

ESTIMATES OF THE NUMBER OF BARREN-
GROUND CARIBOU IN THE CAPE BATHURST
AND BLUENOSE-WEST HERDS DERIVED
USING POST CALVING PHOTOGRAPHY,
JULY 2000

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INTRODUCTION

In 1994, as part of the Bluenose barren-ground caribou herd management planning and environmental impact assessment process, distribution data obtained during population and telemetry surveys done between 1966 and 1993 were analyzed using a computer geographic information system (GIS) to define the seasonal ranges of the Bluenose barren-ground caribou herd (Nagy et al. 1999a). That analysis indicated there were three calving and two rutting areas within the range of the 'Bluenose caribou herd'. Caribou management has been based on the herd concept, where herds are identified based on their use of traditional calving grounds ((Thomas 1969), (Gunn and Miller 1986) . Applying this approach, (Nagy et al. 1999b) hypothesized that there were two, and possibly three, herds within the range of the 'Bluenose' caribou herd.

Satellite tracking and genetic studies similar to those done to define polar bear populations (Paetkau et al. 1995), (Bethke et al. 1996) were initiated in March 1996 to identify the number of caribou herds within the 'Bluenose' range (Nagy et al. 1999b), (Zittlau et al. 2003). Tissue samples were also collected from the well-defined Porcupine (*R. t. granti*) and Bathurst herds (*R. t. groenlandicus*) herds to the west and east of the Bluenose range, respectively, to extract DNA for genetic comparisons. The results of these studies strongly support the hypothesis that there are three herds of barren-ground caribou within the range previously ascribed to the 'Bluenose caribou herd' (Nagy et al. 1999b; Zittlau et al. 2003). These data show that the herds use different seasonal ranges (especially calving) (Nagy et al. 2005) and are genetically different (Nagy et al. 1999b), (Zittlau et al. 2003). For convenience we have referred to these herds as the Cape Bathurst, Bluenose-West, and Bluenose-East herds.

The first photo-census surveys of the 'Bluenose' herd were completed in 1986 and 1987 (McLean and Russell 1992). (Nagy in prep. a) reviewed and mapped (McLean and Russell 1992) capture locations and movement data in order to assign the groups photographed in 1986 and 1987 to Cape Bathurst, Bluenose-West, or Bluenose-East herds and to derive the parameters required to generate population estimate using a modified Lincoln-Petersen estimator (Russell et al. 1996). (Nagy in prep. a) was not able to derive the parameter required to derive a modified Lincoln-Petersen estimate for the 1986 survey as the data were not well documented, however, there were 83,460 and 13,476 non-calf caribou counted in the groups photographed within the post-calving ranges of the Bluenose-West and Cape Bathurst herds, respectively (McLean and Russell 1992). Based on (Nagy in prep. a) re-analysis of the 1987 data, the Bluenose-West and Cape Bathurst herds were estimated at $98,874 \pm 3,145$ and $14,529 \pm 2,542$ non-calf caribou, respectively, in the 1987. A similar re-analysis of the 1992 photo-census data resulted in estimates of $64,705 \pm 9,057$ and $17,521 \pm 5,352$ non-calf caribou in the Bluenose-West herds and Cape Bathurst, respectively (Nagy in prep. a).

Prior to the 1986, 1987, and 1992 photo-census surveys, the majority of the caribou that were radio-collared were captured in the western and central portions of the range of the 'Bluenose' herd (now defined as ranges of the Cape Bathurst and Bluenose-West caribou herds)(Nagy in prep. a). As a result, there were an insufficient number of radio collars deployed in the eastern portion of the 'Bluenose' range (now defined as range of Bluenose-East herd) to derive reliable estimates of the number caribou in this area (Nagy et al. 1999a), (Nagy in prep. a).

In 1999 and 2000, the Department of Environment and Natural Resources, GNWT in cooperation with the Government of Nunavut, designed and completed the first photo-census surveys designed to estimate the size of the Cape Bathurst, Bluenose-West, and Bluenose-East herds. (Patterson et al. 2004) estimated the size of the Bluenose-East herd to be 103974 ± 22101 non-calf caribou in 2000. This report presents the results of photo-census surveys completed for the Cape Bathurst and Bluenose-West barren-ground caribou herds.

METHODS

VHF and satellite radio collar deployment

We used two capture techniques to deploy radio collars. During July 1999 a motorized boat was used to pursue and capture caribou while they were crossing Rendezvous Lake. A shepherd's crook was used to capture the animals around the neck and draw them along side the boat. The capture crew included three people: one person that operated the boat, one person that held the caribou along side the boat, and one person that deployed the radio collars. During winter 1999-2000 caribou wintering near Inuvik and Fort Good Hope were captured with a handheld net gun (Wildlife Control Ltd, Calgary, AB) fired from a Bell 206B helicopter. Capture surveys were conducted over open tundra and lakes during periods when there was (1) sufficient snow to impede 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 VHF radio collars (Telonics Corp. Ltd., Mesa, AZ and Lotek Engineering Inc., Aurora, OT). Caribou were radio-collared in the areas occupied by satellite-collared caribou in each herd and in areas where hunter reports indicated there were caribou.

Reconnaissance/telemetry surveys

We conducted reconnaissance surveys during 9 - 13 June and on 20 June using a Cessna 195 fixed wing aircraft equipped with a pair of strut-mounted antennae. These flights were undertaken to verify the status of radio-collared caribou in the two herds. Telemetry flights were also flown daily, weather permitting, from 26 June to 16 July to locate and monitor the movements and degree of aggregation

of caribou associated with the radio-collared animals. Transect lines were spaced approximately 18.5 km apart. Surveys were flown at an altitude of 914 to 1524 m above ground level (agl) with a Cessna 185 fixed-wing aircraft equipped with a Telonics scanner/receiver and 2 model RA-2AK dual antennae (Telonics Corp. Ltd., Mesa, AZ).

The distribution and movements of the Cape Bathurst and the Bluenose-West herds were monitored by following the movements of 3 Cape Bathurst and 9 Bluenose-West caribou equipped with ARGOS satellite collars and xx active VHF beacons. We regularly mapped the most recent locations of VHF and satellite radio-collared caribou using OziExplorer GPS Mapping Software, Version 3.95.4m, D & L Software Pty Ltd. so that tracking and monitoring efforts could be allocated effectively.

Aerial photography and image processing

Once suitably aggregated, groups were photographed from a Cessna 185 fixed-wing aircraft with a handheld motor driven 35 mm Nikon F70 camera equipped a Tamron AF 28 – 200 zoom lens. We attempted to photograph each aggregation in a single pass to minimize movement of caribou between frames and to allow for 20% overlap between successive photos. We recorded the group number, GPS coordinates, frequencies of radio-collars present, and the roll and frame numbers of any photographs taken of each aggregation. All groups were photographed using Fujichrome Sensia II 200 ASA color transparency film. The slides were then scanned at 2400 dots per inch (dpi) using a Hewlett Packard Photosmart S20 Photo Scanner.

We selected the best photo or series of photos taken of each group and printed these on 38.6 X 50 cm paper. For groups that were photographed over a series of photos, we identified the unique portions of each photo and marked the boundaries of these on the paper prints. We used OziExplorer GPS Mapping Software, Version 3.95.4m, D & L Software Pty Ltd. to create a photomap of each digital image. For groups that were photographed over a series of photos, we transferred the boundaries of the unique portions of each image as marked on the paper prints to the corresponding photomaps by creating track lines on the digital image. Once this was completed, the photomaps were visually scanned on a computer screen and a waypoint was created on each non-calf caribou. The waypoint count gave the number of non-calf caribou present on each photomap. OziExplorer allowed us to easily change the view magnification as required to ensure that all non-calf caribou could be accurately identified and counted

Population Size

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 photo-census (Russell et al. 1996). We estimated the total population size using (Russell et al. 1996) that is based on the Lincoln-Petersen Index as applied to radio-telemetry data by (White and Garrott 1990). 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 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 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 1992 and 2000 was significantly different (Williams et al. 2002). We assumed that capture probabilities were different between 1992 and 2000. 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

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

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.

RESULTS

VHF and satellite radio collar deployment

A number ARGOS satellite collars were deployed on caribou in the Cape Bathurst (n = 5) and Bluenose-West herds (n = 5) during 1996. Two of these collars in each herd were transmitting during late June and early July 2000.

In March 1999 we captured and equipped 1 Cape Bathurst and 8 Bluenose-West cows with ARGOS satellite collars (Table 1). In summer 1999 we attempted to capture and radio-collar caribou at water crossings. In late July 1999 we spent approximately 7 days waiting for the Bluenose-West caribou herd to cross Rendezvous Lake. We positioned ourselves daily at sites where caribou typically crossed Rendezvous Lake during this period (Billy Jacobson, pers. comm.). Few caribou crossed the lake while we were there and we captured and collared only 2 caribou (1 bull and 1 cow)(Table 1)(Figure 1). Again in late August we spent approximately 7 days at Rendezvous Lake and collared only 8 caribou (2 bulls and 6 cows). Although this method of capture may be preferred because stress to the animals is minimized, caribou movements may not be predictable in some years making this method of capture less efficient. Due to our poor success at Rendezvous Lake, we deployed the remainder of the collars using helicopter capture techniques. In March 2000 we deployed radio collars on 13 Cape Bathurst caribou (3 bulls and 11 cows) and on 35 Bluenose-West caribou (7 bulls and 28 cows)(Table 1)(Figure 1).

Verification of Status of Radio-Collared Caribou

We flew telemetry surveys daily, during the period 9 to 13 June, 20 June 2000, and 26 June to 16 July 2000, weather permitting, to verify the status of radio-collared caribou and to monitor their movements (Table 1). The transect lines flown during these surveys are shown in Figure 2. In late June/early July 2000 there were 50 functional radio collars (including VHF and ARGOS satellite collars) on Bluenose-West caribou and 17 on Cape Bathurst caribou (Table 2). We were not able to verify the status of 5 radio collars deployed on the winter range of the Bluenose-West herd and 2 radio collars deployed on the winter range of the Cape Bathurst herd (Table 2). Given the extensive area that was flown during reconnaissance/telemetry surveys (Figure 2) we believe that these collars failed prior to the photo-census.

Distribution of Radio-Collared Caribou Relative to Capture Sites

Figures 3 and 4 show the movements of the radio-collared cow and bull caribou that we tracked during 9 June to 16 July 2000 relative to the sites where they were captured, respectively. Caribou found on the Cape Bathurst calving/post-calving range were mostly captured in the area south and east of Tuktoyaktuk and southeast to Crossley Lakes. One Cape Bathurst cow was collared at

Carcajou Lake (approximately 115 km west of Colville Lake) on the southwestern portion of the Bluenose-West winter range (Figure 3). Caribou found on the Bluenose-West calving/post calving range were captured in the Colville Lake/Rendezvous Lake/Crossley Lakes area. Three cows and one bull in this herd were captured on the winter range of the Cape Bathurst herd (Figure 3 and 4). ENR Inuvik region does not have the capture sites and tracking data documented by Patterson et al. (2004) for caribou radio-collared in the Kugluktuk, NU area. As a result, we were not able to map the movements of the caribou located on the Bluenose-East caribou post-calving range relative to where they were captured. However, one Bluenose-East bull was collared at Manuel Lake (approximately 130 km west of Colville Lake) was located on the southwestern portion of the Bluenose-West winter range in early July 2000 (Figure 4)

Distribution of Satellite-Collared Cows by Herd

Figure 5 shows the movements of the satellite collared (ARGOS) Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou cows during the period 1 March to 15 July 2000. The movements of most of these satellite collared caribou were consistent with those documented by (Nagy et al. 2005). However, there was one anomaly. The satellite tracking data during 1996, 1997, 1998, and 1999 indicated that cow BW16576 belonged to the Bluenose-West herd (Figure 6). In winter 1999-2000 cow BW16576 was near Crossely Lakes with other Cape Bathurst and Bluenose-West caribou (Figure 3 and 4). In March 2000 cow BW16576 migrated northward onto the Cape Bathurst Peninsula and was on the calving, post-calving, and early summer ranges of the Cape Bathurst herd during 1 June to 15 July 2000 (Figure 5 and 6). We do not know how many Bluenose-West cows migrated onto the Cape Bathurst Peninsula with BW16576.

Post-calving Photo-census 2000

i. Bluenose-West Herd

We photographed unique groups of the Bluenose-West caribou were photographed on 6 (Patterson et al. 2004) and 9 July 2000. On 6 July 2000 (approx 02:00 AM) we located a group of approximately 20000 caribou near the south end of Bluenose Lake. This group included 5 Bluenose-West radio-collared caribou (5 VHF). We were not able to photograph this group as we were low on fuel and had to return to Paulatuk. Poor weather at Paulatuk prevented us from returning to the Bluenose Lake area later in the day on 6 July 2000. However, Patterson et al. (2004) photographed 3 groups of caribou totaling 18,748 adults in this area on 6 July 2000 (site 19, Figure 7 and 8). These groups included 3 Bluenose-East radio-collared caribou (2 VHF and 1 UHF) (Patterson et al., 2004). Based on the number of radio-collared Bluenose-West and Bluenose-East animals in the area we assumed that approximately 62.5% (5 of 8

collars) and 37.5% (3 of 8 collars) of these caribou were Bluenose-West and Bluenose-East caribou, respectively (Table 3).

The remainder of the Bluenose-West herd was sufficiently aggregated for photography on 9 July 2000. The sites where we photographed groups of Bluenose-West caribou on 9 July 2000 are shown on Figures 7 and 8. We photographed 18 groups, 14 of these contained radio-collared caribou (Table 3). A total of 32 of the 50 available radio-collared caribou were photographed (Table 4). We counted 30808 non-calf caribou on the photos taken, 26358 of these were in groups that contained at least one radio-collared caribou (excludes Patterson et al. 2004 data). The largest group we photographed included 5401 non-calf and 3 radio-collared caribou. On 9 July we located a large group of approximately 10000 to 15000 caribou in the Rummy Lake area (site 20, Figure 7 and 8). This group contained one radio-collared caribou (Table 3). We were not able to photograph this group as fog was forming along the coast and we had to return to Paulatuk. Fog prevented us from leaving Paulatuk until the afternoon of 11 July and by this time the caribou in the group at site 20 had dispersed. The population estimate generated for this photo session was 74273 ± 10591 non-calf caribou (CV = 10%)(Table 4).

The July 1999 and July 2000 population estimates were not significantly different ($K = 1.14$; upper and lower 95% CI are 0.80 and 1.47, respectively), suggesting that herd size was stable during this period. Weather conditions were generally cool and windy on the post-calving and early summer ranges of the Bluenose-West herd during 26 June to 16 July 2000. As a result, the caribou were dispersed on most days that we flew in the area. Weather conditions were generally hot and relatively calm throughout the area on 9 July 2000 and most of the herd was well aggregated. However, we may have missed significant numbers of caribou because unfavorable weather along the coast prevented us from completing the photo-census. As a result we may have missed some groups of caribou. As a result, we believe that herd size was underestimated.

ii. *Cape Bathurst Herd*

On 8 July 2006 we photographed 8 groups, 6 of these contained radio-collared caribou (Table 5). The sites where we photographed groups of Cape Bathurst caribou are shown on Figure 7 and 9. A total of 15 of the 17 available radio-collared caribou were photographed (Table 5). There were approximately 9857 non-calf caribou in the groups photographed; 8899 of these were in groups that contained at least one radio-collared caribou (Table 5). The largest group included approximately 5302 non-calf and 7 radio-collared caribou (Table 5). The population estimate generated for this photo session was 10013 ± 1132 non-calf caribou (CV = 8%)(Table 5).

The July 1992 and July 2000 population estimates were significantly different ($K = 0.53$; upper and lower 95% CI are 0.22 and 0.85, respectively), suggesting that

the herd had declined during this period. However, we believe that herd size was underestimated due to unfavorable weather conditions. Weather conditions were generally cool and windy on the Cape Bathurst Peninsula during 26 June to 16 July 2000, and as a result, the caribou were dispersed on most days when we flew in the area. We experienced the best conditions on 8 July 2000, although portions of the herd were poorly aggregated and as a result we may have missed as many as 2000-3000 caribou.

DISCUSSION

Comparisons of population estimates derived in 1992 and 2000 for the Cape Bathurst suggests that this herd declined significantly during this period. Data for the Bluenose-West herd suggests that herd size had not changed significantly between 1992 and 2000. However, the weather was cool and windy during late June and early July 2000, as a result the caribou were not aggregated during most days when we flew. The most favorable conditions for photography occurred on the 6 and 9 of July 2000 for the Bluenose-West herd and on 8 July 2000 for the Cape Bathurst herd. Unfavorable weather conditions on 9 July 2000 prevented us from completing the photo-census of the Bluenose-West herd, while not all caribou in the Cape Bathurst herd were aggregated in groups suitable for photography on 8 July 2000. As a result we believe that we may have missed significant numbers of caribou in each herd and therefore herd size was likely underestimated. (Russell et al. 1996) discussed 4 assumptions on which an accurate estimate of population size using post-calving photography and the Lincoln-Petersen estimator is dependent. The degree to which each of these assumptions was met during our photo-census is discussed below:

Assumption 1: The population is closed. Satellite tracking and genetic data indicate that the Cape Bathurst, Bluenose-West, and Bluenose-East herds are distinct from each other and adjacent herds (Porcupine and Bathurst herds) (Nagy et al. 2005; Nagy et al. 1999b; Zittlau et al. 2003). Range overlap occurs in some seasons, particularly during the winter (Nagy et al. 2005) but some overlap occurs between the Bluenose-West and Bluenose-East herds during the post-calving period in some years (Patterson et al. 2004). We found some evidence of mixing of herds on the post-calving and early summer ranges including:

- a group of 18748 caribou located at Bluenose Lake on 6 July 2000 contained 5 Bluenose-West (3 cows and 2 bulls) and 3 Bluenose-East radio-collared caribou,
 - one satellite collared Bluenose-West cow was also in the large group of caribou located at Bluenose Lake on 6 July 2000 but the VHF beacon was not transmitting, and
 - one satellite collared Bluenose-West cow was on the calving, post-calving, and early summer ranges of the Cape Bathurst herd during June and July 2000.
- Mixing of caribou may be more prevalent among large herds whose seasonal ranges are in close proximity. Our data indicates that there was significant overlap among caribou in the Bluenose-West and Bluenose-East herds in early

July, with 10% of the available Bluenose-West (5 of 50) and Bluenose-East (3 of 30) radio-collared caribou photographed in one group near Bluenose Lake on 6 July 2000. In comparison 2% of the available Bluenose-West radio-collared caribou (1 of 50) was photographed with Cape Bathurst during early July 2000. As a result the assumption of closure was not fully met during the survey.

Assumption 2: All highly aggregated groups contain at least one radio-collared caribou and thus can be located. We had a relatively high ratio of collars per caribou in each herd/area including:

- 1 per 1485 caribou in the Bluenose-West herd, and
- 1 per 589 caribou in the Cape Bathurst herd, and

As a result we believe that we located most significant groups of caribou on these post-calving ranges. However, not all groups of caribou were aggregated sufficiently for photography in the Cape Bathurst herd and unfavorable weather conditions prevented us from photographing all groups located in the Bluenose-West herd. Aggregations were clustered non-randomly across the landscape. Not all aggregations photographed contained a radio-collared caribou. We did not fully meet the conditions for this assumption and, as a result, we believe that we underestimated the size of both herds.

Assumption 3: Radio-collared animals are randomly distributed throughout the herd. Radio-collared animals that were available for the photo-census were deployed during March 1996; March, July, and August 1999; and March 2000. Caribou that were radio-collared during 1996 and 1999 had sufficient time to randomly mix in their respective herds. In March 2000, radio collars were deployed randomly on the winter ranges of the Cape Bathurst and Bluenose-West herds. Radio-collared caribou found within the largest groups photographed on the post-calving ranges of the Cape Bathurst herd on 8 July 2000 and the Bluenose-West herd on 9 July 2000, were captured over a wide geographic area suggesting that the radio-collared caribou were randomly distributed within these herds (Figure 10 and 11).

Assumption 4: No significant movement of individual caribou among photographed groups used in the estimate occurred during the photo-census. We did not detect any movement of radio-collared animals among groups when we photographed the Cape Bathurst or Bluenose-West herds on 8 and 9 July, respectively. We believe that this assumption was fully met.

In summary, caribou radio-collared during 1996, 1999, and 2000 were distributed randomly among caribou in these herds, and the status of the majority of these were verified prior to and during the photo-census. Weather conditions during late June and early July 2000 were cool and windy as a result there were few days when caribou aggregated for insect relief. The largest majority of caribou were found in each area because there was a relatively high ratio of radio-collars deployed per caribou in each herd. However, not all groups of caribou were aggregated sufficiently for photography in the Cape Bathurst herd and unfavorable weather conditions prevented us from photographing all groups located in the Bluenose-West herd. We did not fully meet all of the basic assumptions on which an accurate estimate of population size using post-calving

photography and the Lincoln-Petersen estimator is dependent. As a result, we believe that the population estimates generated for caribou on the post-calving ranges of the Cape Bathurst and Bluenose-West barren-ground caribou herds were underestimated.

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John Rees (Arctic Sunwest Charters, Yellowknife) expertly piloted the Cessna 185 fixed-wing aircraft used during the photo-census.

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Table 1. Number of radio-collars deployed on caribou in the winter ranges of the Cape Bathurst and Bluenose-West barren-ground caribou herds during 1996, 1999, and 2000.

Herd	Year	Type of Capture	Sex	Collar Manufacturer			Total
				Lotek VHF	Telonics VHF	Telonics ARGOS Satellite	
Bluenose-West	1996	helicopter assisted	female			2	2
		subtotal				2	2
	1999	helicopter assisted	female			8	8
		boat/water crossing ¹	female		7		7
		boat/water crossing ¹	male		3		3
		subtotal			10	8	18
	2000	helicopter assisted	female	24	4		28
		helicopter assisted	male	5	2		7
		subtotal		30	6		35
	Total			30	16	9	55
Cape Bathurst	1996	helicopter assisted	female			2	2
		subtotal				2	2
	1999	helicopter assisted	female			1	1
		subtotal				1	1
	2000	helicopter assisted	female		11		11
			male		3		3
subtotal				13		13	
Total			0	13	3	17	

¹ Caribou were radio-collared on 27 July 1999 and during 24 to 31 August 1999 at Rendezvous Lake, NT.

Table 2. Number of active radio-collars in the Cape Bathurst and Bluenose-West barren-ground caribou herds during late June and early July 2000.

Herd	Year deployed	No. of radio-collars not located			No. of radio-collars located		
		female	male	total	female	male	total
Bluenose-West	1996	1		1	1		1
	1999	2		2	13	3	16
	2000	2		2	26	7	33
	subtotal	5		5	40	10	50
Cape Bathurst	1996	2		2			
	1999				1		1
	2000				11	3	14
	subtotal	2		2	12	3	15

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Table 3. Number of non-calf caribou counted on photographs taken of Bluenose-West barren-ground caribou herd on 6 and 9 July 2000.

Date	Group	No. radio collars	No. of non-calf caribou counted on photos	Estimate of the no. of non-calf caribou in group
6-Jul-00	19 ¹	5		11700
9-Jul-00	1	1	462	462
9-Jul-00	2	1	1297	1297
9-Jul-00	3	0	2635	2635
9-Jul-00	4	1	119	119
9-Jul-00	5	1	921	921
9-Jul-00	6	0	203	203
9-Jul-00	7	0	1204	1204
9-Jul-00	8	1	1313	1313
9-Jul-00	9	7	4951	4951
9-Jul-00	10	1	758	758
9-Jul-00	11	3	5401	5401
9-Jul-00	12	2	894	894
9-Jul-00	13	2	2103	2103
9-Jul-00	14	1	592	592
9-Jul-00	15	0	408	408
9-Jul-00	16	3	5297	5297
9-Jul-00	17	1	2169	2169
9-Jul-00	18	1	81	81
9-Jul-00	20 ²	1		10000
Total		32	30808	52508

¹On 6 July (approx 02:00 AM) we located a group of approximately 20,000 caribou in the area of Bluenose Lake. This group included 5 Bluenose-West radio collared caribou (5 VHF). We were not able to photograph the group as we were low on fuel and had to return to Paulatuk. Poor weather at Paulatuk prevented us from returning to the area later in the day on 6 July. (Patterson et al. 2004) photographed 3 groups of caribou totaling 18,748 adults in the area on 6 July. These groups included 3 Bluenose-East radio collared caribou (2 VHF and 1 UHF) (Patterson et al. 2004). Based on the number of radio collared Bluenose-West and Bluenose-East animals in the area we assumed that approximately 62.5% (5 of 8 collars) and 37.5% (3 of 8 collars) of these caribou were Bluenose-West and Bluenose-East caribou, respectively.

²On 9 July we located a large group of approximately 10,000 to 15,000 caribou in the Rummy Lake area. We were not able to photograph this group as fog was forming along the coast and we had to return to Paulatuk. Poor weather conditions prevented us from returning to the area until the afternoon of 11 July and by this time the caribou had dispersed.

Table 4. Non-calf population estimates for Cape Bathurst and Bluenose-West barren-ground caribou herds in 1986, 1987, 1992, and 2000.

Herd	Year	M	C	R	N	Number Counted on Photos	Coefficient of Variation (%)
Bluenose-West							
	1986 ¹	?	83460	33	83460	83460	
	1987 ¹	43	96626	42	98874 ± 3145	101067	2
	1992 ²	31	48528	23	64705 ± 9057	72049	10
	2000 ³	50	48058	32	74273 ± 10591	52508	10
Cape Bathurst							
	1986 ¹	?	13476	3	13476	13476	
	1987 ¹	7	12712	6	14529 ± 2542	14173	12
	1992 ²	6	12514	4	17521 ± 5352	15670	22
	2000 ³	17	8899	15	10013 ± 1132	9857	8

The estimate of population size for each census was calculated as (Russell et al. 1996; White and Garrott 1990)

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

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:

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

¹Parameters used to derive population estimates for 1987 were obtained from field and published data (McLean and Russell 1992). There was not sufficient information documented to derive population estimates for 1986; the estimates provided here are the number of caribou counted on photos taken (McLean and Russell 1992)

²Parameters used to derive population estimates were obtained from field and unpublished data (Nagy in prep. a).

³This report.

Table 5. Number of non-calf caribou counted on photographs taken of the Cape Bathurst barren-ground caribou herd on 8 July 2000.

Date	Group	No. radio collars	No. of non-calf caribou counted on photos	Estimate of the no. of non-calf caribou in group
8-Jul-00	1	4	920	920
8-Jul-00	2	1	848	848
8-Jul-00	3 ¹	7	2651	5302
8-Jul-00	4	1	685	685
8-Jul-00	5	1	649	649
8-Jul-00	6	1	495	495
8-Jul-00	7	0	265	265
8-Jul-00	8	0	693	693
Total		15	7206	9857

¹Group 3 was poorly aggregated and was dispersed over a large area. Approximately 50% of the group was photographed. The number of caribou counted on the photos of this group was double to estimate the number of adults used to derive the estimate of population size.

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Figure 1. Sites where Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou were captured and radio-collared during 1999 and 2000.

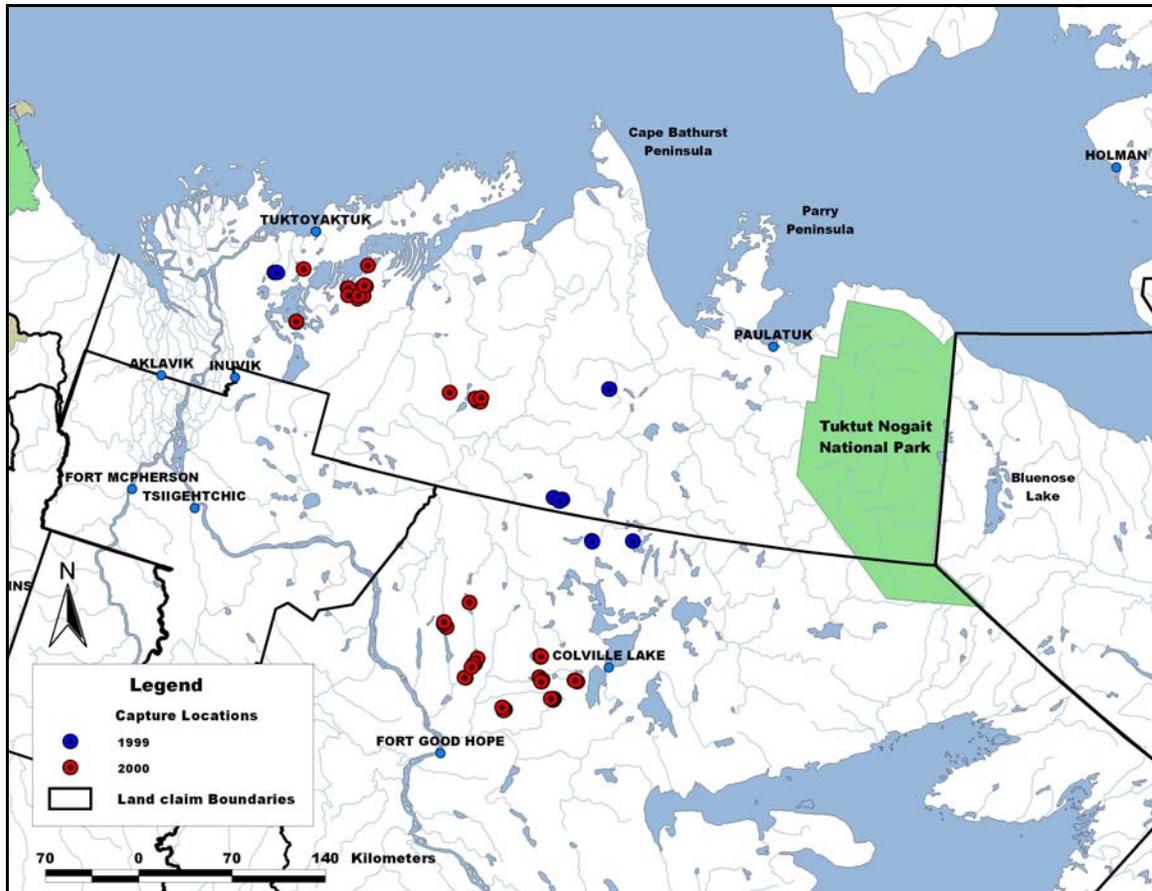


Figure 2. Transect lines flown to locate and monitor the movements of radio-collared caribou in the Cape Bathurst and Bluenose-West herds between 26 June and 16 July 2000.

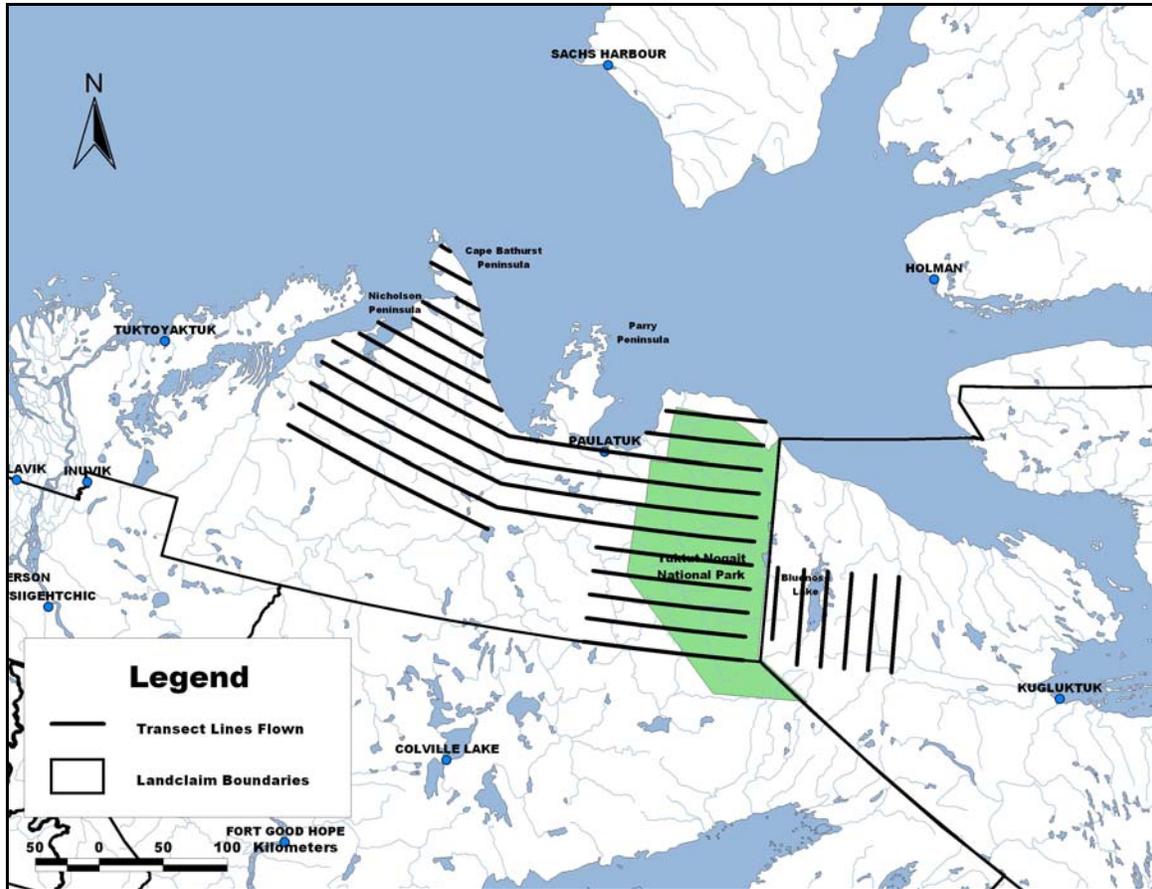


Figure 3. Distribution of radio-collared Cape Bathurst and Bluenose-West cows relative to where they were captured during 1999 and 2000.

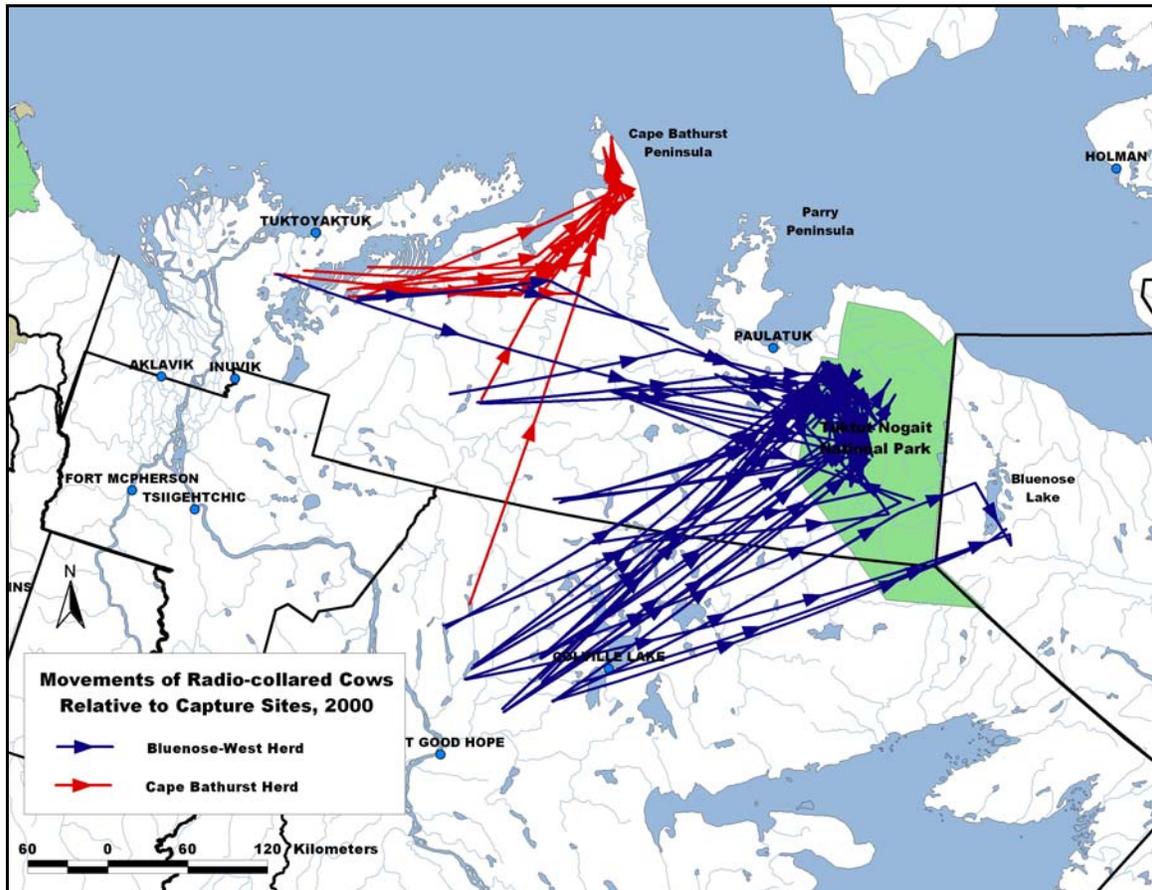


Figure 4. Distribution of radio-collared Cape Bathurst, Bluenose-West, and Bluenose-East bulls relative to where they were captured during 1999 and 2000.

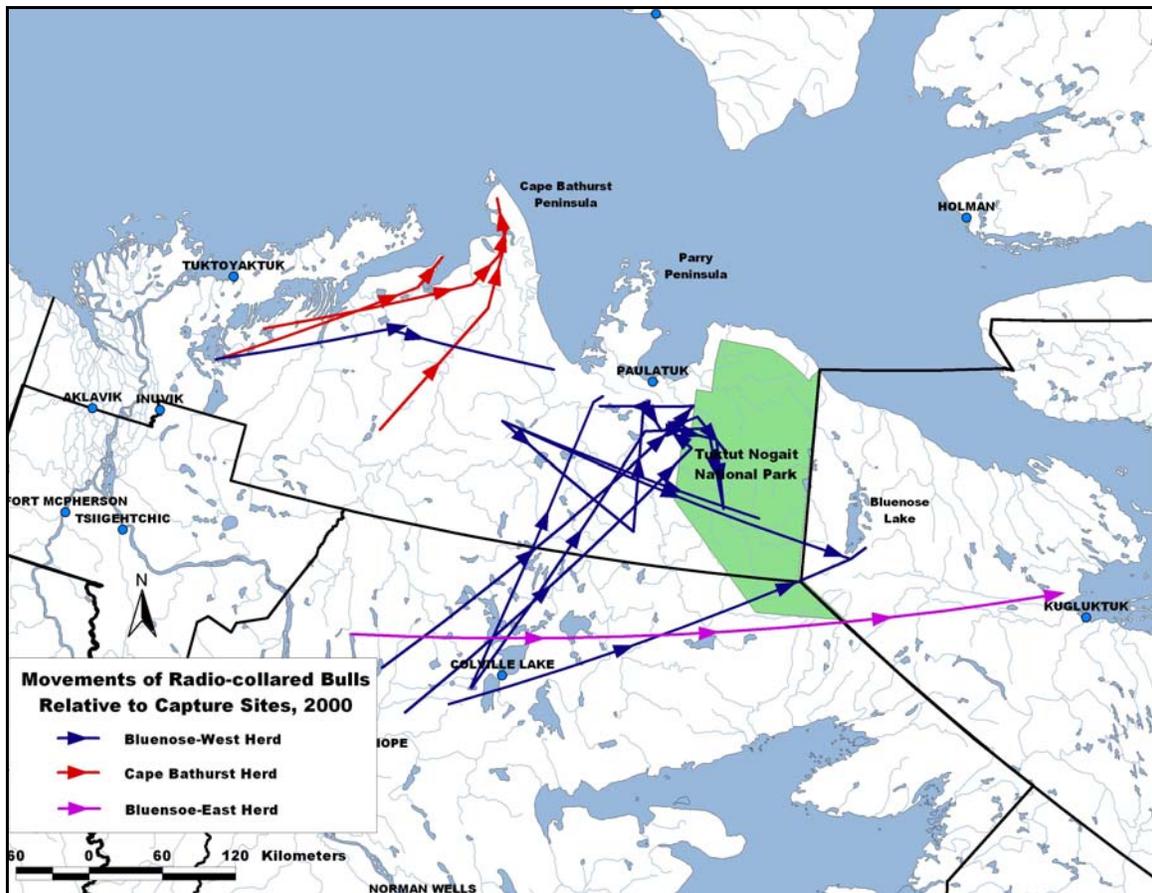


Figure 5. Distribution of satellite-collared in the Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds, 1 March 2000 to 15 July 2000.

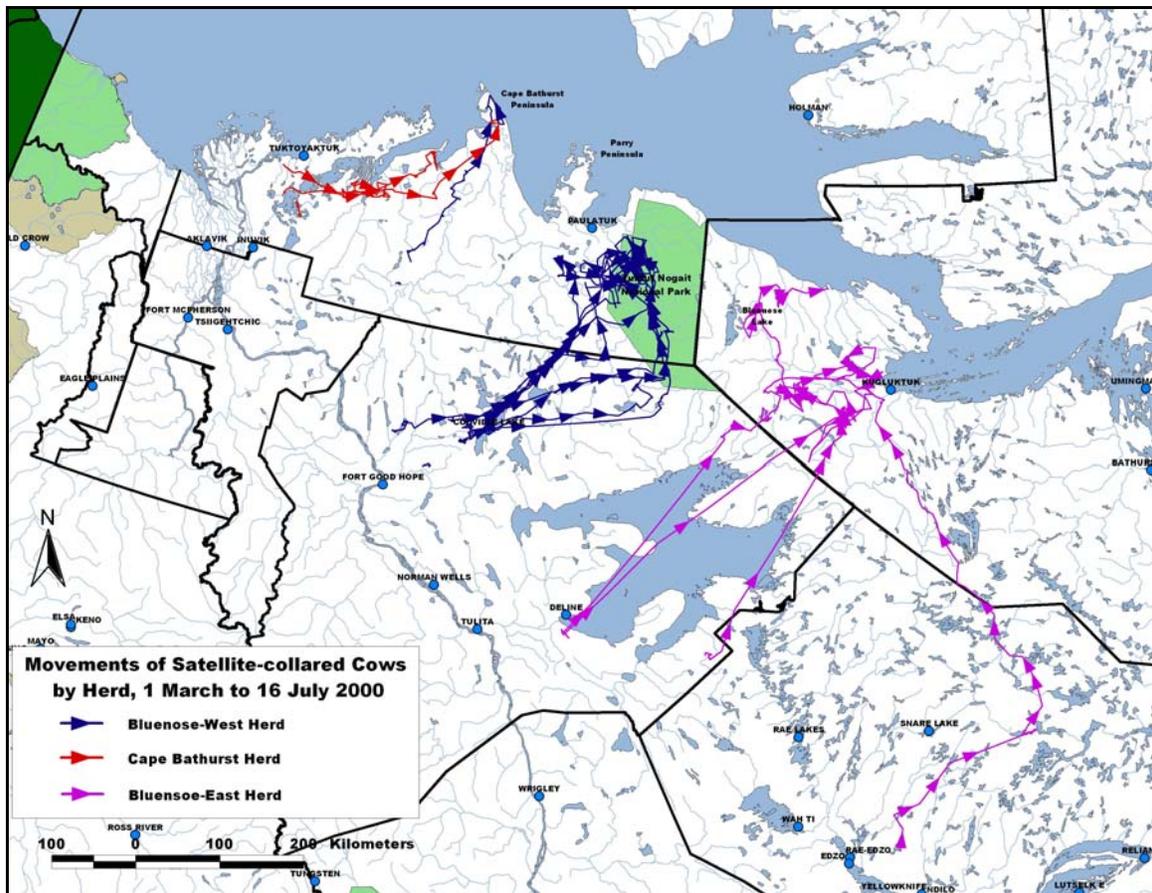


Figure 6. The movements of satellite-collared cow BW16576 during 1 June to 15 July 1996, 1997, 1998, 1999, and 2000.

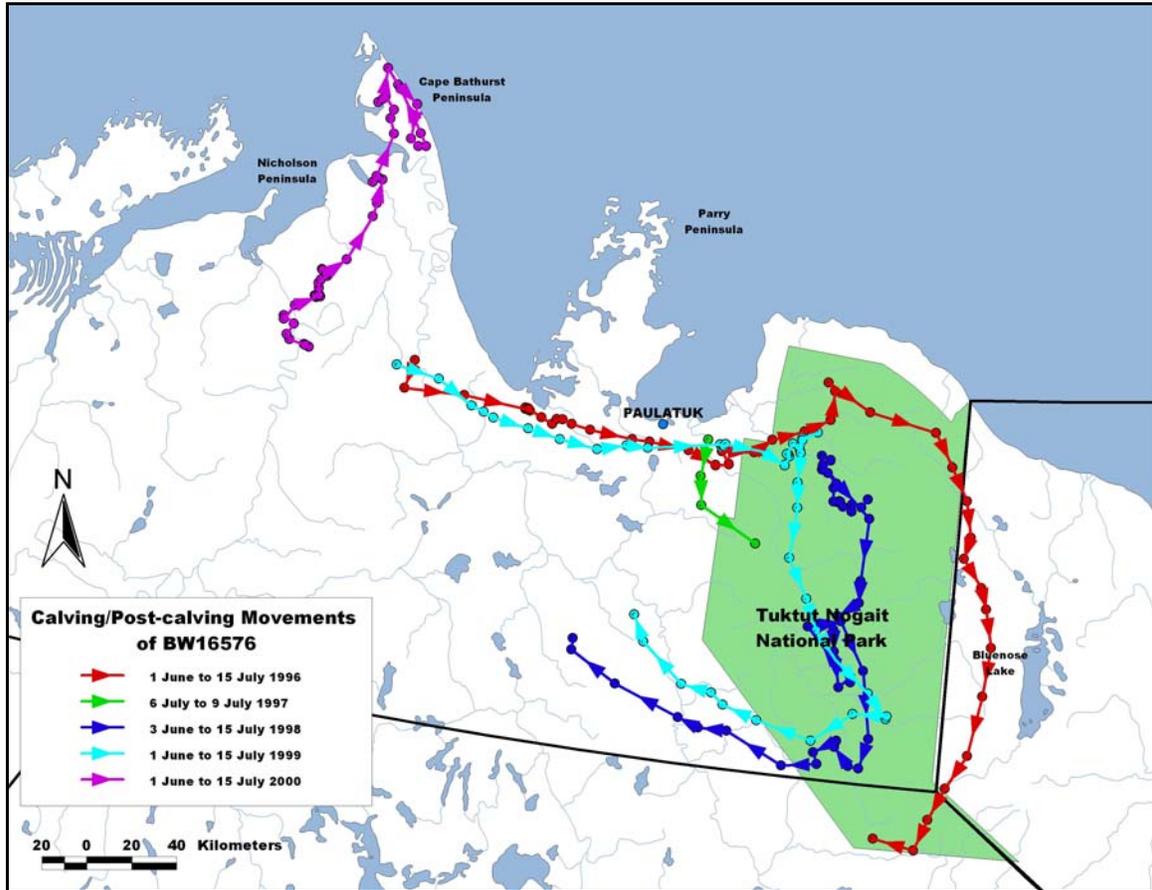


Figure 7. Sites where groups of Cape Bathurst and Bluenose-West barren-ground caribou were photographed on 8 and 9 July 2000.

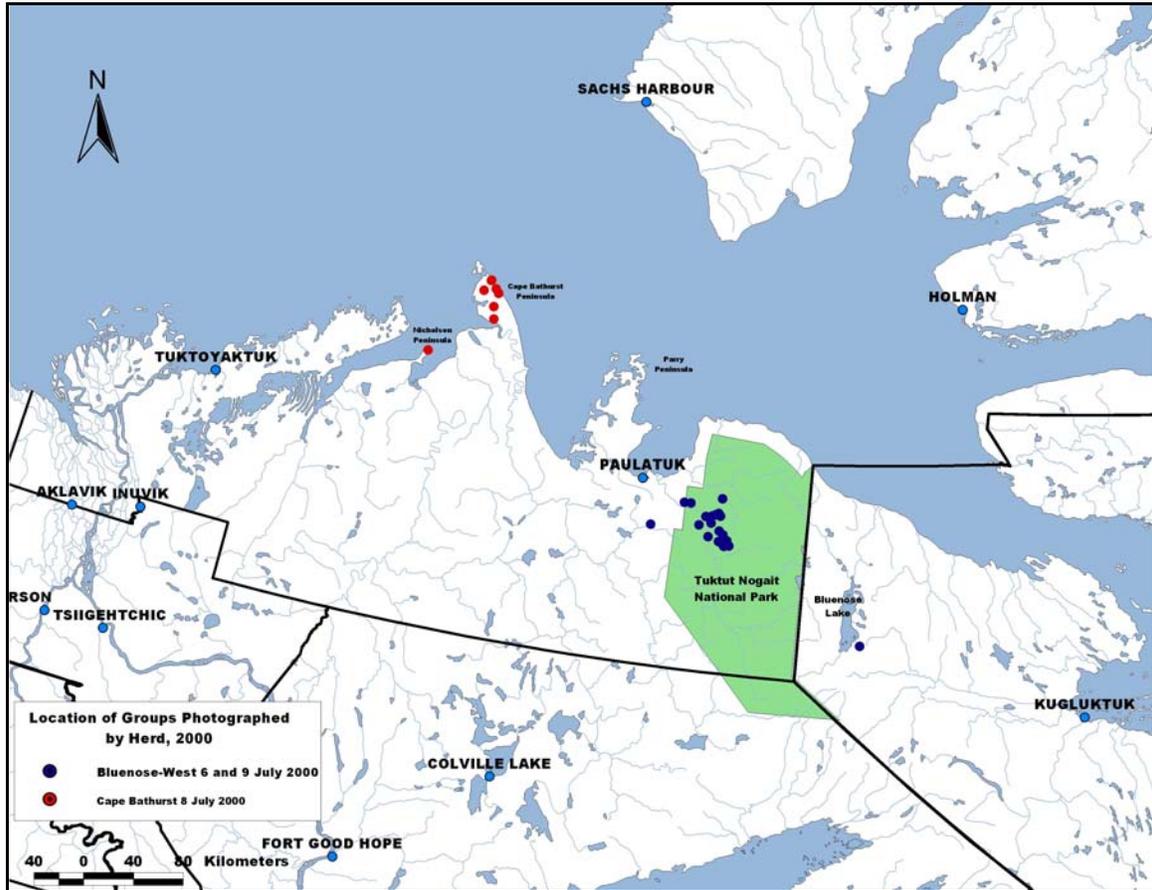


Figure 8. Sites where Bluenose-West barren-ground caribou groups were photographed on 9 July 2000.

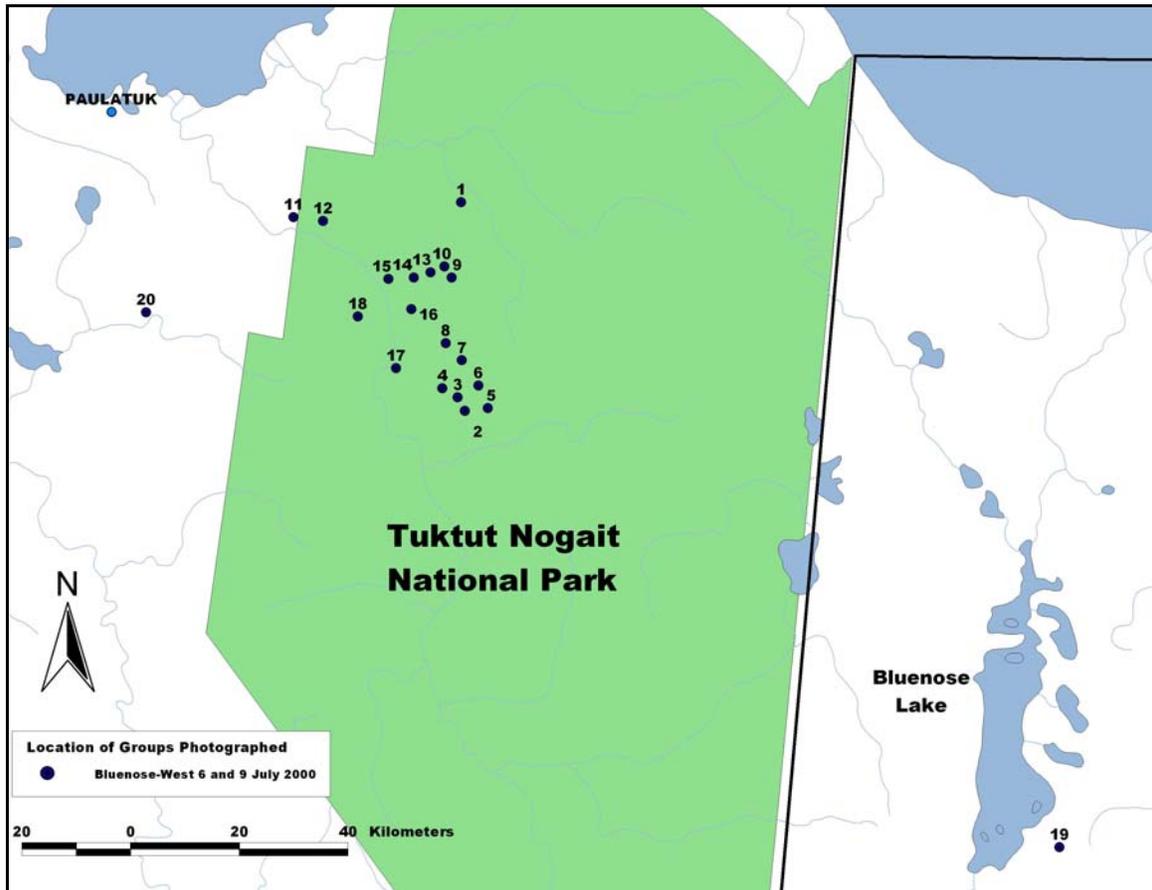


Figure 9. Sites where groups of Cape Bathurst barren-ground caribou were photographed on 8 July 2000.

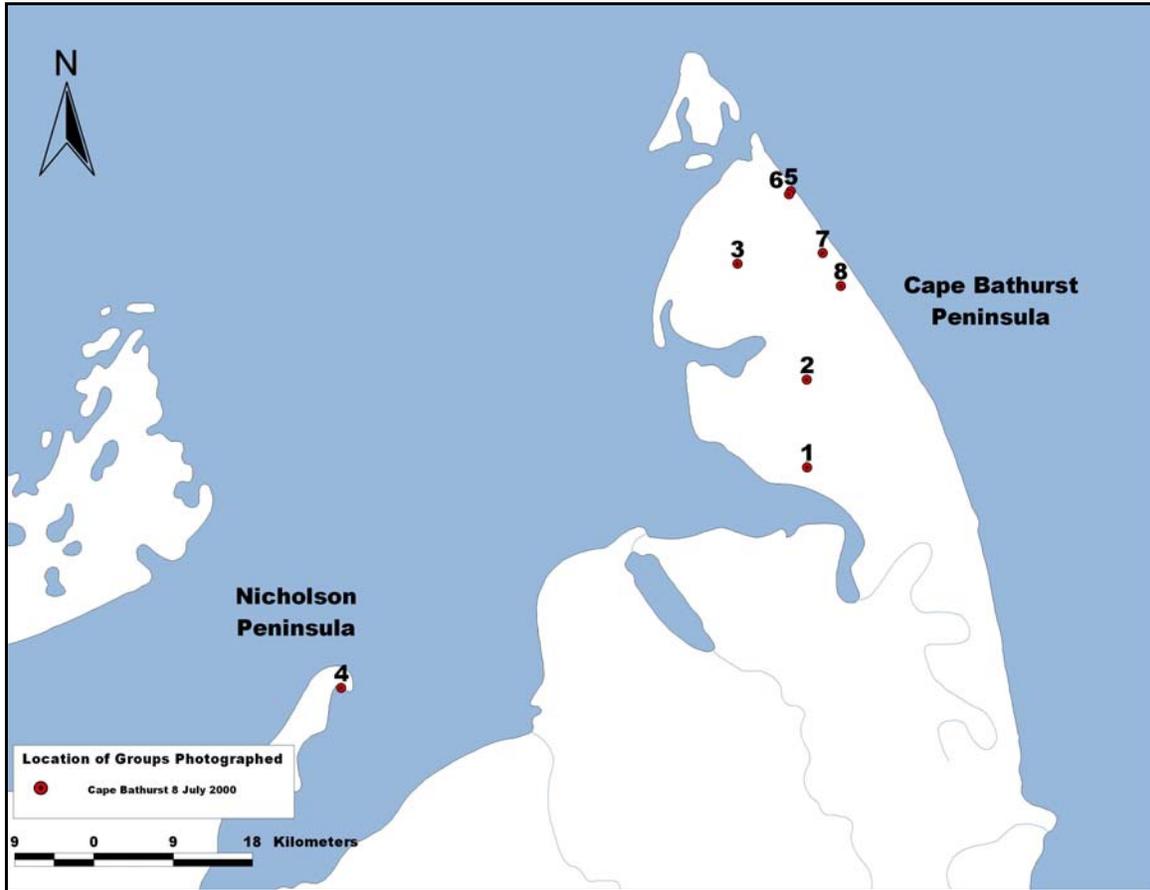


Figure 10. Sites where groups 1 and 3 were photographed in the Cape Bathurst herd on 8 July 2000 relative to the sites where radio-collared caribou in the groups were captured.

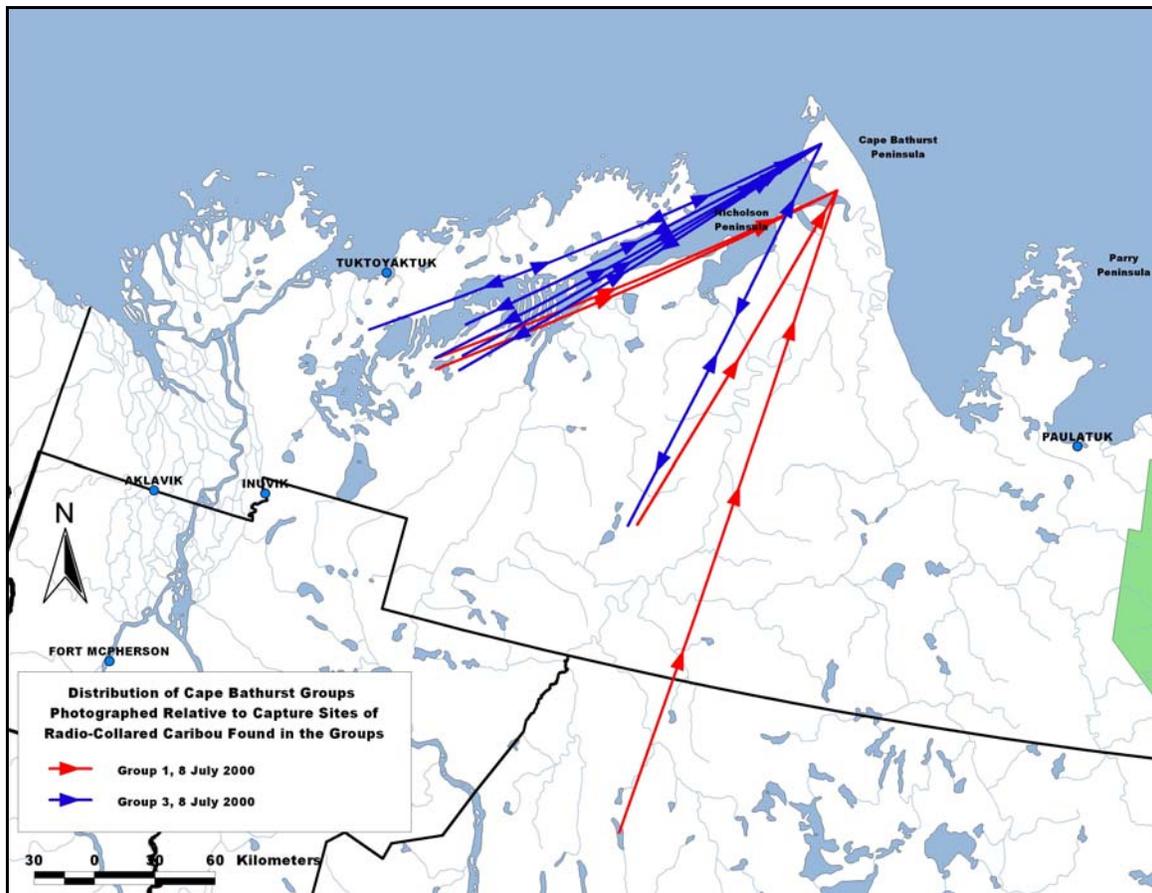
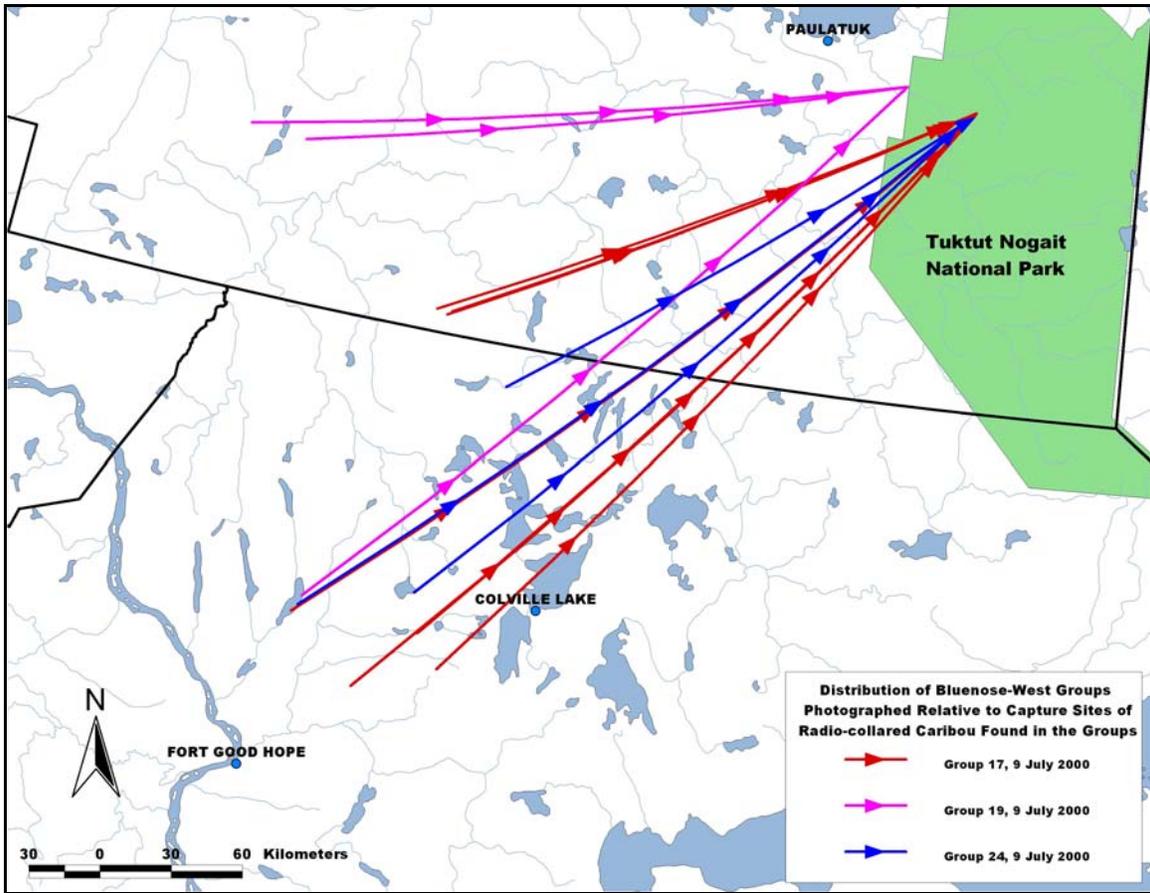


Figure 11. Sites where groups 17, 19, and 24 were photographed in the Bluenose-West herd on 9 July 2000 relative to the sites where radio-collared caribou in the groups were captured.



Reference List

- Bethke, R., Taylor, M., Amstrup, S., and Messier, F. Population delineation of polar bears using satellite collar data. *Ecological Applications* 6, 311-317. 1996.
- Gunn, A. and Miller, F. L. Traditional behaviour and fidelity to caribou calving grounds by barren-ground caribou. *Rangifer Special Issue 1* , 151-158. 1986.
- McLean, B.D. and Russell, H.J. 1992. Photocensus of the Bluenose caribou herd in July 1986 and 1987. Department of Renewable Resources, Government of the Northwest Territories, Inuvik, NWT **File Report No. 108**: 32 pp.
- Nagy, J.A. in prep. a. Populations estimates for the Cape Bathurst and Bluenose-West barren-ground caribou herds derived using post calving photography, July 2000. DRWED Manuscript Report.
- Nagy, J.A., Branigan, M., Veitch, A., Popko, R., and Nishi, J. 1999a. Co-management plan for the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds and work plans for years 1999/2000 to 2003/2004. Department of Resources, Wildlife, and Economic Development, Government of the Northwest Territories, Inuvik, Northwest Territories **Draft**: 41 pp.
- Nagy, J. A., Veitch, A. M., Zittlau, K., Larter, N. C., Cooley, D., Patterson, B. R., and Strobeck, C. Defining herds within the range of "Bluenose" barren-ground caribou in Canada's Northwest Territories and Nunavut. Poster presented at the 10th Arctic Ungulate Conference, Tromso, Norway . 9-12 August 1999.
- Nagy, J. A., Wright, W. H., Slack, T. M., and Veitch, A. M. Seasonal ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds. Department of Environment and Natural Resources, Government of the Northwest Territories, Inuvik and Norman Wells, NT. Manuscript Report No. 167. 44. 2005.
- Paetkau, D., Calvert, W., Stirling, I., and Strobeck, C. Microsatellite analysis of population structure in Canadian polar bears. *Molecular Ecology* 4, 347-354. 1995.
- Patterson, B.R., Olsen, B.T., and Joly, D.O. 2004. Population estimate for the Bluenose-East caribou herd using post-calving photography. *Arctic* **57**: 47-58.
- Russell, H. J., Couturier, S., Sopuck, L. G., and Ovaska, K. Post-calving photocensus of the Rivere George caribou herd in July 1993. *Rangifer Special*

Issue [9], 319-330. 1996.

Thomas, D.C. 1969. Population estimates and distribution of barren-ground caribou in the Mackenzie District, N.W.T., Saskatchewan, and Alberta-- March to May, 1967. Canadian Wildlife Service, Ottawa **Report Series-- No. 9**: 44 pp.

White, G. C. and Garrott, R. A. Analysis of wildlife radio-tracking data. San Diego: Academy Press . 1990.

Williams, B. K., Nichols, J. D., and Conroy, M. J. Analysis and management of animal populations. Academic Press, San Diego, California , 817 pp. 2002.

Zittlau, K., Nagy, J.A., Larter, N.C., and Strobeck, C. 2003. Genetic relatedness of caribou herds in Northwest Territories, western Nunavut and the Yukon Territory. Abstract, Rangifer **Special Issue No. 14**: 328.

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