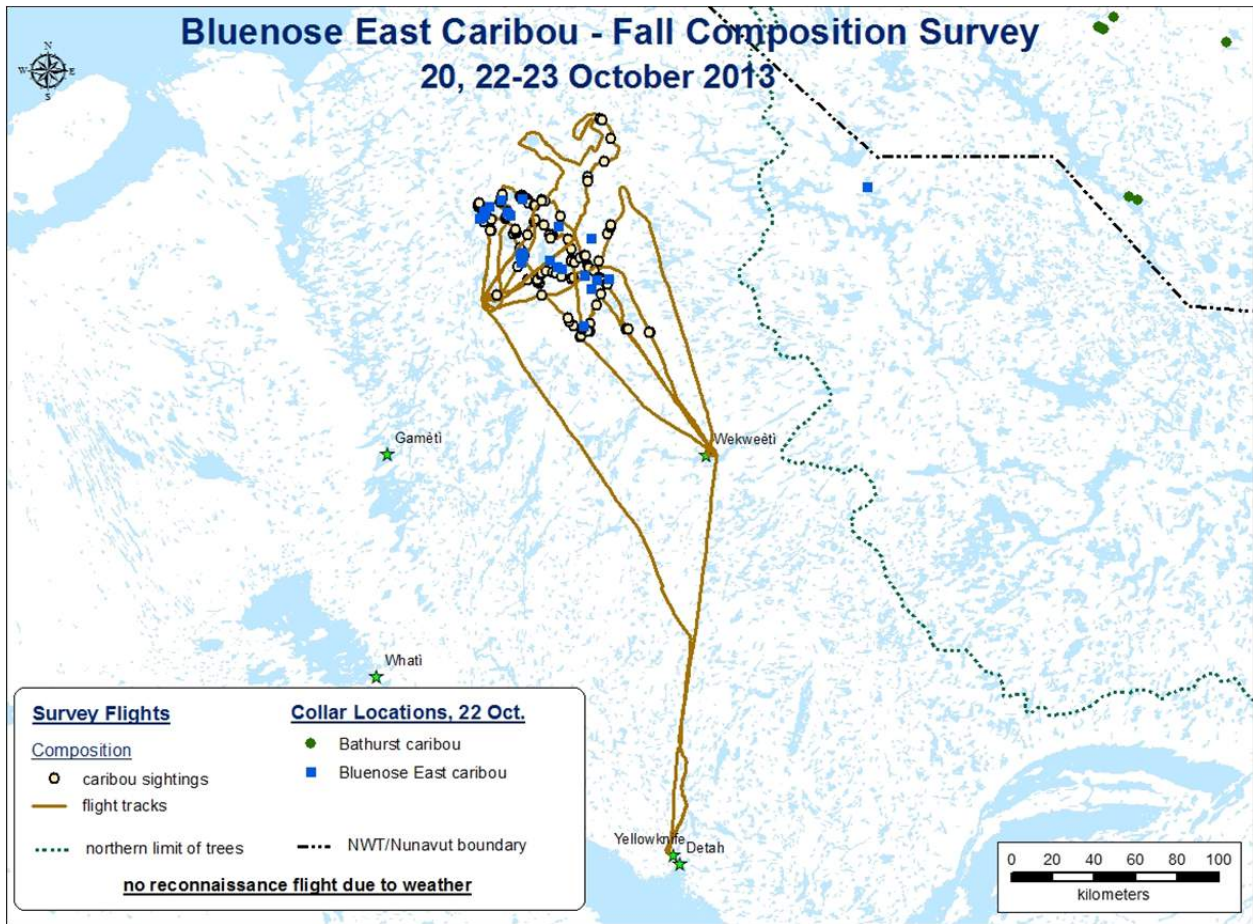

Figure A21. Fall composition survey for the Bathurst caribou herd on 22 October 2014 showing flight lines, sightings, and locations of collared caribou. No reconnaissance survey occurred because of adverse weather. Total distance flown for the composition survey was 1,112 km in 6.6 hours. Collared caribou locations from the Bathurst (15 individuals) are shown for 21-22 October 2014 and the Bluenose East (28 individuals) herd from between 13-22 October 2014.

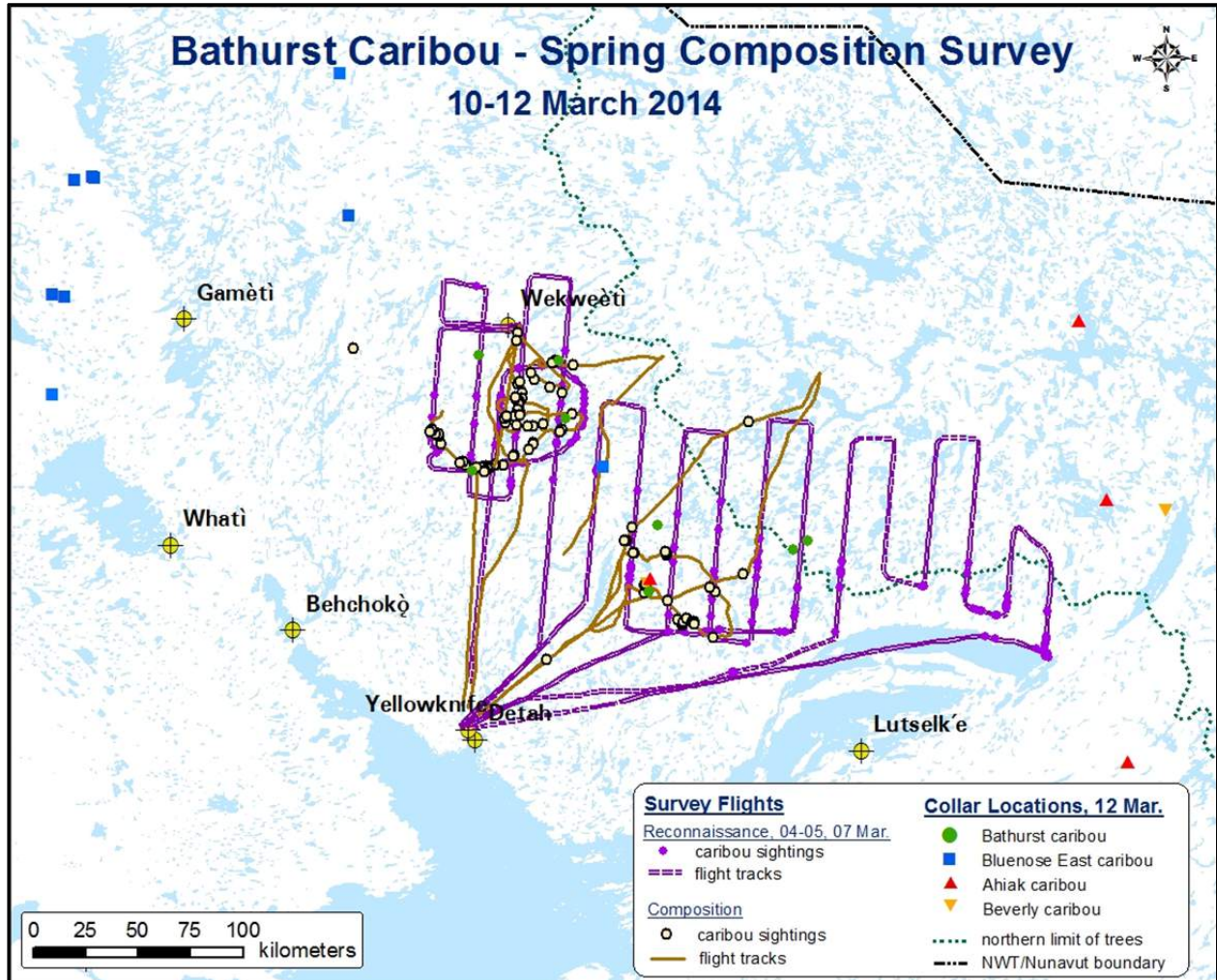# Spring 2015

Bathurst caribou

Figure A22. Spring composition survey for the Bathurst caribou herd on 05-06 March 2015 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 23-27 February 2015, but those in the Bathurst area occurred from 25-27 February. Total distance flown for the composition survey was 1,196 km in 11.0 hours. Collared caribou locations from the Bathurst herd (14 individuals) and the Bluenose East herd (22 individuals) are shown for either 05 or 06 March, and the Beverly/Ahiak herd (1 individual) for 05 March.
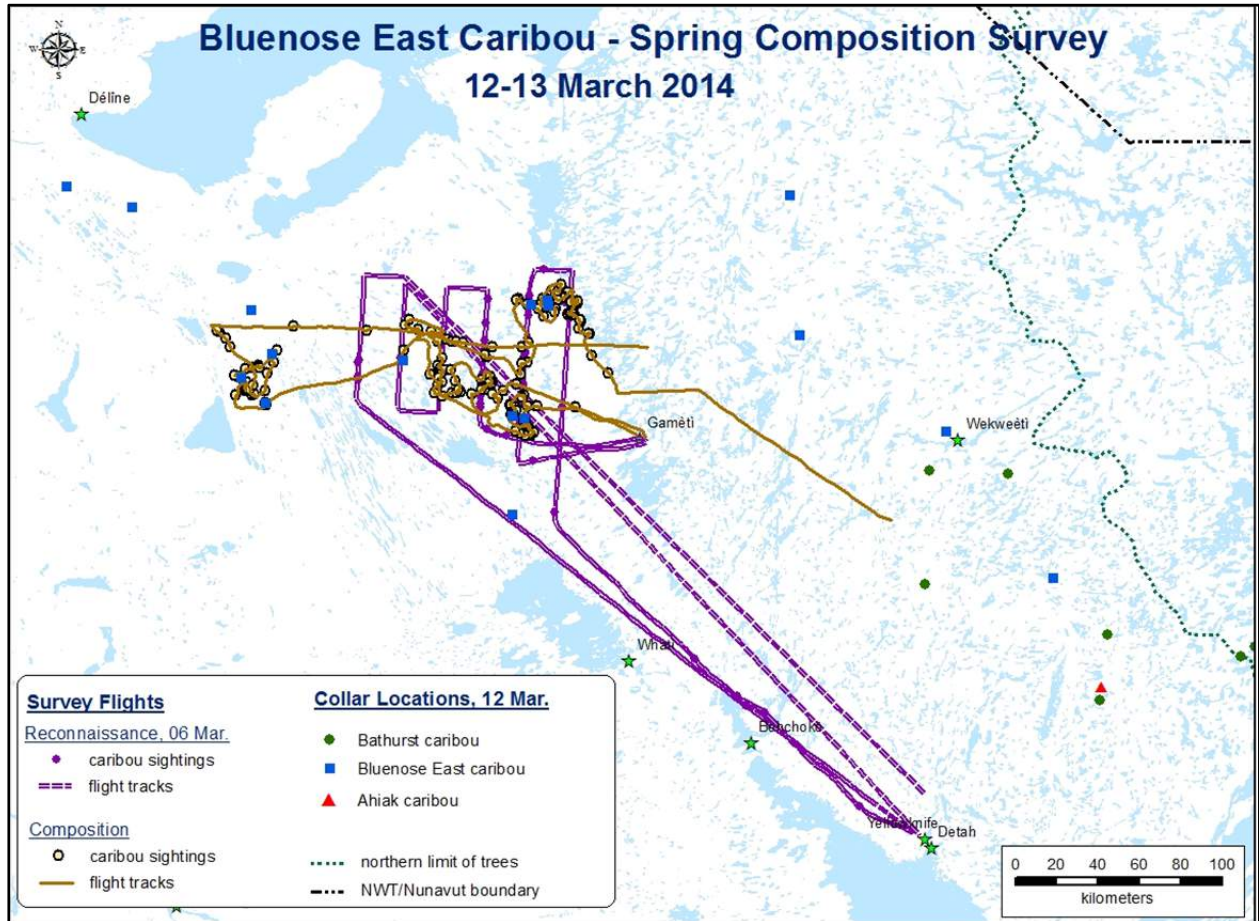
Spring 2015

Bluenose East caribou

Figure A23. Spring composition survey for the Bluenose East caribou herd on 03-05 March 2015 showing flight lines, sightings, and locations of collared caribou. Reconnaissance surveys occurred on 23-27 February 2015 (double dashed line), but those in the Bluenose East caribou area occurred from 23-25 February. Total distance flown for the composition survey was 1,666 km in 10.4 hours for 03 and 04 March. The survey effort (407 km, 3.4 hrs) from Gameti to Yellowknife on 05 March is shown separately (dashed line) because of overlap of Bluenose East and Bathurst caribou between Gameti and Wekweeti, and south of Wekweeti. Collared caribou locations from the Bluenose East herd (23 individuals) and the Bathurst herd (14 individuals) are shown for either 03 or 046 March, and the Beverly/Ahiak herd (1 individual) for 04 March.
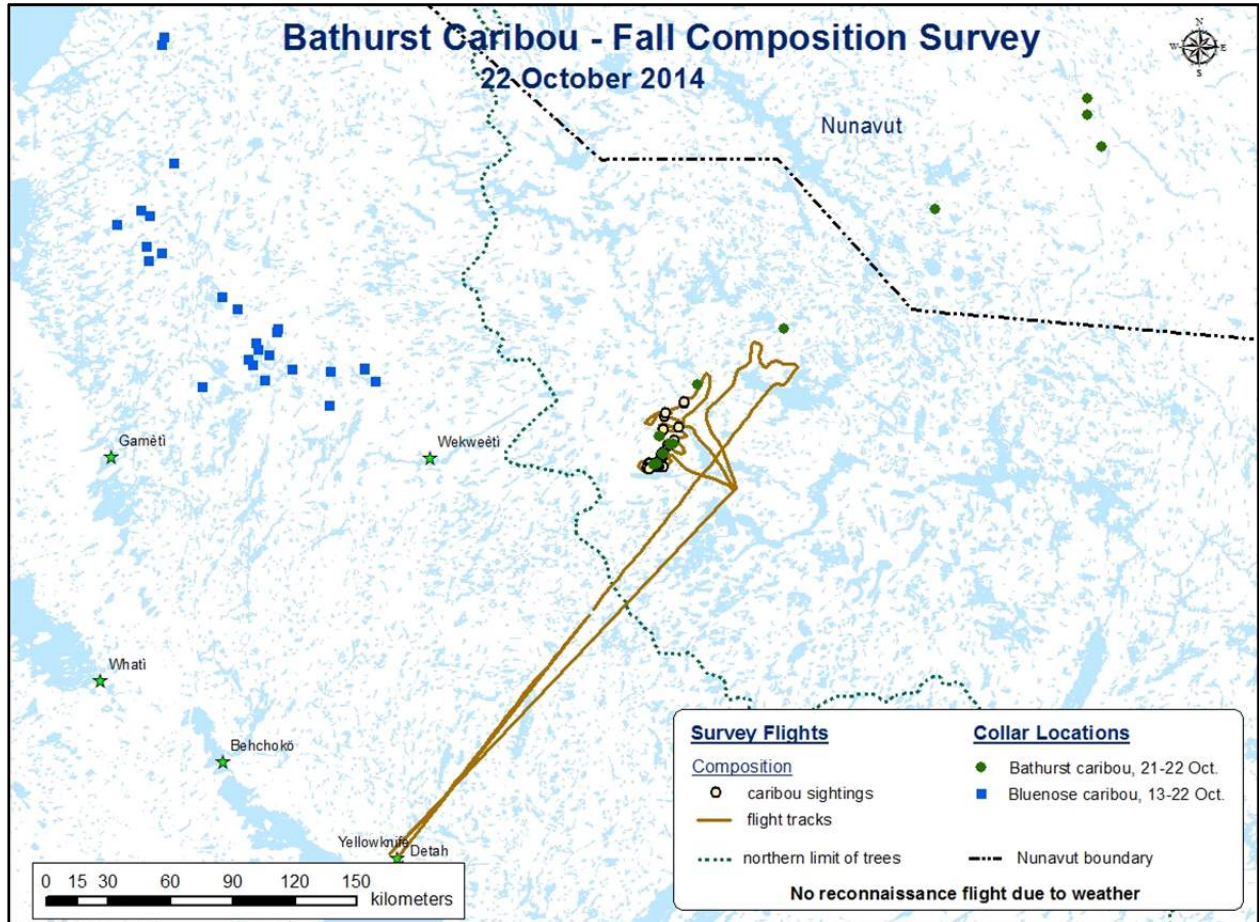
Fall 2015

Bluenose East caribou
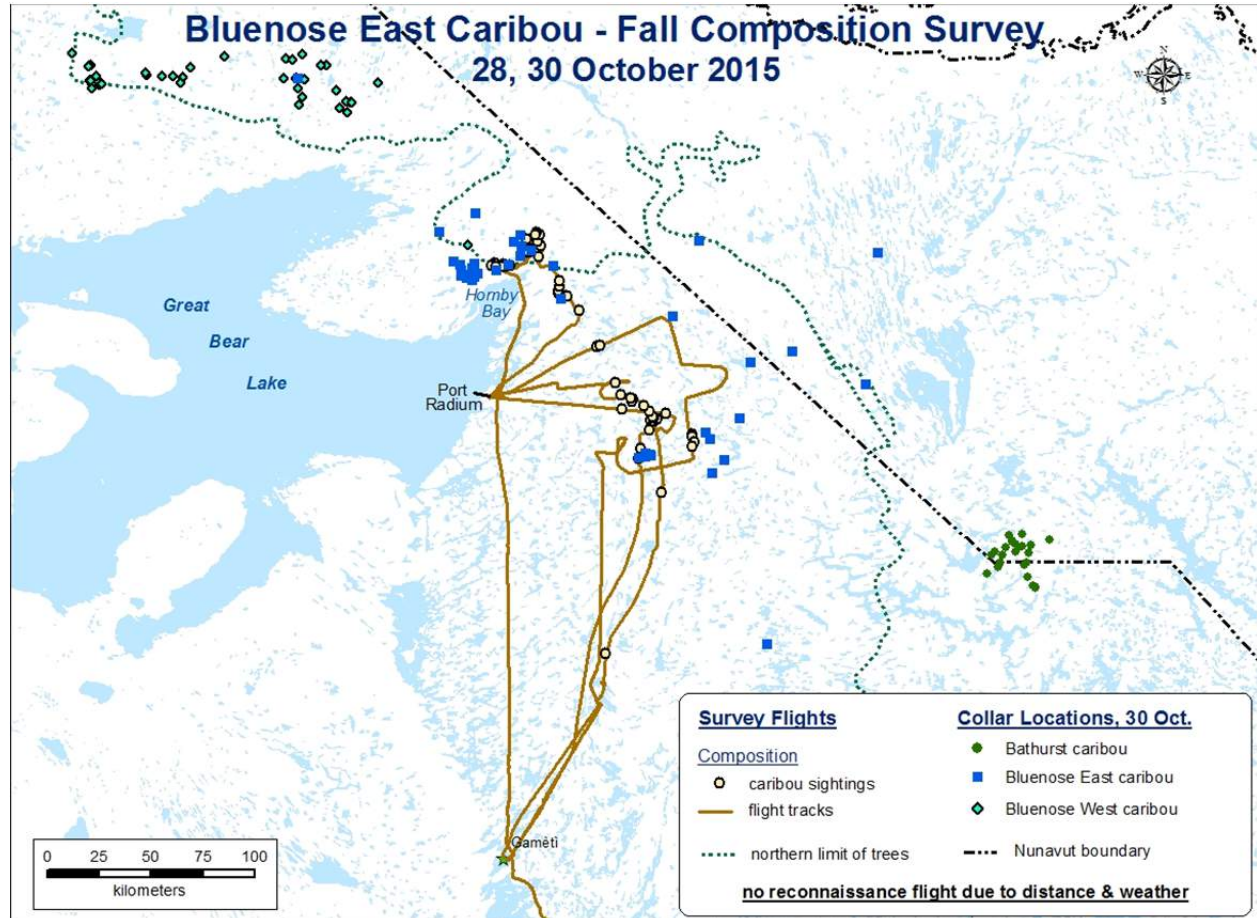
Figure A24. Fall composition survey for the Bluenose East caribou herd on 28, 30 October 2015 showing flight lines, sightings, and locations of collared caribou. There was no reconnaissance flight prior to the survey. Total distance flown for the composition survey was 1,716 km in 10.2 hours based out of Gameti, not including positioning to and from Gameti and Yellowknife. Collared caribou locations from the Bluenose East herd (42 individuals), the Bathurst herd (33 individuals), and the Bluenose West herd (42 individuals) are shown for 30 October.
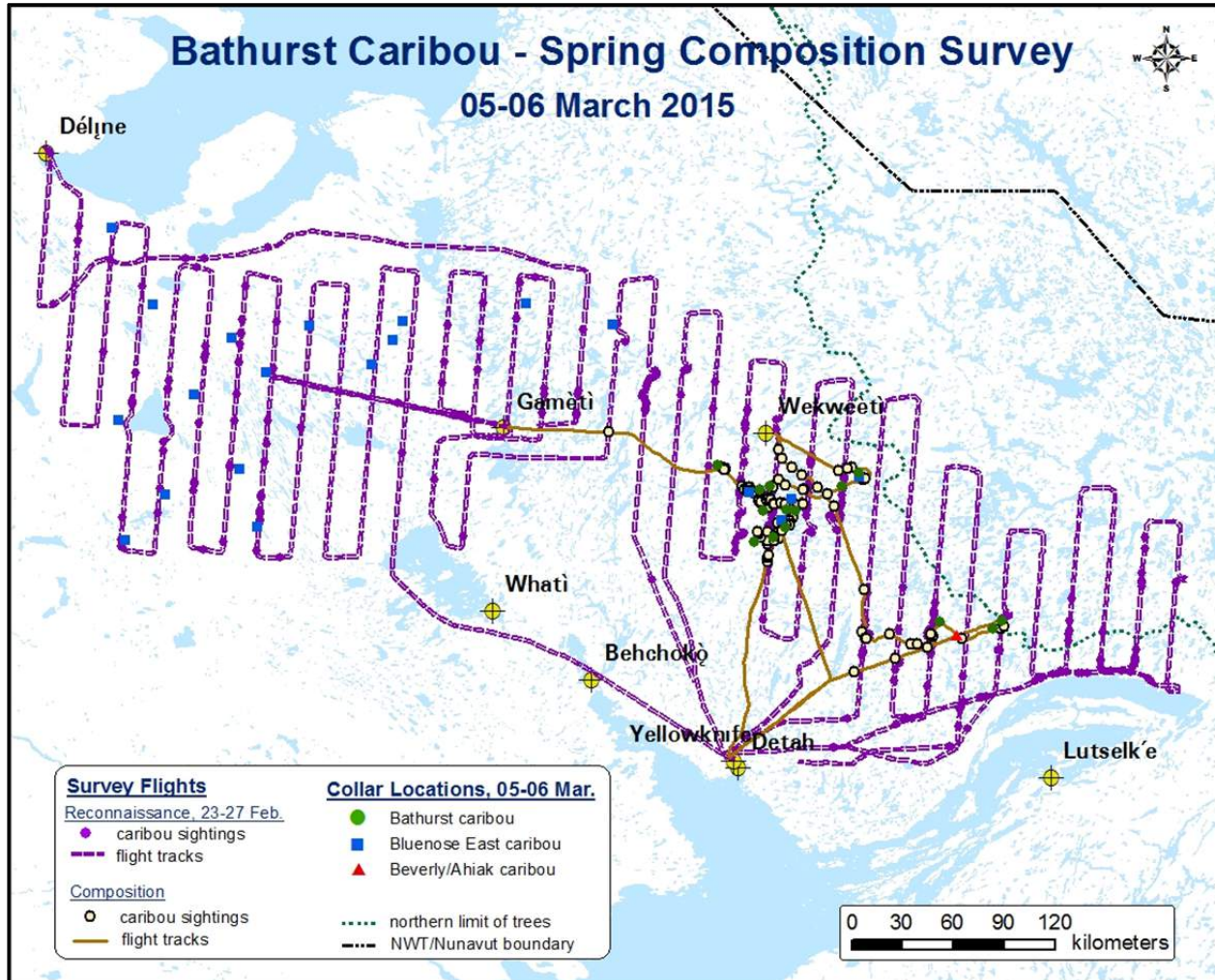
Spring 2016

Bathurst caribou
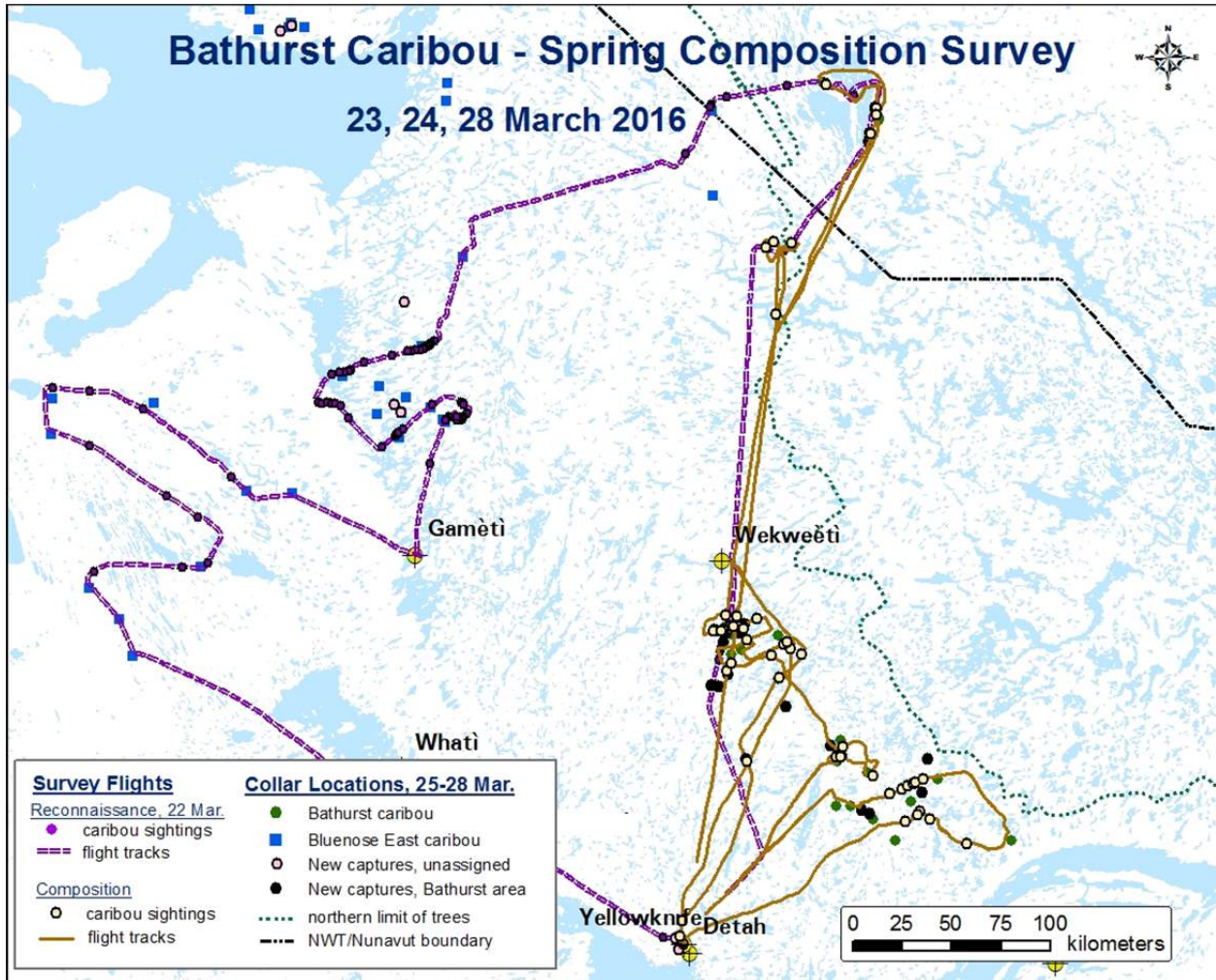
Figure A25. Spring composition survey for the Bathurst caribou herd on 23, 24, and 28 March 2016 showing flight lines, sightings, and locations of collared caribou. A reconnaissance surveys occurred on 22 March 2016 with objectives for both Bluenose East and Bathurst caribou. Total distance flown for the composition survey was 2,221 km in 15.7 hours over the three days. Collared caribou locations from the Bathurst herd (31 individuals), the Bluenose East herd (39 individuals), and newly deployed collars (32 individuals) are shown for late March.

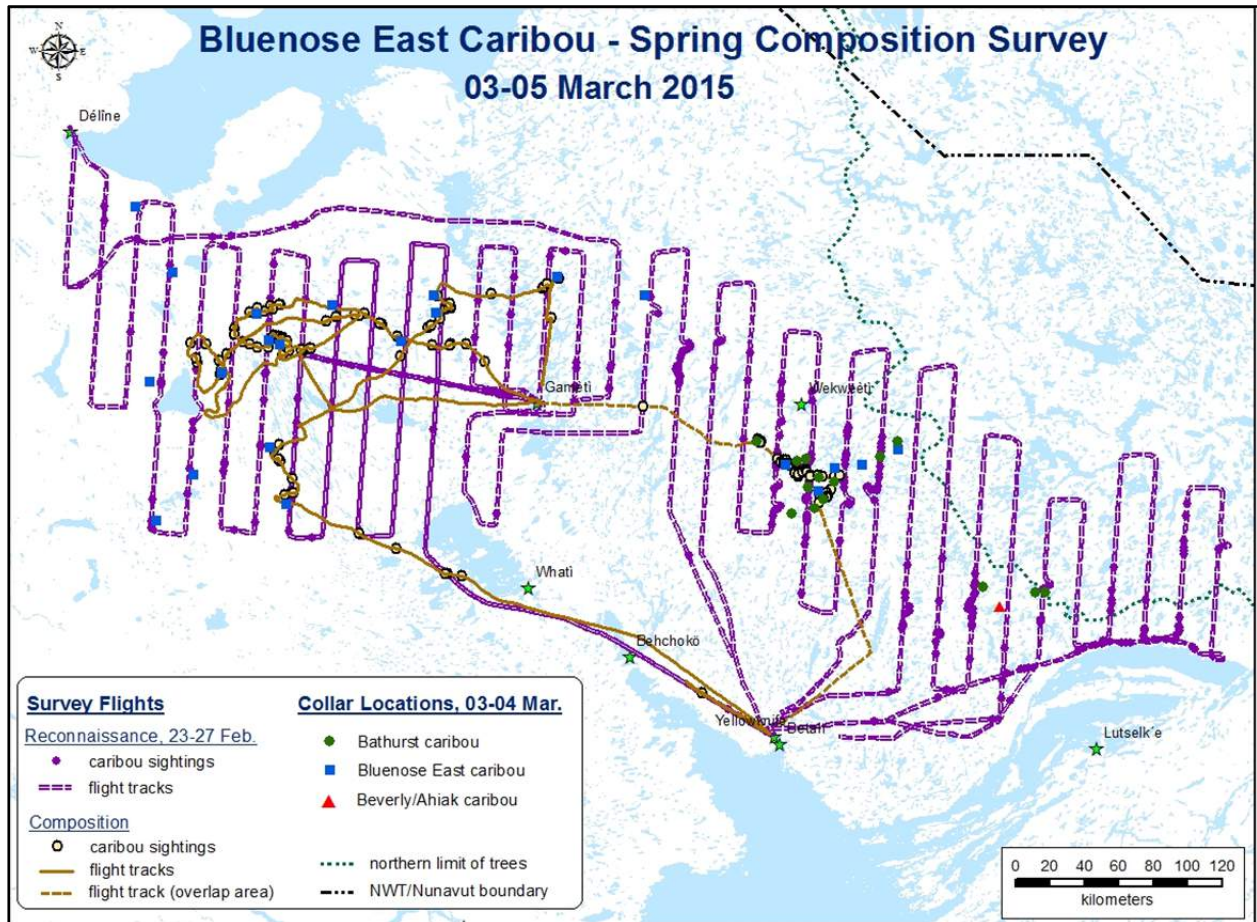# Spring 2016

Bluenose East caribou
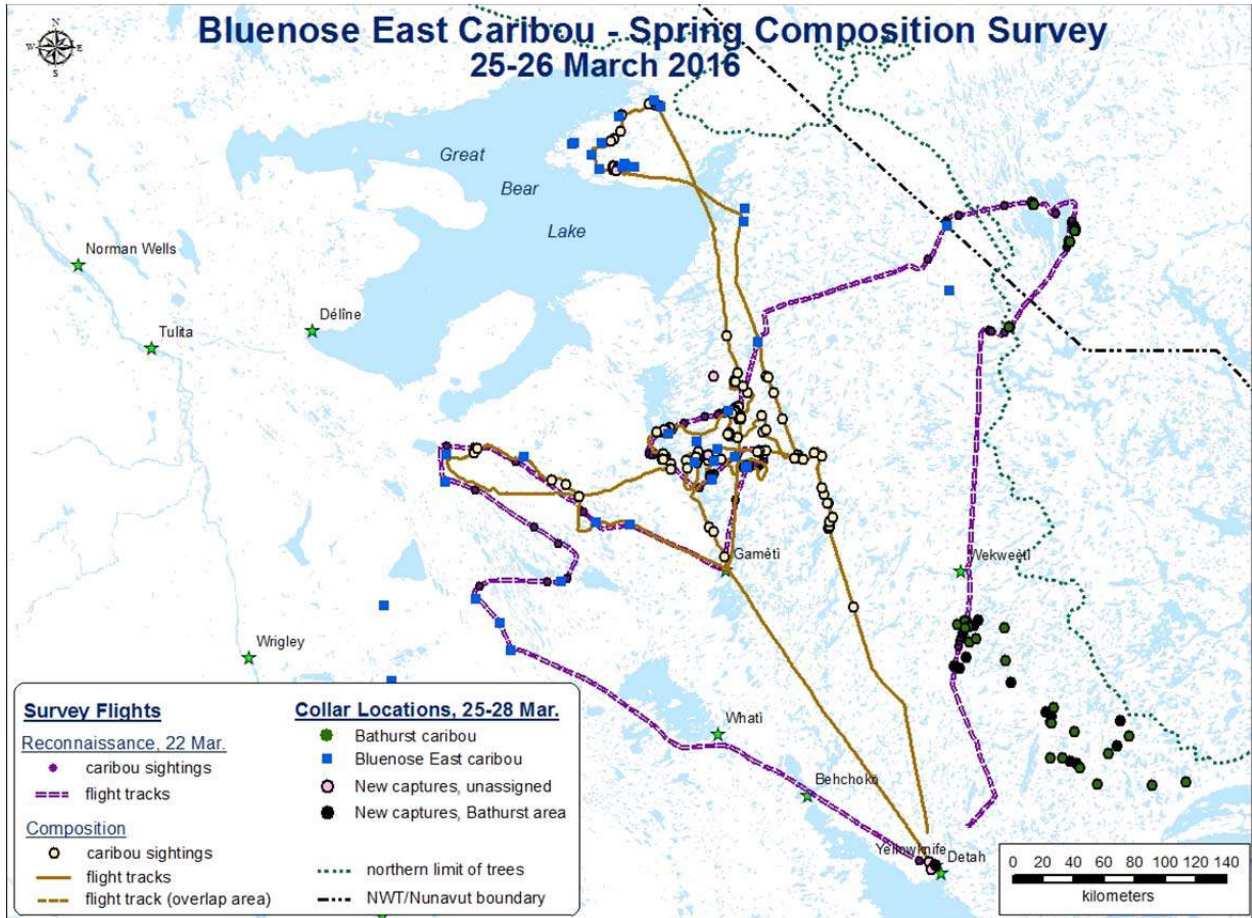
Figure A26. Spring composition survey for the Bluenose East caribou herd on 25-26 March 2016 showing flight lines, sightings, and locations of collared caribou. A reconnaissance surveys occurred on 22 March 2016 with objectives for both Bluenose East ad Bathurst caribou. Total distance flown for the composition survey was 2,297 km in 15.1 hours. Collared caribou locations from the Bathurst herd (31 individuals), the Bluenose East herd (39 individuals), and newly deployed collars (32 individuals) are shown for late March.

APPENDIX B

Table B1. Calf-cow ratios from spring and fall composition surveys conducted on the Bathurst range, 1985 to 2016. Estimates prior to 2006 (Williams & Fournier 1996, Gunn et al. 2005) were updated to correct any data entry errors, and provide standard errors and confidence intervals (via bootstrapping).

| Year	Total caribou classified	Sampling locations	Median group size	Calves / cow	SE [1]	CL [2]	CL [2]	% Calves in sample
Spring counts								
1985	1,539	3		0.339	0.101	0.138	0.476	23
1987	6,502	30		0.429	0.032	0.374	0.502	21
1988	3,590	13		0.741	0.117	0.537	0.998	24
1989	2,268	17		0.391	0.023	0.347	0.439	21
1990	3,558	15		0.330	0.026	0.335	0.436	22
1991	5,492	45		0.489	0.026	0.433	0.548	24.7
1992	4,121	36		0.313	0.018	0.279	0.349	16.6
1993	5,417	44		0.487	0.020	0.448	0.531	23
1994	4,420	40		0.305	0.027	0.260	0.362	15
1995	3,190	39		0.500	0.043	0.422	0.589	26
2001	11,351	240	34	0.291	0.010	0.272	0.309	16.2
2002	7,512	115	24	0.213	0.017	0.183	0.250	14.2
2003	9,181	122	36	0.289	0.015	0.262	0.319	17.7
2004	8,498	247	18	0.215	0.010	0.196	0.236	14.1
2005				0.154	0.013	0.128	0.180	
2006	9,913	378	18	0.086	0.007	0.072	0.102	6.5
2007	10,121	133	45	0.368	0.021	0.327	0.409	25.5
2008	4,501	117	30	0.497	0.020	0.458	0.538	29.7
2009	5,636	100	45	0.399	0.019	0.363	0.438	25.6
2010	1,819	53	25	0.489	0.021	0.449	0.532	26.0
2011	2,758	89	23	0.462	0.019	0.426	0.499	21.7
2012	4,269	99	36	0.251	0.013	0.227	0.276	15.4
2014	2,323	87	19	0.326	0.015	0.298	0.355	21.1
2015[a]	2,742	84	20	0.235	0.013	0.211	0.260	15.2
2016	2,233	38	28	0.200	0.014	0.168	0.221	15.2
Fall counts								
2000	4,693	207	14	0.399	0.013	0.374	0.423	20.2
2001	6,122	148	19	0.324	0.023	0.282	0.372	16.7
2004	12,444	187	24	0.181	0.016	0.156	0.219	11.7
2006	5,616	69	49	0.402	0.024	0.360	0.451	22.7
2007	7,334	156	33	0.552	0.013	0.526	0.577	29.3
2008	3,645	46	43	0.319	0.018	0.288	0.356	18.8
2011	4,965	52	48	0.331	0.016	0.298	0.359	17.3
2012	4,400	33	37	0.228	0.019	0.195	0.266	12.8
2014	2,927	30	65	0.253	0.019	0.213	0.287	14.5

[1] SE = Standard Error   [2] CL=Confidence Limit (lower & upper).

[a] partial overlap with Bluenose East herd

Table B2. Bull-cow ratios from fall composition surveys conducted on the Bathurst and Bluenose East range, 2000 to 2016. *

Year	Total caribou classified	Sampling locations	Median group size	Bull / cow	SE [1]	CL[2]	CL[2]	% Calves in sample
Bathurst								
2000	4,693	207	14	0.530	0.005			20.2
2001	6,122	148	19	0.616	0.070	0.498	0.771	16.7
2004	12,444	187	24	0.364	0.030	0.314	0.433	11.7
2006	5,616	69	49	0.362	0.021	0.323	0.404	22.7
2007	7,334	156	33	0.305	0.016	0.275	0.337	29.3
2008	3,645	46	43	0.379	0.024	0.331	0.427	18.8
2011	4,965	52	48	0.580	0.034	0.524	0.653	17.3
2012	4,400	33	37	0.554	0.029	0.498	0.613	12.8
2014	2,927	30	65	0.490	0.025	0.444	0.540	14.5
Bluenose East								
2008	3,666	76		0.933				
2009	4,531	79	46	0.429	0.017	0.396	0.463	24.4
2013	5,369	107	29	0.426	0.018	0.390	0.461	20.1
2015	4,190	51	31	0.417	0.029	0.367	0.479	19.7

[1] SE = Standard Error   [2] CL=Confidence Limit (lower & upper).

* Updated from Gunn et al. 2005 (MR163) and Judy Williams (pers. comm.)

Literature Cited:

Gunn, A.G., J. Boulanger, and J. Williams. 2005. Calf survival and adult sex ratio in the Bathurst herd of barren-ground caribou 2001-2004. Manuscript Report 163, Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

Williams, T.M., and B. Fournier. 1996. Summary of spring classification surveys of the Bathurst caribou herd, 1985-1995. Manuscript report No. 92, Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, Yellowknife, NT.

APPENDIX C

Sample calculations and formulas

Calf:cow ratio (Cow = 1+ year old female)

(1,363 calves/3,657 1yr$^+$_females) = 0.37 calves: cow
　　　　or to move the decimal to the right to avoid the fraction,

　　(1363 calves/3,657 1yr$^+$_females) x 100 = 37 calves: 100 cows

Bull:cow ratio (Bull = 1+ year old male)
　　Similar formulation as Calf:Cow ratio

　　(1,170 bulls/3,775 1yr$^+$_females) = 0.31 bulls: cow

　　　　or to move the decimal to the right to avoid the fraction,

　　(1,170 calves/3,775 1yr$^+$_females) x 100 = 31 bulls: 100 cows

Coefficient of Variation
The co-efficient of variation (CV) is useful for comparing uncertainty in estimates. The CV of an estimate is calculated as the ratio between the standard error (SE) and the actual estimate, and often expressed as a percentage. The higher the CV, the greater the dispersion is in the variable. Therefore, the variable with the smaller CV is less dispersed than the variable with the larger CV.

Example:
If the calf:cow ratio was estimated to be 0.552 ± 0.014 (± 1 SE).

Then:
$$CV = \frac{SE}{estimate} = \frac{0.014}{0.552} = 0.025 \text{ or } 2.5\%$$

Therefore, the calf:cow ratio estimate could be expressed as 0.552 ± 2.5 % (for 1 SE, or about 2/3 of the variation).

Percent calves in sample
　　Total caribou (sample) = 3,197 cows + 460 calves + 326 yearlings + 1,155 bulls = 6,501 caribou

　　1,363 calves/6,501 [sample total] x 100 = 21% calves

Percent calves in population

Estimate the total number of 1^+yr_Males, (using an assumed population ratio, say 61 males:100 females)

61 x 3,657 females/100 = 2,230 1^+yr_Males

2230 – 1481 = 749 (unobserved male population segment, using above assumed sex ratio)

Percent calves = (1363 calves/6501 + 749)) x 100 = 19% calves

Percent recruitment (increment)

19% calves/ 81% 1^+_animals = 23% increment

Bootstrapping for Standard Error and Confidence Interval estimation

If the parameter we are estimating was normally distributed, then we could expect symmetrical confidence limits (e.g., point estimate $\pm$an estimated value). However, the sampling distribution is not known and therefore we use resampling (bootstrapping) to estimate the standard error and the resultant confidence limits or interval. Bootstrapping resamples the original data set many times and then uses the percentiles (2.5^{th} and 97.5^{th}) to obtain the confidence limits. Often this will result in slight asymmetrical confidence intervals relative to the point estimate especially if the estimate (e.g., calf:cow ratio) is low. That is, the confidence interval will be will be constrained by the lower calf:cow ratios observed. Asymmetry also results because the ratio is constrained by 0 and 1, not like the approach of 1.96*SE that will potentially result in confidence interval ranges that are below 0 or above 1 (if calf:cow ratio is low or high, respectively). In effect, the underlying distribution is binomial (i.e., constrained by 0 and 1) and therefore the confidence interval will only appear normal when the calf:cow ratio is in the mid-range of the distribution.

APPENDIX D

Table D1. Caribou composition survey form (prior to use of tablets).

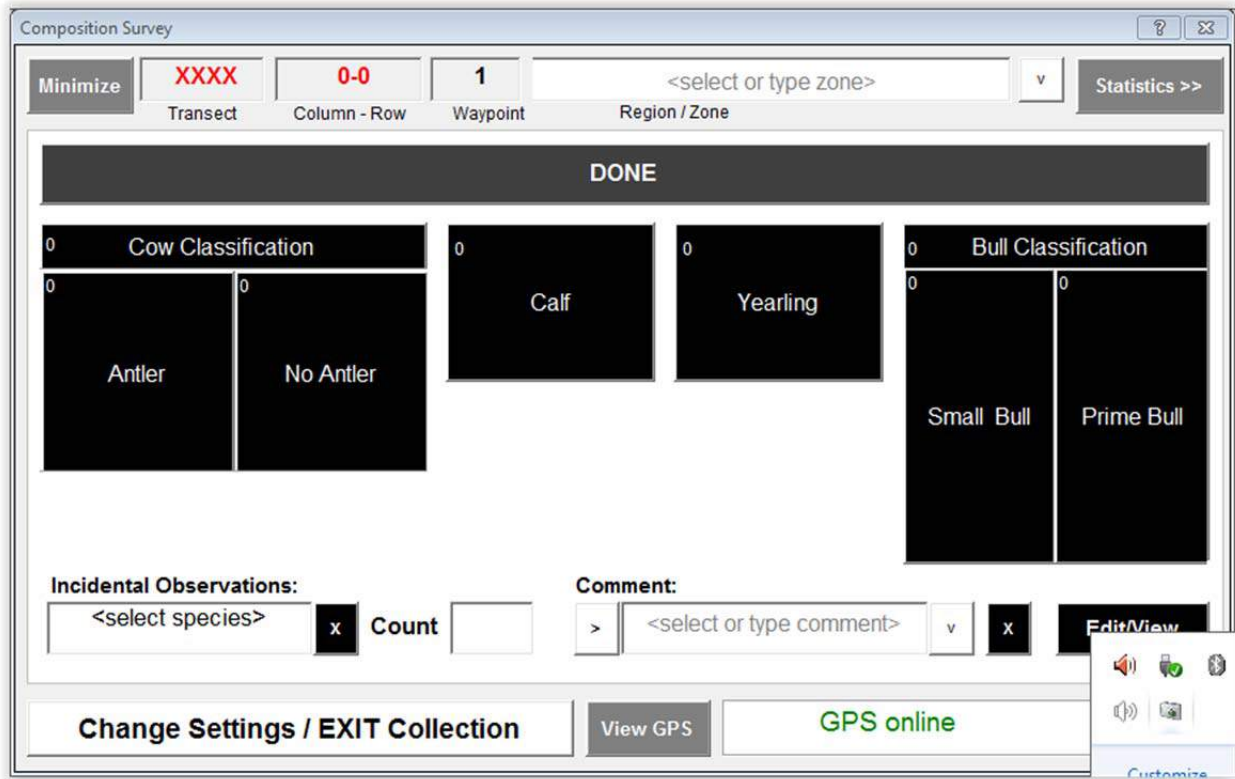| Grp #	Wpt #	Cows	Calves	Young Bulls	Prime Bulls	Yrlgs	Total

Figure D1. Screenshot of Yuma 2 tablet showing the touch-enabled observation data entry screen.