POPULATION ESTIMATES FOR THE CAPE BATHURST AND BLUENOSE-WEST BARREN-GROUND CARIBOU HERDS USING POST-CALVING PHOTOGRAPHY

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ABSTRACT

This paper was prepared to address the following claims made by Andre (2007):

> In 1978, the Bluenose caribou calved in early June, pretty much the same dates as all the other barren ground caribou. Likewise in 1981, when P. Latour and D. Heard did the surveys. In 2005, John Nagy, regional ENR biologist, gave a slideshow at CARMA in Vancouver, discussing the demise of the Cape Bathurst Caribou Herd. The next slide is a photograph from his 2005 survey. It is dated July 17, 2005. In other words, he surveyed a herd in early to mid-July, almost six weeks after peak calving, a herd that had historically been surveyed in early June. And then this information was used to close down hunting in the Inuvik region.
>
> In 1981, the entire Bluenose Herd was estimated at 38,000. 2006 Government estimates put the Cape Bathurst, Bluenose East, and Bluenose West herd at 87,800. (Using consistent herd definitions, we would put the herd at 54,800.) Mr. Nagy says the herds are crashing, and hunting has to be stopped. In the same slideshow, he also says about the Cape Bathurst Herd “qualitative observations suggest lichen have been overgrazed on portions of the winter range.” About the Bluenose West range he says: “he has

> no information to suggest that range conditions or habitat loss is a problem." So, when a winter range gets overgrazed, is that a sign of too many or too few caribou? Apparently, the Cape Bathurst caribou moved east to the Bluenose West range for better winter range, and then stayed there to calf.

We provide the following information:

1) Evidence that Andre (2007) miss-represented the information presented at the 2005 CARMA meeting by John Nagy.
2) A description of how the retrospective analyses of the 1986, 1987, and 1992 photocensus survey data were done to derive estimates of the size of the Cape Bathurst, Bluenose-West, and Bluenose-East herds.
3) A description of the methods used to generate estimates of the size of the Cape Bathurst, Bluenose-West, and Bluenose-East herds during 1986, 1987, 1992, 2000, 2005, and 2006 including:
    a. capture methods
    b. pre-photocensus monitoring of caribou distribution
    c. aerial photography and image processing
    d. methods used to calculate population size, and
    e. methods used to compare population estimates between surveys.
4) Evaluation of the fidelity of Cape Bathurst, Bluenose-West, and Bluenose-East cows and bulls to post-calving/early summer ranges (mapping of

sites where radio-collared caribou were photographed relative to where they were captured).

5) Evaluation of the condition during the 1986, 1987, 2000, 2005, and 2006 photocensus surveys.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EVIDENCE THAT ANDRE (2007) MIS-REPRESENTED THE INFORMATION PRESENTED AT THE 2005 CARMA MEETING BY JOHN NAGY.

John Nagy gave a presentation at the 2005 CARMA meeting in Vancouver on the results of the photocensus surveys of the Cape Bathurst, Bluenose-West, and Bluenose-East herds that were completed in July 2005 (Nagy *et al.*, 2007b). Photocensus surveys are typically conducted during early July. Andre (2007) indicated that the Cape Bathurst herd was historically surveyed early June. In fact, the "Bluenose" herd (now known as the Cape Bathurst, Bluenose-West, and Bluenose-East herds) was surveyed during various times of the year in the past including in late winter (Hawley *et al.*, 1979), during calving (Brackett *et al.*, 1982; Latour and Heard, 1985; Latour *et al.*, 1986), and in early summer (McLean and Russell, 1992; Nagy and Fraser, 2007; Nagy and Bucher, 2007; Nagy and Johnson, 2007c; Nagy and Johnson, 2006a).

Estimates of the size of the "Bluenose" herd between 1948–49 and 1967 varied widely (Hawley *et al.*, 1979). In most years, the estimates were based on limited aerial survey information and the relative accuracy or precision could not be assessed (Hawley *et al.*, 1979). Systematic aerial surveys began in the 1970s (Wooley and Mair, 1977; Hawley *et al.*, 1976; Brackett *et al.*, 1982) but the results of these surveys were not always satisfactory because of large standard errors of the estimates and large potential observer bias (McLean and Russell, 1992). Visual calving ground surveys were felt to underestimate numbers (Latour *et al.*, 1986).

In Alaska and Yukon Territory, researchers were able to survey herds by

locating and photographing large aggregations of caribou in late June and early July and then counting caribou on the photos. By the mid 1980s, post-calving photo surveys became the method of choice for the Porcupine caribou herd and other herds in Alaska (Whitten, 1985; Valkenburg *et al.*, 1985). Williams and Heard (McLean and Russell, 1992) attempted a calving ground photo survey in 1983; they estimated 50,000 to 80,000 non-calf caribou in the Bluenose herd but a report on the survey was not prepared. Since 1986, post-calving photo surveys have been used as the method of choice to estimate the size of the Cape Bathurst, Bluenose-West, and Bluenose-East herds.

The photograph that Andre (2007) refers to was taken on 17 July 2005 while Nagy *et al.* (2007b) were completing a photocensus of the Bluenose-East herd. The point made by John Nagy at CARMA was that a significant number of cows in the Bluenose-East herd had calved approximately one month later then normal. Historical information on calving dates indicates that the “Bluenose” herd (now the Cape Bathurst, Bluenose-West, and Bluenose-East herds) normally calved in early June (Hawley *et al.*, 1979; Brackett *et al.*, 1982; Latour *et al.*, 1986; Latour and Heard, 1985). The key point here is that Nagy *et al.* (2007b) did not do a calving ground survey in mid-July, but rather that when doing post-calving/early summer survey they observed cows in the Bluenose-East herd that, in 2005, had calved approximately one month later than normal. Calves that are born late, just before or during the insect relief period, are not likely to survive, thus, in part providing an explanation for the decline of the herd. Similar observations were made in the Cape Bathurst herd and Bluenose-West herd

during 2000 to 2006 (Nagy and Johnson, 2007a; Nagy and Johnson, 2007b). Andre (2007) missed the significance of the observation and, to be clear, the Department does not do calving ground surveys in mid-July.

Andre (2007) indicates that in 1981, the entire Bluenose herd was estimated at 38,000 and that by 2006 the Government estimates put the Cape Bathurst, Bluenose East, and Bluenose West herd at 87,800. Using his herd definition, Andre (2007) puts the herd at 54,800. The 1981 survey was conducted by Latour and Heard (1985); Latour *et al.* (1986) indicated that visual calving ground surveys were felt to underestimate numbers. The final 2006 population estimates for the Cape Bathurst, Bluenose-West, and Bluenose-East herds were 1,821 ±149, 18,050 ±527, and 66,754 ±5,182 non-calf caribou, respectively. Although these values may vary slightly from values reported earlier, it is unclear how one could combine these values to obtain a value of 54,800 caribou.

Andre (2007) suggests that the Cape Bathurst herd moved onto the range of the Bluenose-West herd in response to what John Nagy believed was poor forage conditions on the winter range of the Cape Bathurst herd. We have not seen a major shift in the winter distribution of satellite-collared caribou in the Cape Bathurst herd. In addition, the majority of the Cape Bathurst herd wintered near Tuktoyaktuk during the winter 2005–2006 despite high hunting pressure and what were believed were poor range conditions.

2.0 RETROSPECTIVE ANALYSES CONDUCTED TO DERIVE POPULATION ESTIMATES FOR THE CAPE BATHURST, BLUENOSE-WEST, AND BLUENOSE-EAST HERDS USING THE 1986, 1987, AND 1992 PHOTOCENSUS SURVEY DATA

Nagy *et al.* (2007a) and Nagy and Fraser (2007) reviewed and mapped the VHF radio telemetry data obtained for each caribou tracked between 1985 and 1993. June and July locations were obtained for 127 of the 138 caribou collared between 1985 and 1992. The remaining 11 collars either failed, the caribou was not re-located, or the caribou died before the first calving period subsequent to their capture. Caribou were assigned to a herd based on the first calving or post-calving range it used. Once each radio-collared caribou was assigned to a herd, we were able to 1) assign each group photographed or counted to a herd based on the radio-collared caribou present, 2) derive the parameters required to generate modified Lincoln-Petersen herd estimates (Russell *et al.*, 1996), and 3) derive estimates of the size of the Cape Bathurst, Bluenose-West, and Bluenose-East herds in 1986, 1987, and 1992. Groups that did not contain radio-collared caribou were assigned to herds based on their proximity to groups containing radio collars.

3.0 POPULATION ESTIMATES FOR THE CAPE BATHURST, BLUENOSE-WEST, AND BLUENOSE-EAST HERDS, 1986, 1987, 1992, 2000, 2005, AND 2006

METHODS

Pre-collar deployment reconnaissance surveys

Reconnaissance surveys were not conducted prior to collar deployment for the 1986, 1987, 1992, and 2000 photocensus surveys of the Cape Bathurst and Bluenose-West herds. However, radio collars were deployed sufficiently in advance of these surveys to allow the radio-collared individuals to disperse in the herd (McLean and Russell, 1992). Collars were deployed throughout the winter range of the Cape Bathurst and Bluenose-West herds prior to the 2000 survey. Patterson *et al.* (2004) used a fixed-wing aircraft, guided by current locations of caribou previously fit with satellite collars to define the distribution of Bluenose-East caribou before deploying collars. Patterson *et al.* (2004) then attempted to deploy radio collars evenly across the geographic range of the herd at that time. Similarly, Nagy and Johnson (2006b) documented the distribution of caribou on the winter ranges of the Cape Bathurst and Bluenose-West herds prior to collar deployment in 2005 and 2006.

Capture methods

Caribou were captured in November (1985, 1991), February (1992), and March (1986, 1987, 1992, 2000, 2005, and 2006) with handheld net guns fired from Bell 206B helicopter and equipped with radio collars. VHF collars were

deployed during 1985–1992 (Telonics Corp. Ltd, Mesa, AZ), VHF and ARGOS satellite collars in 2000 and 2005 (Telonics and Lotek Engineering Inc, Aurora, OT), and VHF, ARGOS satellite, and GPS collars (Telonics) in 2006. Capture efforts 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 (≥ –30^{o}C). Typically, adult cows and bulls were selected at random within groups, but efforts were made to select those animals that were position to minimize chase times and maximize capture efficiency.

In July 1999, a motorized boat was used to pursue and capture caribou crossing Rendezvous Lake. We captured caribou by the neck using a shepherds crook, drew them alongside the boat, and fitted them with radio collars.

Pre-photocensus monitoring of caribou distribution

Following collar deployment during all years (1985 to 2006), the frequencies of radio collars for caribou that were harvested, died of natural causes, or that were on fast pulse but the status of the collar or caribou was not verified, were documented and censored from the database. McLean and Russell (1992) and Nagy and Fraser (2007) conducted reconnaissance surveys in mid- to late June to locate and determine the status of radio-collared caribou and to monitor their movements.

In mid- to late June 2000, 2005, and 2006 telemetry surveys were conducted over the winter and spring/spring migration ranges of the Cape

Bathurst, Bluenose-West, and Bluenose-East herds to searched for radio collars (Nagy and Johnson, 2007c; Nagy and Bucher, in prep; Nagy and Johnson, in prep). Telemetry surveys were flown with a Helio Courier, Cessna 185, Maule, or Cessna 337 fixed-wing aircraft equipped with one or two independent tracking systems comprised of various models of Telonics, Lotek, or ATS (Advanced Telemetry Systems Inc., Isanti, MN) scanner/receivers and 2 model RA-2AK dual antennae (Telonics Corp. Ltd., Mesa, AZ). When two systems were used, one operator scanned the frequencies of the target herd (Cape Bathurst, Bluenose-West, or Bluenose-East) and the other scanned the frequencies of the target herd and those of radio-collared caribou from neighbouring herds for which the status had not yet been verified. Transect lines were spaced approximately 20–40 km apart, while flight altitude ranged between 440 and 1320 m agl.

In late June and early July telemetry surveys were conducted to monitor the movements of radio-collared caribou and to monitor the degree of herd aggregation. The movements of ARGOS and GPS collared caribou were also monitored. The locations of satellite-collared caribou were obtained via email or fax and then mapped so that tracking and monitoring efforts could be allocated more effectively.

Aerial photography and image processing

Once suitably aggregated, groups were photographed from fixed-wing aircraft with handheld cameras. In 1986, 1987, 1992, and 2000, cameras used were 35-mm single-lens reflex equipped with normal 50-mm lenses, motor

drives, and through the lens automatic light metering. Colour transparency film with ASA ratings of 64, 100, and 400 were used. In 2005 and 2006, we used Nikon D70 (6.6 megapixel) and D2x digital (12.4 megapixel) cameras equipped Nikon AF 35 mm 1:2 D lens, respectively. Group photos were taken at an oblique angle from the side windows of an aircraft flying between 110 and 330 m above and parallel to each group when the photos were taken. The photographer sat in the rear seat of the aircraft behind the pilot (Helio Courrier) or in the front passengers seat (Cessna 185) and opened the window for each photo session. We attempted to photograph each group in a single pass to minimize movement of caribou between frames and to allow for approximately 20% overlap between successive frames. The group number, longitude and latitude co-ordinates, frequencies of radio collars present, and frame numbers of photos taken for each group photographed were recorded.

Colour transparencies taken in 1986, 1987, and 1992 were projected onto 21.5 by 28 cm sheets of white paper placed about 45 cm from the projector lens. Overlap lines were drawn between landmarks common to adjacent slides. A magnifying glass was usually required to clearly classify and count animals. A pencil mark was made on the paper under all images between the overlap lines interpreted as being caribou and counted on a tally machine. Adults and calves (when possible) were counted on separate tally machines. Photo interpreter bias was estimated in 1986 and 1987 but not in 1992.

In 2000, colour transparencies were taken and scanned to produce high-resolution digital images. These digital photos and those taken in 2000, 2005,

and 2006 were printed on 38.6 by 50 cm paper. We identified areas of overlap between photos 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. We created track lines to locate the overlap boundaries on each photo. The unique areas of photomaps were visually scanned on a computer screen and a waypoint was created on each caribou. OziExplorer allowed us to easily change the view magnification as required to ensure that all caribou could be accurately identified and counted. We classified caribou as calves, cows, yearlings, young bulls, mature bulls, whenever possible, or unknown. We assigned a unique symbol colour for each class of caribou. The waypoint count gave the number of caribou present and the colour code count gave the number of caribou in each class present. We scanned each photomap with waypoints overlain to ensure that all caribou were counted.

Population Size

The photo count data provided an estimate of the minimum number of non-calf caribou in each herd. However, because not all collared caribou are associated with aggregations and not all aggregations contain 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 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 and

Garrott (1990). Not all groups photographed contained radio-collared caribou but these groups were typically found in close proximity to groups 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 $N_i = 1.96 Var(N)^{0.5}$ where:

$$Var(N) = ((M+1)(C+1)(M-R)(C-R))/(R+1)^2(R+2)$$

Comparison of Population Estimates

We used Lincoln-Petersen estimators to determine if the relative abundance of caribou (K) in each herd during 2005 and 2006 was significantly different (Williams *et al.*, 2002). We assumed that capture probabilities were different between 2005 and 2006. 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:

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

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 $1.96Var(K)^{0.5}$ (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

The population estimates for the Cape Bathurst, Bluenose-West,

Bluenose-East barren-ground caribou herds for photocensus surveys conducted in 1986, 1987, 1992, 2000, 2005, and 2006 are given in Table 1. The Lincoln-Petersen estimators used to determine if the relative abundance of caribou (K) in each herd or herds combined were significantly different between years are given in Table 2.

The 1986, 1987, 1992, and 2000 population estimates for Cape Bathurst herd were not significantly different (Table 1 and 2). The decline from 11,100 caribou in 2000 to 2,400 in 2005 was significant. The 2005 and 2006 estimates were not significantly different. The population trend for the Cape Bathurst (1986 to 2006) is shown in Figure 10.

The 1986, 1987, and 1992 population estimates for the Bluenose-West herd were not significantly different (Table 1 and 2). The decline from 112,400 in 1992 to 76,400 in 2000 was significant. The herd continued to decline to 20,800 in 2005 and 18,100 in 2006; the declines between years were significant. The population trend for the Bluenose-West herd (1986 to 2006) is shown in Figure 11.

The 2000 and 2005 population estimates for the Bluenose-East herd were significantly different, indicating that the population declined from around 119,600 caribou in 2000 to 70,100 in 2005 (Table 1 and 2). The estimates for 2005 and 2006 were not significantly different. The population trend for the Bluenose-East herd is shown (2000 to 2006) in Figure 12.

The population trend for the combined population estimates for the Cape Bathurst and Bluenose-West herds (1986 to 2006) is shown in Figure 13. The

combine population estimates indicate that these herds increased between 1986 and 1992 from 102,200 to 132,200 caribou, respectively, and then declined between 1992 and 2005 to 20,100 caribou.

The population trend for the combined population estimates of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (1986 to 2006) is shown in Figure 14. This population trend is based on Cape Bathurst and Bluenose-West data only for 1986 and 1987. The caribou associated with 5 Bluenose-East caribou photographed in 1992 are included with the Cape Bathurst and Bluenose-West data for 1992. Data for all three herds were available for 2000, 2005, and 2006. Only the portion of the trend line between 2000 and 2006 is valid; the combined number of caribou in these herds declined from 202,600 to 85,100 between 2000 and 2006, respectively.

4.0 FIDELITY OF CAPE BATHURST, BLUENOSE-WEST, AND BLUENOSE-EAST COWS AND BULLS TO POST-CALVING/EARLY SUMMER RANGES

METHODS

We mapped the distribution of sites where radio-collared caribou in the Cape Bathurst, Bluenose-West, and Bluenose-East herds were re-located in early July in 1986, 1987, 1991, 1992, 1993, 2000, 2005, and 2006 in relationship to where they were captured. Maps were generated for cows and bulls separately for each year, for all cows and bulls separately for each herd, cows and bulls pooled by each herd, and all herds combined. In combination, these maps provided additional information the winter and post-calving/early summer ranges used by cows and bulls in each of the herds.

RESULTS

Cape Bathurst herd

Figures 15 to 30 give the distribution of sites where radio-collared Cape Bathurst cows and bulls were photographed or re-located in early July 1986, 1987, 1991, 1992, 1993, 2000, 2005, and 2006 in relationship to where they were captured. Figures 31 and 32 give the distribution of sites where radio-collared Cape Bathurst cows and bulls, respectively, were photographed or re-located during all years in relationship to where they were captured. Similarly,

Figure 33 gives the distribution of sites where all radio-collared Cape Bathurst cows and bulls combined were photographed or re-located in relationship to where they were captured.

The majority of the Cape Bathurst cows and bulls were captured on the lower Tuktoyaktuk Peninsula and Husky Lakes area to Travaillant Lake and were located on the upper Cape Bathurst Peninsula in early July. One cow was located on the Cape Bathurst Peninsula in 1987, at the base of the Parry Peninsula in 1988, and then within the early summer range of the Bluenose-West herd in 1989 (Figure 34). These data indicate that cows and bulls in the Cape Bathurst herd show strong fidelity to early summer ranges on the Cape Bathurst Peninsula; these ranges are used in common by bulls and cows.

Bluenose-West herd

Figures 35 to 50 give the distribution of sites where radio-collared Bluenose-West cows and bulls were photographed or re-located during early July 1986, 1987, 1991 1992, 1993, 2000, 2005, and 2006 in relationship to where they were captured. Figures 51 and 52 give the distribution of sites where radio-collared Cape Bathurst cows and bulls, respectively, were photographed or re-located during all years in relationship to where they were captured. Similarly, Figure 53 gives the distribution of sites where all radio-collared Cape Bathurst cows and bulls combined were photographed or re-located in relationship to where they were captured.

The majority of Bluenose-West cows and bulls were captured in the area between Husky Lakes, Travaillant Lake, and Fort Good Hope in the west to Colville Lake and Rendez-vous Lake in the east and northeast and were then located between the base of the Parry Peninsula and Melville Hills in early July. One cow was located in the Melville Hills in early July in 1986, 1987, and 1988 but was found on the Bluenose-West Peninsula in 1991 (Figure 54). These data indicate that cows and bulls in the Bluenose-West herd show strong fidelity to early summer ranges near the base of the Parry Peninsula to the Melville Hills; these ranges are used in common by bulls and cows.

Bluenose-East Herd

Figures 55 to 62 give the distribution of sites where radio-collared Bluenose-East cows and bulls were photographed or re-located in early July 1991, 1992, 1993, 2000, 2005, and 2006 in relationship to where they were captured. Figures 63 and 64 give the distribution of sites where radio-collared Bluenose-East cows and bulls, respectively, were photographed or re-located during all years in relationship to where they were captured. Similarly, Figure 65 gives the distribution of sites where all radio-collared Bluenose-East cows and bulls combined were photographed or re-located in relationship to where they were captured.

The majority of the radio-collared Bluenose-East caribou were captured in the areas south and east of Great Bear Lake and used the area from the southern Melville Hills/Bluenose Lake/Horton Lakes area and north to the Arctic

coast and east to Kugluktuk, NU during early July. One cow was located east and northeast of Bluenose Lake in 1991 and 1992 but was found in the Melville Hills just south of the Arctic coast in 1993 (Figure 66). These data indicate that cows and bulls in the Bluenose-East herd show strong fidelity to early summer ranges in the southern Melville Hills/Bluenose Lake/Horton Lakes area and north to the Arctic coast and east to Kugluktuk, NU; these ranges are used in common by bulls and cows.

5.0 EVALUATION OF CONDITION DURING THE 1986, 1987, 2000, 2005, AND 2006 PHOTOCENSUS SURVEYS

Valkenburg *et al.* (1985), Russell *et al.* (1996), Rivest *et al.* (1998), and Patterson *et al.* (2004) recommended that a number of conditions needed to be met in order to obtain accurate population estimates using post-calving/early summer photocensus techniques. We identified and used the following nine criteria to evaluate the conditions that prevailed during the photocensus surveys conducted in 1986, 1987, 1992, 2000, 2005, and 2006.

Condition 1: Radio collars are deployed randomly among groups but distributed uniformly across the range used by the herd at the time of collaring (Patterson *et al.*, 2004). This increases the probability that the entire population is detected during the photocensus (Patterson *et al.*, 2004). Patterson *et al.* (2004) used a fixed-wing aircraft, guided by current locations of caribou previously fit with satellite collars to define the distribution of Bluenose-East caribou before deploying collars. Patterson *et al.* (2004) then attempted to deploy radio collars evenly across the geographic range of the herd at that time. Similarly, Nagy and Johnson (2007c) and Nagy and Johnson (2006a) documented the distribution of caribou on the winter ranges of the Cape Bathurst and Bluenose-West herds prior to collar deployment. Alternately, radio collars are deployed sufficiently in advance of the photocensus to allow the radio-collared individuals to disperse in the herd (McLean and Russell, 1992).

1986 and 1987 Photocensus

In 1985, 1986 and 1987 caribou were collared in the southern Eskimo Lakes, Kugaluk River, and Travaillant Lake areas (Figures 1, 2, and 3) (McLean and Russell, 1992). Based on the distribution of captures sites it is unlikely that efforts were made to deploy collars uniformly across the winter range of the Bluenose herd. Based on local observations there were lots of caribou around Colville Lake and none were collared in that area. “I asked Gene Oudzi, and he said that there were a lot of caribou around in the mid-1980s. I also remember seeing a lot of caribou passing by on the lake in the mid-1980s… But the last few years, I did not see any… Did they change their route?” (Margaret Brown, Colville Lake, 6 August 2008)

1992 Photocensus

In preparation for the 1992 photocensus, caribou were collared on winter ranges near the southern Eskimo Lakes, Kugaluk River, and Travaillant Lake areas and east to the Anderson River (Nagy and Fraser, 2007). Caribou were also collared in the Dismal Lakes area east of Bluenose Lake (Figure 4). Based on the distribution of captures sites it is unlikely that efforts were made to deploy collars uniformly across the winter range of the Bluenose herd (Figure 4). However, capture efforts were expanded eastward to include the Rendez-vous Lake area.

2000 Photocensus

In 1999 and 2000, caribou were collared in the southern Eskimo Lakes, Anderson River-Rendezvous Lake, and Colville Lake areas (Figure 5). A reconnaissance survey was not flown prior to the collaring effort in late winter 2000. However, caribou were collared in areas where caribou were known to be wintering based on observations of local hunters and pilots. Caribou were collared over much of the winter range of the Cape Bathurst and Bluenose-West herd (Figure 5). In addition, 10 caribou were captured at Rendez-vous Lake in late July/early August 1999.

2005 and 2006 Photocensus

In late February and March 2005 and 2006 we flew reconnaissance surveys to document the distribution of caribou on the known winter ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Figure 6 and 7). Efforts were made to deploy the collars uniformly across the winter ranges of these herds (Figure 8 and 9) (Nagy and Johnson, 2006a; Nagy and Johnson, 2007c).

Condition 2: Radio collars are deployed on bulls and cows in proportion to their occurrence in the population (30-40% on bulls and 60-70% on cows). This assumes that the sex composition of the population has not been skewed by a sex-biased harvest. Non-random distribution of radio-collared caribou can also result from age/sex segregation if radios are placed predominantly on members of one age or sex class (Valkenburg *et al.*, 1985).

The number of collars available in the Cape Bathurst herd was small during 1986, 1987, and 1992 (Table 6) and as a result the sex ratio data are of little interpretive value. The sex ratio approximated the 60%–70% cows: 30%–40% male ratio in 2000, 2005, and 2006 (Table 6).

The sex ratio for radio-collared caribou in the Bluenose-West herd strongly favoured cows (81% to 91% of collared caribou) during 1986, 1987, 1992, and 2000 (Table 7). As a result, some bulls group may have been missed. The sex ratio approximated the 60%–70% cows: 30%–40% bulls ratio in 2005 and 2006 (Table 7).

The number of collars available in the Bluenose-East herd was small (n = 6) and all were deployed on cows near Dismal Lakes prior to the 1992 photocensus (Table 8), as a result, a population estimate was not derived. Only cows were collared prior to the 2000 photocensus at the request of the Kugluktuk HTO (Patterson *et al.*, 2004), as a result, some bull groups may have been missed. The sex ratio approximated the 60%–70% cows: 30%–40% bull ratio in 2005 and 2006 (Table 8).

Condition 3: A sufficient number of radio collars are deployed uniformly throughout the range used by the population at the time of collaring to ensure that there is a reasonable probability that the entire population will be detected during the photocensus. Rivest *et al.* (1998) indicated that enough collars should be deployed so that the probability of a group having no radio-collared caribou at the time of census is negligible.

We used three criteria in combination with the sex ratio of the radio-collared caribou available for each photocensus survey to evaluate whether or not there were sufficient numbers of radio-collared caribou available to ensure that there was a reasonable probability that the entire population was detected during the photocensus. These included 1) all highly aggregated groups contained at least one radio-collared caribou (Russell *et al.*, 1996), 2) the majority of caribou photographed or counted (≥90% of caribou) were in groups that contained at least one radio-collared caribou, and 3) the ratio of the number of groups to the number radio-collared caribou available for each photocensus was small (Valkenburg et al 1985). This ratio should be < 1.0 group per collar. These criteria are based on the assumption that weather conditions during a photocensus survey are favourable for caribou to aggregate.

Cape Bathurst Herd

All highly aggregated groups contained radio-collared caribou in 2005 and 2006, but this was not the case in 1986, 1987, 1992, and 2000 (Table 6). In 2000, 2005, and 2006, ≥90% of the caribou photographed were in groups that contained radio-collared caribou; in 1986, 1987, and 1992, <90% of the caribou photographed were in groups that contained radio-collared caribou (Table 6). In 1987, 2000, 2005, and 2006, the ratio of the number of groups to radio-collared caribou in groups photographed or counted was ≤1.0; in 1986 and 1992 this ratio was large (1.2 to 2.67) (Table 6). The sex ratio approximated the 60%–70%

cows: 30%–40% male ratio in 2000, 2005, and 2006 (Table 6). The number of collars available in the Cape Bathurst herd was small during 1986, 1987, and 1992, and as a result, the sex ratio data for collared caribou available during these surveys are not useful indicators (Table 6). These data suggest that there were sufficient numbers of radio-collared caribou available in the Cape Bathurst herd during the 2005 and 2006 photocensus surveys, however this does not appear to be the case during 1986, 1987, 1992, and 2000.

Bluenose-West Herd

All highly aggregated groups contained at least one radio-collared caribou in the Bluenose-West herd during 2005 and 2006; this was not the case in 1986, 1987, 1992, and 2000 (Table 7). In 1987, 2000, 2005, and 2006, >90% of the caribou photographed in the Bluenose-West herd were in groups that contained at least one radio-collared caribou (Table 7). The ratio of the number of groups per collar was small during 1987, 2000, and 2005, (range 0.49 to 0.74) but was large in 2006 (1.0) (Table 7). Most of the radio-collared caribou available during the 1986, 1987, 1992, and 2000 photocensus surveys were cows (>80% of radio-collared caribou). The sex ratio most closely approximated the 60%–70% cows: 30%–40% male ratio only in 2005 and 2006 (Table 7). These data suggest that there were sufficient numbers of radio-collared caribou available in the Bluenose-West herd during the 2005 photocensus, likely sufficient during the 2006 photocensus, but not sufficient during the 1986, 1987, 1992, and 2000 photocensus surveys.

Bluenose-East Herd

All highly aggregated groups contained at least one radio-collared caribou in the Bluenose-East herd during 2006; this was not the case in 2000 and 2005 (Table 8). In 2006, >90% of the caribou photographed in the Bluenose-East herd were in groups that contained at least one radio-collared caribou (Table 8). The ratio of the number of groups per collar was small during 2005 and 2006 (range 0.60 to 0.64) but was large in 2000 (0.96) (Table 8). The sex ratio most closely approximated the 60%–70% cows: 30%–40% bulls ratio in 2005 and 2006 (Table 8); all radio-collared caribou available during the 2000 survey were cows. These data suggest that there were sufficient numbers of radio-collared caribou available in the Bluenose-East herd during the 2006 photocensus, but not sufficient during the 2000 and 2005 photocensus surveys.

Condition 4: All radio-collared caribou are heard and precisely located (Valkenburg *et al.*, 1985) to verify their status (alive or dead) so that total number of collars available at the time of census can be accurately determined.

Reconnaissance surveys were flown in mid- to late June during all years when photocensus surveys were conducted. The primary objective of these surveys was to document the status of all radio-collared caribou in each herd.

Condition 5: The population is closed (Russell *et al.*, 1996); the movements and distribution of the target herd and adjacent herds must be known at the time of

the census to ensure that the groups photographed and attributed to the target herd are truly from the target herd.

The movements and distribution of the Cape Bathurst, Bluenose-West, and Bluenose-East herds in 2000, 2005, and 2006 were monitored with the aid of satellite tracking collars. These data in combination with the daily VHF tracking flights indicated that there were no movements of caribou between herds during the surveys. The daily VHF tracking flights during the previous years indicated that there were no movements of caribou between the Cape Bathurst and Bluenose-West herd; the status of the movements of the Bluenose-East herd during these years is unknown.

Condition 6: There are no significant movement of individuals among groups during the period when the groups are photographed to eliminate the potential for double-counting of animals. A sufficient number of survey crews are required to ensure that the herd, once it has aggregated, can be photographed in a short period of time, preferably one day.

Photocensus surveys of the Cape Bathurst and Bluenose-West herds were conducted in one day each in 2000, 2005, and 2006, as a result, there was no potential for movement of caribou among groups in these herds. Photographs of groups in these herds were taken over number of days in 1986, 1987, and 1992 and movement of radio-collared caribou between groups was documented. The group counts were adjusted as required to account for the movements of

radio-collared caribou between groups (McLean and Russell, 1992; Nagy and Fraser, 2007).

The photocensus survey of the Bluenose-East herd was completed in one day in 2000; as a result, there was no potential for movement of among groups. Although the Bluenose-East herd was photographed over a number of days in 2005 and 2006, distinct and spatially distant areas were photographed on the same days. Daily tracking flights and satellite tracking data indicated that there were no significant movements of caribou among these distinct areas.

Condition 7: Weather conditions are favourable throughout the post-calving/early summer range for caribou to aggregate and persist long enough for all aggregations to be photographed. Warm to hot and calm conditions favour insect activity and aggregation of caribou for insect relief.

Weather conditions were favourable during all years to promote aggregation of caribou for insect relief, although the duration of these conditions varied. Contrary to Andre's (2007) belief, the coastal areas of the Northwest Territories, including the Cape Bathurst Peninsula, experience periods of hot calm weather that favour insect activity and aggregation of caribou for insect relief.

Condition 8: Radio-collared caribou are distributed in groups photographed in proportion to group size. Valkenburg *et al.* (1985), Russell *et al.* (1996), Patterson *et al.* (2004), and Rivest *et al.* (1998) suggested that radio-collared

caribou must be randomly distributed throughout the population. Valkenburg *et al.* (1985) tested the null hypothesis that aggregation size and the proportion of radio-collared caribou in an aggregation were independent, or, simply that the distribution of radio-collared caribou among groups was random in the Western Arctic, Delta, Delta/Yanert, and Fortymile herds in Alaska during a photocensus. Valkenburg *et al.* (1985) used chi-square goodness-of-fit tests (contingency analysis) to compare the observed and expected (theoretical) distribution of radio-collared caribou among aggregations in these herds (Gibbons 1985). The number of radio-collared caribou expected in each group was calculated assuming that the collars were distributed among groups in proportion to group size as follows:

> expected number of radio-collars = [number of caribou in a group / total number of caribou in all groups] X [total number of radio-collars in all groups].

The results of contingency tests provided in Tables 1 to 4 by Valkenburg *et al.* (1985) indicate that the distribution of radio-collared caribou among groups was not significantly different from that expected if the radio collars were distributed in proportion to group size. Radio-collared caribou were therefore distributed uniformly rather than randomly in these populations as indicated by Valkenburg *et al.* (1985).

Valkenburg *et al.* (1985) compared the observed vs. expected frequencies of radio-collared caribou in large groups but pooled the data for small groups. For example, in Table 1, Valkenburg *et al.* (1985) pooled data for six groups ranging

in size from 479 to 7,530 caribou. These groups were then evaluated as if they were one group of 23,376 caribou. In addition, most of their comparisons did not follow the common rule of thumb that the chi-square approximation is reliable as long as no more than 20% of the expected frequencies (e_i) are less than 5 and no e_i is less than 1 (Gibbons, 1985). If either of these conditions are not satisfied, the customary procedure is to combine adjacent categories until this rule is met (Gibbons, 1985). We re-analyzed the data presented in Tables 1 to 4 by Valkenburg *et al.* (1985) by grouping the data to satisfy the requirements of a contingency analysis. We sorted groups in descending order of group size. If the e_i of collars in the largest group exceeded 5, this group became row 1 in the contingency table. If the e_i of collars in the largest group was less then 5, we sequentially pooled groups till the e_i exceeded 5. Together these groups became row 1 in the contingency table. Similarly, we used the next group as row 2 in the contingency table if e_i exceeded 5, or we sequentially pooled the next groups till the e_i exceeded 5. Together these groups became row 2 in the contingency table, and so on. Our analysis of Valkenburg *et al.* (1985) data suggests that radio collars were distributed in proportion to group size in the Fortymile and Western Arctic herds but not in the Delta and Delta/Yanert herds.

Contingency analyses are used to compare observed and theoretical (expected) frequency distributions (Gibbons, 1985). If one expects radio collars to be distributed among groups in proportion to group size, there should be a significant linear relationship between the number of radio collars expected and observed in the groups photographed. We used Spearman's rank correlation

tests (Gibbons, 1985) to evaluate the relationships between 1) the number of radio-collared caribou present in groups and group size and 2) the number of radio-collared caribou present in groups and number of radio-collars expected if radio-collars were distributed among groups in proportion to group size. Significant Spearman's rank correlation values ≥0.5 were considered to be strong positive correlations; significant Spearman's rank correlation values <0.5 were considered to be weak positive correlations.

Cape Bathurst Herd

We found a strong positive correlation between the numbers of radio-collared caribou present in groups and group size for the Cape Bathurst herd in 2006; there was no correlation between these values in 2000 and 2005 (Table 6). These analyses suggest that radio-collared caribou were uniformly distributed among groups in proportion to group size during the 2006 photocensus but not during those in 2000 and 2005.

We found a strong positive correlation between the numbers of radio-collared caribou present in groups and the number expected if radio-collared were distributed among groups in proportion to groups size during 2000 and 2005; there was no correlation between these values in 2006 (Table 6). These analyses suggest that radio-collared caribou were uniformly distributed among groups in proportion to groups size during the 2000 and 2005 photocensus but not during that 2006.

Given that 90% to 100% of the caribou photographed or counted during 2000, 2005, and 2006 were associated with radio-collared caribou, these relationships may have little relevance.

Bluenose-West Herd

We found a positive correlation between the numbers of radio-collared caribou present in groups and group size during all years (Table 7). Similarly, we found a positive correlation between the numbers of radio-collared caribou present in groups and the number expected if radio-collared caribou were distributed among groups in proportion to group size in all years (Table 7). These analyses suggest that the radio-collared caribou were uniformly distributed among groups in proportion to group size during the time of the photocensus in all years.

Bluenose-East Herd

We found a positive correlation between the numbers of radio-collared caribou present in groups vs. group size during all years (Table 8). These analyses suggest that the radio-collared caribou were uniformly distributed among groups in proportion to group size during the time of the photocensus in all years. We found a positive correlation between the numbers of radio-collared caribou present in groups and the number expected if radio-collared caribou were distributed among groups in proportion to group size during the time of the photocensus in 2000 and 2006, but not in 2005 (Table 8). These analyses

suggest that the radio-collared caribou were likely uniformly distributed among groups in proportion to group size during the time of the photocensus in all years.

Condition 9: The average distances between or among capture sites for radio-collared caribou that are photographed in groups that contain two or more radio collars, is relatively large. If there is social bonding or a tendency for some radio-collared individuals to associate, some aggregations may contain many radios, while other aggregations of a similar size may contain few or no radios (Valkenburg *et al.*, 1985). If the average distances between or among captures sites is relatively large, radio-collared caribou likely formed post-calving/early summer aggregations in response to environmental rather than behavioural factors.

To evaluate the possibility that caribou were in groups during the photocensus because of social bonding or a tendency for some radio-collared individuals to associate with each other, we mapped the capture sites of caribou that were in groups that contained more than one radio-collared caribou in relationship to where they were photographed. This was done for all multiple collar groups photographed in 1986, 1987, 1992, 2000, 2005, and 2006. We also calculated the distance between all possible pairs of capture sites for caribou in groups containing ≥2 radio-collared caribou and the geometric mean distance between the capture sites for caribou in each group (excluding same site captures).

The geometric mean distances between/among capture sites for caribou in groups that contained two or more collared caribou during the 1986, 1987, 1992, 2000, 2005, and 2006 photocensus surveys are given in Table 5. Multiple captures were made at the same locations for caribou that were photographed or counted in some groups during the 1986, 1987, 1992, and 2006 surveys (Table 5). These include:

1) During the 1986 photocensus of the Bluenose-West herd, one of eight multiple collar groups contained caribou that were captured at the same sites in the same year (Table 5). Group 59 contained 9 collars; eight of these were captured in November 1985. These eight captures were made at five sites; two caribou were captured at each of three locations and two were captured at different sites. These caribou may have been photographed as part of the same group because of social bonding behaviour or because the group contained a large proportion of the herd. Group 59 contained 16,703 adult caribou or approximately 20% of the caribou counted in the herd.
2) During the 1987 photocensus of the Bluenose-West herd, three of seven multiple collar groups contained caribou that were captured at the same site in the same year (Table 5). Group 8 contained four caribou that were captured in November 1985; two of these four were captured at the same site. Group 10 contained 5 caribou that were captured in November 1985; two of these five were captured at the same site. Group 11 contained 6 caribou that were captured in November 1985; 3 of these were captured at

the same site. These caribou may have been photographed as part of the same group because of social bonding behaviour or because these groups contained a large proportion of the herd. Group 8 contained 6,923 adults or 7% of caribou counted, Group 10 contained 16,592 adults or 16% of caribou counted, and Group 11 contained 15,178 adults or 15% of caribou counted in the herd.

3) During the 1992 photocensus of the Bluenose-West herd, group 14 contained 2 caribou that were captured at the same site in November 1990 (Table 5). These caribou may have been photographed as part of the same group because of social bonding behaviour or because the group contained a large proportion of the herd. Group 14 contained 10,272 adults or 14% of the caribou counted in the herd.
4) During the 1992 photocensus of the Cape Bathurst herd, group 56 contained two caribou that were captured at the same location in November 1990 (Table 5). These caribou may have been photographed as part of the same group because of social bonding behaviour or because the group contained a large proportion of the herd. Group 56 contained 5,244 caribou or 32% of the caribou counted in the herd.
5) During the 2006 photocensus of the Bluenose-East herd, group 25 contained 17 radio-collared caribou; two of these were captured at the same site in March 2006. These caribou may have been photographed as part of the same group because of social bonding behaviour or because

the group contained a large proportion of the caribou counted. Group 25 contained 30,149 adults or 47% of the caribou counted in the herd.

By conducting reconnaissance surveys prior to capture efforts, collars have been deployed as uniformly as possible across the winter ranges of these herds and multiple captures at the same site are avoided. As a result, the average distances between capture sites for caribou photographed in the same group, excluding those that were captured at the same sites, are large (Table 5). Figures 68 to 142 show the spatial distribution of capture sites for all multiple collar groups photographed or counted since 1986. Figure 138 provides an excellent example of the spatial distribution of capture sites documented for one Group 25 photographed in the Bluenose-East herd. These data indicate that caribou aggregated on post-calving and early summer ranges during the surveys conducted in 1986, 1987, 1992, 2000, 2005, and 2006 in response to environmental factors rather than as a result of social bonding behaviour.

6.0 CONCLUSIONS

Since 1986, our understanding of the movements and distribution patterns of barren-ground caribou in the northern Northwest Territories has improved significantly. Based on 10 years of satellite tracking studies, we have partitioned the Bluenose herd into 3 separate herds including the Cape Bathurst, Bluenose-West, and Bluenose-East herds. Based on work done by Hawley *et al.* (1979), there was sufficient supporting evidence for separation of the Bluenose herd into 3 separate herds in 1976. VHF radio telemetry data obtained between 1985 and 2006 supplemented data obtained by tracking satellite-collared cows and allowed use to compare the early July distribution of cows and bulls in each herd. We also completed a retrospective analysis of data obtained during photocensus surveys conducted in 1986, 1987, and 1992 and estimated the number of caribou in the Cape Bathurst, Bluenose-West, and Bluenose-East herds during those years. Analyses of capture and radio-telemetry data indicate that caribou aggregate on post-calving and early summer ranges in response to environmental factors rather than as a result of social bonding behaviour.

We have improved the methods used to derive population estimates using photocensus techniques during the period 1986 to 2006 by:

a) defining the number of populations and ranges used by those populations within the range originally ascribed to the Bluenose herd,
b) conducting reconnaissance surveys to define the distribution of these herds prior to radio collar deployment,

c) selecting individual caribou at random within groups while deploying radio collars but ensuring that radio collars are deployed as uniformly as possible, given weather and logistic constraints, throughout the ranges used by these herds at the time of radio collar deployment,

d) increasing the number of radio collars deployed in each herd to ensure that there is a reasonable probability that all caribou in the herd are detected during the photocensus,

e) achieving a sex ratio of 30%–40% bulls to 60%–70% cows for radio-collared caribou at the time of the photocensus and so that cow and bull groups in each herd are located during the photocensus,

f) conducting range-wide reconnaissance surveys, if required, to ensure that the status of all-radio collared caribou is known prior to the photocensus,

g) taking high resolution photographs of groups during the photocensus so that caribou can be easily identified and counted on photos,

h) using GIS software to count caribou on photos, thus ensuring that counts are accurate and repeatable,

i) monitoring the movements of VHF radio-collared and satellite-collared caribou to ensure that there are no movements of caribou between herds or between groups in each herd during the photocensus,

j) using standardized techniques to derive population estimates and compare population estimates among years.

These improvements were made over a number of years. More changes may occur in the future as our knowledge of the movements and distribution of caribou in this area improves and technology improves.

A thorough review of the data obtained during the photocensus surveys conducted between 1986 and 2006 was undertaken to derive the population estimates provided in this document. These population estimates indicate that the Cape Bathurst, Bluenose-West, and Bluenose-East herds have declined significantly.

LITERATURE CITED

Andre, J. Caribou by the numbers. Qaivvik Limited and Caribou Pass Outfitters Limited . 2007.

Brackett, D., Spencer, W., and Hall, E. 1982. Bluenose caribou surveys, 1978-1979. Northwest Territories Wildlife Service File Report No. 24: 22 pp.

Hawley, V., Hawley, A., Poll, D., and Brown, R. 1979. The Bluenose caribou herd, 1974-1976. Canadian Wildlife Service, Edmonton, Alberta draft report: 113 pp.

Hawley, V., Poll, D., and Brown, R. 1976. Status of the Bluenose caribou herd. Canadian Wildlife Service, Edmonton, Alberta. 55 pp.

Latour, P. and Heard, D.C. 1985. A population estimate for the Bluenose caribou herd in 1981. NWT Wildlife Service, Government of the Northwest Territories, Yellowknife, NWT File Report 56: 25 pp.

Latour, P., Williams, M., and Heard, D. 1986. A calving ground and population estimate for the Bluenose caribou herd in 1983. Department of Renewable Resources, Government of the Northwest Territories, Yellowknife, NWT File Report No. 61: 23 pp.

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. and Bucher, C. 2007. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West herds derived using post calving photography, July 2000. Department of Environment and Natural Resources Manuscript Report. 28 pp.

Nagy, J.A. and Bucher, C. Distribution and abundance of caribou on the post-calving ranges of the Cape Bathurst and Bluenose-West barren-ground caribou herds, 2004. Department of Environment and Natural Resources Manuscript Report . In prep.

Nagy, J.A. and Fraser, P. 2007. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West herds derived using post calving photography, July 1992. Department of Environment and Natural Resources, Government of Northwest Territories manuscipt report 23 pp.

Nagy, J.A. and Johnson, D. 2006a. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West herds and reideer/caribou on the upper Tuktoyaktuk Peninsula derived using post calving photography, July 2006. Department of Environment and Natural Resources, Government of the Northwest Territories, Northwest Territories, Canada Manuscript Report No. 171: 56.

Nagy, J.A. and Johnson, D. Calf:cow ratios estimated at or near the peak of calving for the Bluenose-West herd, 2002 to 2005. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT X1A 2L9, Canada and Department of Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT X0E 0P0, Canada, 62 pp. 2007.

Nagy, J.A. and Johnson, D. Calf:cow ratios estimated at or near the peak of calving for the Cape Bathurst herd, 2002 to 2006. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT X1A 2L9, Canada and Department of Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, NT X0E 0P0, Canada, 61 pp. 2007.

Nagy, J.A. and Johnson, D. 2007c. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West herds derived using post calving photography, July 2005. Department of Environment and Natural Resources, Government of Northwest Territories manuscript report. 34 pp.

Nagy, J.A. and Johnson, D. Distribution and abundance of caribou on the post-calving ranges of the Cape Bathurst and Bluenose-West barren-ground caribou herds, 2003. Department of Environment and Natural Resources Manuscript Report. In prep.

Nagy, J.A., McLean, B.D., and Russell, H.J. 2007a. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West herds derived using post-calving photography, July 1986 and 1987. Department of Environment, Government of Northwest Territories, Yellowknife, NT Manuscript Report. 31 pp.

Nagy, J.A., Tracz, B., and Gunn, A. 2007b. Estimates of the number of barren-ground caribou in the Bluenose-East herd derived using post calving photography, July 2005. Department of Environment and Natural Resources, Government of Northwest Territories Manuscript Report. 25 pp.

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.

Rivest, L., Couturier, S., and Crepeau, H. 1998. Statistical methods for estimating caribou abundance using postcalving aggregations detected by radio telemetry. *Biometrics* 54: 865-876.

Russell, H.J., Couturier, S., Sopuck, L.G., and Ovaska, K. 1996. Post-calving photo-census of the Rivere George caribou herd in July 1993. *Rangifer Special Issue* 319-330.

Valkenburg, P., Anderson, D.A., Davis, J.L., and Reed, D.J. 1985. Evaluation of an aerial photocensus technique for caribou based on radio-telemetry. Alaska Department of Fish and Game: 287-299.

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

Whitten, K.R. 1985. Censusing the porcupine caribou herd: Practical application of aerial photo techniques. In Proceedings of the 2nd North American Caribou Workshop. T.C. Meredith and A.M. Martell (eds). McGill Subarctic Research Paper. No. 40. 327 pp.

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

Wooley, D.R. and Mair, M.B. 1977. A survey of the Bluenose caribou herd on their winter range, 1977. Unpublished report prepared for Canadian Arctic Gas Pipeline Ltd. by Renewable Resources Consulting Services Ltd. 42 pp.

Table 1. Population estimates for the Cape Bathurst, Bluenose-West, Bluenose-East barren-ground caribou herds, 1986 to 2006.

Herd and Year	M[1]	C[1]	R[1]	N[1]	95% CI[1]	Lower[1] 95%CI	Upper[1] 95%CI	CV (%)
				Cape Bathurst herd				
1986[2]	3	13,476	3	13,476	0	13,476	13,476	0.0
1987[2]	6	10,728	5	12,516	3,504	9,012	16,020	28.0
1992[2]	6	16524	5	19,278	5,397	13,881	24,675	28.0
2000	17	9,857	15	11,089	1,756	9,333	12,845	15.8
2005	32	2,213	29	2,434	257	2,178	2,691	10.5
2006	33	1,714	31	1,821	149	1,672	1,971	8.2
				Bluenose-West herd				
1986	35	83,460	33	88,369	6,899	81,470	95,269	7.8
1987	44	104,512	43	106,887	4,655	102,233	111,542	4.4
1992	33	76,008	22	112,360	25,566	86,794	137,926	22.8
2000	47	52,508	32	76,376	14,347	62,029	90,723	18.8
2005	63	17,875	54	20,800	2,040	18,760	22,840	9.8
2006	66	17,781	65	18,050	527	17,523	18,578	2.9
				Bluenose-East herd				
1992[3]	6	13323	5	15,544	4,352	11,192	19,895	28.0
2000	33	84,412	23	119,584	25,419	94,165	145,003	21.3
2005	43	60,524	37	70,081	8,120	61,961	78,200	11.6
2006	51	61,619	47	66,754	5,182	61,572	71,936	7.8
				Cape Bathurst and Bluenose-West herds combined				
1986	38	96,936	36	102,176	7,356	94,820	109,531	7.2
1987	50	115,240	48	119,944	6,582	113,361	126,526	5.5
1992	39	92,532	27	132,189	26,348	105,841	158537.2	19.9
2000	64	62,365	47	84,453	12,089	72,364	96,542	14.3
2005	95	20,088	83	22,958	1,722	21,236	24679.9	7.5
2006	99	19,495	96	20,098	688	19,410	20785.5	3.4
				Cape Bathurst, Bluenose-West, and Bluenose-East herds combined				
1992[3]	39	105855	32	128,309	18,040	110,270	146,349	14.1
				Cape Bathurst, Bluenose-West, and Bluenose-East herds combined				
2000[4]	97	146,777	70	202,594	24,557	178,037	227,151	12.1
2005	138	80,612	120	92,604	5,909	86,695	98,513	6.4
2006	150	81,114	143	85,057	2,978	82,079	88,035	3.5

[1]Population estimate calculated as:

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

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 $N_i = 1.96 Var(N)^{0.5}$, where:

$$Var(N) = ((M+1)(C+1)(M-R)(C-R))/(R+1)^2(R+2)$$

[2]There was a small number of radio-collared caribou in the herd however the Cape Bathurst area is relatively small and was flown extensively. Large groups that did not contain collars were found in the area when searching for radio-collared caribou in 1986 and 1987.

[3] Ten cows were fitted with radio collars in the Dismal Lakes area during March 1988 (n = 2) and November 1989 (n = 8). Six of these cows were alive during the 1992 photocensus; caribou associated with 5 of these radio-collared caribou were photographed. There were too few radio-collared caribou in the Bluenose-East herd to obtain a reliable population estimate during the 1992 photocensus. The area was not flown extensively to locate other caribou in the area.

[4] The Cape Bathurst, Bluenose-West, and Bluenose-East herds were first censused as separate herds in 2000. Radio collars were deployed throughout the fall (Bluenose-East herd) and winter ranges (Cape Bathurst and Bluenose-West herds) in preparation for this survey.

Table 2. Lincoln-Petersen estimators used to determine if the relative abundance of caribou (K) in each herd or herds combined were significantly different between years.

Herds and Years Compared	K[1]	Lower 95% CI[2]	Upper 95% CI[2]	Difference in Population Estimates between Years
		Cape Bathurst		
1986 vs. 1987	1.00	0.559	1.441	no significant difference
1987 vs. 1992	0.83	0.054	1.613	no significant difference
1992 vs. 2000	**0.83**	0.570	1.097	no significant difference
2000 vs. 2005	0.88	0.832	0.933	herd size significantly lower in 2005 than 2000
2005 vs. 2006	0.91	0.800	1.012	no significant difference
		Bluenose-West		
1986 vs. 1987	0.94	0.826	1.059	no significant difference
1987 vs. 1992	0.98	0.787	1.167	no significant difference
1992 vs. 2000	0.67	0.438	0.895	herd size significantly lower in 2000 than 1992
2000 vs. 2005	0.68	0.617	0.744	herd size significantly lower in 2005 than 2000
2005 vs. 2006	0.86	0.765	0.949	herd size significantly lower in 2006 than 2005
		Bluenose-East		
2000 vs. 2005	**0.70**	0.539	0.855	herd size significantly lower in 2005 than 2000
2005 vs. 2006	**0.86**	0.718	1.003	no significant difference
		Cape Bathurst and Bluenose-West combined		
1986 vs. 1987	0.95	0.831	1.064	no significant difference
1987 vs. 1992	0.96	0.774	1.146	no significant difference
1992 vs. 2000	0.69	0.511	0.874	combined number significantly lower in 2000 than 1992
2000 vs. 2005	0.73	0.686	0.783	combined number significantly lower in 2005 than 2000
2005 vs. 2006	0.87	0.799	0.948	combined number significantly lower in 2006 than 2005
		Cape Bathurst, Bluenose-West, Bluenose-East combined		
2000 vs. 2005	0.72	0.653	0.790	combined number significantly lower in 2005 than 2000
2005 vs. 2006	0.87	0.801	0.939	combined number significantly lower in 2006 than 2005

[1]We estimated K and constructed the appropriate 95% confidence intervals as follows (Williams *et al.*, 2002b):

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

with

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

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.

[2]We calculated the 95% CI of K as $1.96Var(K)^{0.5}$ (Williams *et al.*, 2002b). 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.

Table 3. Test statistics for Spearman's rank correlation test of the relationship between the number of radio-collared caribou in groups located and photographed or counted during a photocensus vs. the number of caribou in those groups.

Number of collars observed vs. the number of caribou in groups by herd	Year	N	Spearman's rho	Prob > t	Correlation
Bluenose-East (Patterson *et al.*, 2004)	2000	22	0.649	0.001	strong positive
Bluenose-East	2005	25	0.431	0.032	weak positive
Bluenose-East	2006	28	0.657	0.000	strong positive
Bluenose-West	1986	35	0.682	0.000	strong positive
Bluenose-West	1987	21	0.570	0.007	strong positive
Bluenose-West	1992	30	0.460	0.011	weak positive
Bluenose-West	2000	20	0.533	0.016	strong positive
Bluenose-West	2005	40	0.735	0.000	strong positive
Bluenose-West	2006	65	0.566	0.000	strong positive
Cape Bathurst	2000	8	0.702	0.052	no
Cape Bathurst	2005	15	0.421	0.118	no
Cape Bathurst	2006	11	0.613	0.000	strong positive
Delta (Valkenburg *et al.*, 1985)	1983	30	0.671	0.000	strong positive
Delta and Yanert (Valkenburg *et al.*, 1985)	1984	12	0.854	0.000	strong positive
Fortymile (Valkenburg *et al.*, 1985)	1984	22	0.766	0.000	strong positive
George River (Rivest *et al.*, 1998)	1993	28	0.886	0.000	strong positive
Western Arctic (Valkenburg *et al.*, 1985)	1982	12	0.700	0.011	strong positive

Table 4. Test statistics for Spearman's rank correlation test of the relationship between the number of radio-collared caribou in groups located and photographed or counted during a photocensus vs. the number of collars expected in those groups if radio-collared caribou were distributed among groups in proportion to groups size.

Number of collars observed vs. the number of expected in groups by herd	Year	N	Spearman's rho	Prob > t	Correlation
Bluenose-East (Patterson *et al.*, 2004)	2000	22.000	0.522	0.013	strong positive
Bluenose-East	2005	25.000	0.375	0.065	no
Bluenose-East	2006	28.000	0.726	0.000	strong positive
Bluenose-West	1986	35.000	0.587	0.000	strong positive
Bluenose-West	1987	21.000	0.597	0.004	strong positive
Bluenose-West	1992	30.000	0.577	0.001	strong positive
Bluenose-West	2000	20.000	0.549	0.012	strong positive
Bluenose-West	2005	40.000	0.730	0.000	strong positive
Bluenose-West	2006	65.000	0.493	0.000	weak positive
Cape Bathurst	2000	8.000	0.761	0.028	strong positive
Cape Bathurst	2005	15.000	0.395	0.145	no
Cape Bathurst	2006	11.000	0.833	0.002	strong positive
Delta (Valkenburg *et al.*, 1985)	1983	30.000	0.700	0.000	strong positive
Delta and Yanert (Valkenburg *et al.*, 1985)	1984	12.000	0.871	0.000	strong positive
Fortymile (Valkenburg *et al.*, 1985)	1984	22.000	0.779	0.000	strong positive
George River (Rivest *et al.*, 1998)	1993	28.000	0.929	0.000	strong positive
Western Arctic (Valkenburg *et al.*, 1985)	1982	12.000	0.787	0.002	strong positive

Table 5. Geometric mean distance between capture sites for caribou in groups that contained two or more collared caribou.

Year	Herd	Group No.	No. of Collars	Geometric Mean Distance (km) Mean	Min	Max	Capture Dates/Comments
1986	BW	1	2	24.1			1 captured November 1985; 1 in March 1986
1986	BW	4	2	68.7			2 captured November 1985
1986	BW	5	2	31.1			2 captured March 86
1986	BW	33	4	61.9	17.2	110.1	2 captured November 1985; 2 in March 1986
1986	BW	34	2	46.2			2 captured November 1985
1986	BW	54	2	94.0			1 captured November 1985; 1 in March 1986
1986	BW	57	2	23.5			1 captured November 1985; 1 in March 1986
1986	BW	59	9	45.2	0.0	81.2	8 captured November 1985; 1 in March 1986; 2 caribou captured at each of 3 locations
1986	CB						no multiple collar groups
1987	BW	4	2	93.8			1 captured November 1985; 1 in February 1987
1987	BW	7	4	42.0	9.9	90.6	3 captured November 1985; 1 in February 1987
1987	BW	8	5	55.7	0.0	94.0	4 captured November 1985; 1 in March 1986; 2 of 4 captured at same site
1987	BW	10	6	56.9	0.0	121.8	5 captured November 1985; 1 in February 1987; 2 of 5 captured at same site
1987	BW	11	7	48.1	0.0	110.1	6 captured November 1985; 1 in March 1986; 3 of 6 captured at same site
1987	BW	20	3	64.4	54.2	89.8	2 captured November 1985; 1 in February 1987
1987	BW	25	4	66.3	17.9	131.4	1 captured November 1985; 3 in February 1987
1987	CB	22	2	91.4			1 captured March 1986; 1 in February 1987
1987	CB	26	2	55.8			1 captured November 1985; 1 in February 1987
1992	BE	50	2	26.4			1 captured March 1988; 1 in November 1989
1992	BW	13	2	158.5			2 captured November 1990
1992	BW	14	2	0.0			2 captured November 1990 at same site
1992	BW	23	3	30.4	7.7	63.0	1 captured March 1986; 2 in November 1990
1992	BW	36	3	61.2	25.2	95.9	2 captured March 1986; 1 March 1991
1992	BW	37	2	85.6			1 captured November 1985; 1 November 1990
1992	BW	53	3	119.1	40.5	212.0	1 captured November 1985; 1 in November 1990; 1 in March 1992
1992	CB	56	2	0.0			captured at same location November 1990
2000	BW	17	7	60.3	2.5	162.4	3 captured April 1999; 4 in March 2000
2000	BW	19	3	96.8	23.9	198.7	3 captured March 2000
2000	BW	20	2	76.2			2 captured March 2000
2000	BW	21	2	133.7			1 captured April 1999; 1 in March 2000
2000	BW	24	3	83.8	49.2	126.3	1 captured April 1999; 2 in March 2000
2000	BW	BP	5	60.6	1.2	239.2	1 captured July 1999; 4 in March 2000
2000	CB	1	4	96.6	5.4	250.1	all captured March 2000
2000	CB	3	6	40.7	7.3	159.9	all captured March 2000
2000	CB	5	2	10.3			all captured March 2000
2005	BE	4	2	341.1			all captured March /April 2005
2005	BE	9	2	53.5			all captured March / April 2005

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Year	Herd	Group No.	No. of Collars	Geometric Mean Distance (km) Mean	Min	Max	Capture Dates/Comments
2005	BE	10	2	87.6			all captured March / April 2005
2005	BE	17	4	386.3	142.4	546.8	all captured March / April 2005
2005	BE	19	7	219.5	60.6	615.9	all captured March / April 2005
2005	BE	23	6	118.7	2.7	479.4	all captured March / April 2005
2005	BE	24	4	150.8	95.7	247.9	all captured March / April 2005
2005	BW	8	6	56.7	10.6	173.5	all captured March 2005
2005	BW	9	7	53.8	0.2	172.3	all captured March 2005
2005	BW	10	3	17.0	0.4	111.6	all captured March 2005
2005	BW	11	2	141.3			all captured March 2005
2005	BW	13	3	159.5	87.7	256.4	all captured March 2005
2005	BW	17	4	95.2	45.0	152.7	all captured March 2005
2005	BW	19	2	15.0			all captured March 2005
2005	BW	21	10	74.5	0.5	194.5	all captured March 2005
2005	BW	22	2	54.7			all captured March 2005
2005	BW	34	2	112.2			all captured March 2005
2005	CB	1	2	41.0			all captured March 2005
2005	CB	6	10	27.8	4.2	78.2	all captured March 2005
2005	CB	8	2	43.1			all captured March 2005
2005	CB	9	2	159.0			all captured March 2005
2005	CB	15	3	68.2	41.8	107.0	all captured March 2005
2006	BE	1	4	58.2	18.2	96.2	all captured March / April 2005
2006	BE	5	2	87.6			all captured March / April 2005
2006	BE	24	3	128.3	53.8	211.6	all captured March / April 2005
2006	BE	25.1	17(8 in 2005)	178.3	32.1	571.4	8 captured March / April 2005
2006	BE	25.2	17(9 in 2006)	181.9	0.0	440.7	9 captured March 2006; 2 caribou captured at same site
2006	BE	26	3	201.6	185.4	218.5	all captured March / April 2005
2006	BE	27	2	254.8			2 captured March 2006
2006	BE	28	2	39.3			all captured March / April 2005
2006	BE	30	2	159.7			1 captured March 2005; 1 in March 2006
2006	BW	1	3	134.4	79.0	180.9	all captured March 2005
2006	BW	6	7	78.5	15.9	220.6	4 captured March 2005; 3 in March 2006
2006	BW	11	6	73.0	4.4	222.7	3 captured March 2005; 3 in March 2006
2006	BW	13	10	86.1	8.3	172.0	8 captured March 2005; 2 in March 2006
2006	BW	14	2	121.8			2 capture March 2005
2006	BW	19	2	51.5			1 captured March 2005; 1 in March 2006
2006	BW	28	2	116.6			1 captured March 2005; 1 in March 2006
2006	BW	30	2	31.0			2 capture March 2005
2006	CB	2	2	150.4			2 captured March 2005
2006	CB	3	7	57.6	4.1	249.3	1 captured March 2002; 4 in March 2005; 2 in March 2006
2006	CB	4	19	45.6	1.0	175.0	8 captured March/April 2005; 11 in March 2006

Table 6. Evaluation of conditions during the 1986, 1987, 1992, 2000, 2005, and 2006 photocensus surveys of the Cape Bathurst herd.

Evaluation Criteria for Cape Bathurst Herd	Year					
	1986	1987	1992	2000	2005	2006
1a) Reconnaissance survey was conducted prior to collaring	No	No	No	No	Yes	Yes
1b) Collars were distributed uniformly within range	No	No	No	Yes	Yes	Yes
1c) Sufficient time allowed for dispersal of collared caribou in herd	Yes	Yes	Yes	N/A	N/A	N/A
2) Sex ratio of caribou available for photocensus was approx 30%–40% M: 60%–70% F (assumes composition of population has not been skewed by sex-biased harvest)	2F:1M (67:33)	4F:2M (67:33)	3F:3M (50:50)	13F:4M (76:24)	23F:9M (72:28)	24F:9M (73:27)
3) Sufficient number of radio-collars deployed	No	No	No	No	Yes	Yes
a) All highly aggregated groups contained at least one radio-collared caribou	No	No	No	No	Yes	Yes
b) Majority of caribou photographed (≥90%) were in groups that contained radio-collared caribou	No	No	No	Yes	Yes	Yes
- Number of groups without radio-collared caribou	5 of 8 groups	1 of 4 groups	3 of 6 groups	2 of 8 groups	0 of 19 groups	5 of 11 groups
- % of caribou in groups that contained radio-collared caribou	41%	86%	84%	90%	100%	99%
c) Number of groups photographed not large relative to the number of radio-collared caribou located	8 groups 3 collars	4 groups 5 collars	6 groups 5 collars	8 groups 15 collars	15 groups 29 collars	11 groups 31 collars
- Number of groups per radio-collared caribou located	2.67	0.8	1.2	0.53	0.52	0.35
4) All collars heard and precisely located (status known)	Yes	Yes	Yes	Yes	Yes	Yes
5) Movements of target and adjacent herds known (population is closed)	No	No	No	Yes	Yes	Yes
6) No significant movement of caribou among groups during census	No	No	No	No	No	No
7) Weather conditions favorable for caribou to aggregate	Yes	Yes	Yes	Yes	Yes	Yes
8) Radio collars were distributed uniformly among groups in proportion to group size during the photocensus				No	No	Yes
- correlation between number of collars in groups vs. group size	- small sample size of collars	- small sample size of collars	- small sample size of collars	no correlation	no correlation	strong +correlation
- correlation between number of collars observed vs. expected	- small sample size of collars	- small sample size of collars	- small sample size of collars	strong +correlation	strong +correlation	no correlation
9) Average distance between capture sites for caribou in groups containing 2 or more collars is large	N/A	Yes	No	Yes	Yes	Yes
- Number of groups with 2 or more collars	None	2	1	3	5	3
- Number of collared caribou in groups with 2 or more collars that were captured at the same site	None	None	1 capture site 2 caribou	0	0	0
- Geometric mean distance between capture sites	N/A	55.8 - 91.4 km	0 km	10.3 - 96.6 km	41.0 - 159.0 km	45.6 - 150.4 km

Table 7. Evaluation of conditions during the 1986, 1987, 1992, 2000, 2005, and 2006 photocensus surveys of the Bluenose-West herd.

Evaluation Criteria for Bluenose-West	Year					
	1986	1987	1992	2000	2005	2006
1a) Reconnaissance survey were done prior to collaring	No	No	No	No	Yes	Yes
1b) Collars were distributed uniformly within range	No	No	No	Yes	Yes	Yes
1c) Sufficient time allowed for dispersal of collared caribou in herd	Yes	Yes	Yes	N/A	N/A	N/A
2) Sex ratio of caribou available for photocensus was approx 30%–40% M: 60%–70% F (assumes composition of population has not been skewed by sex-biased harvest)	32F:3M (91:9)	39F:4M (91:9)	23F:4M (85:15)	38F:9M (81:19)	39F:15M (72:28)	51F:15M (77:23)
3) Sufficient number of radio-collars deployed	No	No	No	Yes	Yes	Yes
a) All highly aggregated groups contained at least one radio-collared caribou	No	No	No	No	Yes	Yes
b) Majority of caribou photographed (≥90%) were in groups that contained radio-collared caribou	No	Met	No	Yes	Yes	Yes
- Number of groups without radio-collared caribou	9 of 25 groups	2 of 21 groups	16 of 30 groups	4 of 20 groups	17 of 54 groups	26 of 65 groups
- % of caribou in groups that contained radio-collared caribou	88%	96%	73%	92%	94%	92%
c) Number of groups photographed not large relative to the number of radio-collared caribou located	25 groups: 33 collars	21 groups: 43 collars	30 groups: 23 collars	20 groups: 32 collars	40 groups: 54 collars	65 groups: 65 collars
- Number of groups per radio-collared caribou located	0.76	0.49	1.30	0.63	0.74	1.00
4) All collars heard and precisely located (status known)	Yes	Yes	Yes	Yes	Yes	Yes
5) Movements of target and adjacent herds known (population is closed)	No	No	No	Yes	Yes	Yes
6) No significant movement of caribou among groups during census	Yes	Yes	Yes	Yes	Yes	Yes
7) Weather conditions favorable for caribou to aggregate	Yes	Yes	Yes, in part	Yes, in part	Yes	Yes
8) Radio collars were distributed uniformly among groups in proportion to group size during the photocensus	Yes	Yes	Yes	Yes	Yes	Yes
- correlation between number of collars in groups vs. group size	strong +correlation	strong +correlation	weak +correlation	strong +correlation	strong +correlation	strong +correlation
- correlation between number of collars observed vs. expected	strong +correlation	strong +correlation	strong +correlation	strong +correlation	strong +correlation	weak +correlation
9) Average distance between capture sites for caribou in groups containing 2 or more collars is large	Yes, in part	Yes, in part	Yes, in part	Yes	Yes	Yes
- Number of groups with 2 or more collars	8	7	6	6	10	8
- Number of collared caribou in groups with 2 or more collars that were captured at the same site	3 capture sites 6 caribou	3 capture sites 7 caribou	1 capture site 2 caribou	0	0	0
- Geometric mean distance between capture sites	23.0 - 94.0 km	48.1 - 93.8 km	30.4 - 158.5 km	60.3 - 133.7 km	15.0 - 159.5 km	31.0 - 134.4 km

Table 8. Evaluation of conditions during the 1986, 1987, 1992, 2000, 2005, and 2006 photocensus surveys of the Bluenose-East herd.

Evaluation Criteria for Bluenose-East	Year					
	1986	1987	1992	2000	2005	2006
1a) Reconnaissance survey were done prior to collaring						
1b) Collars were distributed uniformly within range	None collared	None collared	No	Yes	Yes	Yes
1c) Sufficient time allowed for dispersal of collared caribou in herd			Yes	N/A	N/A	N/A
2) Sex ratio of caribou available for photocensus was approx 30%–40% M: 60%–70% F (assumes composition of population has not been skewed by sex-biased harvest)			6F:0M (100:0)	33F:0M (100:0)	32F:11M (74:26)	51F:15M (77:23)
3) Sufficient number of radio-collars deployed			No	No	No	Yes
a) All highly aggregated groups contained at least one radio-collared caribou			No	No	No	Yes
b) Majority of caribou photographed (≥90%) were in groups that contained radio-collared caribou			Yes	No	No	Yes
- Number of groups without radio-collared caribou			0 of 4 groups	6 of 22 groups	8 of 38 groups	8 of 28 groups
- % of caribou in groups that contained radio-collared caribou			100%	87%	81%	98%
c) Number of groups photographed not large relative to the number of radio-collared caribou located			4 groups: 5 collars	22 groups: 23collars	25 groups: 38 collars	28 groups: 47 collars
- Number of groups per radio-collared caribou located			0.80	0.96	0.66	0.60
4) All collars heard and precisely located (status known)			Yes	Yes	Yes	Yes
5) Movements of target and adjacent herds known (population is closed)			No	No	Yes	Yes
6) No significant movement of caribou among groups during census			No	Yes	Yes	Yes
7) Weather conditions favorable for caribou to aggregate			Yes, in part	Yes, in part	Yes	Yes
8) Radio collars were distributed uniformly among groups in proportion to group size during the census			N/A	Yes	Yes	Yes
- correlation between number of collars in groups vs. group size			- small sample size of collars	strong +correlation	weak +correlation	strong +correlation
- correlation between number of collars observed vs. expected			- small sample size of collars	strong +correlation	no correlation	strong +correlation
9) Average distance between capture sites for caribou in groups containing 2 or more collars is large			Yes	data not available	Yes	Yes
- Number of groups with 2 or more collars			1	data not available	7	8
- Number of collared caribou in groups with 2 or more collars that were captured at the same site			0	data not available	0	1 capture site 2 caribou
- Geometric mean distance between capture sites			26.4 km	data not available	53.5 - 386.3 km	39.3 - 254.8 km

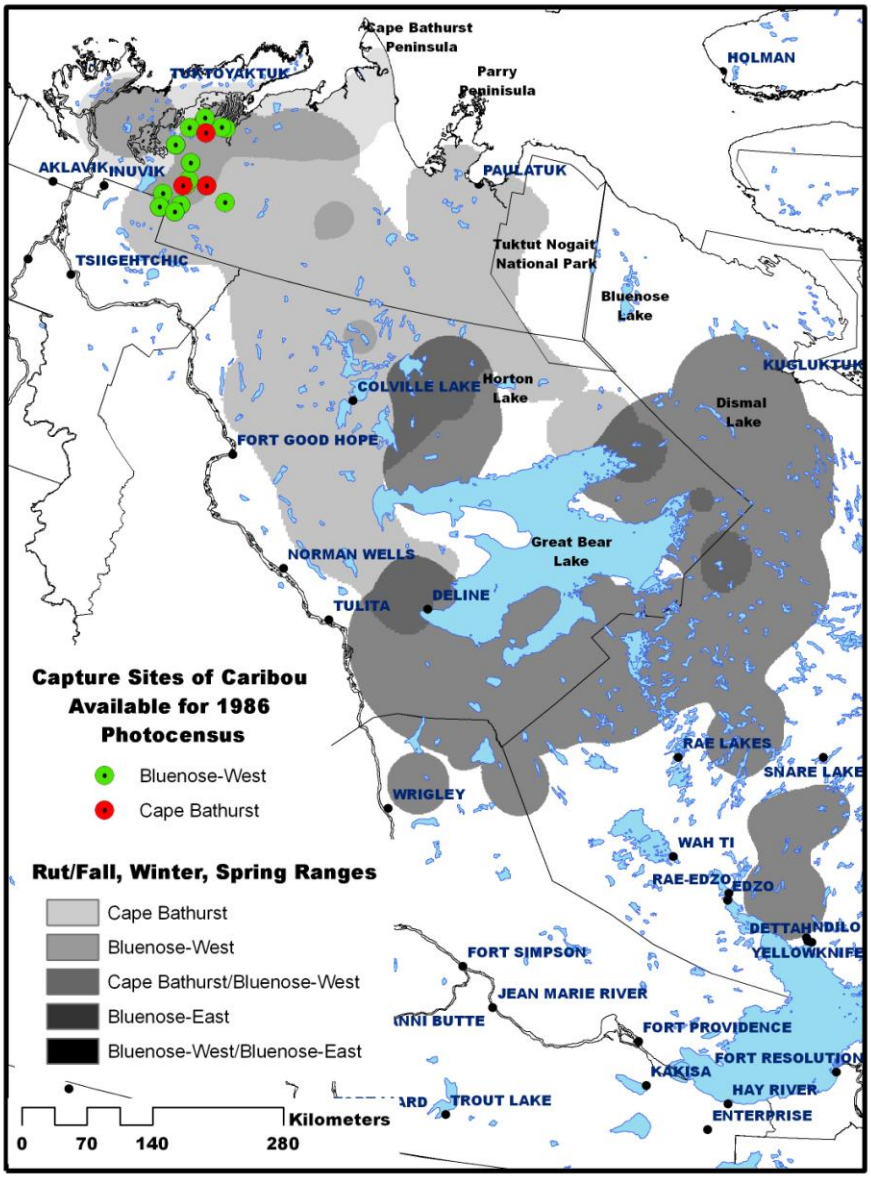

Figure 1. Capture sites for radio-collared caribou available for the 1986 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds base on the first calving ground used following capture.

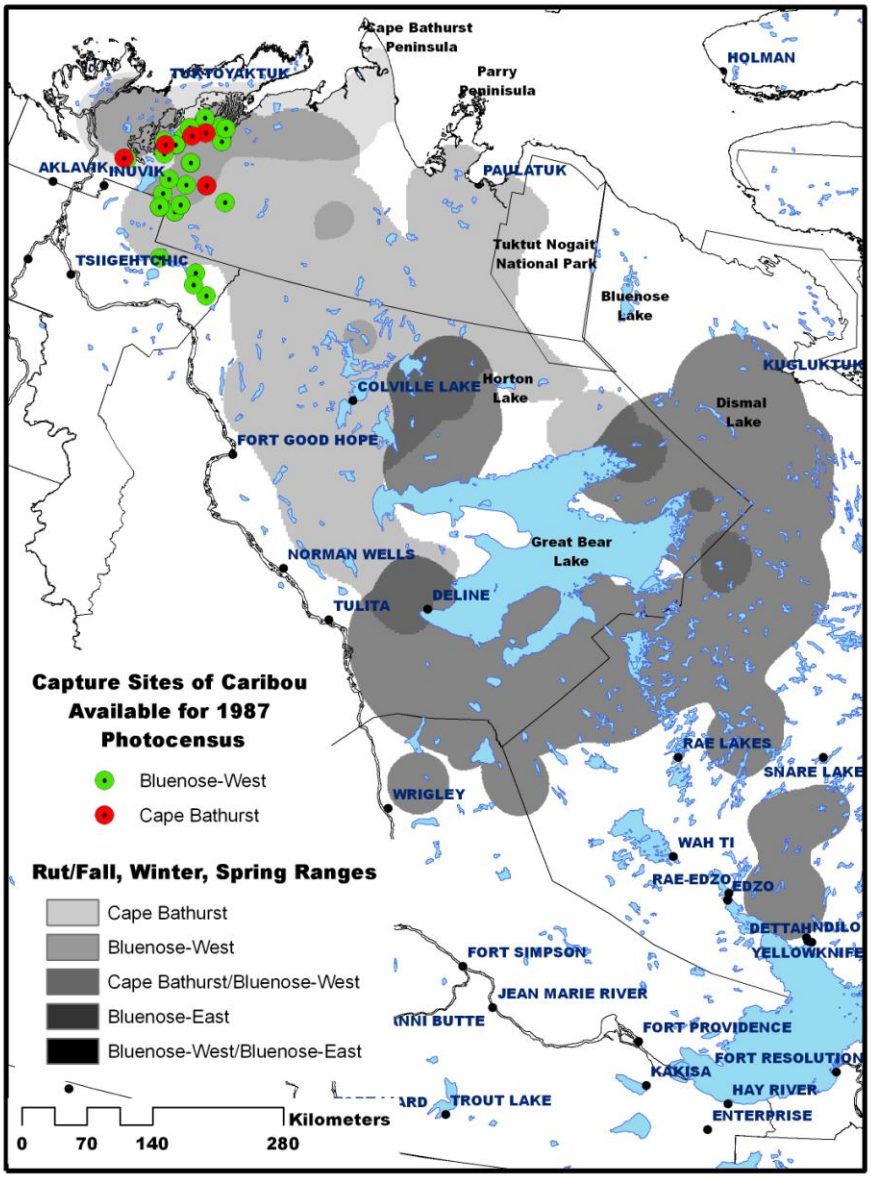

Figure 2. Capture sites for radio-collared caribou available for the 1987 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds base on the first calving ground used following capture.

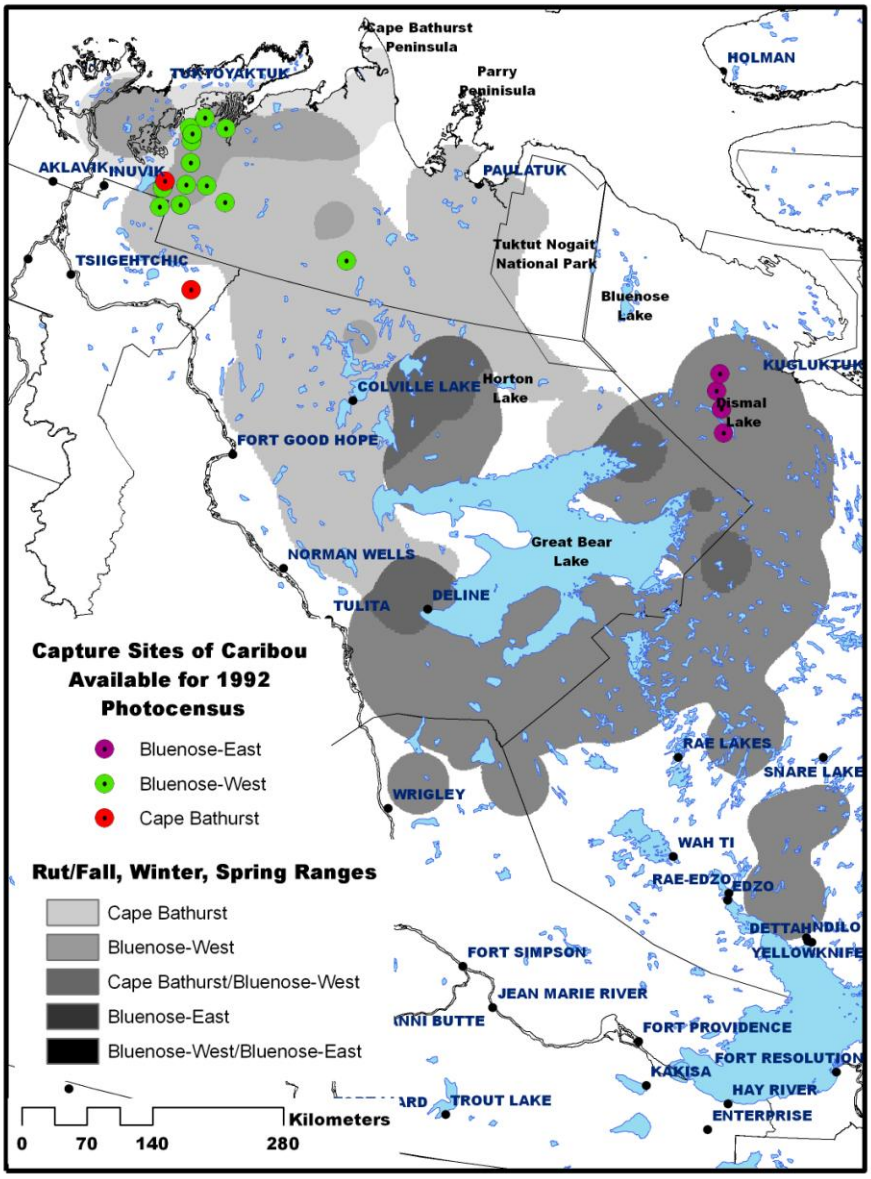

Figure 3. Capture sites for radio-collared caribou available for the 1992 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds base on the first calving ground used following capture.

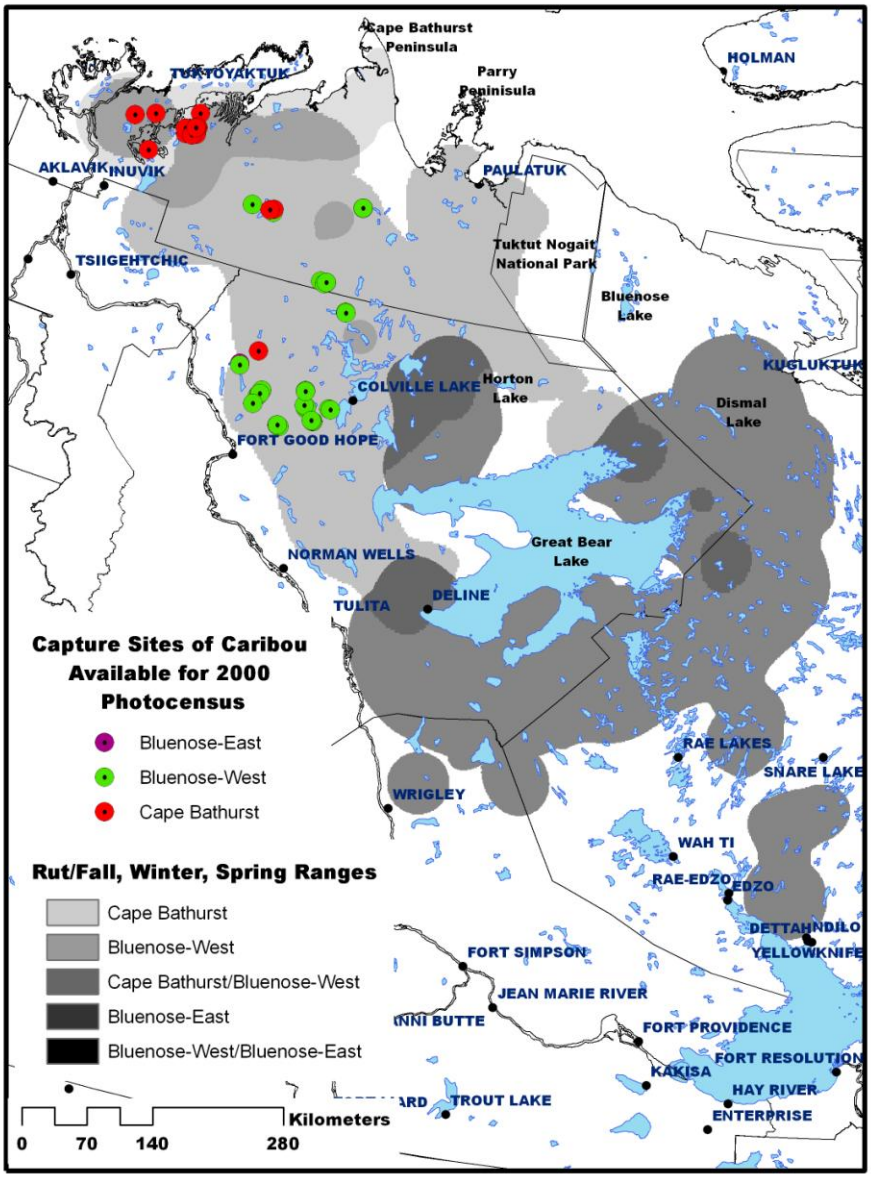

Figure 4. Capture sites for radio-collared caribou available for the 2000 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds base on the first calving ground used following capture.

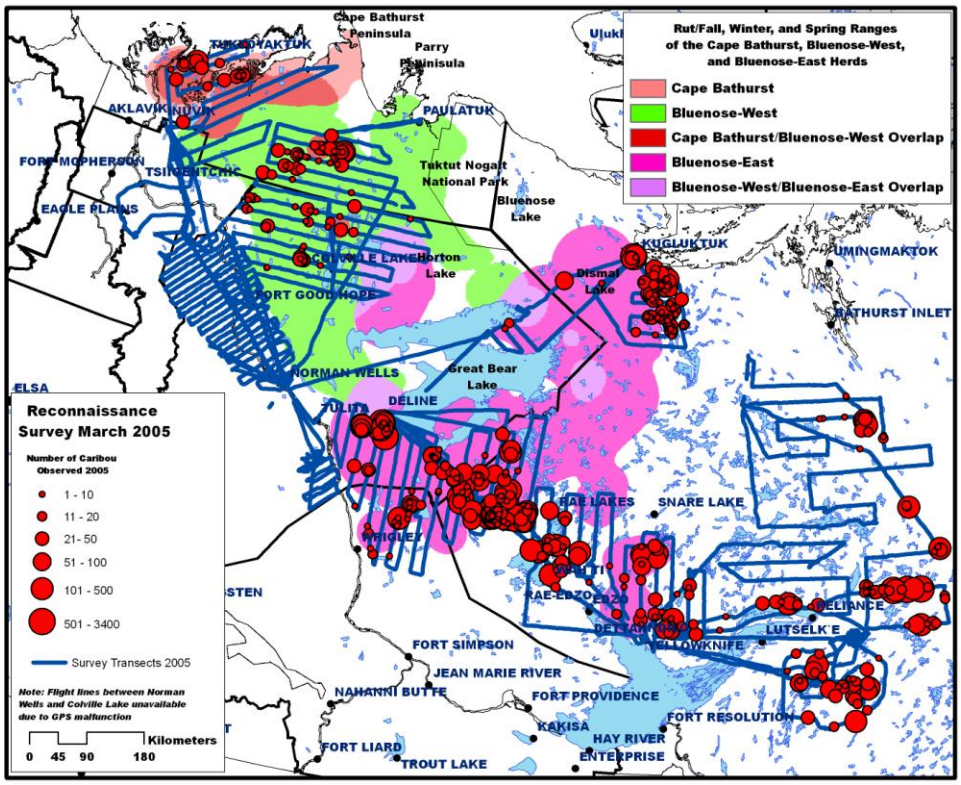

Figure 5. Transect lines flown during February and March 2005 to document the distribution of caribou on the winter ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds. Surveys done west of the Mackenzie River were primarily for boreal caribou.

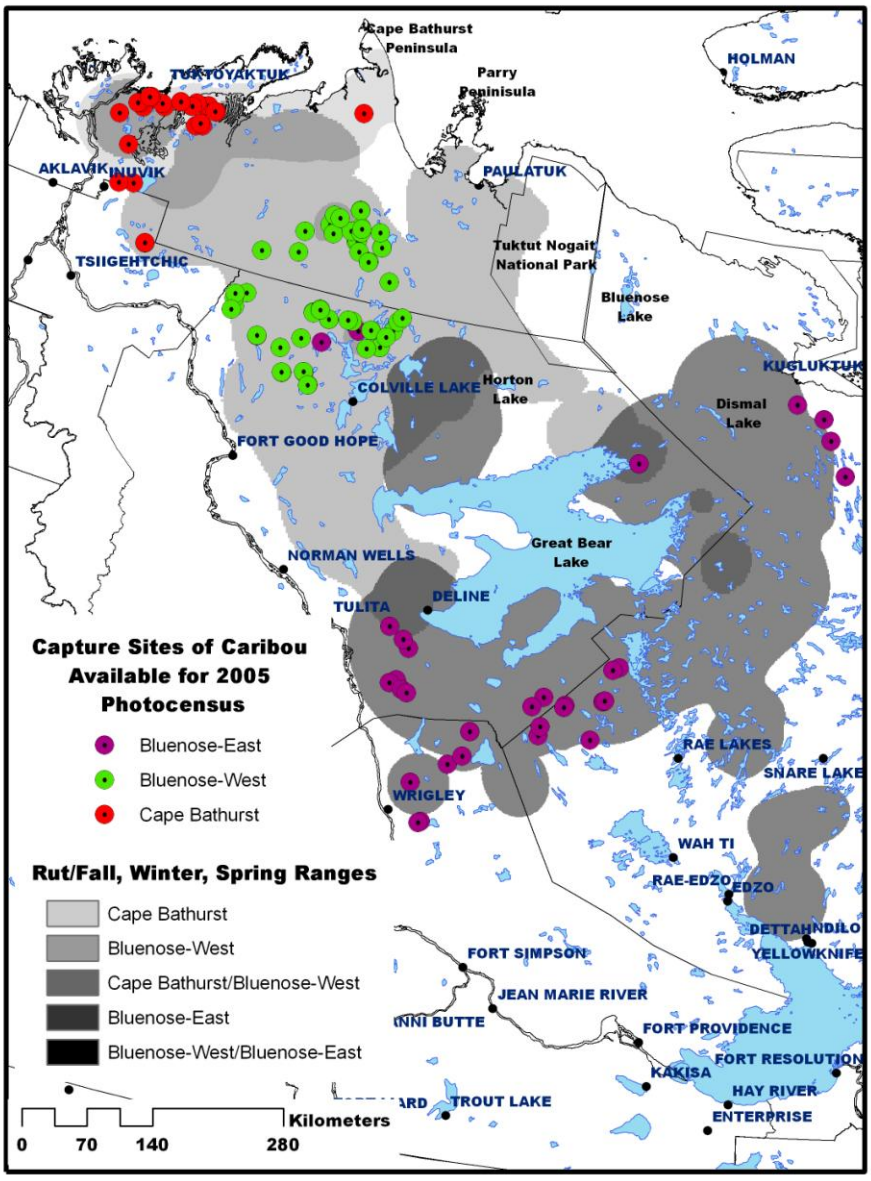

Figure 6. Capture sites for radio-collared caribou available for the 2005 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds base on the first calving ground used following capture.

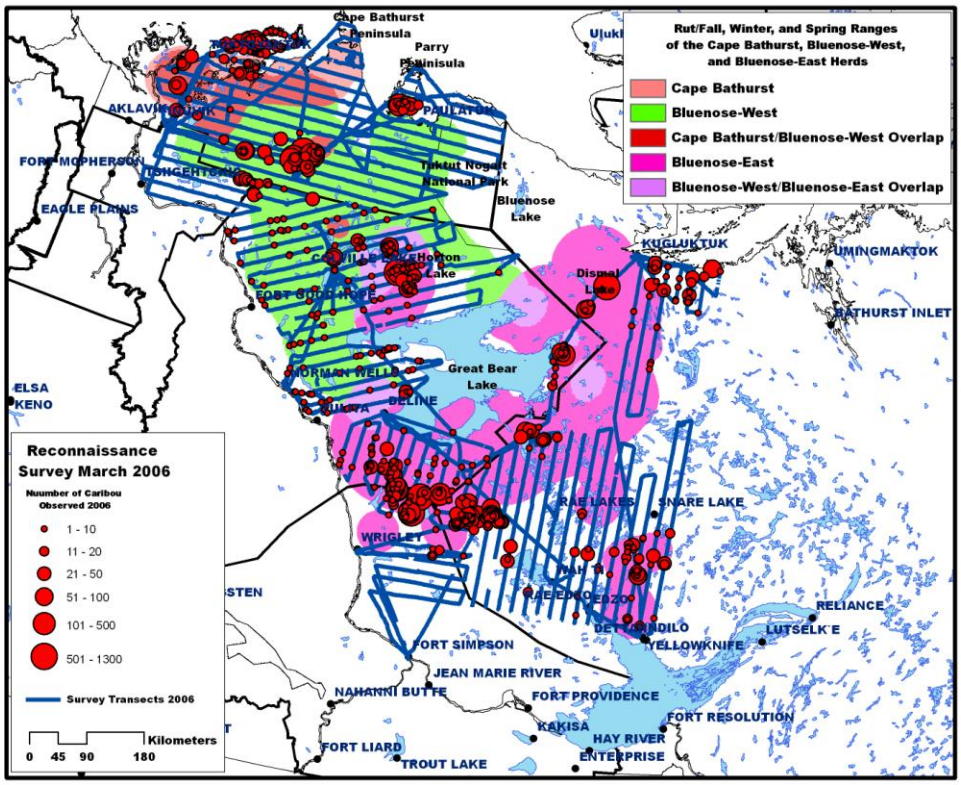

Figure 7. Transect lines flown during February and March 2006 to document the distribution of caribou on the winter ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds.

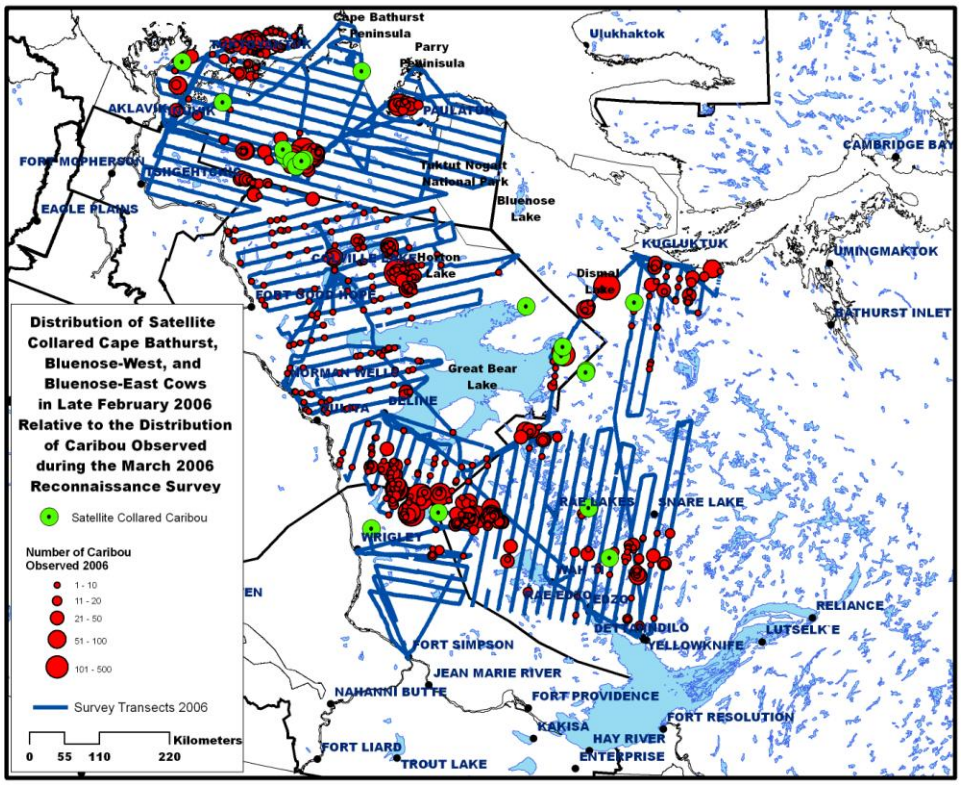

Figure 8. Transect lines flown during February and March 2006 to document the distribution of caribou on the winter ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds.

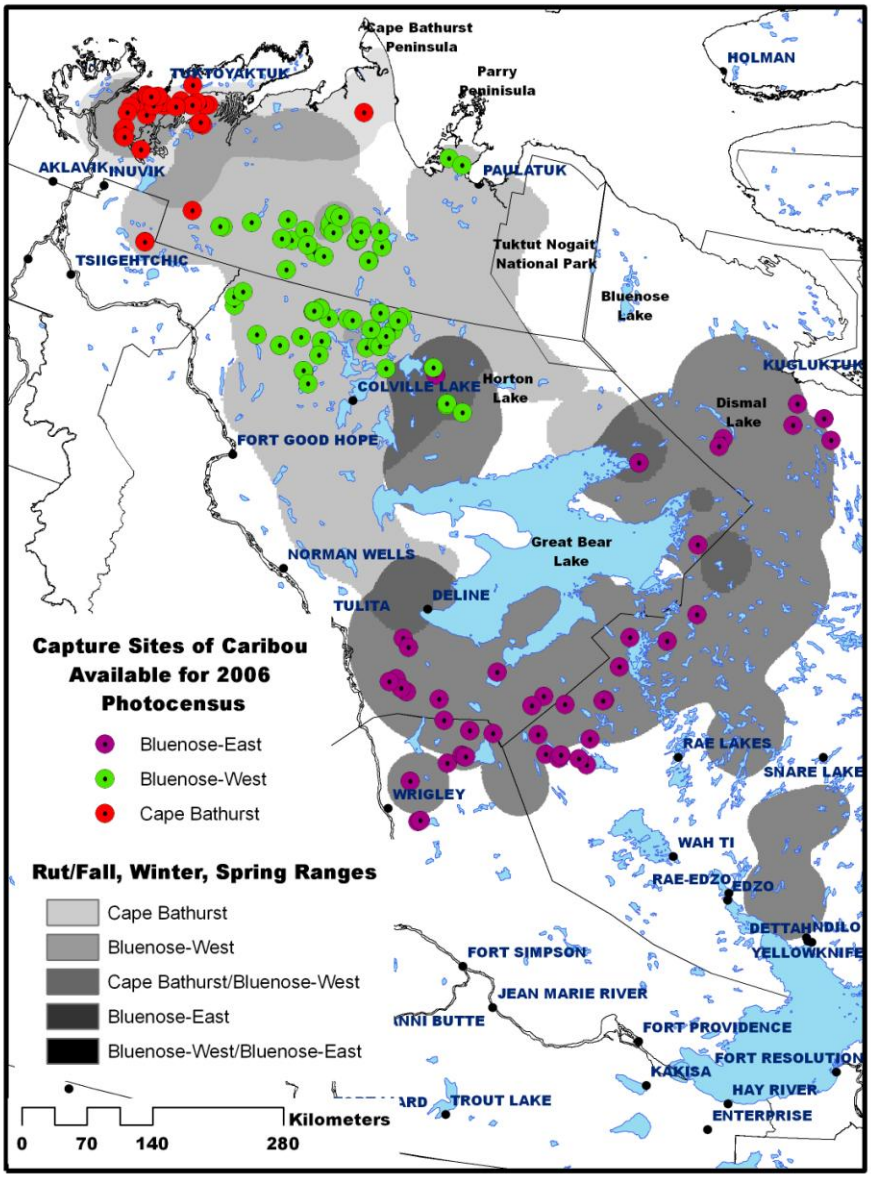

Figure 9. Capture sites for radio-collared caribou available for the 2006 photocensus in relationship to the post-rut/winter/spring-spring migration ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Nagy *et al.*, 2005). Caribou were assigned to the Cape Bathurst, Bluenose-West, and Bluenose-East herds based on the first calving ground used following capture.

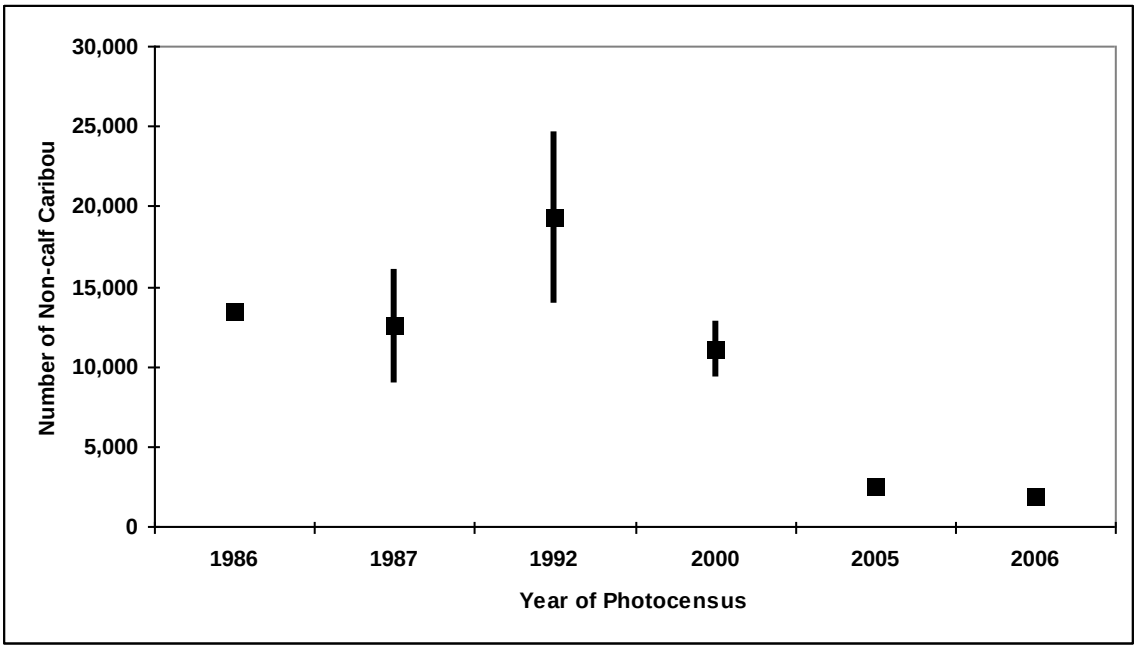

Figure 10. Population trend for the Cape Bathurst herd, 1986 to 2006.

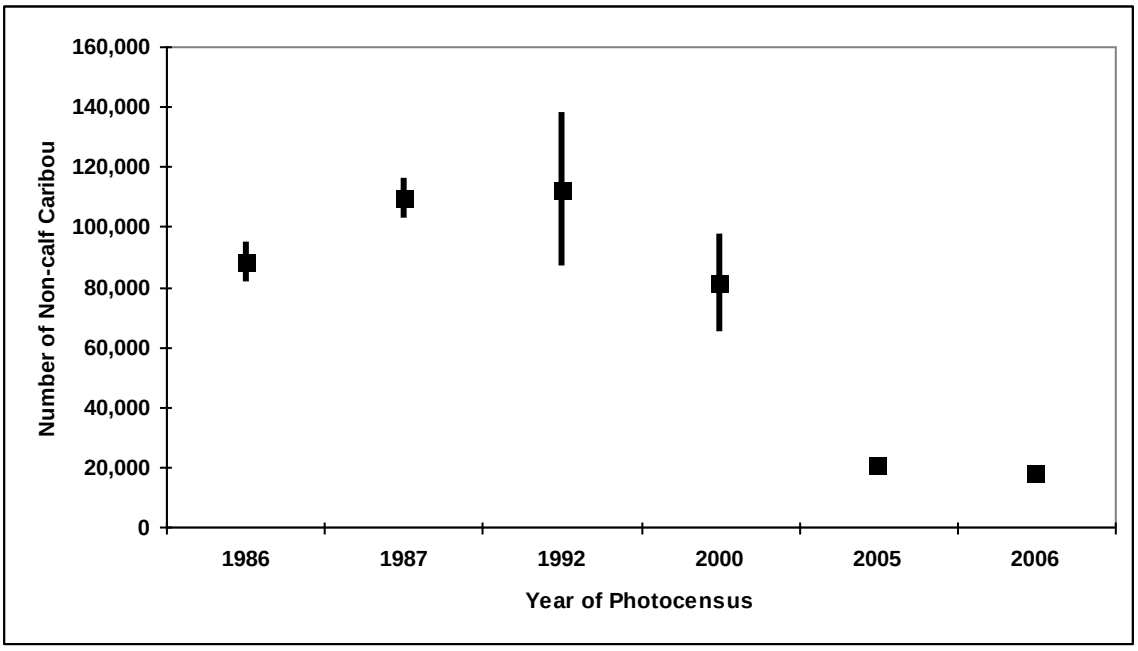

Figure 11. Population trend for the Bluenose-West herd, 1986 to 2006.

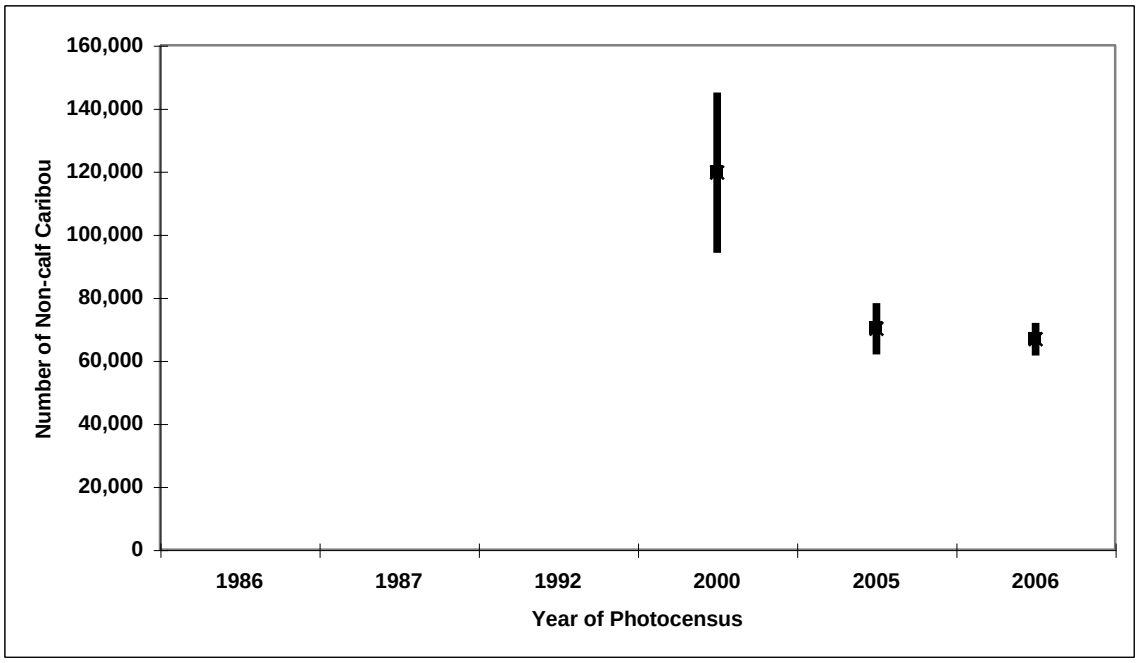

Figure 12. Population trend for the Bluenose-East herd, 2000 to 2006. Data for the caribou associated with 5 Bluenose-East caribou photographed in 1992 were not included.

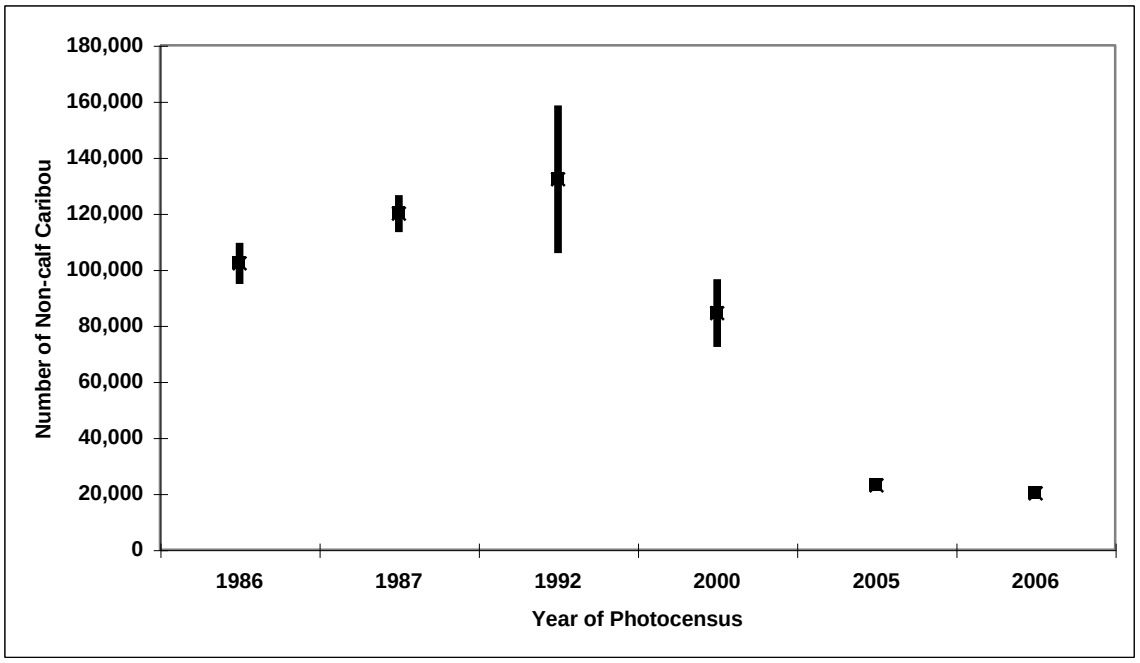

Figure 13. Population trend for the Cape Bathurst and Bluenose-West herds combined, 1986 to 2006.

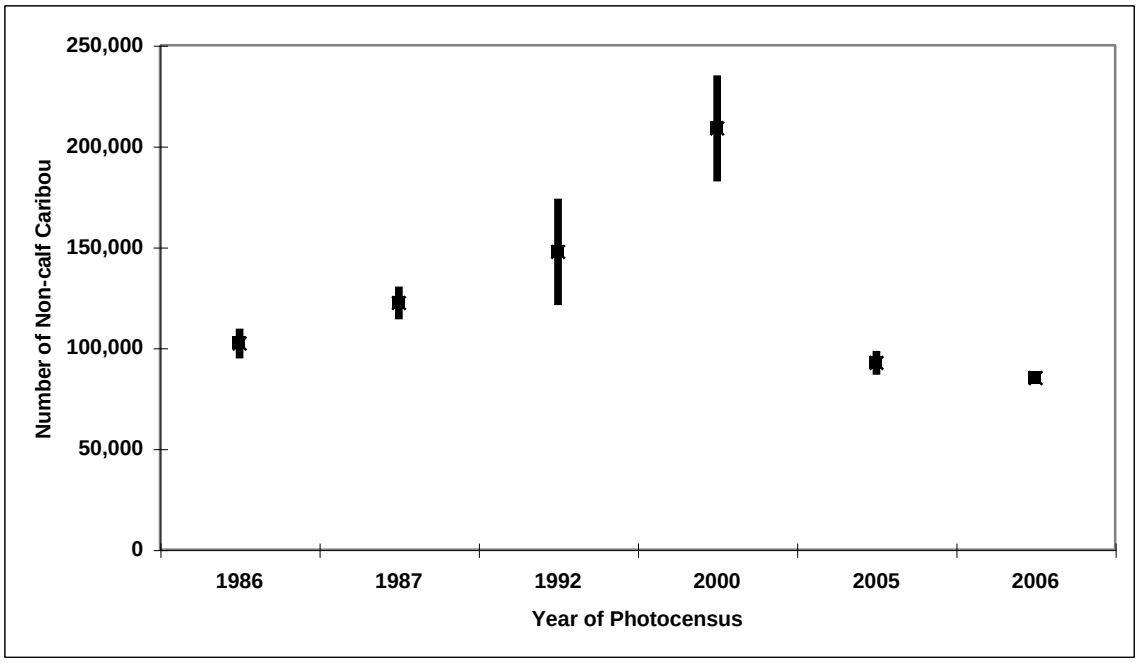

Figure 14. Population trend for the Cape Bathurst, Bluenose-West, and Bluenose-East herds combined, 1986 to 2006. Data for 1986 and 1987 are for the Cape Bathurst and Bluenose-West only. Data for 1992 are for the Cape Bathurst, Bluenose-West, and the caribou associated with 5 Bluenose-East caribou photographed in 1992. Data for 2000, 2005, and 2006 are for the three herds combined.

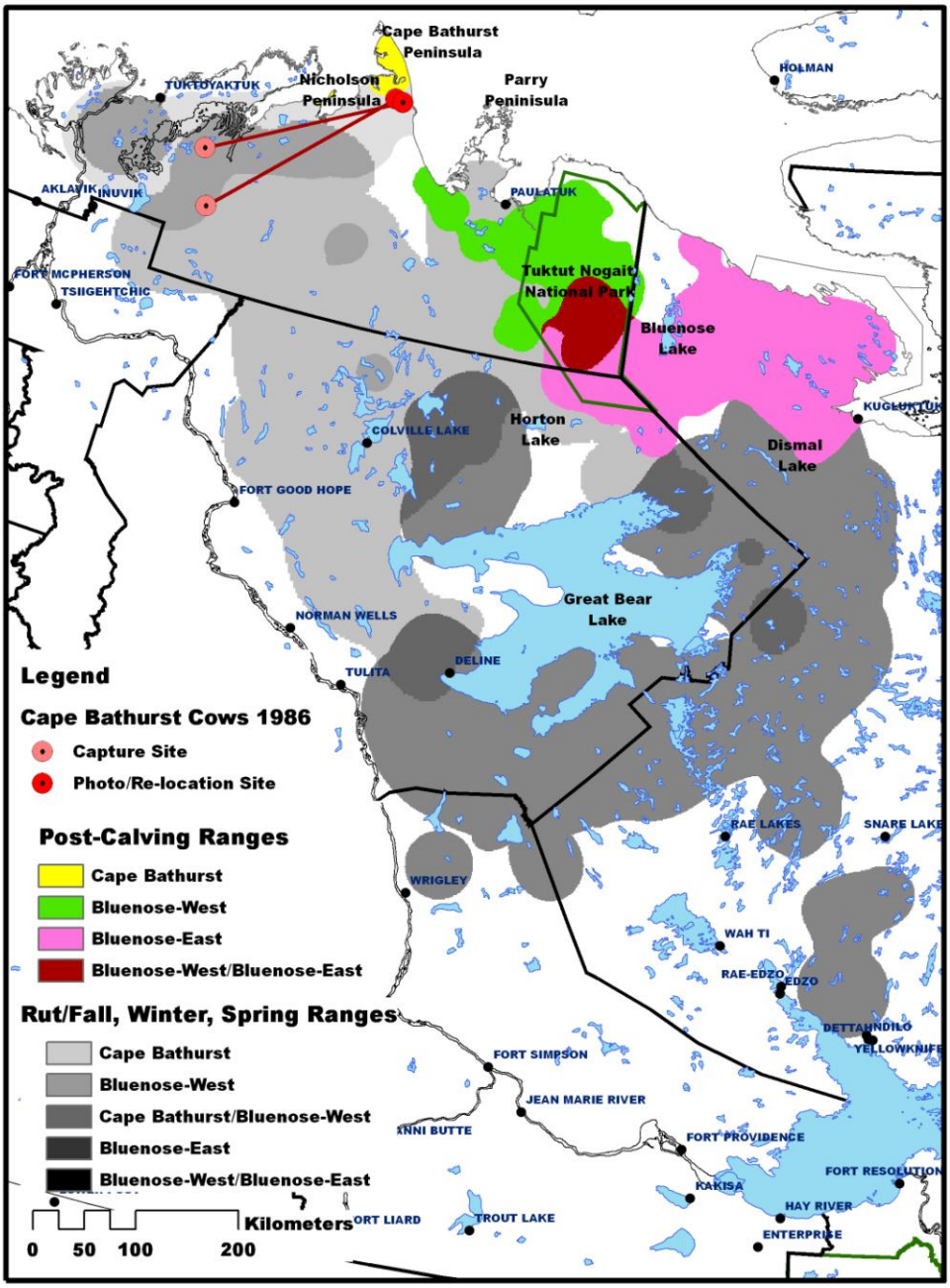

Figure 15. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 1986 photocensus surveys.

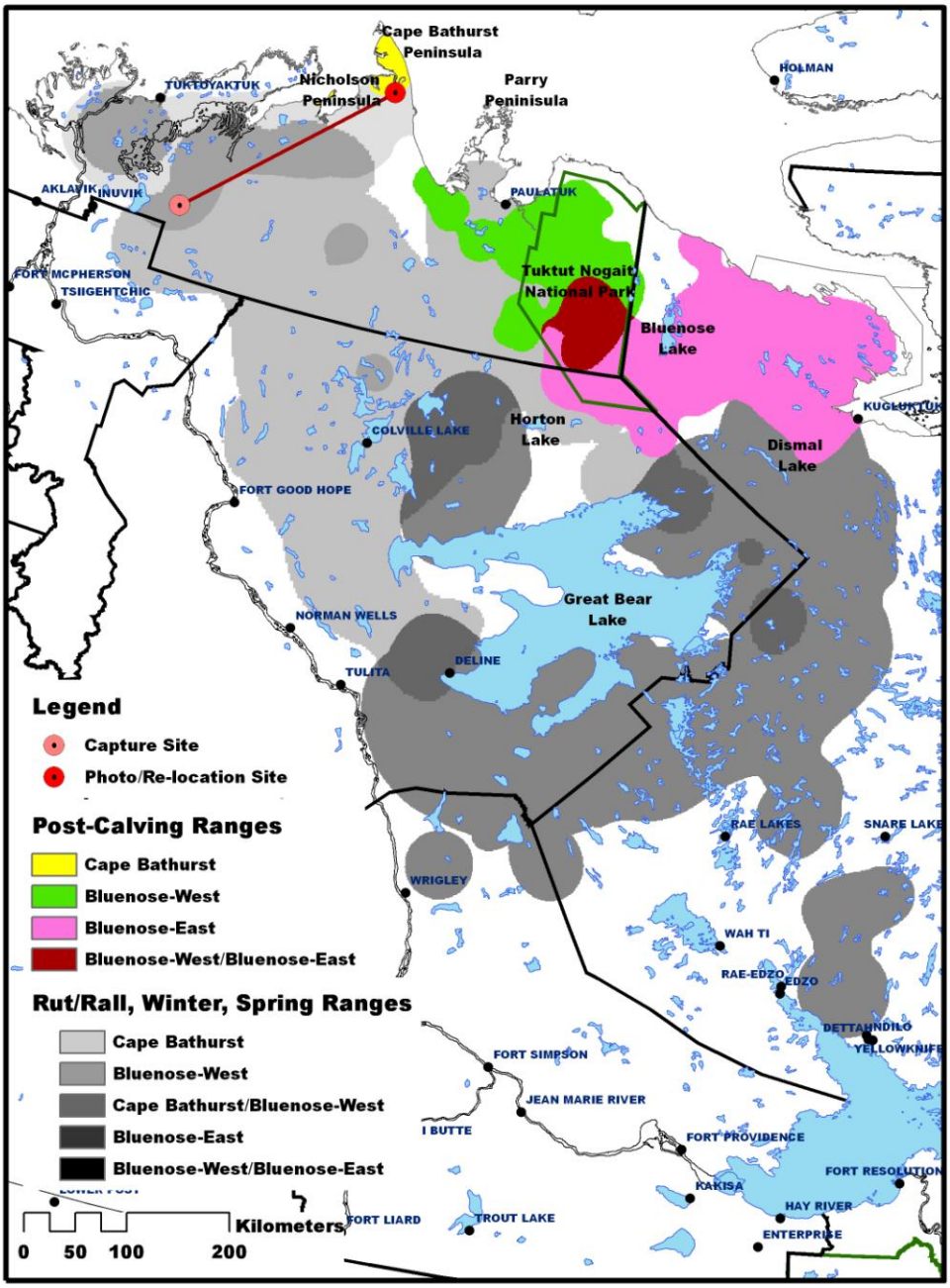

Figure 16. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the 1986 photocensus.

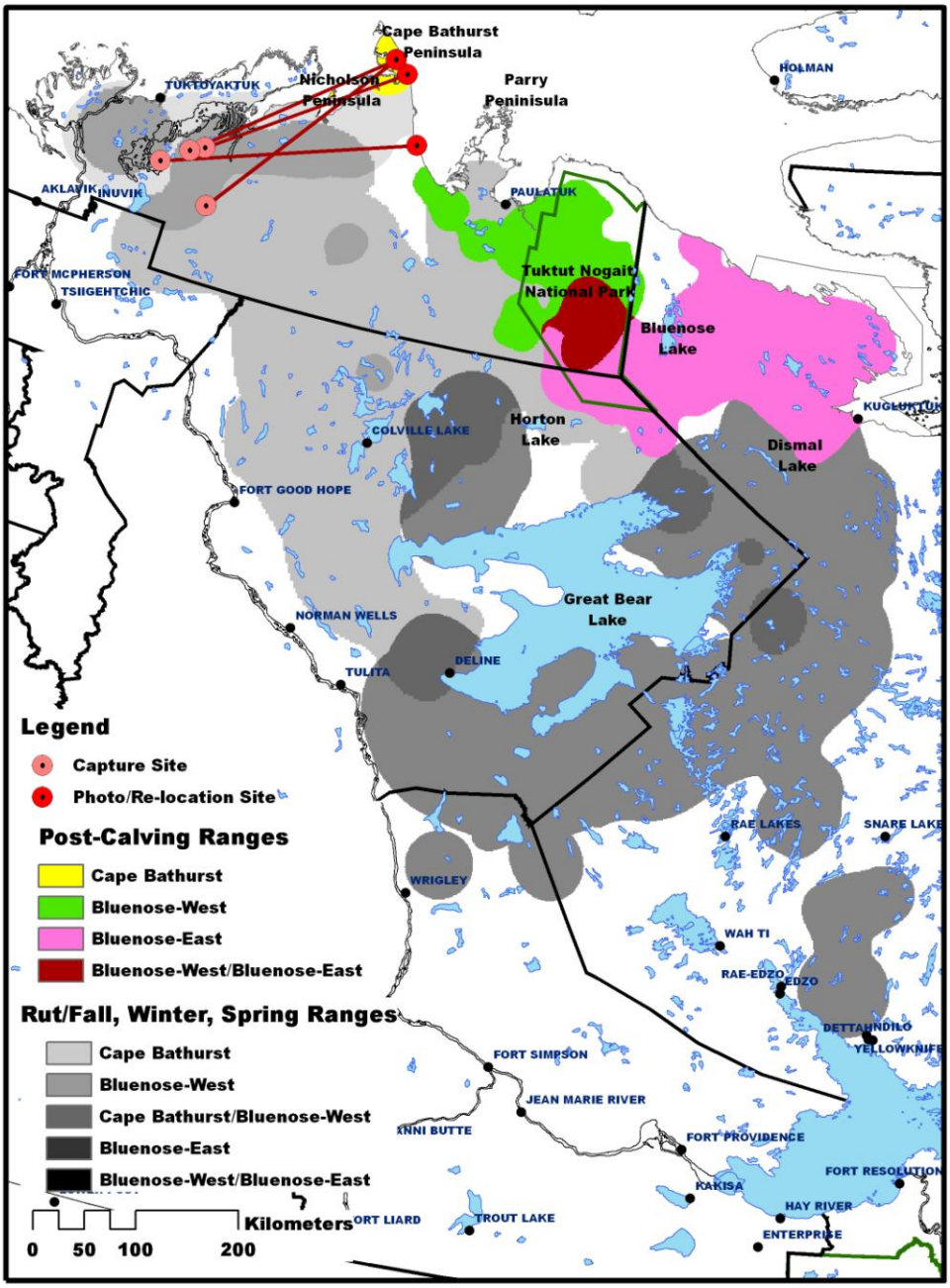

Figure 17. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 1987 photocensus.

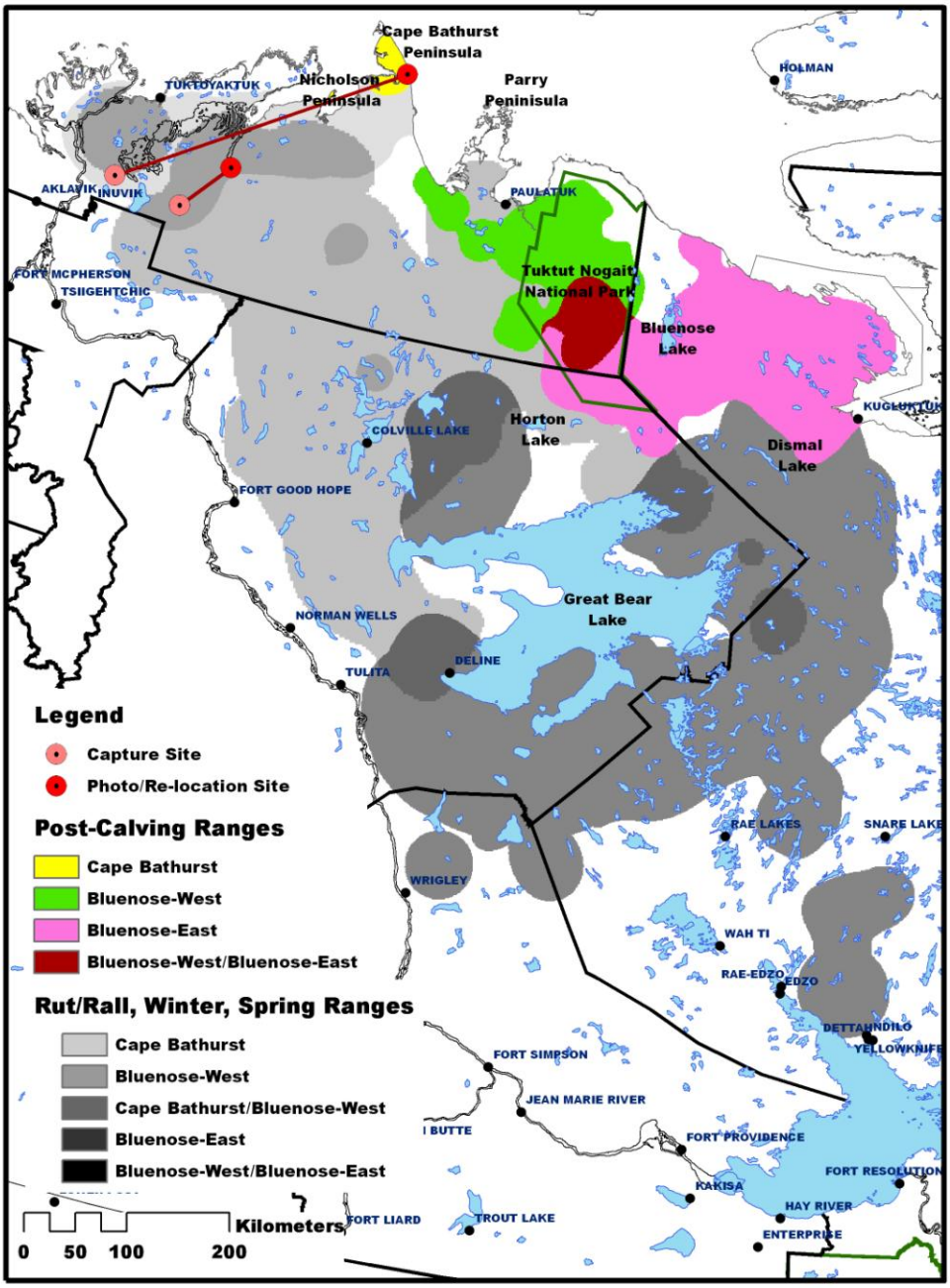

Figure 18. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they photographed or relocated during the 1987 photocensus.

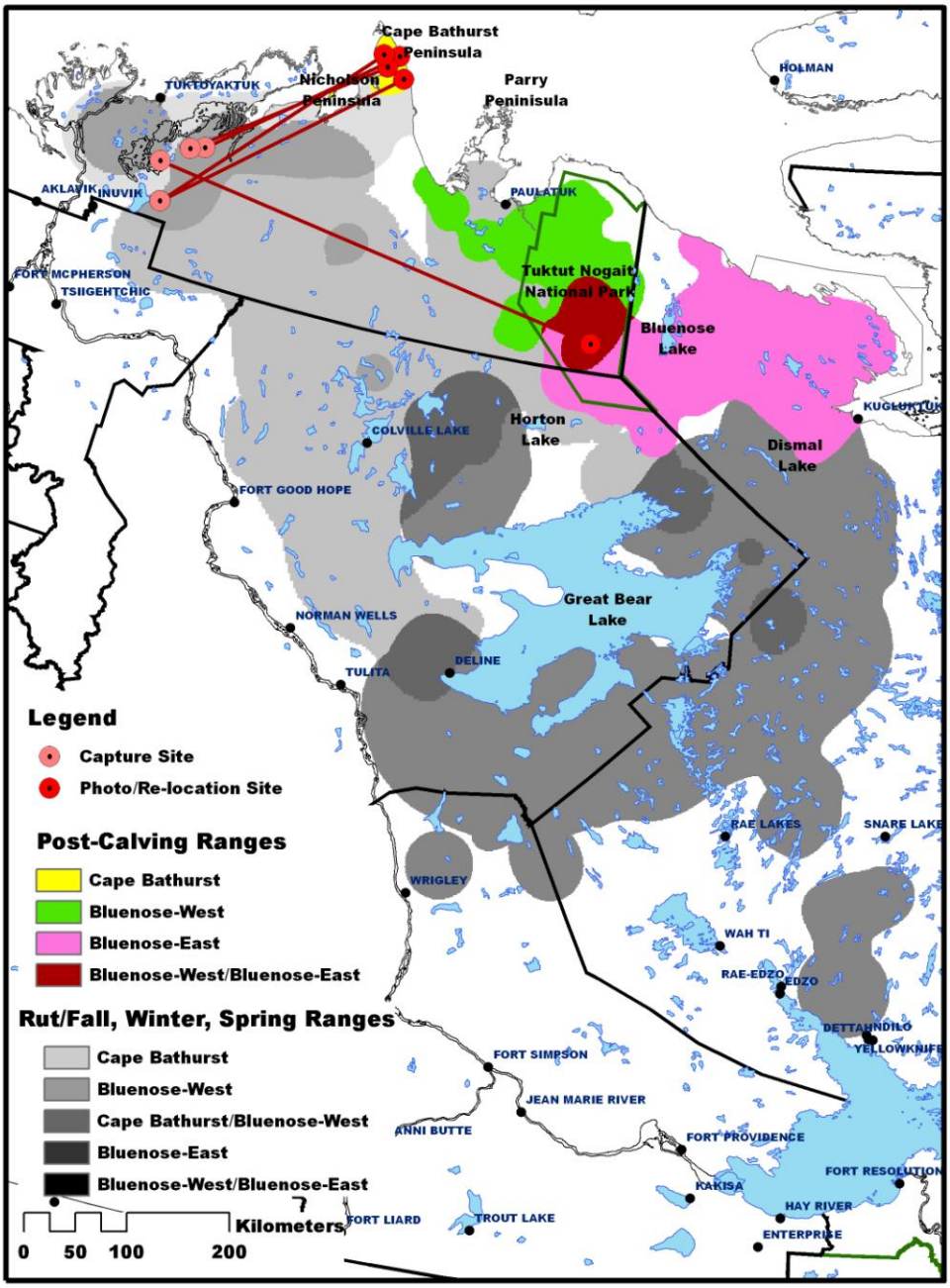

Figure 19. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were relocated during the 1991 post-calving period.

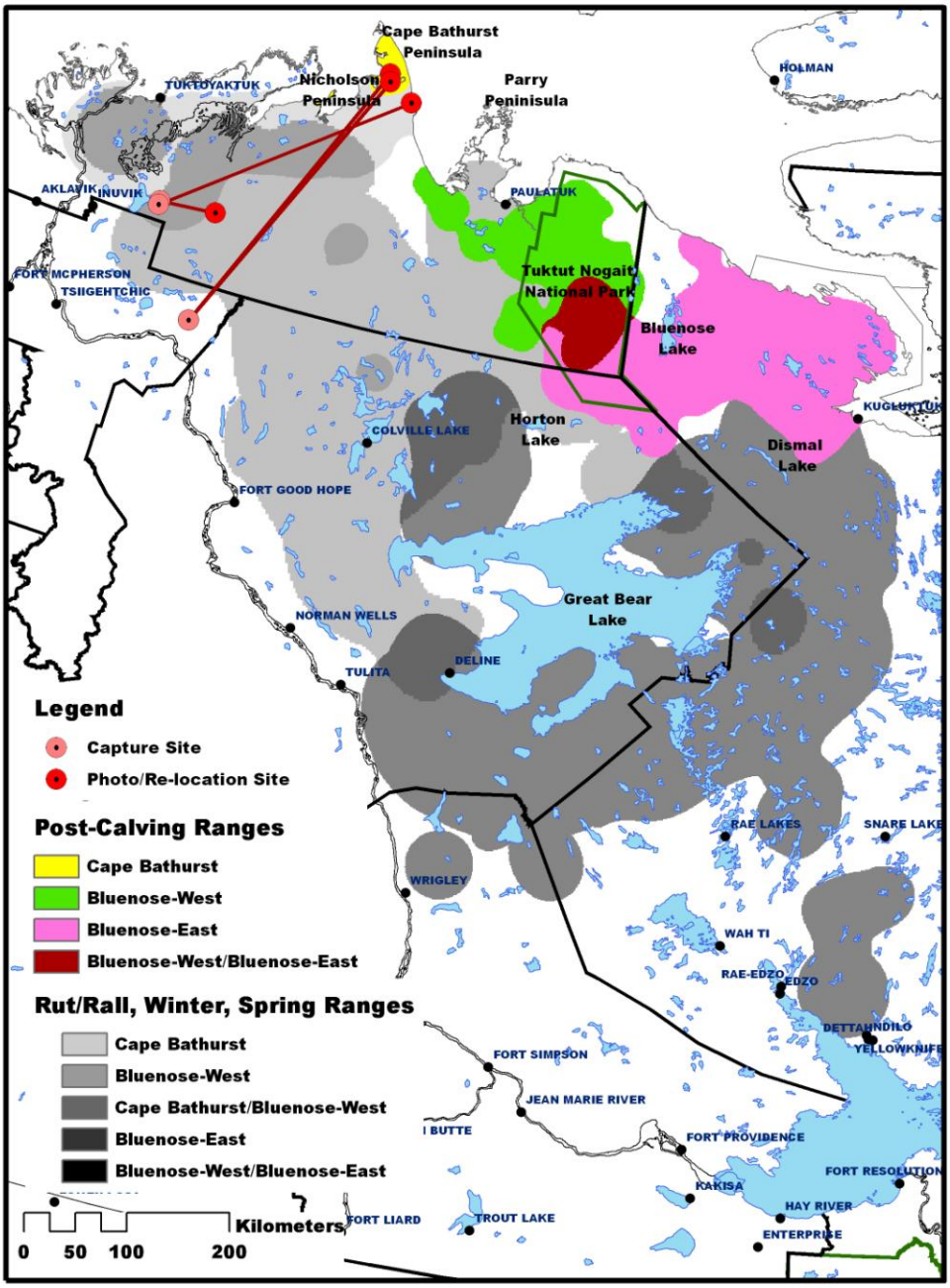

Figure 20. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed relocated during the 1991 post-calving period.

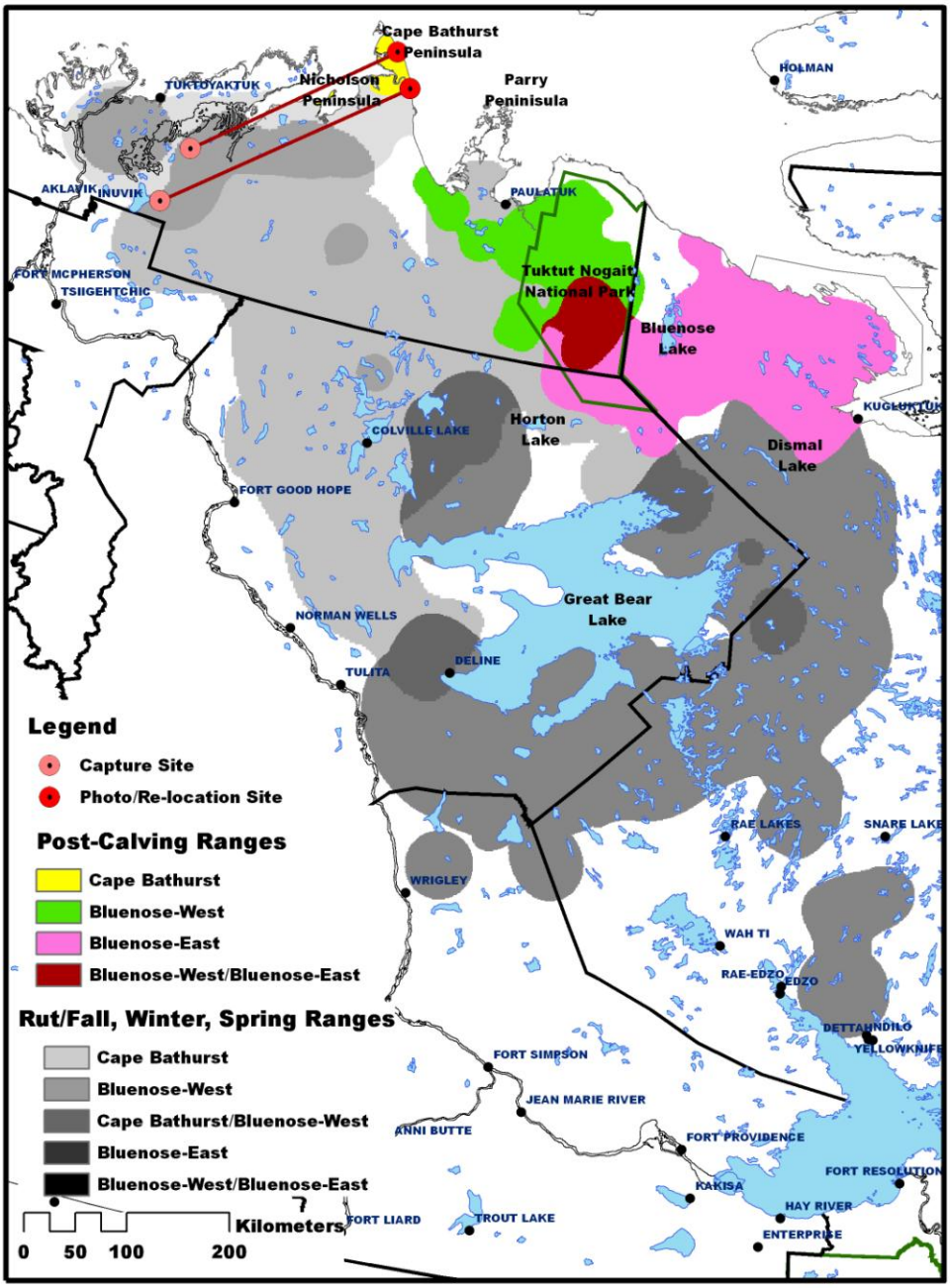

Figure 21. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 1992 photocensus.

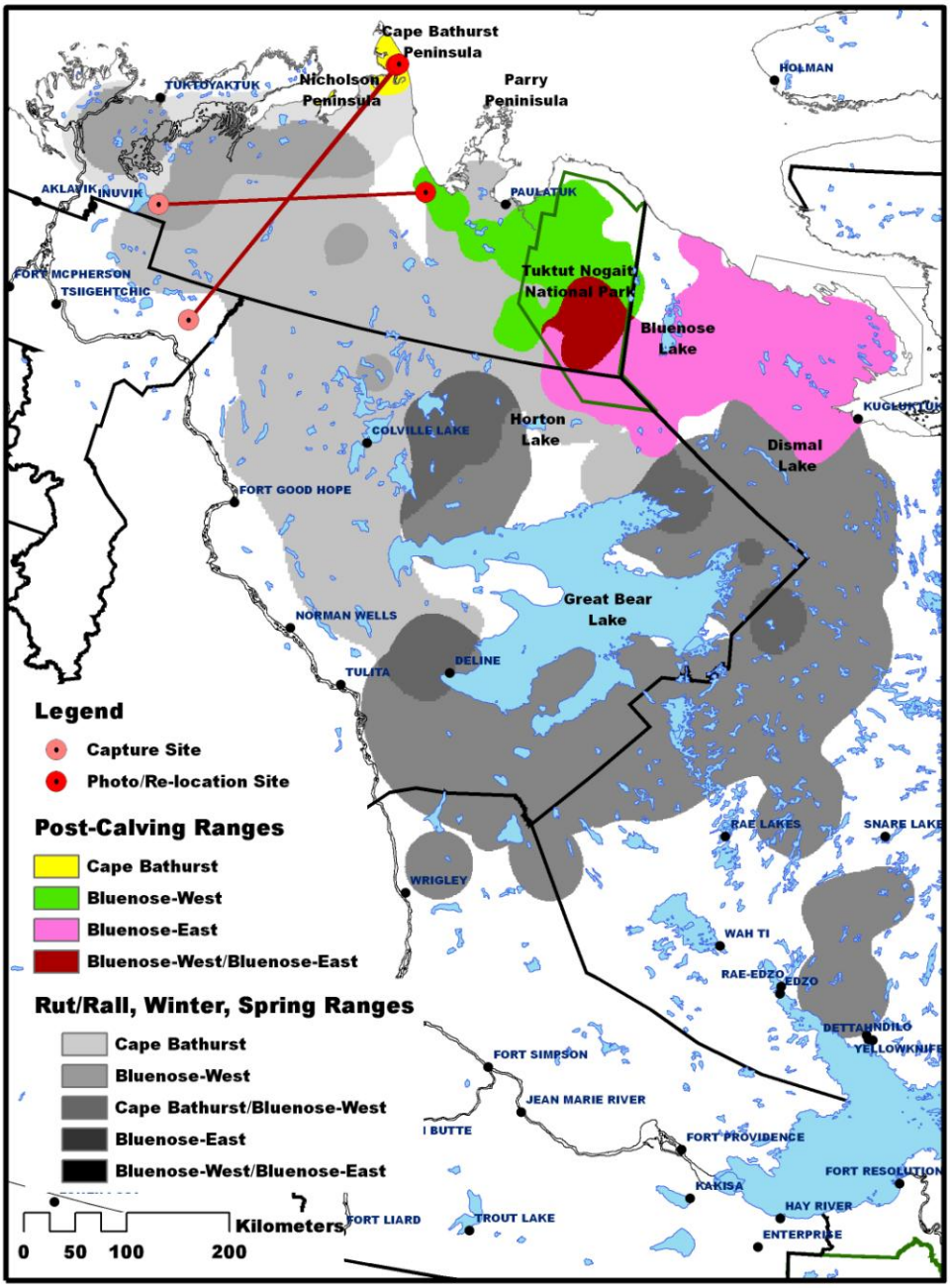

Figure 22. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the 1992 photocensus.

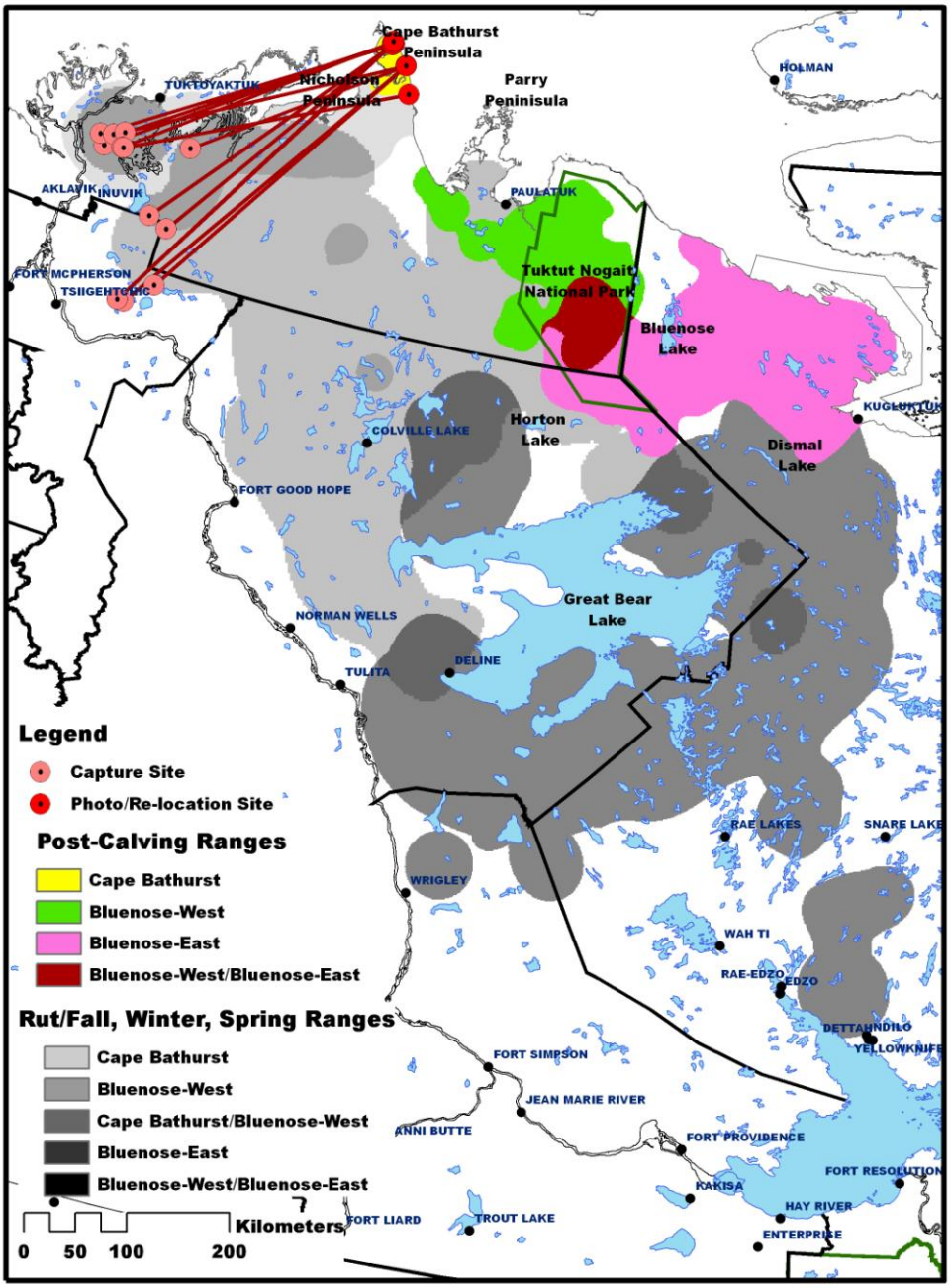

Figure 23. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were relocated during the 1993 post-calving period.

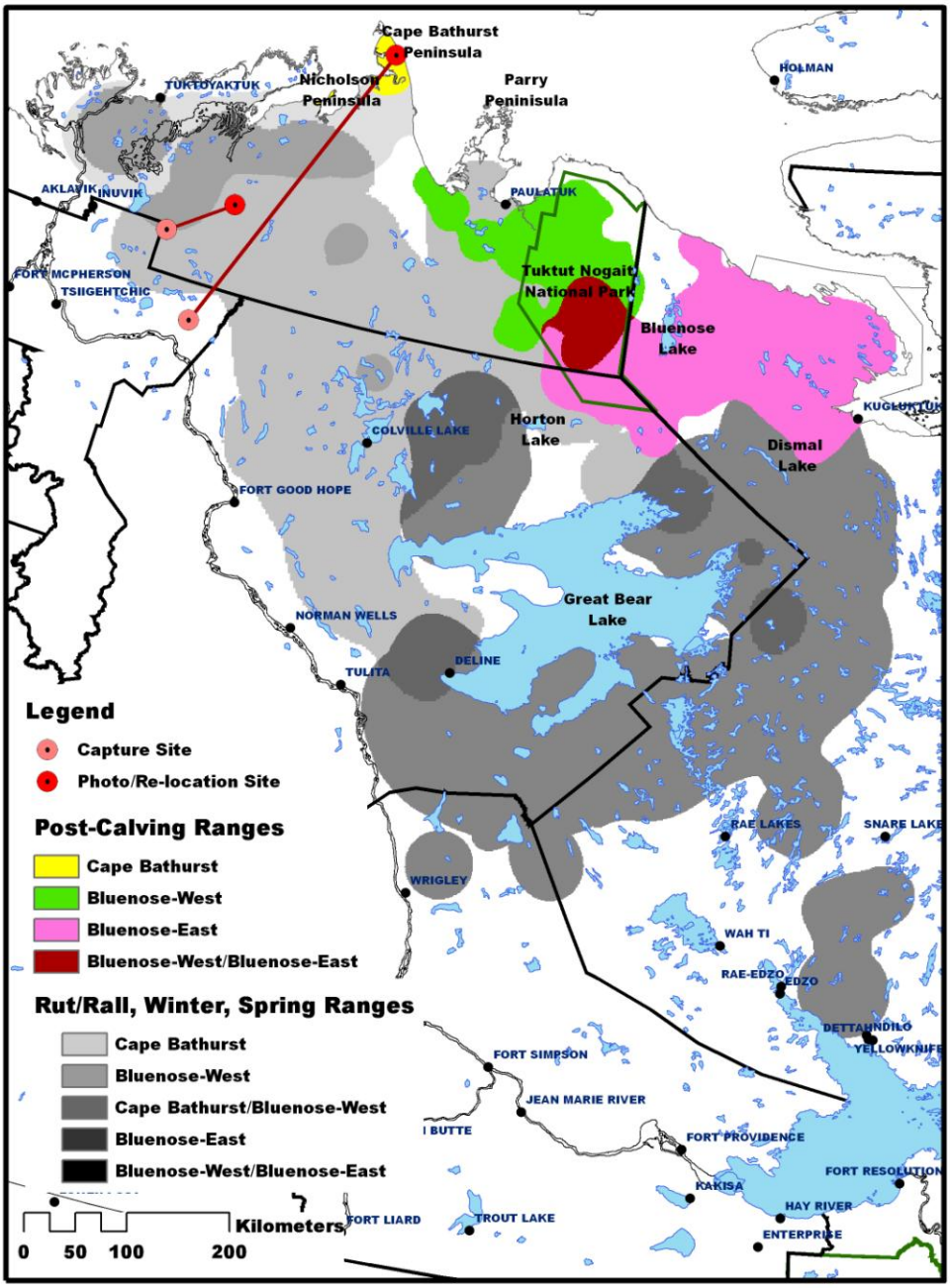

Figure 24. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were relocated during the 1993 post-calving period.

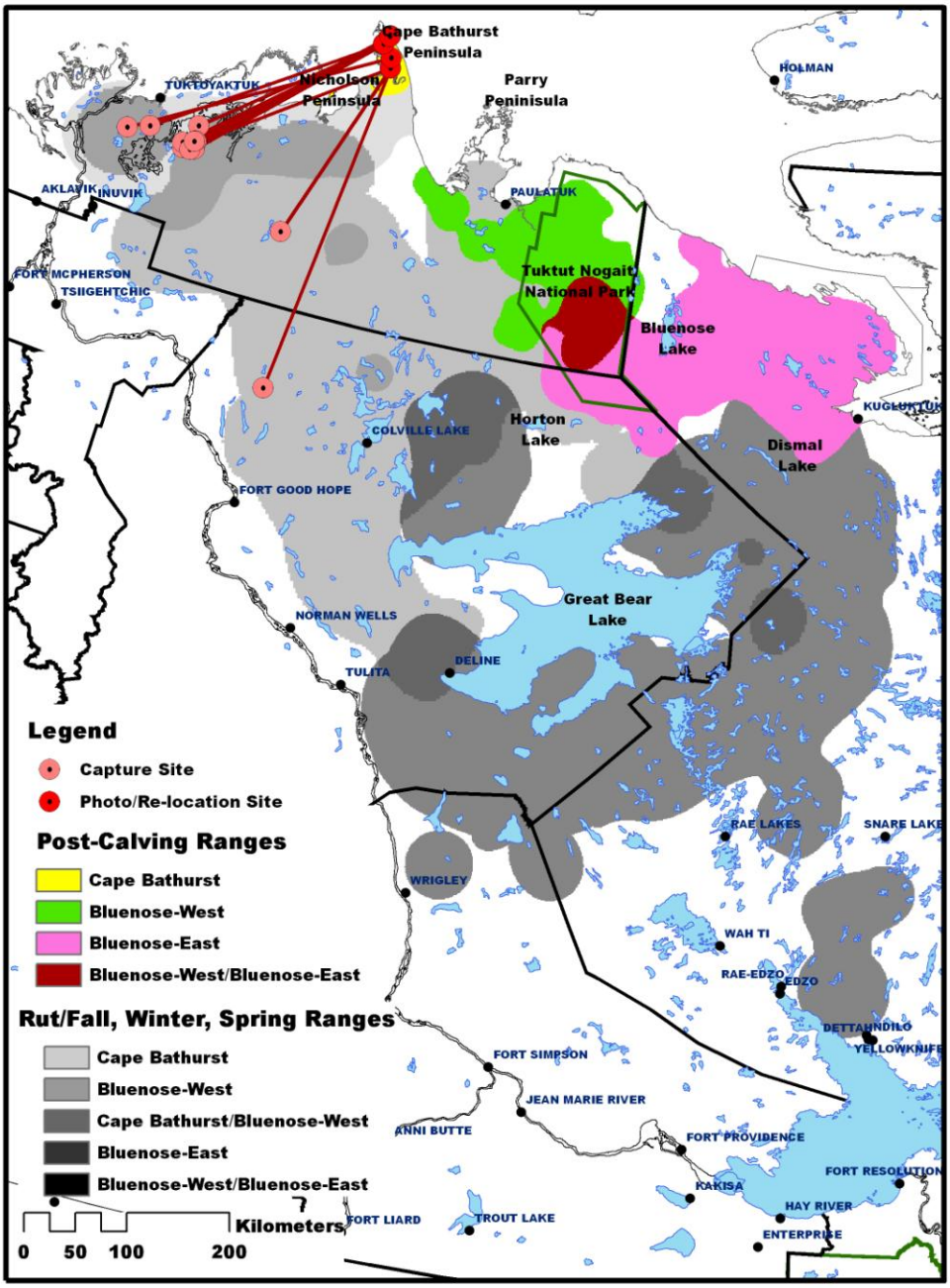

Figure 25. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 2000 photocensus.

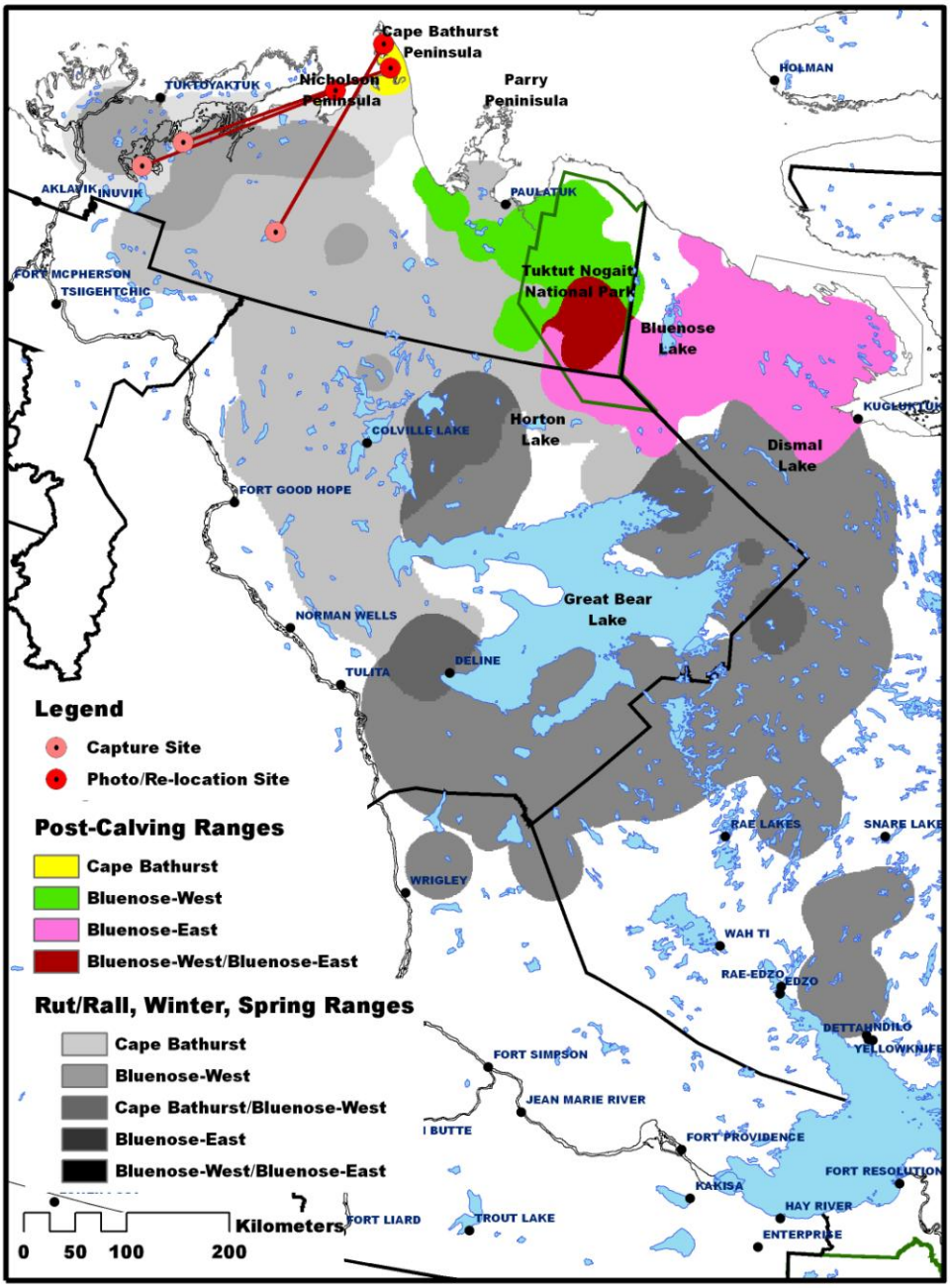

Figure 26. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the 2000 photocensus.

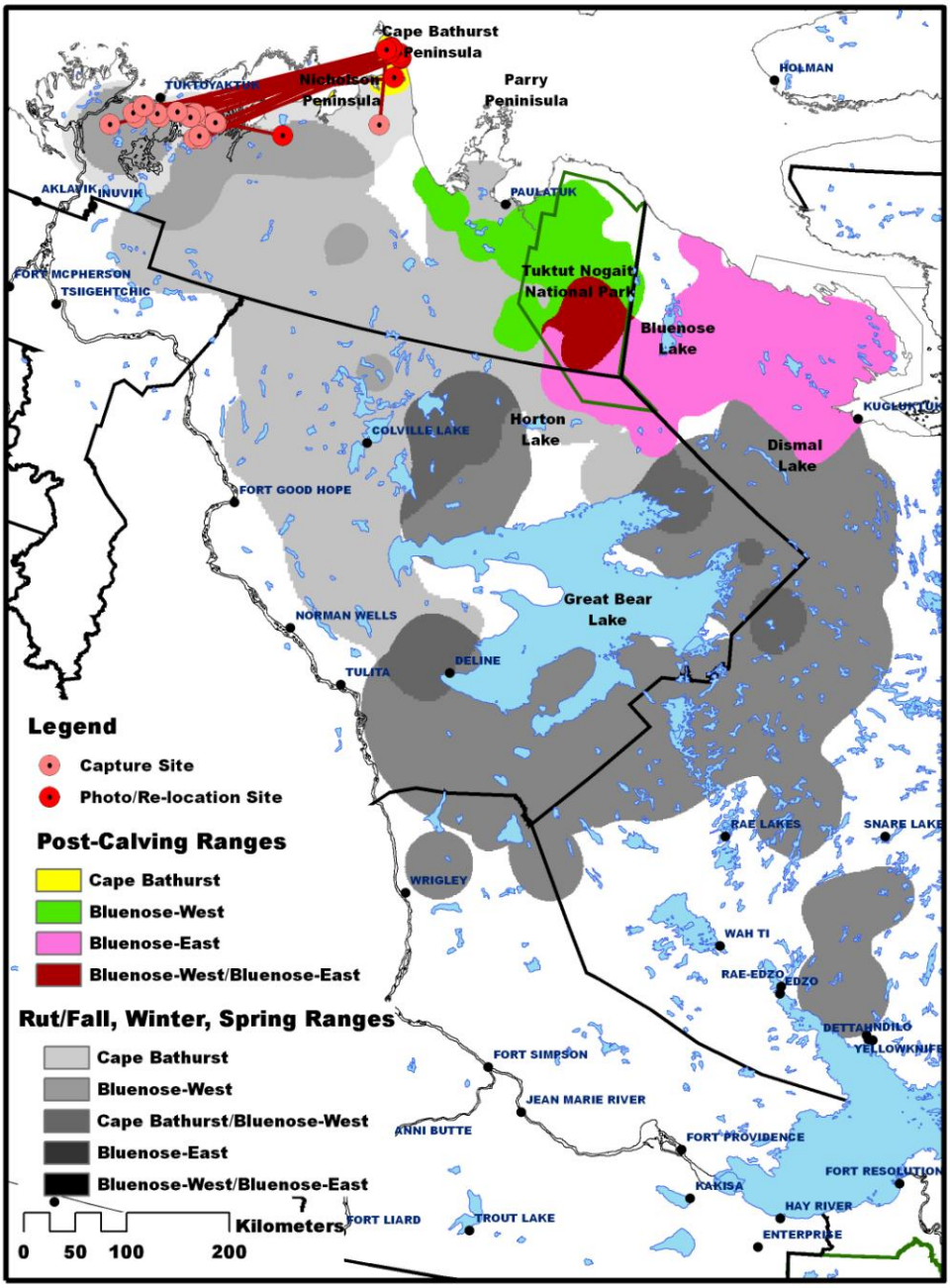

Figure 27. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 2005 photocensus.

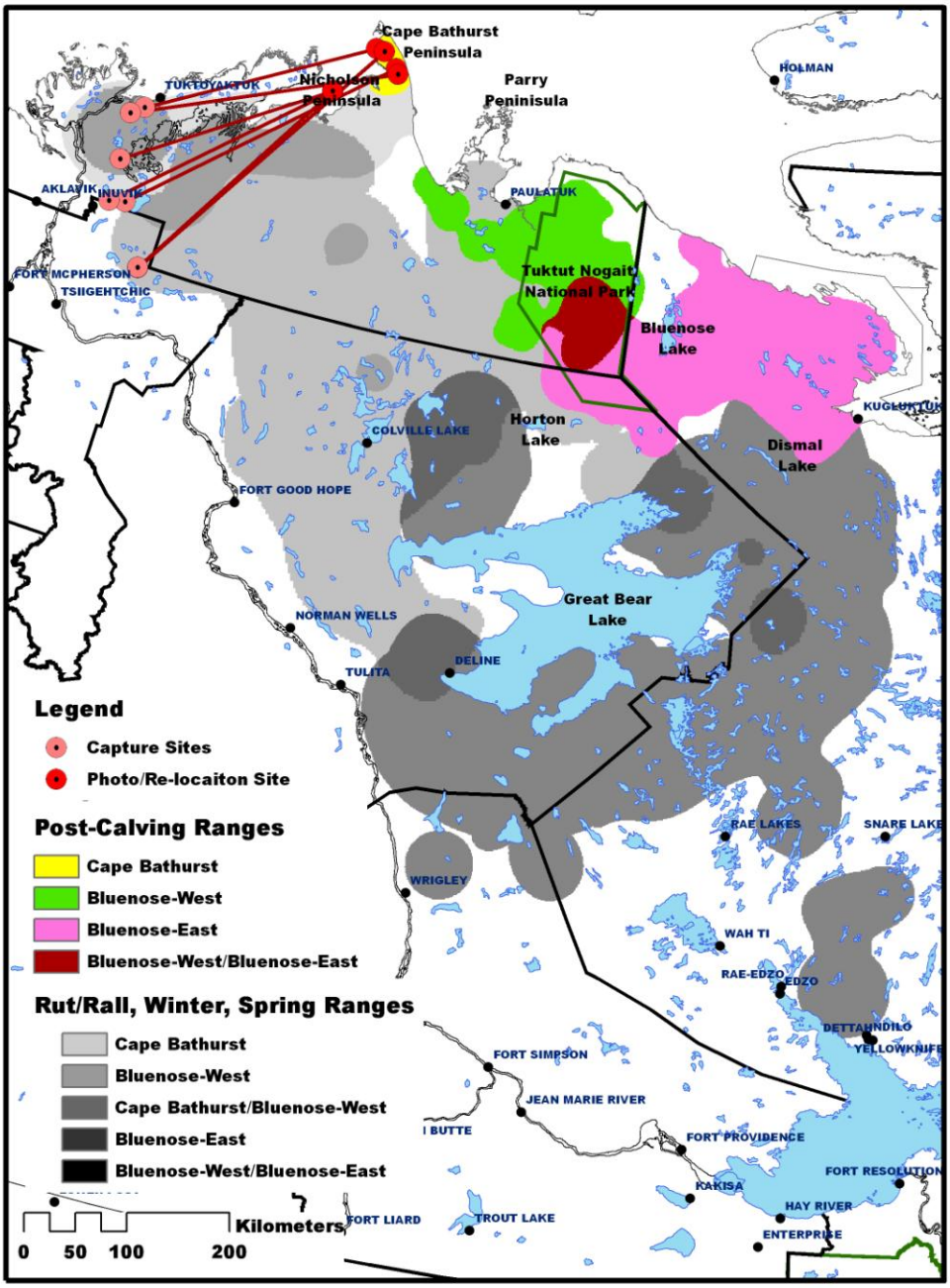

Figure 28. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the 2005 photocensus.

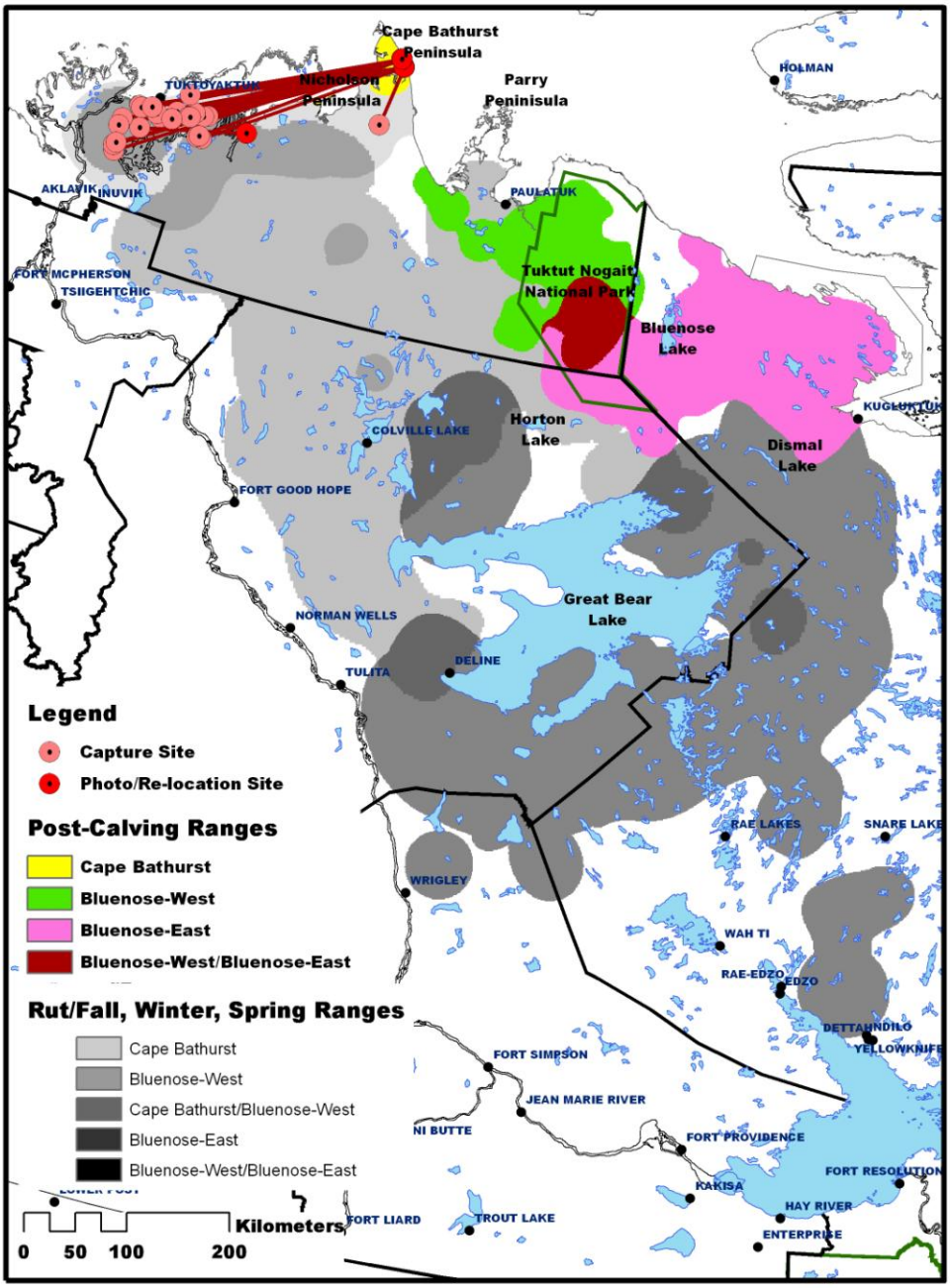

Figure 29. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the 2006 photocensus.

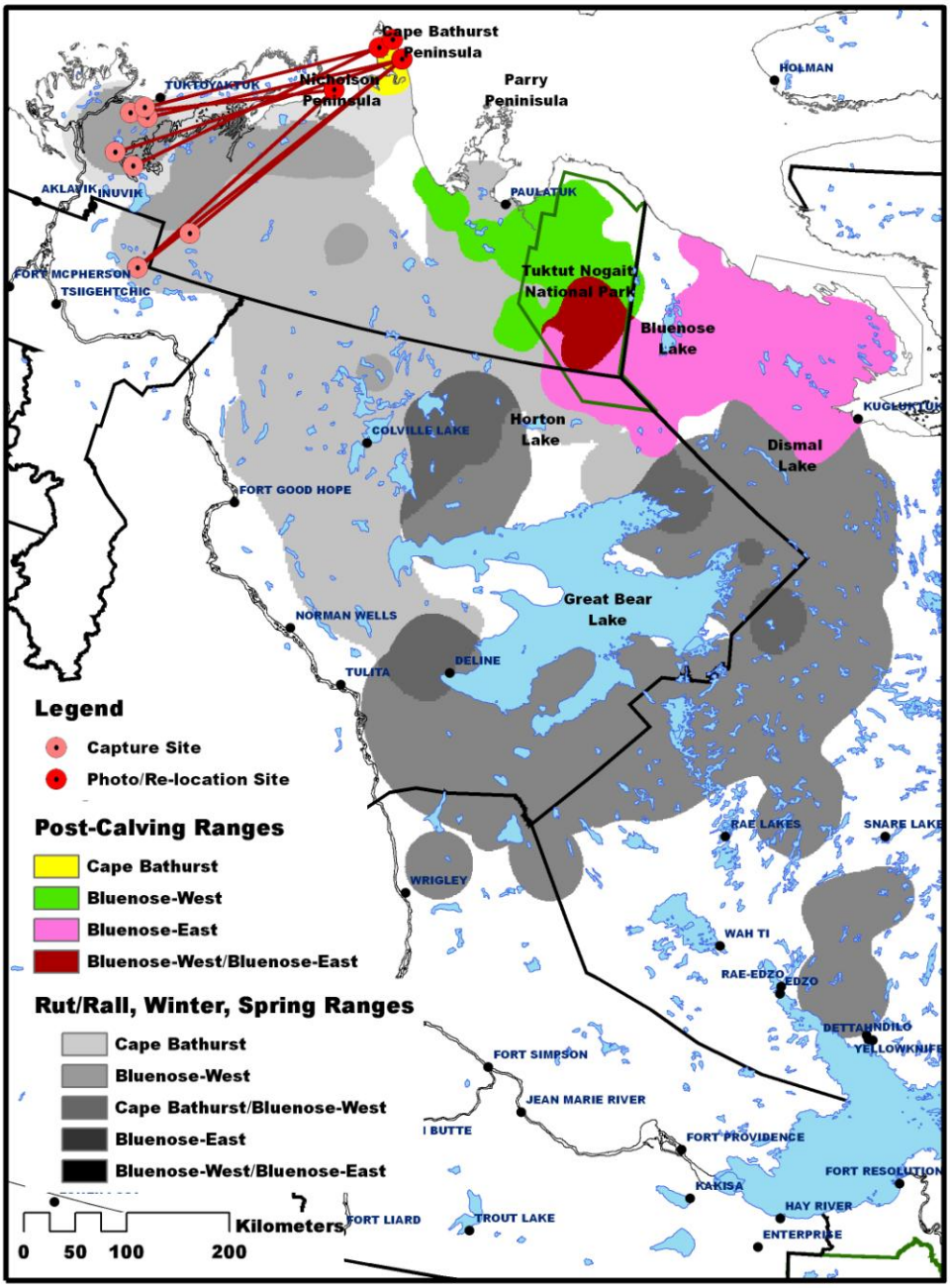

Figure 30. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the 2006 photocensus.

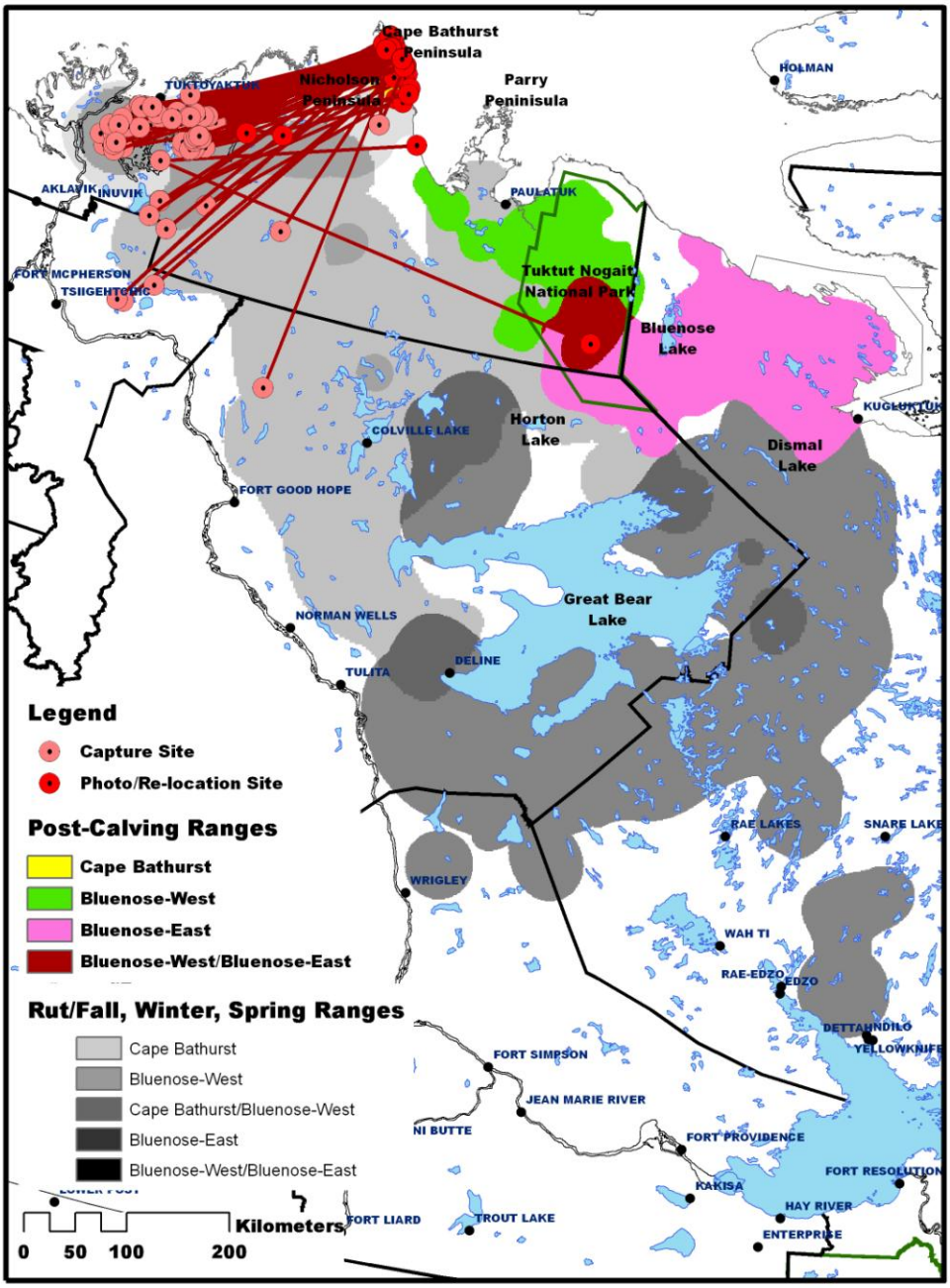

Figure 31. Distribution of capture sites for radio-collared Cape Bathurst cows in relationship to where they were photographed or relocated during the post-calving period, 1986–2006.

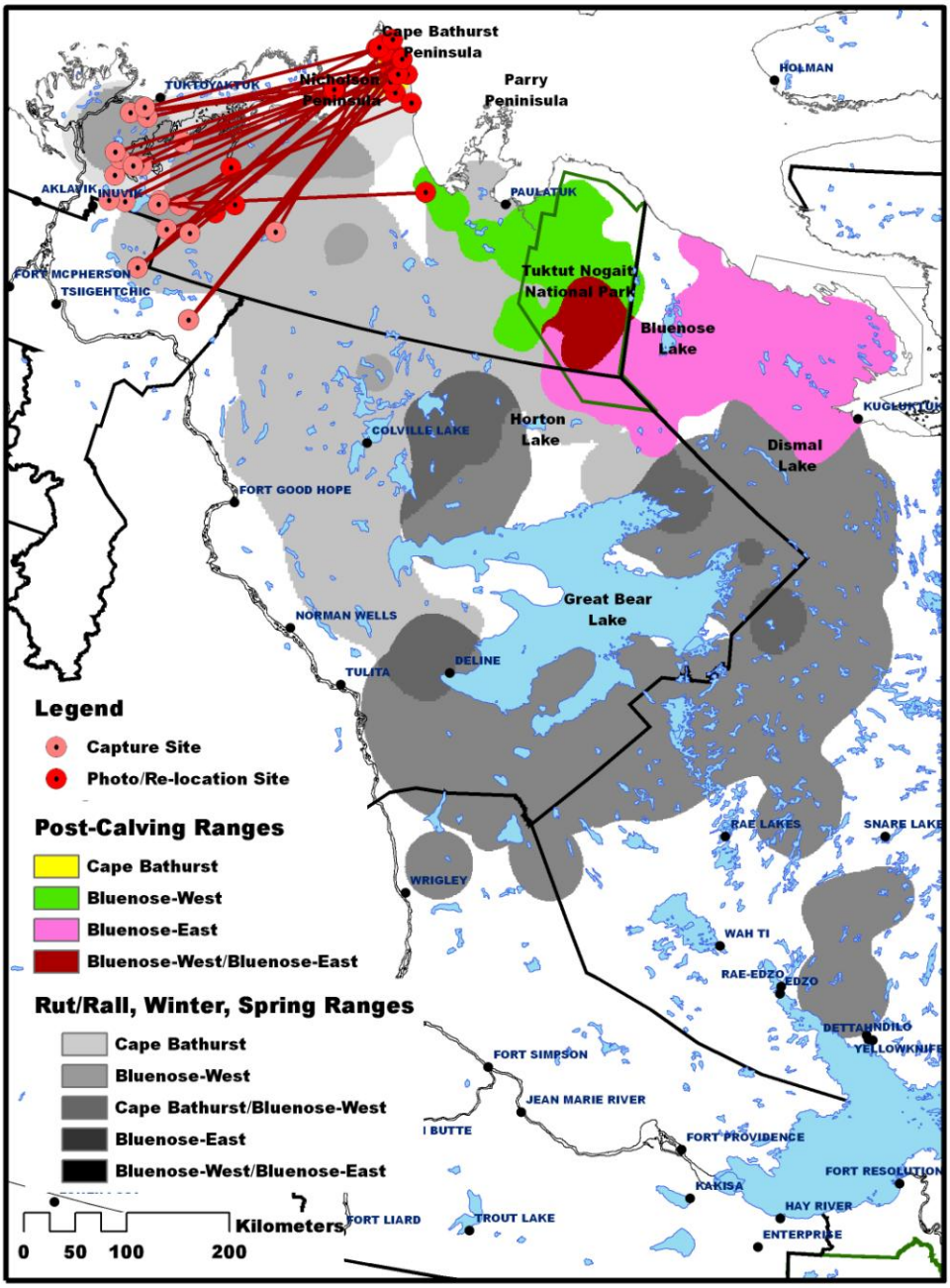

Figure 32. Distribution of capture sites for radio-collared Cape Bathurst bulls in relationship to where they were photographed or relocated during the post-calving period, 1986–2006.

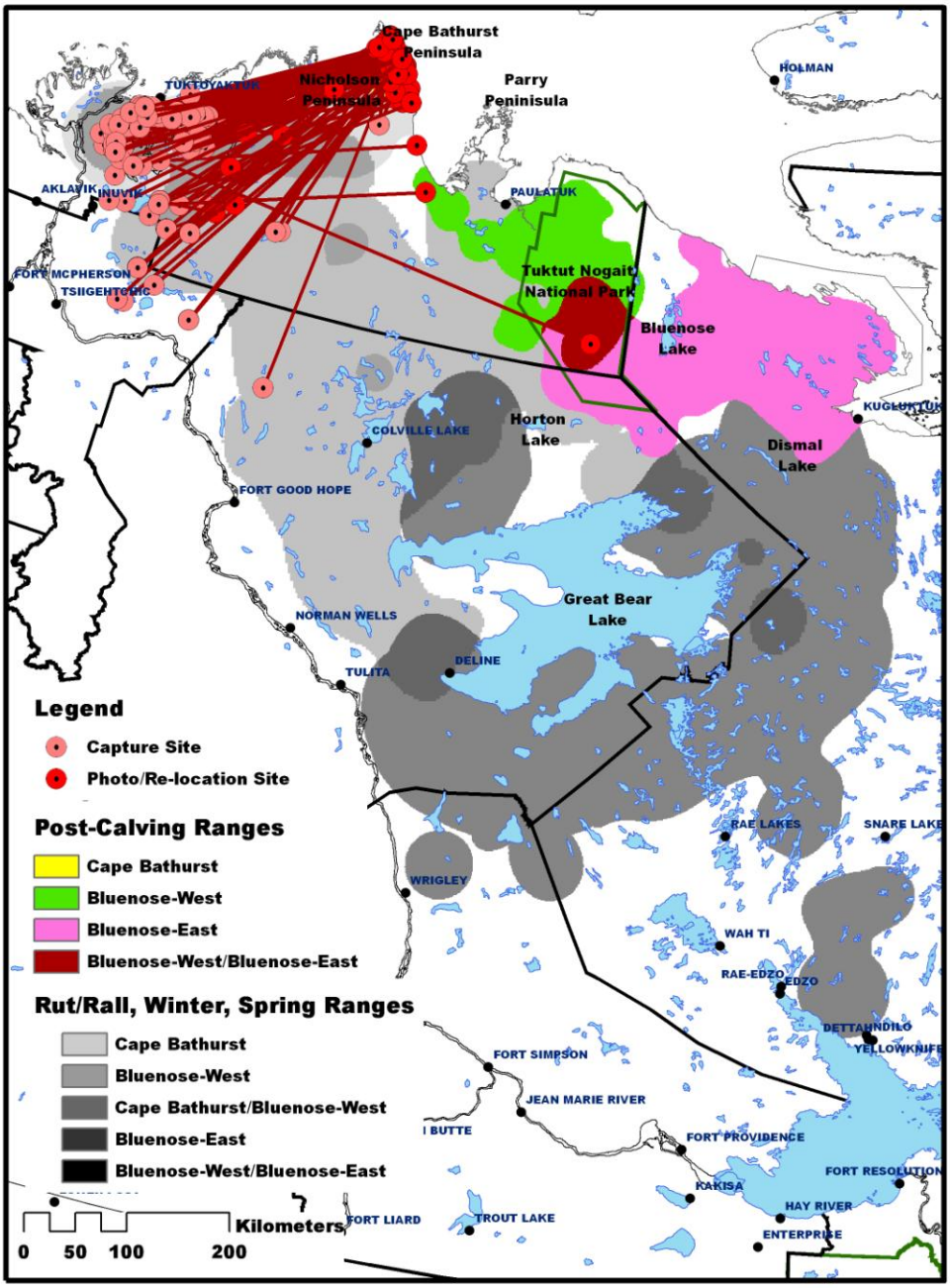

Figure 33. Distribution of capture sites for radio-collared Cape Bathurst cows and bulls in relationship to where they were photographed or relocated during the post-calving period, 1986–2006.

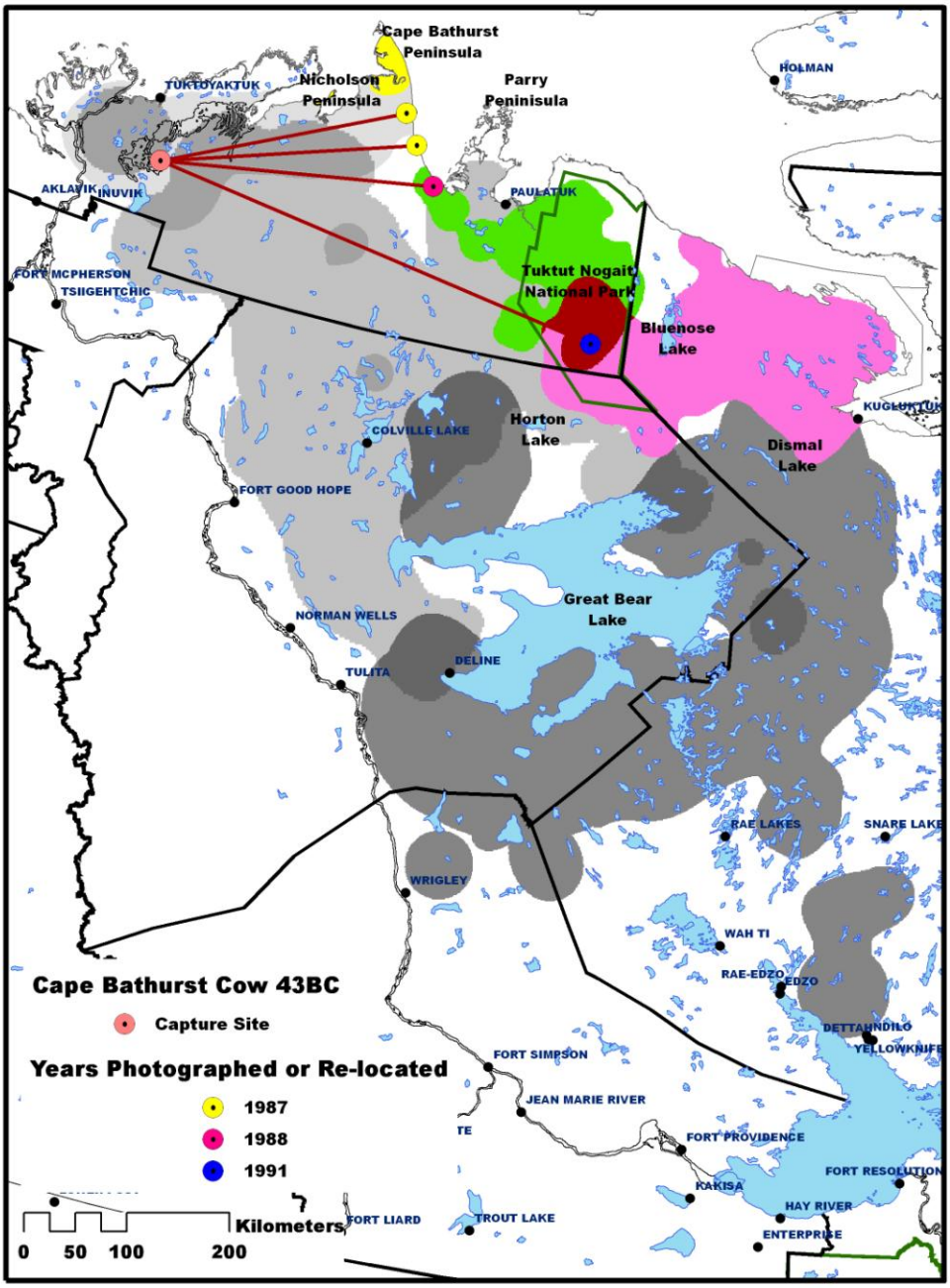

Figure 34. Distribution of sites where Cape Bathurst Cow 43BC was located during the post-calving period in 1987, 1988, and 1991.

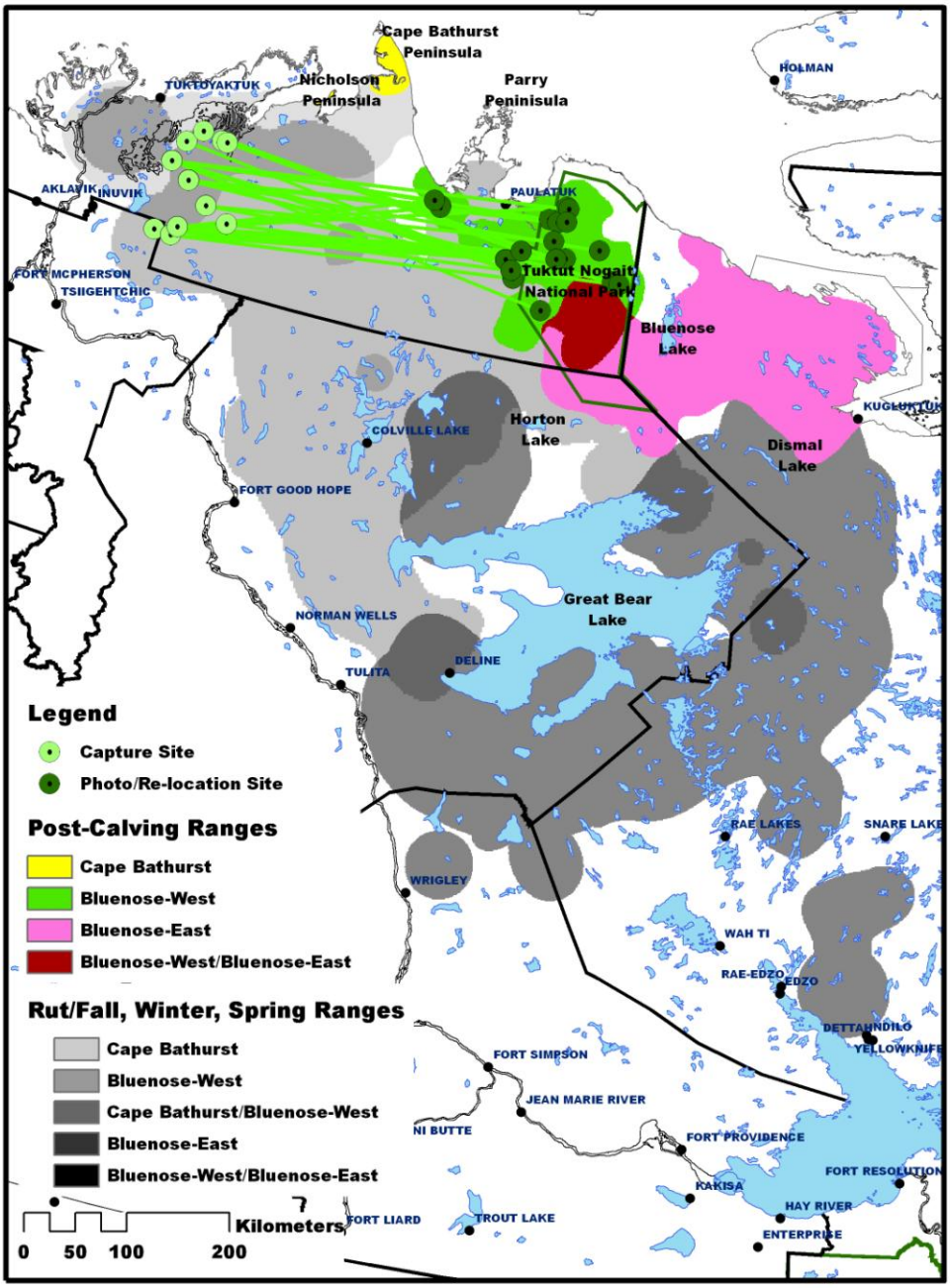

Figure 35. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 1986.

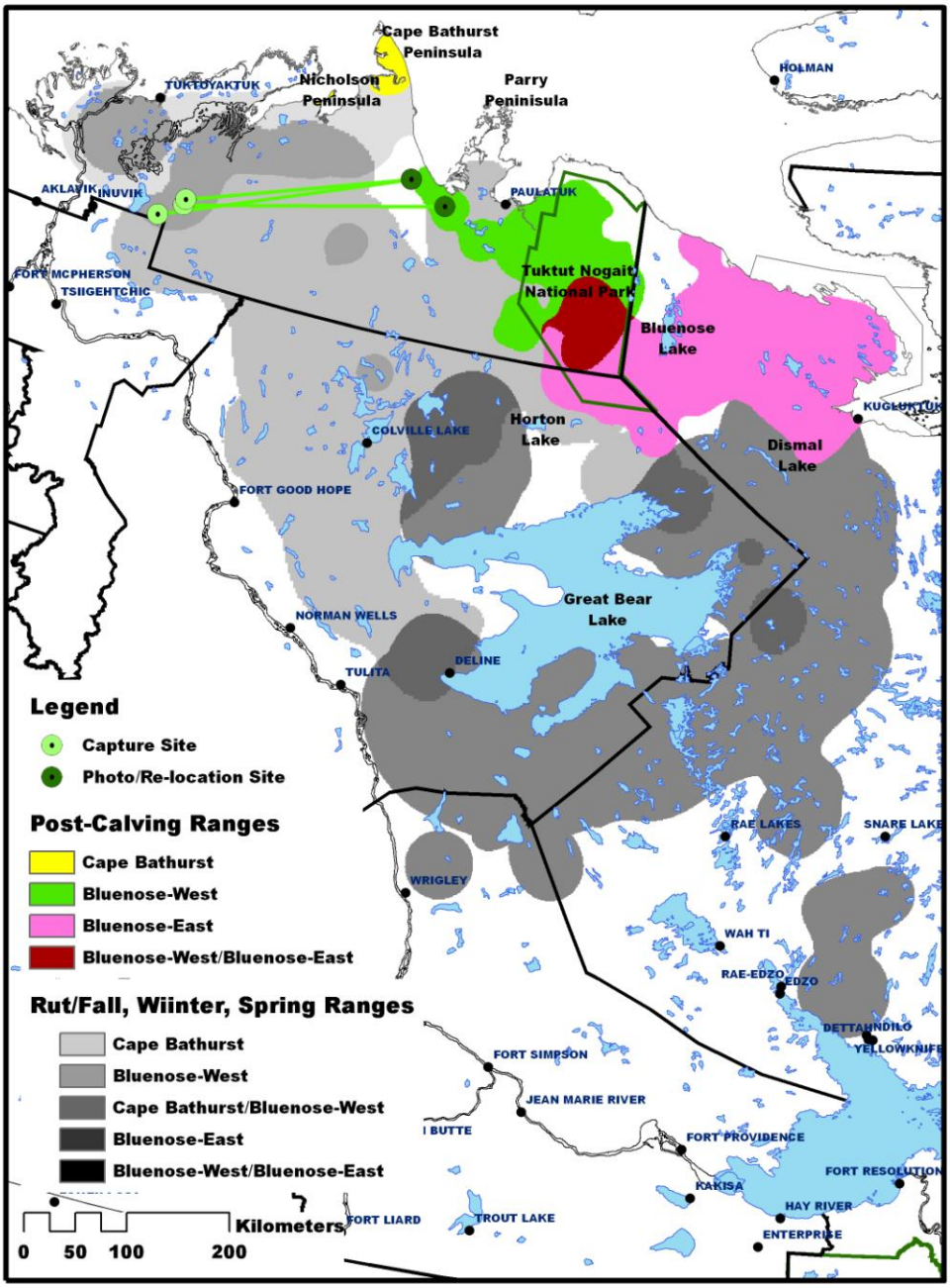

Figure 36. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 1986.

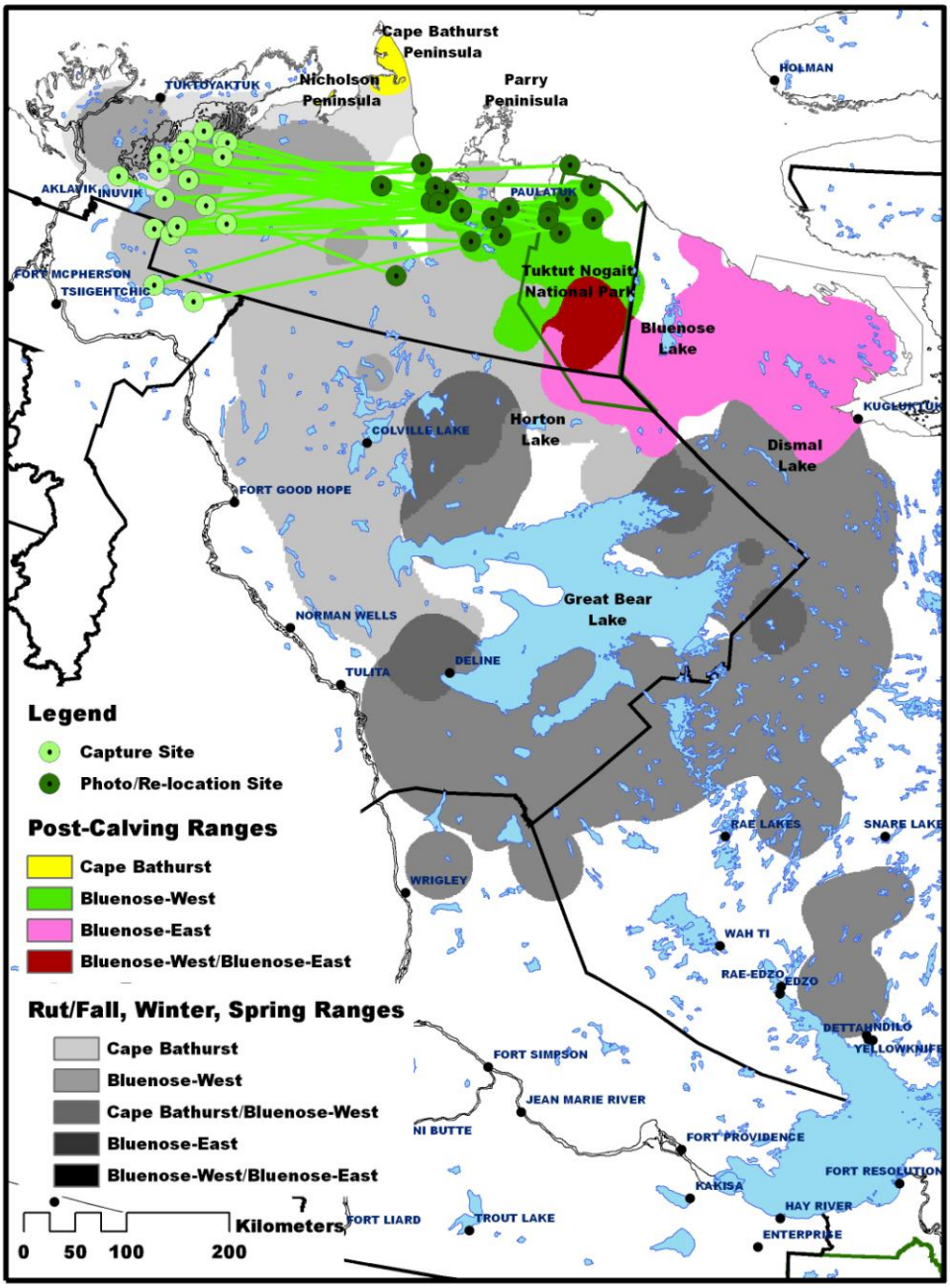

Figure 37. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 1987.

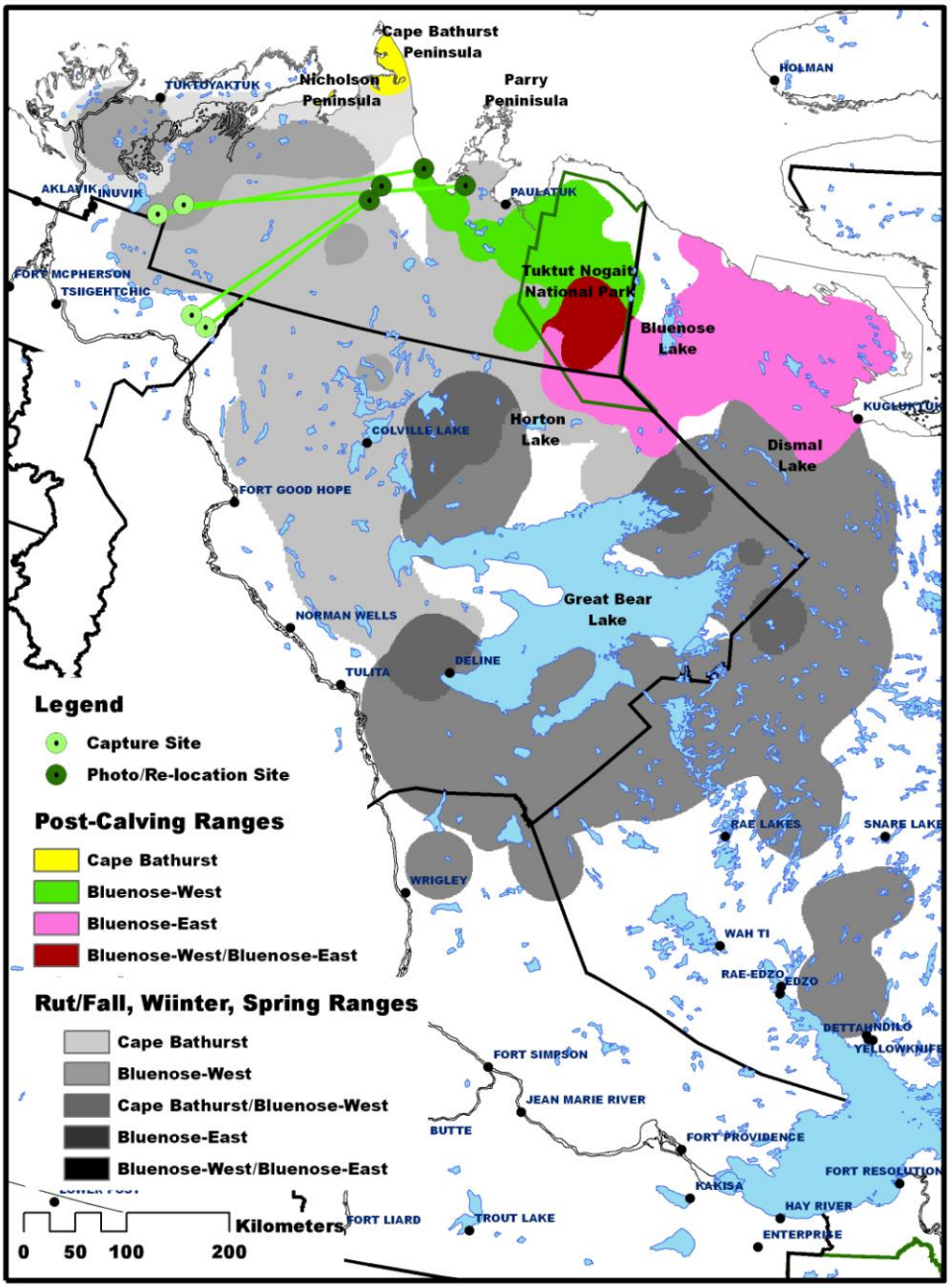

Figure 38. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 1987.

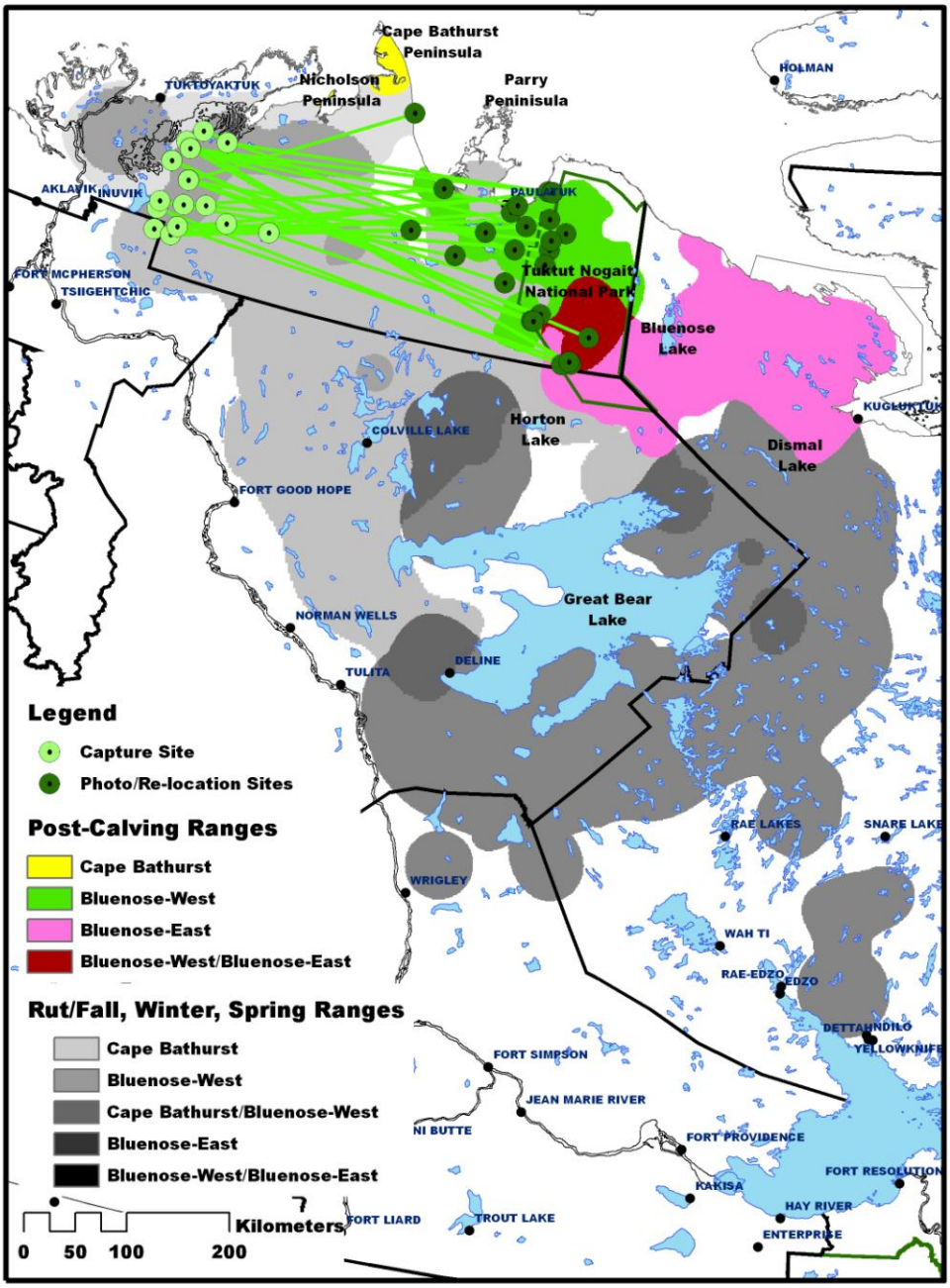

Figure 39. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 1991.

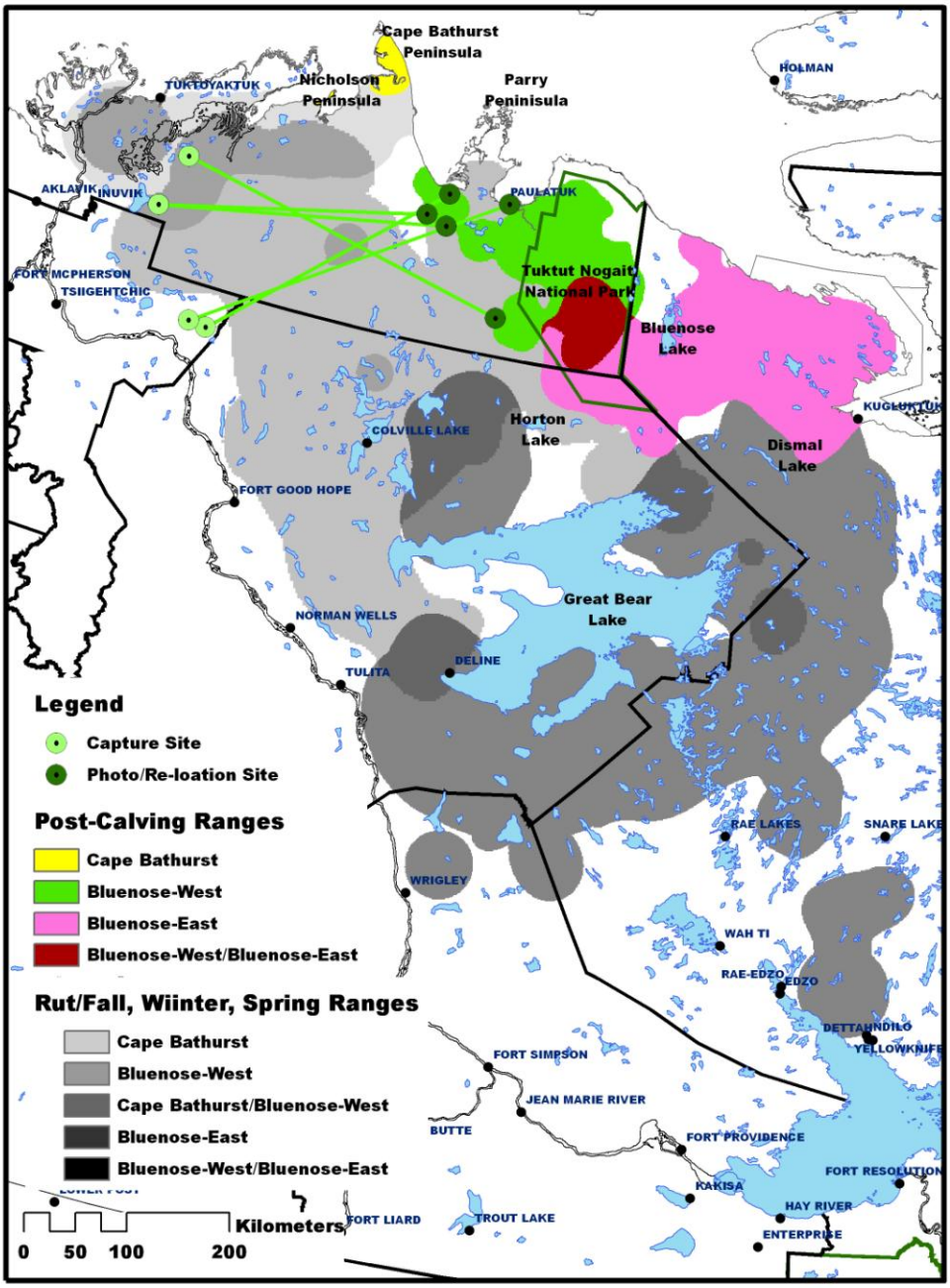

Figure 40. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 1991.

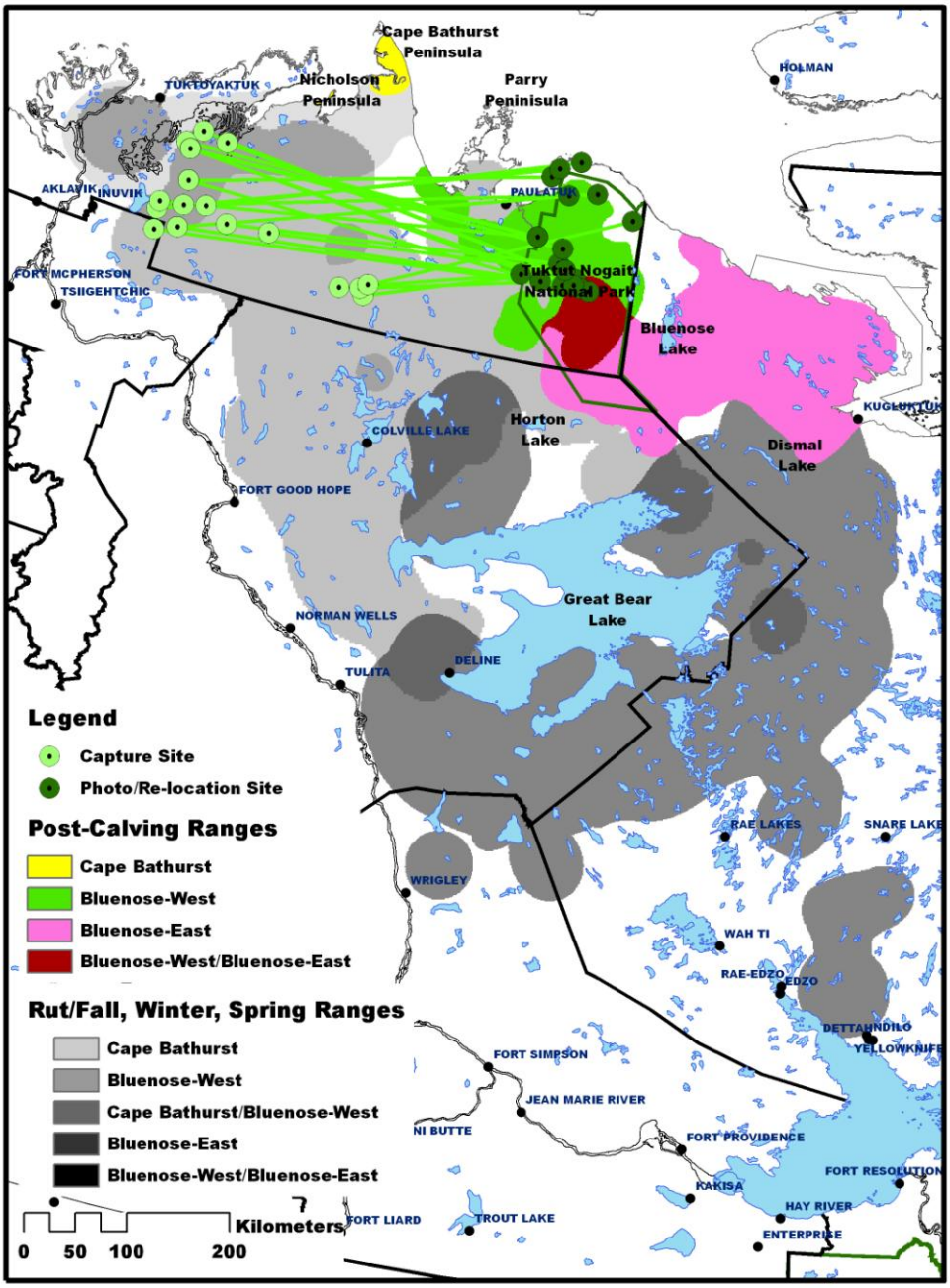

Figure 41. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 1991.

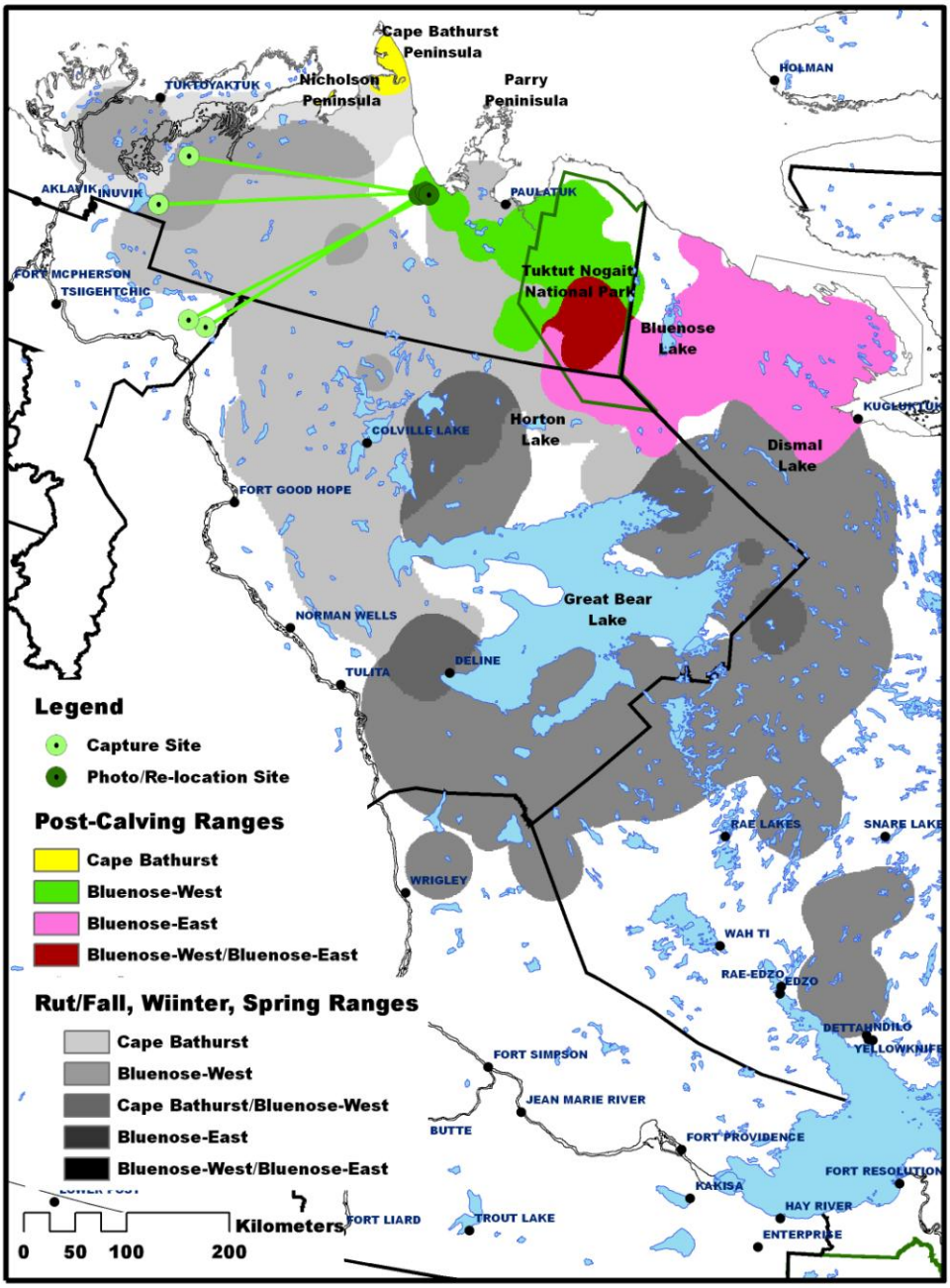

Figure 42. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 1992.

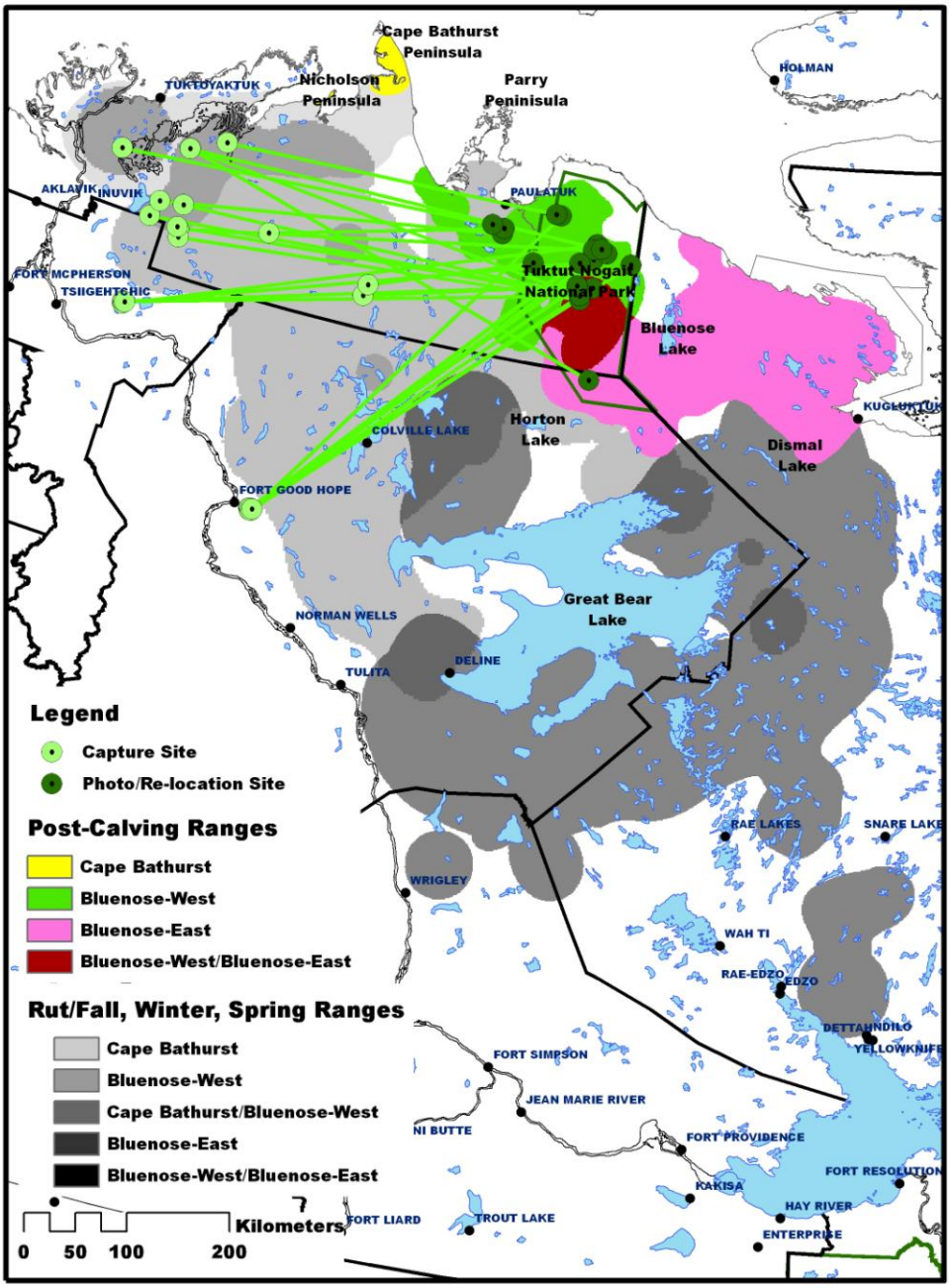

Figure 43. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were relocated during the post-calving period in 1993.

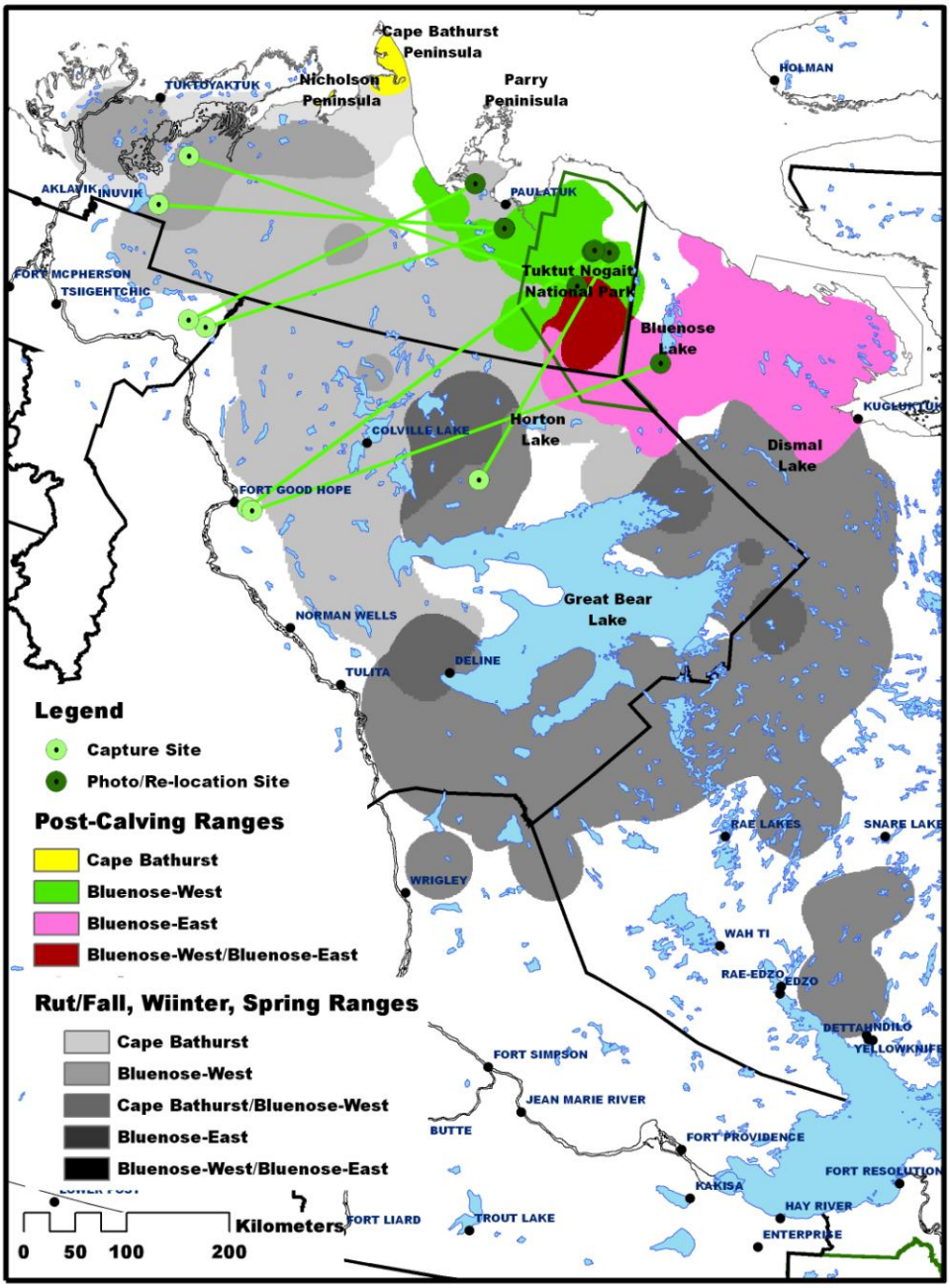

Figure 44. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were relocated during the post-calving period in 1993.

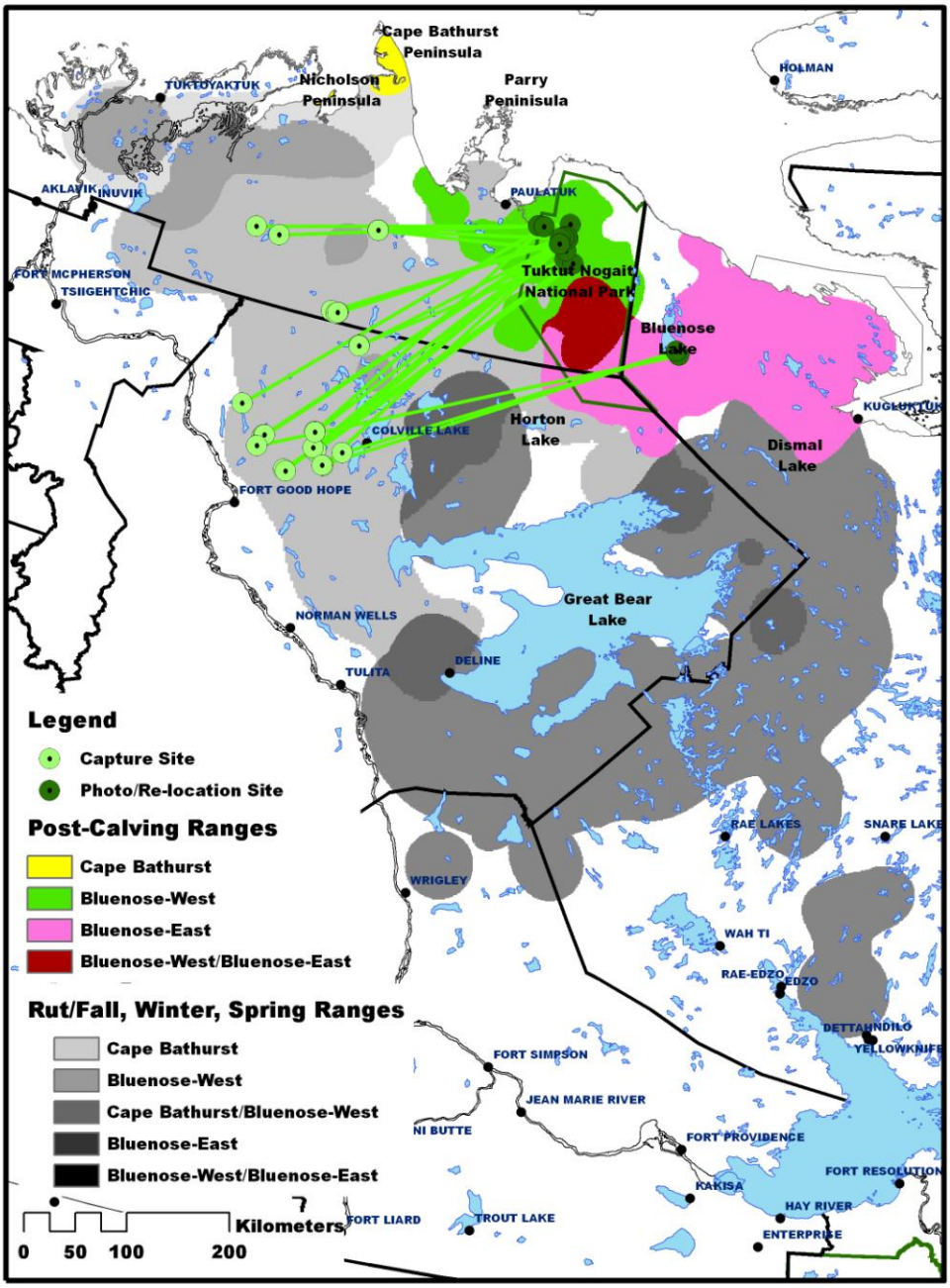

Figure 45. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 2000.

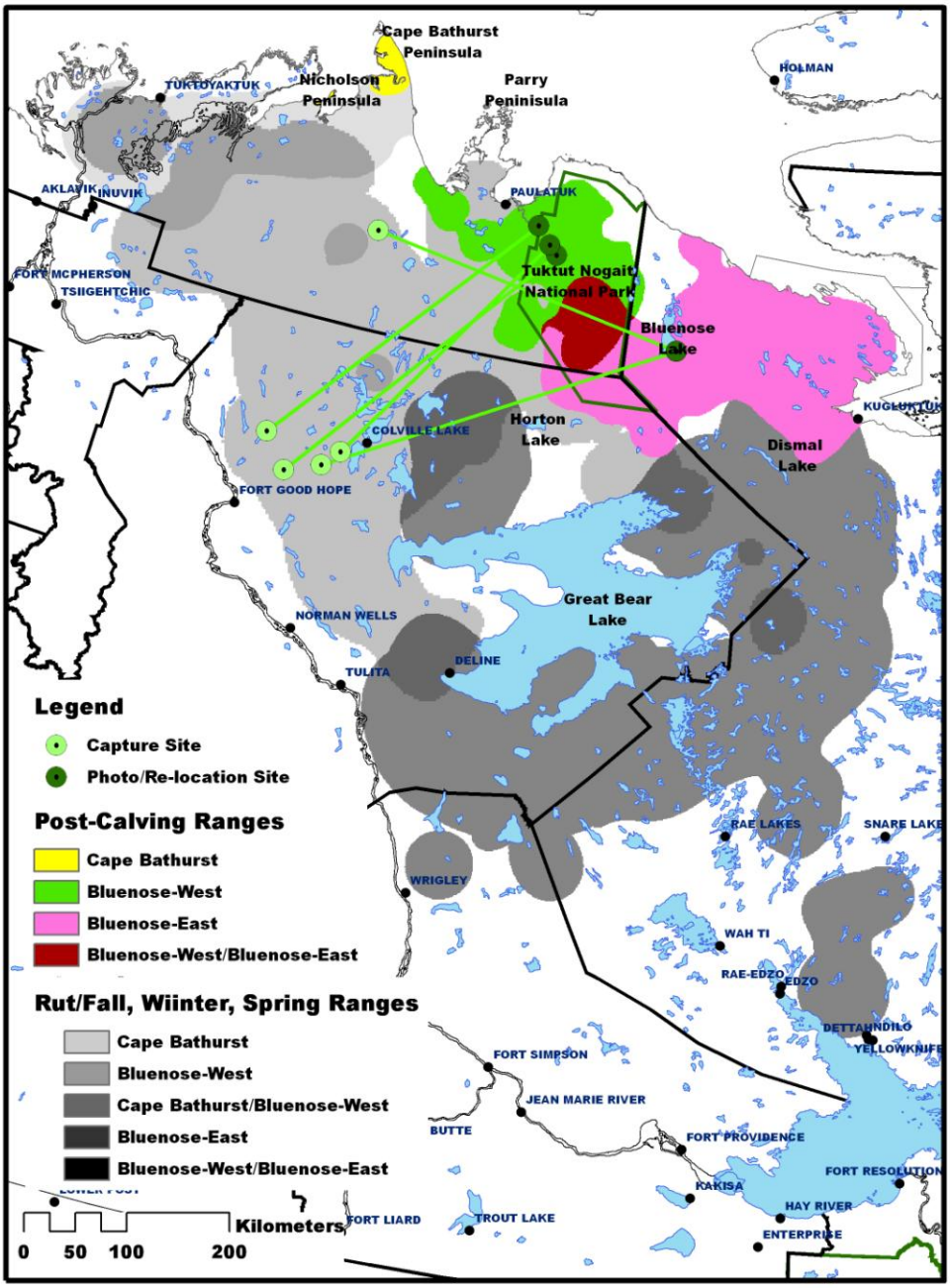

Figure 46. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 2000.

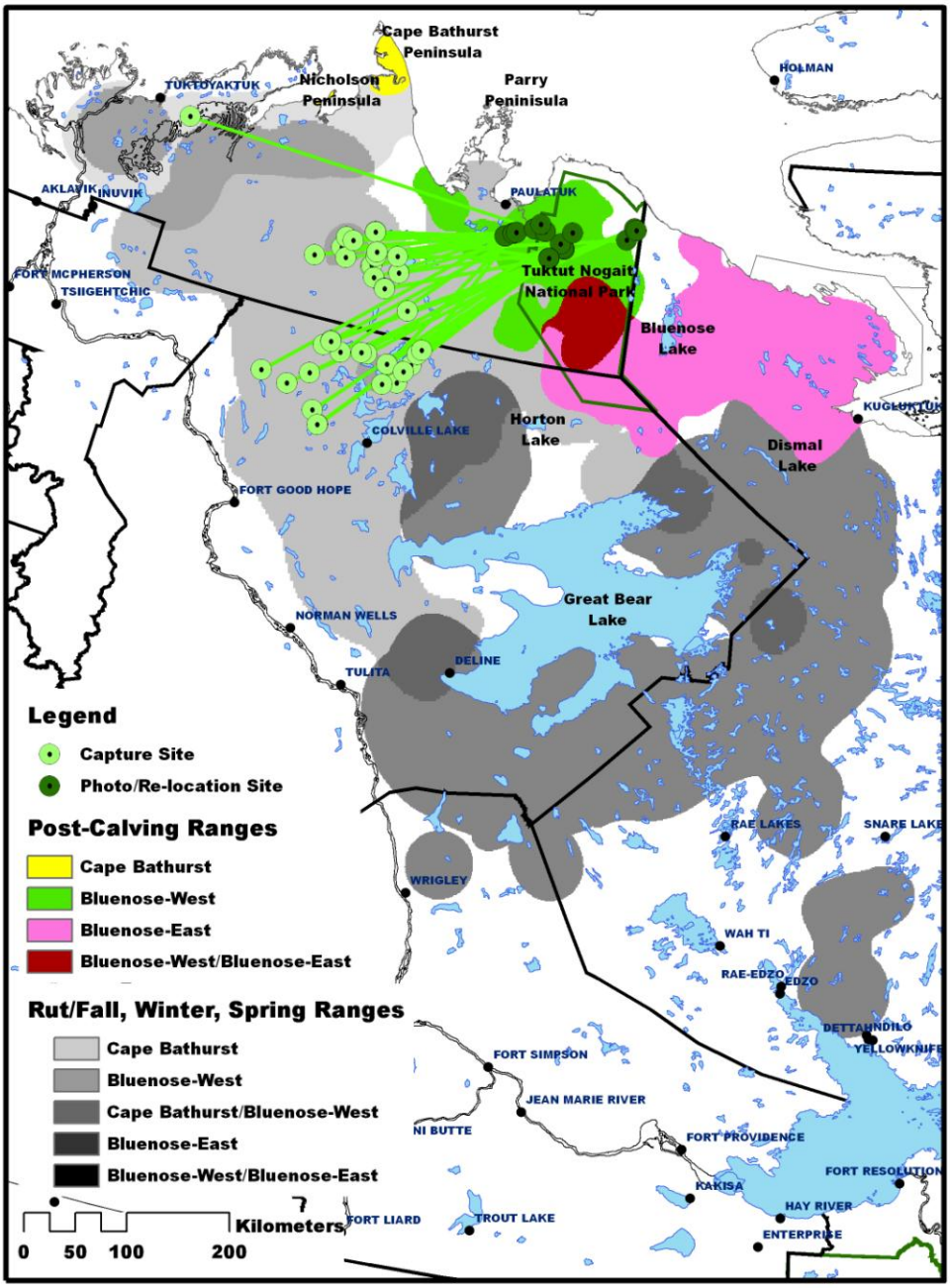

Figure 47. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 2005.

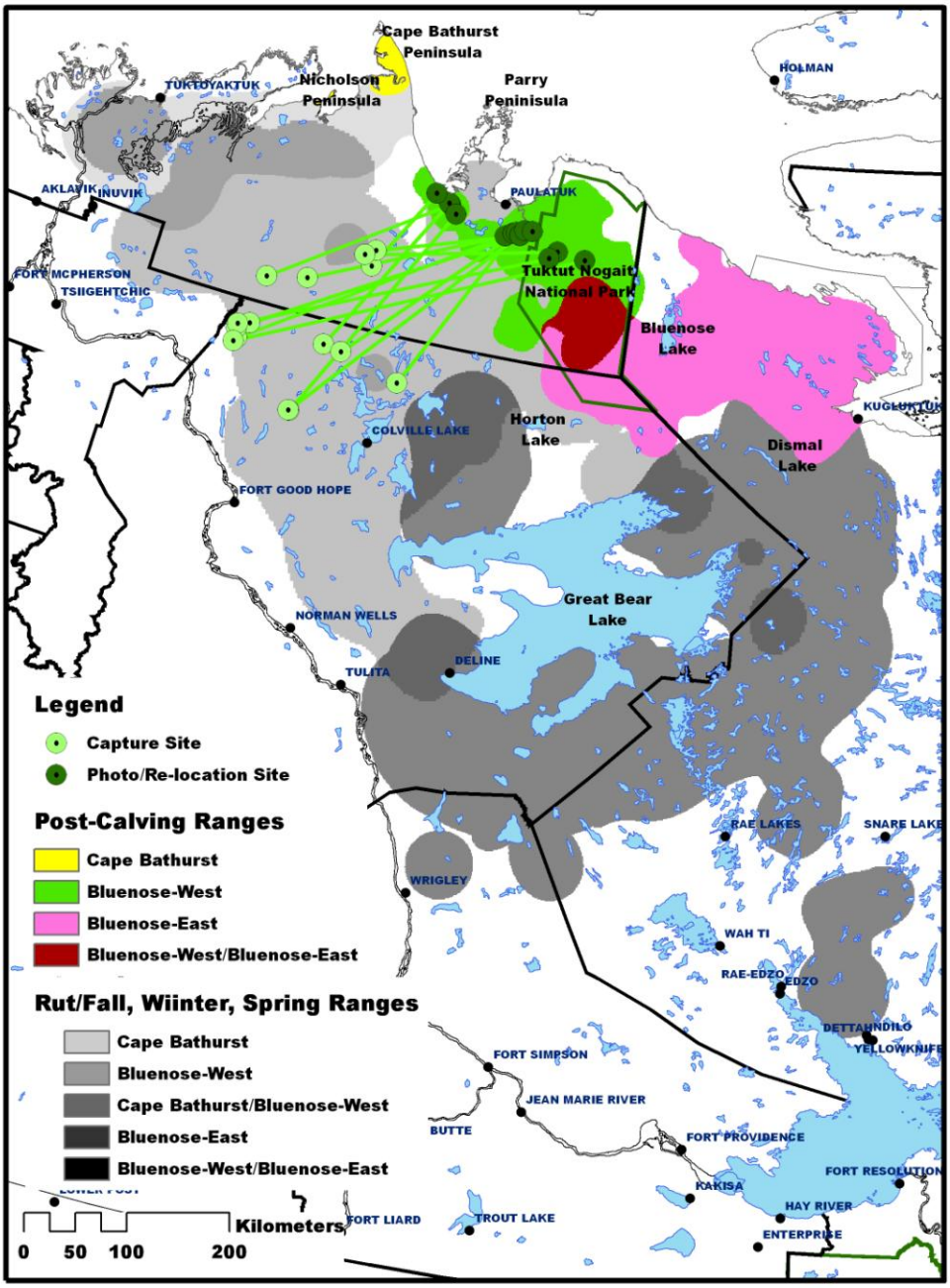

Figure 48. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 2005.

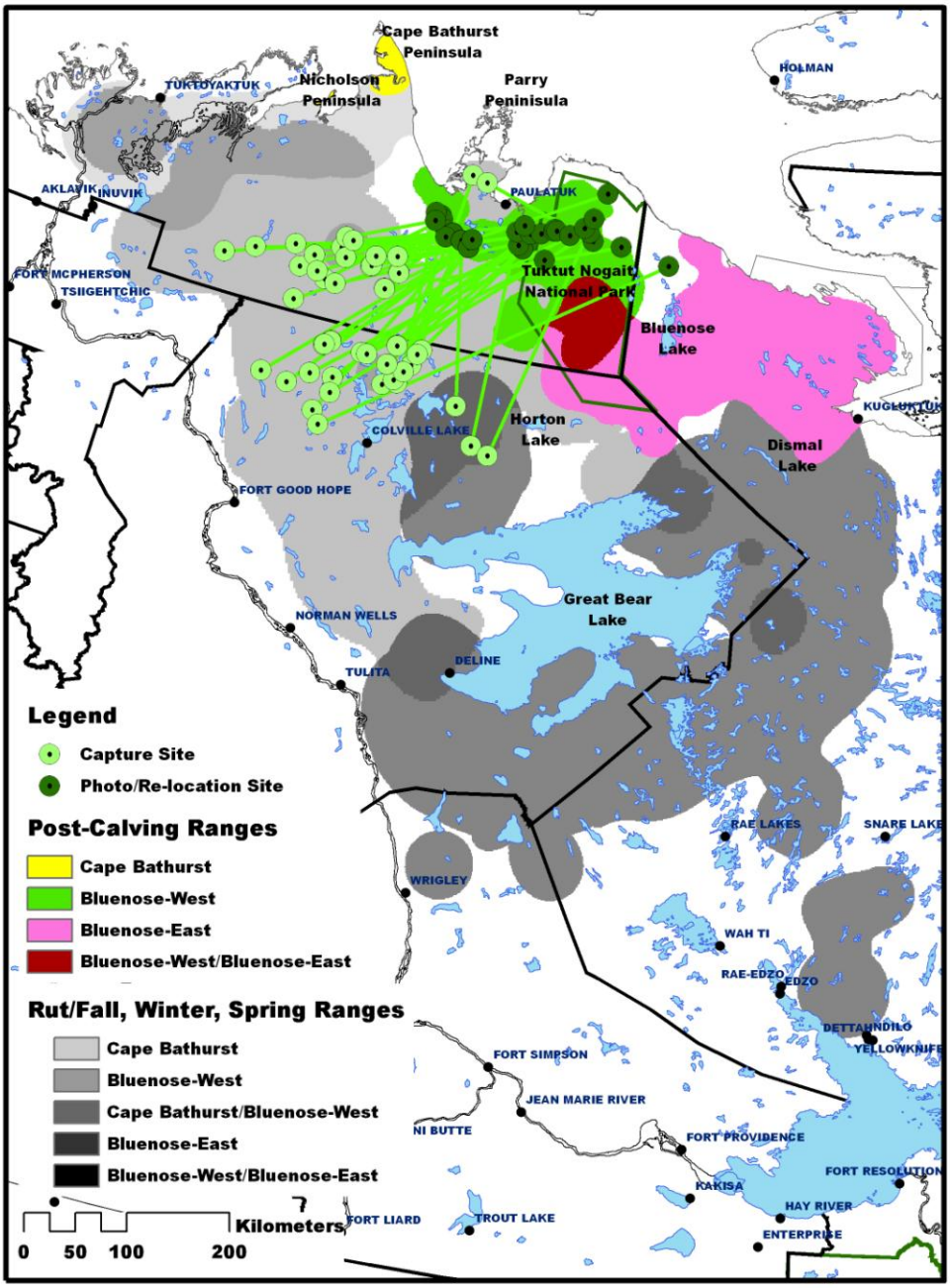

Figure 49. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period in 2006.

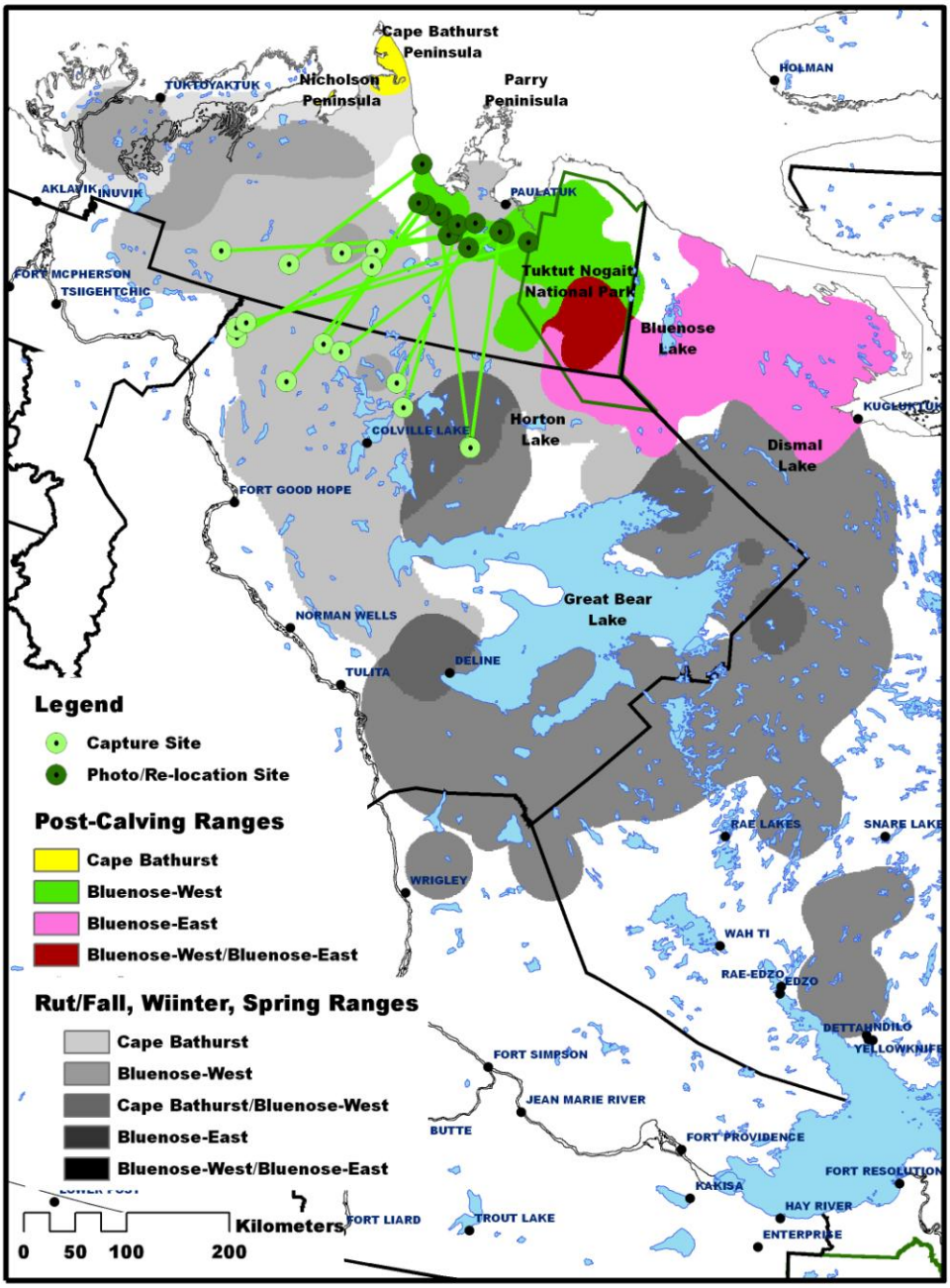

Figure 50. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period in 2006.

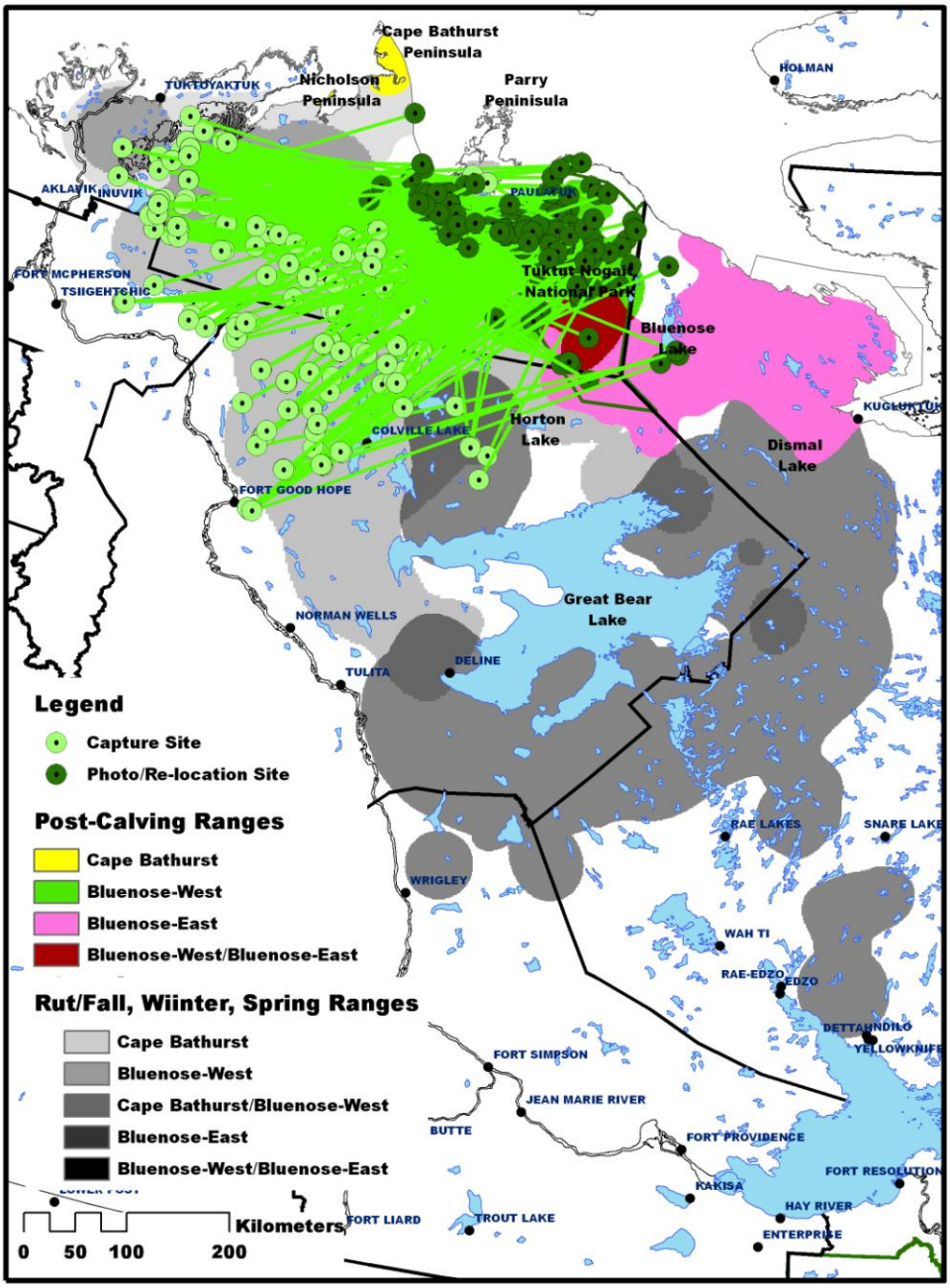

Figure 51. Distribution of capture sites for radio-collared Bluenose-West cows in relationship to where they were photographed or relocated during the post-calving period, 1986 to 2006.

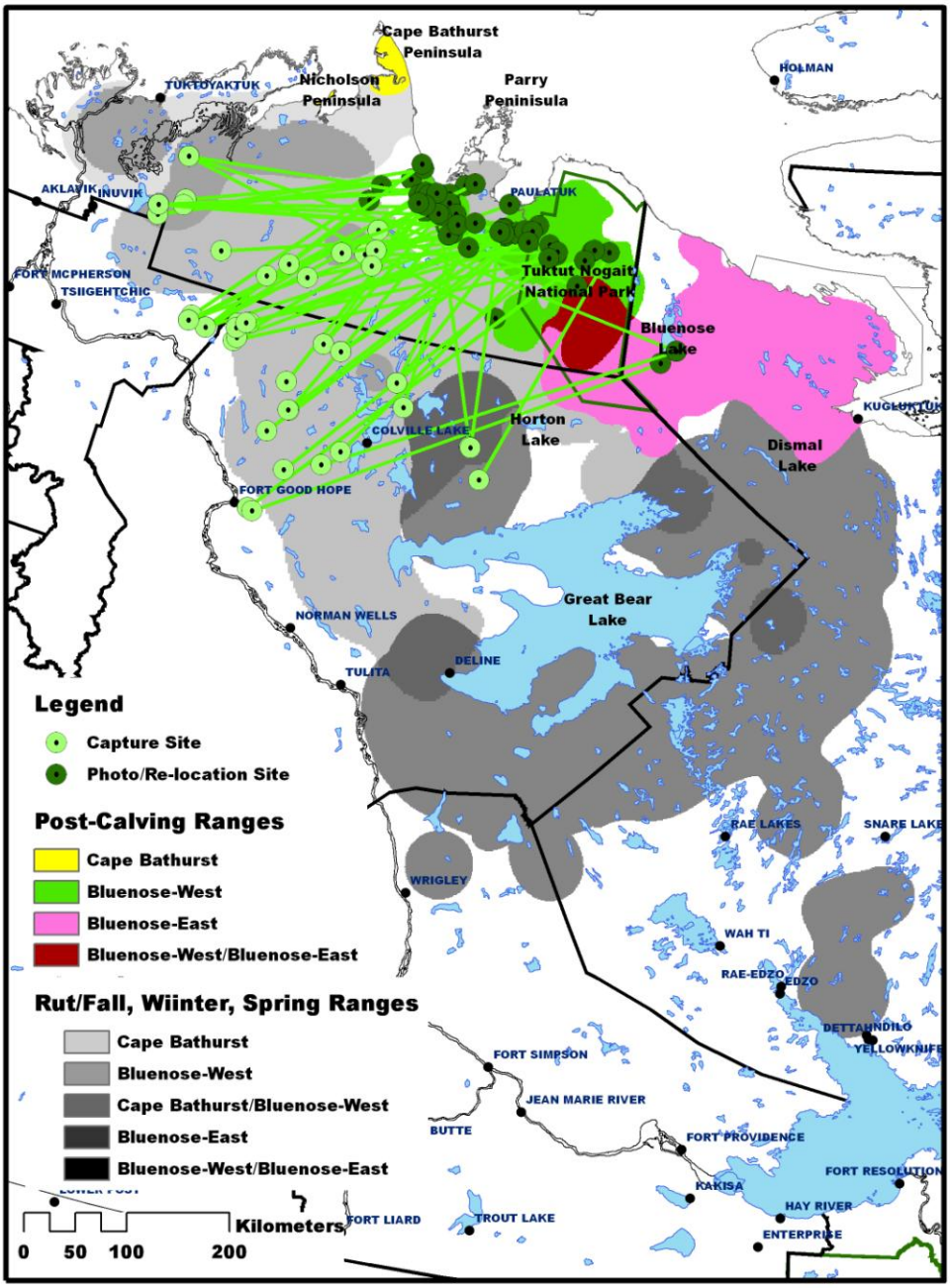

Figure 52. Distribution of capture sites for radio-collared Bluenose-West bulls in relationship to where they were photographed or relocated during the post-calving period, 1986 to 2006.

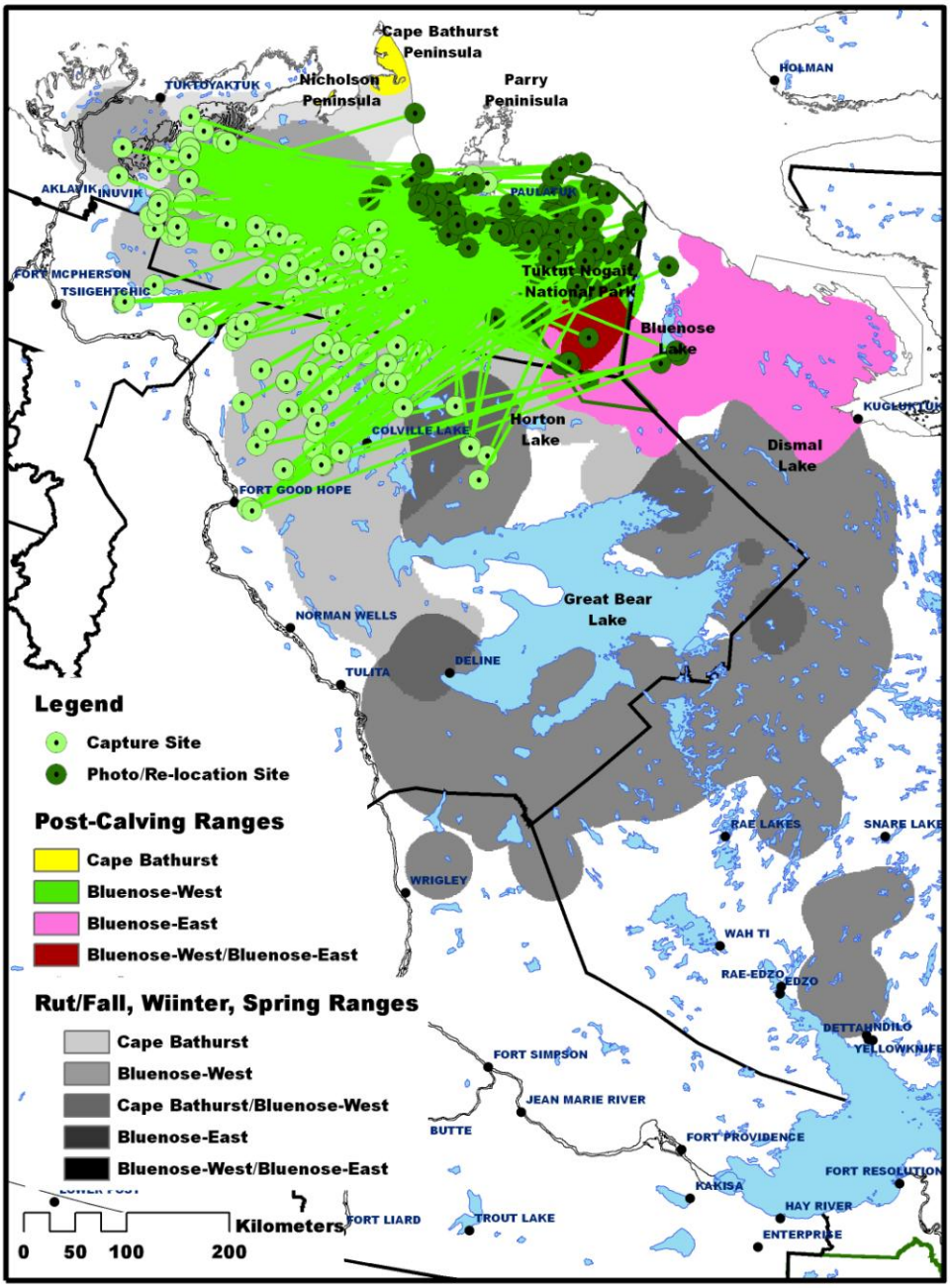

Figure 53. Distribution of capture sites for radio-collared Bluenose-West cows and bulls in relationship to where they were photographed or relocated during the post-calving period, 1986 to 2006.

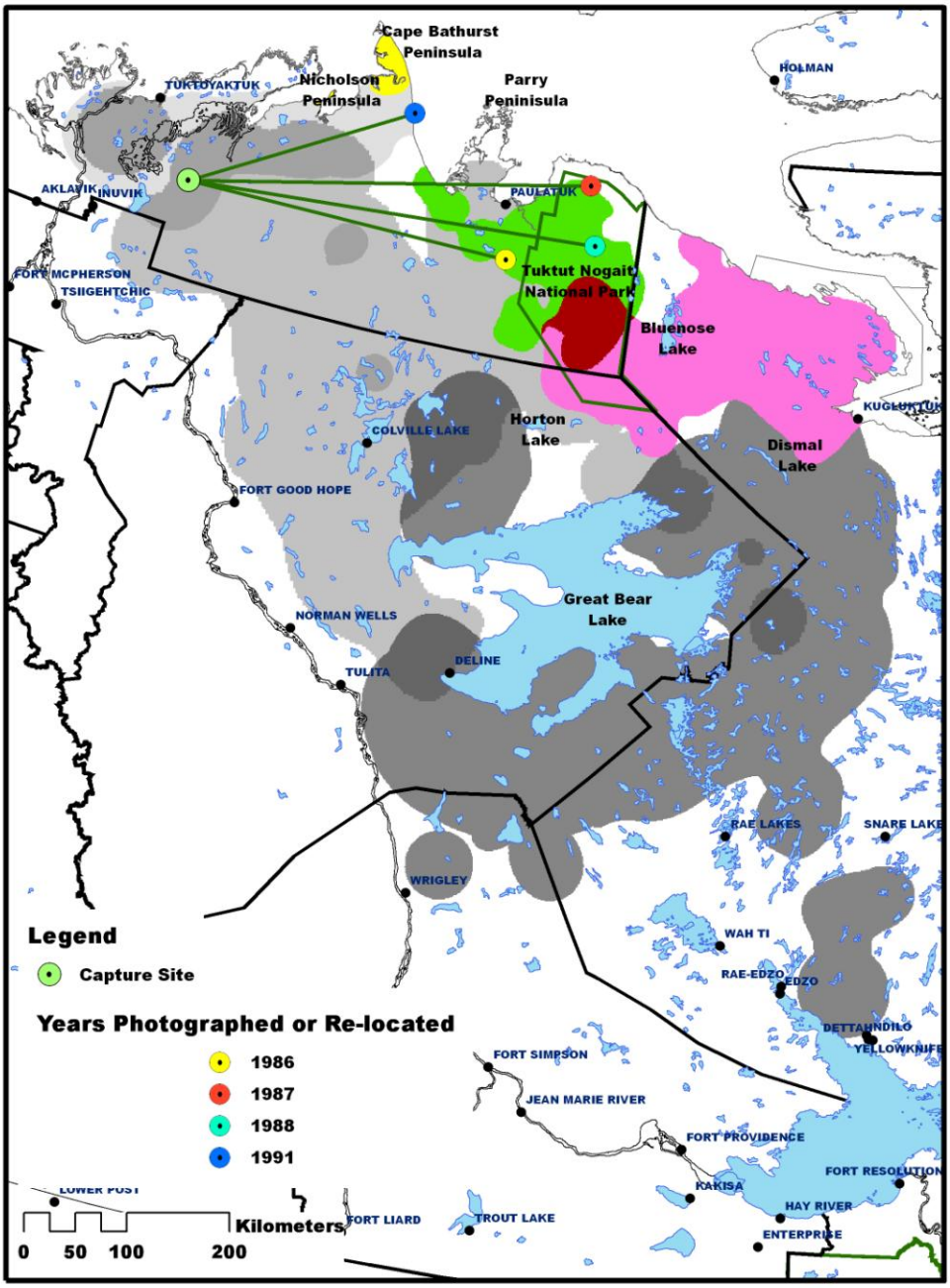

Figure 54. Distribution of sites where Bluenose-West cow 05b was located during the post-calving period in 1986, 1987, 1988, and 1991.

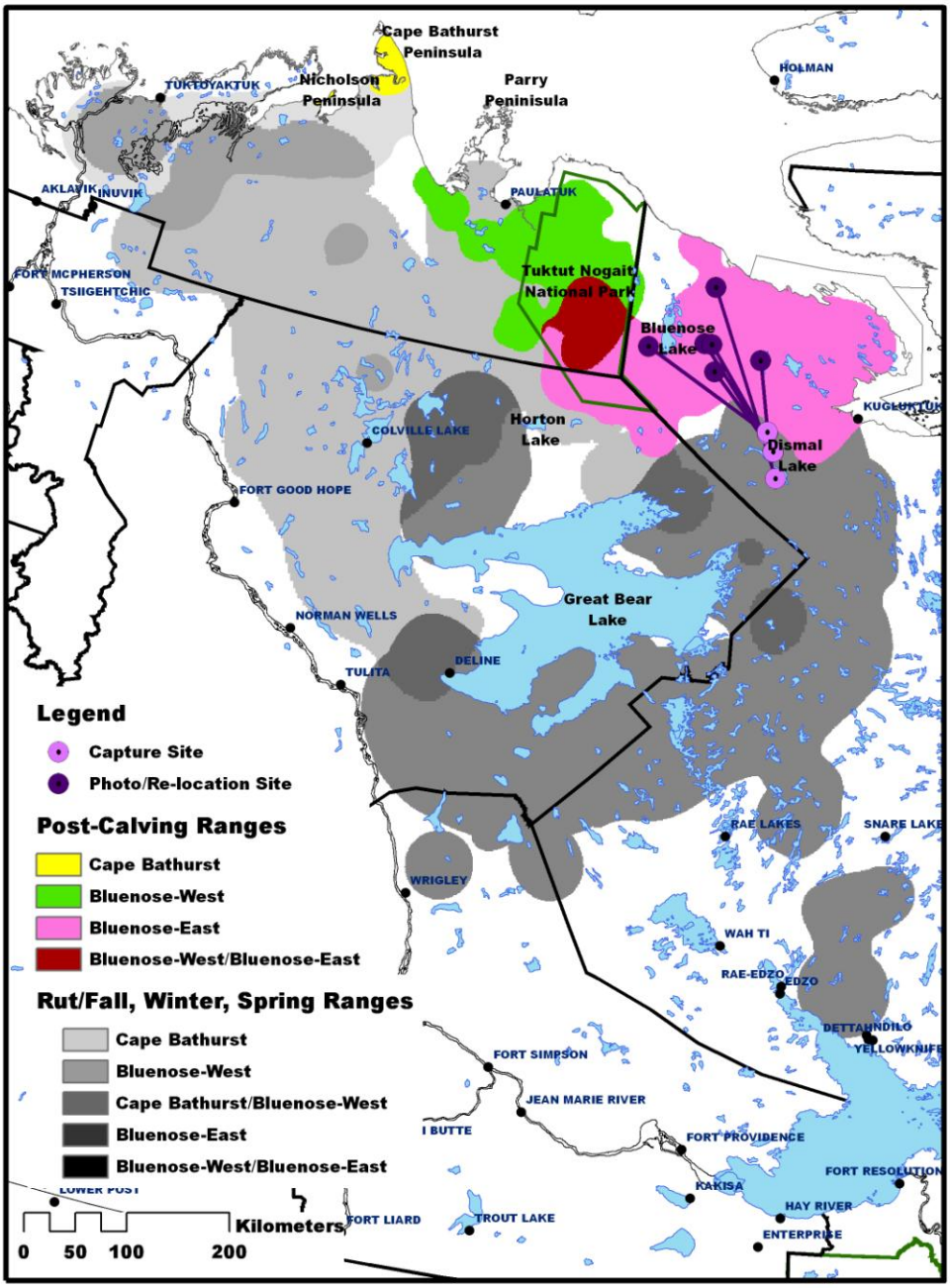

Figure 55. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were relocated during the post-calving period in 1991.

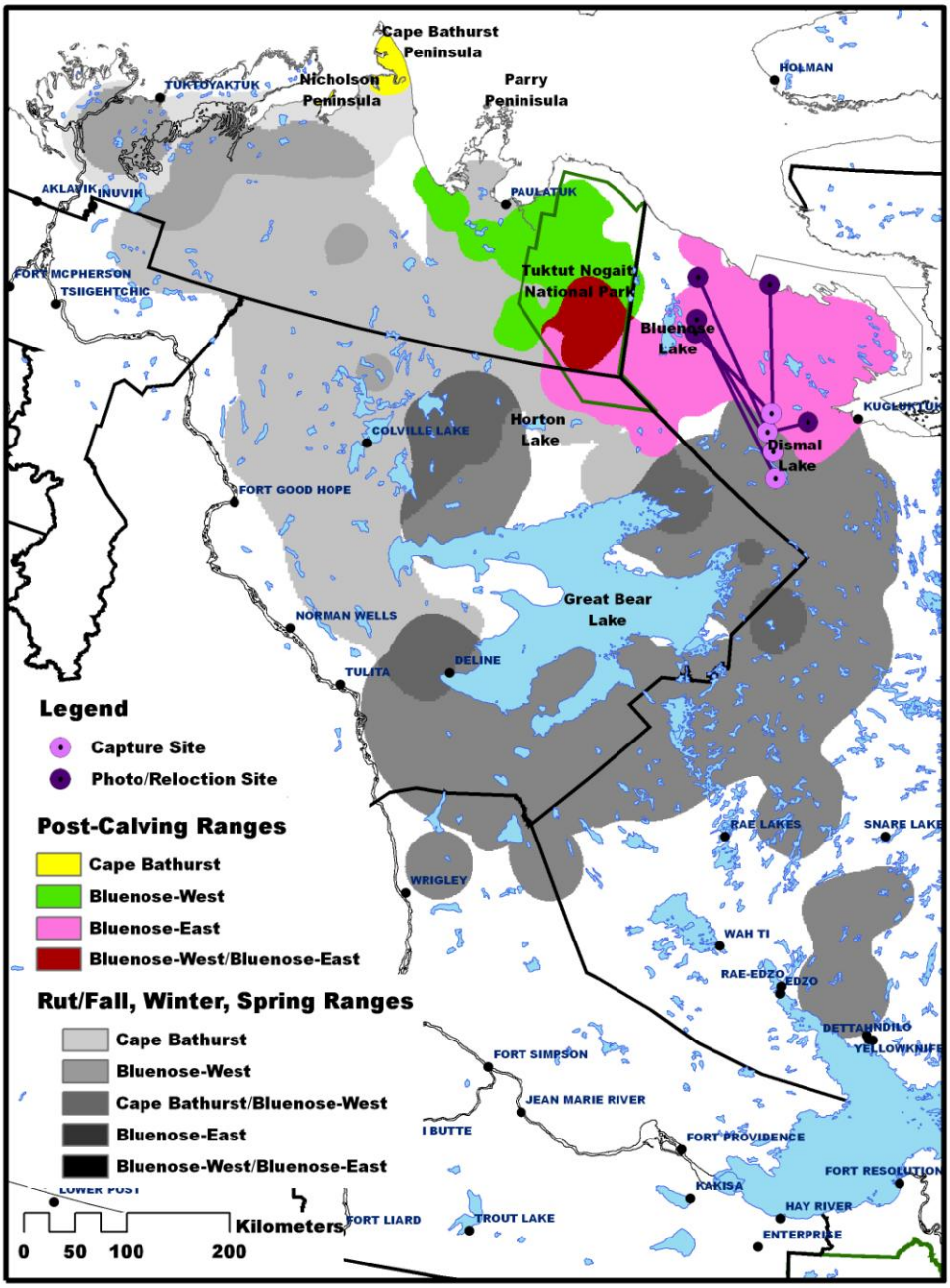

Figure 56. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were photographed or relocated during the post-calving period in 1992.

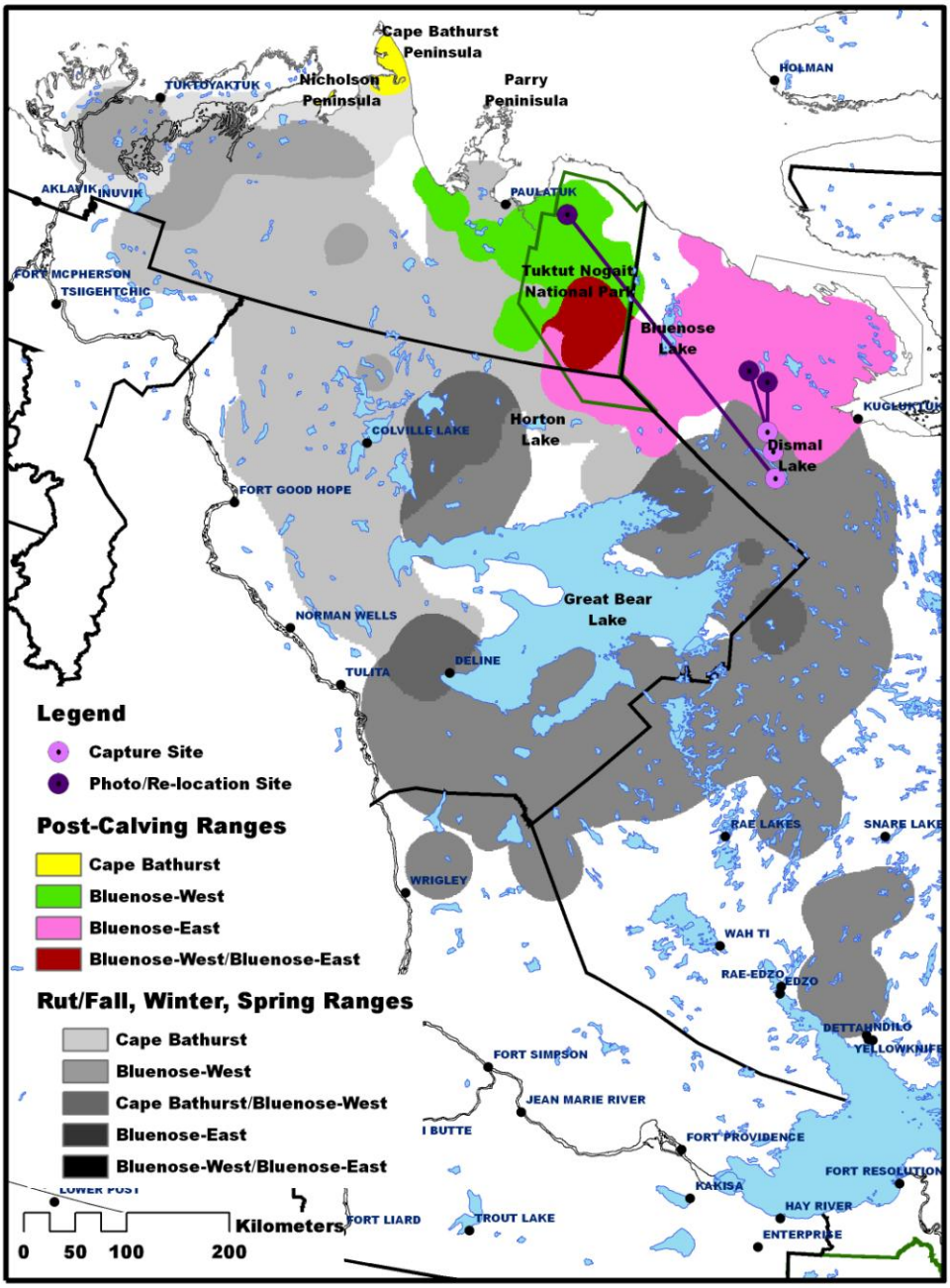

Figure 57. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were relocated during the post-calving period in 1993.

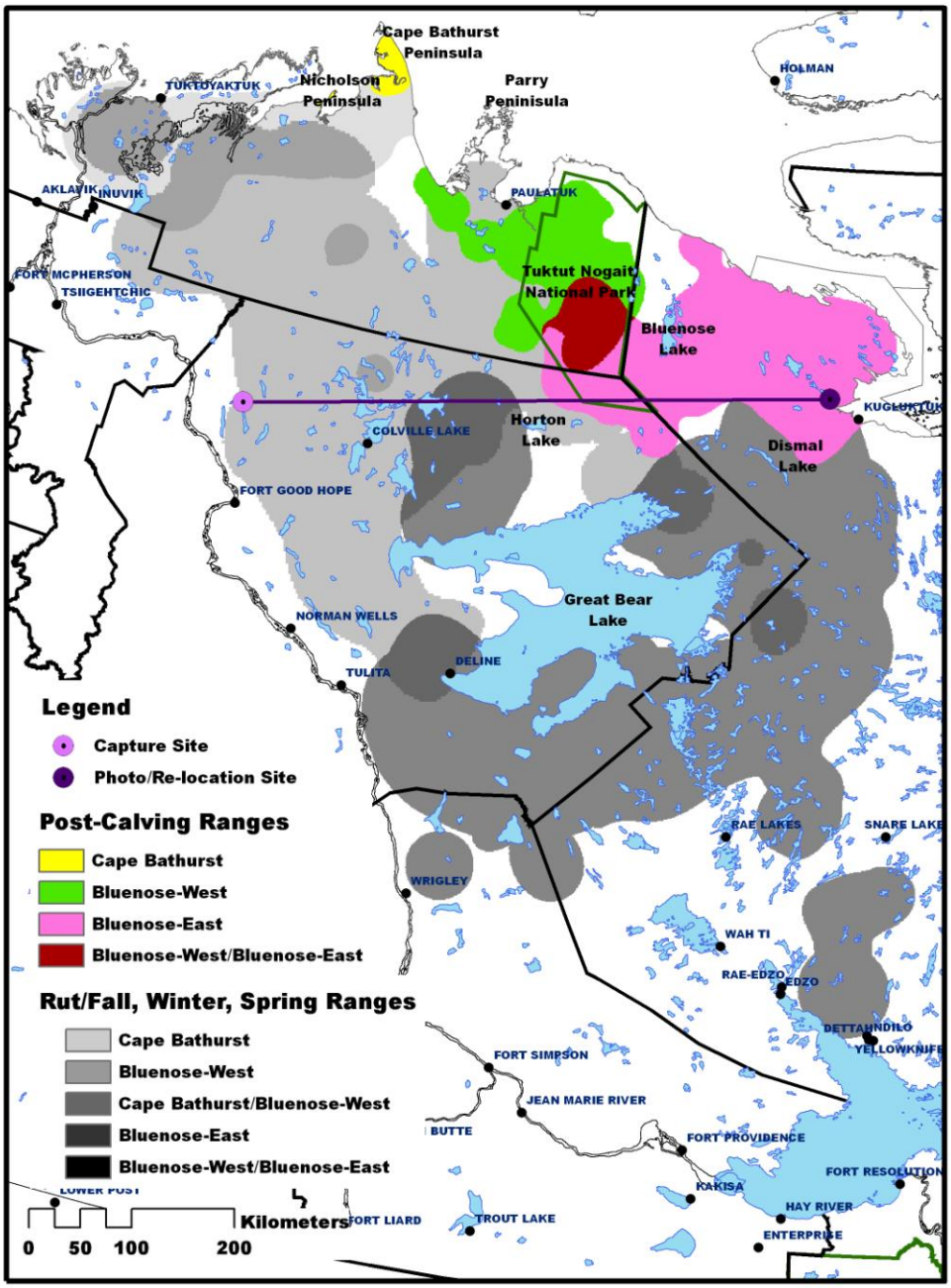

Figure 58. Distribution of capture sites for radio-collared Bluenose-East bulls in relationship to where they were photographed or relocated during the post-calving period in 2000.

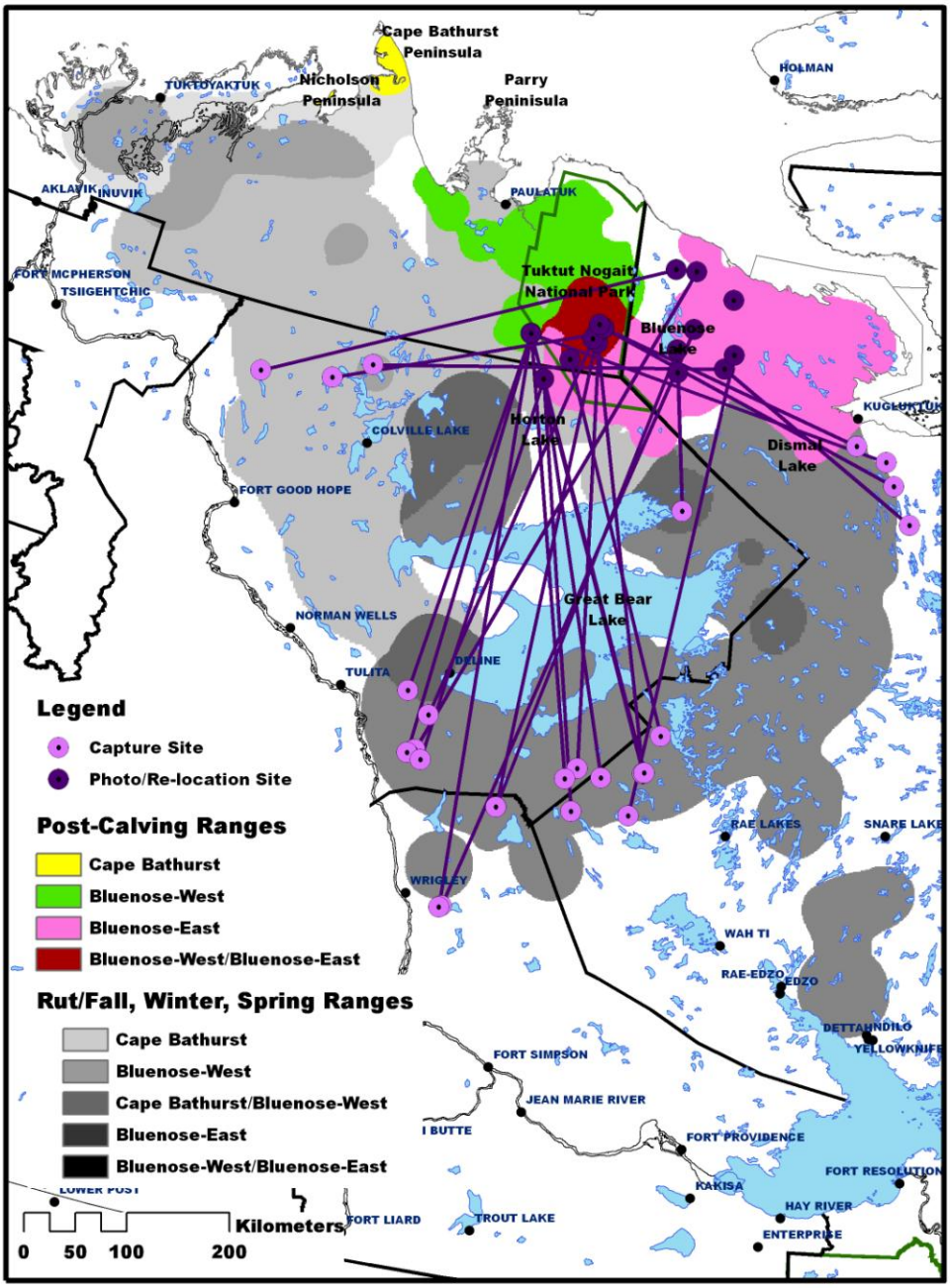

Figure 59. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were photographed or relocated during the post-calving period in 2005.

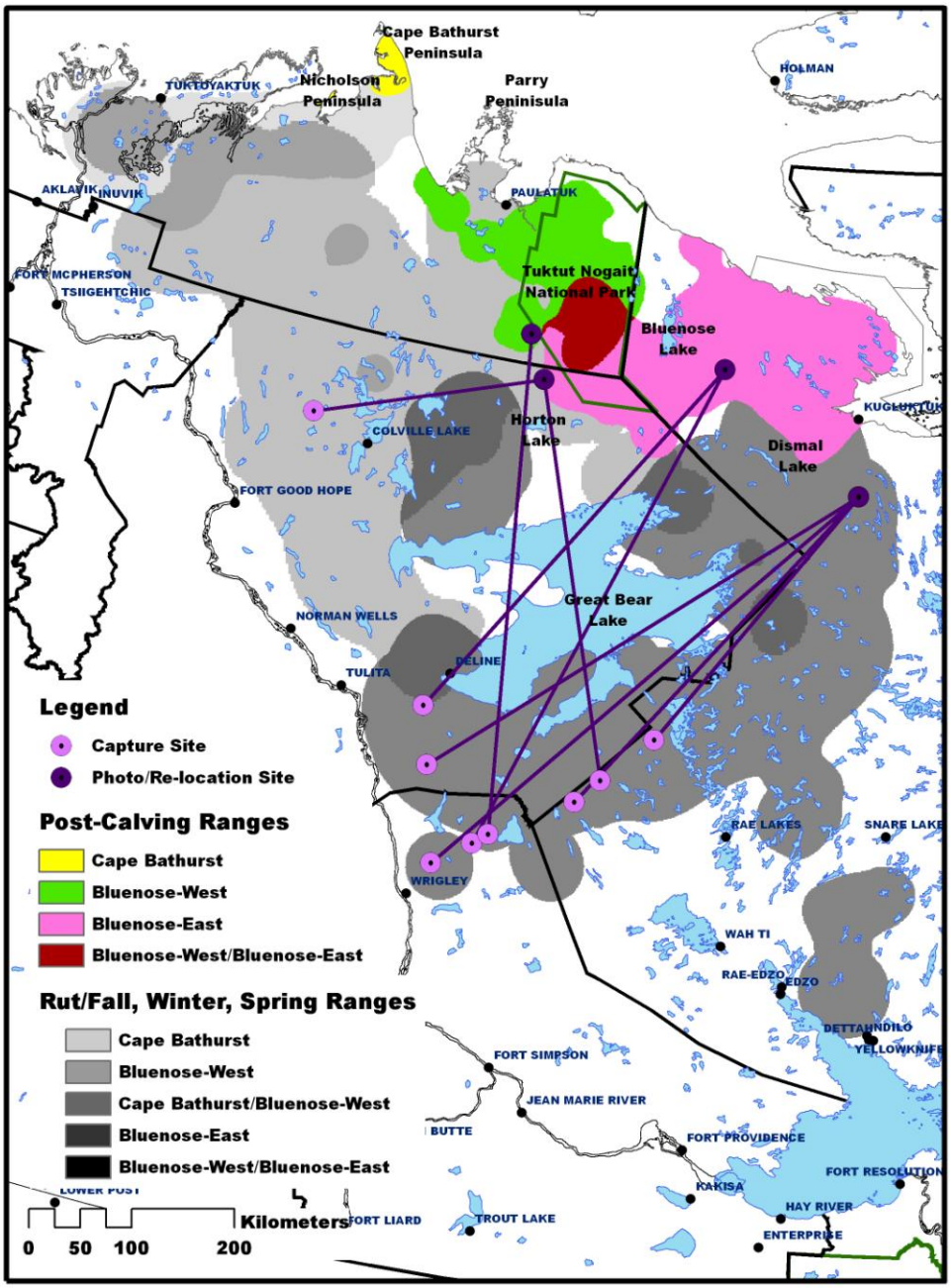

Figure 60. Distribution of capture sites for radio-collared Bluenose-East bulls in relationship to where they were photographed or relocated during the post-calving period in 2005.

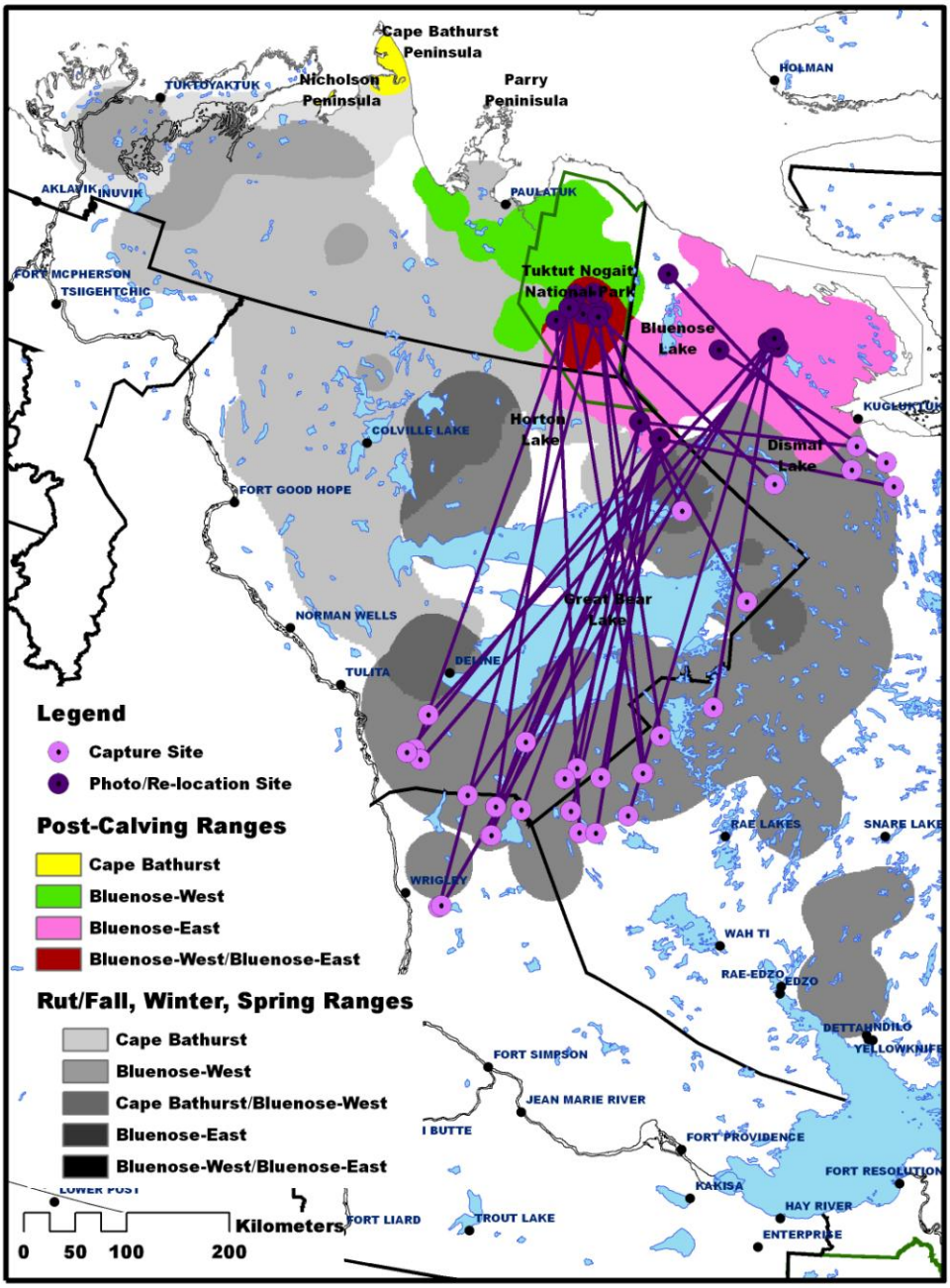

Figure 61. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were photographed or relocated during the post-calving period in 2006.

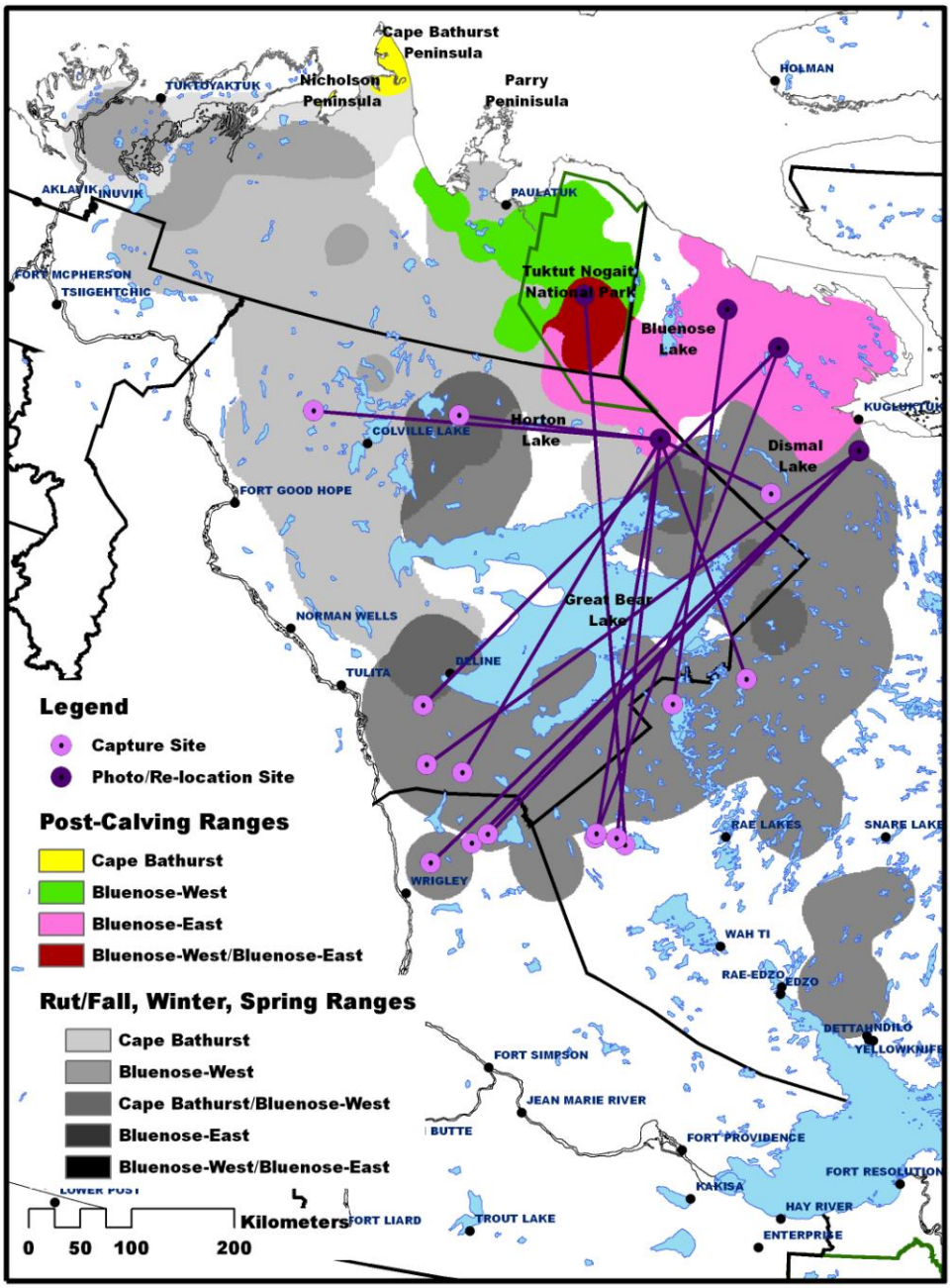

Figure 62. Distribution of capture sites for radio-collared Bluenose-East bulls in relationship to where they were photographed or relocated during the post-calving period in 2006.

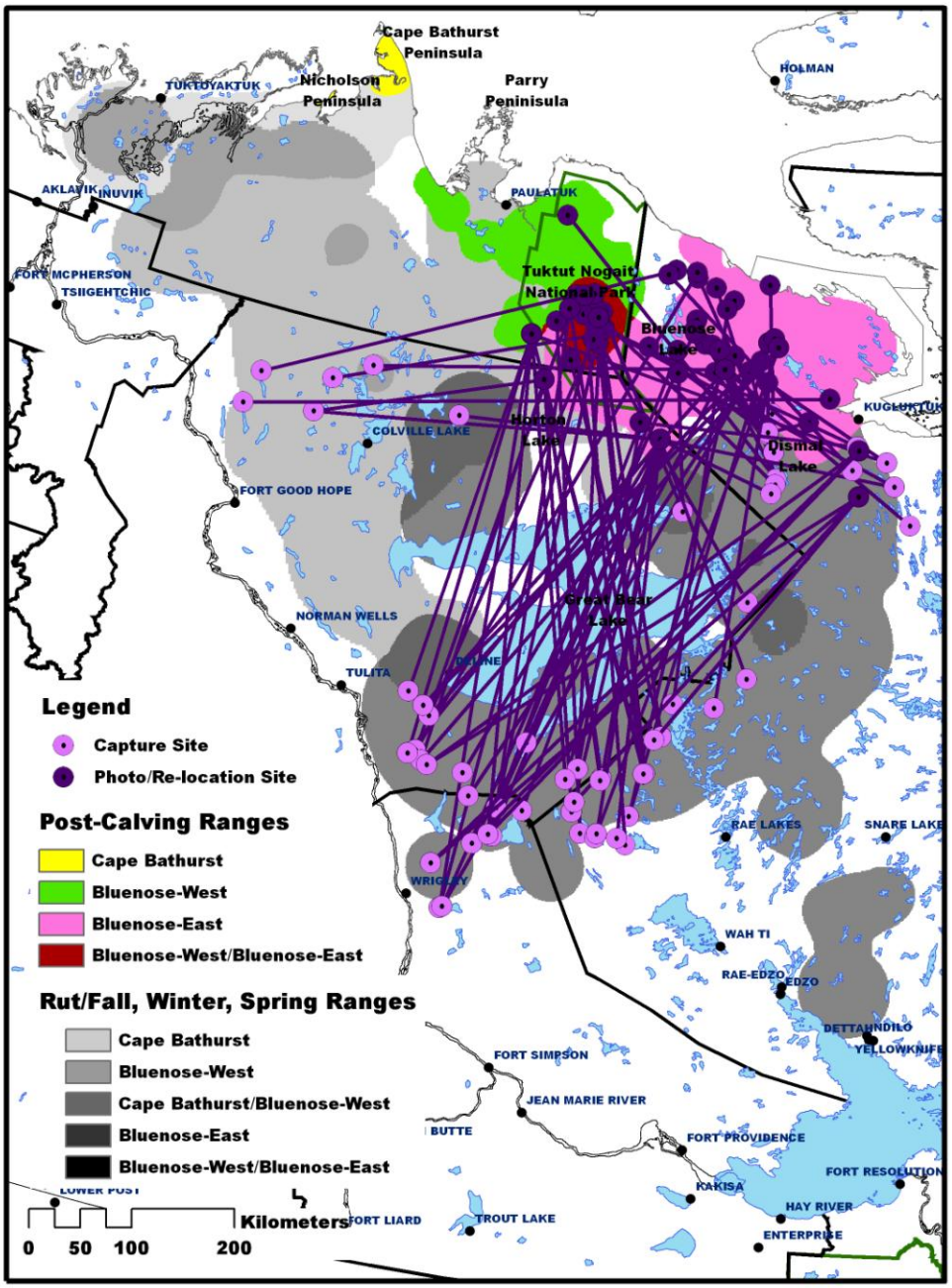

Figure 63. Distribution of capture sites for radio-collared Bluenose-East cows in relationship to where they were photographed or relocated during the post-calving period, 1991 to 2006.

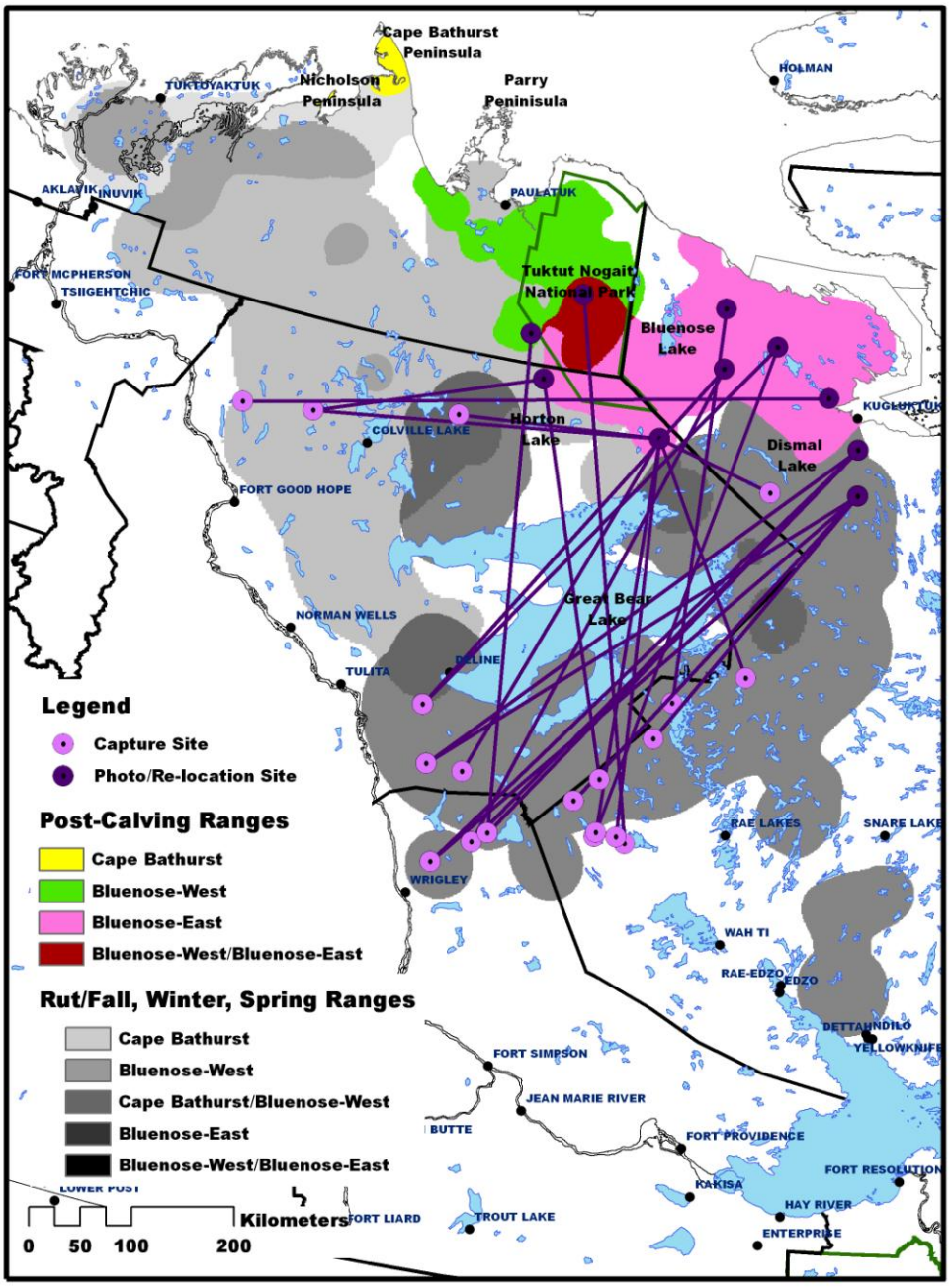

Figure 64. Distribution of capture sites for radio-collared Bluenose-East bulls in relationship to where they were photographed or relocated during the post-calving period, 2000 to 2006.

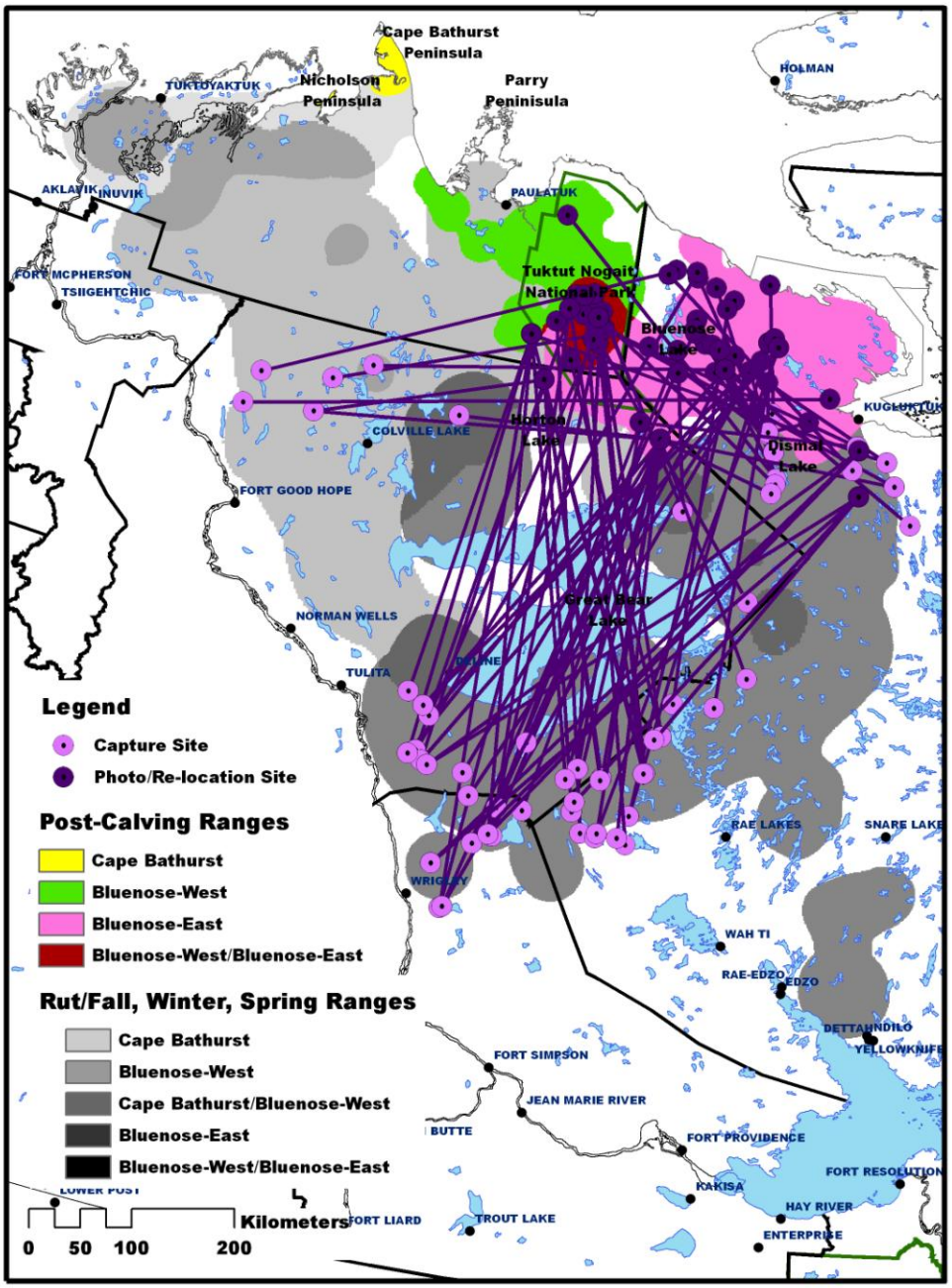

Figure 65. Distribution of capture sites for radio-collared Bluenose-East cows and bulls in relationship to where they were photographed or relocated during the post-calving period, 1991 to 2006.

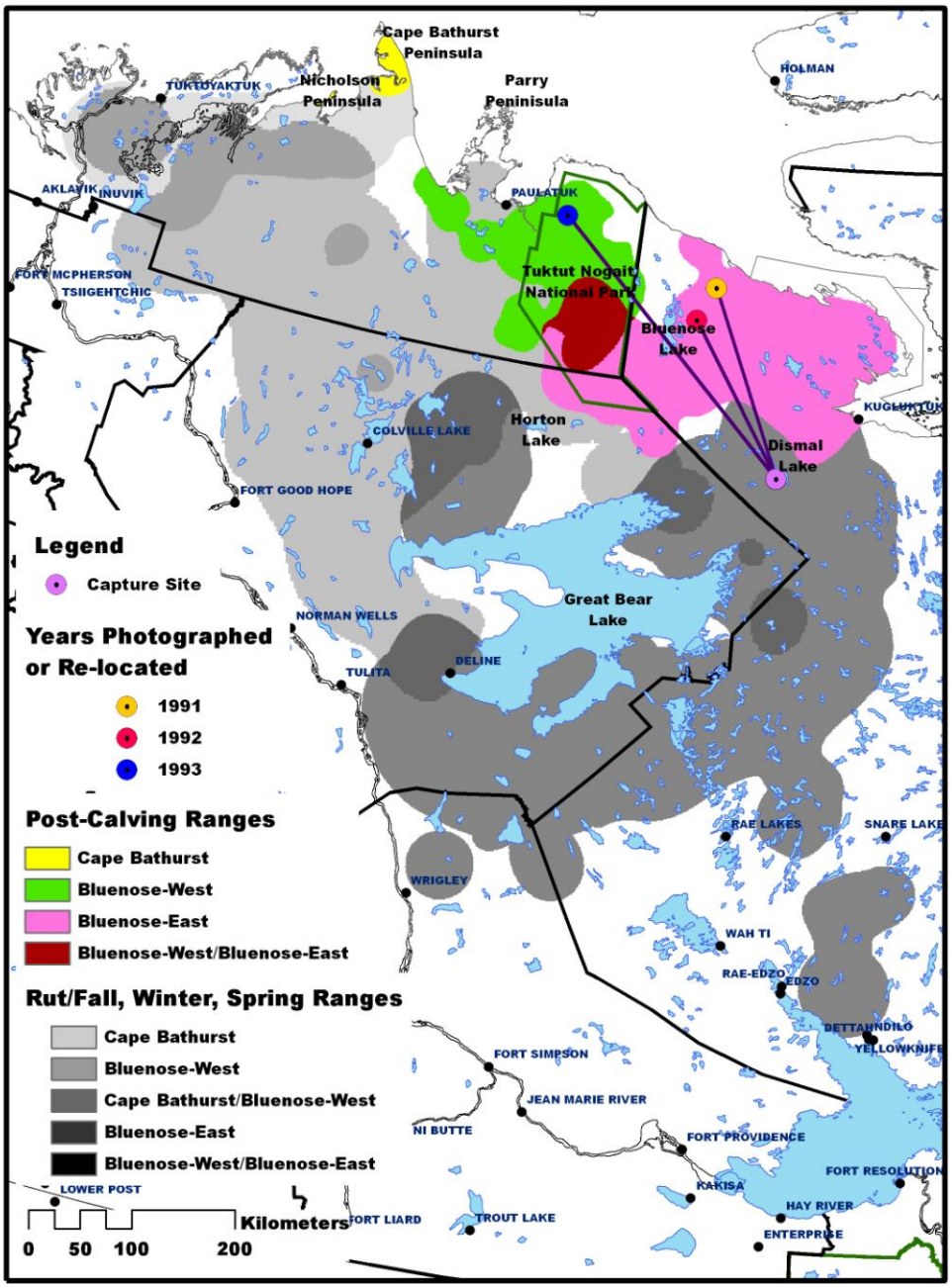

Figure 66. Distribution of sites where Bluenose-East cow 57b was located during the post-calving period in 1991, 1992, and 1993.

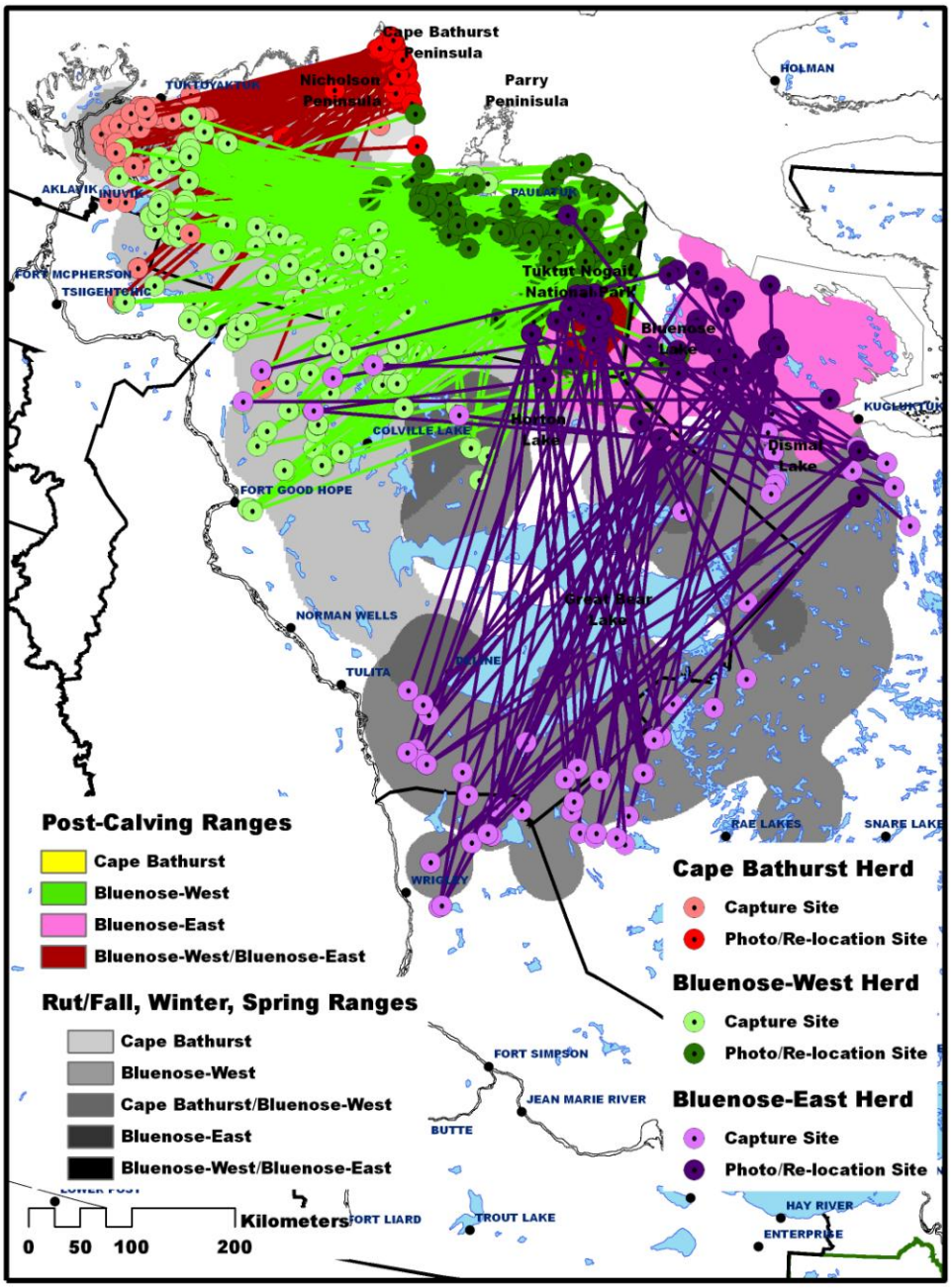

Figure 67. Distribution of capture sites for radio-collared Cape Bathurst, Bluenose-West, and Bluenose-East cows in relationship to where they were photographed or relocated during the post-calving period, 1986 to 2006.

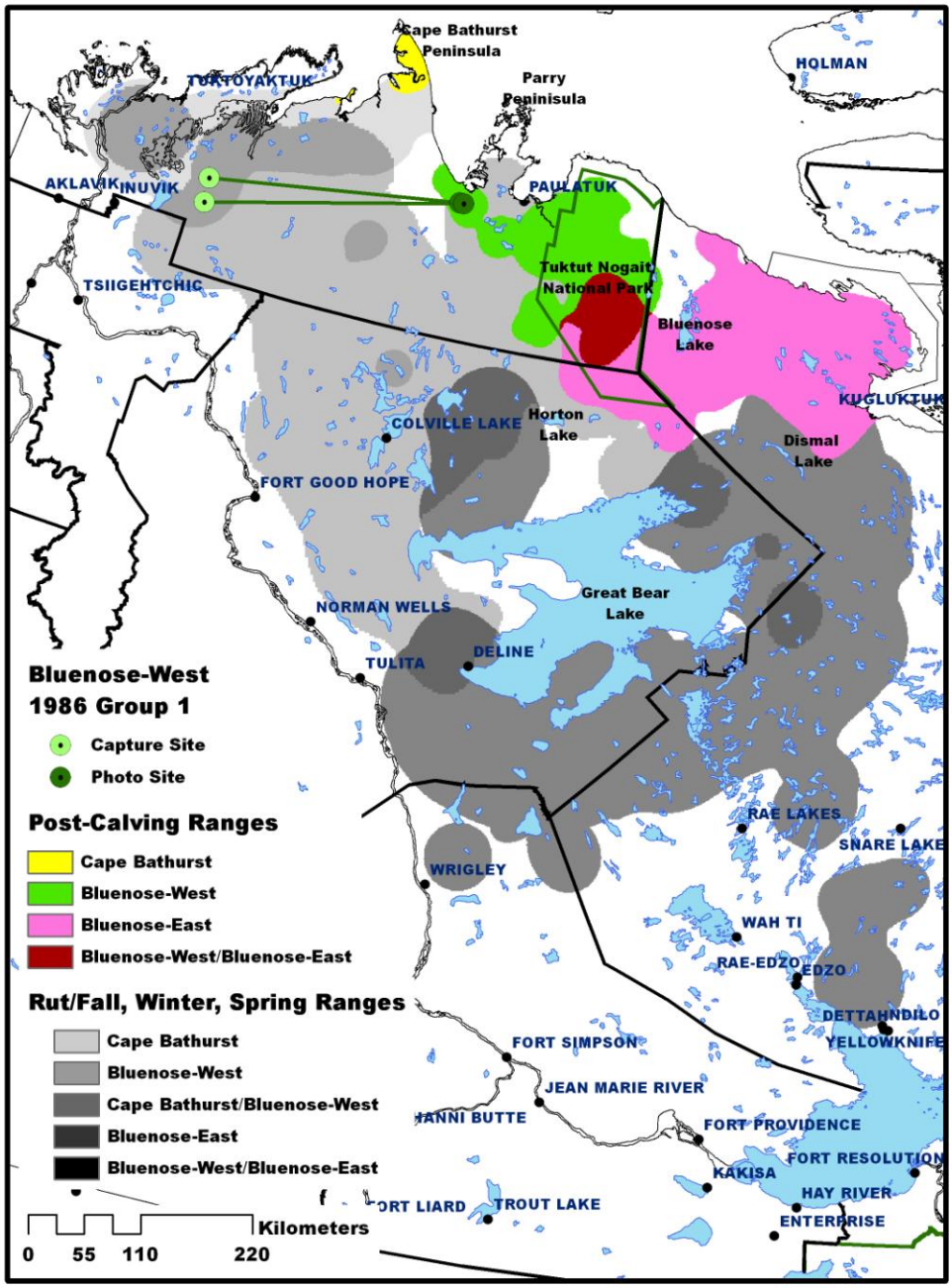

Figure 68. Bluenose-West herd 1986 group 1 contained 2 radio-collared caribou, 2,251 adults, and 691 calves. The distance between capture sites for the radio-collared caribou was 24.1 km.

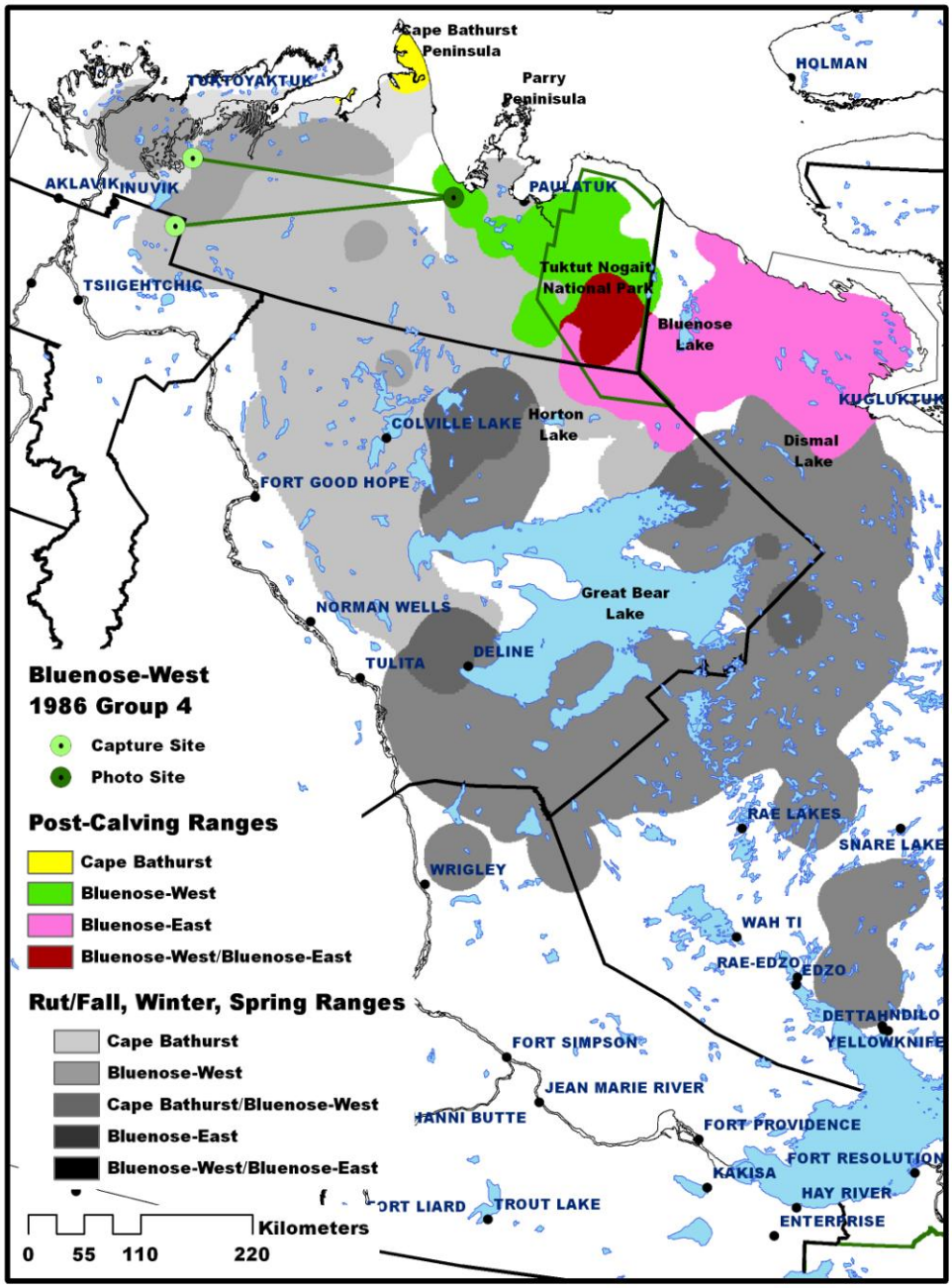

Figure 69. Bluenose-West herd 1986 group 4 contained 2 radio-collared caribou, 5,166 adults, and 1,954 calves. The distance between capture sites for the radio-collared caribou was 68.7 km.

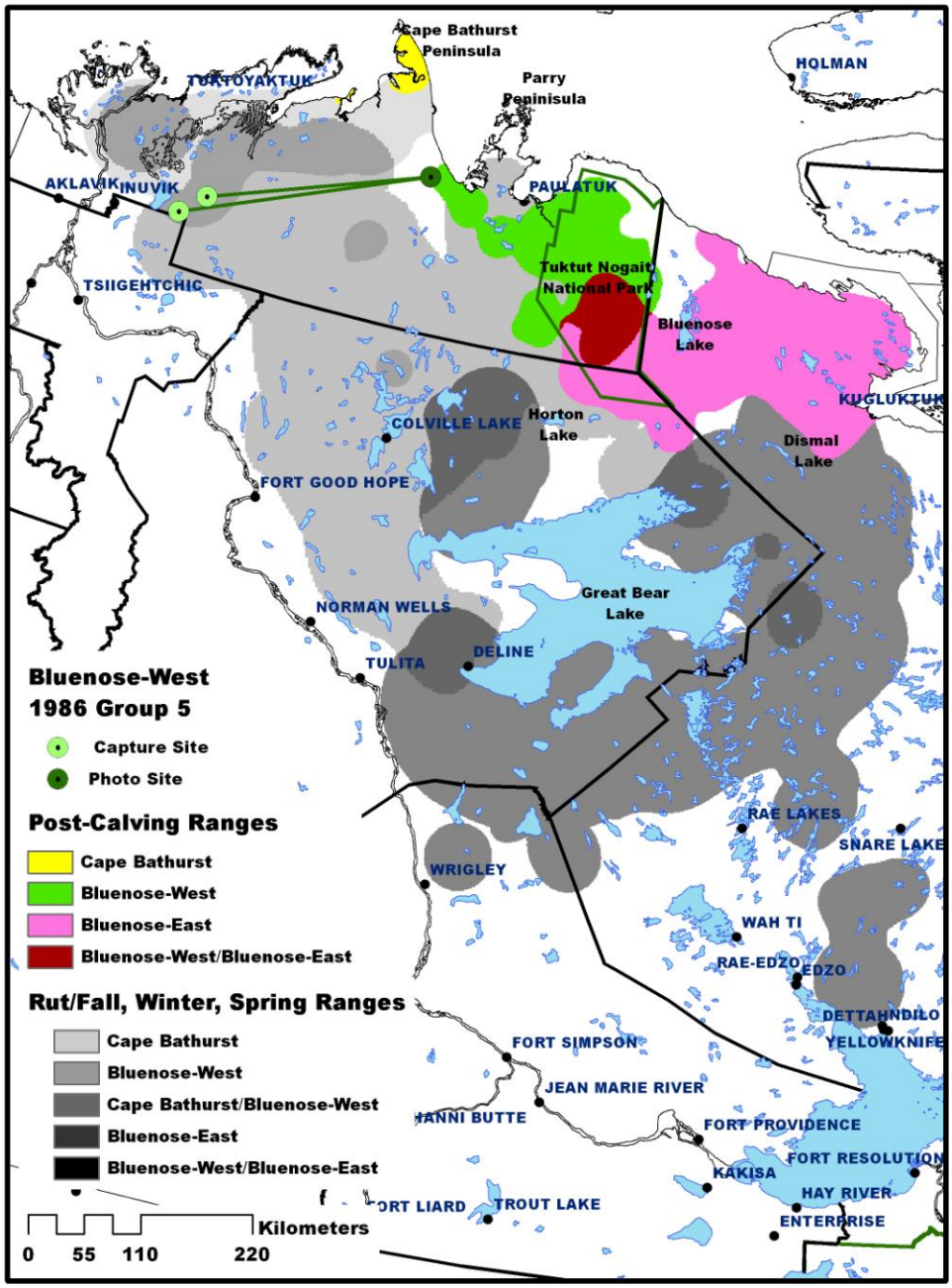

Figure 70. Bluenose-West herd 1986 group 5 contained 2 radio-collared caribou, 19,788 adults, and 545 calves. The distance between capture sites for the radio-collared caribou was 31.1 km.

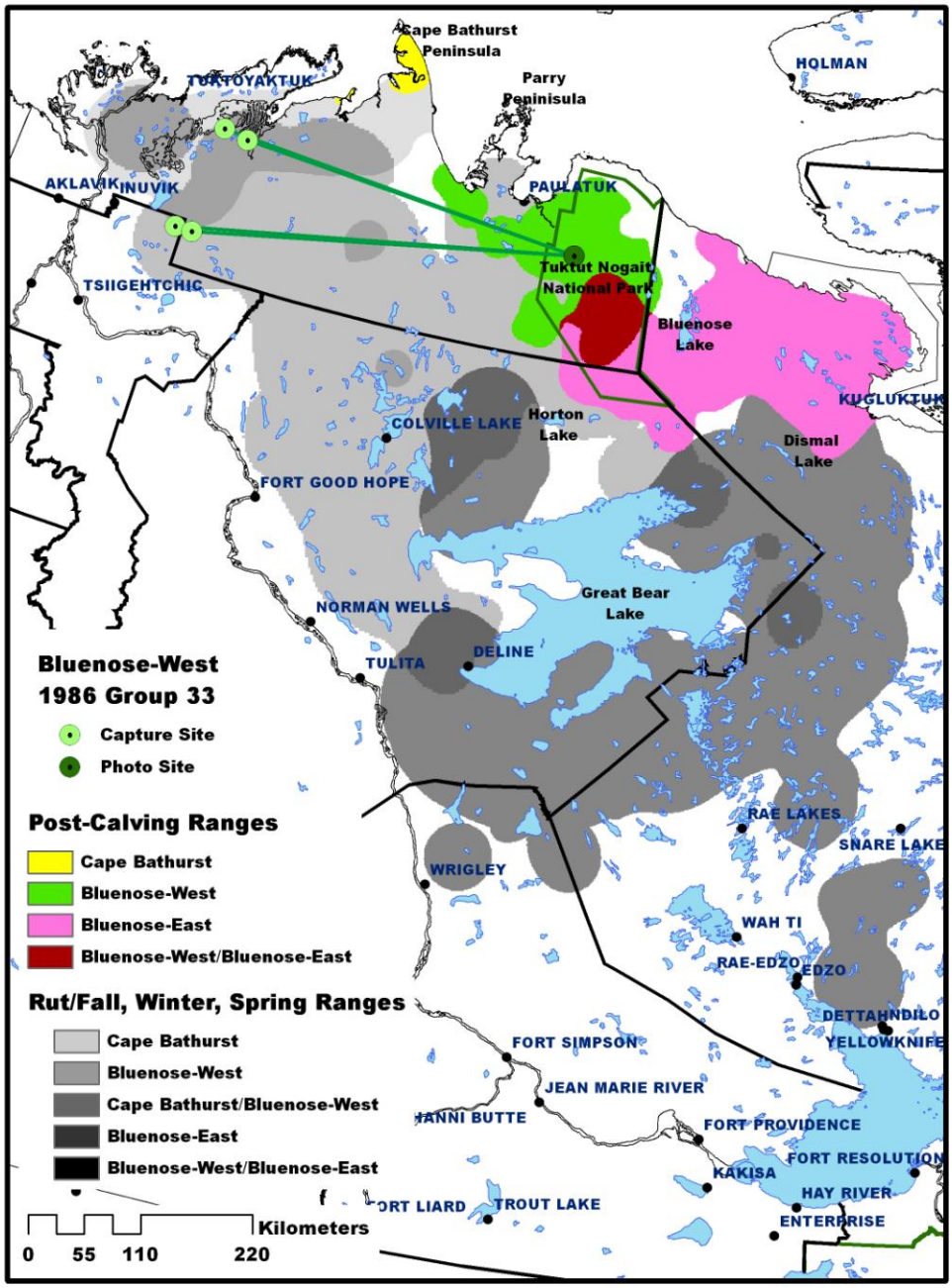

Figure 71. Bluenose-West herd 1986 group 33 contained 4 radio-collared caribou, 4,658 adults, and 1,856 calves. The geometric mean distance between capture sites for the radio-collared caribou was 61.9 km (range 17.2 to 110.1 km).

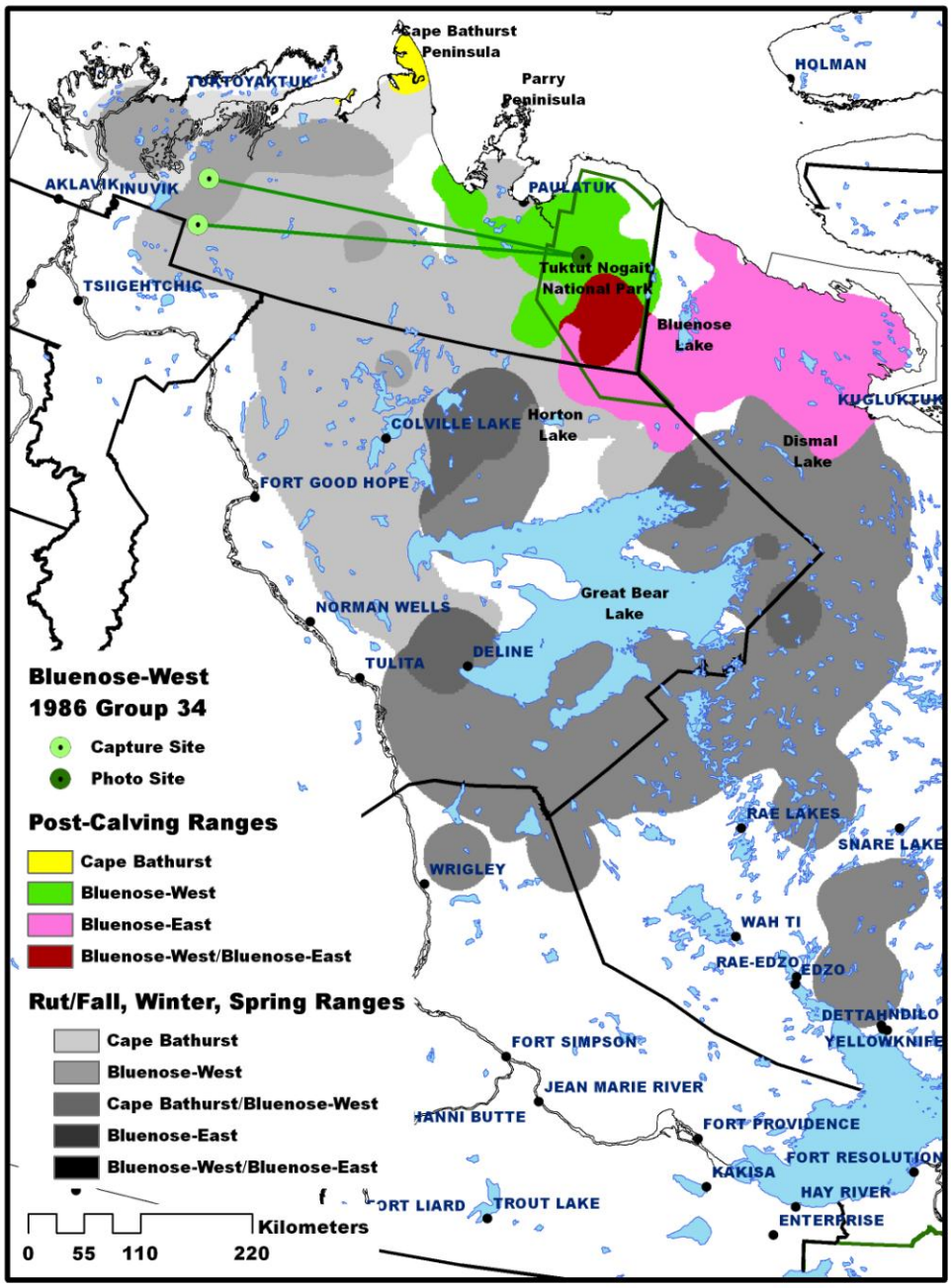

Figure 72. Bluenose-West herd 1986 group 34 contained 2 radio-collared caribou, 2,729 adults, and 1,086 calves. The distance between capture sites for the radio-collared caribou was 46.2 km.

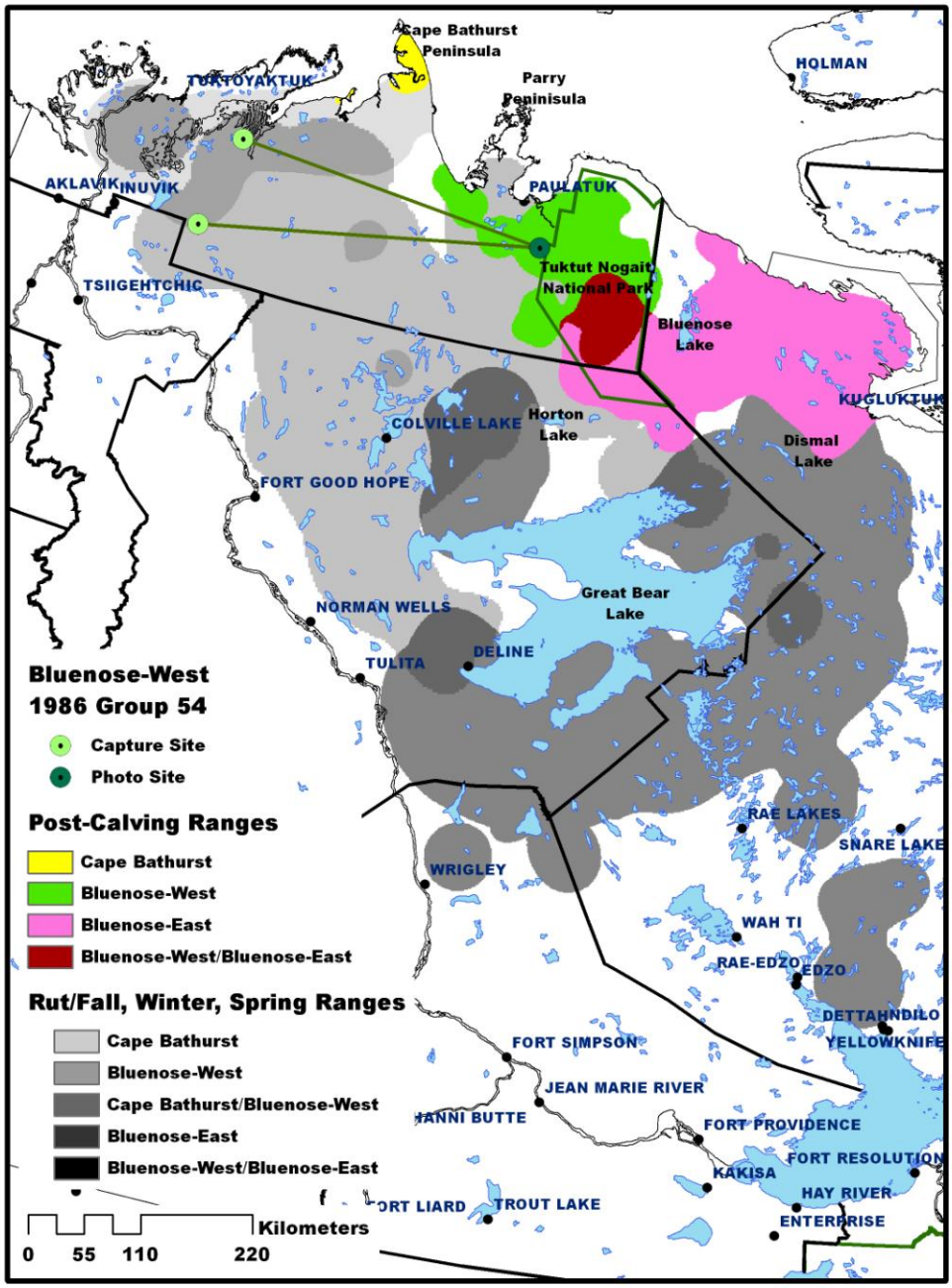

Figure 73. Bluenose-West herd 1986 group 54 contained 2 radio-collared caribou, 4,622 adults, and 983 calves. The distance between capture sites for the radio-collared caribou was 94.0 km.

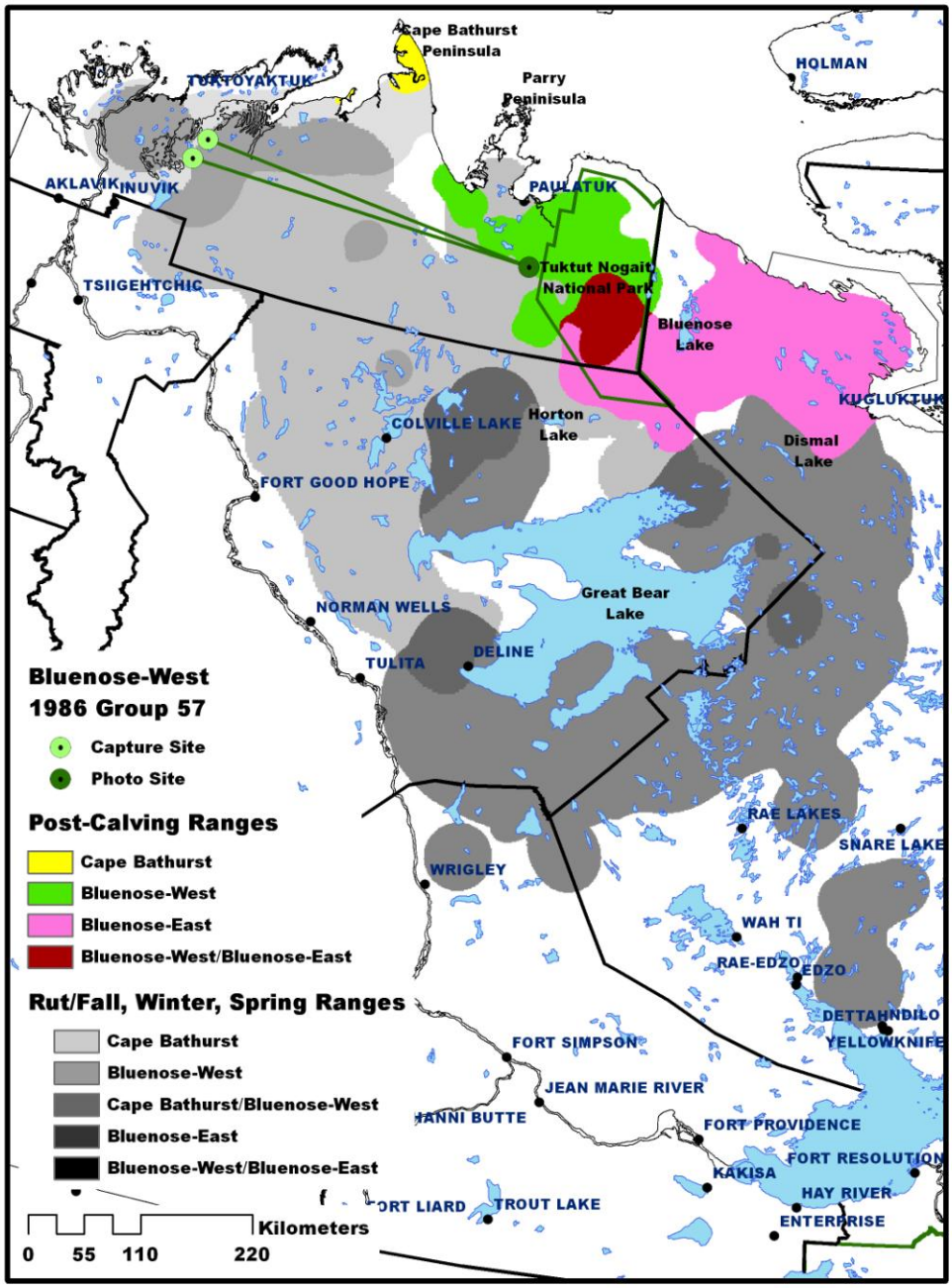

Figure 74. Bluenose-West herd 1986 group 57 contained 2 radio-collared caribou, 3,646 adults, and 741 calves. The distance between capture sites for the radio-collared caribou was 23.5 km.

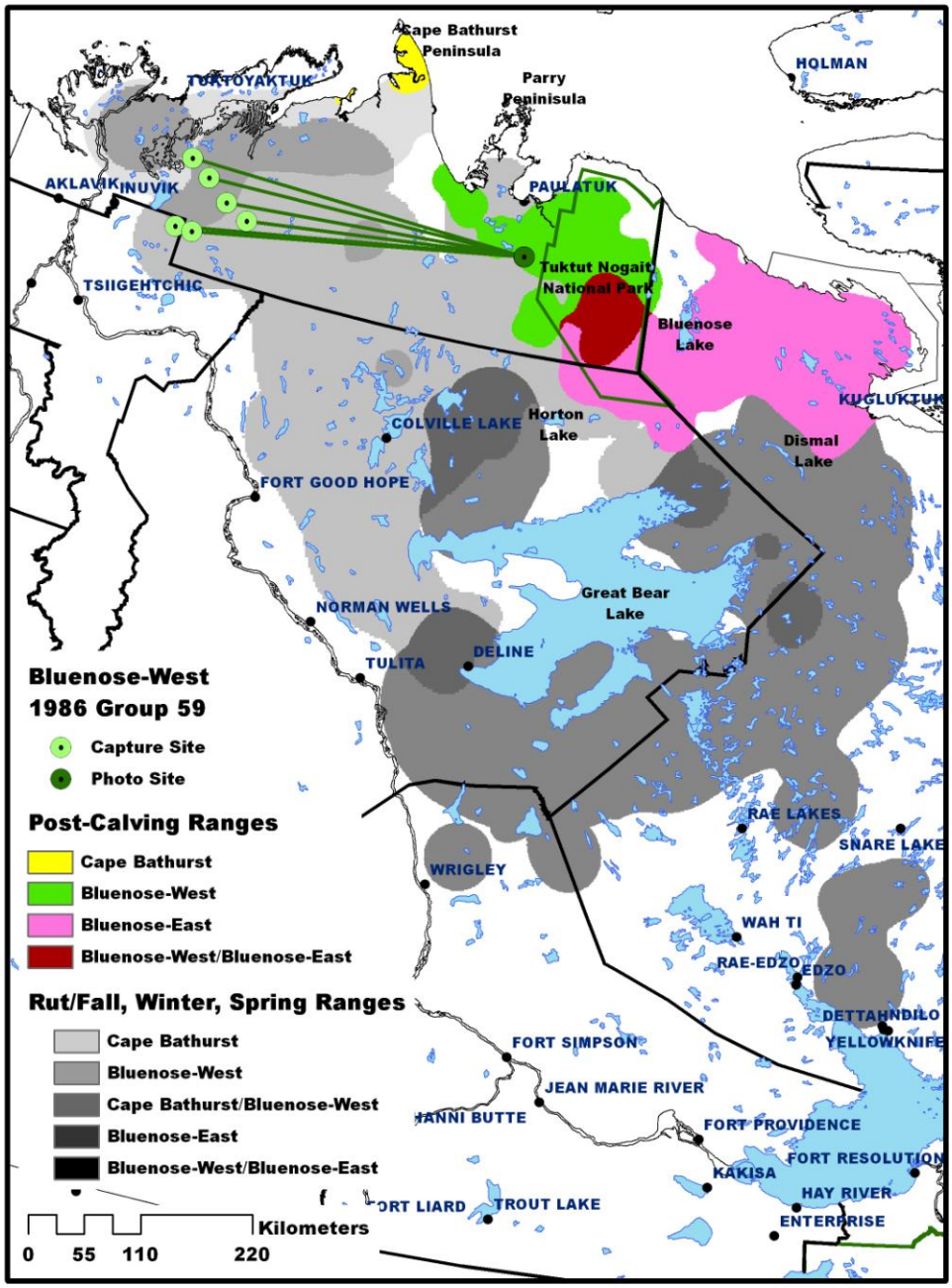

Figure 75. Bluenose-West herd 1986 group 59 contained 9 radio-collared caribou, 16,703 adults, and 5,783 calves. The geometric mean distance between capture sites for the radio-collared caribou was 45.2 km (range 0 to 81.2 km).

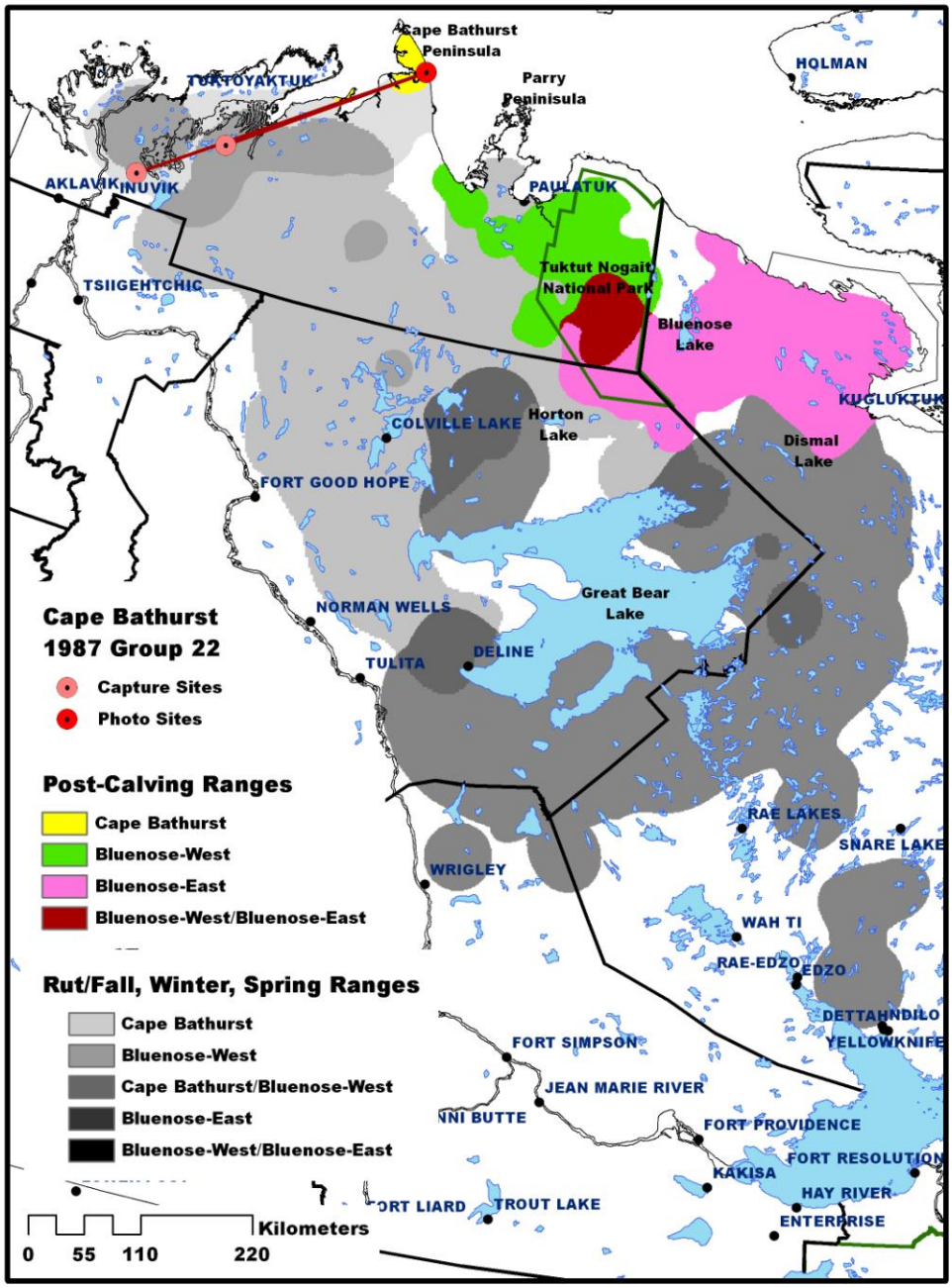

Figure 76. Cape Bathurst herd 1987 group 22 contained 2 radio-collared caribou, 5,720 adults, and 615 calves. The distance between capture sites for the radio-collared caribou was 91.4 km.

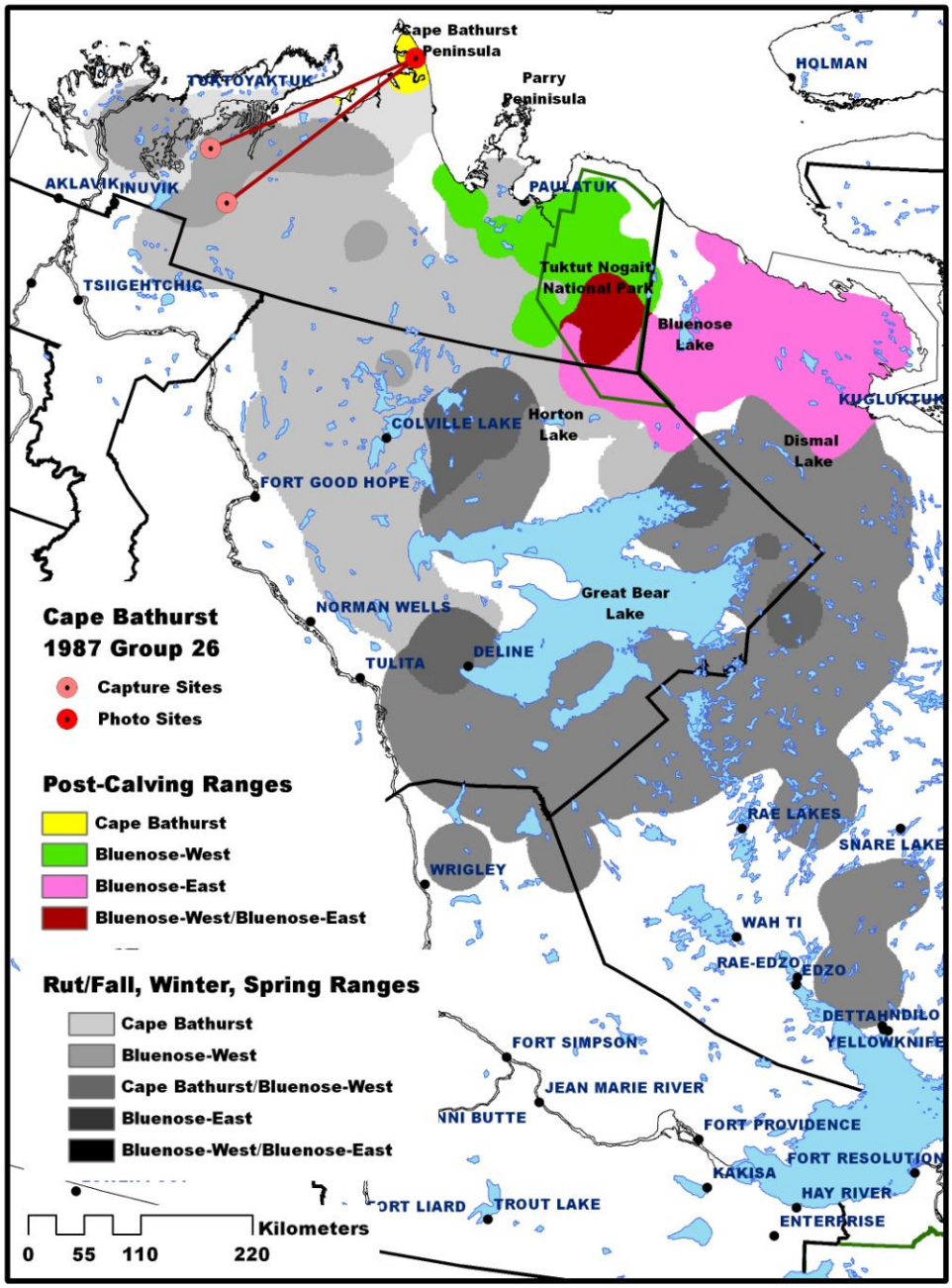

Figure 77. Cape Bathurst herd 1987 group 26 contained 2 radio-collared caribou and an estimated 2,500 caribou. The distance between capture sites for the radio-collared caribou was 55.8 km.

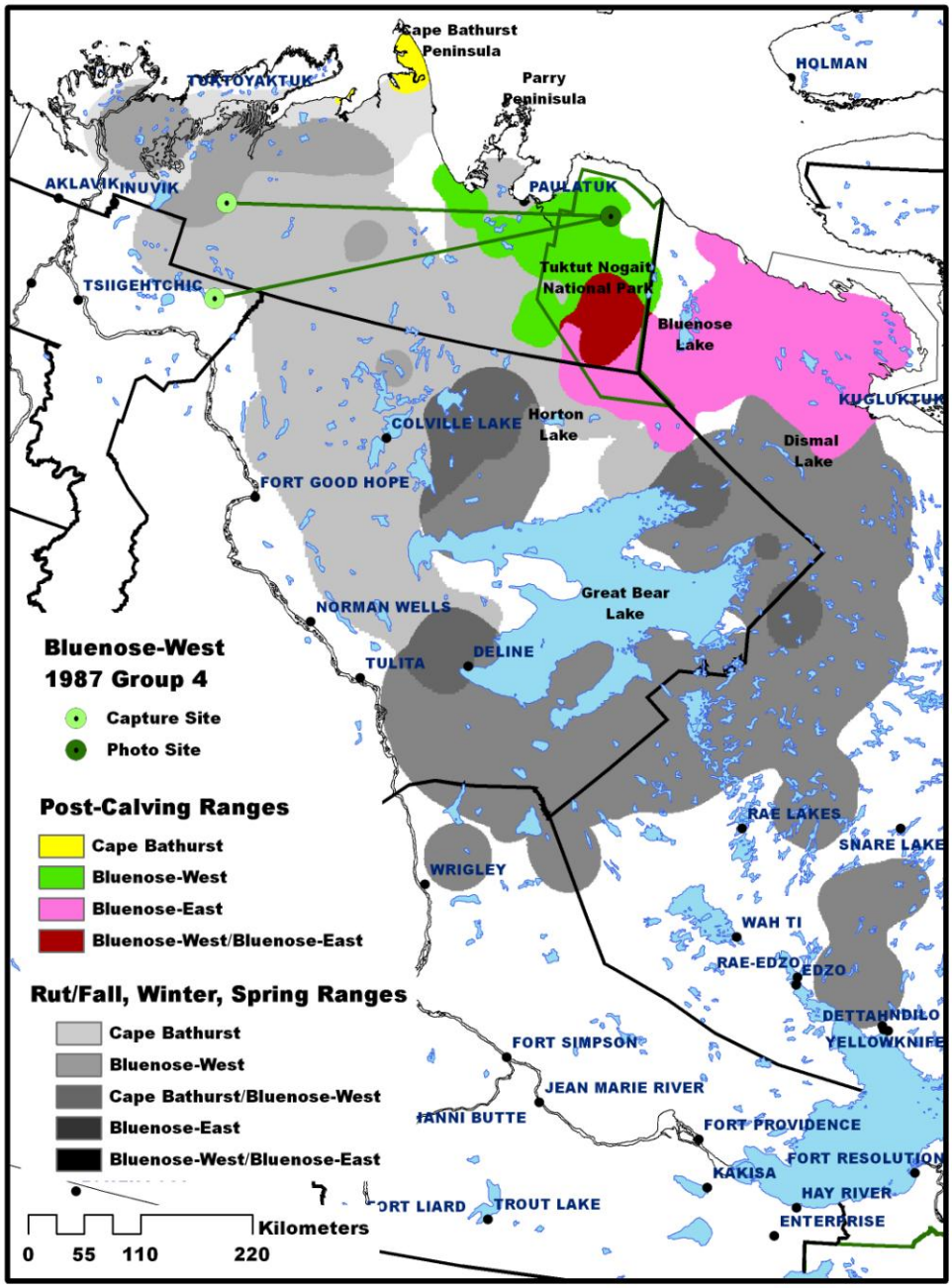

Figure 78. Bluenose-West 1987 herd group 4 contained 2 radio-collared caribou, 1,479 adults, and 39 calves. The distance between capture sites for the radio-collared caribou was 93.4 km.

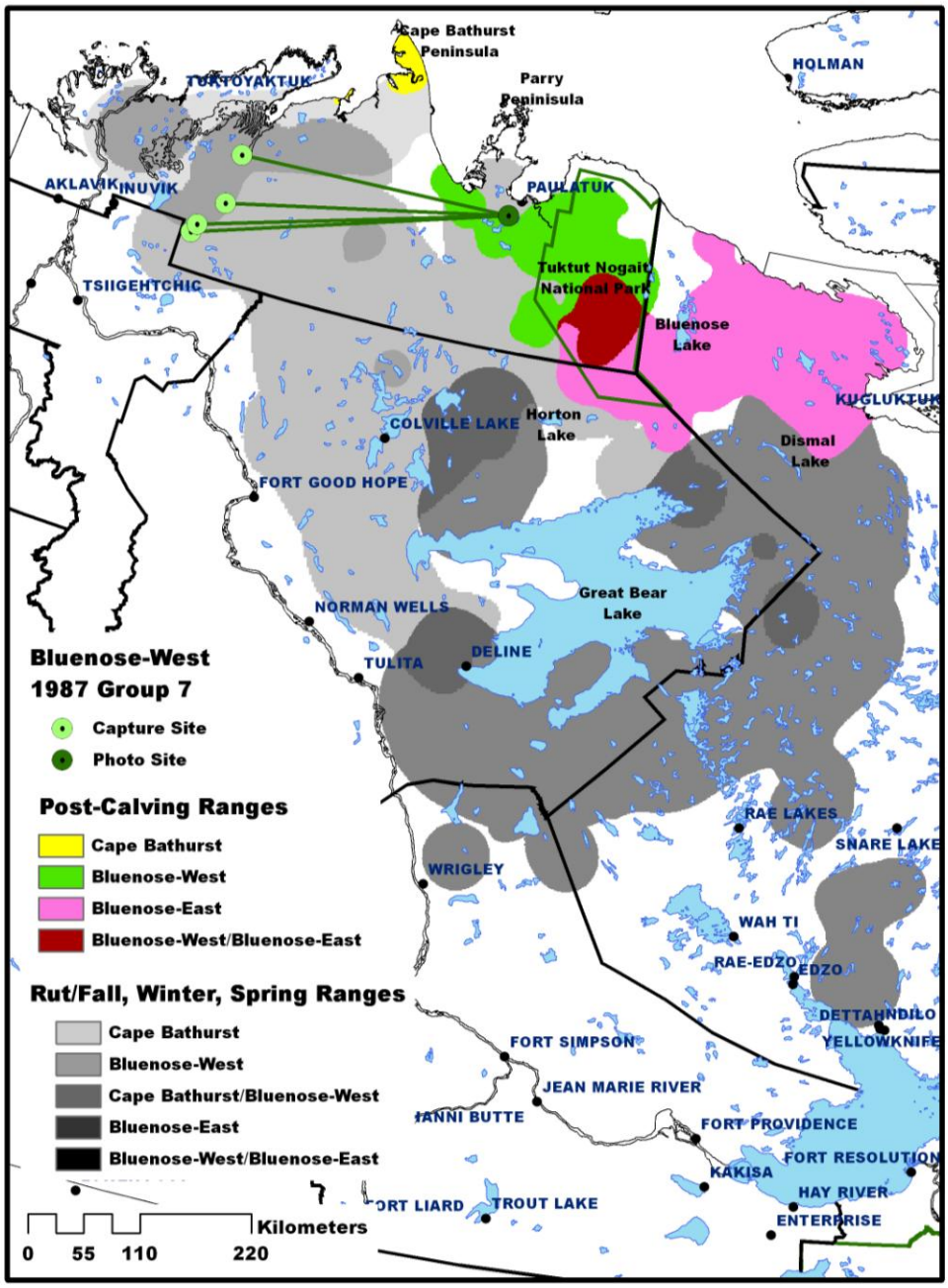

Figure 79. Bluenose-West herd 1987 group 7 contained 4 radio-collared caribou, 2,763 adults, and 552 calves. The geometric mean distance between capture sites for the radio-collared caribou was 42.0 km (range 9.9 to 90.6 km).

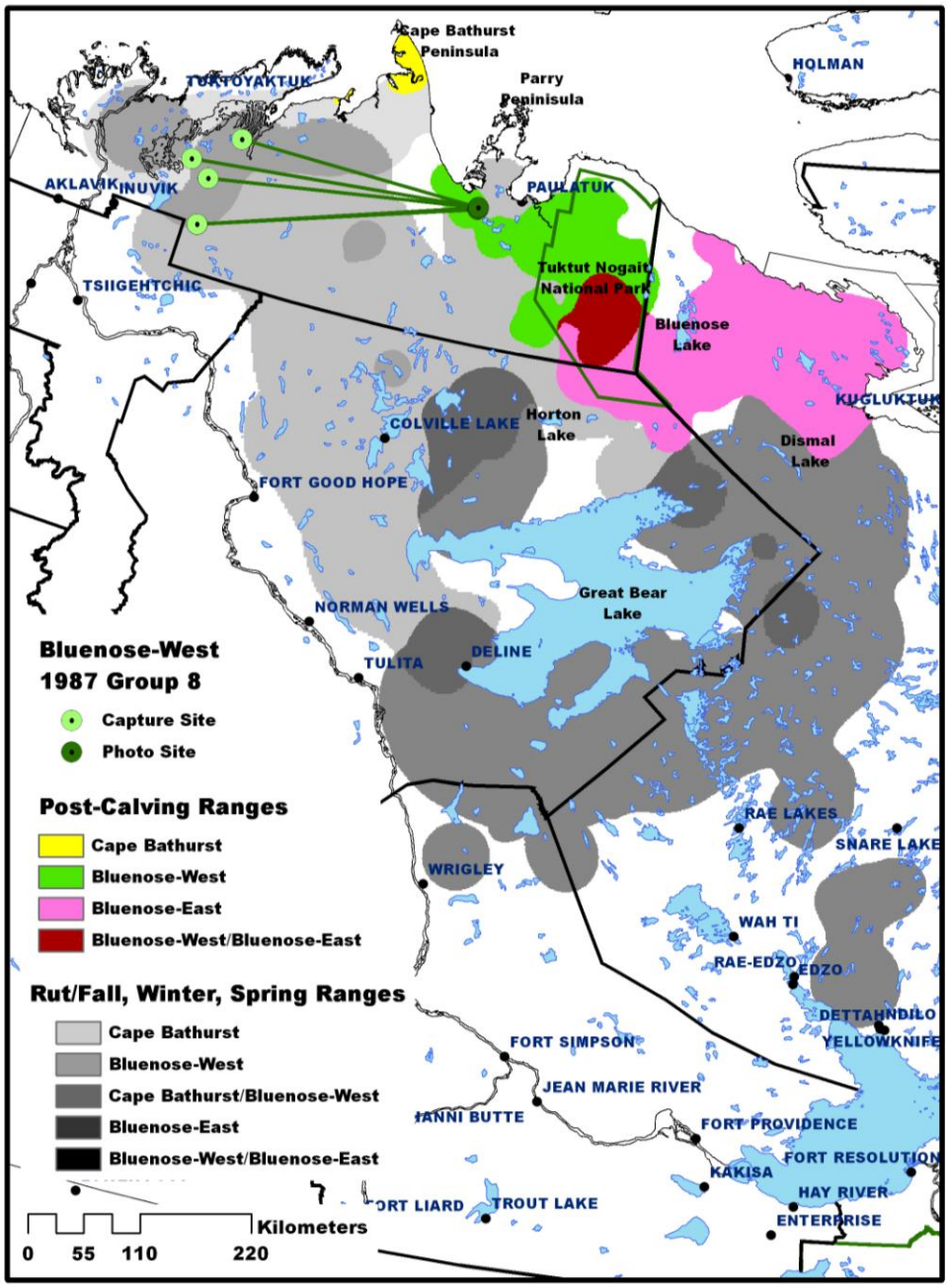

Figure 80. Bluenose-West herd 1987 group 8 contained 5 radio-collared caribou, 6,923 adults, and 708 calves. The geometric mean distance between capture sites for the radio-collared caribou was 55.7 km (range 0 to 94.0 km). Two caribou were captured at the same site.

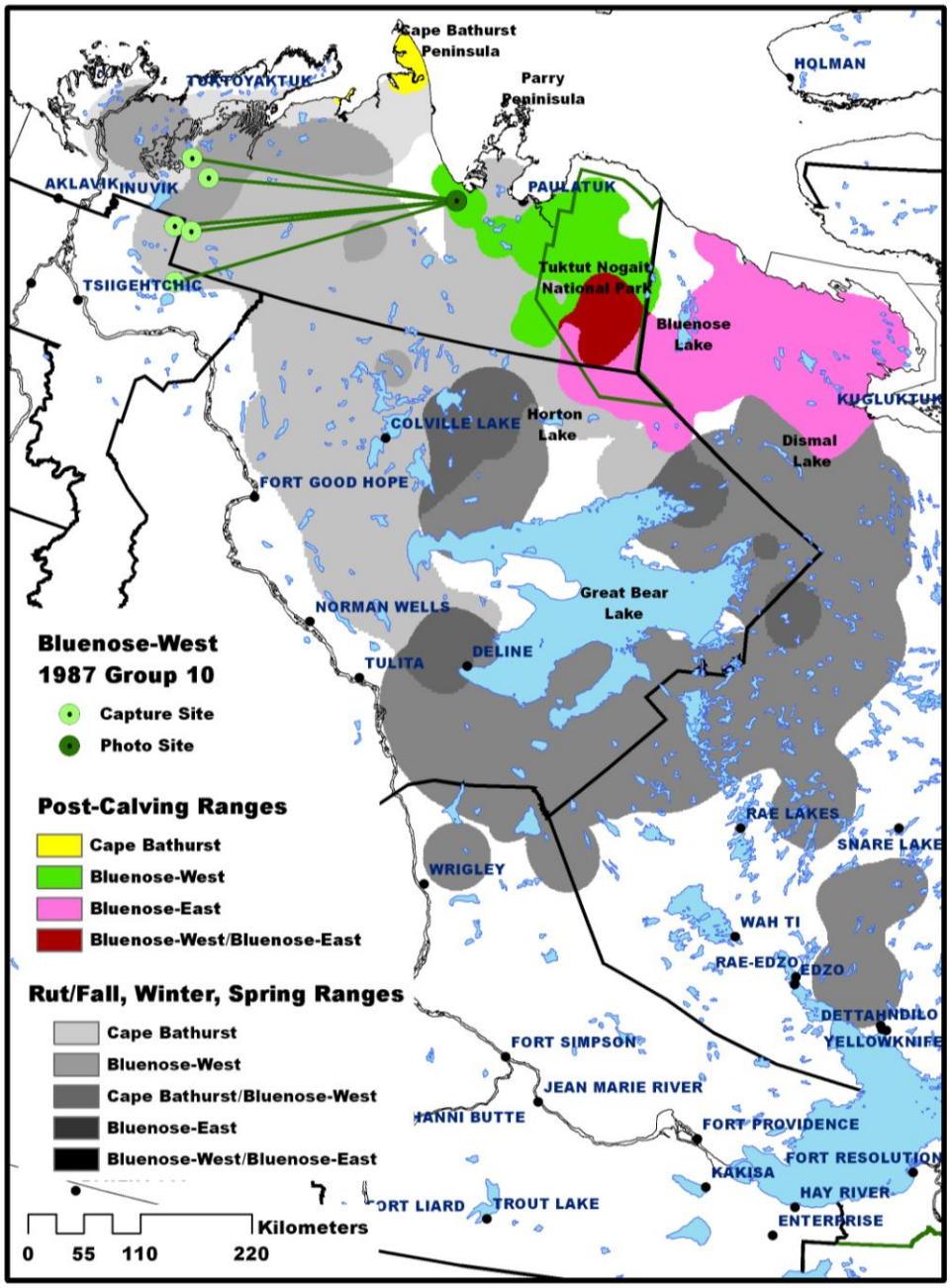

Figure 81. Bluenose-West herd 1987 group 10 contained 6 radio-collared caribou, 16,592 adults, and 4,453 calves. The geometric mean distance between capture sites for the radio-collared caribou was 56.9 km (range 0 to 121.8 km). Two caribou were captured at the same site.

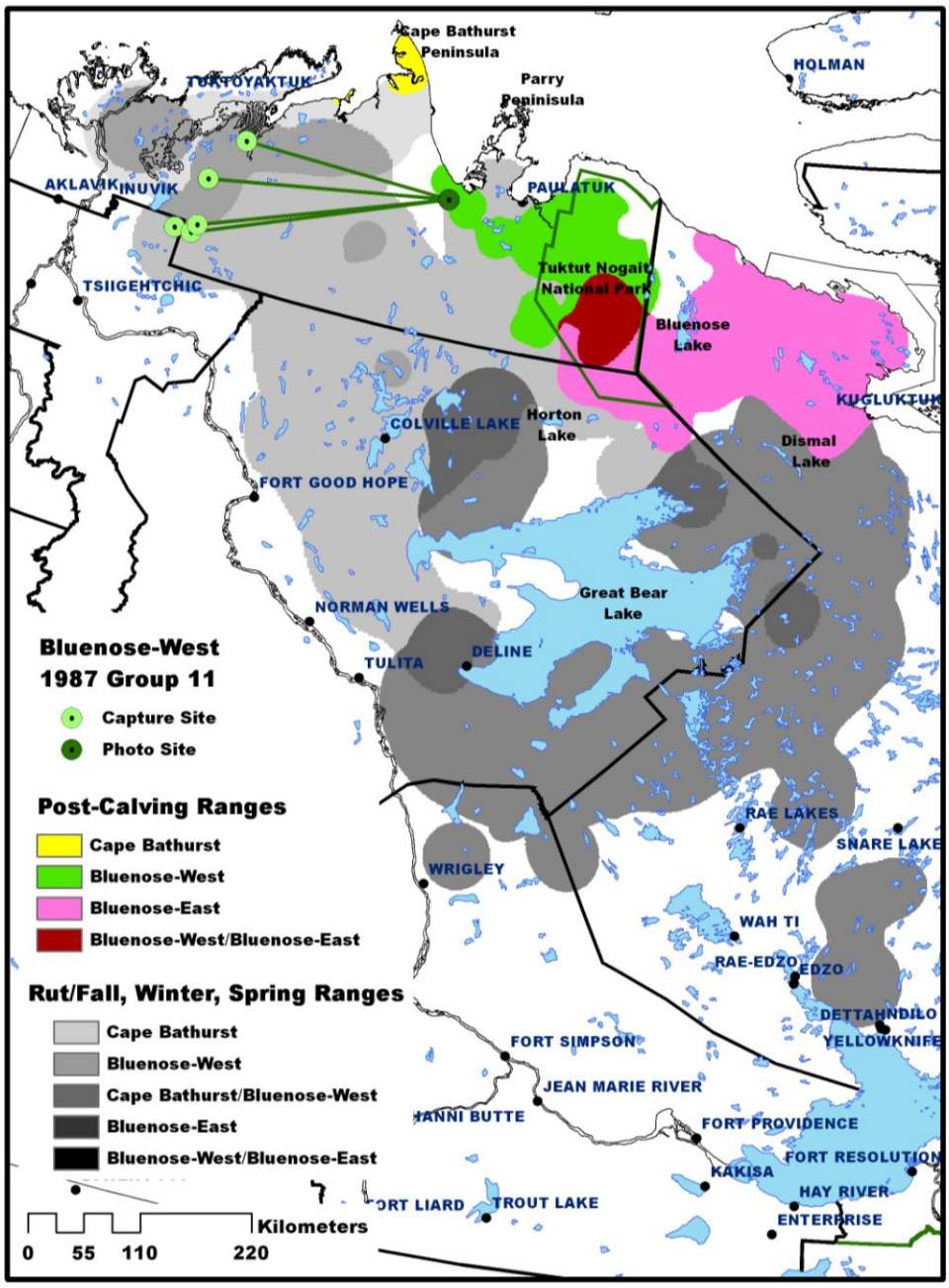

Figure 82. Bluenose-West herd 1987 group 11 contained 7 radio-collared caribou, 15,178 adults, and 3,566 calves. The geometric mean distance between capture sites for the radio-collared caribou was 48.1 km (range 0 to 110.1 km). Three caribou were captured at the same site.

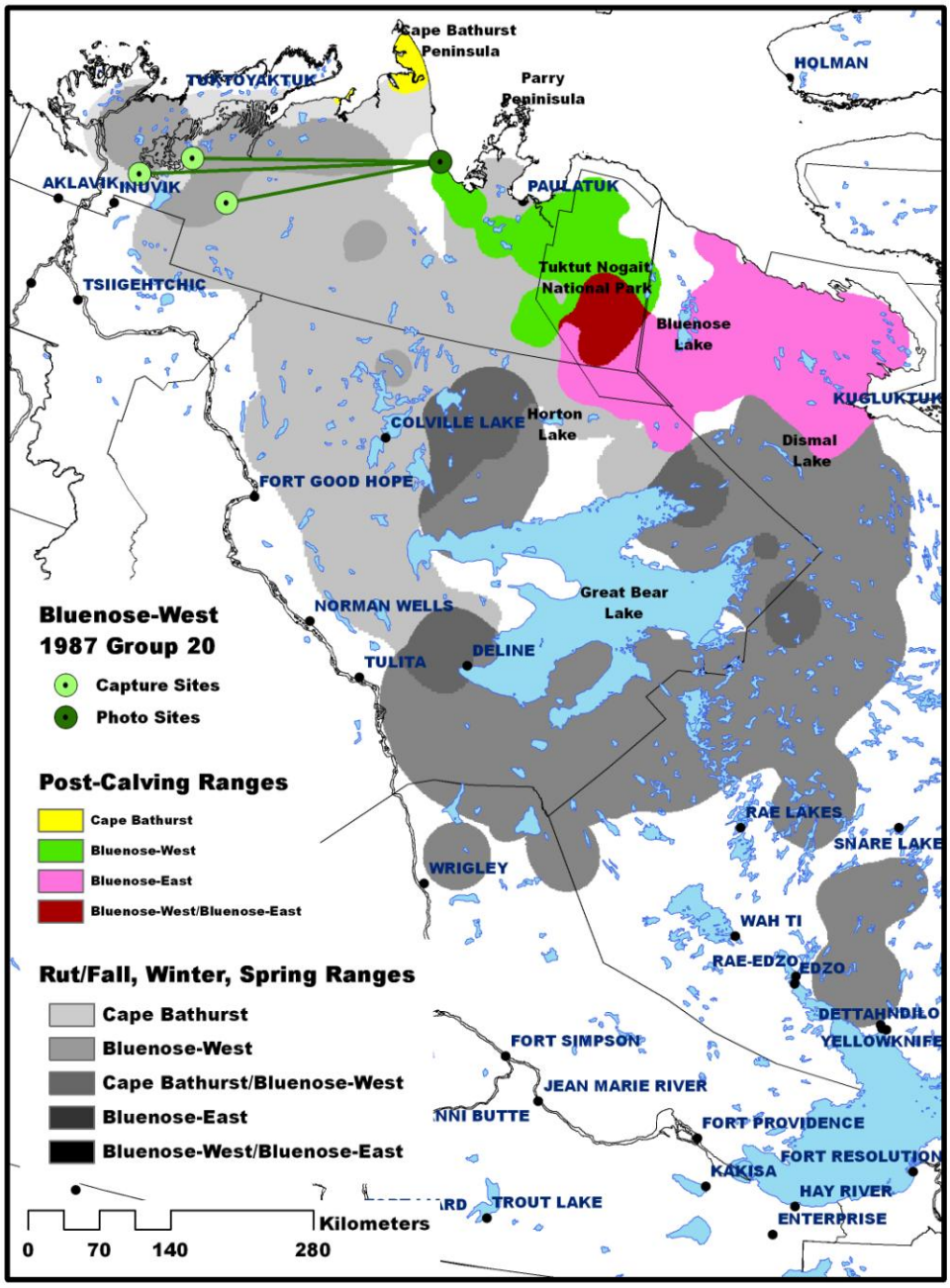

Figure 83. Bluenose-West herd 1987 group 20 contained 3 radio-collared caribou, 7,014 adults, and 382 calves. The geometric mean distance between capture sites for the radio-collared caribou was 64.4 km (range 54.2 to 89.5 km).

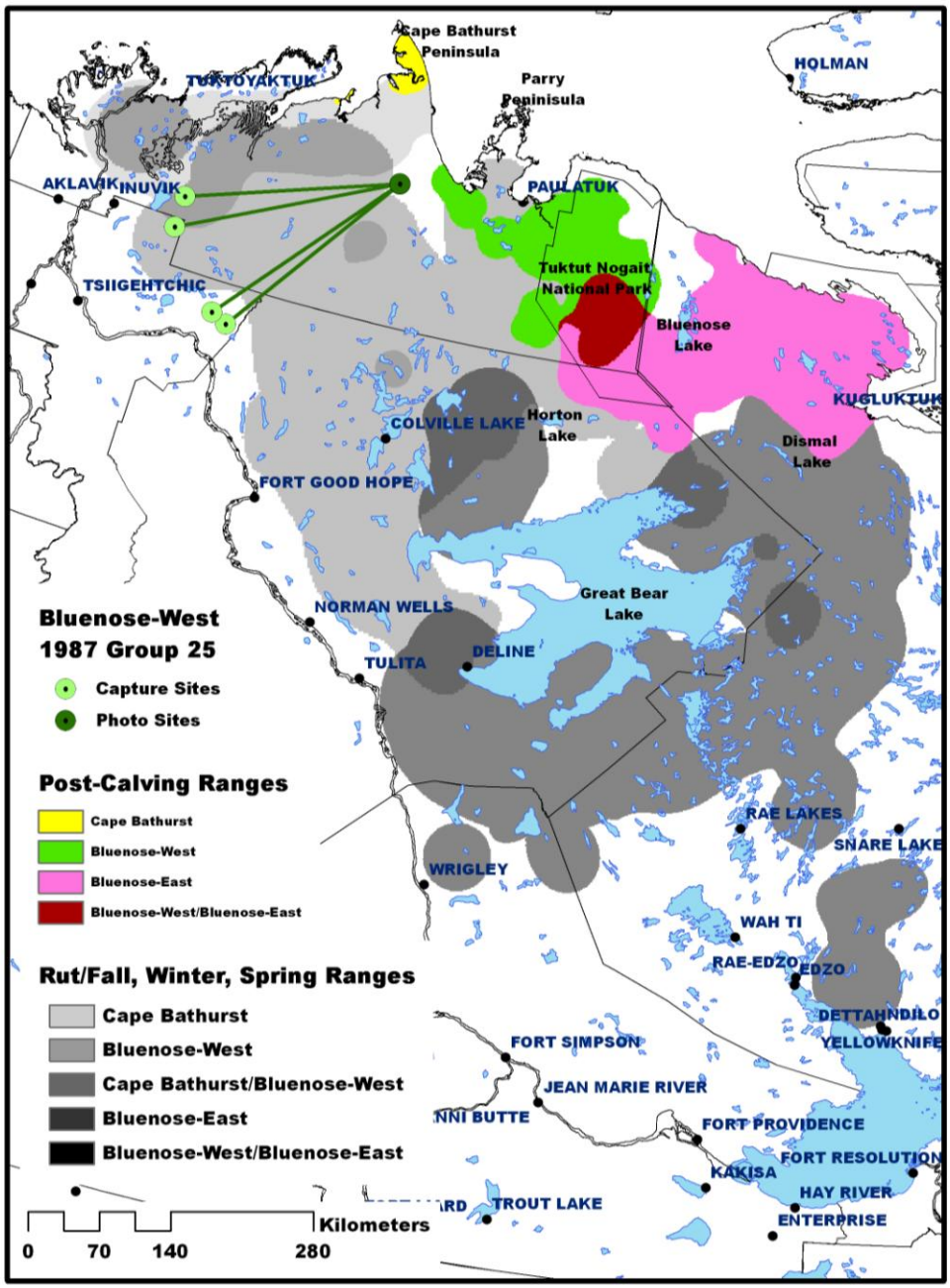

Figure 84. Bluenose-West herd 1987 group 25 contained 4 radio-collared caribou, 2,2843 adults, and 712 calves. The geometric mean distance between capture sites for the radio-collared caribou was 66.3 km (range 17.9 to 116.4 km).

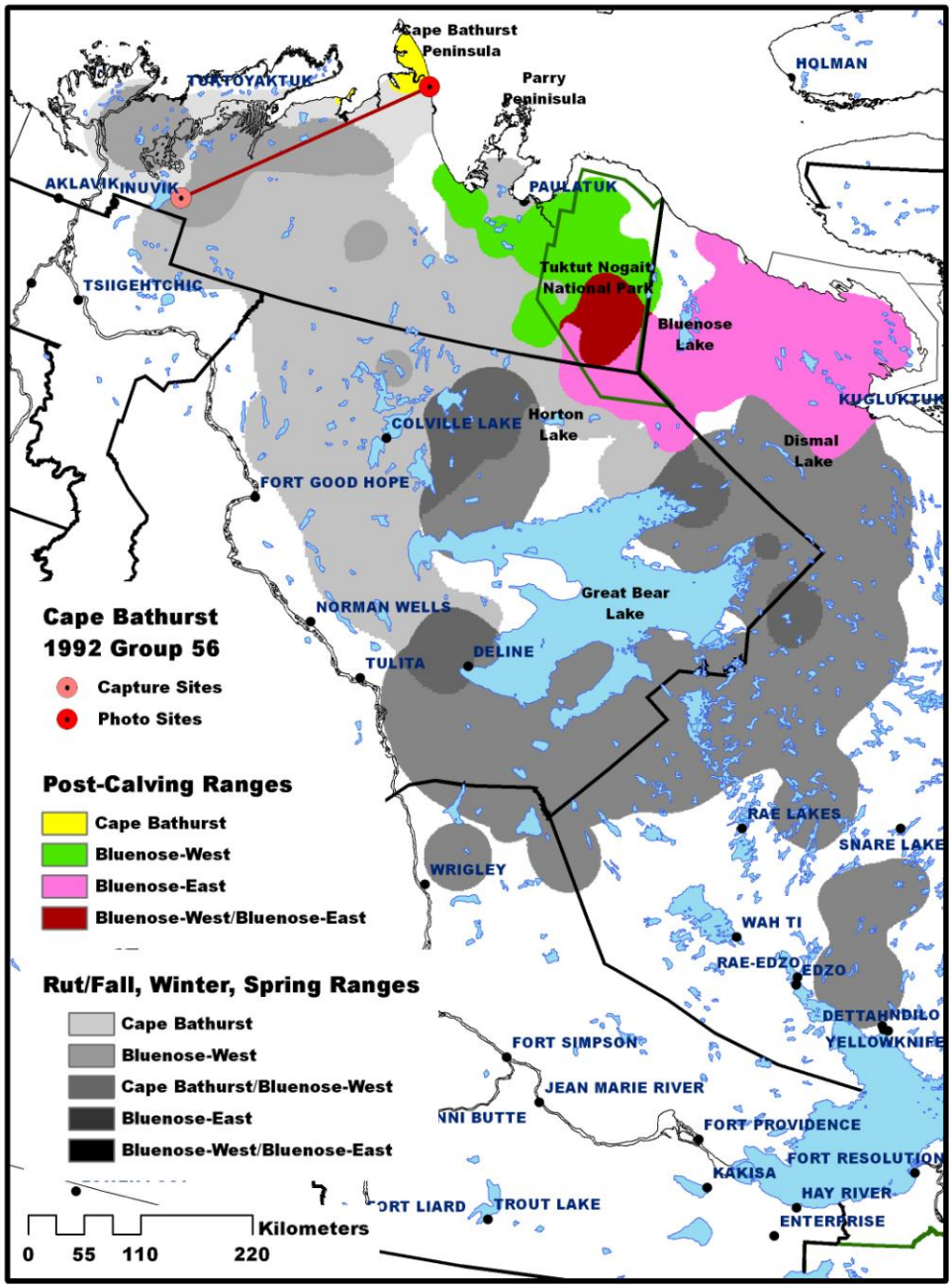

Figure 85. Cape Bathurst herd 1992 group 56 contained 2 radio-collared caribou and 5,244 adults. The radio-collared caribou were captured at the same site.

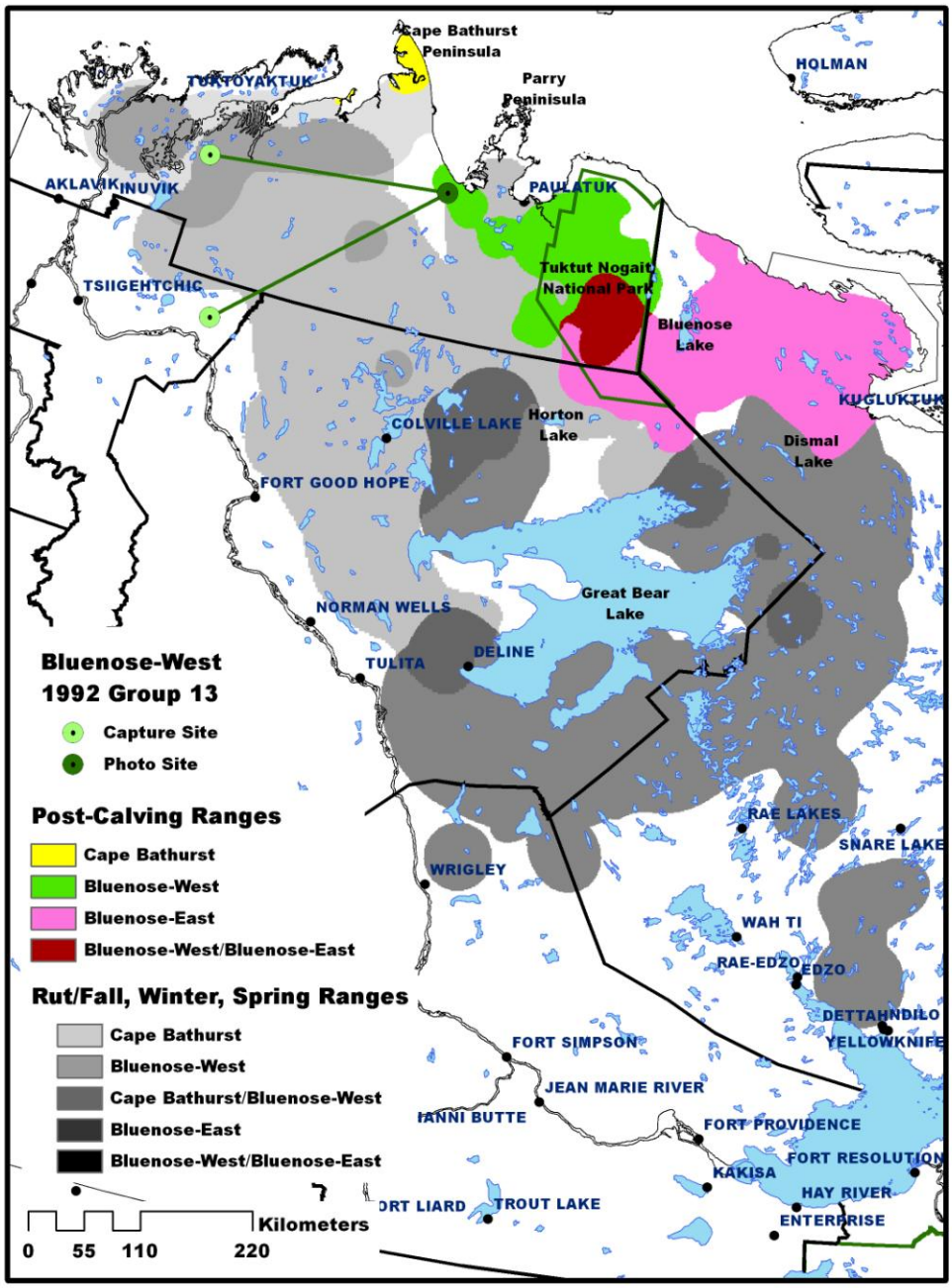

Figure 86. Bluenose-West herd 1992 group 13 contained 2 radio-collared caribou and 4,395 adults. The distance between capture sites for the radio-collared caribou was 158.5 km.

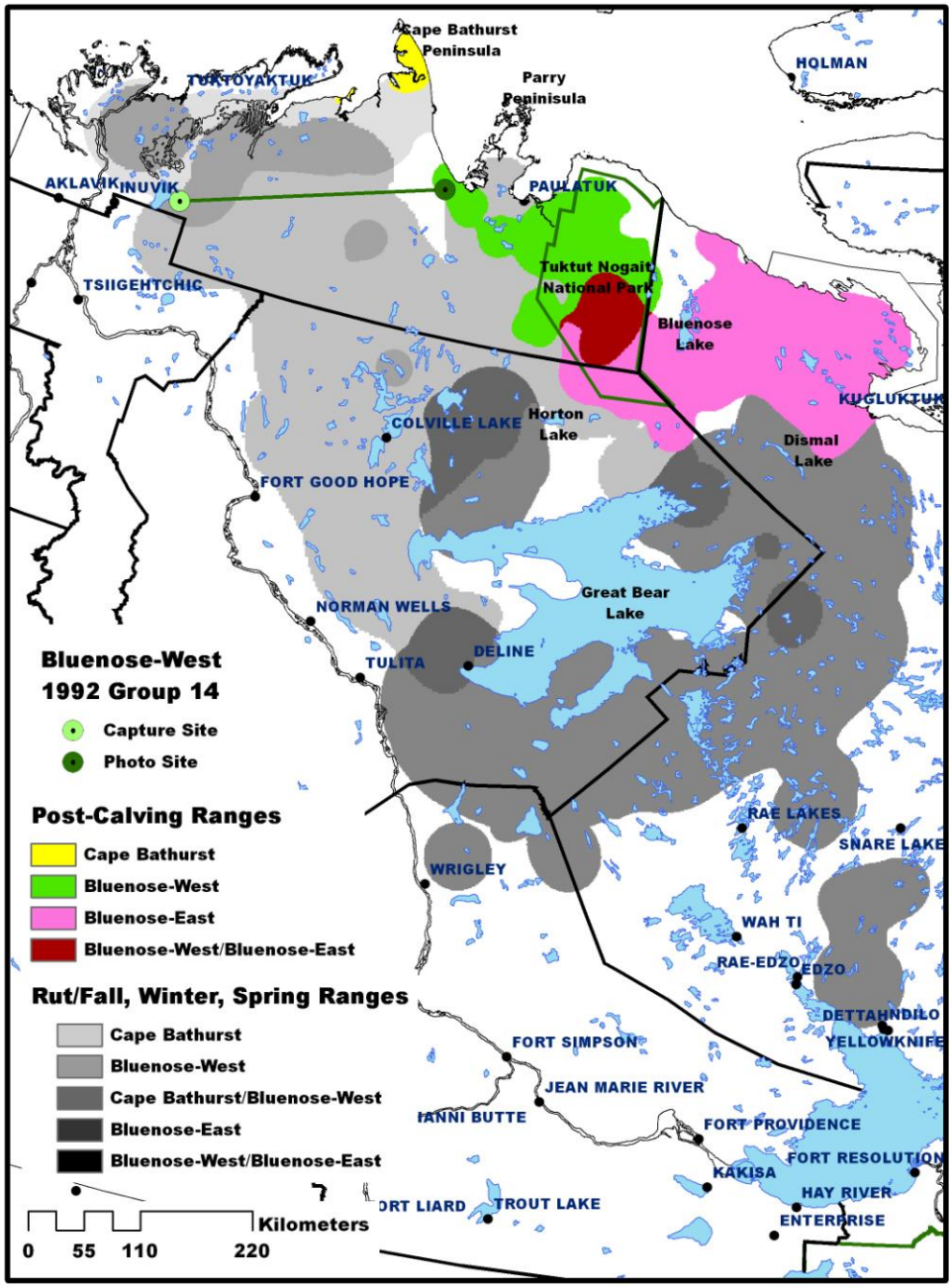

Figure 87. Bluenose-West herd 1992 group 14 contained 2 radio-collared caribou and 10,272 adults. The radio-collared caribou were captured at the same site.

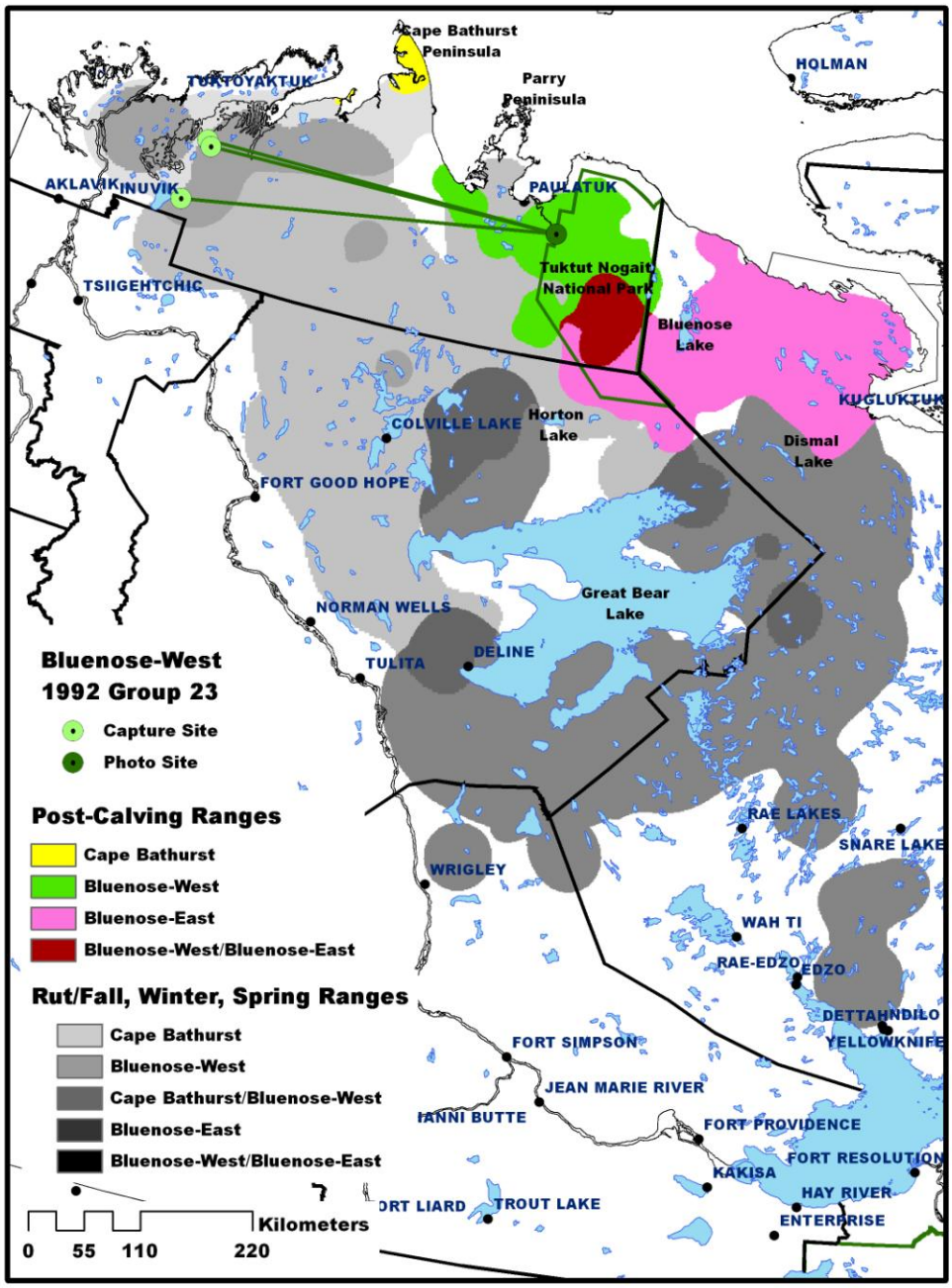

Figure 88. Bluenose-West herd 1992 group 23 contained 3 radio-collared caribou and 3,436 adults. The geometric mean distance between capture sites for the radio-collared caribou was 30.4 km (range 7.7 to 63.0 km).

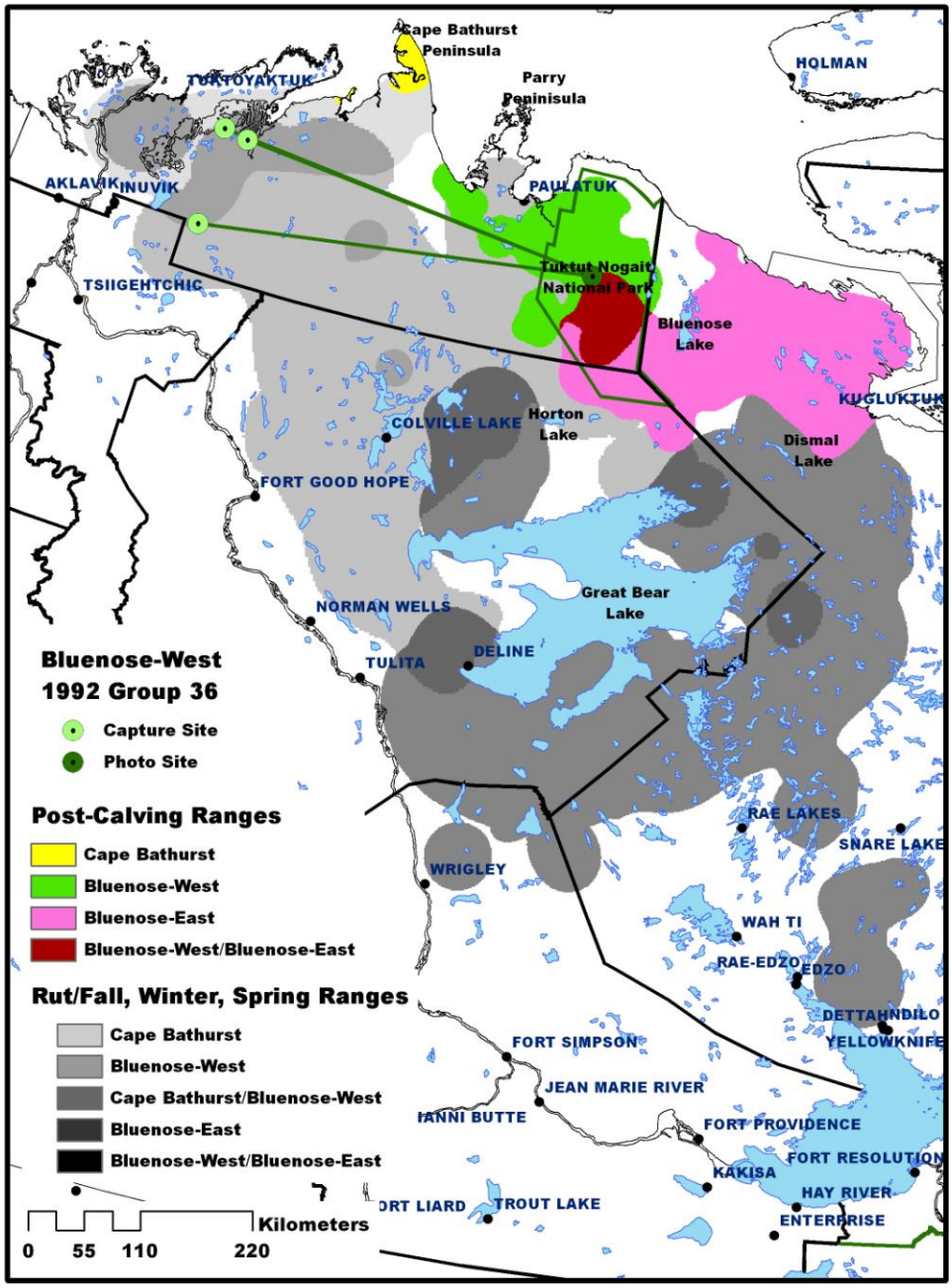

Figure 89. Bluenose-West herd 1992 group 36 contained 3 radio-collared caribou and 12,262 adults. The geometric mean distance between capture sites for the radio-collared caribou was 61.2 km (range 25.2 to 95.9 km).

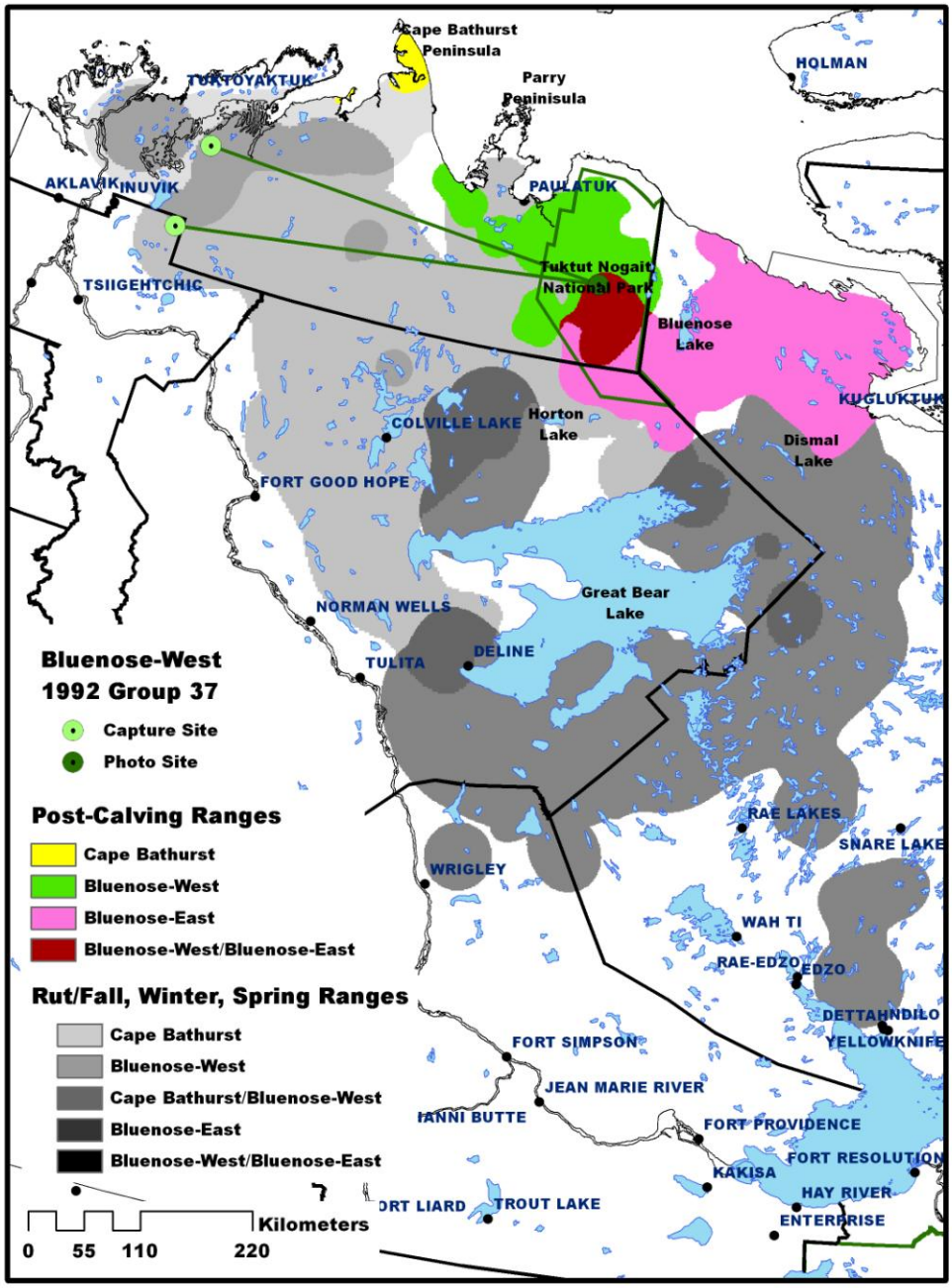

Figure 90. Bluenose-West herd 1992 group 37 contained 2 radio-collared caribou and 3,834 adults. The distance between capture sites for the radio-collared caribou was 85.6 km.

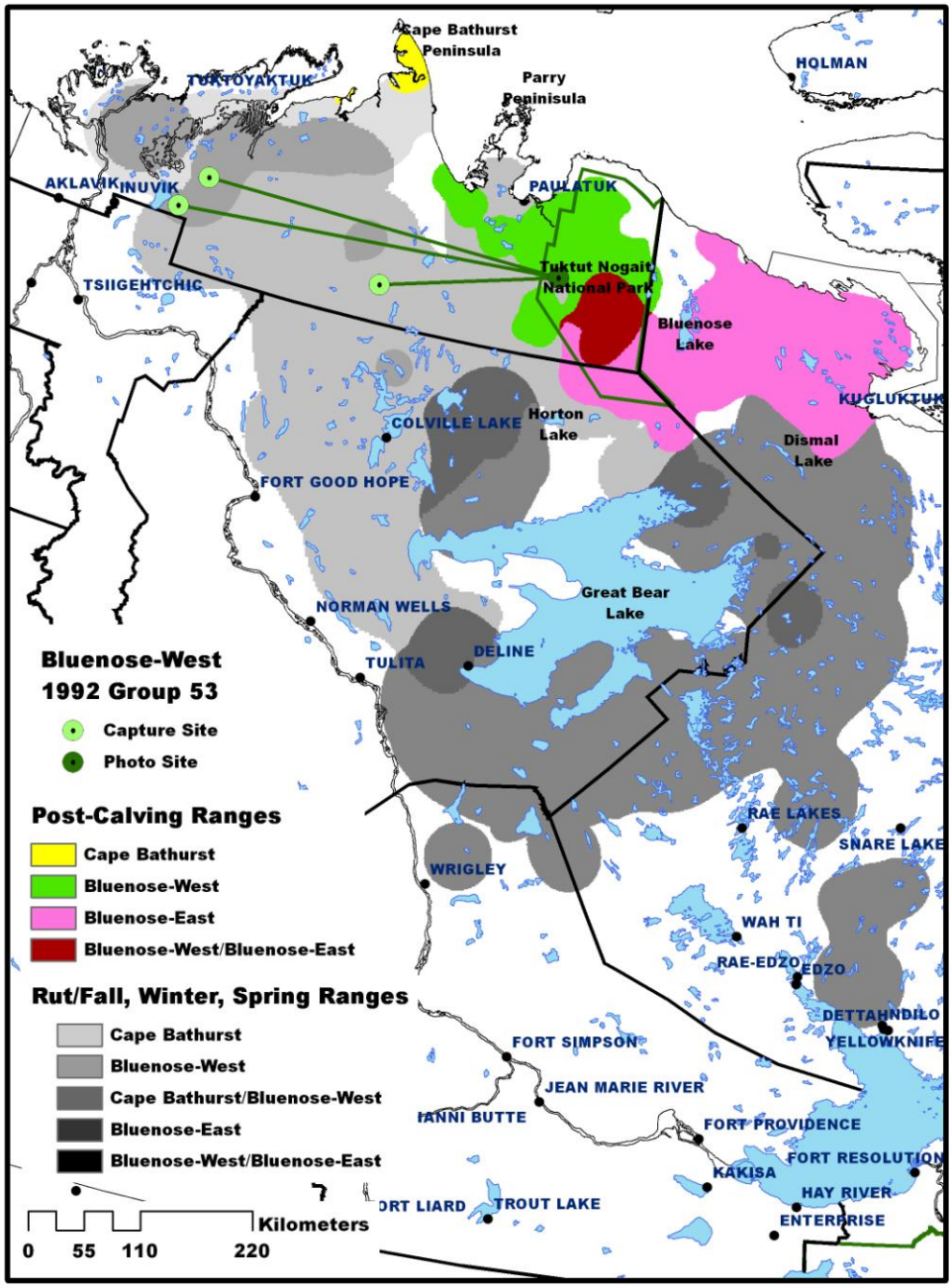

Figure 91. Bluenose-West herd 1992 group 53 contained 3 radio-collared caribou and 5,715 adults. The geometric mean distance between capture sites for the radio-collared caribou was 119.1 km (range 40.5 to 212 km).

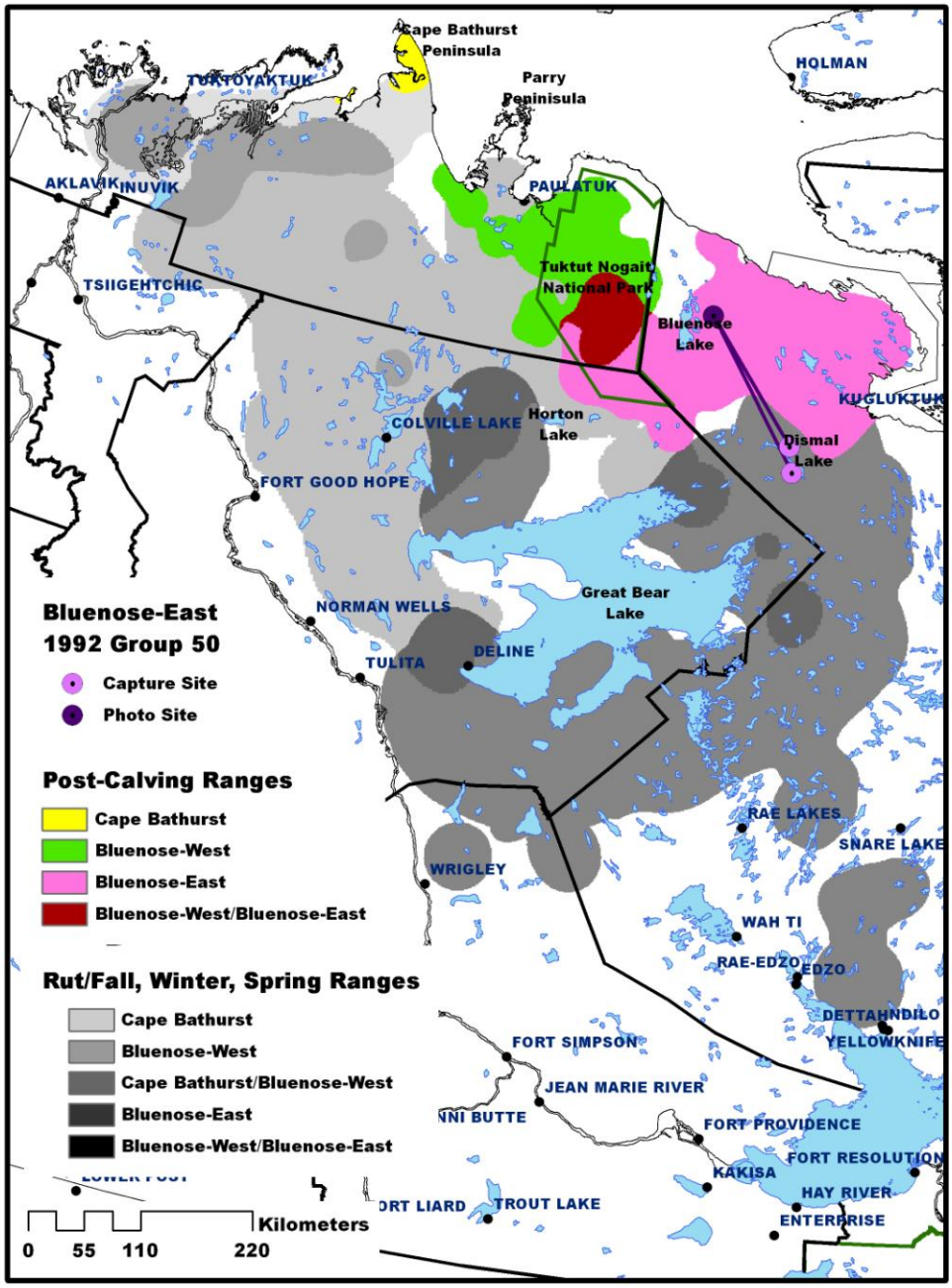

Figure 92. Bluenose-East herd 1992 group 50 contained 2 radio-collared caribou and 9,678 adults. The distance between capture sites for the radio-collared caribou was 26.4 km.

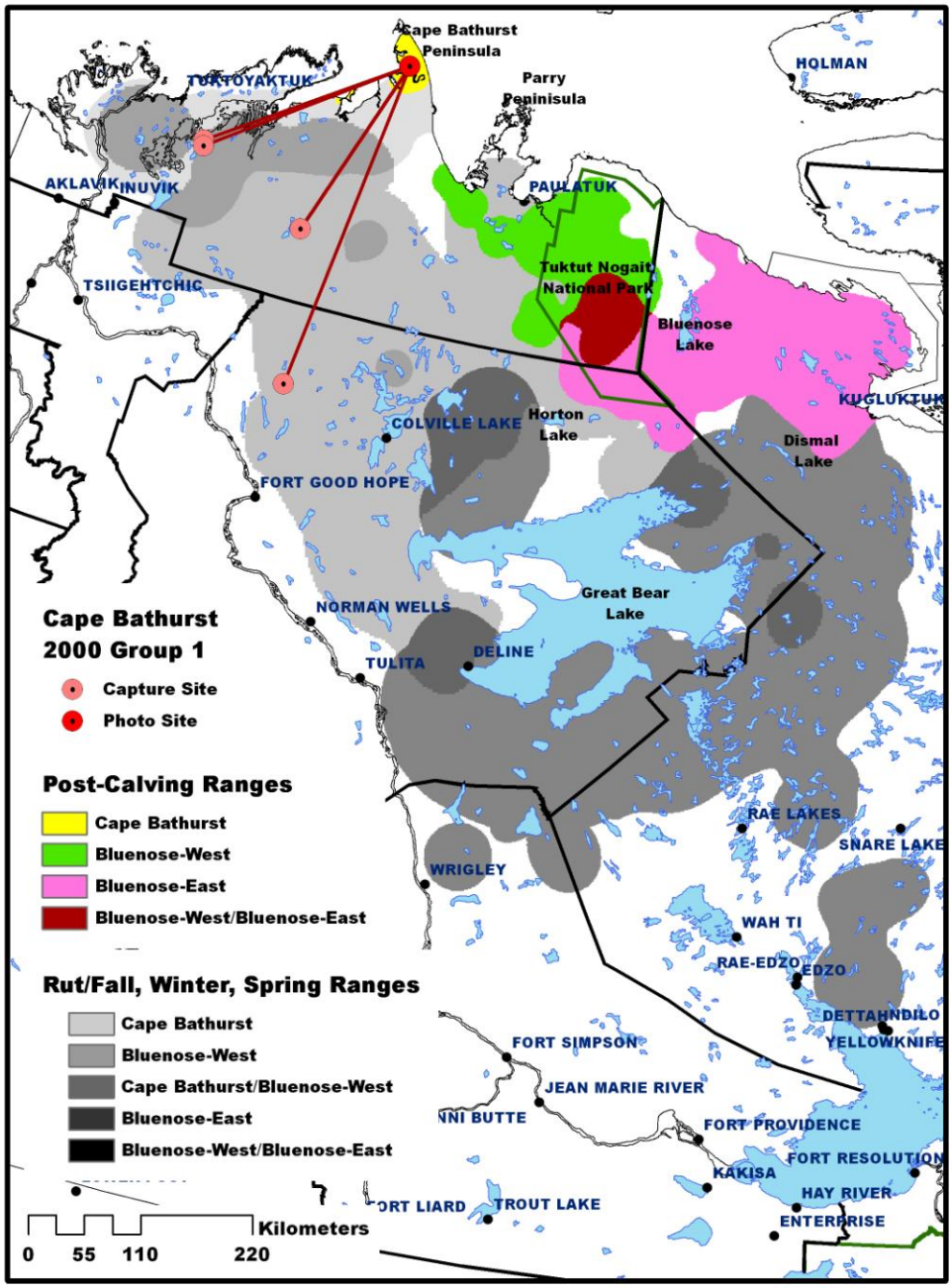

Figure 93. Cape Bathurst herd 2000 group 1 contained 4 radio-collared caribou and 920 adults. The geometric mean distance between capture sites for the radio-collared caribou was 96.6 km (range 5.4 to 250.1 km).

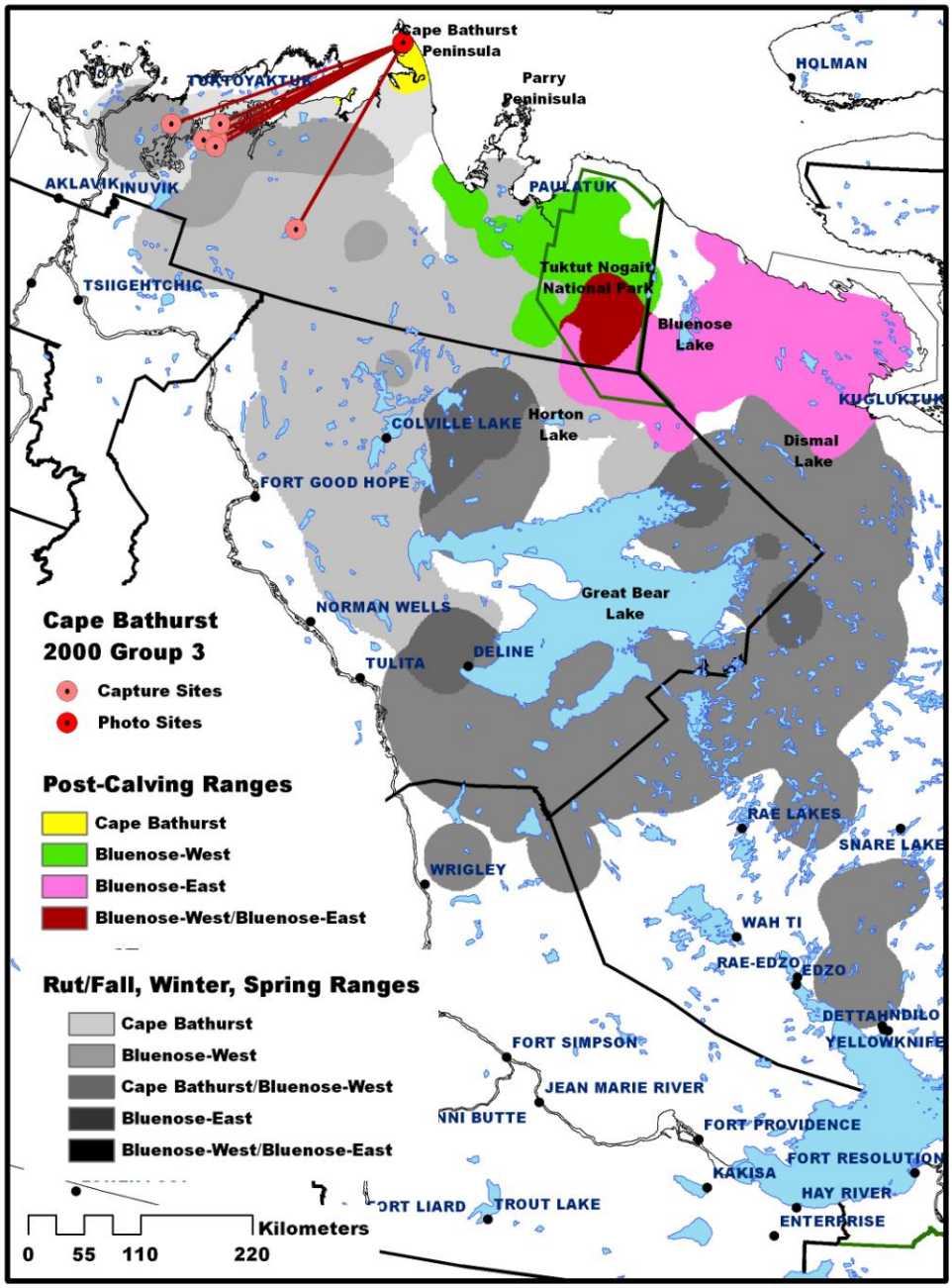

Figure 94. Cape Bathurst herd 2000 group 3 contained 6 radio-collared caribou and 5,302 adults. The geometric mean distance between capture sites for the radio-collared caribou was 40.7 km (range 7.3 to 159.9 km).

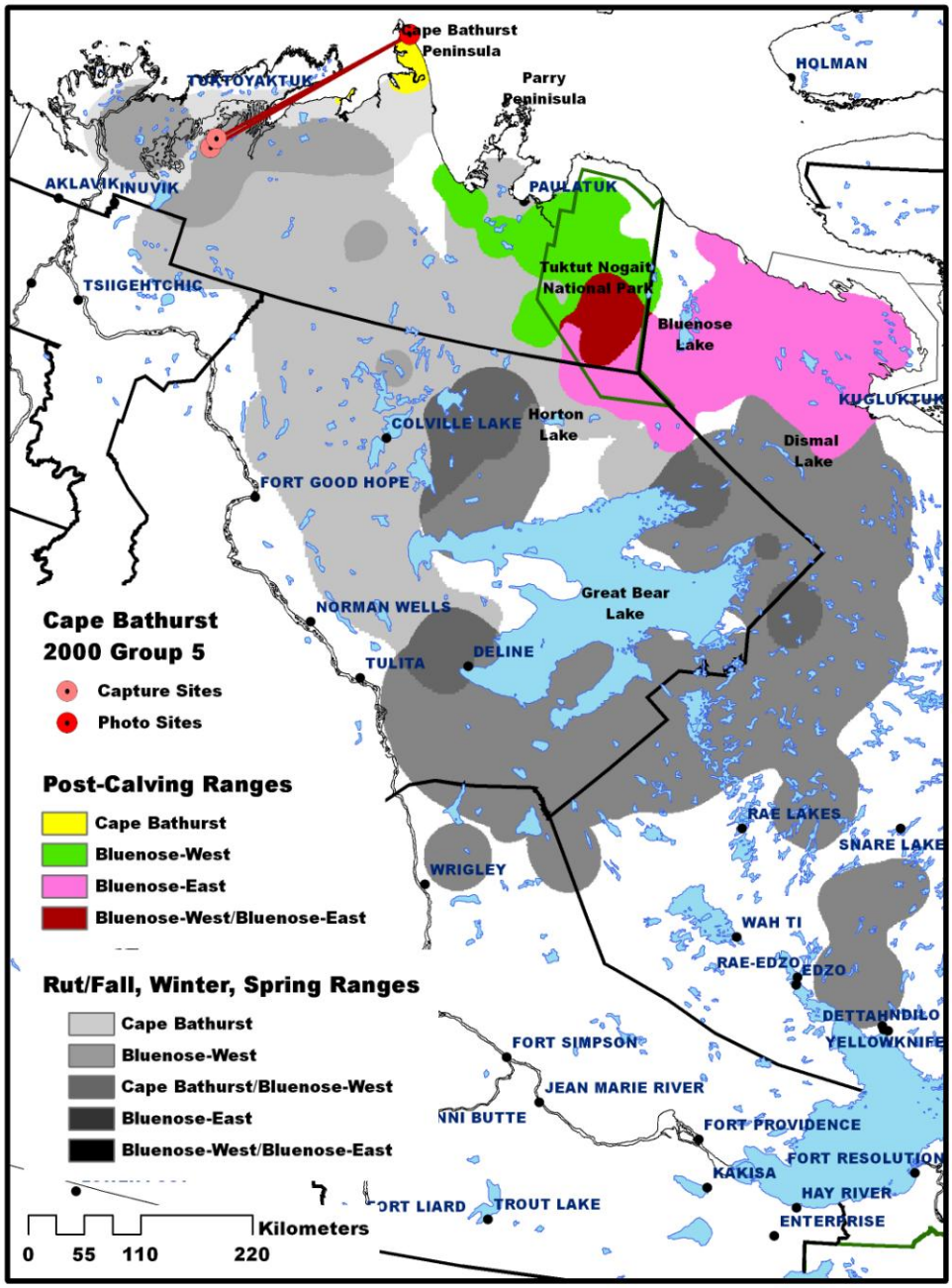

Figure 95. Cape Bathurst herd 2000 group 5 contained 2 radio-collared caribou and 649 adults. The distance between capture sites for the radio-collared caribou was 10.3 km.

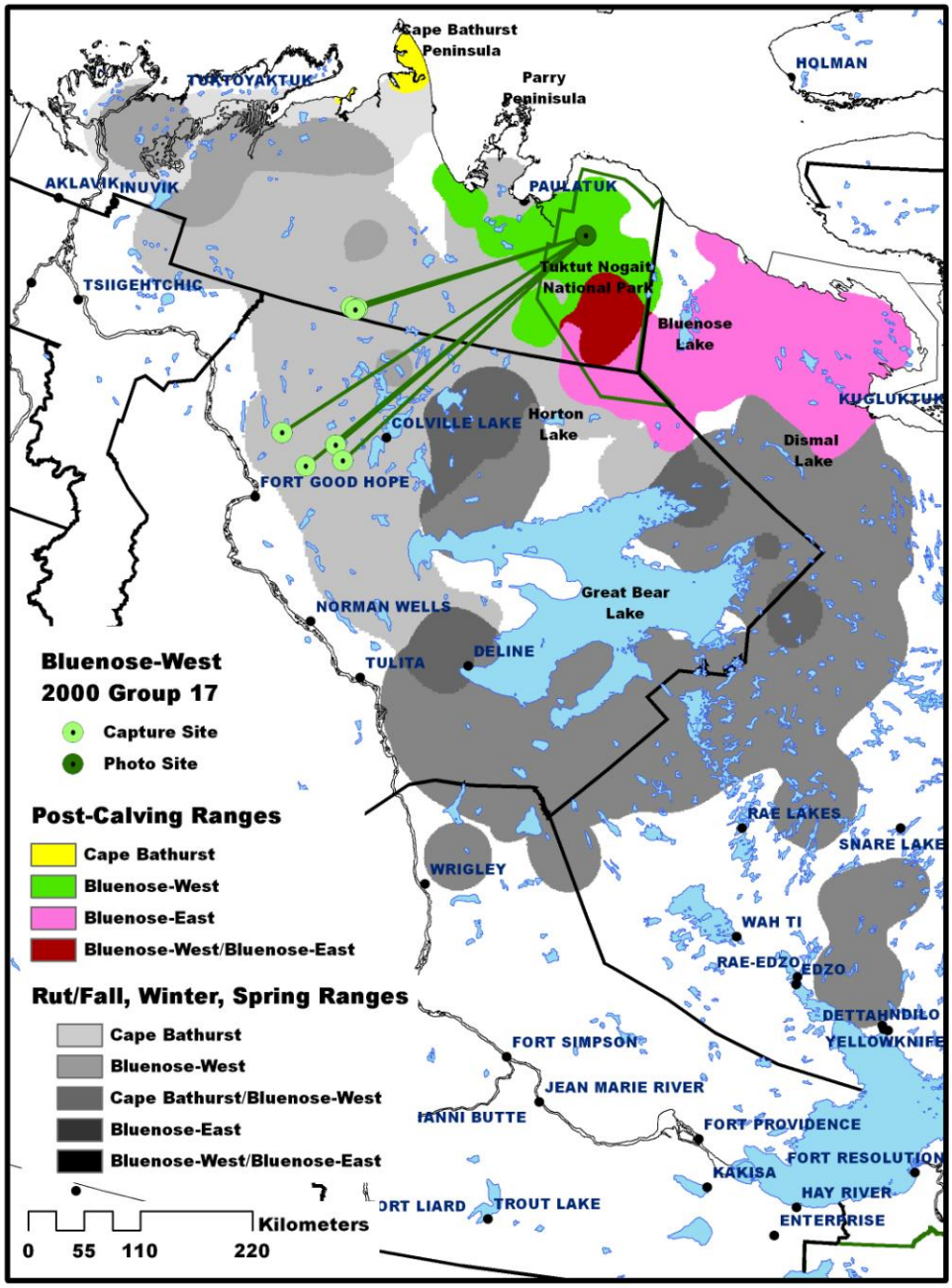

Figure 96. Bluenose-West herd 2000 group 17 contained 7 radio-collared caribou and 4,951 adults. The geometric mean distance between capture sites for the radio-collared caribou was 60.3 km (range 2.5 to 162.4 km).

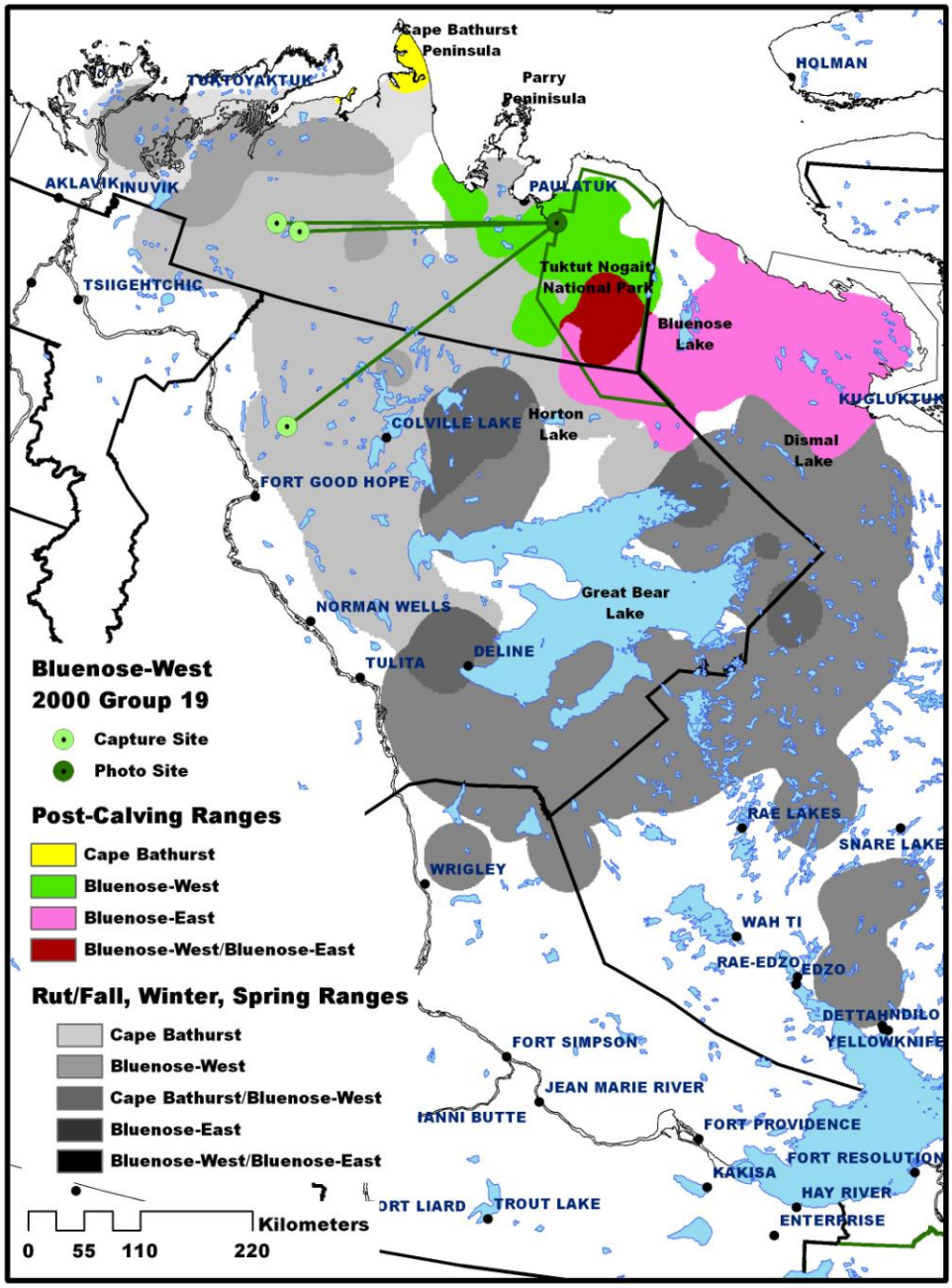

Figure 97. Bluenose-West herd 2000 group 19 contained 3 radio-collared caribou and 5,401 adults. The geometric mean distance between capture sites for the radio-collared caribou was 96.8 km (range 23.9 to 198.7 km).

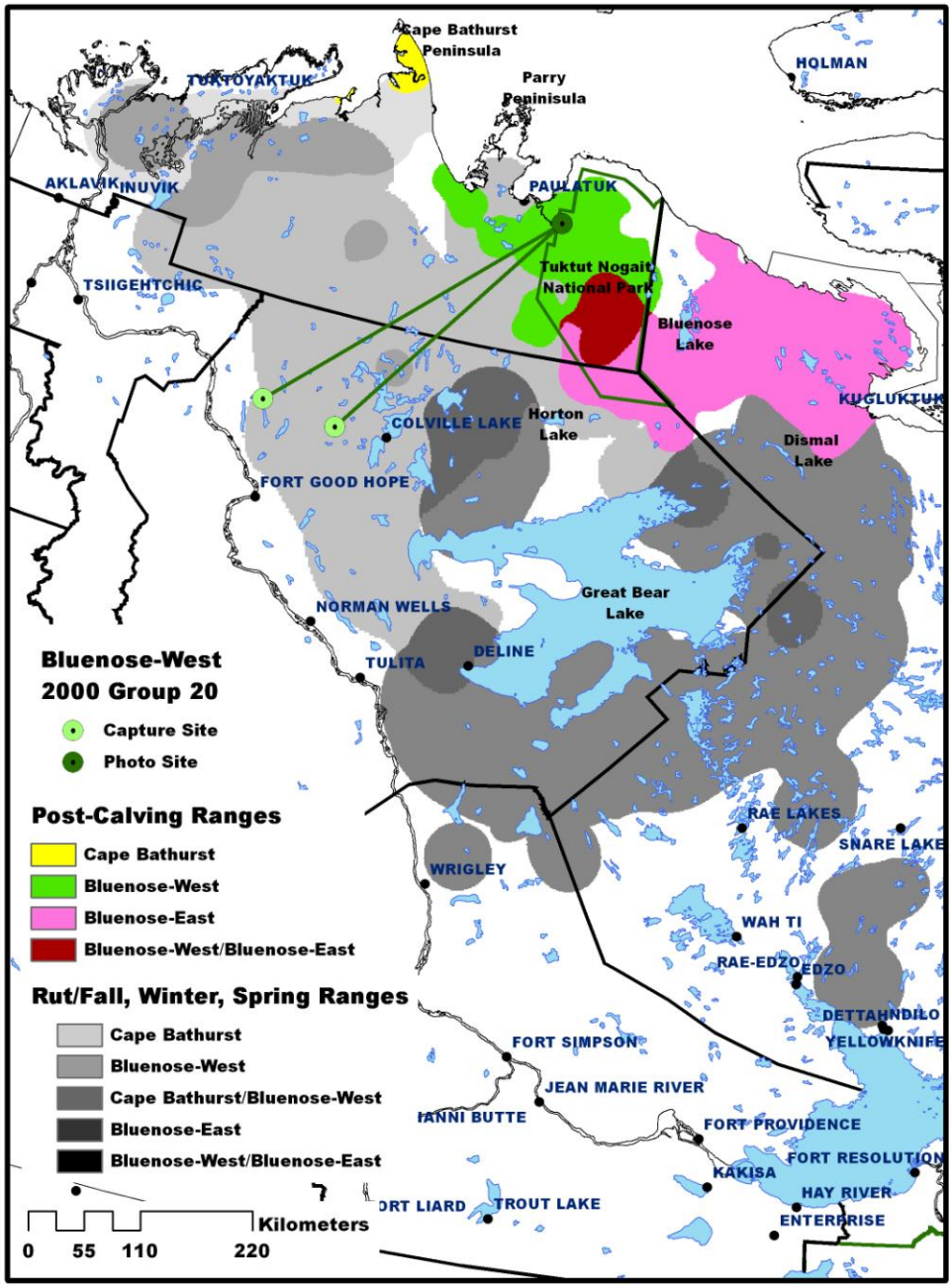

Figure 98. Bluenose-West herd 2000 group 20 contained 2 radio-collared caribou and 894 adults. The distance between capture sites for the radio-collared caribou was 76.2 km.

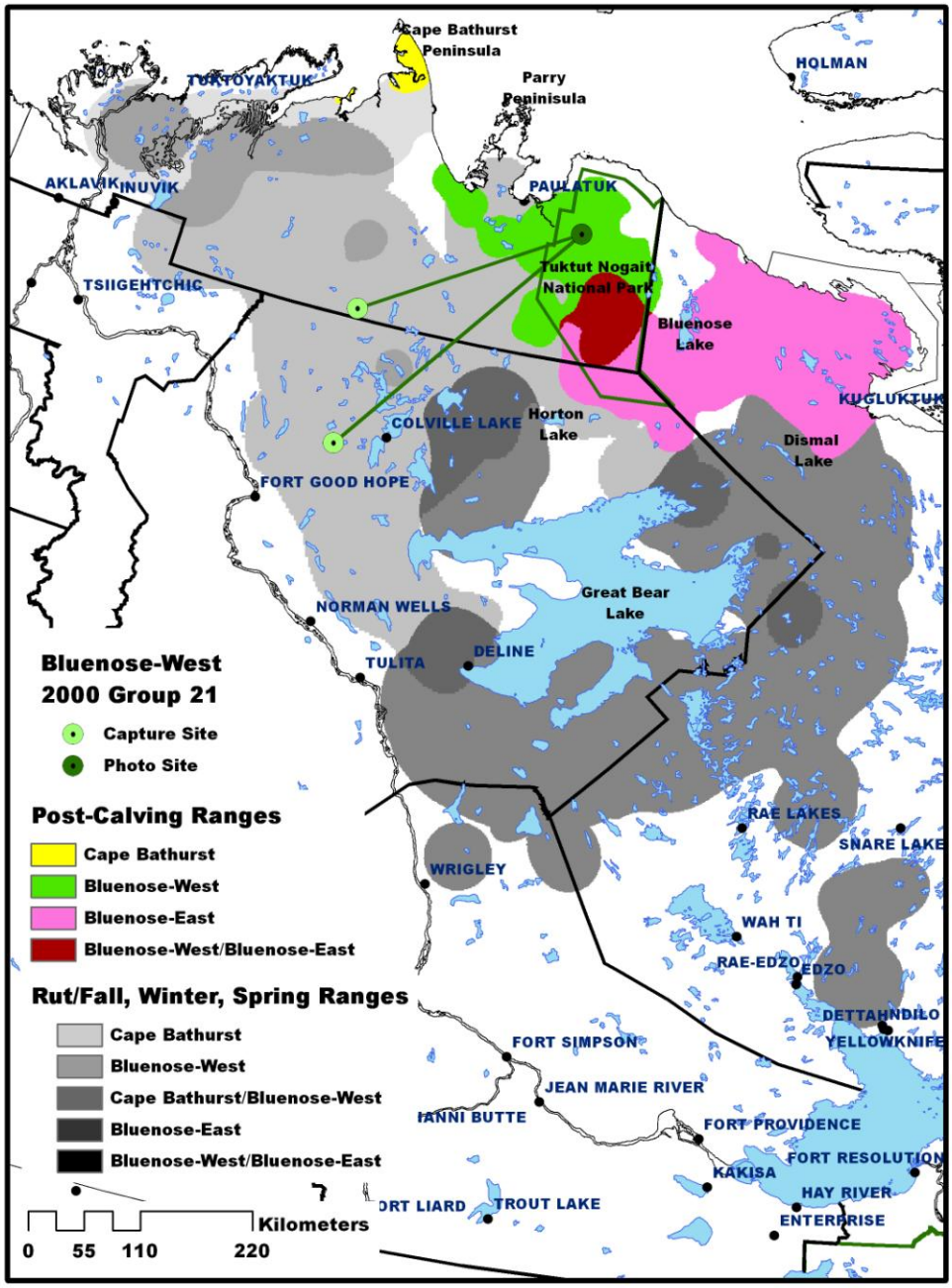

Figure 99. Bluenose-West herd 2000 group 21 contained 2 radio-collared caribou and 2,103 adults. The distance between capture sites for the radio-collared caribou was 133.7 km.

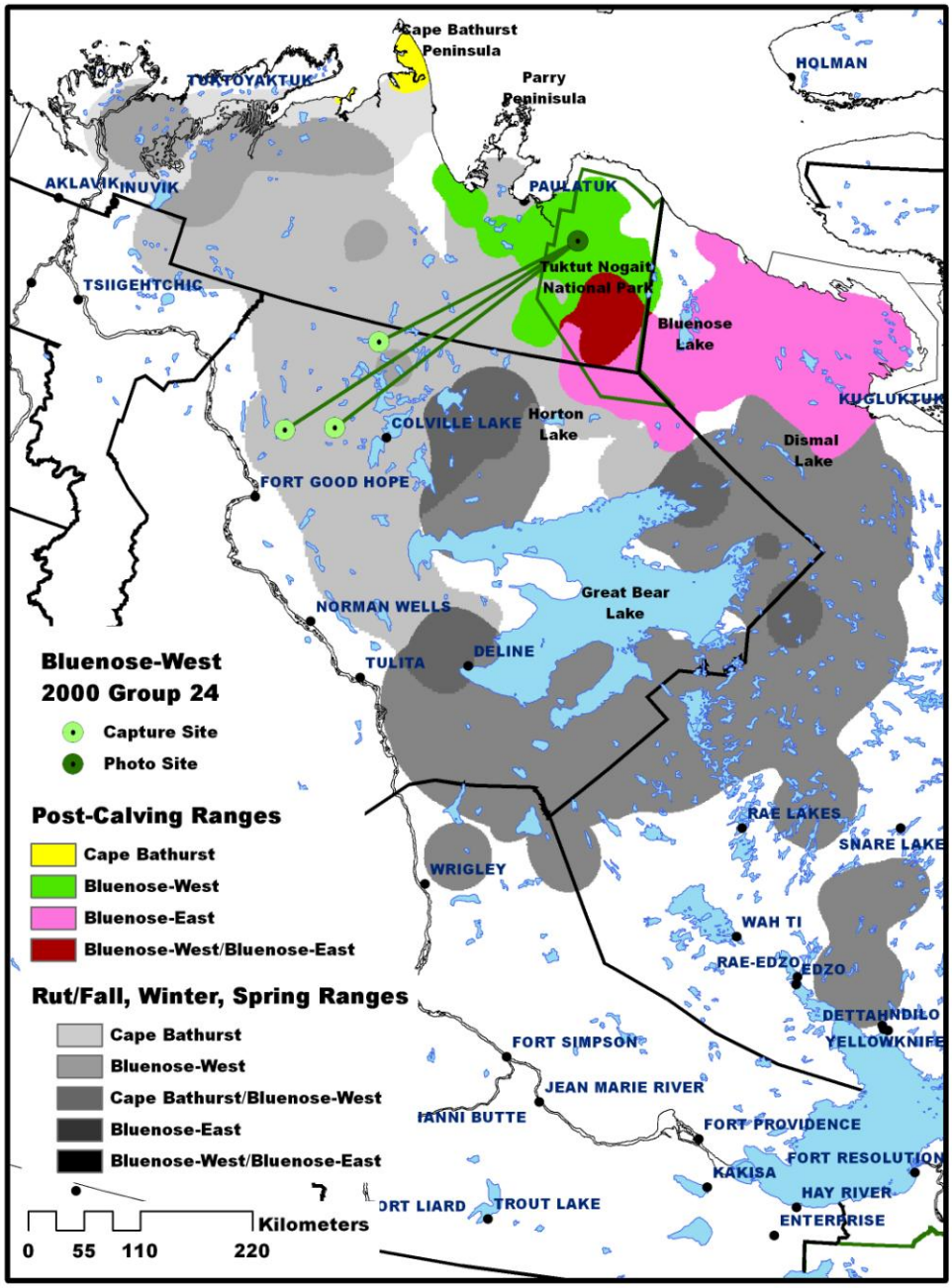

Figure 100. Bluenose-West herd 2000 group 24 contained 3 radio-collared caribou and 5,297 adults. The geometric mean distance between capture sites for the radio-collared caribou was 83.8 km (49.2 to 126.3 km).

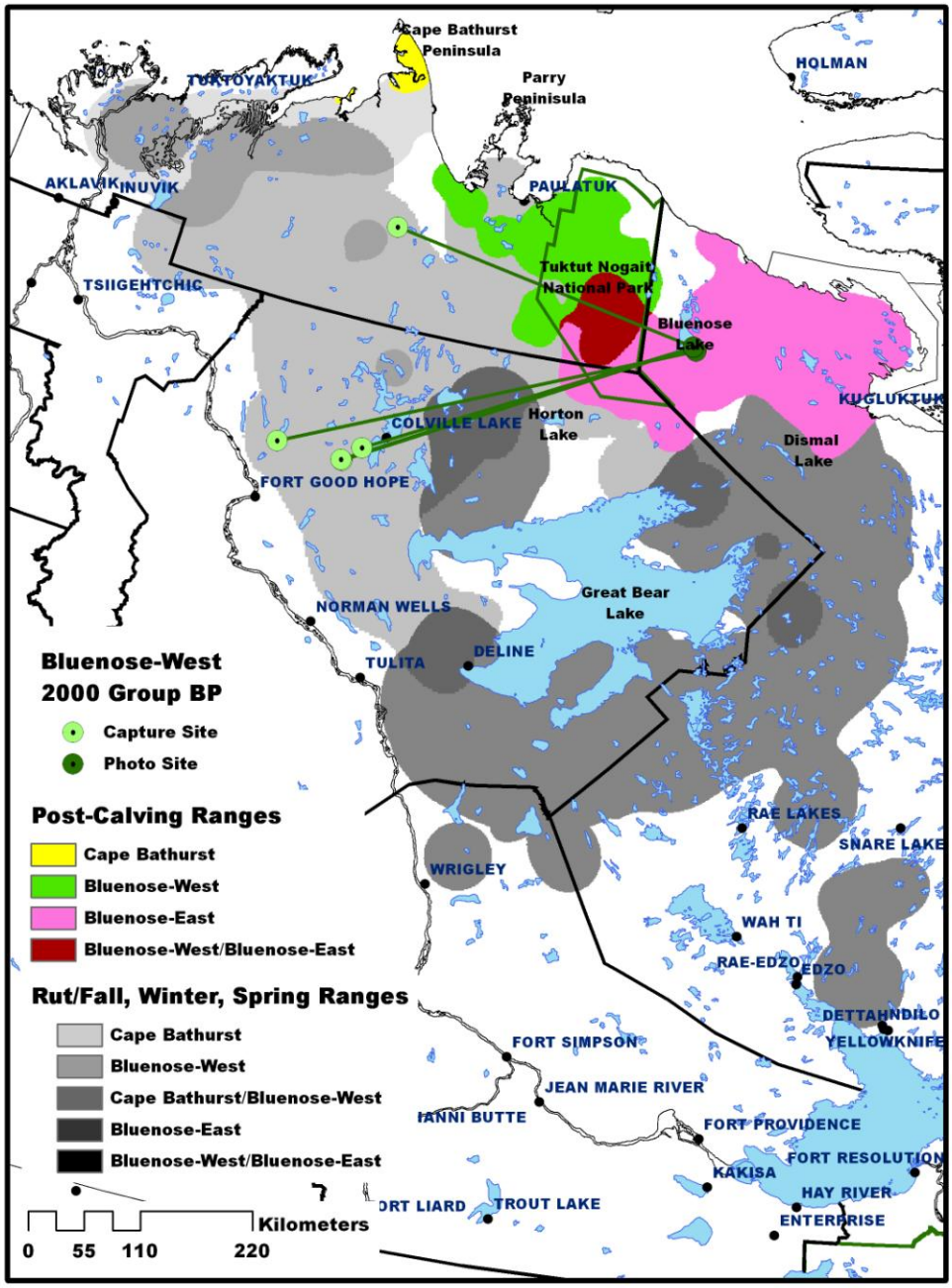

Figure 101. Bluenose-West herd 2000 group BP contained 5 radio-collared caribou and 11,700 adults. The geometric mean distance between capture sites for the radio-collared caribou was 60.6 km (range 1.2 to 239.2).

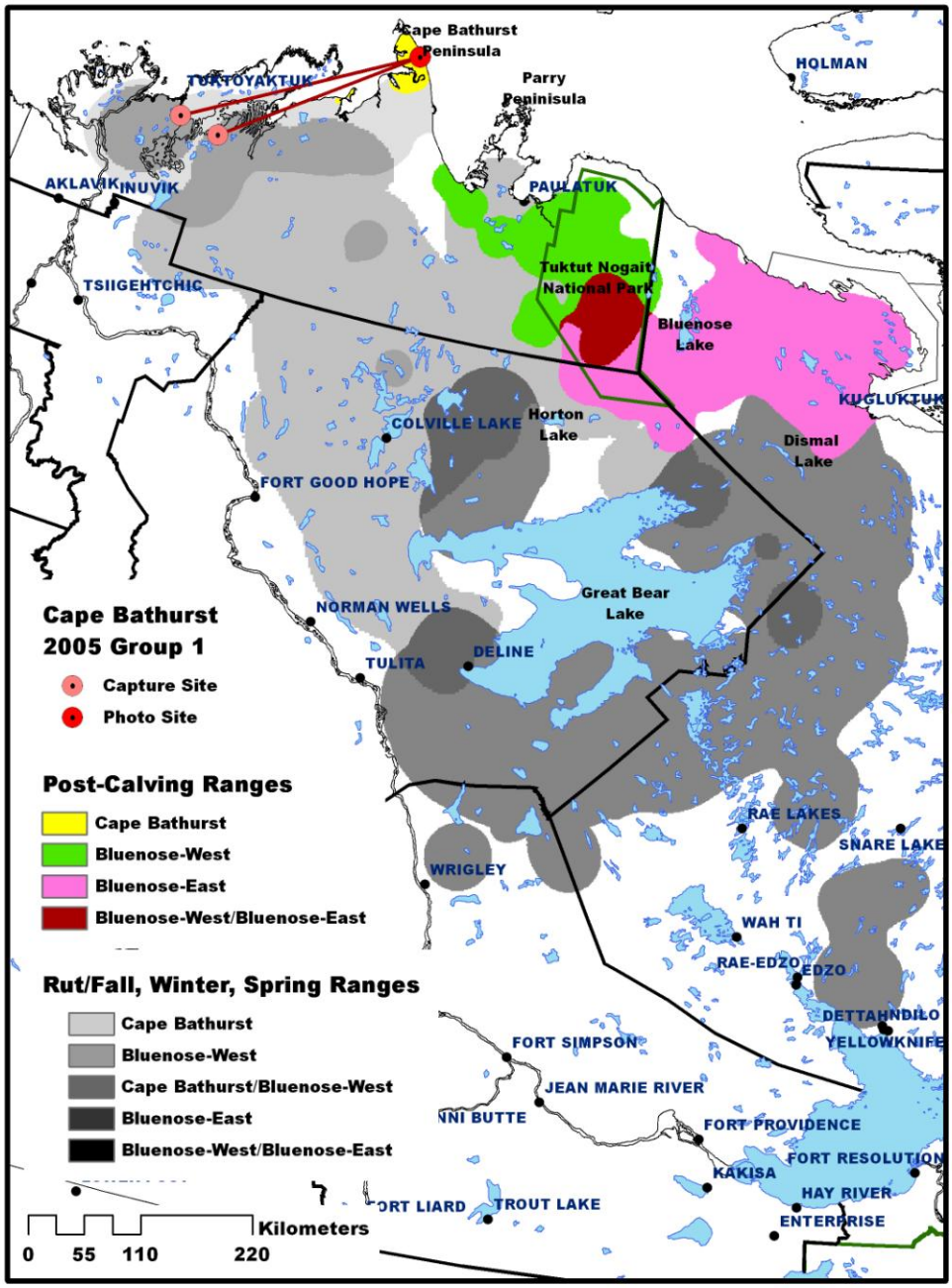

Figure 102. Cape Bathurst herd 2005 group 1 contained 2 radio-collared caribou, 7 adults, and 2 calves. The distance between capture sites for the radio-collared caribou was 41.0 km.

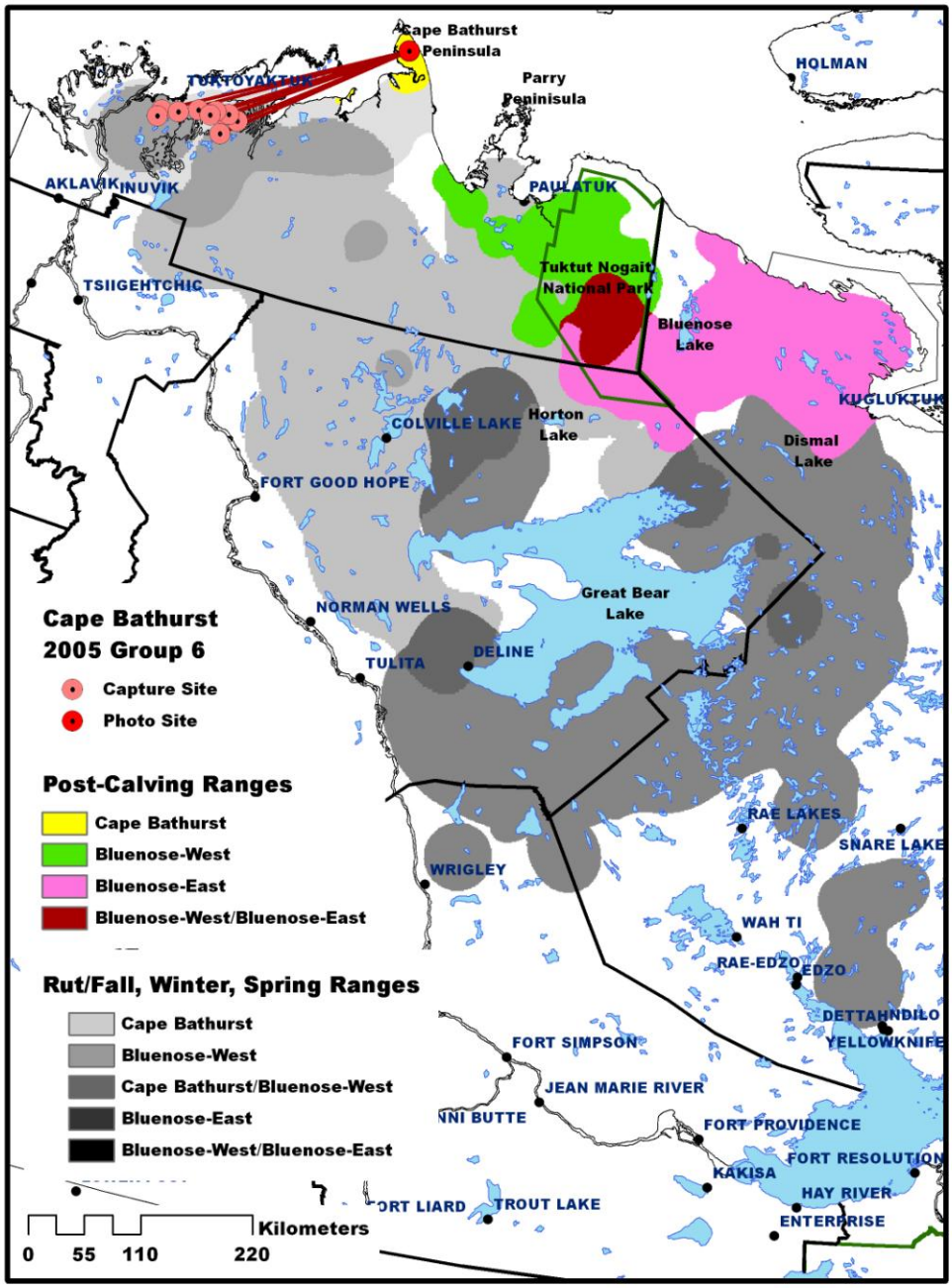

Figure 103. Cape Bathurst herd 2005 group 6 contained 10 radio-collared caribou, 492 adults, and 153 calves. The geometric mean distance between capture sites for the radio-collared caribou was 27.8 km (4.2 to 78.2 km).

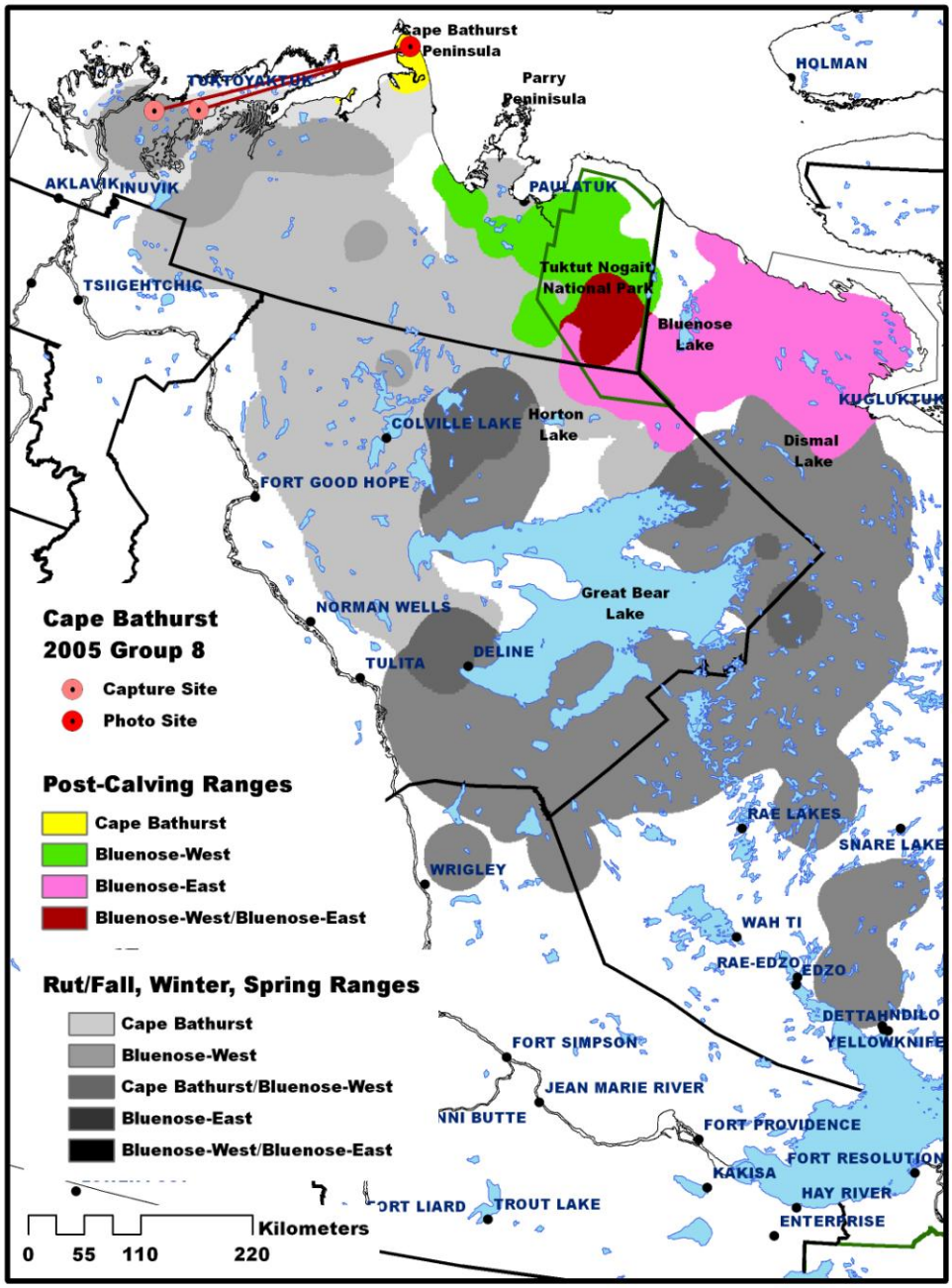

Figure 104. Cape Bathurst herd 2005 group 8 contained 2 radio-collared caribou, 228 adults, and 47 calves. The distance between capture sites for the radio-collared caribou was 43.1 km.

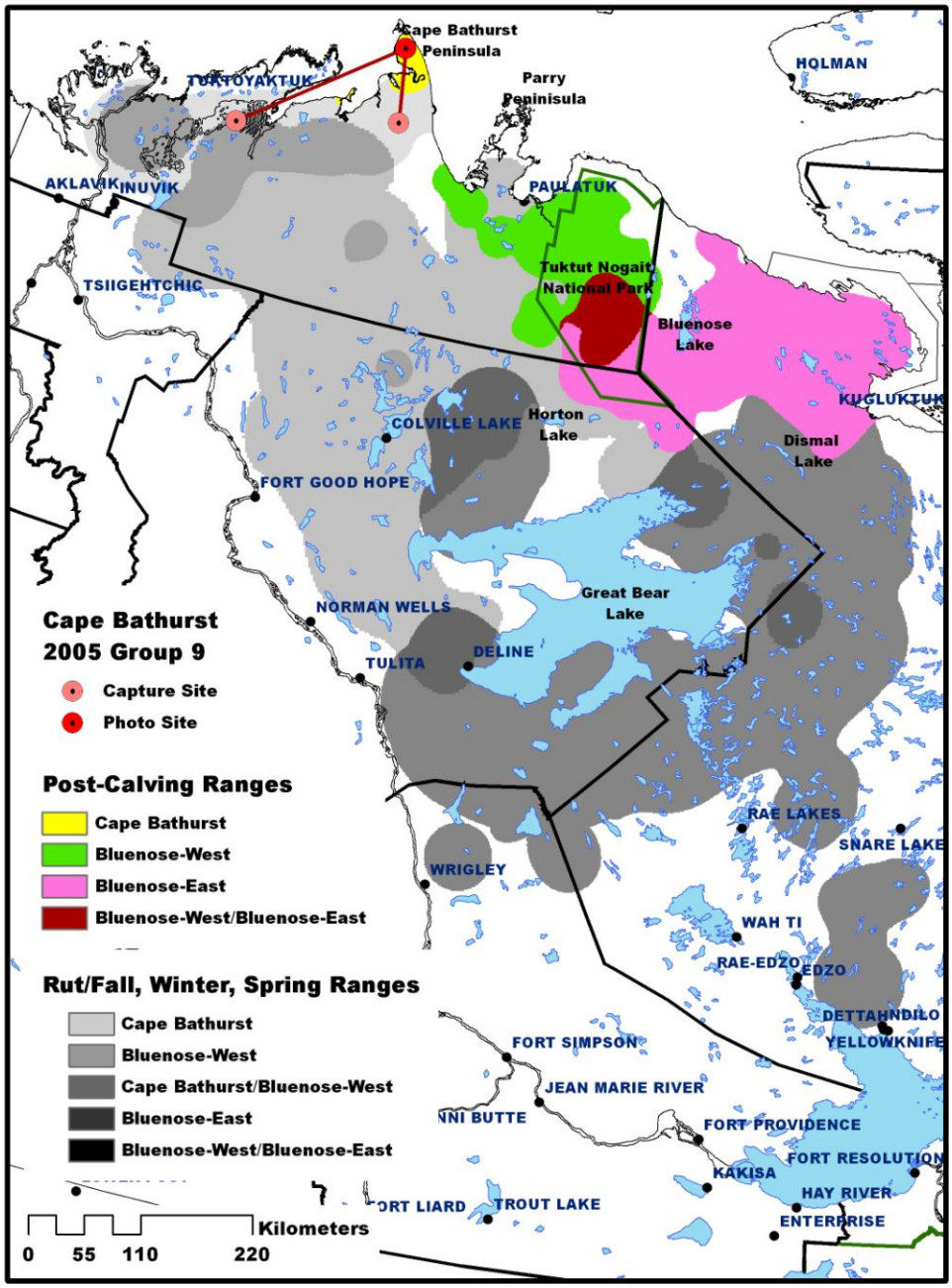

Figure 105. Cape Bathurst herd 2005 group 9 contained 2 radio-collared caribou, 138 adults, and 67 calves. The distance between capture sites for the radio-collared caribou was 159 km.

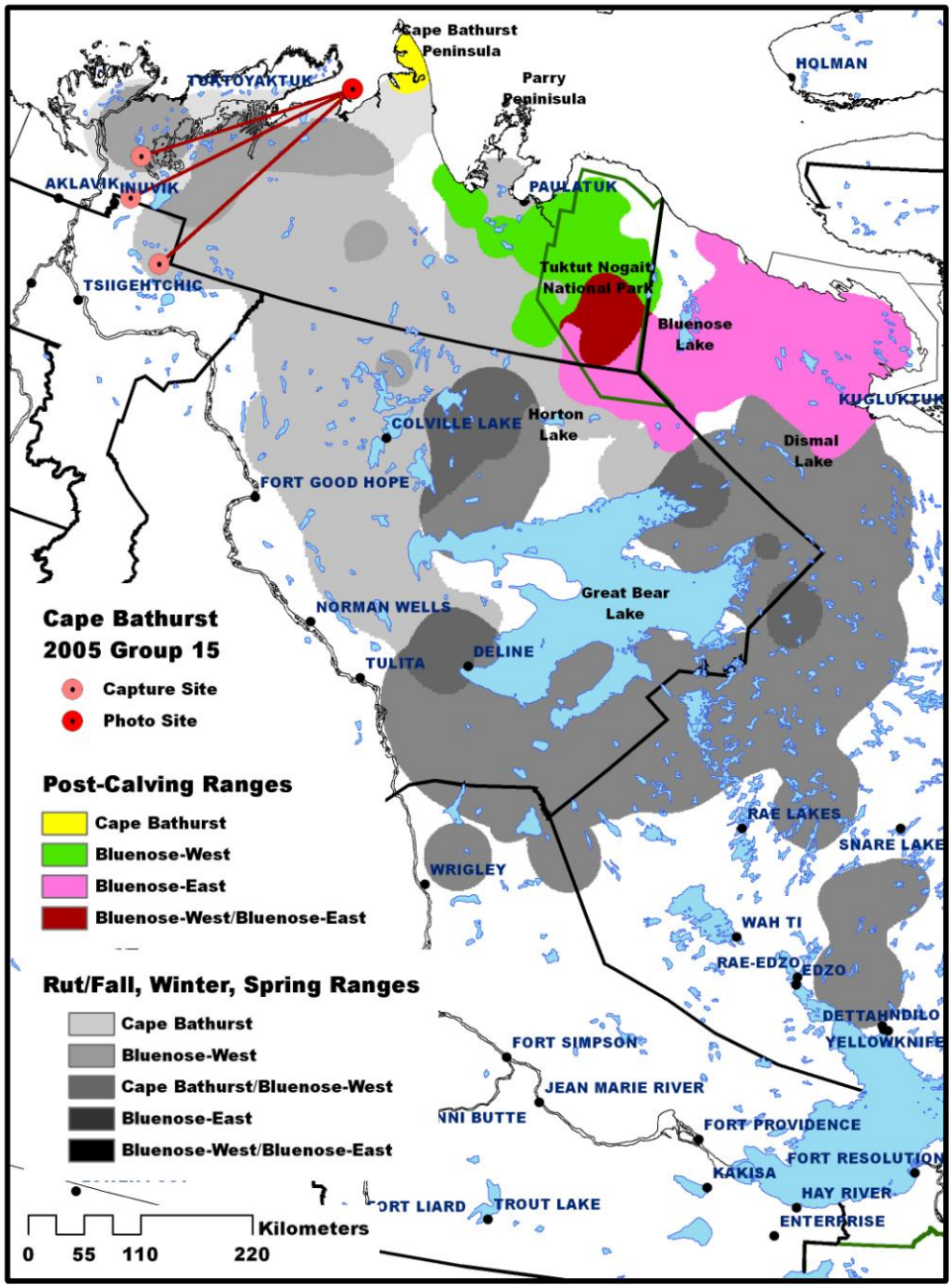

Figure 106. Cape Bathurst herd 2005 group 15 contained 3 radio-collared caribou and 174 adults. The geometric mean distance between capture sites for the radio-collared caribou was 68.2 km (41.8 to 107.0 km).

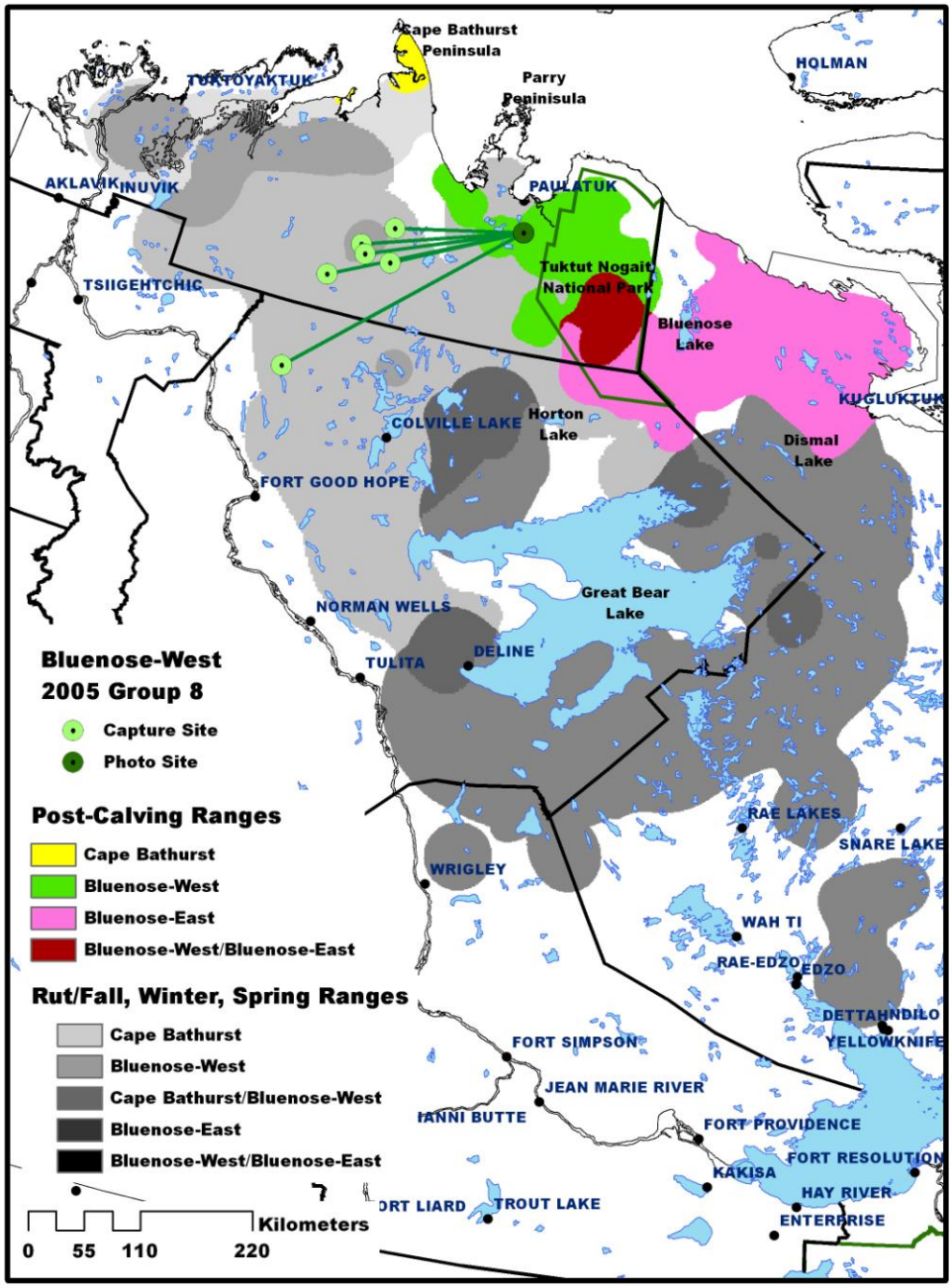

Figure 107. Bluenose-West herd 2005 group 8 contained 6 radio-collared caribou and 1,750 adults. The geometric mean distance between capture sites for the radio-collared caribou was 56.7 km (10.6 to 173.5 km).

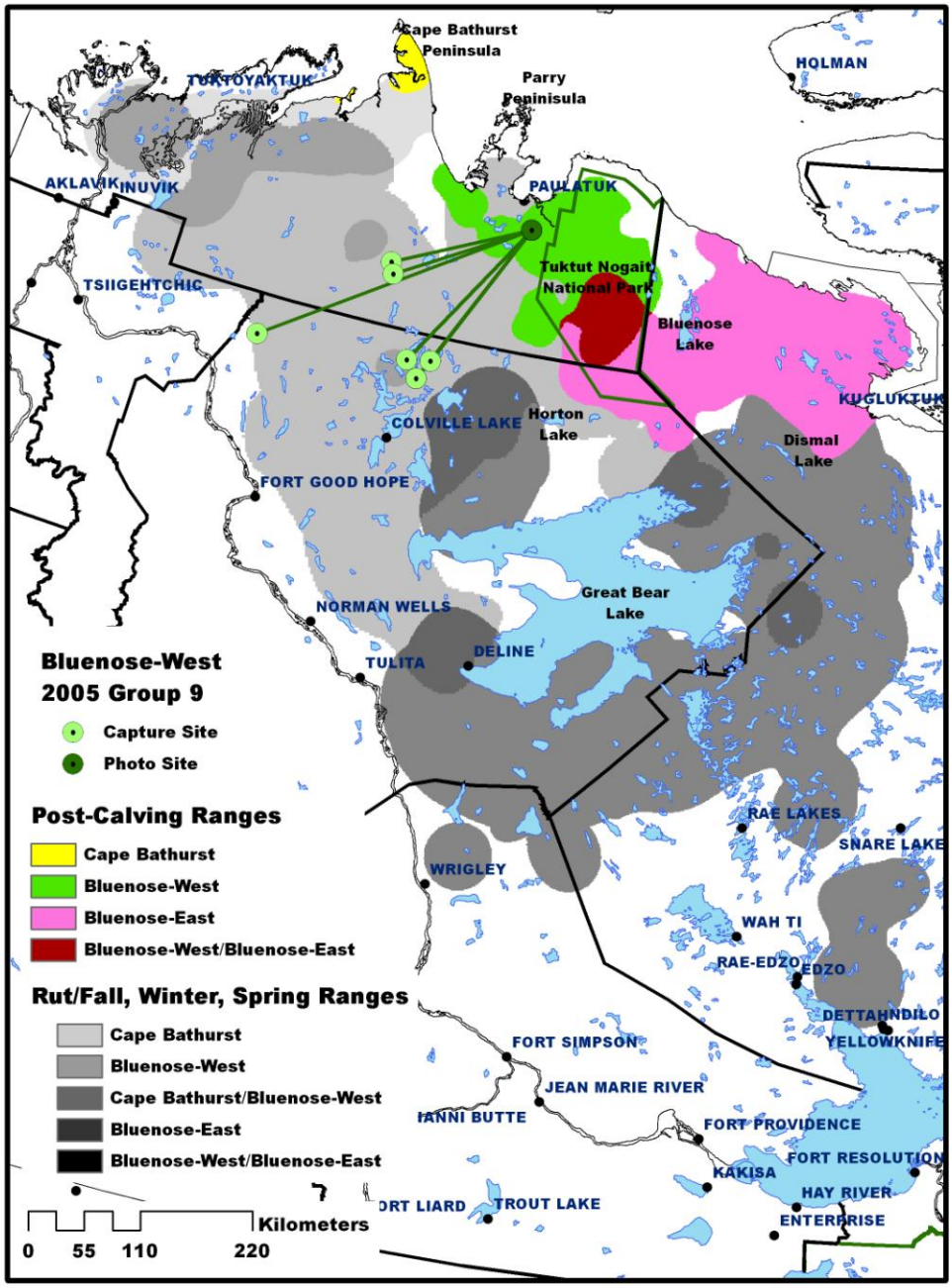

Figure 108. Bluenose-West herd 2005 group 9 contained 7 radio-collared caribou and 1,321 adults. The geometric mean distance between capture sites for the radio-collared caribou was 53.8 km (0.2 to 172.3 km).

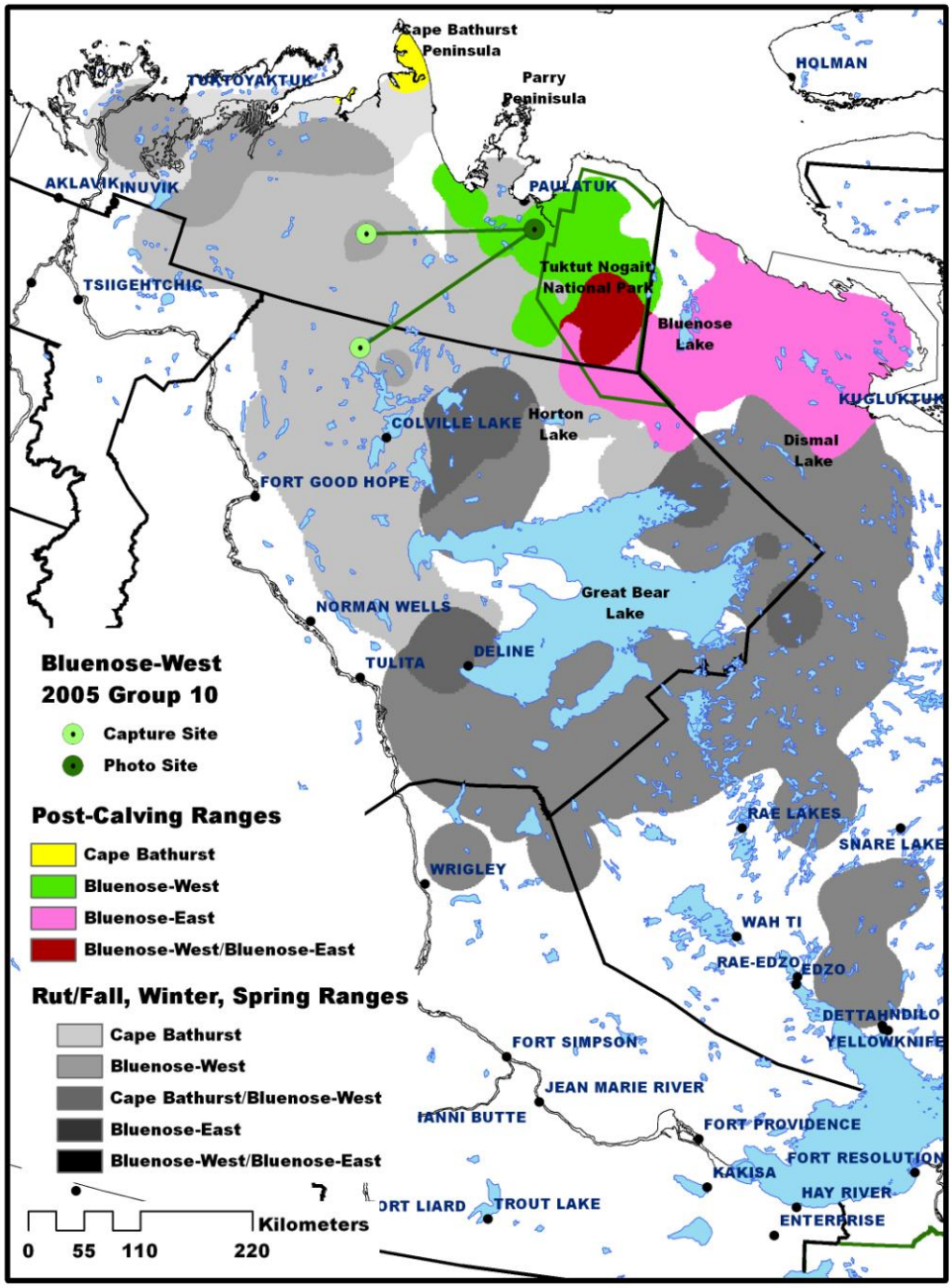

Figure 109. Bluenose-West herd 2005 group 10 contained 3 radio-collared caribou and 1,256 adults. The geometric mean distance between capture sites for the radio-collared caribou was 17.0 km (0.4 to 111.6 km).

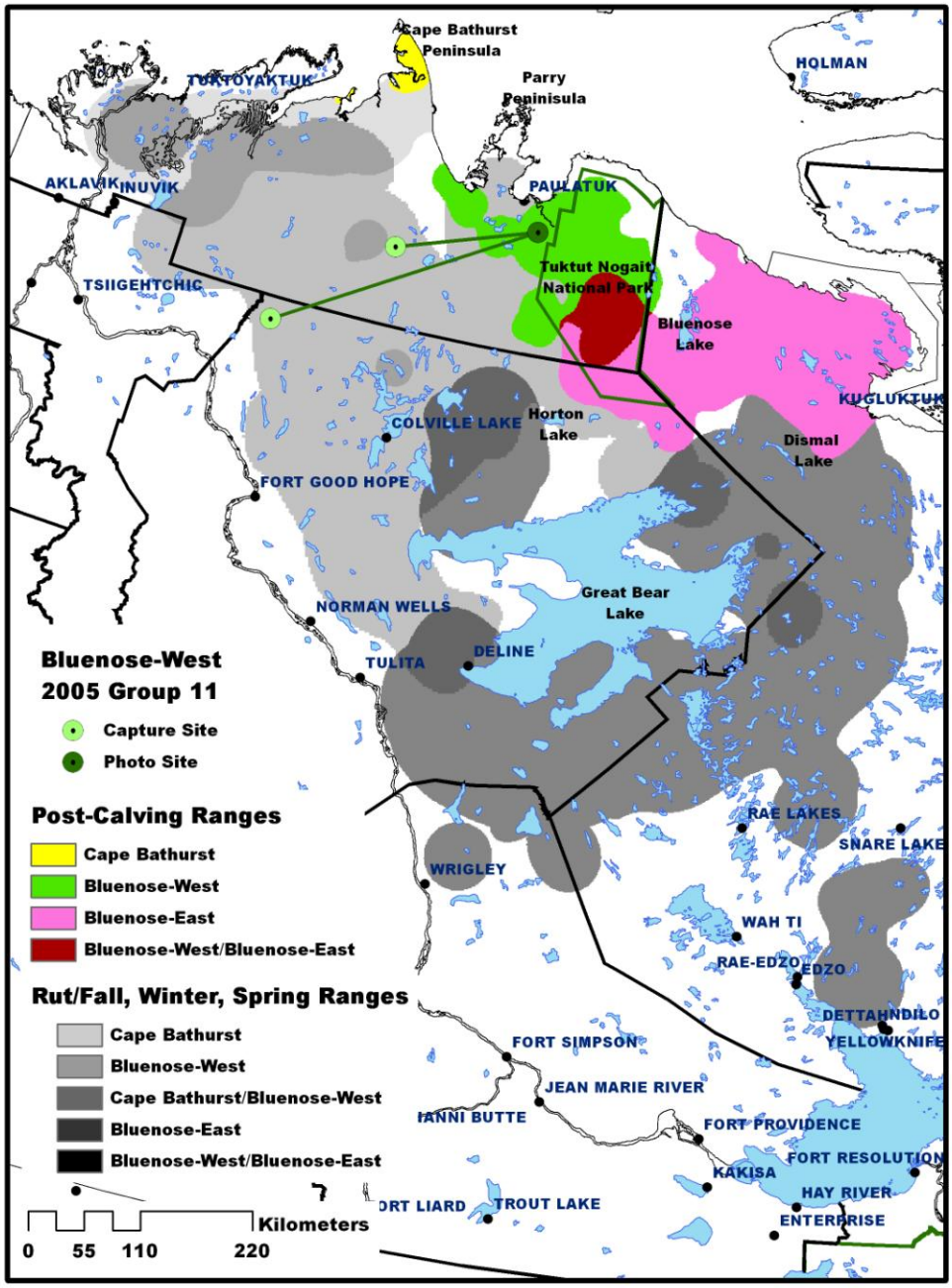

Figure 110. Bluenose-West herd 2005 group 11 contained 2 radio-collared caribou and 571 adults. The distance between capture sites for the radio-collared caribou was 141.3 km.

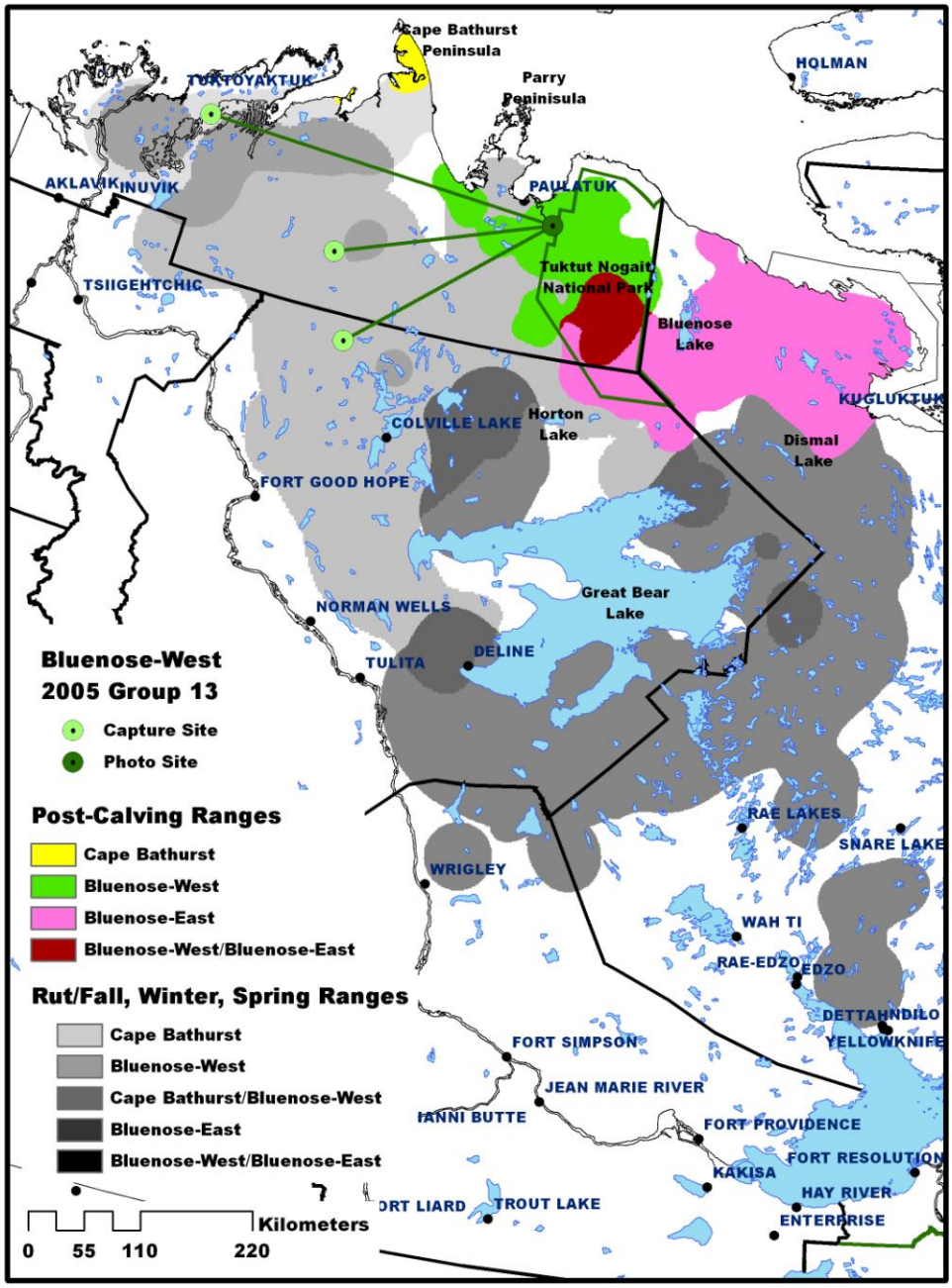

Figure 111. Bluenose-West herd 2005 group 13 contained 3 radio-collared caribou and 591 adults. The geometric mean distance between capture sites for the radio-collared caribou was 159.5 km (87.7 to 256.4 km).

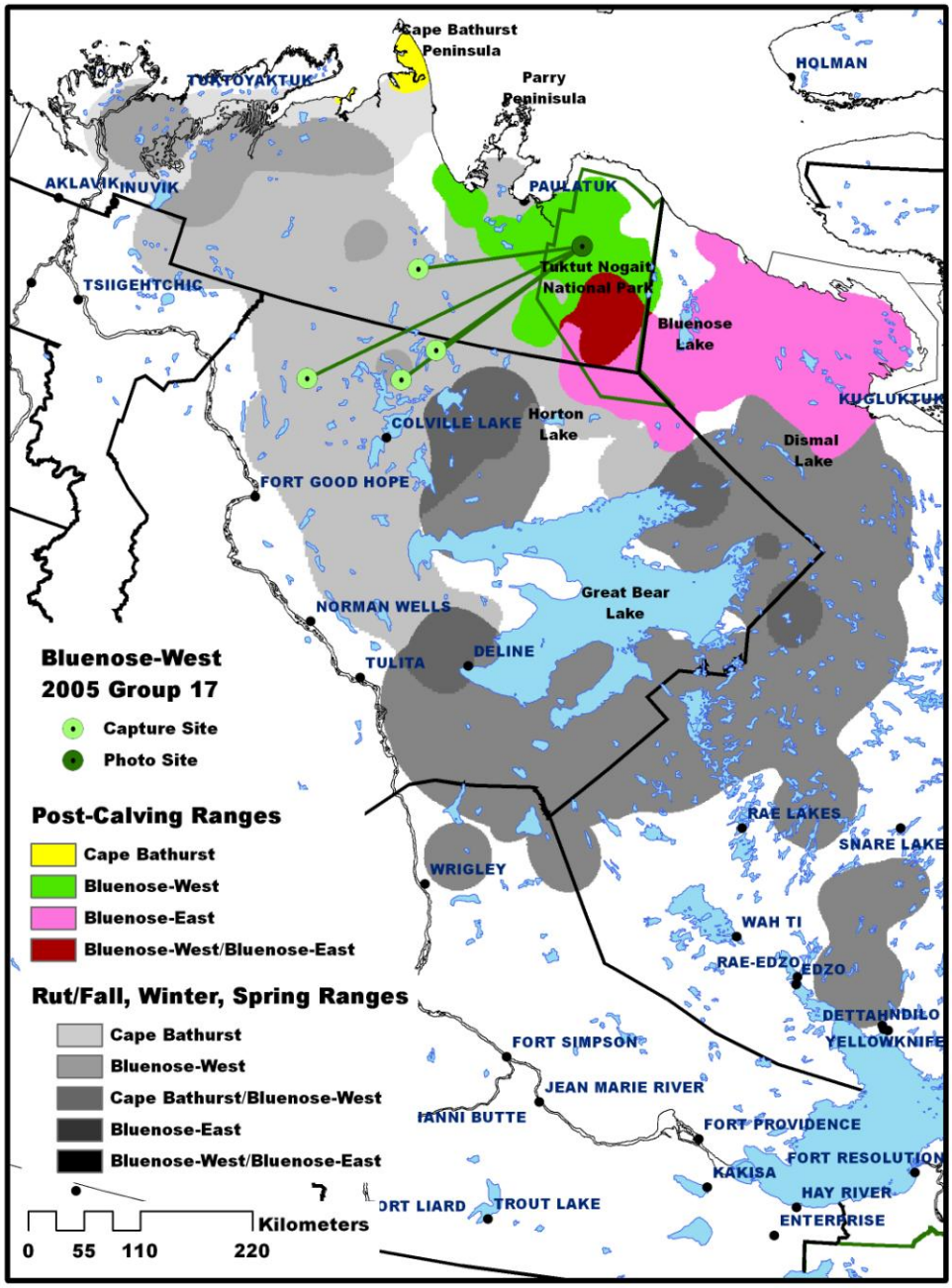

Figure 112. Bluenose-West herd 2005 group 17 contained 4 radio-collared caribou and 470 adults. The geometric mean distance between capture sites for the radio-collared caribou was 95.2 km (45.0 to 152.7 km).

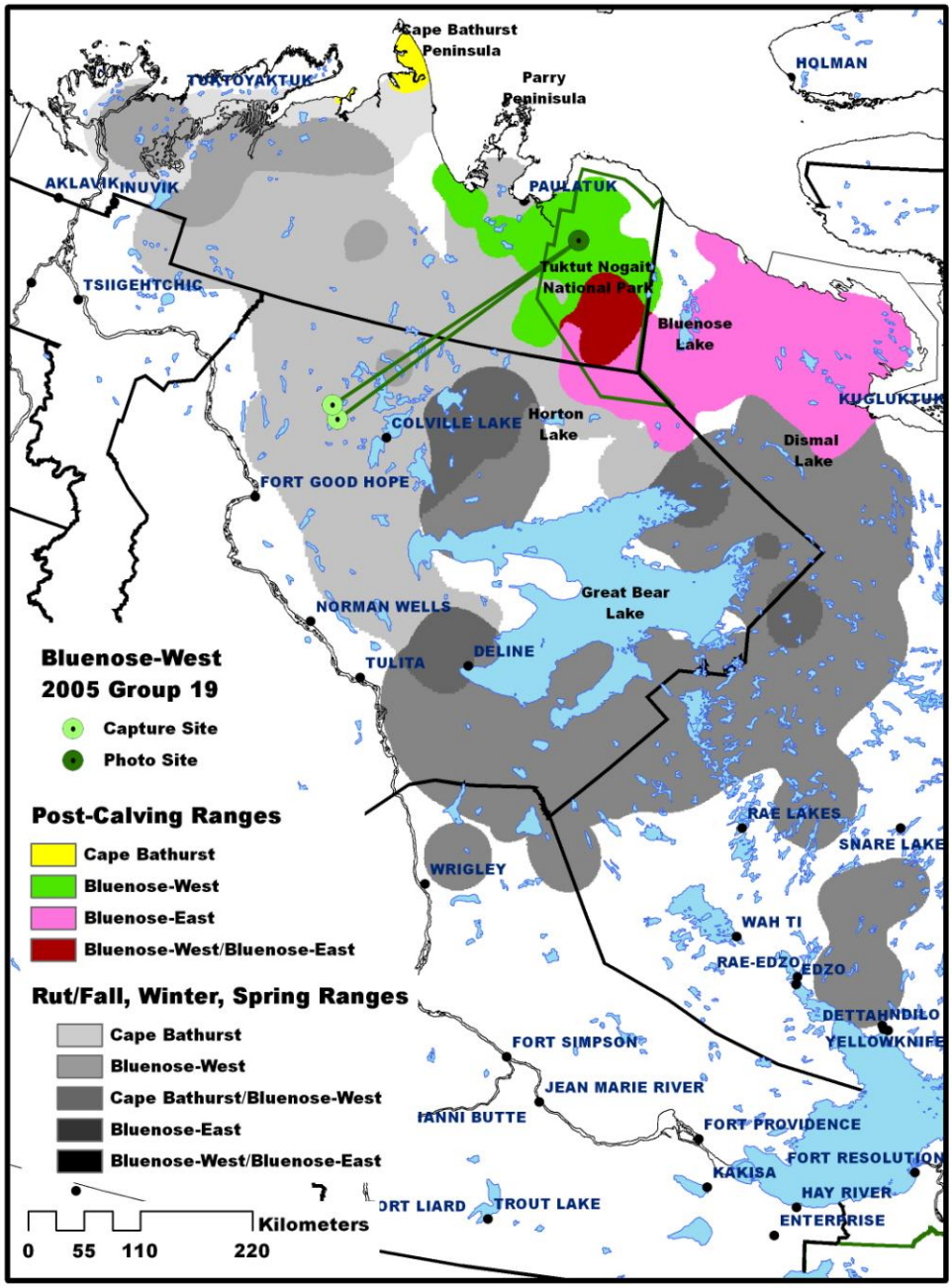

Figure 113. Bluenose-West herd 2005 group 19 contained 2 radio-collared caribou and 1,678 adults. The distance between capture sites for the radio-collared caribou was 15.0 km.

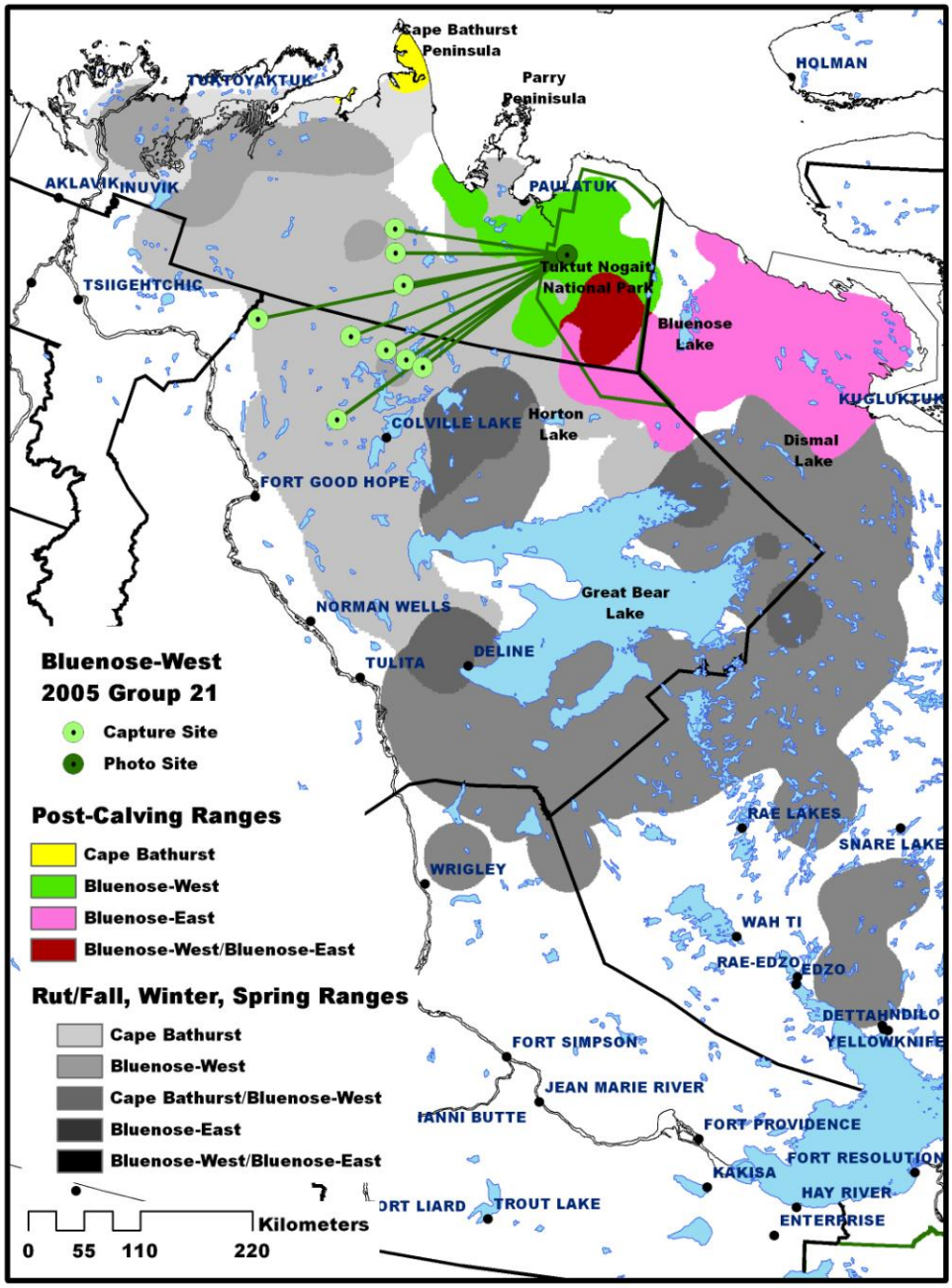

Figure 114. Bluenose-West herd 2005 group 21 contained 10 radio-collared caribou and 4,913 adults. The geometric mean distance between capture sites for the radio-collared caribou was 74.5 km (0.5 to 194.5 km).

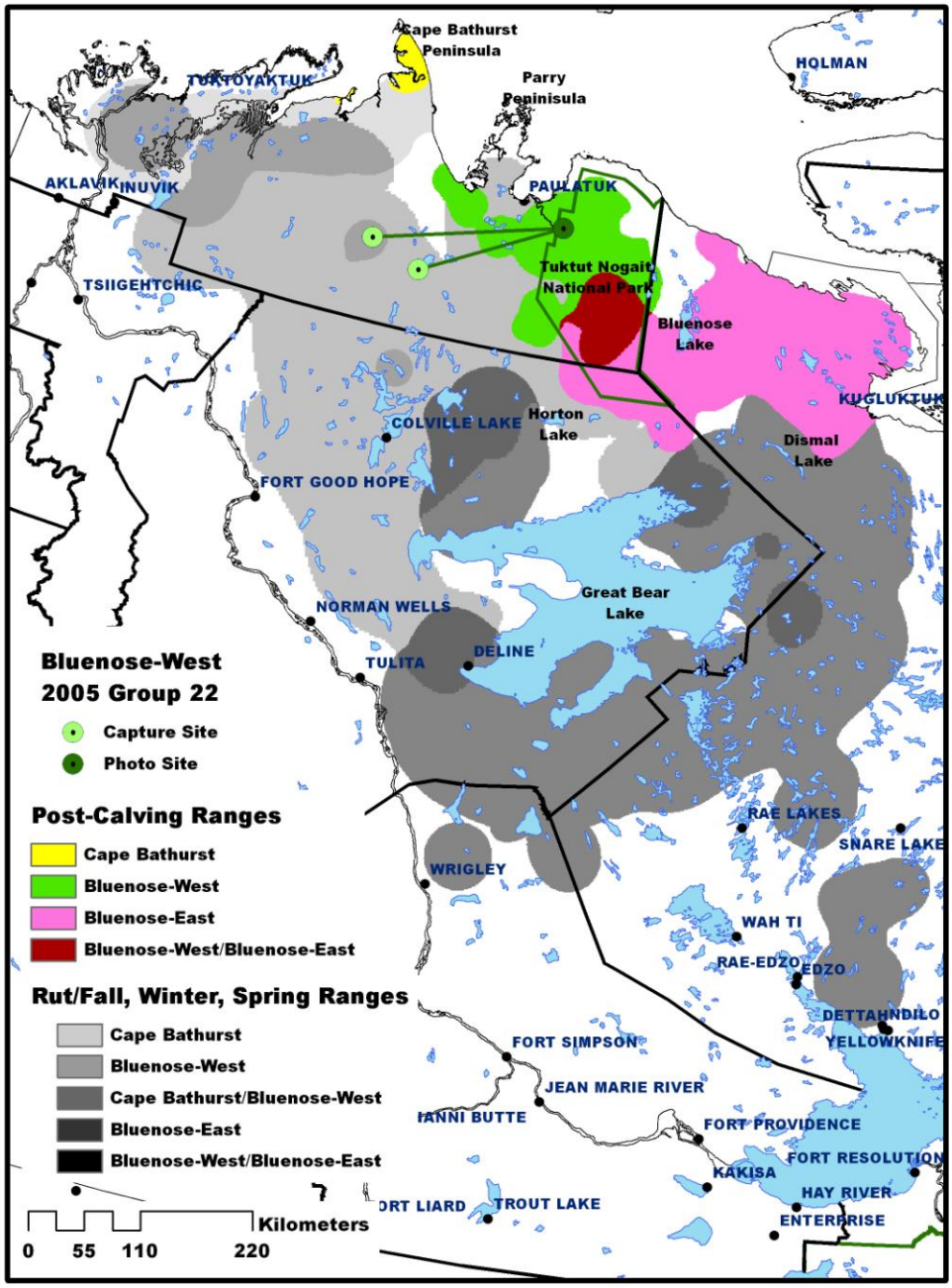

Figure 115. Bluenose-West herd 2005 group 22 contained 2 radio-collared caribou and 857 adults. The distance between capture sites for the radio-collared caribou was 54.7 km.

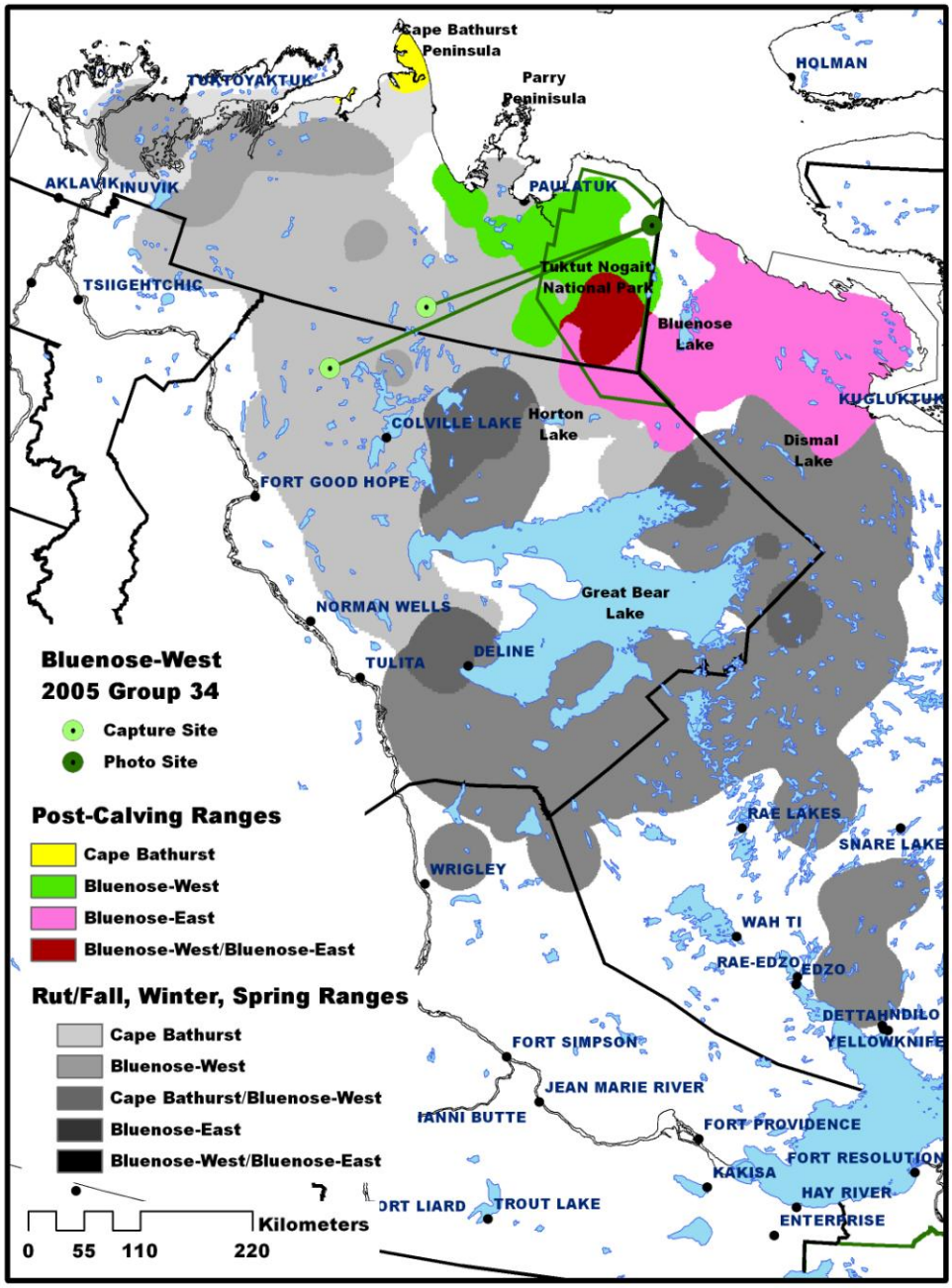

Figure 116. Bluenose-West herd 2005 group 34 contained 2 radio-collared caribou and 308 adults. The distance between capture sites for the radio-collared caribou was 112.2 km.

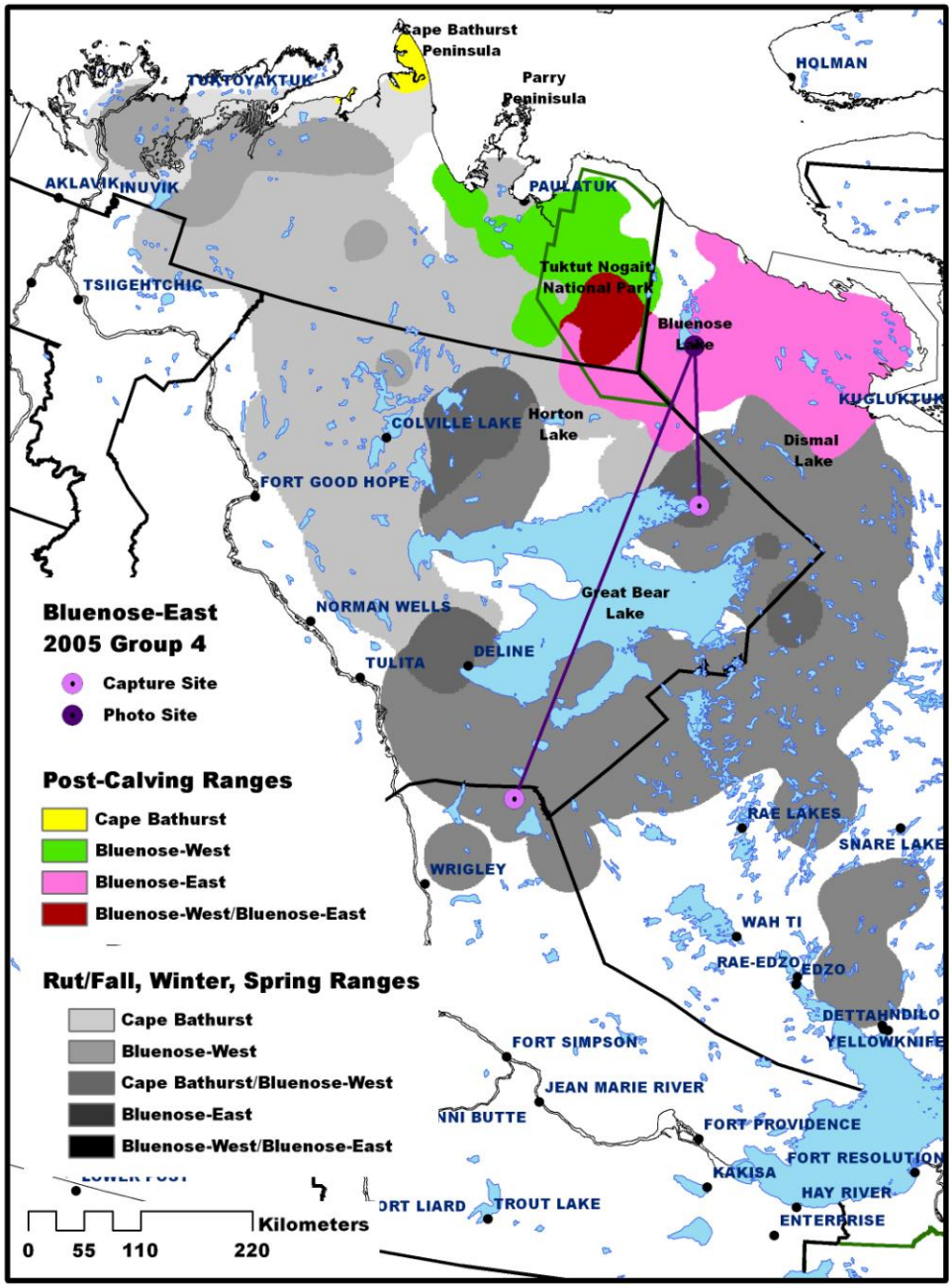

Figure 117. Bluenose-East herd 2005 group 4 contained 2 radio-collared caribou and 565 adults. The distance between capture sites for the radio-collared caribou was 341.1 km.

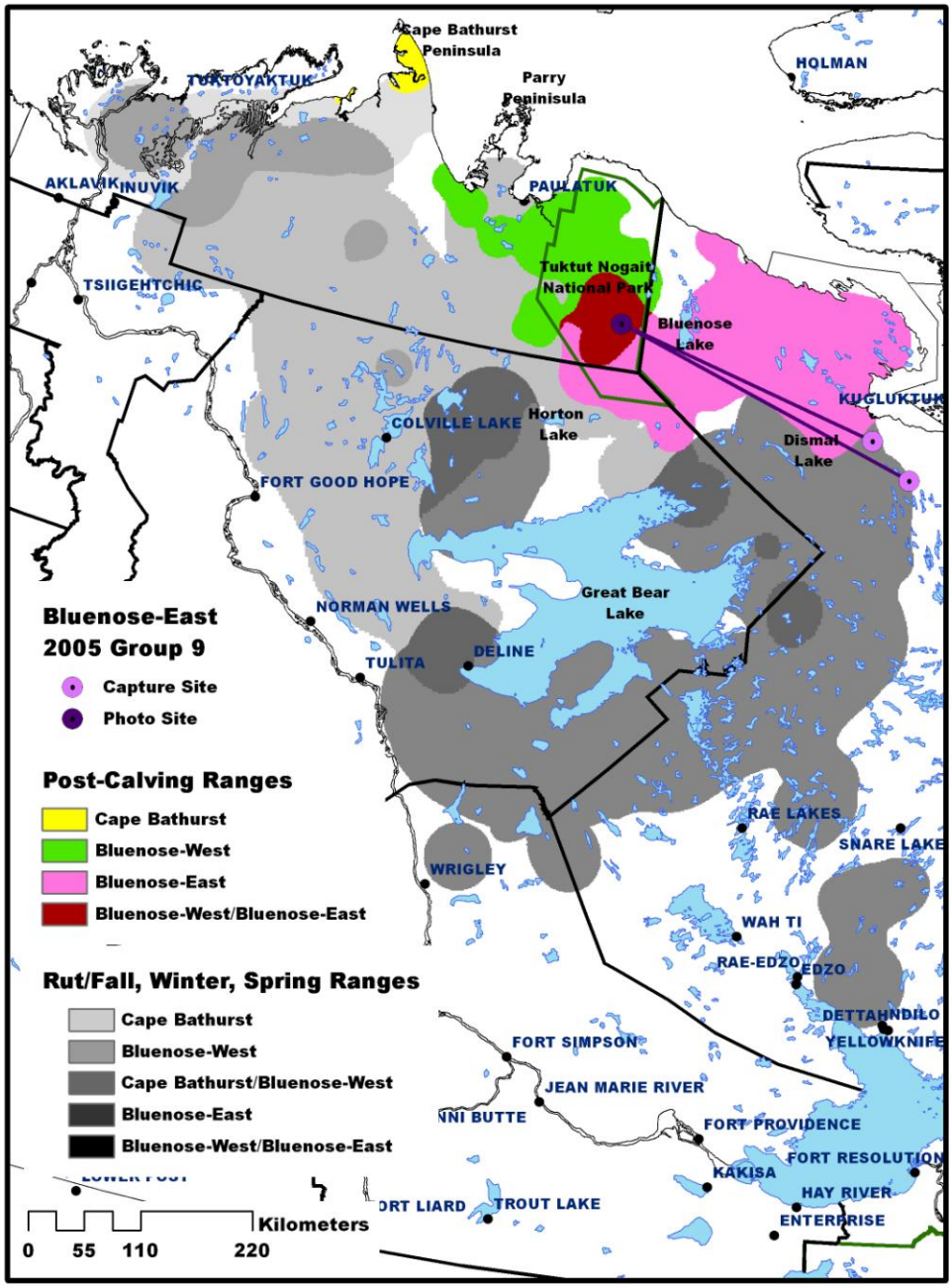

Figure 118. Bluenose-East herd 2005 group 9 contained 2 radio-collared caribou and 2,595 adults. The distance between capture sites for the radio-collared caribou was 53.5 km.

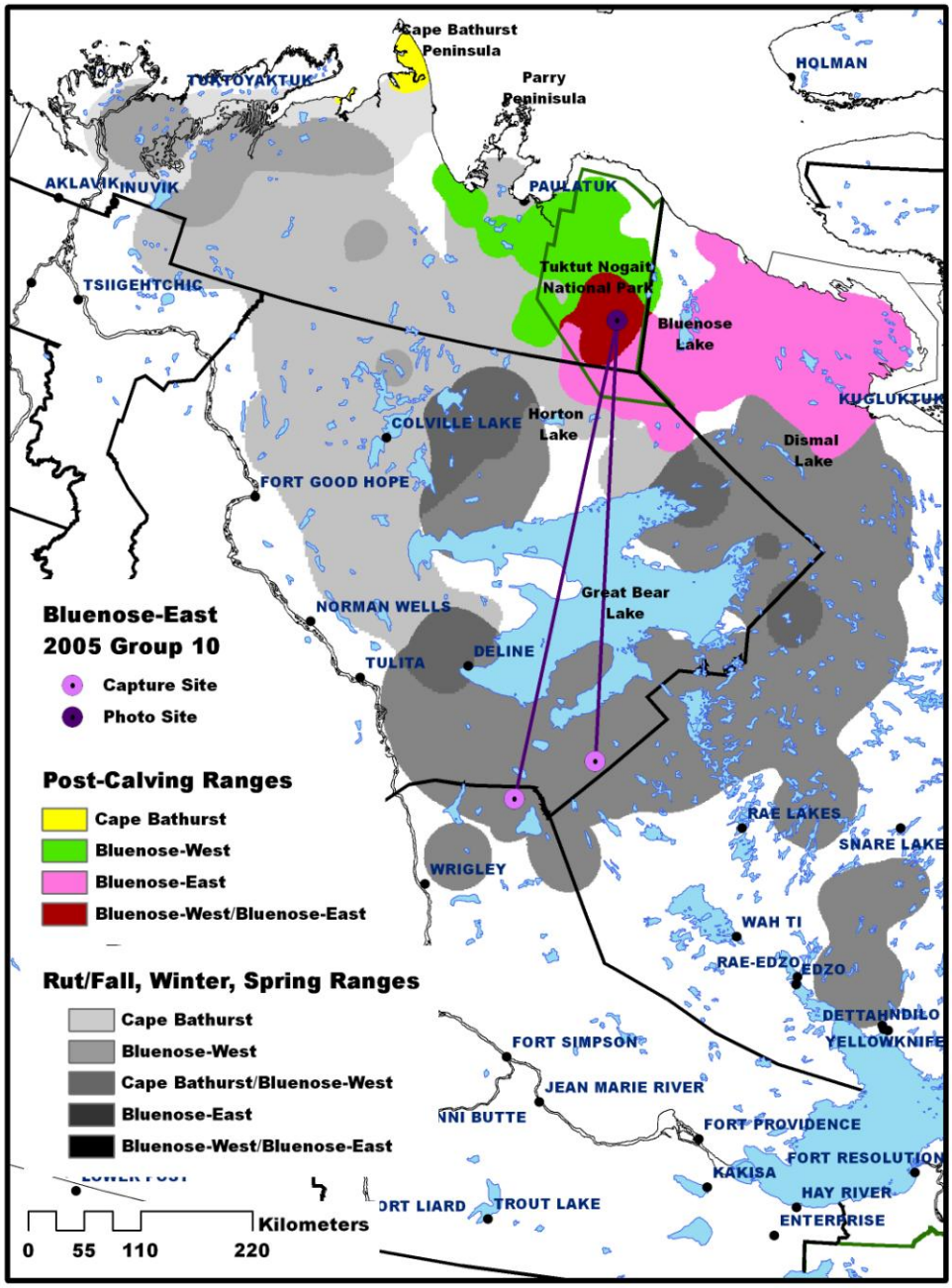

Figure 119. Bluenose-East herd 2005 group 10 contained 2 radio-collared caribou and 2,941 adults. The distance between capture sites for the radio-collared caribou was 87.6 km.

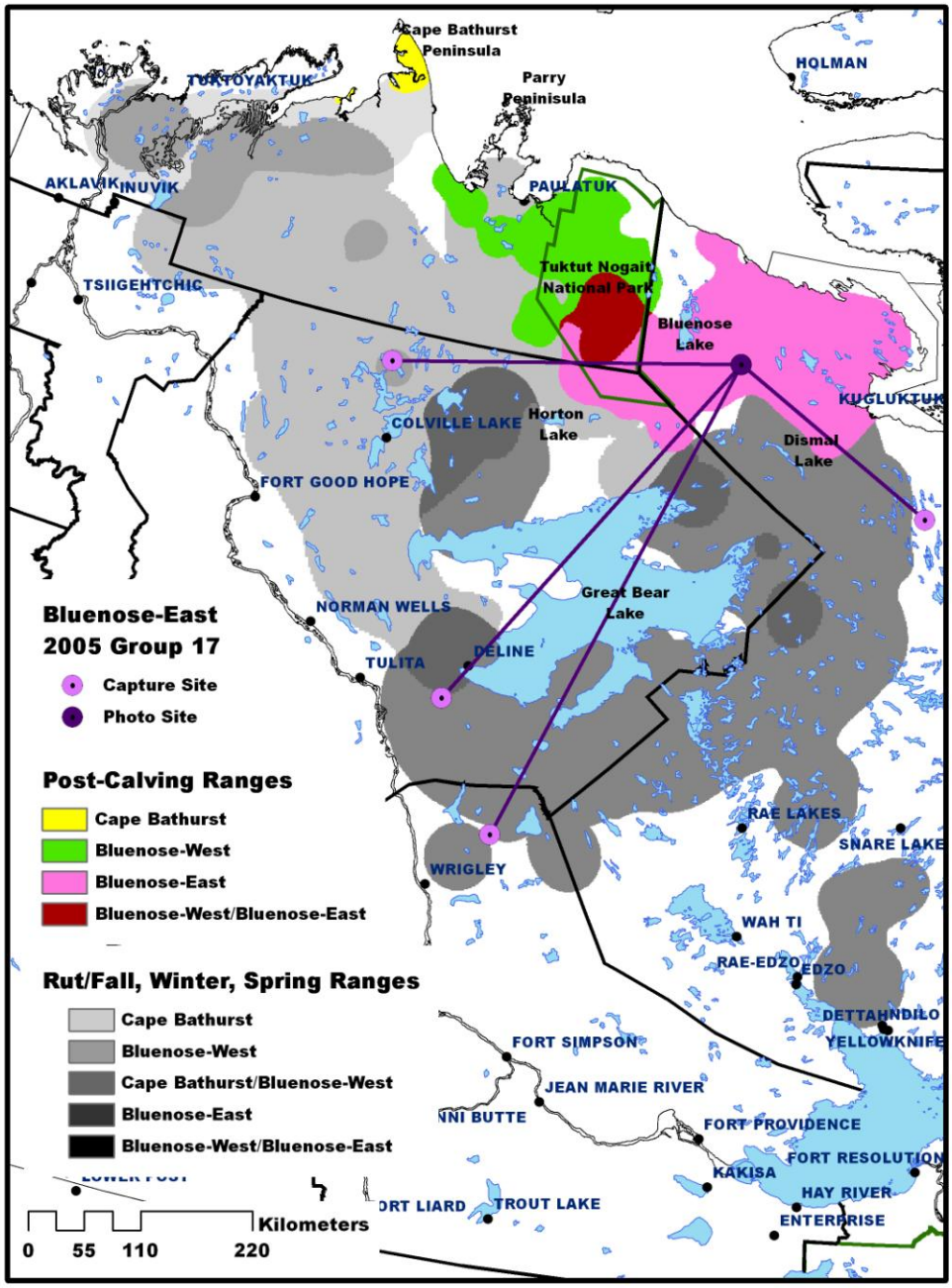

Figure 120. Bluenose-East herd 2005 group 17 contained 4 radio-collared caribou and 5,726 adults. The geometric mean distance between capture sites for the radio-collared caribou was 386.3 km (142.4 to 546.8 km).

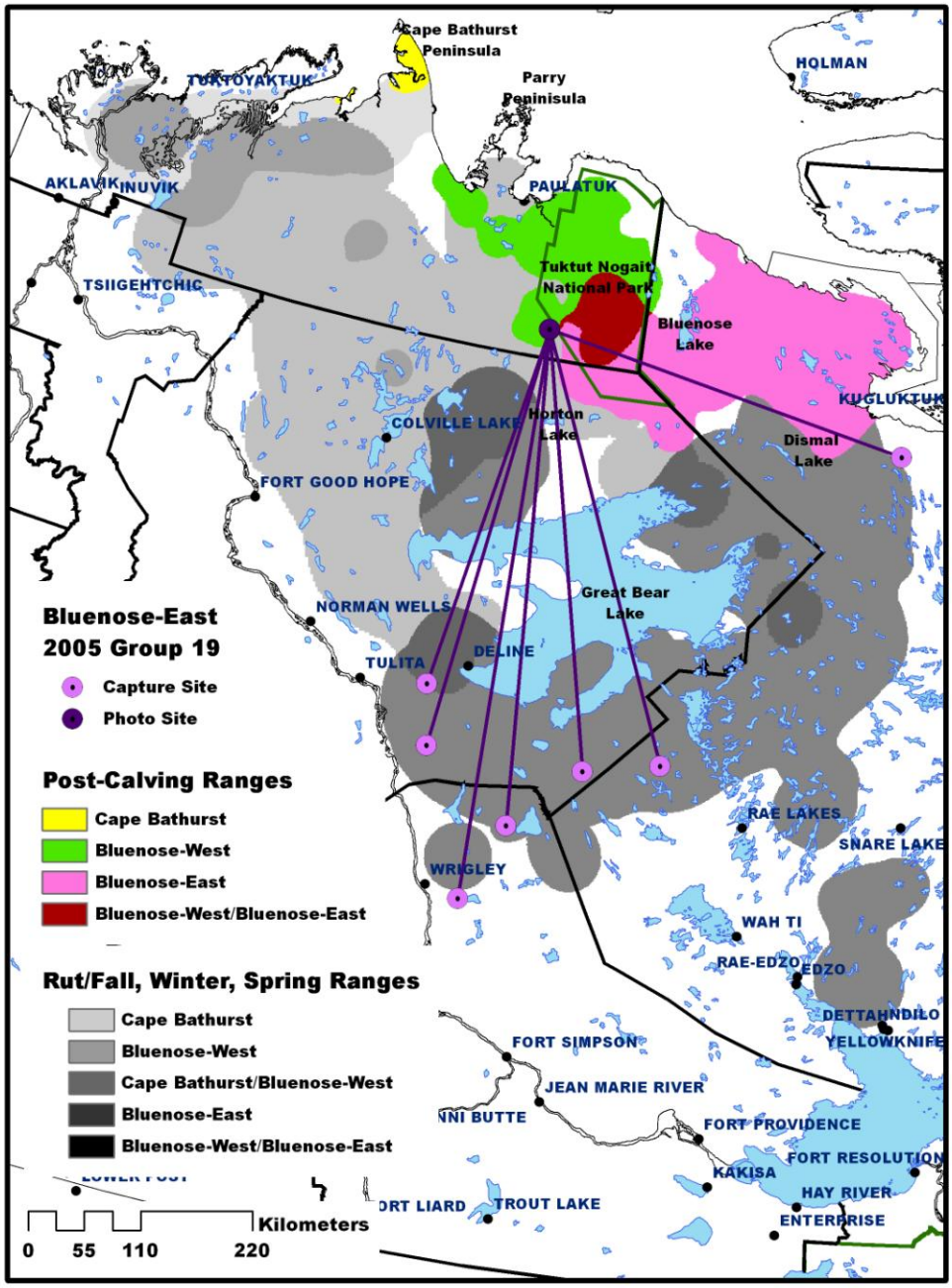

Figure 121. Bluenose-East herd 2005 group 19 contained 7 radio-collared caribou and 25,950 adults. The geometric mean distance between capture sites for the radio-collared caribou was 219.5 km (60.6 to 615.9 km).

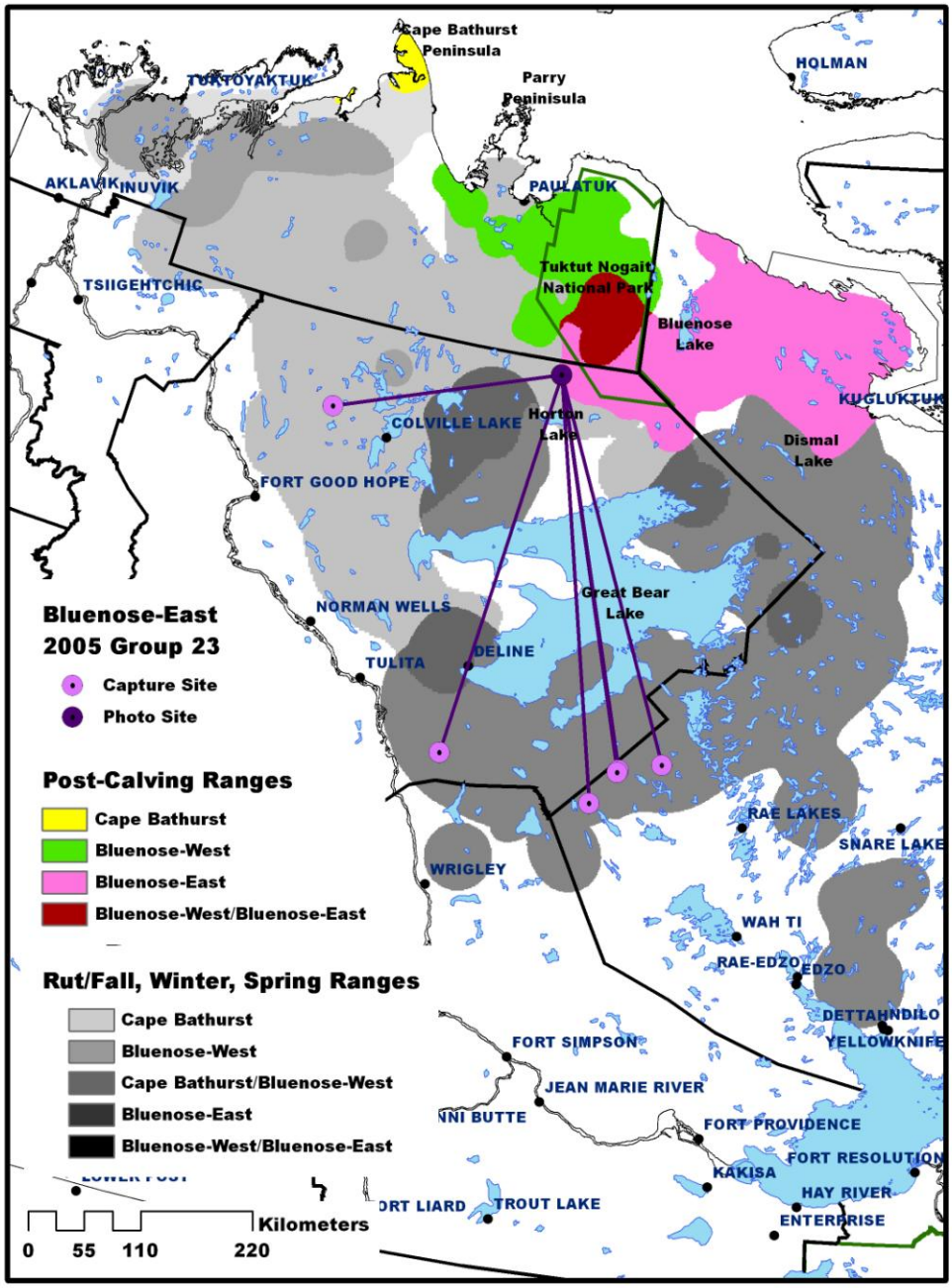

Figure 122. Bluenose-East herd 2005 group 23 contained 6 radio-collared caribou and 15,084 adults. The geometric mean distance between capture sites for the radio-collared caribou was 118.7 km (2.7 to 479.4 km).

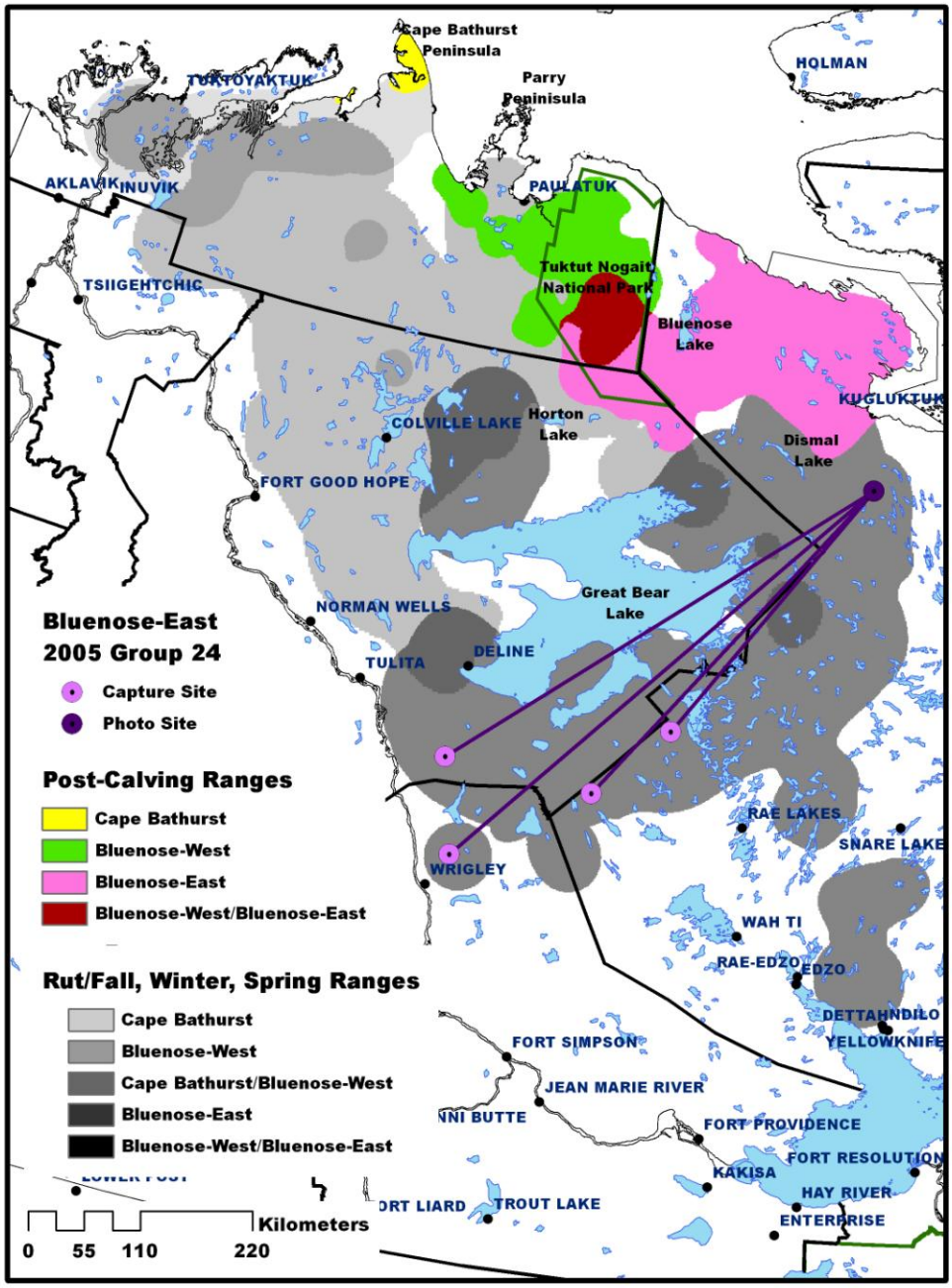

Figure 123. Bluenose-East herd 2005 group 24 contained 4 radio-collared caribou and 2,201 adults. The geometric mean distance between capture sites for the radio-collared caribou was 150.8 km (95.7 to 247.9 km).

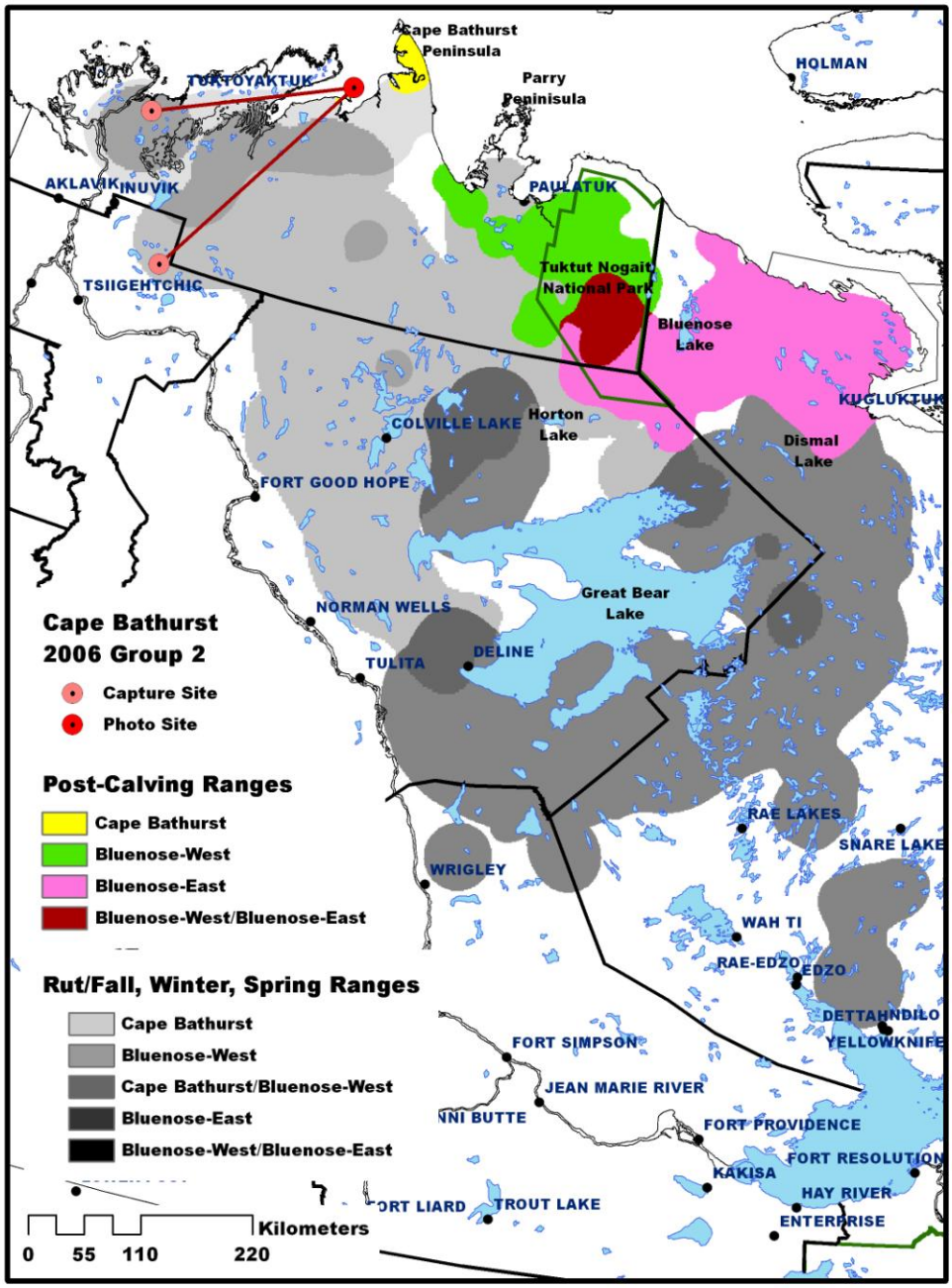

Figure 124. Cape Bathurst herd 2006 group 2 contained 2 radio-collared caribou, 106 adults, and 7 calves. The distance between capture sites for the radio-collared caribou was 150.4 km.

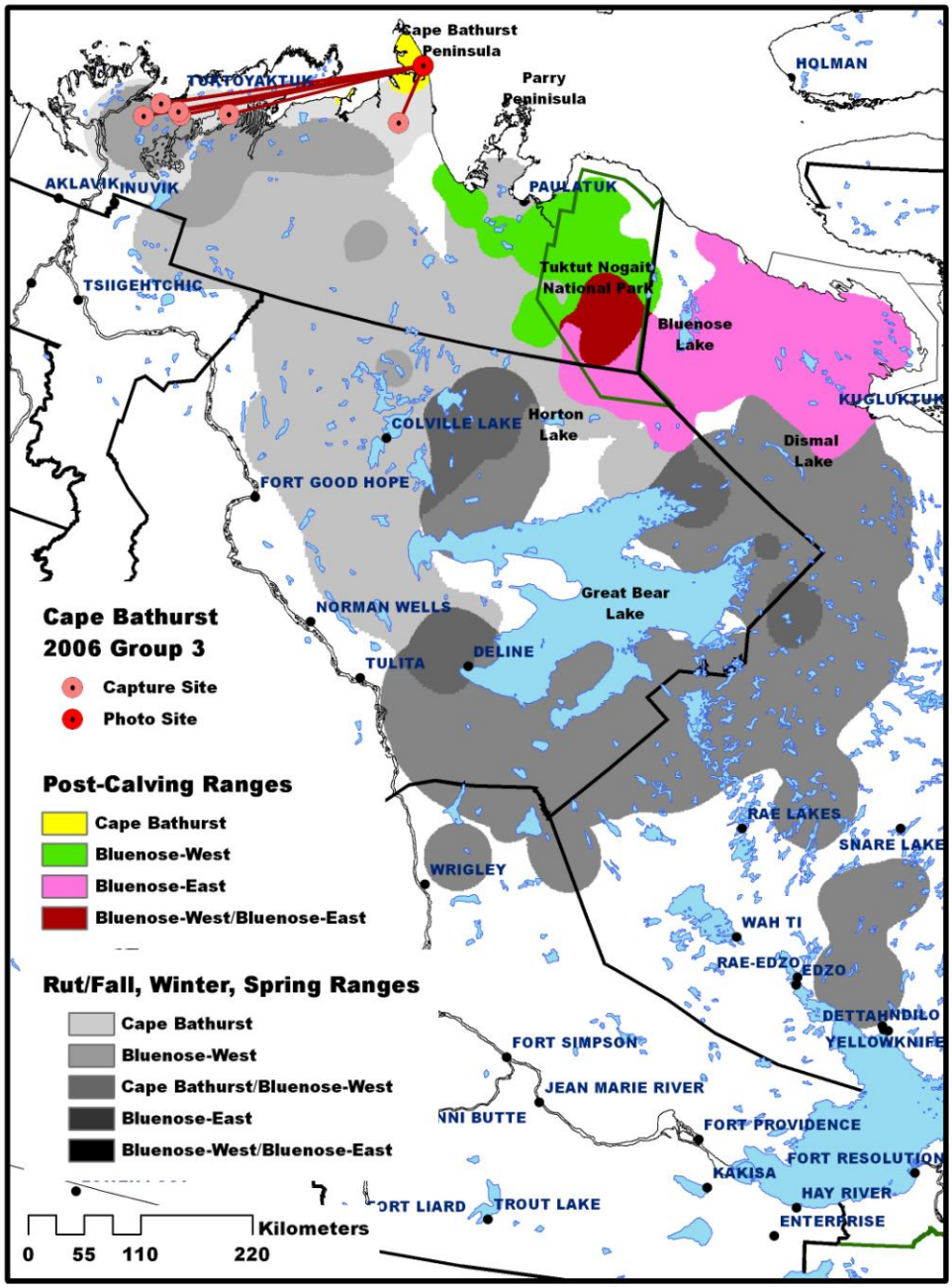

Figure 125. Cape Bathurst herd 2006 group 3 contained 7 radio-collared caribou, 225 adults, and 25 calves. The geometric mean distance between capture sites for the radio-collared caribou was 57.6 km (4.1 to 249.3 km).

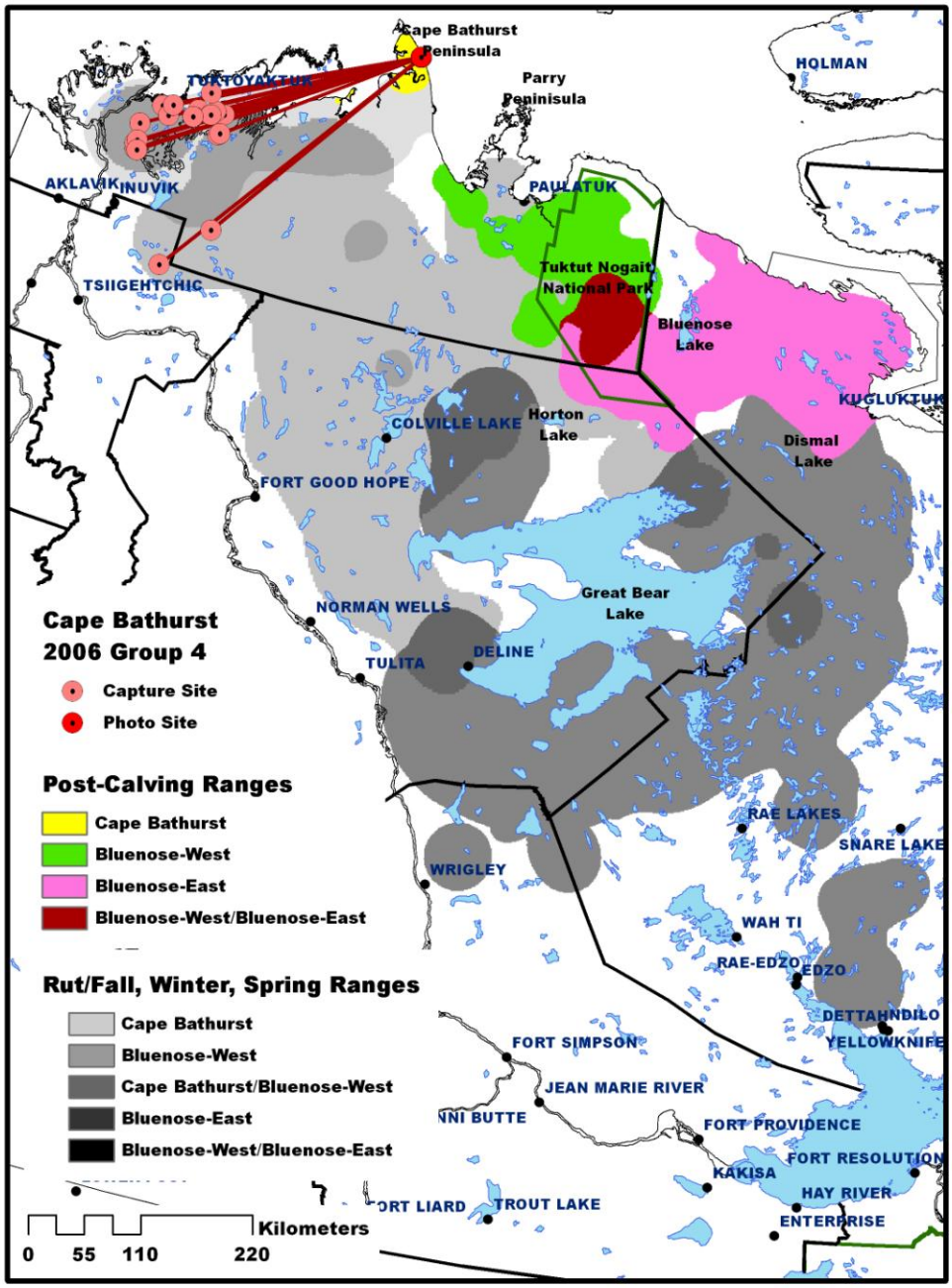

Figure 126. Cape Bathurst herd 2006 group 4 contained 19 radio-collared caribou, 1,367adults, and 266 calves. The geometric mean distance between capture sites for the radio-collared caribou was 45.6 km (1.0 to 175 km).

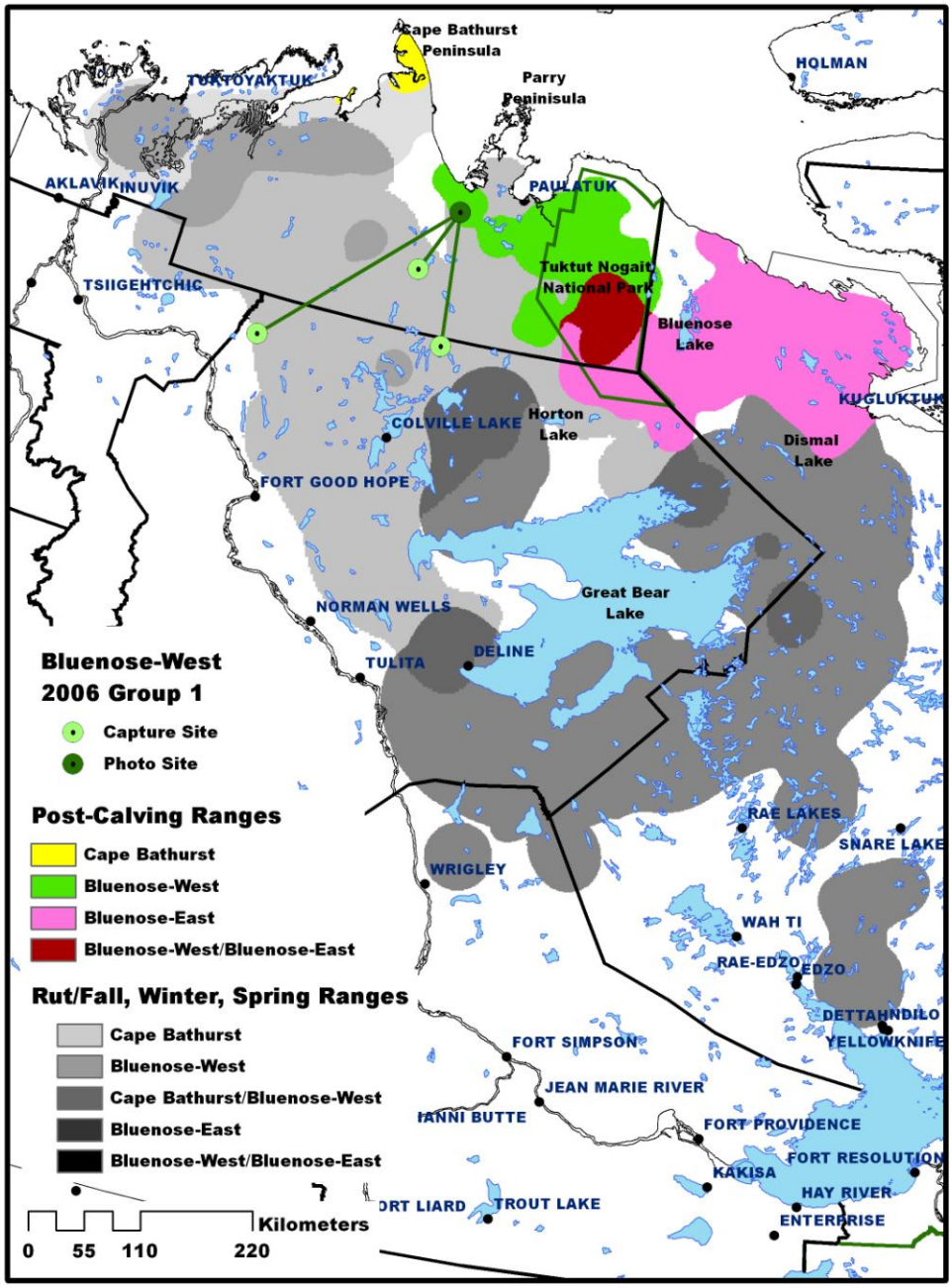

Figure 127. Bluenose-West herd 2006 group 1 contained 3 radio-collared caribou, 486 adults, and 42 calves. The geometric mean distance between capture sites for the radio-collared caribou was 134.4 km (79.0 to 180.9 km).

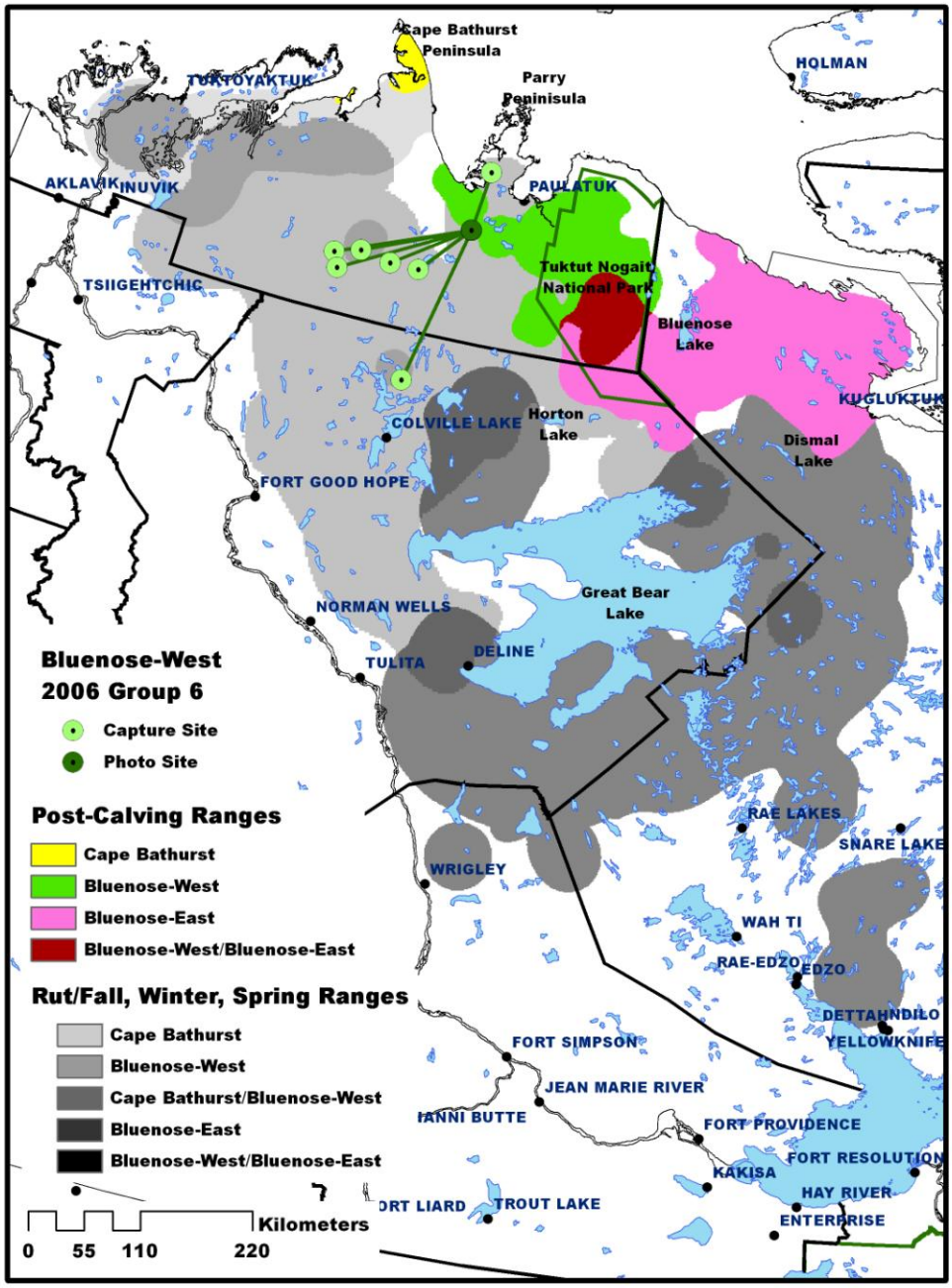

Figure 128. Bluenose-West herd 2006 group 6 contained 7 radio-collared caribou, 1,511 adults, and 377 calves. The geometric mean distance between capture sites for the radio-collared caribou was 78.5 km (15.9 to 220.6 km).

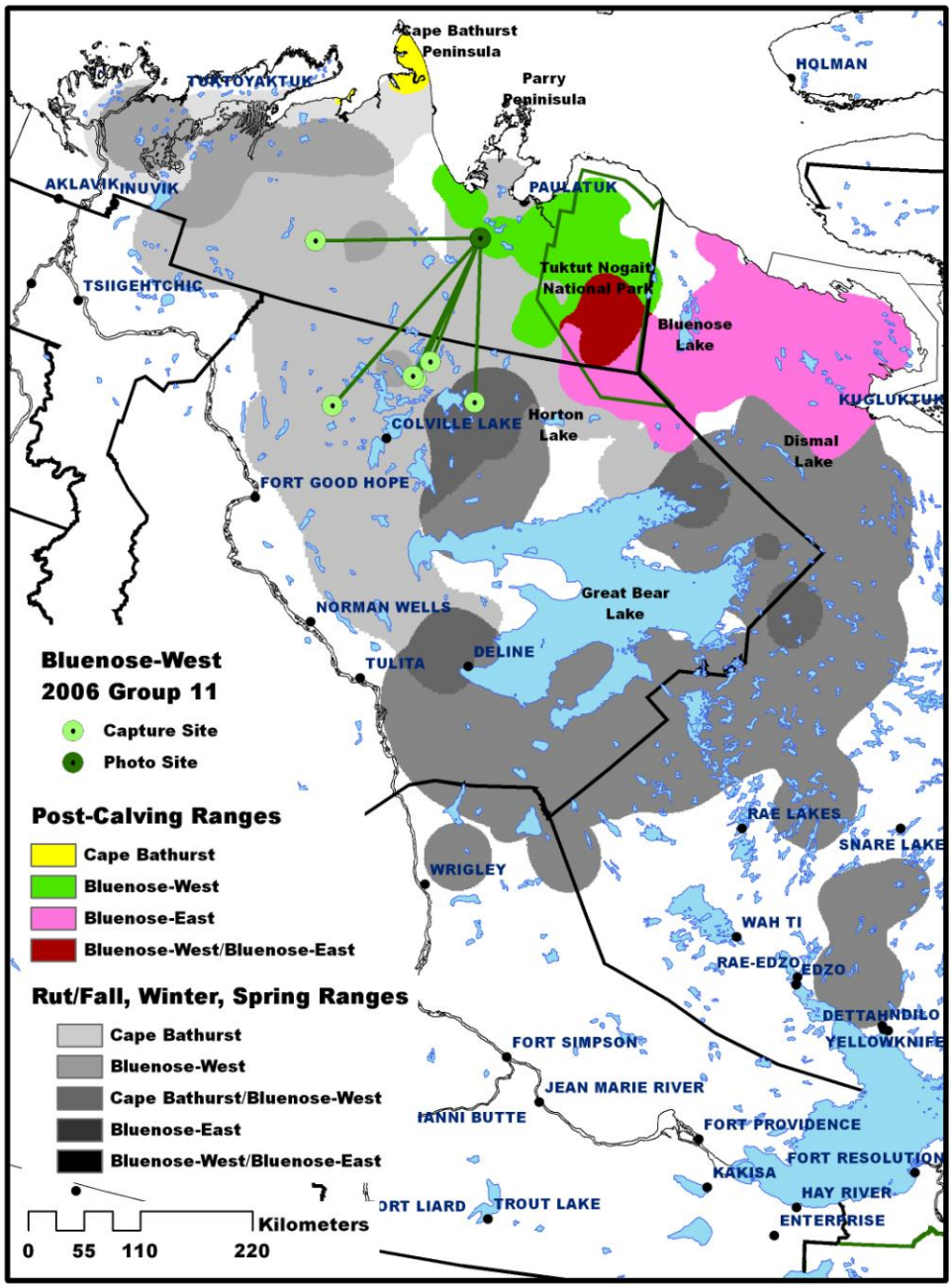

Figure 129. Bluenose-West herd 2006 group 11 contained 6 radio-collared caribou, 1,271 adults, and 525 calves. The geometric mean distance between capture sites for the radio-collared caribou was 73.0 km (4.4 to 222.7 km).

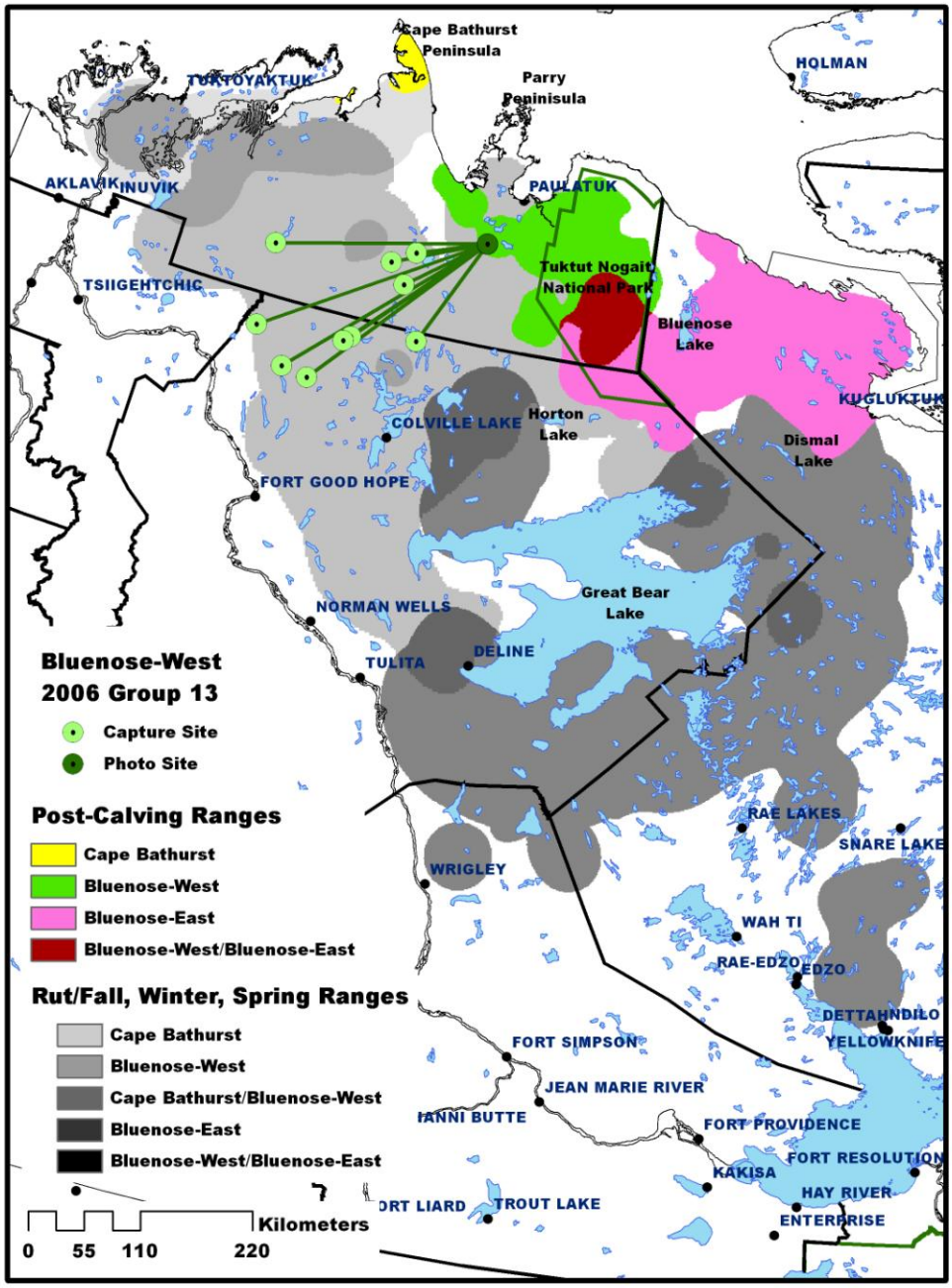

Figure 130. Bluenose-West herd 2006 group 13 contained 10 radio-collared caribou, 3,028 adults, and 947 calves. The geometric mean distance between capture sites for the radio-collared caribou was 86.1 km (8.3 to 172.0 km).

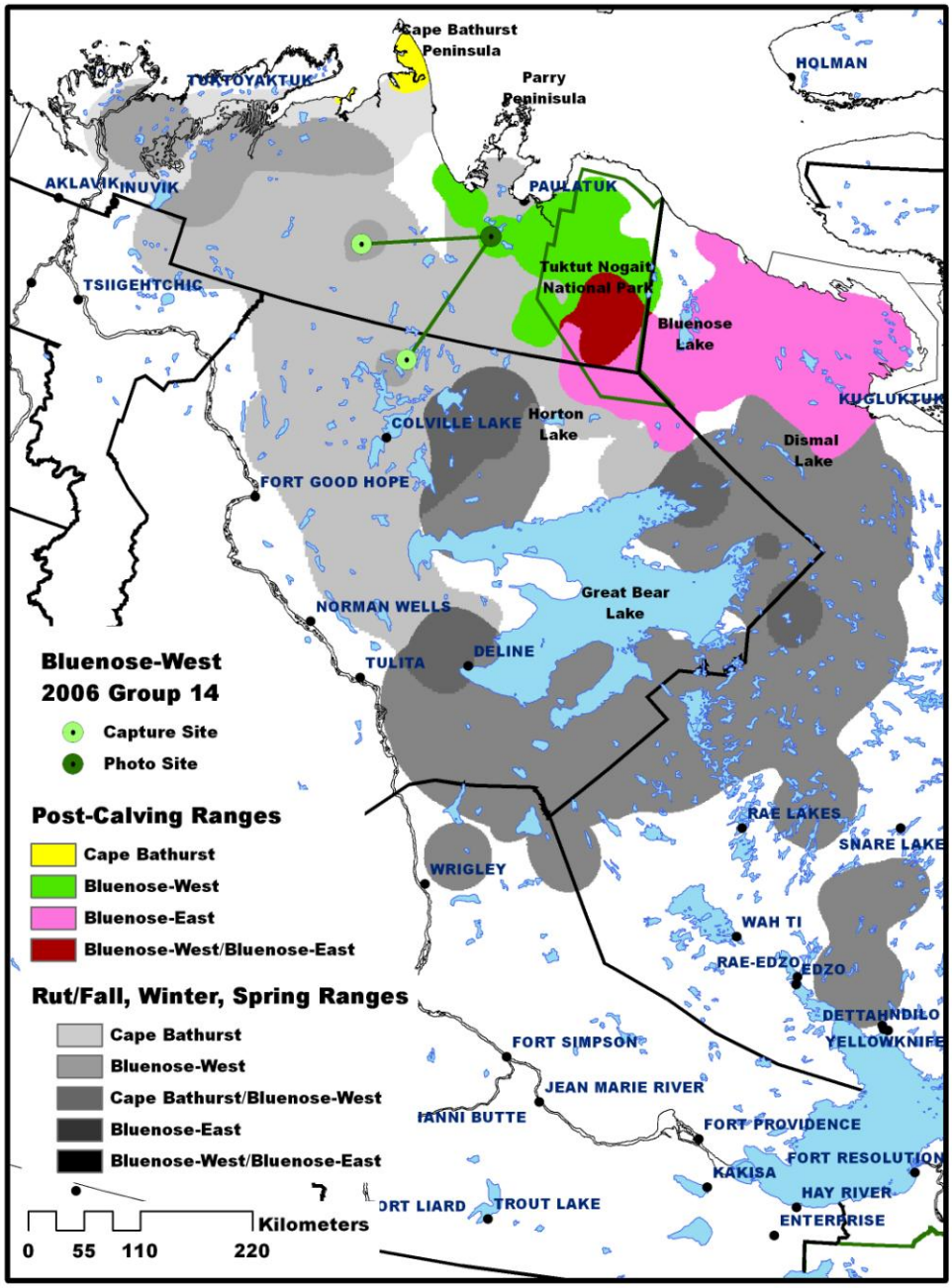

Figure 131. Bluenose-West herd 2006 group 14 contained 2 radio-collared caribou, 173 adults, and 88 calves. The distance between capture sites for the radio-collared caribou was 121.8 km.

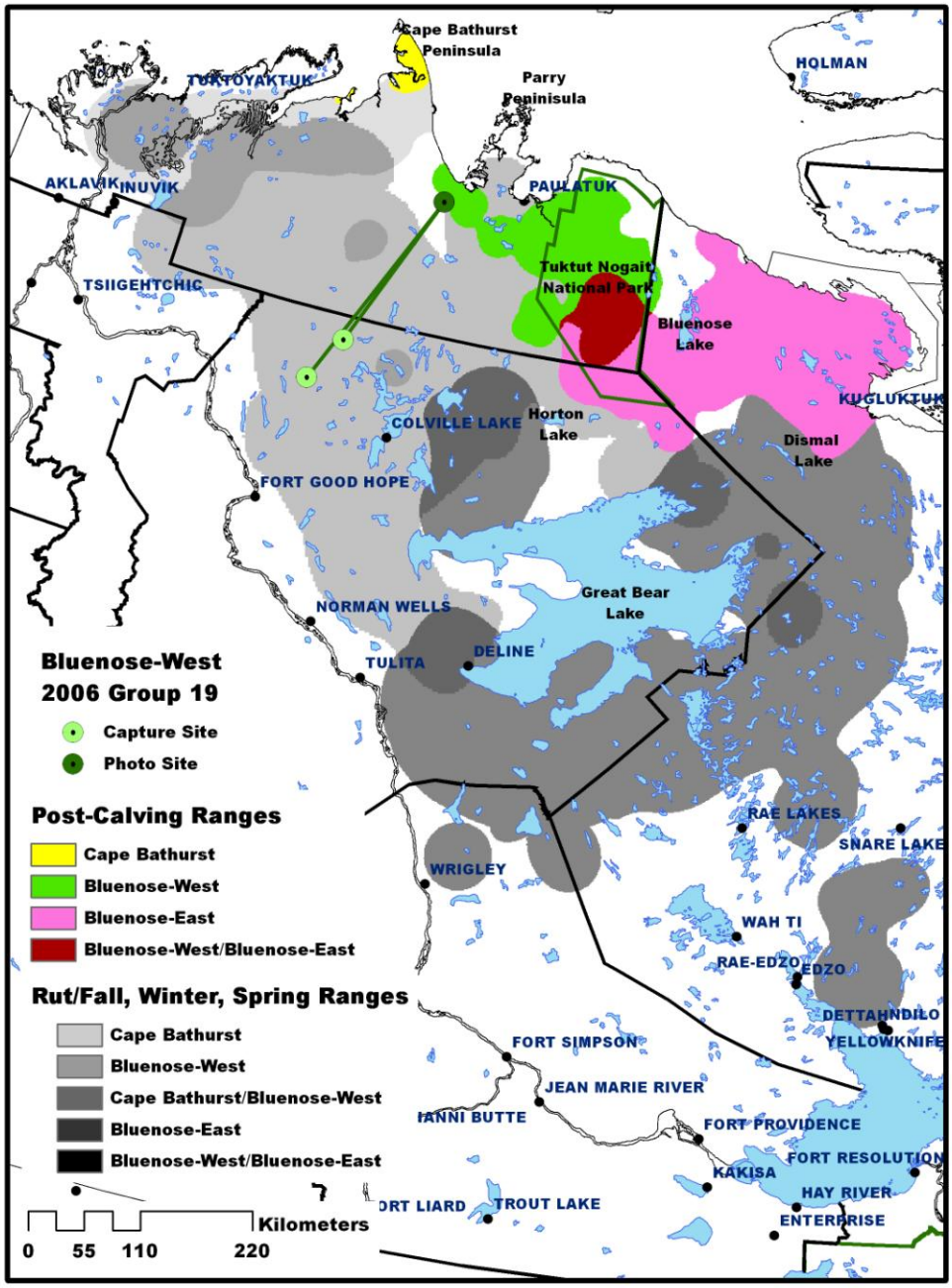

Figure 132. Bluenose-West herd 2006 group 19 contained 2 radio-collared caribou, 384 adults, and 4 calves. The distance between capture sites for the radio-collared caribou was 51.5 km.

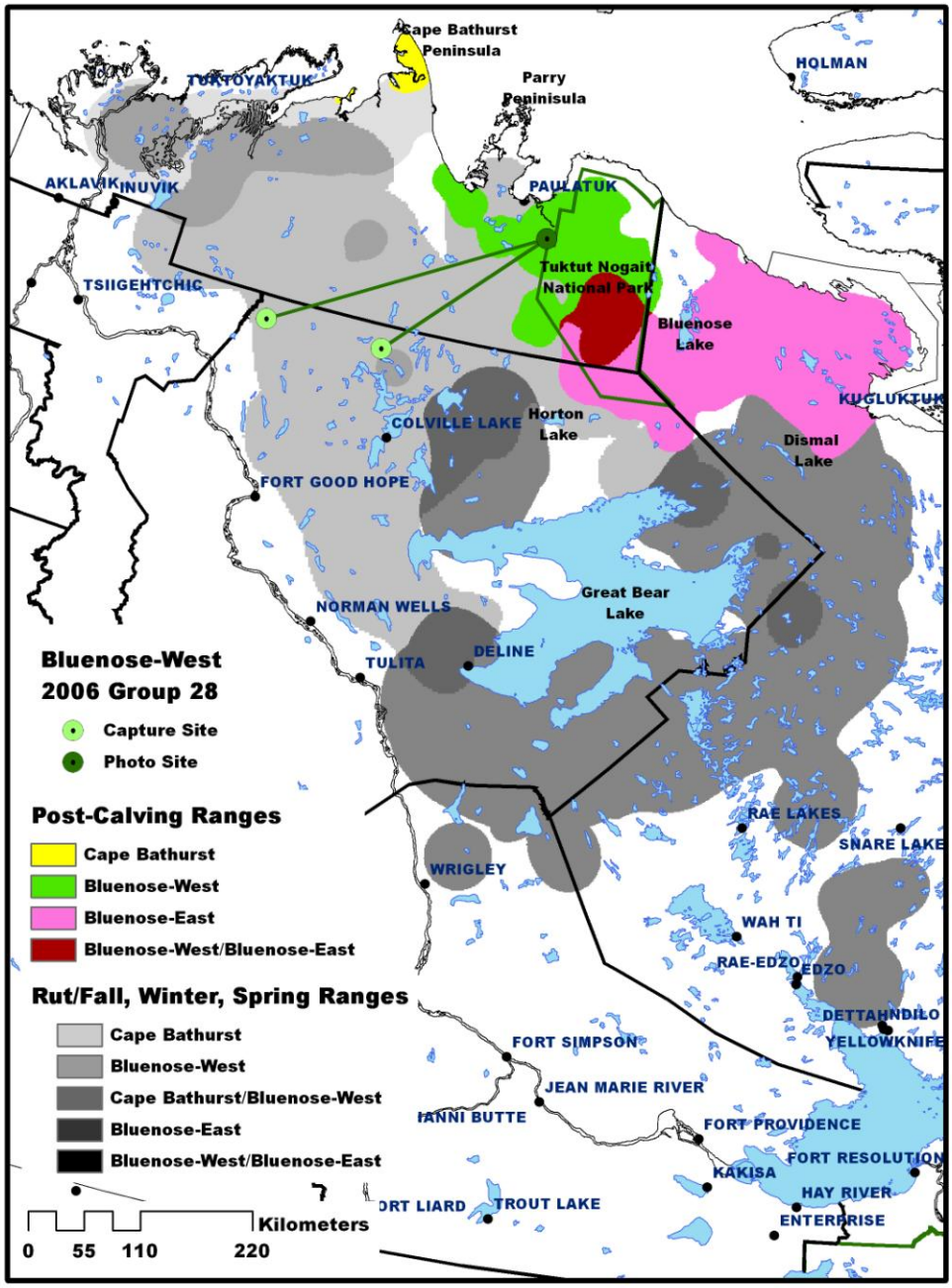

Figure 133. Bluenose-West herd 2006 group 28 contained 2 radio-collared caribou, 283 adults, and 119 calves. The distance between capture sites for the radio-collared caribou was 116.6 km.

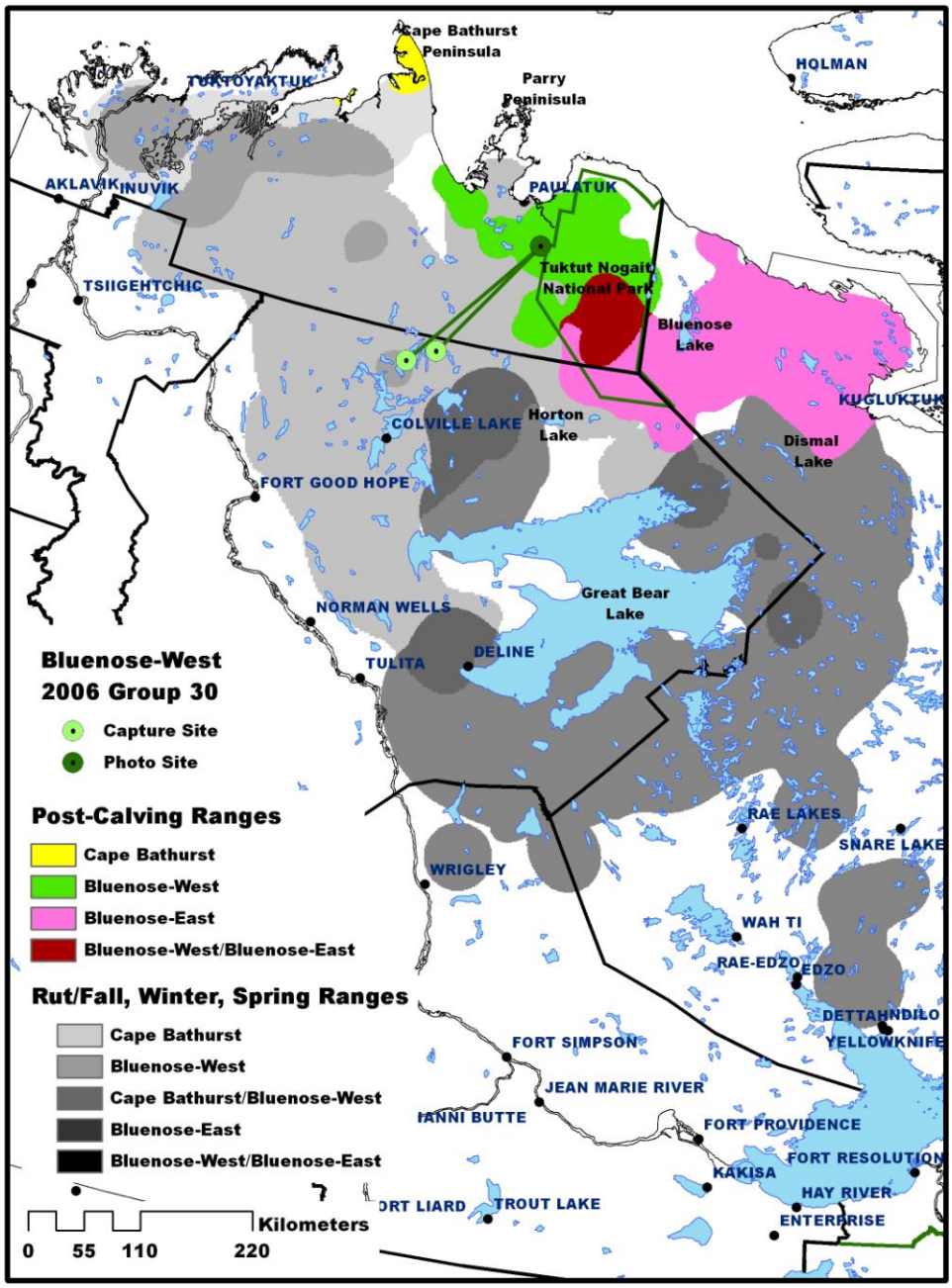

Figure 134. Bluenose-West herd 2006 group 30 contained 2 radio-collared caribou, 757 adults, and 230 calves. The distance between capture sites for the radio-collared caribou was 31.0 km.

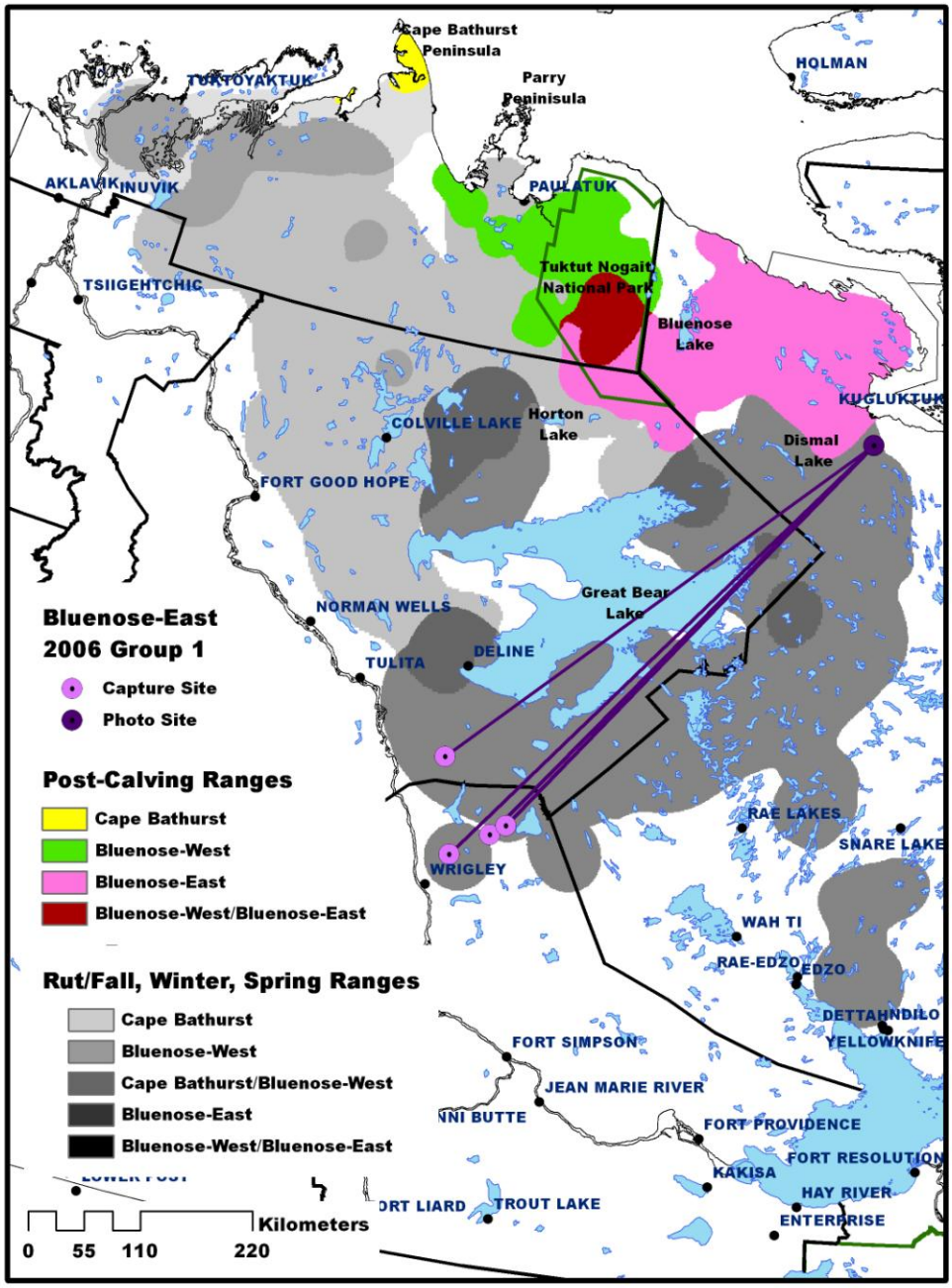

Figure 135. Bluenose-East herd 2006 group 1 contained 4 radio-collared caribou and 3,000 adults. The geometric mean distance between capture sites for the radio-collared caribou was 58.2 km (18.2 to 96.2 km).

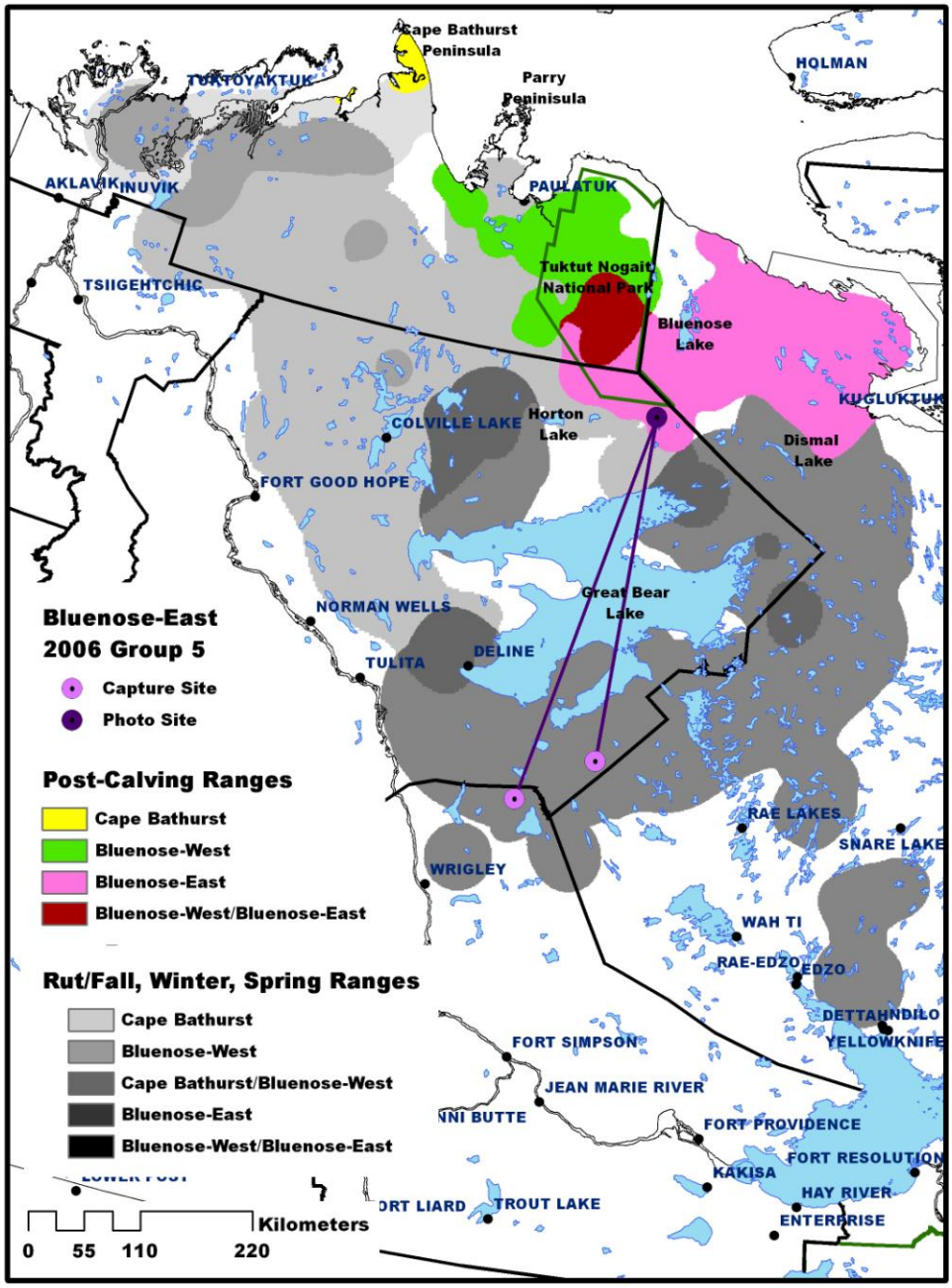

Figure 136. Bluenose-East herd 2006 group 5 contained 2 radio-collared caribou and 2,252 adults. The distance between capture sites for the radio-collared caribou was 87.6 km.

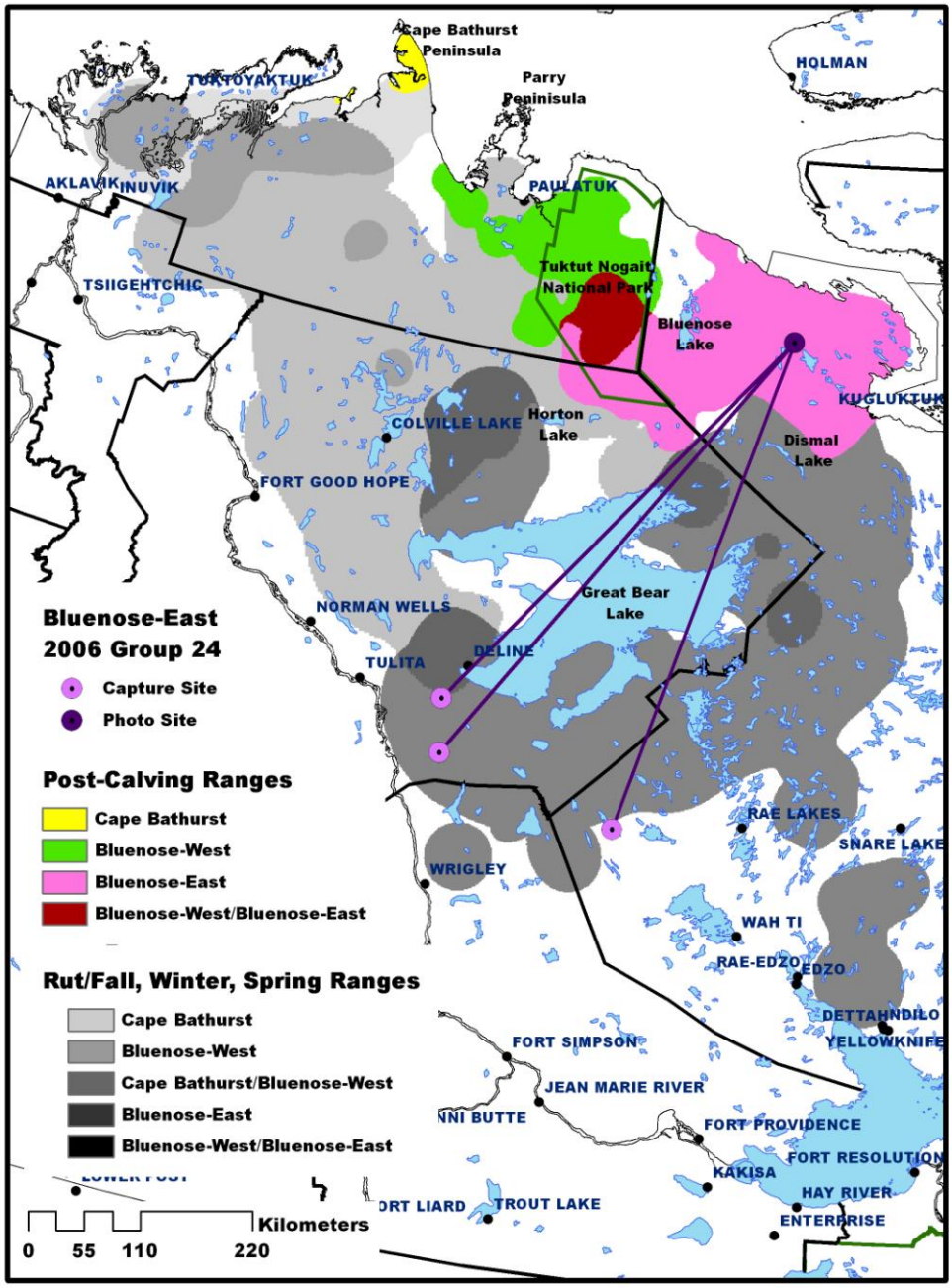

Figure 137. Bluenose-East herd 2006 group 24 contained 3 radio-collared caribou and 4,499 adults. The geometric mean distance between capture sites for the radio-collared caribou was 128.3 km (range 53.8 to 211.6 km).

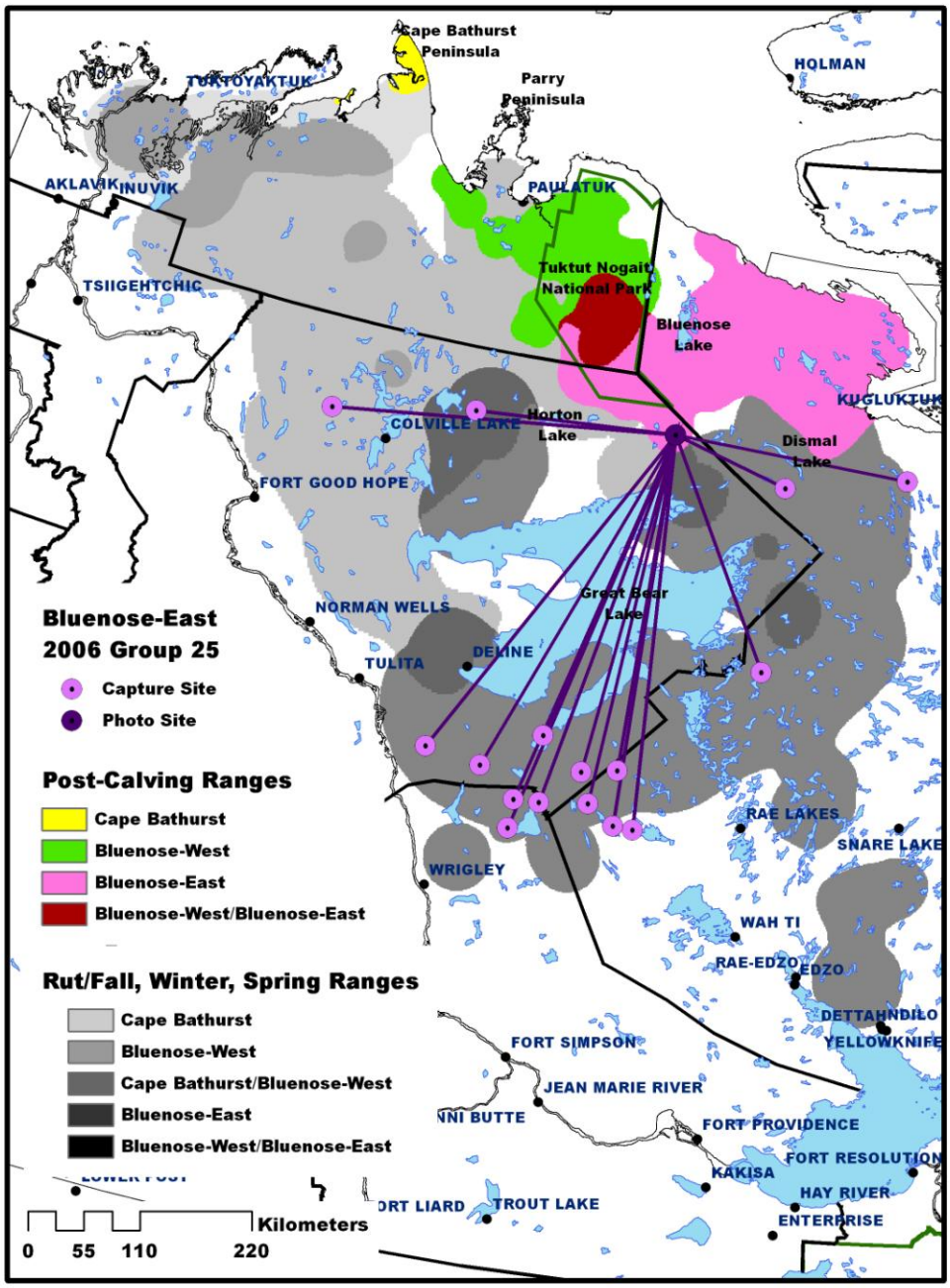

Figure 138. Bluenose-East herd 2006 group 25 contained 17 radio-collared caribou and 30,149 adults. The geometric mean distance between capture sites for 8 radio-collared caribou captured in 2005 was 178.3 km (range 32.1 to 571.4 km) while that for 9 radio-collared caribou captured in 2006 was 181.9 km (range 0 to 440.7 km). Two caribou in the latter group were captured at the same site.

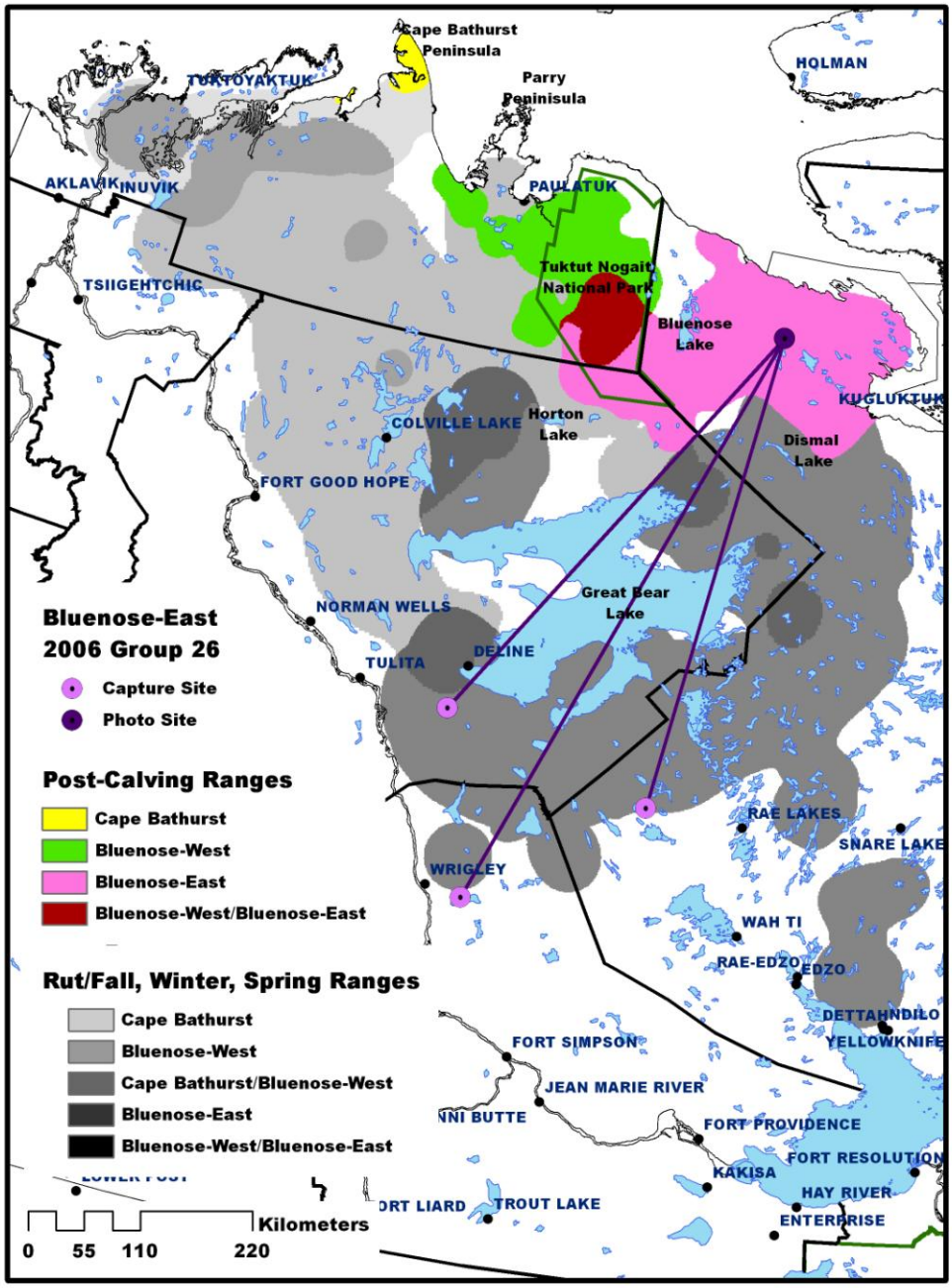

Figure 139. Bluenose-East herd 2006 group 26 contained 3 radio-collared caribou and 1,593 adults. The geometric mean distance between capture sites for the radio-collared caribou was 201.3 km (range 185.4 to 218.5 km).

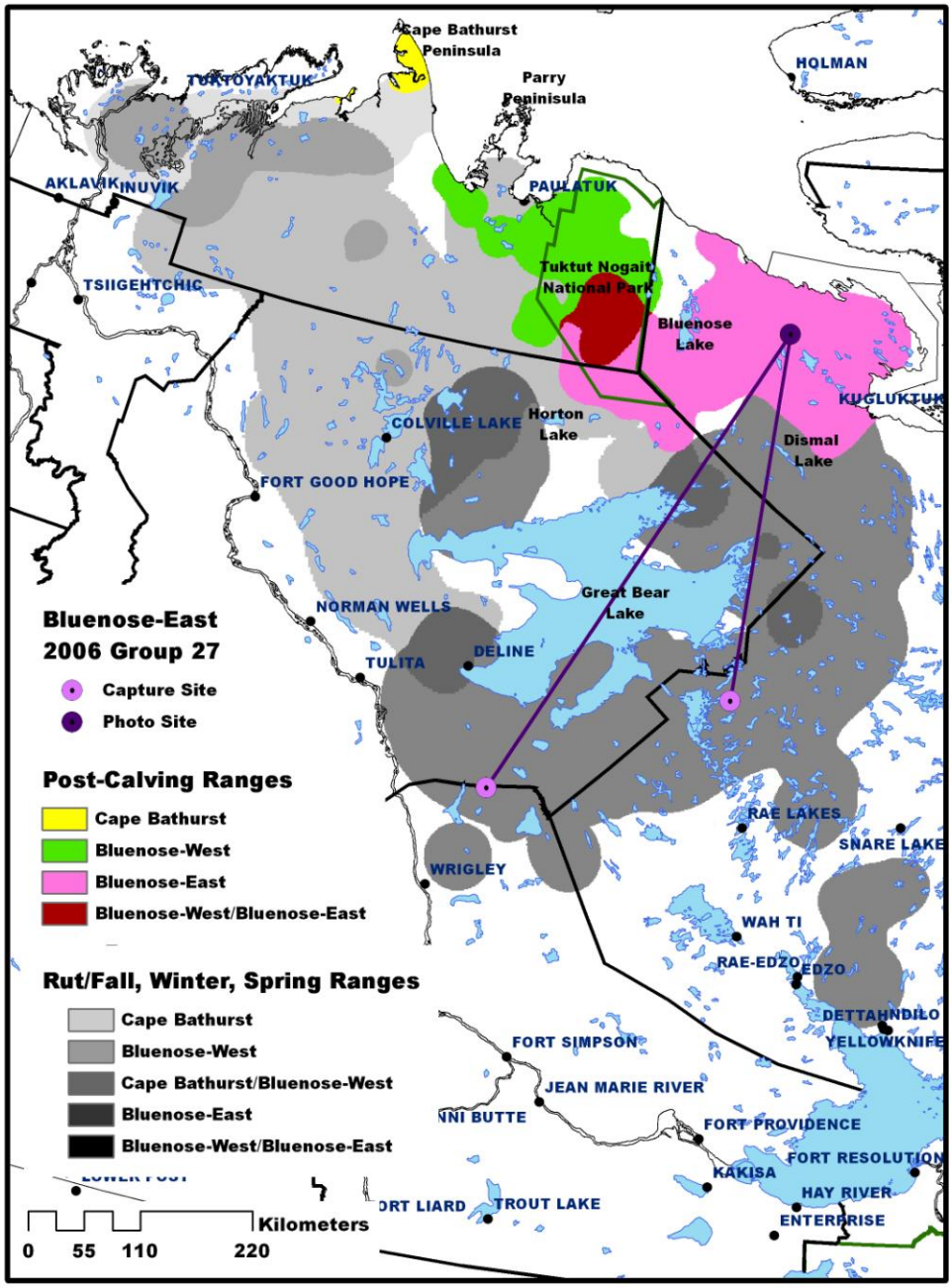

Figure 140. Bluenose-East herd 2006 group 27 contained 2 radio-collared caribou and 3,000 adults. The distance between capture sites for the radio-collared caribou was 254.8 km.

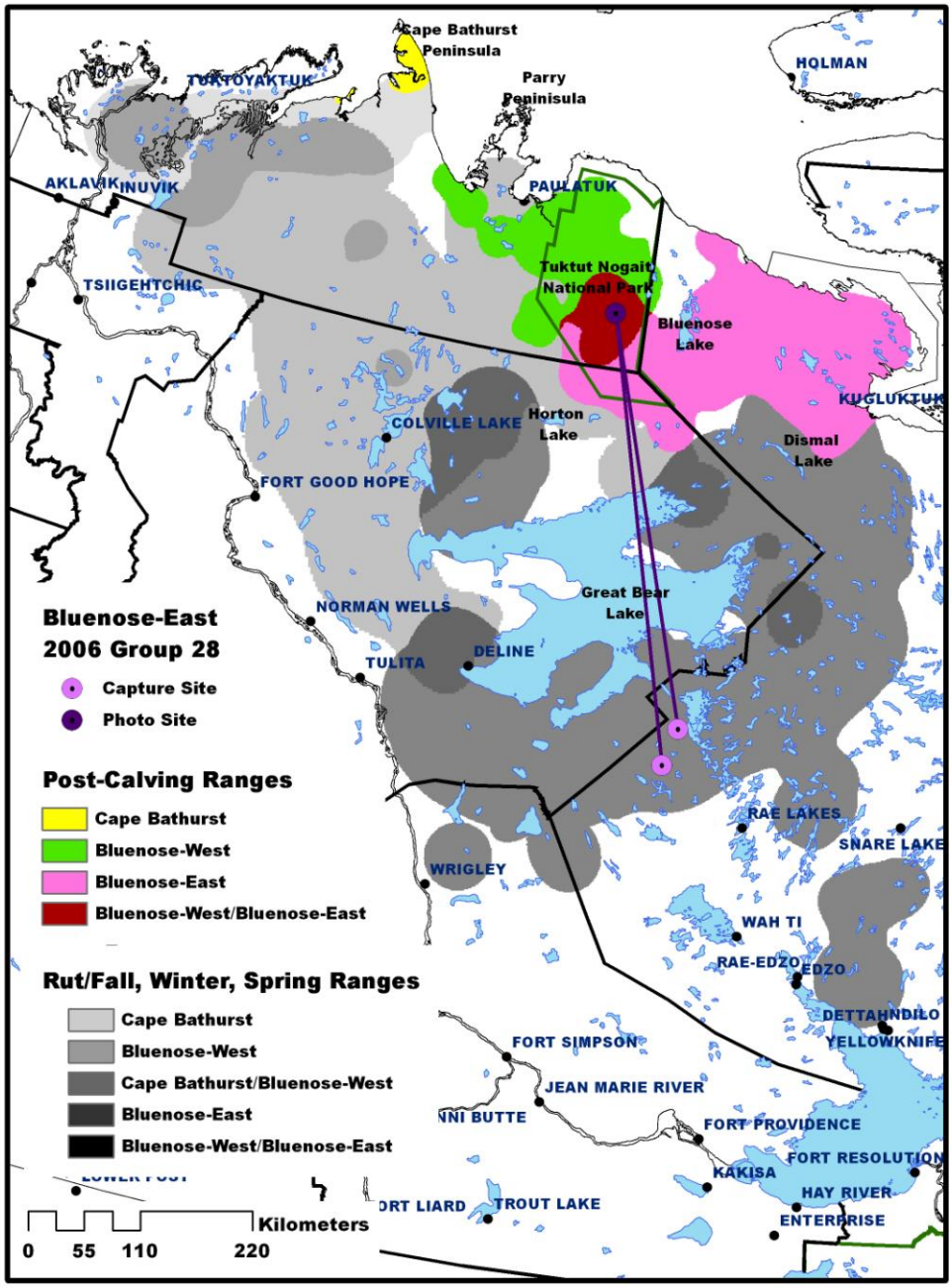

Figure 141. Bluenose-East herd 2006 group 28 contained 2 radio-collared caribou and 2,056 adults. The distance between capture sites for the radio-collared caribou was 39.3 km.

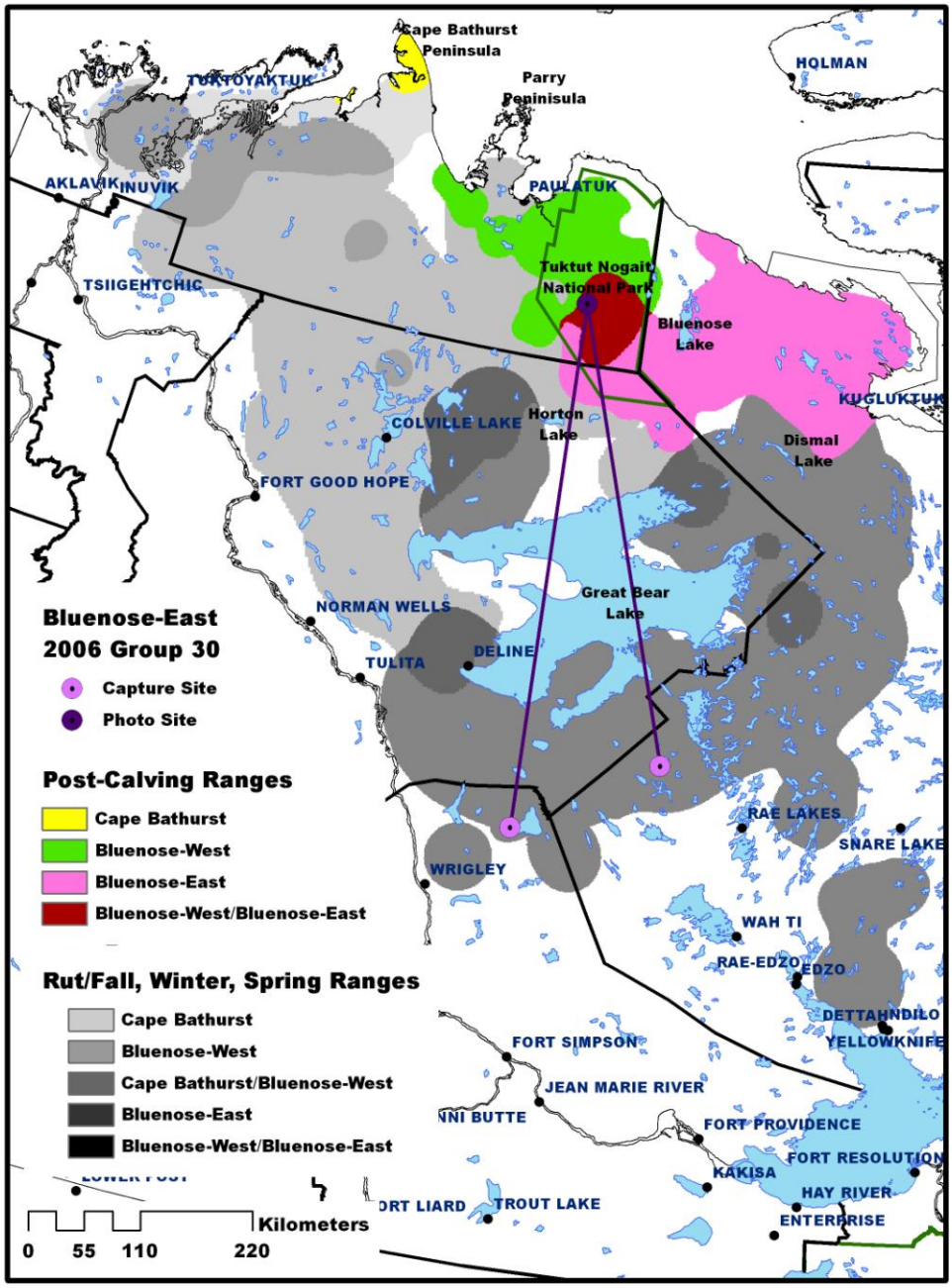

Figure 142. Bluenose-East herd 2006 group 30 contained 2 radio-collared caribou and 2,309 adults. The distance between capture sites for the radio-collared caribou was 159.7 km.