

**BARREN-GROUND CARIBOU ANALYSIS
METHODS SUMMARY REPORT
DRAFT**

Submitted to:

**Government of Nunavut
Department of Environment, Wildlife Research Branch**

Submitted by:

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1.0 INTRODUCTION

1.1 Overview

The following report provides a technical summary of the analyses conducted on barren-ground caribou telemetry data for presentation in an atlas and for map products generated for the Government of Nunavut's submission to the Nunavut Planning Commissions (NPC) land use plan. The maps and tables in this document are examples of the products to be included in the atlas being prepared for the Governments of Nunavut (GN) and Northwest Territories (GNWT).

1.2 Study Area








The study area for the atlas consists of the annual home ranges for the ten barren-ground caribou subpopulations (Ahiak, Bathurst, Beverly, Bluenose East, Bluenose West, Cape Bathurst, Dolphin and Union, Lorillard, Qamanirjuaq, and Wager Bay) found within the Northwest Territories and mainland Nunavut (Figure1). The majority of the study area falls within the Northwest Territories and Nunavut, but also extends south into Manitoba, Saskatchewan and Alberta. The NPC analyses were generated for the following eight subpopulations:

1. Ahiak
2. Bathurst
3. Beverly
4. Bluenose East
5. Bluenose West
6. Lorillard
7. Qamanirjuaq
8. Wager Bay

Figure 1

Study Area

Legend

-  Community
-  Tree Line
-  Road
-  River/Stream
-  Lake
-  Study Area
- Elevation (m)**
 2,200
 0

Area of Detail



0 50 100 150 200
Kilometres

Projection:
Canada Lambert Conformal Conic

Data Sources:
Government of Nunavut, Government of Northwest Territories, Natural Resources Canada, GeoBase®, National Topographic Database



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2.0 DATA LAYERS

Different types of spatial data were compiled to cover the full extent of the study area. Telemetry data, showing the caribou locations over time forms the main dataset for the analyses. Base data (at various scales) and anthropogenic information were also compiled to facilitate the mapping and to provide a time snapshot of what the current conditions are on the landscape.

2.1 Caribou Telemetry Data

Telemetry points, collected at various intervals over the past 25 years, were supplied by the Wildlife Division of GN's Department of Environment and GNWT's Department of Environment and Natural Resources. Both satellite and GPS locations, from fourteen different datasets, were imported into an Access database and normalized into a common data structure (Table 1).

Table 1. Normalized Telemetry Data Structure

Field Name	Data Type	Description
CollarID	Number	A unique ID that is used to link back to a master list of collars
PTT	Text	Unique identifier for the collar
AnimalID	Text	Unique identifier for the collared animal – with dataset prefix
Source_AnimalID	Text	Unique identifier for the collared animal as supplied in the dataset
Herd_Code	Text	Two letter code for the each subpopulation
Herd	Text	Subpopulation (herd) name
Herd_Source	Text	The method for identifying the subpopulation the animal belongs to
Latitude	Number	Latitude coordinate of the location (measured in decimal degrees)
Longitude	Number	Longitude coordinate of the location (measured in decimal degrees)
Radian_Lat	Number	Latitude coordinate of the location (measured in radians)
Radian_Lon	Number	Longitude coordinate of the location (measured in radians)
Km	Number	Distance between the location and the previous location in kilometres
DateDiff	Number	Time difference between the location and the previous location
Km_per_day	Number	Movement rate calculated from the Km and DateDiff attributes
FixDate	Date/Time	Date the location was acquired
FixTime	Date/Time	Time that the location was acquired
FixDateTime	Date/Time	Date and time of location
Yr	Number	Year of location
Julian	Number	Julian date
Season	Text	Season that the location falls within
KLC_SPRM	Number	Key life cycle attribute – identifies if the location is within the spring migration – year by year analysis for each collar
KLC_CALV	Number	Key life cycle attribute – identifies if the location is consistent with calving behaviour – year by year analysis for each collar
KLC_LSF	Number	Key life cycle attribute - identifies if the location is consistent with late summer feeding behaviour – year by year analysis for each collar
KLC_FALLMA	Number	Key life cycle attribute – identifies if the location is within the fall migration pattern, before rut – year by year analysis for each collar
KLC_FALLMB	Number	Key life cycle attribute – identifies if the location is within the fall migration

Field Name	Data Type	Description
		pattern, after rut – year by year analysis for each collar
Comments	Text	
CollarType	Text	The type of collar deployed (with GPS or Satellite)
Jurisdiction	Text	The jurisdiction that deployed the collar (GNWT or GN)
Source	Text	Source dataset that the location came from

The data were then examined and processed as per the following tasks:

- The non-unique animal IDs from different data sources were resolved.
- The different sample intensities were normalized to only include daily locations (i.e., removal of multiple locations per day).¹
- The data for each collar were assigned to the appropriate subpopulation using one of two methods:
 1. If the collar was included in the 2010 or 2011 Nagy analysis (Nagy 2011) it was assigned to the same subpopulation identified by Nagy.
 2. If the collar was newer than the Nagy analysis, its data were examined spatially and assigned to the subpopulation that best fits its movement based on a visual inspection of the data. If there was any uncertainty to which subpopulation the animal belonged to, it was assigned to an 'unknown' class and not included in the analyses.
- The locations for each subpopulation were assigned a season attribute based on date ranges specific to each subpopulation.

The resulting telemetry data provided the starting point for the density and key life cycles analyses described in Section 3.0. Table 2 lists the subpopulations with a breakdown of each of the data sources contributing data for that subpopulation, the number of collars and the date range applicable to each source dataset.

¹ The first occurrence in the data table for a given date was the one maintained.

Table 2. Summary of Telemetry Information by Subpopulation and Source

Subpopulation	Source Dataset	Number of Collars	Date Range
Ahiak	GN_BakerLake_2008_2013	22	2008-2012
	GNWT_Ahiak_2001_2009	2	2001-2009
	GNWT_Beverly_Ahiak_2006_2012	7	2006-2012
Bathurst	GNWT_Bathurst_GPS_2008_2012	34	2008-2012
	GNWT_Bathurst_Sat_1996_2010	44	1996-2010
	GNWT_Beverly_Ahiak_2006_2012	2	2006-2012
	GNWT_BluenoseEast_GPS_2006_2013	2	2006-2012
	GNWT_BluenoseEast_Satellite_2005_2013	1	2005-2012
Beverly	GNWT_Ahiak_2001_2009	10	2001-2009
	GNWT_Bathurst_Sat_1996_2010	1	1996-2010
	GNWT_Beverly_Ahiak_2006_2012	55	2006-2012
	GNWT_QueenMaudGulf_1996_1998	3	1996-1998
Bluenose East	GNWT_Bathurst_GPS_2008_2012	4	2008-2012
	GNWT_Bathurst_Sat_1996_2010	5	1996-2010
	GNWT_BLE_BLW_CB_Sat_1996_2013	10	1996-2012
	GNWT_BluenoseEast_GPS_2006_2013	68	2006-2012
	GNWT_BluenoseEast_Satellite_2005_2013	69	2005-2012
	GNWT_DolphinUnion_1987_2006	1	1987-2006
Bluenose West	GNWT_BLE_BLW_CB_Sat_1996_2013	78	1996-2012
	GNWT_BluenoseWest_CapeBathurst_GPS_2006_2013	57	2006-2012
Cape Bathurst	GNWT_BLE_BLW_CB_Sat_1996_2013	25	1996-2012
	GNWT_BluenoseWest_CapeBathurst_GPS_2006_2013	61	2006-2012
Dolphin Union	GNWT_DolphinUnion_1987_2006	44	1987-2006
Lorillard	GN_BakerLake_2008_2013	9	2008-2012
	GN_Lorillard_1999_2006	15	1996-2006
	GN_Qaminirjuaq_1993_2013	2	1993-2012
	GN_WagerBay_2000_2006	2	2000-2006
Qamanirjuaq	GN_Qaminirjuaq_1993_2013	89	1993-2012
	GNWT_Beverly_Ahiak_2006_2012	3	2006-2012
Wager Bay	GN_BakerLake_2008_2013	2	2008-2013
	GN_Lorillard_1999_2006	2	1999-2006
	GN_WagerBay_2000_2006	12	2000-2006

2.2 Caribou Seasons

The seasons identified in the Nagy analyses (Nagy 2011) were correlated for each subpopulation and grouped into nine seasons for this project: spring migration, calving, post-calving, summer, late summer, fall migration – pre-breeding, rut/breeding, fall migration – post-breeding, and winter. The date ranges defining the season for each subpopulation are outlined in Table 3. Based on a review of the movement patterns, some of the date ranges for Ahiak, Lorillard, and Wager Bay were refined from the Nagy seasons based on the animal movements.

Table 3. Season Date Ranges by Subpopulation

	Season	Spring migration	Calving	Post-calving	Summer	Late Summer	Fall migration, pre-breeding	Rut/Breeding	Fall migration, post-breeding	Winter
	Subpopulation									
Date Ranges	Ahiak	Apr 6 - Jun 12	Jun 13 - 25	Jun 26 - Jul 12	Jul 13 - Aug 12	Aug 13 - Sep 21	Sep 22 - Oct 22	Oct 23 - Nov 8	Nov 9 - Dec 15	Dec 16 - Apr 5
	Bathurst	Apr 20 - Jun 1	Jun 2 - 16	Jun 17 - 28	Jun 29 - Aug 17	Aug 18 - Sep 6	Sep 7 - Oct 16	Oct 17 - 31	Nov 1 - 30	Dec 1 - Apr 19
	Beverly	Apr 10 - Jun 5	Jun 6 - 19	Jun 20 - Jul 8	Jul 9 - Aug 12	Aug 13 - Sep 11	Sep 12 - Oct 20	Oct 21 - Nov 3	Nov 4 - Dec 15	Dec 16 - Apr 9
	Bluenose East	Apr 10 - May 27	May 28 - Jun 20	Jun 21 - Jul 3	Jul 4 - Aug 12	Aug 13 - Sep 6	Sep 7 - Oct 11	Oct 12 - Nov 4	Nov 5 - Dec 25	Dec 26 - Apr 9
	Bluenose West	Apr 25 - May 28	May 29 - Jun 23	Jun 24 - Jul 3	Jul 4 - Aug 2	Aug 3 - 22	Aug 23 - Oct 12	Oct 13 - Nov 7	Nov 8 - 30	Dec 1 - Apr 24
	Cape Bathurst	Apr 15 - May 25	May 26 - Jun 16	Jun 17 - Jul 3	Jul 4 - Aug 17	Aug 18 - Sep 6	Sep 7 - Oct 9	Oct 10 - 31	Nov 1 - 30	Dec 1 - Apr 14
	Dolphin and Union	Apr 25 - May 28	May 29 - Jun 23	Jun 24 - Jul 3	Jul 4 - Aug 2	Aug 3 - 22	Aug 23 - Oct 12	Oct 13 - Nov 7	Nov 8 - 30	Dec 1 - Apr 24
	Lorillard	Apr 5 - May 28	May 29 - Jun 25	Jun 26 - Jul 13	Jul 14 - Aug 12	Aug 13 - Sep 21	Sep 22 - Oct 22	Oct 23 - Nov 8	Nov 9 - Dec 15	Dec 16 - Apr 4
	Qamanirjuaq	Apr 15 - Jun 8	Jun 9 - 22	Jun 23 - Jul 3	Jul 4 - Aug 22	Aug 23 - Sep 16	Sep 17 - Oct 18	Oct 19 - Nov 6	Nov 7 - Dec 15	Dec 16 - Apr 14
	Wager Bay	Apr 1 - May 29	May 30 - Jun 25	Jun 26 - Jul 12	Jul 13 - Aug 12	Aug 13 - Sep 21	Sep 22 - Oct 22	Oct 23 - Nov 8	Nov 9 - Dec 15	Dec 16 - Mar 31

3.0 ANALYSIS METHODS

The telemetry data were analysed for each season and subpopulation. Density maps, derived from a kernel density analysis on the location data (points), were developed for the calving, post-calving, summer, late summer, rut/breeding and winter seasons. Corridor (high movement rate) analyses were conducted on the paths (walk lines between locations) for spring, fall – pre-breeding, and fall – post-breeding migrations. The resulting derivative datasets were then used to define the core seasonal ranges. These analyses were developed separately for each subpopulation and the results merged together to derive a study area wide dataset depicting regional distribution. Where there is overlap the highest density took priority.

3.1 Migration Corridors

The migration key life cycles represent periods of high movement. They occur in the spring when the caribou are travelling to the calving grounds and in the fall when they are travelling to their wintering grounds. A detailed analysis, based on movement rates, was conducted on each collar for each year to identify the actual start and stop dates for these periods. Yearly migration corridors were derived from transect kernel densities for individual populations for each of the migration seasons. The search radius for the corridor analysis was 20 kilometres, which is an estimate of the maximum line-of-sight that a caribou would have on relatively flat terrain (Caslys 2010). To bring the individual migration density layers to a common scale, they were reclassified into the utilization distribution classes used in the seasonal home range layers. Higher use areas, from a year-to-year basis, were determined through the addition of yearly corridor layers.

3.2 Kernel Density

The density layers (based on a kernel analysis) were derived from the caribou telemetry point datasets to identify seasonal home ranges (the area the population occupies within the specified date range). The density analysis used a search radius of 11 kilometres. This distance has found to be the threshold for avoidance behaviour for caribou related to human disturbance (Boulanger, Poole, Gunn & Wierzchowski 2012). The density surface was then grouped into classes (80%, 90%, 95%, and 100%) based on the probability of finding a caribou in the range. These probability classes represent the utilization distribution within the seasonal home range.

Areas with a higher utilization distribution are less critical because they encompass a larger extent of the landscape. For example, within a home range there is a 100% probability of caribou being present but much of the range is not being heavily utilized at any given time. Key habitats are those with higher densities of caribou. They represent a smaller proportion of the landscape and, as a result, have lower utilization distribution values when compared to the entire home range. These smaller areas are where the higher densities of caribou are found during the specified season.

3.3 Core Seasonal Ranges

Core seasonal ranges were determined for the each of the nine seasons for each subpopulation. The migratory seasons (spring and fall migrations) use the 80% utilization distribution boundary to define the core seasonal range. The other seasonal ranges are based on a modified version of the 95% utilization distribution boundary. To remove outliers, areas within the 95% class had to surround an area of higher density. The following geoprocesses were then applied to connect individual patches of habitat, yielding contiguous polygons:

- the individual polygons were buffered by a distance of 11 kilometres;
- the polygons, together with the 11 kilometre buffer zone, were dissolved; and

- a negative buffer of 11 kilometres was then applied to reduce the size of the polygon back to the 95% class extent.

3.4 Key Access Corridors

Key access corridors represent the core migratory ranges within the core post-calving range that fall outside the core calving range. These analyses were not generated for the Bluenose West, Cape Bathurst, or Dolphin and Union subpopulations.

4.0 MAP EXAMPLES

The following maps provide examples of each analysis type:

- Figure 2. Kernel Density Example – Bluenose East – Winter (Dec 26 – Apr 9)
- Figure 3. Merged Kernel Density Example – All Subpopulations, Seasonal Land Use - Winter
- Figure 4. Migration Corridor Example – Bluenose East Spring Migration Corridors (Apr 10 – May 27)
- Figure 5. Core Seasonal Range Example – Bluenose East – Winter (Dec 26 – Apr 9)
- Figure 6. Key Access Corridor Example – Qamanirjuaq

Figure 2
Kernel Density Example
Bluenose East - Winter
(Dec 26 - Apr 9)

Legend

- Community
- ▲ Tree Line
- River/Stream
- All-season Road
- - - Winter Road
- Lake
- ▭ Annual Home Range*
- Utilization Distribution (%)
- 50
- 80
- 90
- 95
- 100
- ↑ Increasing Density

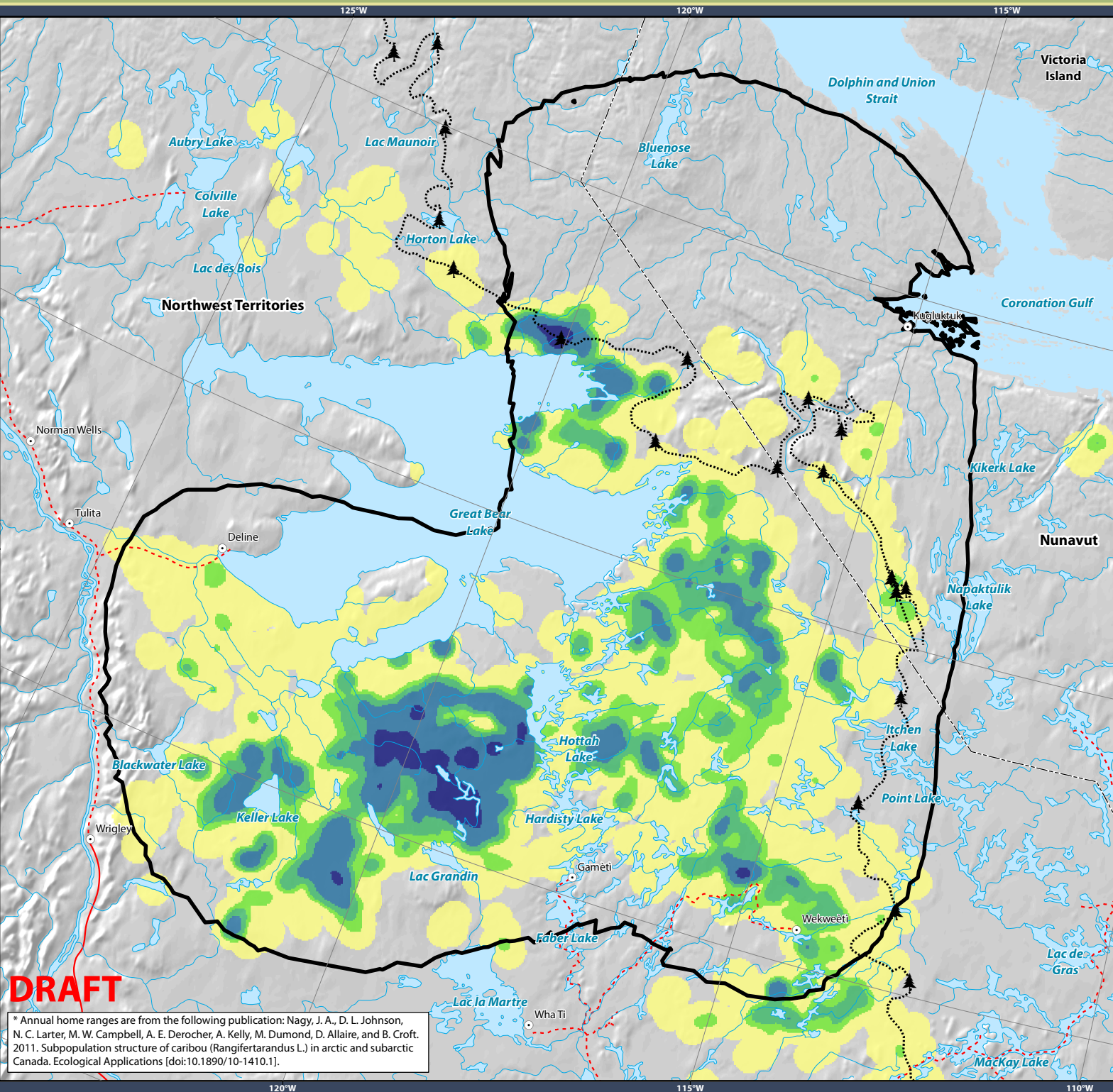


Projection:
Canada Lambert Conformal Conic

Data Sources:
Government of Nunavut, Government of Northwest Territories, Natural Resources Canada, GeoBase®, National Topographic Database



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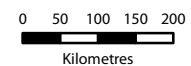
* Annual home ranges are from the following publication: Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft. 2011. Subpopulation structure of caribou (*Rangifer tarandus* L.) in arctic and subarctic Canada. *Ecological Applications* [doi:10.1890/10-1410.1].

Figure 3
Merged Kernel Density
Example - All Subpopulations
Seasonal Land Use
Winter

Legend

- Community
 - ▲▲ Tree Line
 - Road
 - ~ River/Stream
 - ◡ Lake
 - ▭ Study Area
 - Utilization Distribution (%)*
 - 80
 - 90
 - 95
 - 100
- ↑ Increasing Density

Area of Detail

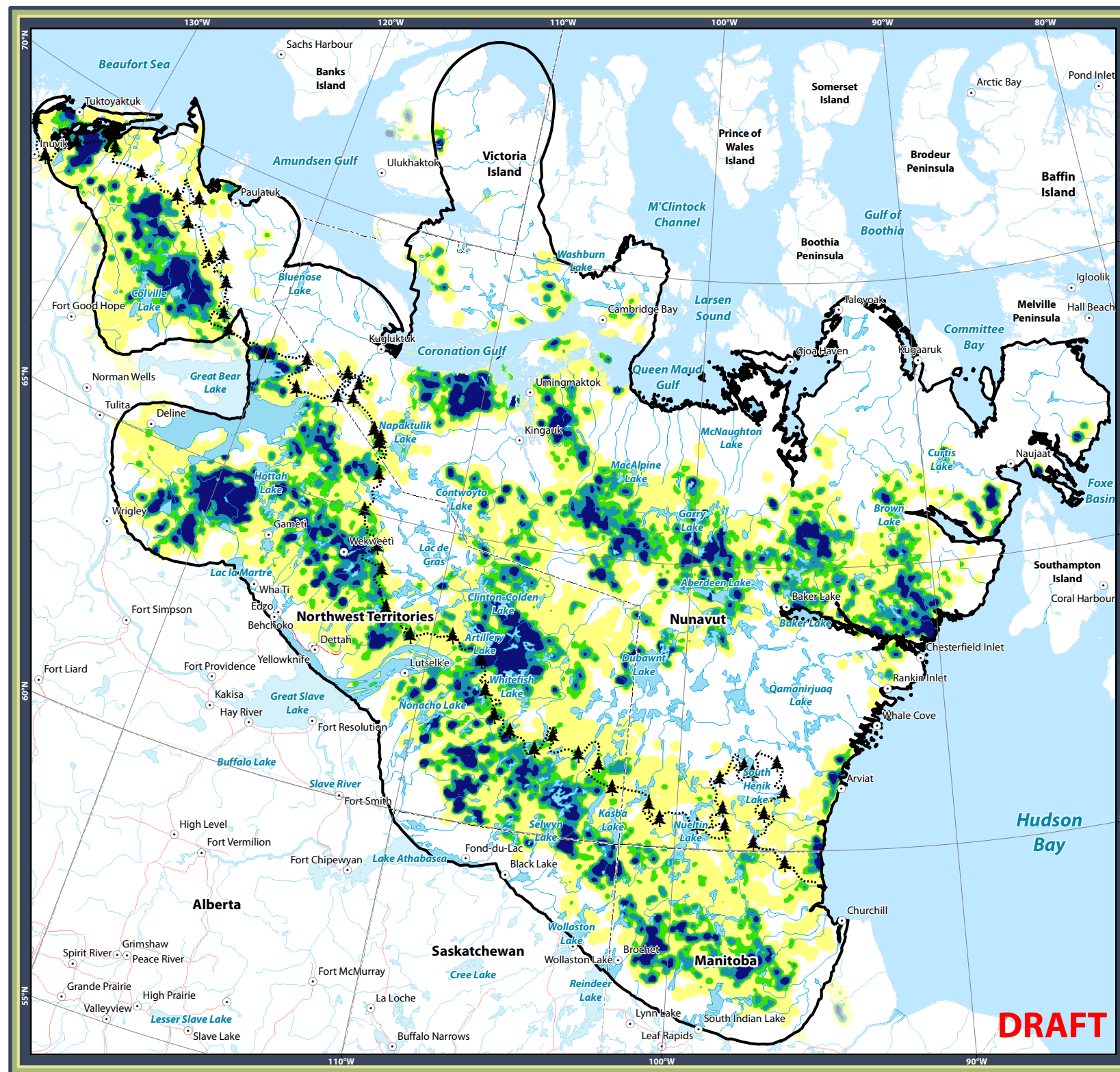


Projection:
 Canada Lambert Conformal Conic

Data Sources:
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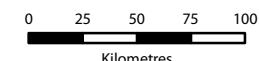
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Figure 4
Migration Corridor Example
Bluenose East
Spring Migration Corridors
(Apr 10 - May 27)

Legend

- Community
- ▲ Tree Line
- River/Stream
- All-season Road
- - - Winter Road
- Lake
- ▭ Annual Home Range*
- ▭ Core Seasonal Range
- Utilization Distribution (%)
- 50
- 80
- 90
- 95
- 100
- ↑ Increasing Density

Area of Detail



Projection:
 Canada Lambert Conformal Conic

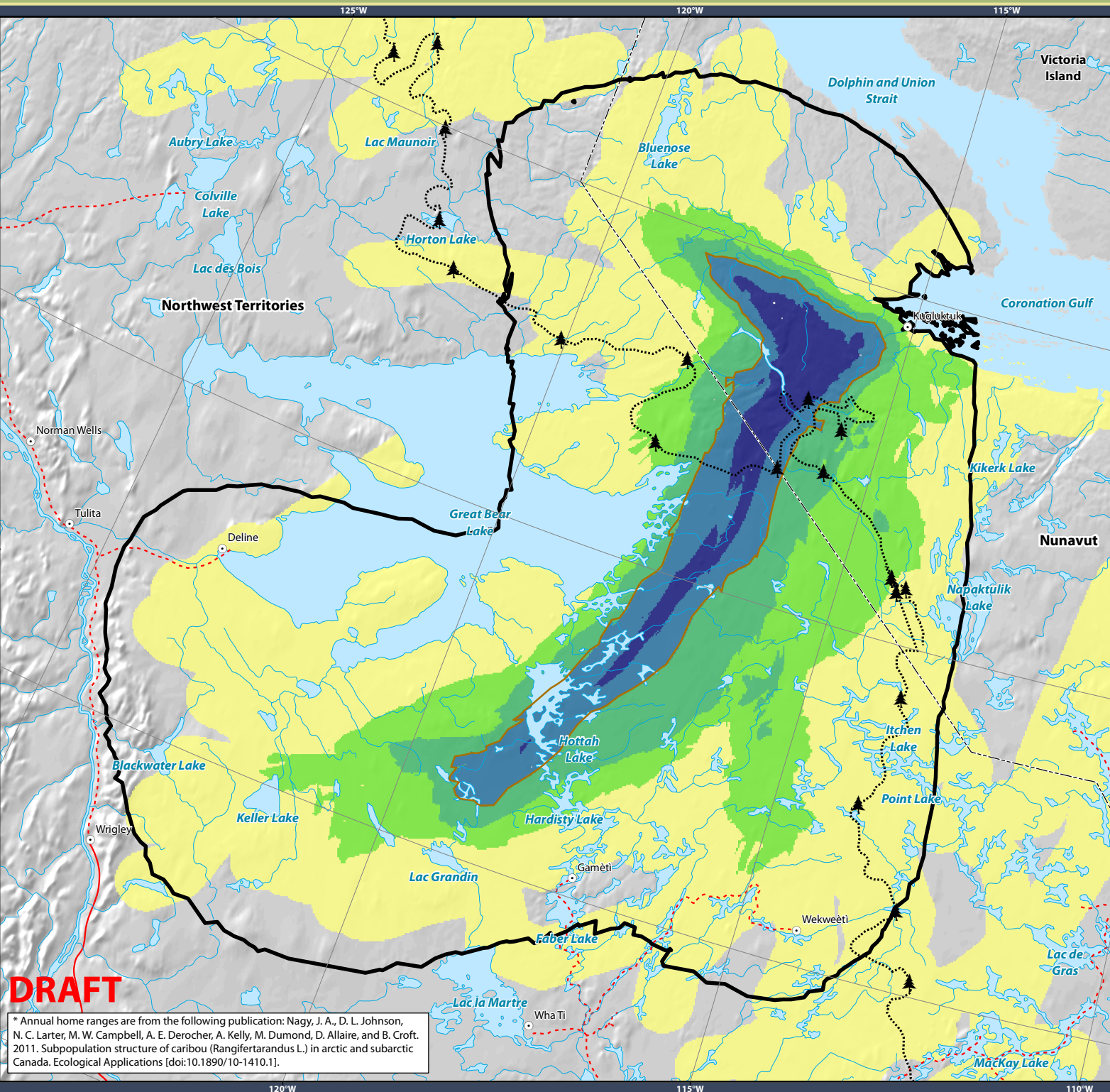
Data Sources:

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Figure 5
Core Seasonal Range
Example - Bluenose East
Winter (Dec 26 - Apr 9)

Legend

- Community
- ▲▲ Tree Line
- River/Stream
- All-season Road
- - - Winter Road
- Lake
- ▭ Annual Home Range*
- ▨ Core Seasonal Range
- Utilization Distribution (%)
- 50
- 80
- 90
- 95
- 100
- ↑ Increasing Density

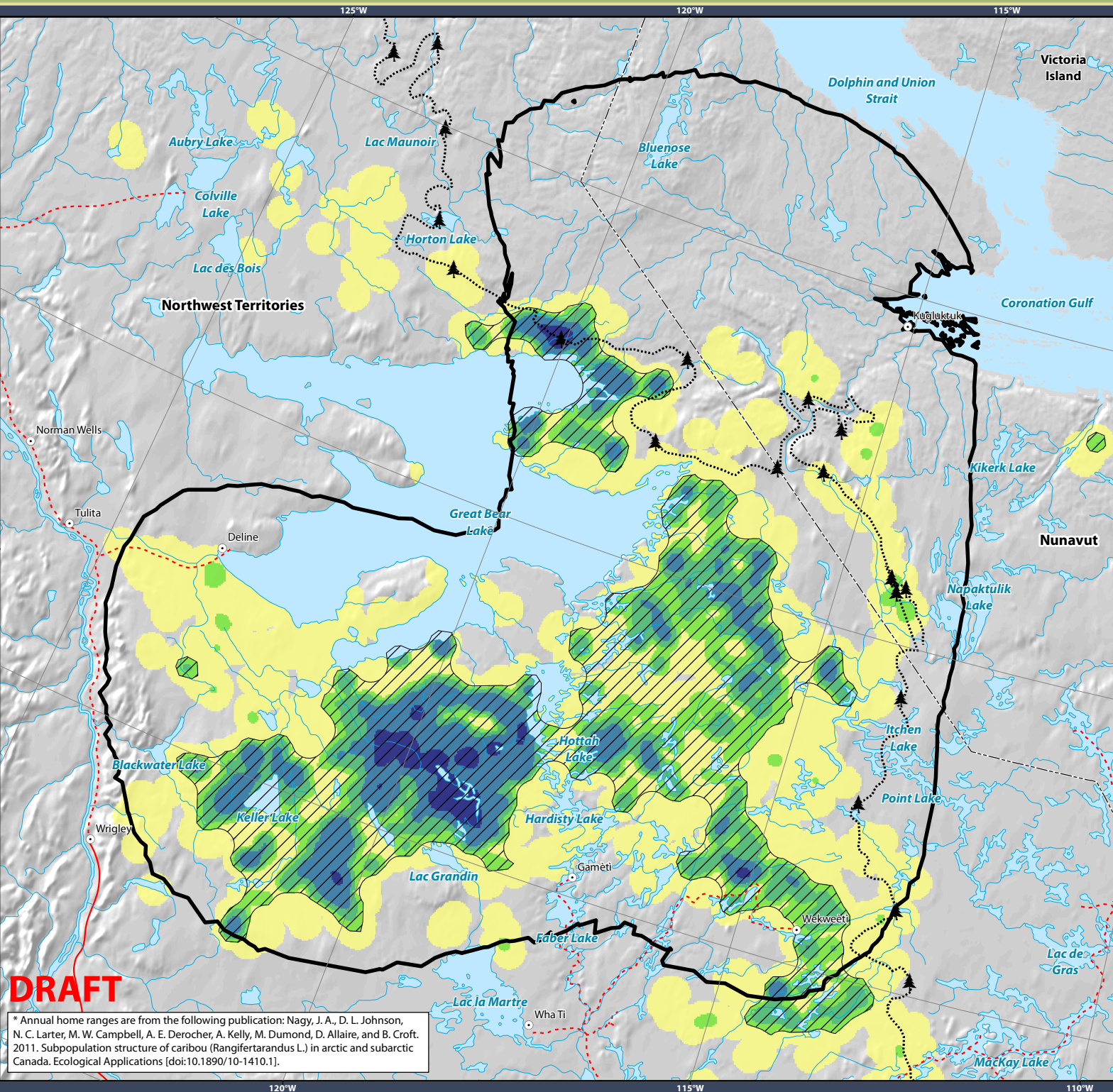


Projection:
 Canada Lambert Conformal Conic

Data Sources:
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Figure 6
**Key Access
 Corridors Example
 Qamanirjuaq**

Legend

-  Community
-  Tree Line
-  Core Spring
-  Migration Corridor
-  Key Access Corridors
-  Post-calving Areas
-  Core Calving Areas
-  River/Stream
-  All-season Road
-  Winter Road
-  Lake
-  Annual Home Range*

Area of Detail



Projection:

Canada Lambert Conformal Conic

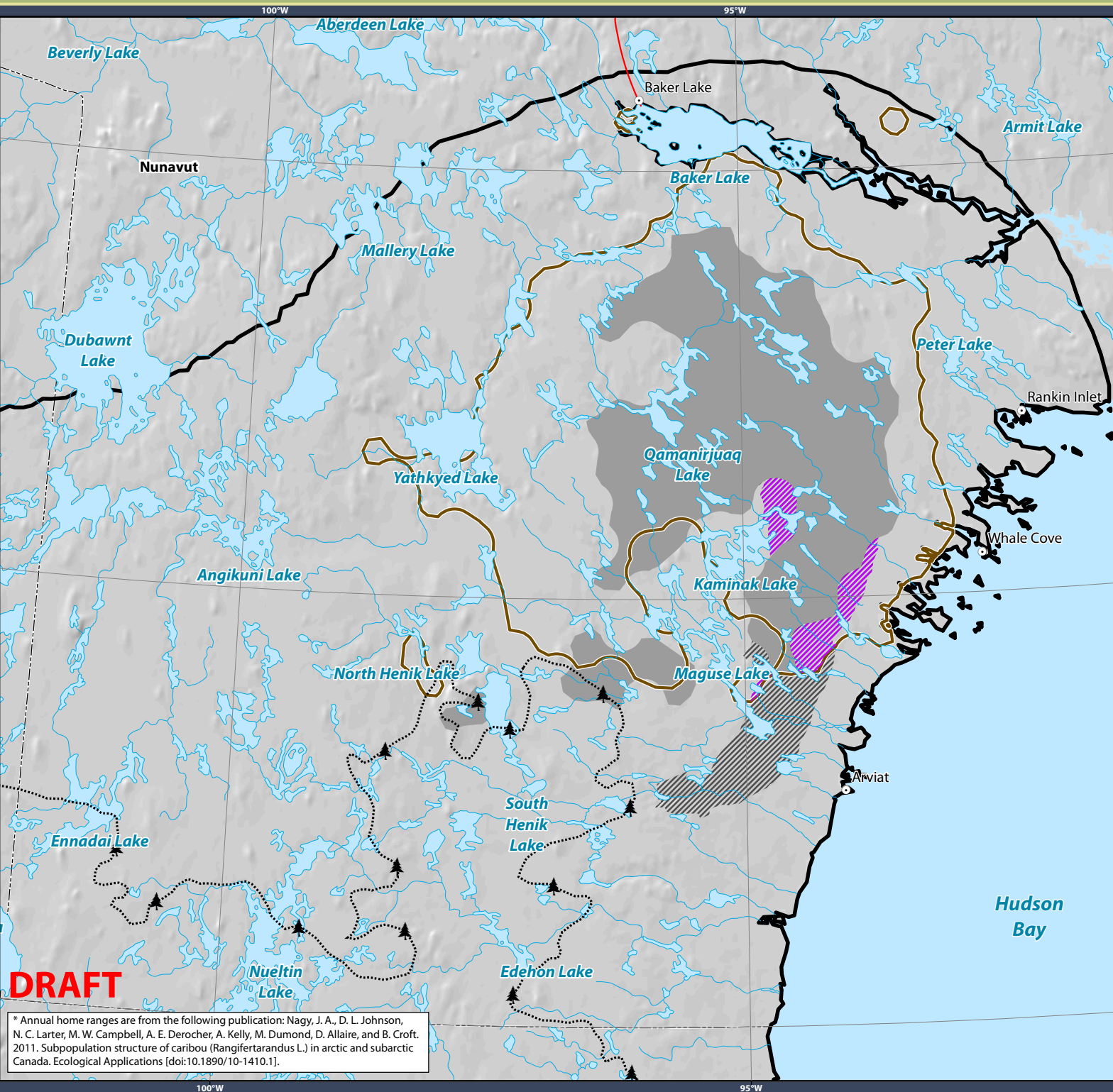
Data Sources:

Government of Nunavut, Government of Northwest Territories, Natural Resources Canada, GeoBase®, National Topographic Database



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