

Estimates of the number of barren-ground
caribou in the Cape Bathurst and Bluenose-West
herds derived using Post Calving Photography,
July 1992

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2007

Manuscript Report No. IN PRESS

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INTRODUCTION

The first photo-census surveys of the Cape Bathurst and Bluenose West herds were completed in 1986 and 1987 (Nagy, McLean & Russell, 2007). A follow-up survey was conducted in 1992 but was not previously reported. Since the 1992 survey evidence has been compiled that supports the hypothesis that there are three herds occupying the area surveyed in 1992 (Nagy et al. 1999b). Capture locations and movement data from 1992 were reviewed and mapped to retrospectively assign the groups photographed to Cape Bathurst, Bluenose West or Bluenose East herds. This assignment was then used to derive the parameters required to generate population estimate.

METHODS

Radio-collaring

Caribou wintering near Inuvik in 1990 were captured with a handheld net gun (Wildlife Control Ltd, Calgary, Alberta) fired from a Bell 206B helicopter (Barrett, Nolan & Roy, 1982). Capture surveys were conducted over open tundra and lake during periods when there was (1) sufficient snow to impeded the movement of caribou and cushion their fall after netting, (2) good contrasting light conditions, (3) little or no wind, and (4) temperatures were not severe. Caribou were fitted with radio collar (model 600, SA mortality sensors, Telonics Corp. Ltd., Mesa, AZ; model LMRT-4, STO-1 mortality sensor, Lotek Engineering Inc., Aurora, Ont.; AVM collars with mortality sensor, AVM, Calif.). Collars were covered with numbered colored canvas covers (orange with black numbers and green with yellow numbers) to make them more conspicuous. We captured the caribou during November, February, and March to allow enough time for the radio-collared animals to disperse throughout the population prior to the July photocensus.

Reconnaissance/telemetry surveys

Telemetry surveys were flown during late winter to determine the number of caribou with active radio collars. Reconnaissance surveys were conducted on a daily basis prior to and during the photo survey to locate and monitor the movements and distribution of caribou associated with radio-collared animals. Transect lines were spaced 18.5 apart to provide 100% telemetry coverage of the post-calving area. Surveys were flown with a Cessna 185 aircraft equipped with a model TS-1 scanner/receiver and 2 model RA-2AK dual element antennae (Telonics Corp. Ltd., Mesa, AZ), at an altitude of 3,076 m (10,000 ft) above ground level (agl).

Photography

Once suitably aggregated, groups were photographed from a Cessna 185 aircraft using 35 mm single lens reflex cameras equipped with standard 50 mm lenses, motor drives, through-the lens automatic light metering and Kodachrome 64 slide film. Two observe/aircraft teams were used during the photo survey, one to photograph groups in the Paulatuk area and the second to photograph groups in the Coppermine area. The photographs were taken at an oblique angle from the opened side windows of the aircraft which was positioned 150 to 300 m agl, slightly back from the near edge of the group, and between the sun and the caribou to ensure good contrast. Continuous exposure could be obtained through the use of two cameras as one observer could reload while the other photographed. The identification number, Global Positioning System (GPS) location, radio frequency of the collars present, film roll number and frame number were recorded for each group photographed.

Photo interpretation

Once developed, the slides were projected onto 21.5 by 28 cm sheets of white paper. The extent of overlap between adjacent slides was determined by drawing lines along natural topographic features common to both slides. Areas of overlap were excluded. All features on the images that were considered to be caribou were marked with a pencil and counted using a tally machine. A magnifying glass was usually used to aid in photo interpretation. Calves were not counted because they are difficult to identify or accurately count on aerial photos. One observer was used to complete the photo count. Photo interpreter bias was not estimated.

Estimates of group size

Unique groups of caribou were identified by tracking radio-collared animals. Group size was determined by counting caribou on the photos taken of each group.

Population size

The number of caribou available for the 1992 photocensus was determined by reviewing the VHF telemetry tracking records for the period 1986 and 1993. The photo count data provided an estimate of the minimum number of non-calf caribou in the Cape Bathurst and Bluenose-West barren-ground caribou herds. However, because not all collared caribou are associated with aggregations and not all aggregations will always contain a collared caribou, total herd size will always be larger than the minimum count obtained during a photocensus (Russell et al., 1996). We estimated the total population size using a modification of the method presented by (Russell et al., 1996) that is based on the Lincoln-Petersen Index as applied to radio-telemetry data by (White & Garrott, 1990). Not all aggregations photographed contained a radio-collared caribou but they were typically found in close proximity to aggregations that

contained radio-collared caribou. We assumed that these groups formed a general aggregation of caribou that under more favorable conditions would have form one group. By this method

$$N = (((M+1)(C+1))/(R+1))-1$$

Where: N = estimate of population size during the census

M = number of radio-collared caribou present in the herd (including all collars known to be active during the survey)

C = number of caribou in all aggregations observed during the survey

R = number of radio-collared caribou observed in these aggregations during the survey.

The 95% CI for the estimate can then be calculated as $N_i = 1.96 \text{ Var}(N)^{0.5}$, where:

$$\text{Var}(N) = ((M+1)(C+1)(M-R)(C-R))/(R+1)^2(R+2)$$

Comparison of population estimates

We used Lincoln-Petersen estimators to determine if the relative abundance of caribou (K) in each herd during 1987 and 1992 was significantly different (Williams et al., 2002). We assumed that capture probabilities were different between 1987 and 1992. We estimated K and constructed the appropriate 95% confidence intervals as follows (Williams et al., 2002):

$$K = [((n_{b1}+1)(n_{b2}+1)/(m_{b2}+1))-1]/(n_{a1}n_{a2})/m_{a2}$$

with

$$\text{var}(K) = (m_{a2}n_{b1}^3n_{b2}/m_{b2}^3n_{a1}^3n_{a2})[((n_{b2}-m_{b2})(n_{b1}-m_{b2})(m_{a2}n_{a1}n_{a2}))+((n_{a2}-m_{a2})(n_{a1}-m_{a2})(m_{b2}n_{b1}n_{b2}))]$$

where n_1 = number of collared animals available for the photo-census, n_2 = number of caribou associated with radio collared caribou located, m_2 = number of collared caribou located during the photo-census, and the subscripts a and b refer to time period 1 and 2 of the comparisons, respectively.

We calculated the 95% CI of K as $1.96 \text{ Var}(K)^{0.5}$ (Williams et al., 2002). If K was < 1 and the 95% CI did not include 1, the population estimate for time period 2 was significantly lower than that for time period 1. If K was > 1 and the 95% CI did not include 1, the population estimate for time period 2 was significantly higher than that for time period 1. If the 95% CI around K included 1, the population estimates for time periods 1 and 2 were not significantly different.

Group size and number of collars

To determine whether or not there was a relationship between groups size and the number of collars (regardless of sex), we compared the observed versus expected number of radio-collared caribou among the groups located during the census using a Chi-square test (Gibbons, 1985). The expected number was based on the mean number of caribou observed per radio collar during the census.

Evaluation of the photocensus

For a radio-search census to be accurate, the following 3 conditions must be met (Valkenburg, Anderson, Davis & Reed, 1985):

1. the caribou must be aggregated during the census, and the number of groups must not be large compared to the number of radio-collared individuals;
2. radio-collared caribou must be distributed randomly throughout the population, that is, group size and the number of radios in a groups are independent; and,
3. all radio-collared caribou must be heard and precisely located.

The first requirement was assessed during the census. To assess the second requirement, a contingency analysis was used to test whether radio-collared caribou were randomly distributed among groups by group size. The number of radio collars heard and precisely located was recorded during the survey (requirement 3).

RESULTS

Radio-collaring

Forty-seven caribou (8 males, 39 females) were radio-collared on winter ranges in the Inuvik, NT area and near Dismal Lakes, NU during winters of 1988 to 1992, including 30 females and 8 males between Inuvik and the Anderson River and 9 females in the Dismal Lakes and Rae/Richardson rivers area west of Kugluktuk. Seven (2 males and 5 females) of the 47 caribou died prior to July 1992, two of these were from the Kugluktuk area. One collar had not been heard since June 1988 and was considered to have expired. Forty radio-collared animals were available for the 1992 photocensus including 7 in the Bluenose-East herd (7 females), 27 in the Bluenose-West herd (22 females and 5 males), and 6 in the Cape Bathurst herd (3 females and 3 males).

Reconnaissance/telemetry surveys

Reconnaissance telemetry surveys for the photocensus were conducted 30 June – 5 July 1992 (Figure 1). Cow groups were located north of Harrowby Bay on the Cape Bathurst Peninsula and between the Hornaday River and Bluenose Lake. Bull groups were located east of Harrowby Bay and west of Langton Bay. Five of the seven radio-collared female caribou from the Kugluktuk area were located east of Bluenose Lake.

Photography

Caribou were loosely associated on 30 June and 1 – 2 July but had formed large post-calving aggregations suitable for photography by 6 July. During 2 July and 6 to 11 July, a total of 56 post-calving aggregations were photographed.

Photo interpretation

To avoid the possibility of double counting caribou, only 40 of the 56 groups photographed were considered to be discrete (i.e. 19 groups without collars, 21 groups with 32 collars unique to them) and were included in the analysis. Five collars were located on the post-calving grounds but not included in the photocensus: 1) #50 was a lone bull, 2) #90 was a cow with a calf, 3) #68 was photographed in group 21 with #73, however, #73 was counted in group 56 with #75, 4) #85 and #88 were with #38 in group 40, however #38 was counted in group 36 with #41 and #78. Caribou in the 40 groups photographed were counted over a 15 day period by the individual who did the 1986 and 1987 counts (John Russell).

Population estimates

Four of the six available radio-collared caribou in the Cape Bathurst herd were photographed (Table 4). We counted 16,524 non-calf caribou on the photos taken (Table 1). Three of the 6 groups photographed contained radio-collared caribou (Table 1). The largest group photographed was 5,244 non-calf (Table 4). The population estimate for this herd was 23,134 \pm 9,894 non-calf caribou (CV = 8%) (Table 4). The population estimates based on the groups and radio-collared caribou photographed on in 1992 was not significantly different from that for 1986 (K = 1.72; upper and lower 95% CI are 0.68 and 2.76, respectively) or 1987 (K = 1.80; upper and lower 95% CI are 0.51 and 3.09, respectively).

Twenty-three of the 27 available radio-collared caribou in the Bluenose-West herd were photographed (Table 4). We counted 76,008 non-calf caribou on the photos taken (Table 2). Fourteen of the 30 groups photographed contained radio-collared caribou (Table 2). The largest group photographed contained 12,262 non-calf caribou (Table 2). The population estimate for this herd was 88,676 \pm 13,137 non-calf caribou (CV = 22%)(Table 4). The population estimates based on the groups and radio-collared caribou photographed on in 1992 was not significantly different from that for 1986 (K = 1.00; upper and lower 95% CI are 0.82 and 1.18, respectively), but was significantly lower than that for 1987 (K = 0.81; upper and lower 95% CI are 0.67 and 0.95, respectively).

We photographed 4 groups of caribou on the post-calving range of the Bluenose-East herd (Table 3). These groups included 5 of the 7 available collars. We counted 13,232 non-calf caribou in these groups. There were an insufficient number of caribou radio-collared in the Bluenose-East herd to obtain a population estimate.

Evaluation of the photocensus

The condition that caribou must be grouped during the census was fulfilled. Forty discrete groups were photographed of which 21 (52.5%) contained radio-collared caribou (Tables 1, 2, and 3). The groups photographed in the Cape Bathurst herd that contained radio-collared caribou included 80% of the non-calf caribou counted for this herd. Similarly, the groups photographed in the Bluenose-West herd that contained radio-collared caribou included 73% of the non-calf caribou counted for this herd. In both herds the majority of the caribou counted were in groups that contained radio-collared caribou. The condition that radio-collared caribou must be distributed randomly throughout the population was satisfied. Contingency analyses failed to reject the null hypothesis that group size and the number of radio collars in a group are independent ($X^2 = 6.833$, $df = 4$, $0.10 < p < 0.25$, Table 5). The condition that all radio collars must be heard and precisely located was not satisfied as 9 radio-collars were not located.

DISCUSSION

The 1992 photocensus provides only minimum population estimates for the Cape Bathurst and Bluenose-West barren-ground caribou herds. There was an insufficient number of radio collars deployed within the range of the Bluenose-East herd to obtain a minimum estimate. The proportion of radio-collared caribou located, movement of collars, herd composition, and photo interpretive error influence the accuracy and precision of photocensus population estimates. Collar movement was a problem and necessitated omitting 3 radio-collared caribou from the count to avoid double counting. Herd composition was not determined and photo interpretive error was not estimated.

The status of the Cape Bathurst and Bluenose-West herds, i.e., whether they were stable, increasing, or decreasing is inconclusive. Given the estimated size of the Cape Bathurst and Bluenose-West herds in 1986, 1987, and 1992, there was likely an insufficient number of radio-collared caribou in these herds to obtain an accurate population estimate. The size and status of the Bluenose-East herd is unknown.

ACKNOWLEDGEMENTS

Funding for the radio-collaring and surveys was provided under the terms of the Inuvialuit Final Agreement. Jim Hodges and Michael McNeil (Sunrise Helicopters, Inuvik) and Bob Chelifors (Canadian Helicopters, Inuvik) flew Bell 206B helicopters during capture/radio-collaring surveys. Cecil Rilling (Inuvik Air Charter, Inuvik) flew Cessna 185 fixed-wing aircraft during reconnaissance,

telemetry and photocensus surveys. Bruce McLean assisted with the capture and radio-collaring and took many of the photos during the photocensus. John Russell counted caribou on the census photos. Steve Gray produced the maps. Anne Gunn and Mark Williams of the GNWT Renewable Resources, and Ken Whitten, Alaska Department of Fish and Game, reviewed an earlier draft and provided constructive criticism.

ADDENDUM

Due to the uncertainty of the July 1992 population estimate, a photocensus was attempted again in July 1993. Our objectives were to locate all radio-collars caribou in 1993 and to conduct composition counts on photographed groups. We assumed only 29 (4 males and 25 females) of the 46 collars that had been working in July 1992 would be functioning in July 1993 including:

- 1) 1 of 9 collars deployed during 1985 – 1987 was relocated and known to be active in March 1993. The remaining 8 had expired.
- 2) 28 of 37 collars deployed during 1988 – 1992. Fifteen of the 28 were relocated and known to be active in March 1993. Six collars were on mortality mode while 3 had not been heard since they were deployed.

Thirty-five adult caribou (5 males and 30 females) were radio-collared during 25 March and 6 April 1993, bringing the total number of radio-collared caribou to 64 (9 males and 55 females). A pre-census flight of the post-calving area was flown between 29 June and 9 July 1993. Fifty-five of the 64 radio collars (86%) were relocated: 20 of 30 (67%) radio collars deployed during 1985 – 1992 and all 35 of the radio collars deployed in 1993. However, these 55 collars only accounted for approximately 30,000 non-calf caribou. Areas as far west as Liverpool Bay and as far south as Great Bear Lake were searched but no other collars or caribou were located, and the photocensus was called off.

Table 1. Number of radio-collars and caribou in each group photographed in the Cape Bathurst herd on 6 to 11 July 1992.

Group No.	No. Collars	Date	Latitude	Longitude	Adults
2	0	06-Jul-92	70.200	-127.567	720
7	1	06-Jul-92	70.300	-127.567	4871
19	1	08-Jul-92	70.317	-127.500	3107
20	0	08-Jul-92	70.383	-127.467	1922
22	0	08-Jul-92	70.483	-127.750	660
56	2	11-Jul-92	70.133	-127.067	5244
6	4				16524

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Table 2. Number of radio-collars and caribou in each group photographed in the Bluenose-West herd on 6 to 11 July 1992.

Group No.	No. Collars	Date	Latitude	Longitude	Adults
8	0	07-Jul-92	68.883	-123.167	370
11	0	07-Jul-92	68.933	-123.083	1448
13	2	08-Jul-92	69.267	-126.000	4395
14	2	08-Jul-92	69.283	-126.083	10272
15	0	08-Jul-92	69.350	-125.767	1379
16	0	08-Jul-92	69.350	-125.783	1966
17	0	08-Jul-92	69.367	-125.833	4427
23	3	08-Jul-92	69.100	-123.167	3436
24	1	08-Jul-92	69.033	-122.517	721
25	0	08-Jul-92	69.033	-122.567	334
26	0	08-Jul-92	69.033	-122.417	168
27	0	08-Jul-92	69.033	-122.450	385
28	0	08-Jul-92	69.433	-122.400	182
29	1	09-Jul-92	68.900	-122.550	271
30	1	09-Jul-92	68.717	-122.383	1305
32	0	09-Jul-92	68.733	-122.133	1366
33	0	09-Jul-92	68.850	-121.917	768
34	0	09-Jul-92	68.850	-121.917	447
35	0	09-Jul-92	69.050	-122.683	2934
36	3	09-Jul-92	68.783	-122.100	12262
37	2	09-Jul-92	68.717	-121.933	3834
38	0	09-Jul-92	68.733	-122.267	1741
39	1	09-Jul-92	68.700	-121.733	3680
44	1	10-Jul-92	69.550	-121.883	69
45	1	10-Jul-92	69.800	-122.417	52
47	1	10-Jul-92	69.500	-122.583	1861
52	1	11-Jul-92	69.633	-123.083	7778
53	3	11-Jul-92	68.717	-122.917	5715
54	0	11-Jul-92	68.783	-122.883	928
55	0	11-Jul-92	69.133	-126.167	1514
30	23				76008

Table 3. Number of radio-collars and caribou in each group photographed in the Bluenose-East herd on 6 to 11 July 1992.

Group No.	No. Collars	Date	Latitude	Longitude	Adults
48	1	10-Jul-92	68.950	-119.167	181
49	1	10-Jul-92	68.950	-117.417	1957
50	2	10-Jul-92	68.583	-119.083	9678
51	1	10-Jul-92	68.467	-119.083	1416
4	5				13232

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Table 4. Non-calf population estimates for Cape Bathurst and Bluenose-West barren-ground caribou herds in 1986, 1987, and 1992.

Herd	Year	M	C	R	N	95% CI	Number Counted on Photos	Coefficient of Variation (%)
Cape Bathurst	1986	3	13476	3	13476			
	1987	6	10728	5	12516	± 3504	10728	14
	1992	6	16524	4	23134	± 9894	16524	8
Bluenose-West	1986	35	83460	33	88369	± 6899	83460	4
	1987	45	104512	43	109263	± 6655	104512	3
	1992	27	76008	23	88676	± 13137	76008	22

The estimate of population size for each census was calculated as

$$N = (((M+1)(C+1))/(R+1)) - 1; \text{ where:}$$

N = estimate of population size during the census

M = number of radio-collared caribou present in the herd (including all collars known to be active during the survey)

C = number of caribou observed in aggregations containing at least one radio-collared caribou during the survey

R = number of radio-collared caribou observed in these aggregations during the survey.

The 95% CI for the estimate was calculated as $N_i \pm 1.96 \text{ Var}(N)^{0.5}$, where:

$$\text{Var}(N) = ((M-1)(C-1)(M-R)(C-R))/(R+1)^2(R+2)$$

Table 5. Distribution of radio-collared caribou among post-calving aggregations of Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou, 2 – 11 July 1992.

Group Size	No. of Groups	Group No.	No. of Caribou	No. of Collars Observed	No. of Collars Expected
1 - 1600	21	2,8,15,22,24,25,26, 27,28,29,30,32,33, 34,44,45,47,48,51, 54,55 11,16,19,20,35,38,	16214	8	5.1
1601 - 3100	7	49	16203	2	5.1
3101 - 4400	5	7,23,37,39,53	19442	10	6.1
4401 - 10000	5	13,14,17,52,56	26973	7	8.5
10001 - 13000	2	36,50	22469	5	7.1
Total	40		101301	32	32

Number of caribou per radio-collar = 3166
 Chi-square = 6.833, d.f. = 4, 0.10 < p < 0.25

Figure 1. Distribution of capture sites for Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou radio collared during winters 1988 to 1992.

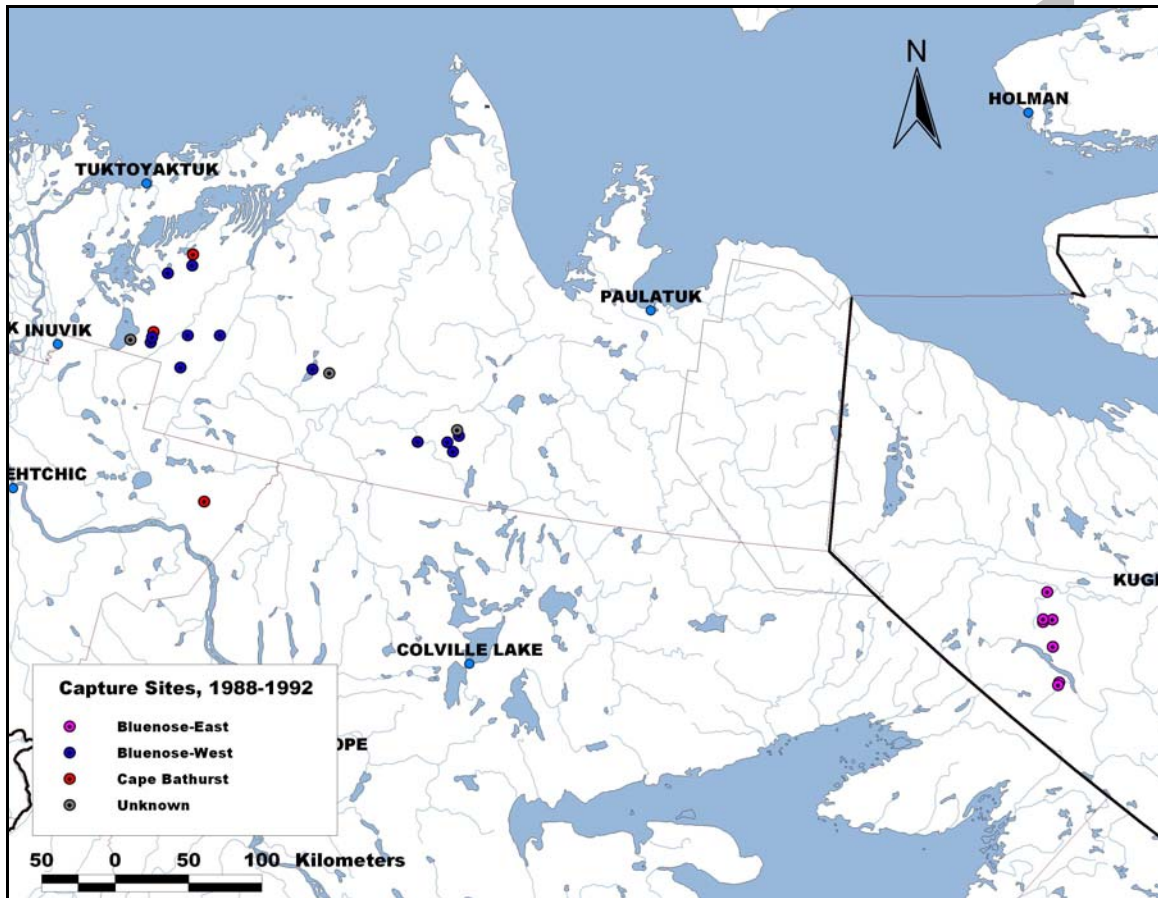


Figure 2. Survey lines (Ray I have a draft map that we produced in 1992 that I will have scanned as a jpeg and insert here—I don't have the coordinates for the ends of the transect lines to generate a map in ArcView)

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Figure 3. Distribution of radio-collared Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou relative to where they were captured during winters 1988 to 1992.

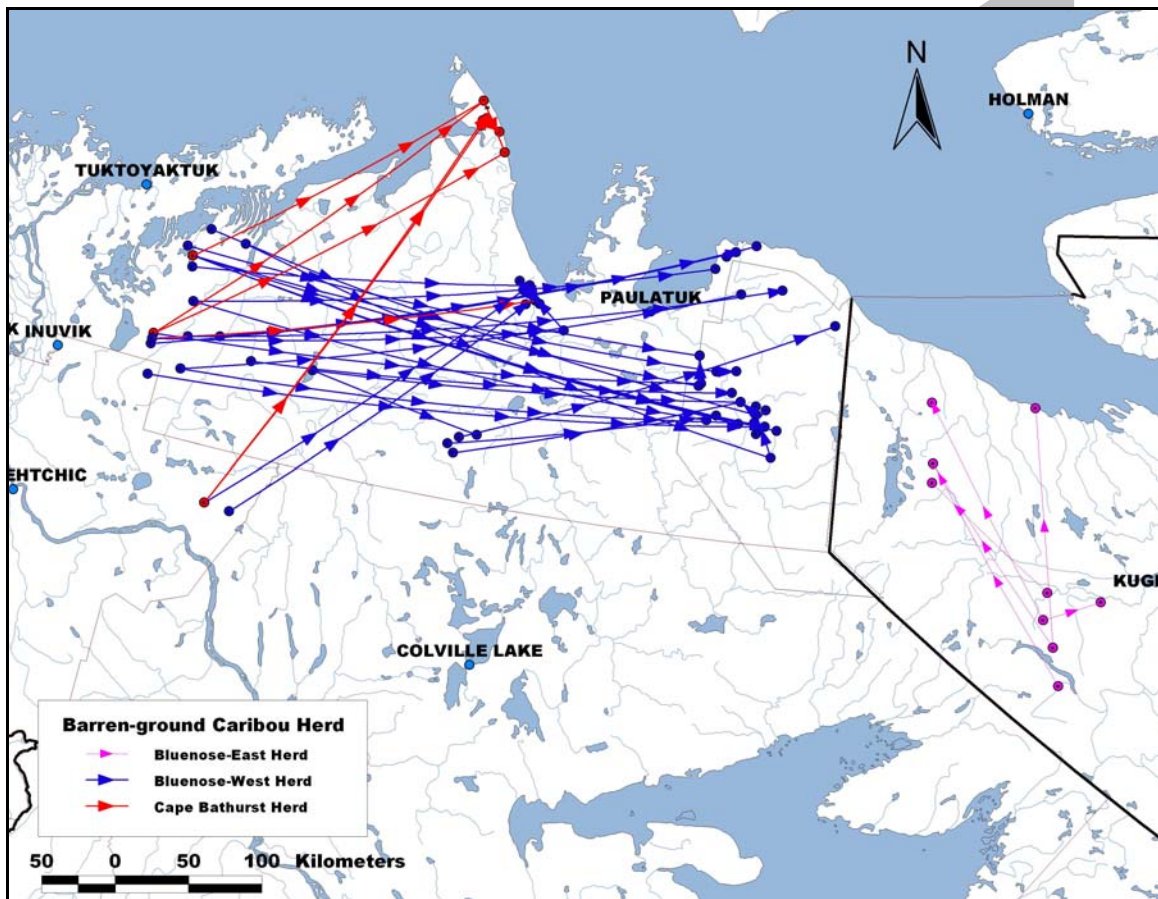


Figure 4. Distribution of groups of Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou photographed during 2 to 11 July 1992.

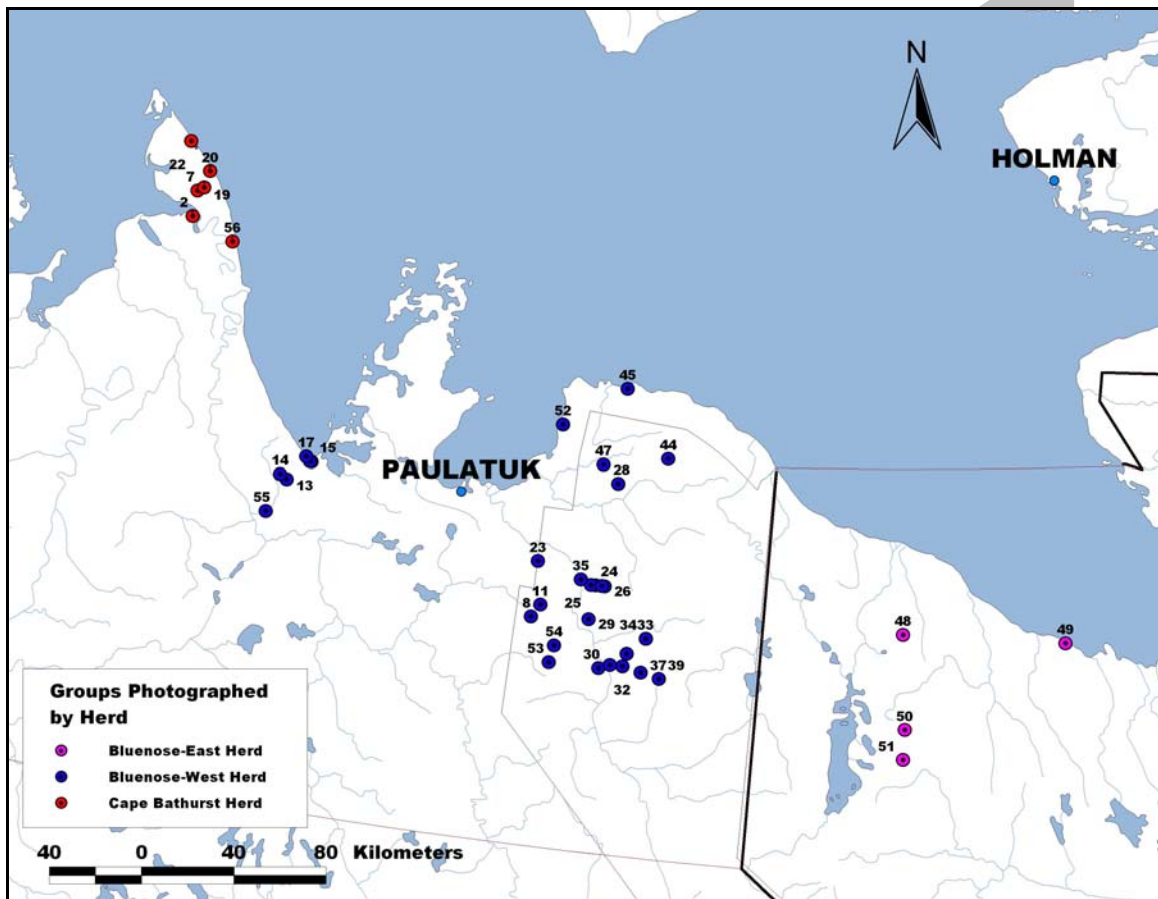
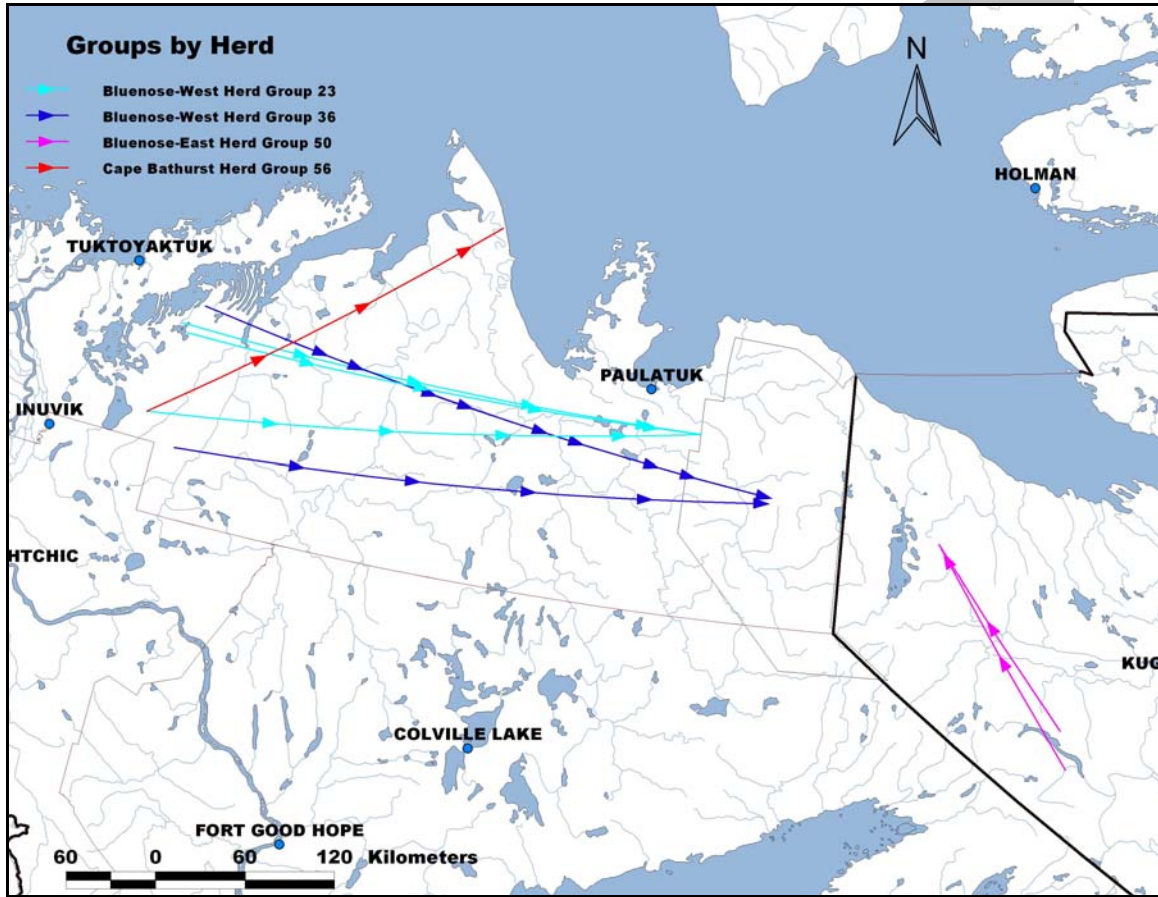


Figure 5. Distribution of the largest groups photographed in the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds relative to the sites where the radio-collared caribou in those groups were captured.



Appendix 1. Post-calving photo survey field schedule and weather conditions, 30 June – 11 July 1992.

Date	Weather	Activity
30-Jun-92	clear, 24°C	radio tracking Paulatuk
01-Jul-92	clear, 24°C	radio tracking Paulatuk
02-Jul-92	fog, low cloud, drizzle, 4°C	weather day
03-Jul-92	fog, low cloud, drizzle, 4°C	ferry to Inuvik
04-Jul-92		Inuvik
05-Jul-92	15% cloud cover, 16°C	radio tracking Paulatuk
06-Jul-92	clear, 6°C	photos, grps 3 - 7, Paulatuk
07-Jul-92	clear, 6°C	photos, grps 8 - 12, Paulatuk
08-Jul-92	clear, 9°C	photos, grps 13 - 28, Paulatuk
09-Jul-92	clear, 18°C (Paulatuk)	photos, grps 29 - 39, Paulatuk
09-Jul-92	clear, 12°C (Kugluktuk)	radio tracking Kugluktuk
10-Jul-92	clear, 12°C (Paulatuk)	photos, grps 40 - 47, Paulatuk
10-Jul-92	clear, 22°C (Kugluktuk)	photos, grps 48 - 51, Kugluktuk
11-Jul-92	clear, 22°C (Paulatuk)	photos, grps 52 - 56, Paulatuk



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