COSEWIC
Assessment and Update Status Report

on the

Peary Caribou
Rangifer tarandus pearyi

and

Barren-ground Caribou
Rangifer tarandus groenlandicus

Dolphin and Union population

in Canada

PEARY CARIBOU – ENDANGERED
BARREN-GROUND CARIBOU (DOLPHIN AND UNION POPULATION) SPECIAL CONCERN
2004

COSEWIC
COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES ESPÈCES EN PÉRIL AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC 2004. COSEWIC assessment and update status report on the Peary caribou *Rangifer tarandus pearyi* and the barren-ground caribou *Rangifer tarandus groenlandicus* (Dolphin and Union population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 91 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous report:

Gunn, A., F.L. Miller and D.C. Thomas. 1979. COSEWIC status report on the Peary caribou *Rangifer tarandus pearyi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 40 pp.

Miller, F.L. 1991. Update COSEWIC status report on the Peary caribou *Rangifer tarandus pearyi* In Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 124 pp.

Production note:

1. COSEWIC acknowledges Lee E. Harding for writing the update status report on the Peary caribou *Rangifer tarandus pearyi* and the barren-ground caribou *Rangifer tarandus groenlandicus* (Dolphin and Union populations) in Canada. The report was overseen and edited by Marco Festa-Bianchet, COSEWIC Co-chair Terrestrial Mammals Species Specialist Subcommittee.
2. This species was previously listed by COSEWIC as Peary caribou *Rangifer tarandus pearyi*. Please note that in this status report, the barren-ground caribou, population of Dolphin and Union, is often referred to as the Dolphin and Union Caribou herd or to the Dolphin and Union caribou.

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Cover illustration:
[top] Peary caribou (male) — photo by Frank Miller. [bottom] Dolophin and Union caribou – photo by Mathieu Dumond.

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COSEWIC
Assessment Summary

Assessment Summary – May 2004

Common name
Peary caribou

Scientific name
Rangifer tarandus pearyi

Status
Endangered

Reason for designation
This caribou is a Canadian endemic subspecies. Numbers have declined by about 72% over the last three generations, mostly because of catastrophic die-off likely related to severe icing episodes. The ice covers the vegetation and caribou starve. Voluntary restrictions on hunting by local people are in place, but have not stopped population declines. Because of the continuing decline and expected changes in long-term weather patterns, this subspecies is at imminent risk of extinction.

Occurrence
Northwest Territories, Nunavut

Status history
The original designation considered a single unit that included Peary caribou, *Rangifer tarandus pearyi,* and what is now known as the Dolphin and Union population of the barren-ground caribou, *Rangifer tarandus groenlandicus.* It was assigned a status of Threatened in April 1979. Split to allow designation of three separate populations in 1991: Banks Island (Endangered), High Arctic (Endangered) and Low Arctic (Threatened) populations. In May 2004 all three population designations were de-activated, and the Peary Caribou, *Rangifer tarandus pearyi*, was assessed separately from the Barren-ground Caribou (Dolphin and Union population), *Rangifer tarandus groenlandicus.* The subspecies *pearyi* is composed of a portion of the former “Low Arctic population” and all of the former “High Arctic” and “Banks Island” populations, and it was designated Endangered in May 2004. Last assessment based on an update status report.

Assessment Summary – May 2004

Common name
Barren-ground caribou (Dolphin and Union population)

Scientific name
Rangifer tarandus groenlandicus

Status
Special Concern

Reason for designation
This population of caribou is endemic to Canada. Once thought to be extinct, numbers have recovered to perhaps a quarter of the population historic size. They have not been censused since 1997 and are subject to a high rate of harvest, whose sustainability is questioned by some. They migrate between the mainland and Victoria Island and climate warming or increased shipping may make the ice crossing more dangerous. The population, however, increased substantially over the last three generations and was estimated at about 28,000 in 1997.

Occurrence
Northwest Territories, Nunavut

Status history
The original designation considered a single unit that included Peary caribou, *Rangifer tarandus pearyi,* and what is now known as the Dolphin and Union population of the barren-ground caribou, *Rangifer tarandus groenlandicus.* It was assigned a status of Threatened in April 1979. Split to allow designation of three separate populations in 1991: Banks Island (Endangered), High Arctic (Endangered) and Low Arctic (Threatened) populations. In May 2004 all three population designations were de-activated, and the Peary caribou, *Rangifer tarandus pearyi*, was assessed separately from the barren-ground caribou (Dolphin and Union population), *Rangifer tarandus groenlandicus.* The Dolphin and Union population is composed of a portion of the former "Low Arctic population", and it was designated Special Concern in May 2004. Last assessment based on an update status report.

COSEWIC
Executive Summary

Peary Caribou
Rangifer tarandus pearyi
and
Barren-ground Caribou
Rangifer tarandus groenlandicus
(Dolphin and Union population)

Species information

English name:	Peary caribou
French name:	Caribou de Peary
Inuinnaqtun name:	Ualiniup Tuktui (plural). Tuktu (singular) preceded by a place name, such as “kingailik tuktu” meaning “Prince of Wales Island caribou”
Latin name:	*Rangifer tarandus pearyi* (Allen 1902)

Peary caribou occur as at least 4 distinct populations: (1) Queen Elizabeth Islands; (2) Banks Island and northwestern Victoria Island; (3) Prince of Wales Island and Somerset Island, and (4) Boothia Peninsula.

The “Dolphin and Union” barren-ground caribou are included in this report because they were included in the previous COSEWIC assessment. They summer on Victoria Island and cross Dolphin and Union Strait to winter on the mainland. This herd is genetically distinct from both Peary caribou and other barren-ground caribou (*Rangifer tarandus groenlandicus*) and for the purpose of this report is considered separately[1].

A taxonomic revision of caribou on Canadian Arctic islands is required. In particular the description of Dolphin and Union caribou as *R. t. groenlandicus-pearyi* (Manning 1960) needs revision to reflect their genetic and phenotypic distinctiveness.

Peary and Dolphin and Union caribou are integral components of Inuit and Inuvialuit culture, economy, and spirit world.

[1]EDITOR’S NOTE: please note that in this status report, the barren-ground caribou, population of Dolphin and Union, is often referred to as the Dolphin and Union Caribou herd or as the Dolphin and Union caribou.

Distribution

The normal range of Peary caribou is entirely within the Arctic Archipelago, except for a population on the Boothia Peninsula. Some individuals from the Boothia Peninsula winter as far south as the Hayes River. A few Peary caribou have occurred sporadically to the west on the coastal mainland near Cape Bathurst and at Old Crow, Yukon during environmentally stressful years on Banks and Victoria islands. Peary caribou do not occur on Baffin Island or on the islands in the Foxe Basin and Hudson Bay, where barren-ground caribou (*R. t. groenlandicus*) occur.

Habitat

Peary caribou and the caribou of the Dolphin and Union herd live exclusively in arctic tundra in environments that range from relatively flat and featureless in the south and west to mountainous in the north and east. When winter snow and ice conditions are extreme, survival depends on finding snow-free or shallow snow-covered ridges and other topographical exposures where they feed on a variety of shrubs, gramminoids, and forbs in mesic to xeric sites.

Characteristically, Peary caribou migrate seasonally between islands. Infrequently, Peary caribou make environmentally forced movements to other islands and to the mainland. The caribou of the Dolphin and Union herd seasonally migrate across the sea-ice to winter on the mainland and to return to Victoria Island for calving, summer, and the rut. Peary caribou live in a ‘non-equilibrium grazing system’ where sporadic, unpredictable, abiotic variables such as snow and ice usually govern their fate.

Except for those on the Boothia Peninsula, Peary caribou live on islands and inter-island movements are critical to their survival. Inter-island movements within traditional ranges are common and can be characterized as seasonal or periodic range shifts to optimize use of available habitat. Inter-island movements outside of traditional ranges are widely thought to occur on an infrequent basis, but have not been documented.

Peary caribou habitat is stable, large, (>800 000 km^2) and relatively unchanged by human activities. Trends in habitat quality have not been well documented. The productivity of the land is low and pockets of higher quality forage are thinly scattered over large areas. Some population declines have been related to sporadic winter snow and icing events that caused the forage to become temporarily unavailable. Other declines have been more gradual and prolonged; in these, winter severity was a factor in some cases, as was hunting.

All populations are under the primary management of wildlife co-management boards established pursuant to the Inuvialuit Final Agreement in the west and the Nunavut Land Claims Agreement in the east.

Biology

Peary caribou face a brief pulse of high quality nutrition during the plant growth season and about 10 months when most plant nutrients are stored in below-ground plant structures. Some dwarf shrubs have evergreen leaves and some grasses and sedges also have over-winter green leaves. Peary caribou nutrition is closely tied to plant phenology, especially green-up in spring and flowering in summer. All seasons are critical: spring for gestation and to replace energy stores lost during the winter, summer for lactation and growth, summer and fall to build up energy reserves for the early winter rut, and winter to find enough food to survive the harsh arctic environment.

Peary caribou males typically reach breeding age at 4 years, and females at 3 years (rarely 2 years); both sexes are reproductively capable up to at least 13 years and may live up to at least 15 years. About 80% of 3+ yr-old females produce calves in good years. In severe winters, yearling recruitment can drop to 0. Pregnancy rates vary from nearly 0% to 100% and are associated with physical condition of adult females. Except during exceptionally severe winters, winter calf survival ranges from about 20% to 90% and is often greater than 50%.

Peary caribou populations can increase at annual rates of up to about 19% for short periods of a few years. Over periods of a decade or more, population increases of no more than about 13% per year have been observed.

Peary caribou are found in small groups relative to barren-ground caribou which likely reflects foraging strategies, relatively low caribou densities, and the absence of intense insect harassment. Relative to other caribou, lichens form lower proportions of Peary caribou diets, and mosses higher. Peary caribou have larger rumens relative to other caribou, which may be an adaptation to lower-quality forage. They also have other adaptations to the High Arctic such as a long, densely-haired winter pelage, furry muzzle, short face and short, broad hooves. In winter, once snow/ice pack characteristics prevent or make cratering energy-inefficient, they forage on windswept ridges and hilltops, and in boulder fields where snow is soft and not crusted by wind. During widespread icing conditions, caribou leave iced-over range and seek forage on ice-free and snow-free or shallow snow-covered sites on south-facing slopes, ridges and prominences, which also are where spring green-up occurs earliest. After green-up, Peary caribou feed selectively, favouring flowers that are high in energy and protein.

If Peary caribou went extinct, it is unlikely that other caribou could fill the ecological niche that they now occupy. This is likely also true of the Dolphin and Union herd.

Population sizes and trends

Tracking population trends is hindered by the irregular timing of surveys to estimate numbers (except for the populations on Banks and Bathurst islands). The eastern Queen Elizabeth Islands were covered by a virtually range-wide aerial survey in 1961 and have not been widely surveyed since then. Peary caribou populations have continued to declines since the 1991 assessment report (Miller 1991), which used data up to 1987. The 1991 assessment report identified declines of 86% (1961-1987) for the 2 local populations in the western Queen Elizabeth Islands, a 50% decline on Banks Island and trends were either stable or not discernable for the other metapopulations. Over the last 3 generations (i.e., since about 1980), Peary caribou have declined overall by about 72%—but 84% in the last 4 decades. Since 1980, the Peary caribou of the Queen Elizabeth Islands have declined by about 37% (despite increasing at 13% per year from 1974 to 1994 within the Bathurst Island complex), the Banks Island-northwestern Victoria Island population by about 72%, and the Prince of Wales-Somerset population by about 99%. The Boothia population has increased by about 10%. The best current estimate for total (including calves) Peary caribou is 7890 and the range of population estimates is 5971 to 9146.

The Dolphin and Union population, historically estimated at about 100 000, was reduced to a handful by about 1924, and has since recovered to about 25% of its former abundance.

Limiting factors and threats

Factors known to have contributed to caribou declines include: (1) irregular winter events with heavy and persistent snow accumulation, particularly in association with freezing rain or unusually warm periods resulting in deep, crusted snow or a glaze of ice covering the forage; and (2) unsustainable hunting.

Interactions with muskoxen (*Ovibos moschatus*), possibly involving predator-prey interactions or competition for space or forage, have been suggested as contributing to Peary caribou population declines, but have not been demonstrated as a cause, despite the relatively high mean density of muskoxen in association with caribou. Although there is no evidence for wolves having seriously depressed these caribou populations, their potential impact is much greater now that the caribou populations are so small.

Industrial activities have the potential to threaten both Peary and Dolphin and Union caribou by interrupting migration or causing excessive disturbance during critical life stages such as calving, rutting or winter and spring-summer foraging. Population-level impacts have not, however, been demonstrated.

Genetic diversity and numbers are so low in at least 1 population (Prince of Wales-Somerset) that its ability to adapt to environmental challenges may be seriously compromised and its susceptibility to inbreeding depressions is a concern. The same may also be true of the Peary caribou of the western Queen Elizabeth Islands.

Climate change is the most serious threat. If it were to increase the frequency and severity of winter icing events, Peary caribou would probably go extinct or experience local extirpations. In such a situation, populations would be unable to sustain any large annual harvests.

Special significance of the subspecies

Peary and Dolphin and Union caribou are endemic to Canada, they are the only cervid in the Arctic Archipelago, are uniquely adapted to the polar desert environment, and play a key role in the culture and economy of Inuit and Inuvialuit.

Existing protection or other status designations

Peary caribou are protected by the land claim agreements mentioned above that recognize and specify Aboriginal rights to harvest wildlife, subject to conservation and public safety, and which provide for the establishment of wildlife management boards. Local management authorities, such as hunters' and trappers' organizations and regional wildlife organizations, have the authority to restrict or prohibit hunting by their members. The authority of the wildlife management boards is subject to the ultimate responsibility of government. There are no lands where hunting is prohibited by statute.

Industrial operations are normally required to avoid harassment or other disturbance to caribou under the terms of their territorial and/or federal operating permits or licences of occupation.

COSEWIC designated Peary caribou of the Queen Elizabeth Islands (the "High Arctic") population and Banks Island as endangered, and the Prince of Wales-Somerset, Boothia and Dolphin and Union (collectively, "Low Arctic") populations as threatened in 1991. The World Conservation Union assessed Peary caribou as endangered in 1996.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species and include the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal organizations (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership, chaired by the Canadian Museum of Nature), three nonjurisdictional members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The committee meets to consider status reports on candidate species.

DEFINITIONS
(AFTER MAY 2004)

Species	Any indigenous species, subspecies, variety, or geographically or genetically distinct population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.

** Formerly described as “Not In Any Category”, or “No Designation Required.”

*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

Environment Canada / Environnement Canada
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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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(Dolphin and Union population)

in Canada

2004

TABLE OF CONTENTS

List of figures

List of tables

List of appendices

INTRODUCTION

At the height of the last glaciation of the Pleistocene, about 20 000 years before present (ybp), the Laurentide ice sheet covered the mainland and some of the southern islands including Victoria Island and Baffin Island, while smaller ice caps covered Melville Island, Bathurst Island and the islands to the northeast (Pielou 1991). Sea level was about 150 m lower than now. What would become Banks Island and parts of the western Queen Elizabeth Islands were polar desert (as they are now), contiguous with Beringia (Figure 1) (Adams and Faure 2003). The caribou of Beringia—progenitors of today's Alaskan and northern Canadian subspecies—were not isolated from those of the High Arctic.

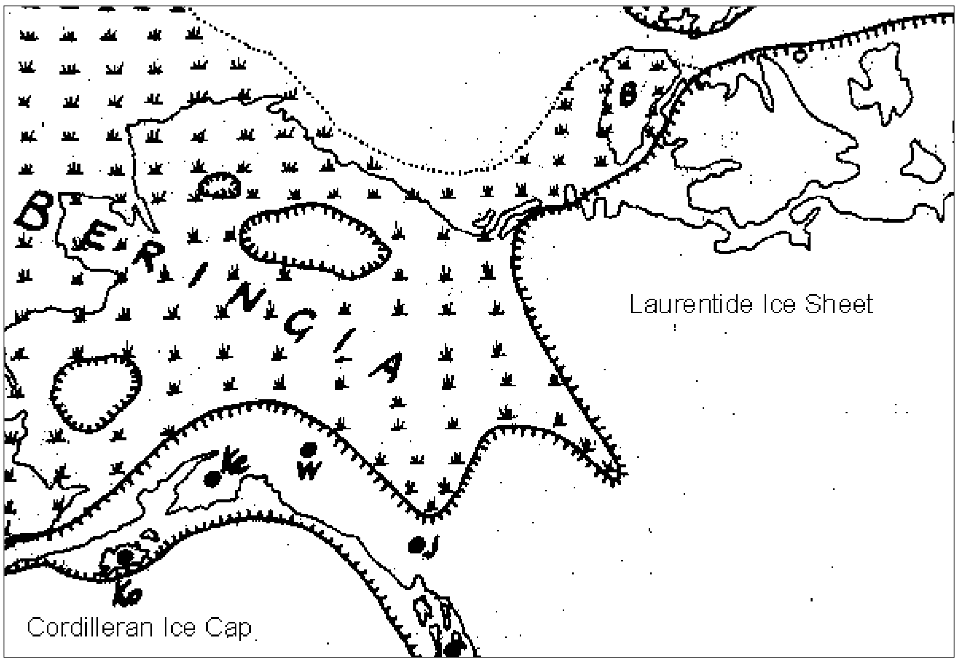

Figure 1. Beringia about 18 000 ybp (from Pielou 1991).

By 13 000 years ago, Banks Island was separate from the mainland, while part of Melville Island, which was connected by land to Prince Patrick Island, as well as some smaller islands to the northeast, had also become ice free (Pielou 1991). Rising water levels isolated caribou populations from those in Beringia and, to some extent, from each other, although they could still swim or walk across winter ice. After the rapid warming that marked the beginning of the Holocene, about 10 000 ybp, came an even warmer interval of 3000 to 4000 years of to 4° C warmer than now (Intergovernmental Panel on Climate Change 1990). During that time, warmer weather resulted in more extensive open water in winter (Dyke *et al.* 1996), isolating Arctic islands caribou even more than now. Although the caribou were relatively isolated, they enjoyed better habitat because the vegetation changed from polar desert to dry tundra (Figure 1) (Adams and Faure 2003).

For the Inuit and Inuvialuit the caribou have been there as long as they have. They are part of the landscape, members of the spirit world, and providers of food, clothes, and tools. Yet, as this COSEWIC status report is written, the extinction of Peary caribou seems possible.

The first written record of Peary caribou was the skin of a “white deer” that the famous Dene statesman, Matonabbee, gave to the Hudson’s Bay Company in 1774 or 1775. Matonabbee guided Samuel Hearne from Hudson’s Bay to the mouth of the Coppermine River during 1771–1772. Within a century, some of the caribou of the Arctic islands were in trouble. The introduction of firearms made it easier to kill these docile animals. By about 1924, the Dolphin and Union herd had gone from around 100 000 to essentially extinct. In 1973 another crisis loomed, this time caused by climate: freezing fall rain covered virtually the entire range in the western Queen Elizabeth Islands with a glaze of ice, locking up the winter forage. The caribou population there crashed in the winter and spring of 1973–1974 by 49% from its 1973 level and was down about 89% from 1961 (Tener 1963, Miller *et al.* 1977a).

Peary caribou are difficult to census in their vast and remote range. Their inter-island movements are not easily monitored. Documenting their behaviour and relationships with habitats, competitors, and predators requires dealing with the difficulties of working in the Arctic. Rarely has a population’s entire range been surveyed at once; the whole subspecies, never. As a consequence, even intensive surveys, with high precision for the areas that were covered, may have missed substantial portions of the populations. Also, some authors have reported estimates for total caribou, while others have reported only adult, or 1+ year-old caribou, and those numbers cannot be directly compared. This problem was exacerbated by surveys at different seasons, when the proportions of calves were changing because of new births or deaths. These uncertainties and inconsistencies presented difficulties in establishing trends.

To establish historic and recent (3 generations, or about 21 years) population trends, the report writer assembled the available records of surveys and, in most cases, contacted the authors to sort out inconsistencies as noted above. The report writer extrapolated trends between major survey years using the exponential model:

$$N_t = N_{t-1} + N_{t-1} R_{max}$$

where N is the number of individuals in the population at a given point in time, t, increasing at a constant annual rate, R_{max}. I then summed trends in local populations to give trends for each population. The current population, represented by the most recent survey results, was then compared with the first reported estimate and with the 1980 populations to arrive at trends over 3 generations (21 years).

This method is imperfect for the following reasons: (1) some trends did not fit an exponential model, so that intermediate estimates between starting and ending points were under- or over-represented; (2) some inconsistencies in the resulting data set remained, for example, when different authors reported different estimates for the same population; (3) the decision as to which starting and ending points to use when several estimates were available in a given period was somewhat arbitrary, and influenced the results; and, (4) when the first and last reported estimates of different local populations of the same population were in different years, they were nevertheless summed to arrive at the "first count" and "last count," respectively, for the population. The original survey estimates and trend calculations are presented in Appendix 1.

Peary caribou taxonomy is better known now than for the last assessment, but is still incomplete. There is still no collection of specimens sufficiently complete to measure morphometric and pelage variability in all parts of their range. Molecular methods to discern genetic relationships have been applied, but, the distribution of samples is incomplete and important results are still unpublished.

"In this report, "local population" refers to a definable portion of a population, based on some geographic feature such as their summer or winter range, calving grounds, or migration route. "Local population" is approximately synonymous with "herd" as applied traditionally to migratory caribou elsewhere in Canada (Thomas and Gray 2002).

Inuvialuit in the western Arctic and Inuit in the eastern Arctic, through their conservation organizations (such as Hunters and Trappers Organizations), have newly recognized responsibilities for some aspects of wildlife management, such as harvest allocation. Through oral dissemination of qaujimajatuqangit (Inuit/Inuvialuit traditional knowledge), they may have an understanding of caribou behaviour and biology that complements or supplements that available from scientific publications. Territorial and federal government policies have begun requiring that qaujimajatuqangit be incorporated into wildlife management decisions (Government of the Northwest Territories 1993, Government of Canada 1995).

The cultural knowledge, values, and understanding of local residents can enhance scientific inquiry, not only for the factual content of qaujimajatuqangit, but for the greater insight it confers to interpretation of the data (Wolfe *et al.* 1992, Berkes 1993, Dwyer 1994, Berkes 1998, Deurden and Kuhn 1998). Several authors have proposed methods of incorporating qaujimajatuqangit into environmental decision-making (Gunn *et al.* 1988, Freeman 1992, Johnson 1992, Stevens 1994). Usher (2000) reviewed these and offered the following criteria and procedures for traditional ecological knowledge (TEK) to be used in environmental management:

1. TEK must be comprehensible and testable.
2. There is a need to differentiate between observation and inference or association.
3. Intermediaries trained in social sciences who have the support of the holders of TEK must document TEK in an organized manner, usually requiring interviews.

For this report, the following types of qaujimajatuqangit were reviewed:

- interviews by the author with representatives of hunters' and trappers' organizations and government agencies in Resolute Bay and Inuvik;
- second-hand observations and opinions cited as personal communications in scientific publications and reports;
- scientific publications and reports in which qaujimajatuqangit was collected through formal interviews by Inuktitut-speaking Inuit or Inuvialuit and summarized or transcribed by the collectors (e.g. Adjun 1993, Elias 1993, Ferguson and Messier 1997, Nunavut Tusaavut Inc. 1997, Ferguson *et al.* 1998);
- workshops in which there was substantial Inuit or Inuvialuit representation (Gunn *et al.* 1986, e.g. Gunn *et al.* 1998); and
- scientific reports that were co-authored by Inuit or Inuvialuit (e.g. Gunn *et al.* 1986, Gunn *et al.* 1988, Ferguson *et al.* 2001).

In addition to these attributable sources, many of the surveys that provided data essential to the scientific studies on which this review is based used local Inuit or Inuvialuit as observers (e.g. F.F. Slaney & Co. Ltd. 1975a, b, Gunn and Dragon 1998, Miller 1998, Larter and Nagy 2000b, Ferguson *et al.* 2001, Gunn and Dragon 2002). Their contributions, usually recognized in the Acknowledgements sections, can be assumed to have contributed to the understanding derived from the study and reflected in the reports. This status assessment is an update of Miller (1991), also published as Miller (1990b).

SPECIES INFORMATION

Name and classification

English name:	Peary caribou
French name:	Caribou de Peary
Inuktitut name:	Tuktu preceded by a place name, such as "kingailik tuktu" means "Prince of Wales Island caribou"
Family:	*Cervidae*
Latin name:	*Rangifer tarandus pearyi* J.A. Allen 1902. Bulletin of the American Museum of Natural History 16:409.

Originally considered a separate species and later a subspecies of *R. arcticus*, Peary caribou are considered a subspecies of caribou, *R. tarandus* (Banfield 1961). Their usual habitat is confined to the Arctic islands and Boothia Peninsula. Some individuals that calve on Boothia Peninsula winter on the mainland below the Boothia Isthmus as far south as Hayes River (Gunn *et al.* 2000a). During environmentally forced movements, Peary caribou can make extensive movements, such as those in the 1950s to the mainland and as far west as Old Crow in the Yukon (Manning and Macpherson 1958, Banfield 1961, Youngman 1975).

Peary caribou occur as at least 4 geographically and genetically distinct populations or metapopulations: (1) Queen Elizabeth Islands; (2) Banks Island and northwestern Victoria Island; (3) Prince of Wales Island and Somerset Island, and (4) Boothia Peninsula.

The barren-ground caribou of the “Dolphin and Union herd,” are included because they were included in the previous COSEWIC assessment. They summer on Victoria Island and cross Dolphin and Union Strait to winter on the mainland. This herd is genetically distinct from both Peary caribou and other barren-ground caribou (*Rangifer tarandus groenlandicus*) and for the purpose of this report is considered separately.

Description

Peary caribou are small (mean total length of males 1.668 m) and short, with a pointed rostrum and high cranium. The pelage is long, silky, and creamy-white in early winter, becoming shaggy and brown-tinged on the back by spring (Figure 2). The summer coat is slate above, sometimes lacking pronounced flank stripe, white below; legs, white except for narrow frontal stripe (Figure 3). The hooves are extremely short and broad. Their antler velvet is grey. The antlers are bone-coloured, often lacking lateral divergence, and digitate ("finger-like") (Banfield 1961).

Figure 2. Peary caribou male, winter/spring pelage, Queen Elizabeth Islands (photo by Frank Miller).

Figure 3. Peary caribou males in summer pelage, Prince of Wales Island (photo by Anne Gunn).

Compared to other caribou, Peary caribou have a more densely haired pelage, are whiter and smaller and have shorter, furrier faces, shorter, blunter but wider hooves, and usually more narrowly spreading antlers.

Dolphin and Union caribou are smaller than barren-ground caribou but larger than Peary caribou except for the 'super *pearyi* deme' (Banfield 1961) on Prince of Wales Island. Dolphin and Union caribou have the characteristic pelage patterning of Peary caribou but are slightly darker. Their antler velvet is grey, similar to Peary caribou and in contrast to barren-ground caribou. These differences, plus other pelage, skeletal and antler differences, distinguish the Dolphin and Union caribou visually from barren-ground caribou and from most Peary caribou (Figure 4).

Figure 4. Dolphin and Union caribou, Victoria Island (Photo by Mathieu Dumond).

Manning (1960) found that the hooves of Queen Elizabeth Island caribou were shorter and blunter than those of the other 4 groups, with no overlap in measurements between them and caribou from the mainland. The Dolphin and Union caribou had hooves just slightly narrower than the Queen Elizabeth Islands group, while the Banks Island caribou's hooves were intermediate between those from mainland caribou and those from the Queen Elizabeth Islands.

DISTRIBUTION

Global range

Anderson (1946) suggested that the caribou from northwestern Greenland north of Kane Basin may be Peary caribou. Banfield (1961) stated that this was definitely so, but the current taxonomic status of the northwestern Greenland population is in doubt. Miller (1991), citing Meldgaard (1986), and summarizing reports of Greenland Inuit, confirmed that small caribou, possibly migrants from Canada, were regularly seen and shot there. The Inuit reported that normally up to 10 (but 100 to 140 in 1990) were taken annually and that caribou tracks were often seen crossing from Ellesmere Island to Greenland. Banfield (1961) suggested that the caribou south of Kane Basin, around Inglefield Bay, may have been intergrades between *R. t. pearyi* and *R. t. groenlandicus,* but Roby *et al.* (1984 cited by Miller 1991) concluded that the Inglefield Bay caribou were environmentally stunted *R. t. groenlandicus.*

Canadian range

Aside from a possible occurrence in Greenland, Peary caribou occur only in Canada (Figure 5).

CLASSIFICATION

Phenotypes

Peary caribou were formally described in 1902 from a specimen collected on northeast Ellesmere Island (Allen 1902, 1908). Anderson (1934) gave their range as from Greenland to the mainland, including Victoria Island. Anderson (1946) maintained Allen's (1902, 1908) classification of Peary caribou as *R. pearyi.* He gave their range as Ellesmere Island, Sverdrup Island and "probably" other islands in the *northern* part of the Canadian Arctic Archipelago (from which he had no specimens), while assigning to barren-ground caribou (*R. a. arcticus*) those populations in "the southern fringe of islands north of the mainland coast," as well as the mainland.

Figure 5. Distribution of Peary caribou and the Dolphin and Union herd in relation to the distribution of barren-ground caribou and a small group of introduced reindeer (*R. t. tarandus*). The boundary between the Dolphin and Union and NW Victoria populations is uncertain.

On the basis of skull dimensions (19 measurements) and skull shape (14 measurements), Manning (1960) found a stepped clinal distribution from the smallest caribou in the Queen Elizabeth Islands through Banks Island to the Dolphin and Union herd of Victoria Island, to mainland caribou, with the largest step being the last. The Dolphin and Union herd formerly migrated annually between Victoria Island and the adjacent coastal mainland across Coronation Gulf, but was apparently reproductively isolated from mainland caribou because of the timing and location of the rut on southern Victoria Island. The distribution and darkness of brown versus white pelage paralleled that of the skeletal measurements, the lighter animals being in the north. Hoof size and shape completely separated Queen Elizabeth Islands caribou from mainland caribou, but Manning had no hooves from Banks and Dolphin and Union animals. Within the Queen Elizabeth Islands group, there were no differences in these characteristics from widely separated locations from Prince Patrick and Melville islands in the southwest to Ellesmere and Axel Heiberg islands in the northeast, a distance of some 1100 km. In addition to these groups, there were also resident caribou on Victoria Island that did not migrate; Manning (1960) was unable to include these in his analysis because he had only 1 ambiguous specimen. On the basis of skull and hoof measurements and pelage and antler velvet colour, Manning (1960) referred the Banks Island caribou to *R. a. pearyi* (now *R. t. pearyi*) and the Dolphin and Union herd tentatively to *R. a. arcticus* (now *R. t. groenlandicus*), barren-ground caribou.

Manning and Macpherson (1958: 221-222) reported local accounts that both *arcticus* and *pearyi* occur on Somerset Island, but that there is no intergradation between them. Most of the mainland caribou are migratory, moving northward over Boothia to Somerset Island before break-up, and southward again before, during, and after freeze-up, but some remain on Somerset Island all winter and would therefore be in contact with *pearyi* during the rutting season. A few mainland caribou sometimes visited Prince of Wales Island.

Banfield (1961) returned the species designation to *R. tarandus*. Otherwise he maintained Manning's (1960) classification and distribution of phenotypes, with the inclusion of caribou along the northwestern tip of Victoria Island as *R. t. pearyi* on the basis of Aboriginal traditional knowledge. He noted that the Prince of Wales population of *R. t. pearyi* is unique in having typical *pearyi* skeletal and pelage characteristics, but a larger size: a "super *pearyi* deme". He accepted "Eskimo and European reports" that Peary caribou cross between Prince of Wales and Somerset Island, and that although mainland caribou occasionally stray to these islands, they remain reproductively isolated. He noted the occurrence of "typical *groenlandicus*" on the Boothia and Adelaide peninsulas. His maps (1961: 46, 48) show the Boothia Peninsula and southern Victoria Island as having been occupied by barren-ground caribou and northern Victoria Island with Peary caribou up to the end of the 19th century but vacant except for Peary caribou along the northwestern coast at the date of publication.

Banfield (1974) maintained the same classification and distribution, showing Victoria Island and the adjacent mainland coast vacant except for the northwestern tip, which is occupied by Peary caribou.

Thomas *et al.* (1976, 1977) and Thomas and Broughton (1978) measured femur length in caribou in the western Queen Elizabeth Islands and the Prince of Wales-Somerset group and concluded that although there were inter-island differences, all were Peary caribou.

Thomas and Everson (1982) took caribou skeletal measurements from the Boothia Peninsula and concluded that they ranged from "*the typical R. t. pearyi phenotype to the typical R. t. groenlandicus phenotype.*" They also described a stepped cline in skull measurements with the western Queen Elizabeth Islands (55 adult skulls from Prince Patrick, Melville, and Bathurst islands) forming a relatively homogenous group compared to 35 adult skulls collected from Prince of Wales and Somerset islands. Their skull measurements and pelage colour of caribou from Boothia Peninsula supported at least 2 types of caribou there.

To determine whether the caribou newly inhabiting Victoria Island were the same as those from the historic Dolphin and Union herd, Gunn and Fournier (1996) collected 55 skulls near Cambridge Bay. They compared them to published information on specimens from Melville Island, Boothia Peninsula, Prince of Wales Island, the type specimens of Dolphin and Union caribou collected by Anderson (1934) in 1915–1916 and barren-ground caribou from near Pelly Bay. The Victoria Island skulls were intermediate in size between those from Melville and Prince of Wales islands. There were no significant differences in skull measurements between the new series and the 1913–1916 series except for nasal length, which the authors attributed to a difference in measurement technique. They concluded that the extant caribou there were the same as the historic Dolphin and Union herd.

Gunn (2003) reviewed the pelage and morphometric measurements and analysis and the distribution of specimens used by the early taxonomists. She noted that, of all the physical characteristics, pelage colour patterns and antler velvet were not clinal or stepped as are skull and skeletal measurements, but instead were relatively homogenous within the Arctic islands (including the Dolphin and Union caribou) and showed a discontinuous distribution with respect to mainland caribou.

Genotypes

Gravlund *et al.* (1998), using mitochondrial DNA sequences from the 3 circumpolar, small-bodied caribou subspecies, including 15 specimens from the Canadian Arctic Archipelago, found that *R. t. pearyi* and *R. t. eogroenlandicus* shared a haplotype, which was not found in other clades and was common in *R. t. pearyi*. They concluded that *R. t. platyrhynchus* evolved convergently from large-bodied Eurasian reindeer. They have shown that the small-bodied caribou are at least diphyletic and possibly even polyphyletic.

Eger *et al.* (1999, 2003), used mitochondrial DNA for caribou from 13 locations in Canada and Alaska, including 6 locations in the range of Peary caribou: Bathurst Island, Prince Patrick Island, Banks Island, Prince of Wales Island, Somerset Island, and the Boothia Peninsula. They found evidence of ancient divergence between northern caribou of Beringia and those of eastern Canada. Analysis of molecular variance indicated that the subspecies, *R. t. pearyi* as defined by Banfield (1961), is not monophyletic (Eger *et al.* 2003). They suggest that there were 3 distinct sources (refugia) of caribou in North America: Alaska, south-eastern North America, and the High Arctic (Eger *et al.* 2003).

Røed *et al.* (1986) analysed blood protein transferrin type frequencies in several populations of small-bodied, Arctic island caribou and concluded that the Prince of Wales–Somerset caribou were predominately *pearyi* , although there were significantly different frequencies between them and those from the Queen Elizabeth Islands.

Zittlau *et al.* (2003) used microsatellite DNA analyses and larger sample sizes from Melville Island, the Bathurst Island complex, Banks Island, northwestern Victoria Island, south-central Victoria Island (the Dolphin and Union herd), the Prince of Wales Island-Somerset islands group and the Boothia Peninsula to assess distinctiveness and genetic variation among Peary caribou populations. They found that:

- The Banks Island and northwestern Victoria Island populations are not significantly different from each other, indicating past and/or recent movement between these islands; however, the lack of difference may also result from the small sample size from northwestern Victoria Island.
- The next most closely related populations are those on Melville Island, the Bathurst Island complex and the Prince of Wales-Somerset Island complex (indicating movements among these groups over a time scale of ~1000 years).
- The Boothia Peninsula and Banks Island populations are closely related, but the Boothia population that was sampled is strongly differentiated from the Prince of Wales-Somerset population.
- The Dolphin and Union caribou are the most differentiated from the other Arctic island populations and are also distinct from barren-ground caribou of the adjacent mainland. The Dolphin and Union caribou also cross-assigned the least, suggesting little genetic exchange with other groups.

These relationships are illustrated in Figure 6. The unrooted neighbour-joining tree of Nei's standard genetic distance D_s for Arctic islands and neighbouring caribou populations is shown in Figure 7. These results agree with the occurrence of a single refugium for the progenitors of barren-ground and Peary caribou during the Wisconsin glaciation, about 20 000 years before present. Arctic island forms later differentiated from barren-ground caribou and, to a lesser extent from each other.

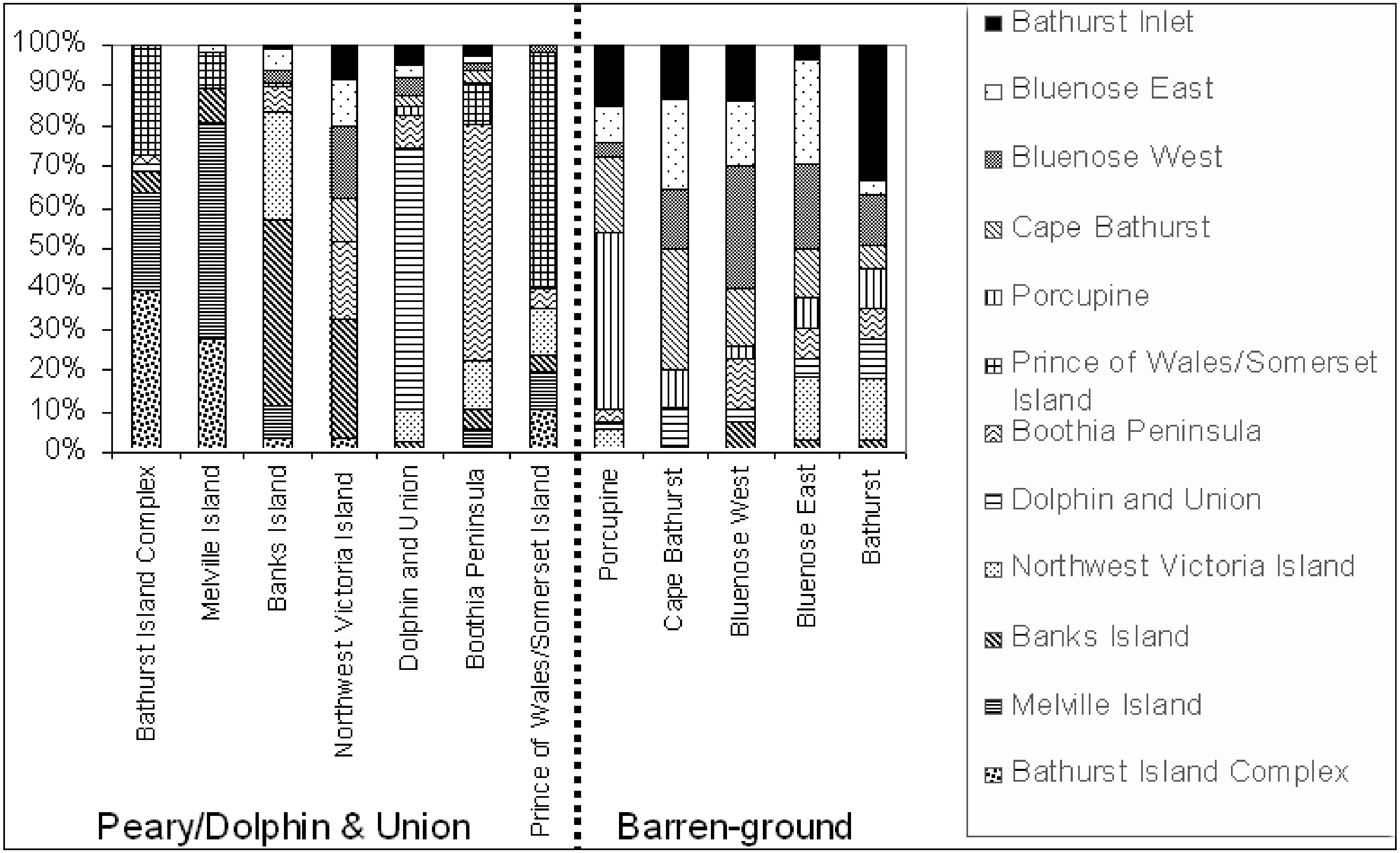

Figure 6. Assignment test results based on micro-satellite DNA frequencies in Peary/Dolphin and Union and barren-ground caribou (Zittlau *et al.* 2003). Values (y axis) indicate the percentage of caribou in each population (x axis) assigned to each potential source population (legend).

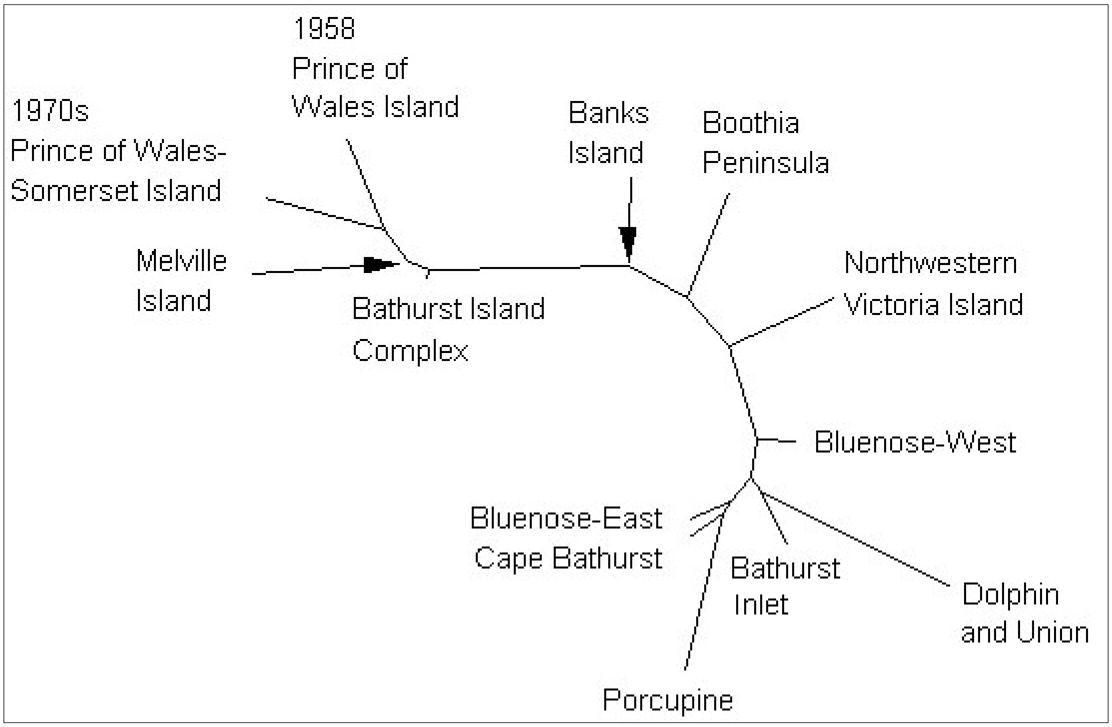

Figure 7. Neighbour-joining tree of genetic distances (Zittlau *et al.* 2003).

Considering the available evidence as summarized above, participants at a caribou genetics and relationship workshop, held in Edmonton in February 2003, (Strobeck 2003) concluded that there are 5 distinct populations (or metapopulations) of Peary-type caribou:

- Western Queen Elizabeth Islands,
- Prince of Wales-Somerset islands,
- the Boothia Peninsula,
- Banks Island-northwestern Victoria Island, and
- Dolphin and Union (distinct from both Peary and barren-ground caribou).

Although there have been no DNA samples of caribou from the eastern Queen Elizabeth Islands analysed for genetic relationships, based on morphology, they group with western Queen Elizabeth Islands caribou.

Summary of taxonomy

Pending a revision of the genus, all caribou north of the mainland, except for the Dolphin and Union herd and the barren-ground caribou on Baffin Island and those on the islands in Foxe Basin and Hudson Bay, should be referred to as Peary caribou. Peary caribou also occur on the Boothia Peninsula (which they share with barren-ground caribou) and sporadically on adjacent parts of the mainland.

The Dolphin and Union herd remains problematic. Their behavioural, morphometric (skeletal characteristics), and genetic affinities lean toward barren-ground caribou, *R. t. groenlandicus*, as per Anderson (*R. t. arcticus*: 1946), Manning (1960) and Banfield (1961, 1974), from which, however, they are clearly distinct. Their pelage and antler velvet colour make them look more like Peary caribou (Gunn 2003). Some biologists, Inuit, and Inuvialuit recognize them as Peary-type or island caribou as opposed to barren-ground or mainland caribou. A. Gunn (Government of the Northwest Territories, pers. comm. July 3, 2003) notes that, "*Genetically and phenotypically, the Dolphin and Union caribou appear so different [from barren-ground caribou] that in the context of diversity it is misleading to label them as barren-ground. The original taxonomic description was based on only a few museum skulls and hides rather than the living caribou and current genetic techniques*." Pending a revision of the species, however, there is no justification for re-classifying them as *R. t. pearyi*.

Population designations

Although a single assessment is applied to all Peary caribou in Canada, 4 populations can be recognized, in addition to the Dolphin-Union caribou. These population are shown in Table 1 and described in the following sections.

<u>Queen Elizabeth Islands</u>

The western Queen Elizabeth Islands have 24% of the land mass, or 98 651 km^2, and include 2 island complexes within which caribou exhibit regular, inter-island seasonal movements. There have also been past (based on genetic similarities) and recent, but limited, inter-island movements of caribou between these 2 complexes:

- the Melville Island complex, 61 237 km^2, consisting of Melville, Prince Patrick, Eglinton, Byam Martin and Emerald islands; and the Prime Minister Group, 8606 km^2, which includes the islands of Mackenzie King, Borden and Brock.
- the Bathurst Island complex, 28 808 km^2, consisting of Bathurst, Cornwallis, Lougheed, Vanier, Cameron, Alexander, Massey, Little Cornwallis, Helena, Baillie-Hamilton, Griffith and Lowther islands.

The eastern Queen Elizabeth Islands have 76% of the landmass, about 318 089 km^2, based on 14 islands each > 130 km^2. The complex includes Ellesmere, Devon, Axel Heiberg, Ellef Ringnes, Amund Ringnes, Cornwall, Graham, Meighen, King Christian, North Kent, Coburg, Stor, Hoved, and Buckingham islands, as well as associated lesser islands. Much (about 34%, *ca*. 110 000 km^2) of Ellesmere, Devon, and Axel Heiberg islands are covered with ice caps and permanent snow fields.

Table 1. Summary of Arctic islands caribou populations and 1991 COSEWIC designations.

Population	Latin name	COSEWIC name[1]	COSEWIC designation[1]	Extent of Occurrence
Queen Elizabeth Islands[2]	*Rangifer tarandus pearyi*	High Arctic population	Endangered	20 main western islands > 130 km^2 totalling 98 651 km^2 and 14 main eastern islands totalling 318 089 km^2): 416 740 km^2 total of the main islands, 419 061 km^2 total of all islands
Banks Island-northwestern Victoria Island	*Rangifer tarandus pearyi*[5]	Banks Island population	Endangered	Banks Island (70 028 km^2) and northwestern Victoria Island (21 874 km^2)
Prince of Wales-Somerset	*Rangifer tarandus pearyi*	Low Arctic population	Threatened	Prince of Wales Island (33 339 km^2), Somerset Island (24 786 km^2), Russell Island (940 km^2) and nearby islands
Boothia Peninsula[3]	*Rangifer tarandus pearyi*	Low Arctic population	Threatened	Boothia Peninsula (32 328 km^2)
Dolphin & Union	*Rangifer tarandus groenlandicus*[4]	Low Arctic population	Threatened	Victoria Island less northwestern Victoria Island (195 417 km^2) and Stefansson Island (4463 km^2)

[1]Based on the 1991 COSEWIC assessment.
[2]Queen Elizabeth Islands caribou may comprise a meta-population of 2 or more populations (Gunn *et al.* 2000b).
[3]The Boothia Peninsula also has barren-ground caribou that are not part of this assessment.
[4]Although the Dolphin and Union caribou are putatively *R. t. groenlandicus* (Manning 1960; Banfield 1961), their taxonomic status is uncertain; some biologists, Inuit and Inuvialuit recognize them as Peary-like or island caribou as opposed to barren-ground or mainland caribou.
[5]Banfield 1961 referred to the Banks Island specimens that he examined as *R. t. pearyi x groenlandicus* but included Banks Island within the range of *R. t. pearyi* as did Banfield 1974.

Many caribou in the Melville complex winter on Prince Patrick Island and move in spring to Eglinton, Emerald, Melville, and Byam Martin islands for the summer (Miller *et al.* 1977b, Gunn and Dragon 2002). Regular inter-island movements are also known for the Bathurst complex (Miller 1990a, Miller 1995, Miller 2002).

Banks Island–northwestern Victoria Island

The population includes a complex of local populations. Peary caribou on Banks Island move to the northwest to calve and there is likely a second calving area on the east-central coast around Jesse Bay, based on local knowledge and aerial surveys (Manning and Macpherson 1958, Urquhart 1973, Wilkinson and Shank 1974, Fraser *et al.* 1992, Nagy *et al.* 1996).

In some winters, Inuvialuit see caribou migrating between Victoria and Banks islands (Elias 1993). In the 1960s caribou from Banks Island migrated to northwestern Victoria Island, where they thrived. In some years, however, so many cross from Victoria Island to Banks Island that few are left on Victoria Island (north of Minto Inlet). During the 1990s, when caribou numbers were low, the inter-island movements were infrequent. Peary caribou on northwestern Victoria Island migrate north in spring to calve and south to the Minto Inlet area in winter (Gunn and Fournier 2000).

A few Peary caribou have sporadically appeared on the mainland as far west as Old Crow, Yukon, during or shortly after exceptionally severe environmental years on Banks Island and/or on Victoria Island (Manning and Macpherson 1958, Banfield 1961, Youngman 1975). Youngman (1975) reported that Kutchin (Dene) hunters from Old Crow often commented on the occasional small caribou mixed with herds of larger animals.

Dolphin and Union Strait

Anderson (1913, 1934) described and collected specimens from a large migratory herd that summered on Victoria Island and crossed the Dolphin and Union Strait to winter on the mainland around Coronation Gulf.

Inuvialuit from Holman recognize two kinds of caribou on Victoria Island that differ in size, colour, and taste: Peary caribou of the northwest and "mainland caribou" (i.e., Dolphin and Union caribou) that summer on the central, southern and eastern parts (Elias 1993). Somewhat confusingly, Inuit from Cambridge Bay also distinguish Peary and mainland caribou, but in this case the "Peary caribou" are the Dolphin and Union herd and the mainland caribou are barren-ground caribou that do not cross to Victoria Island (i.e., the Bathurst Inlet, Bluenose or Ahiak herds of *R. t. groenlandicus*). Inuit from Victoria Island are also aware of migratory and non-migratory island caribou on Victoria Island.

Most of what is known of the population's previous life history and numbers comes from Aboriginal traditional knowledge including the following sources:

- Recorded by early naturalists such as Jennes (1922) and Anderson (1913, 1922) and summarized by Manning (1960);
- Recorded by Elias (1993) through formal interviews; and
- Recorded by the Inuvialuit Game Council (Inuvialuit Game Council 2002b, 2002a) during workshops in communities on Banks and Victoria islands.

Before about 1920, when they were still abundant, they crossed Dolphin and Union Strait at various points west as far as Cape Bexley and Coronation Gulf east to Queen Maud Gulf in the spring. They moved rapidly northwards to the north coast and spread out over most of the island. Some, perhaps 2000, remained on the Wollaston Peninsula during the summer, while the main herd continued north past Prince Albert Sound. Around 20 000 went further west. Some may have crossed to Banks Island. In the autumn, after the rut, they returned to the mainland south of Coronation Gulf and west at least to Cape Dalhousie.

When the migration ended by the early 1920s, the herd was assumed to be nearly extinct (Manning 1960, Banfield 1974), although 1000 were reported on Victoria Island in 1949 (Banfield 1950). Inuit from Cambridge Bay reported that they were still seeing caribou on southern Victoria Island, but rarely until the 1970s and 1980s when their numbers began to increase; by 1993 up to 7000 were migrating annually across Coronation Gulf and Dease Strait (Gunn et al. 1997, Gunn and Nishi 1998, Gunn and Fournier 2000). The skull measurements, pelage colour, and migratory behavior of caribou on southern Victoria Island in the 1980s were similar to those previously described by Manning (1960) for the Dolphin and Union herd (Gunn and Fournier 1996). Genetic evidence also supports its distinctiveness and genetic isolation from other populations (Zittlau 2003).

Currently most of the central/southern/eastern Victoria Island caribou migrate to the mainland in winter but some do not. Elias (1993) summarized Aboriginal traditional knowledge that the resident Victoria Island caribou migrate north of Prince Albert Sound to calf in the spring; they winter around there or on islands to the east or south of the coast. Some of those caribou cross to Read Island, while others go east to Cambridge Bay. Those that migrate across the sea ice to the mainland in November, winter in the area of Elu Inlet, and then return in April to southeast Victoria Island.

Prince of Wales Island–Somerset Island

Large-scale (involving hundreds of caribou) east–west movements occur between winter range on Somerset Island and calving areas on Prince of Wales Island and their satellite islands such as Pandora, Prescott, Vivian, and Lock, but these do not involve all the caribou, and use of the various islands differs among years (Miller and Gunn 1978, 1980, Miller and Kiliaan 1980, 1981, Miller *et al.* 1982, Miller 1990a, Miller 1991, Miller 1997a). Lesser (in terms of numbers; some were regular migrations) movements were north-south between Prince of Wales Island and the nearby Mecham, Russell, Hamilton, Young, and Lowther islands in Barrow Strait, inferred by tracks on sea ice and by changing densities of caribou on the smaller island. After extensive searching by helicopter for caribou or caribou tracks crossing Barrow Strait to Bathurst, Cornwallis, or Little Cornwallis islands during 1977-1980, Miller (1990a) concluded that no regular, large-scale movements occurred between the Prince of Wales–Somerset group and the Queen Elizabeth Islands. These observations are consistent with the recent genetic results reviewed above that showed the Prince of Wales–Somerset and Queen Elizabeth Islands populations to be distinct, albeit with some past and possibly current movement between them.

Tracks on sea ice of Franklin Strait also indicate smaller-scale spring migrations directly from Boothia Peninsula to Prince of Wales Island and from Somerset Island to Prince of Wales Island on Peel Sound (Miller and Gunn 1978, 1980, Miller *et al.* 1982, Miller 1990a). The migrations allow those caribou to winter on Somerset Island and/or Boothia Peninsula, then summer and calve mainly on Prince of Wales Island but also on Somerset Island and Russell Island. A few also summer on lesser satellite islands in the Prince of Wales Island-Somerset Island-Boothia Peninsula Complex.

Boothia

Formerly considered part of a metapopulation together with the caribou of Prince of Wales and Somerset islands (Gunn *et al.* 2000b), at least some of the caribou on the Boothia Peninsula are now known to be genetically distinct. Like the Dolphin and Union herd, caribou on the Boothia Peninsula essentially disappeared and then reappeared during this century (Gunn 1998a). However, the Boothia Peninsula caribou populations are not clearly understood.

Both Peary and barren-ground caribou occur on the Boothia Peninsula. Peary caribou calve on the northwest of the peninsula and then summer there or move to southern Somerset Island or Prince of Wales Island before returning to around Taloyoak for the winter; however, the barren-ground local population calves on the northeast, summers there and returns to south of Taloyoak for the winter (Gunn 1998a). During the winter, hunters from Taloyoak found Peary caribou from Taloyoak to Thom Bay and Nalluqtaq Inlet to Brentford Bay (David Tucktoo pers. comm. 1986 cited by Gunn 1998a). Gunn *et al.* (2000a) found that Peary caribou fitted with satellite transmitters on northwestern Boothia Peninsula occurred throughout the peninsula in the course of the year and wintered on the mainland at least as far south as the Hayes River, about 350 km south of the Boothia isthmus.

Other islands

King William and other nearby islands near the Boothia Peninsula have uncertain status in terms of caribou subspecies and populations. Miller (1991) cited Gunn's personal communication of 1989, reporting only a handful of "Peary-like" caribou there in 1989, and that Inuit hunters recognize both Peary-like immigrants and barren-ground migrants from the Boothia Peninsula and the mainland. Their taxonomic status is uncertain, and may comprise a mixture of Peary caribou, Dolphin and Union barren-ground and mainland barren-ground caribou.

HABITAT

Habitat requirements

Miller (1991) described Peary caribou habitat and it is well enough known not to need extensive review. The climate of the Queen Elizabeth Islands was summarized by Miller (1991): weather is variable and severe with short, cool summers and long, cold winters. Total annual precipitation normally averages < 100 mm, defining much of the range as polar desert. Air temperatures average below -17.7° C from December to March and mean daily temperatures generally do not rise above 0° C until after 1 June on the extreme south of the region or 15 June on the north of the region. Snow cover can persist from mid-August to the following July in the most severe years. Across the Arctic islands, the climate is strongly regionalized with east-west and north-south gradients in precipitation and temperatures due to the influence of Pacific air masses in the west and Atlantic air masses in the east (Maxwell 1981).

The following habitat notes are from Miller (1991). Icefields, bare ground and rock limit the area of suitable forage for Peary caribou to a small percentage of the total area. Peary caribou use poorly to moderately vegetated dry to moist habitats. Forage of high digestibility is selected when available but when not they eat more low digestibility forages. Summer foraging areas are on mesic habitats with sedges (*Carex spp.*), willow (*Salix arctica*), grasses and forbs, especially purple saxifrage *Saxifraga oppositifolia*). In winter, caribou use more exposed sites with shallower snow cover. On Somerset Island, winter range is mainly broken rock outcrops where snow depth is variable but usually soft and less often crusted. Winter foraging sites are xeric and vegetated with dryas (*Dryas integrifolia*), purple saxifrage, arctic willow, sedges and lichens.

Caribou can travel 3-4 km per hour while actively foraging (Miller *et al.* 1982). Under ideal conditions when the snow is soft and relatively shallow, the caribou forage by simply pushing the snow off the vegetation with their noses. When the snow cover is denser but still above a ‘threshold hardness, they dig small individually scattered craters, unlike the large cratered areas often used by muskoxen and mainland barren-ground caribou. Once the snow cover passes a threshold hardness and greater density, the caribou seek forage at snow-free sites or at sites with only shallow fresh snow cover. Caribou will also forage by breaking blocks of hard-packed snow off edges of windblown areas to get to the vegetation.

On Banks Island, caribou often feed in winter by cratering in the snow of upland habitats (upland barrens, hummock tundra, and stony barrens) where it is softer and shallower than in wet meadows, and snow depth and hardness can be used to determine winter severity (Larter and Nagy 2000b).

Schaefer and Messier (1994) described the spatial structure of plant communities in southeast Victoria Island: (1) graminoid-dominated wet meadows (*Carex aquatilis-C. Atrofusca-Eriophorum angustifolium*), (2) wetter willow-sedge meadows (*Salix lanata-Kobresia* spp*.-Arctagrostis latifolia*), (3) mesic-hydric meltwater slopes (*Eroiphorum angustifolium* and *Cassiope tetragona*), (4) sparsely vegetated uplands (*Poa spp.-Carex rupestris-Saxifraga tricuspidata-Oxytropis maydelliana*), (5) raised beaches with little vegetation, (6) mesic-xeric areas of *Carex rupestris-C. misandra-Kobresia* spp*.-Dryas* spp*.),* (7) xeric, highly exposed communities of *Carex ruprestris-Cetraria-Saxifraga oppositif*olia, and (8) mesic between-polygon communities of *Arctagrostis latifolia—Dryas* spp*.-Oxytropis maydelliana*).

Banks Island is the only Peary caribou habitat with extensive, well-vegetated rolling hills that fall mostly within the “wet tundra class” of the satellite image-generated North American Land Cover database (Gunn and Dragon 1998). The 4 principal Banks

Island caribou habitats are (Kevan 1974, Wilkinson *et al.* 1976, Ferguson 1991, Larter and Nagy 2000b):

1. Wet sedge meadows are generally level hydric and hydric lowlands characterized by water sedge (*Carex aquatilis*), cotton sedge (*Eriophorum scheuchzeri*), and tundra grass (*Dupontia fisheri*).

2. Upland barrens are well drained sites found on the upper and middle parts of slopes. Vegetation is dominated by mountain avens (*Dryas integrifolia*) and arctic willow (*Salix arctica*).

3. Hummock tundra is found on moderately steep slopes and is characterized by individual hummocks which are vegetated primarily by dwarf shrubs including mountain avens, arctic willow and arctic heather (*Cassiope tetragona*).

4. Stony barrens have a coarse gravelly substrate and are sparsely vegetated. This habitat is found on wind blown areas, ridges and gravel and sand bars.

Calving, post-calving, and rutting areas are likely critical habitats because caribou are vulnerable as they congregate in those areas. This is a particularly important concern as the use of those areas is at times when uninterrupted foraging is important to the annual cycle of physical condition and calf growth. Cows are faithful to calving areas (Gunn and Miller 1986, Heard and Stenhouse 1992, both cited in Gunn 1993) although calving is at a lower density and more dispersed than the high densities usually described for barren-ground caribou (Gunn and Fournier 2000, Nishi and Buckland 2000). Calving site fidelity is balanced, however, by occasional range shifts within a population's traditional territories, which allows forage to recover in 1 area while caribou use the available forage in another part of their territory. Also, caribou may shift calving locations because of snow and ice conditions in 1 calving area while in search for better conditions in another. Banks Island caribou calve on the northwest and northeast tips of the island and in the mid-east coastal area across Prince of Wales Strait from Victoria Island (Larter and Nagy 2000a). Likewise, the Minto Inlet herd on Victoria Island calves just across Prince of Wales Strait from Banks Island, while the Dolphin and Union population calves south of Prince Albert Sound (Gunn 1993). Aboriginal traditional knowledge suggests that the Dolphin and Union herd also calves, or used to calve, north of Prince Albert Sound (Gunn 1993).

Calving areas of the Prince of Wales-Somerset and Boothia populations have included the Wrottesley Inlet area on northwestern Boothia Peninsula, the Aston Bay area on the northwest coast of Somerset Island, the southwestern Arrow Smith Plains, the northeastern coastal area from Young Bay to Inner Browne Bay, the northwest coast and the Mount Clarendon 'peninsula-like' area of northwestern Prince of Wales Island and western Russell Island (Fischer and Duncan 1976, Miller and Gunn 1978, 1980, Miller and Kiliaan 1981, Miller *et al.* 1982). Many caribou from Somerset Island used to cross to Prince of Wales Island for calving (Gunn and Dragon 1998).

The variability of weather parameters such as mean daily temperatures and snowfall contributes to the severity of the climate (Miller and Gunn 2003a). This is because Peary caribou are at the edge of the range for herbivores as the High Arctic is close to the climatic limits for plant growth. The plant growing season is brief and relatively fixed in duration but the timing of the onset of plant growth is annually variable (Svoboda 1977). For example, Svoboda (1977) reported only 45 to 80 days separated the time between snowmelt to mean temperature below freezing in 1970, 1971 and 1972 at Devon Island's Truelove Lowlands. At Resolute on Cornwallis Island, the number of days with temperatures above 0º during the same 3 years averaged 61±13.5 SD days and ranged from 46 to 72 days (Miller and Gunn 2003a). Therefore, in some years, the renewal of plant growth can be delayed at least 2 to 3 weeks in June when lactating cows need high quality forage from new plant growth.

The absolute availability of forage (plant growth) is driven by climate variability, and the relative availability of forage during the 10-month season of snow and freezing conditions is also governed by climate variability (the timing and type of snowfall etc.). Thus, Peary caribou live in a 'non-equilibrium grazing system' where sporadic, unpredictable abiotic variables—i.e., snow and ice—usually govern the fate of the caribou over time (e.g., Caughley and Gunn 1993, Behinke 2000, Miller and Gunn 2003). Under such environmental conditions, the broad distribution of Peary caribou across the various climate regions has enhanced the probability of persistence.

Trends in habitat

Miller (1991) noted that in temperate region ungulate management, winter range is regarded as controlling the upper limits of population, but in the Arctic, summer range may be critical because of the short growing season available for caribou to build up their fat reserves. He found no evidence that either winter or summer habitats were limiting factors in terms of absolute forage availability. Peary caribou researchers (e.g. Gunn 1998b, Miller 1998, Larter and Nagy 2000b, Ferguson *et al.* 2001, Gunn and Dragon 2002, Miller and Gunn 2003b) are careful to distinguish between absolute forage availability and relative or seasonal availability when limited by winter snow and ice.

Although communities are likely to increase in size and some oil and gas and mining development is possible, effects on habitat are likely localized and the overall trend in habitat will be unaffected. Atmospheric transport brings pollutants to the Arctic, but implications for trends in habitat are unknown (Arctic Monitoring and Assessment Programme 1997). In caribou from the Kent Peninsula sampled in 1993, Belkin (pers. comm. to Gunn and Nishi 1998) found relatively low concentrations of organochlorine, heavy metal and radionuclide contaminants.

Protection/ownership

Most Peary caribou range is in Nunavut, but Banks Island, the northwest quarter of Victoria Island and the major part of the Melville complex on the southwestern Queen

Elizabeth Islands and virtually all of the Prime Minister Group on northwestern Queen Elizabeth Islands are in the Northwest Territories. Most land in the Northwest Territories and Nunavut is federal Crown land.

A new National Park, Aulavik (12 000 km^2), has been established on Banks Island (Quttinirpaaq National Park, 39 500 km^2, on Ellesmere Island was established previously). Polar Bear Pass National Wildlife Area, with 2461 km^2 of land area, is on central Bathurst Island. Banks Island also has 2 migratory bird sanctuaries. A national park is also being planned for northern Bathurst Island. Although these designations provide protection for habitat, Inuit and Inuvialuit retain their rights, as defined by land claims settlements, to hunt Peary caribou for subsistence purposes in all protected areas.

Management authorities

Wildlife in the Peary caribou range is co-managed by governments and Inuvialuit pursuant to the Inuvialuit Final Agreement and by governments and Inuit pursuant to the Nunavut Land Claims Agreement. While the terms of these agreements differ, in general they recognize the Aboriginal rights of Inuit and Inuvialuit to manage the harvest of wildlife, subject only to the need for conservation and public safety. The circumstances in which either the territorial or federal governments can intervene in these rights are carefully circumscribed by the terms of the agreements. The primary management authorities are two wildlife co-management boards: the Wildlife Management Advisory Council (WMAC) for the Inuvialuit Settlement Region in the Northwest Territories and the Nunavut Wildlife Management Board (NWMB) for Nunavut. Although their mandates differ somewhat, both organizations bring together aboriginal and government representatives.

In the Northwest Territories, the Inuvialuit Game Council represents hunters' and trappers' committees from 6 Arctic communities and appoints Inuvialuit members to the WMAC. The Department of Resources, Wildlife and Economic Development (Government of the Northwest Territories) and the Canadian Wildlife Service (Government of Canada) participate on the WMAC and undertake research. In Nunavut, the Nunavut Department of Sustainable Development and the Canadian Wildlife Service both appoint members to sit on the NWMB, along with Inuit appointed by their regional organizations. NWMB membership also includes other federal departments and Nunavut Tunngavik Incorporated. As an institution of public government, all NWMB members represent the public interest and not necessarily the interests or opinions of their appointing bodies. These boards are supported by local hunters' and trappers' associations and other community committees:

- Sachs Harbour Hunters and Trappers Committee
- Olokhaktomiuk Hunters and Trappers Committee (Holman Island)
- Kugluktuk Angonaitit Association
- Burnside Hunters and Trappers Association, Bathurst Inlet
- Omingmaktok Hunters and Trappers Organization, Bay Chimo

- Ekaluktutiak Hunters and Trappers Organization, Cambridge Bay
- Spence Bay Hunters and Trappers Association, Taloyoak
- Gjoa Haven Hunters and Trappers Organization
- Kurtairojuark Hunters and Trappers Organization, Kugaaruk
- Kitikmeot Hunters and Trappers Association
- Kitikmeot Inuit Association
- Qikiqtaani Inuit Association
- Resolute Bay Hunters and Trappers Organization
- Grise Fiord Hunters and Trappers Organisation
- Qikiqtaaluk Wildlife Board, Baffin Region

The relevant government departments and the wildlife management boards cooperate across interjurisdictional boundaries according to the provisions of the land claims.

BIOLOGY

General

Peary caribou and Dolphin and Union carbou live in a harsh environment where occasionally severe winters limit the available forage, causing periodic mass starvation and environmentally forced emigration. This latter point is controversial. Large-scale movements beyond a population's traditional range have not been documented, but genetic evidence suggests that they have occurred (perhaps in the distant past). Recent evidence for such movements is discussed below.

Peary caribou differences from barren-ground caribou (other than Dolphin and Union carbou) are thought to be specific adaptations to their High Arctic environment. The extent of specific adaptations is largely unknown and may include the following:

- The furry face protects from the severe cold. Long legs are not needed in the arctic desert where snow is typically shallow and often packed hard.
- The function of the modified skull shape (shorter and broader, especially in the nasal bones) is unknown, but may pre-heat breath intake to prevent freezing the lungs; or it may be an adaptation for browsing the low height of vegetation.
- The rumen of Peary caribou is proportionately larger than in reindeer (no data were available for other caribou), possibly to accommodate increased amounts of low-nutrition forage (Staaland *et al.* 1997, cited by Gunn and Dragon 1998).
- The light coat colour is obviously an adaptation to a region where winter lasts from September 1 to May 31 (Miller 1991).

Reproduction and survival

Although healthy Peary caribou cows may breed as yearlings and produce their first calves as 2-year-olds, first calf production at 3 years is more common. Pregnancy rates (especially of yearlings) and calf survival are strongly affected by their nutritional condition (Thomas *et al.* 1976, Thomas and Broughton 1978, Thomas 1982, Larter and Nagy 2000b). Gunn *et al.* (1998) suggested that males typically reach breeding age at 4 years, and females at 2 years; both are reproductively capable up to 13 years and live up to 15 years; and up to 80% of adult females may produce calves in a given year. The proportion of females producing calves in any given year varies markedly, depending on prevailing environmental pressures (Thomas and Broughton 1978, Thomas 1982).

Monitoring of calf production and survival has been sporadic except for Banks Island in the 1980s and 1990s. The consistent picture for Peary caribou is high annual variability in both pregnancy or calf production and in calf survival. In severe winters, yearling recruitment can drop to 0. Pregnancy rates vary from nearly 0% to nearly 100% and are associated with physical condition. For example, Thomas and Broughton (1978) found that in 1978, 88% of adult female Peary caribou collected on Melville and Prince Patrick islands were pregnant, up from 6-7% in 1975, 1976, and 1977 – during the first 3 years after the disastrous 1973-1974 winter. At the same time, mean percentage of femur marrow fat increased from 76% to 88%. Likewise, in those same years, the pregnancy rate on Somerset Island and Prince of Wales Island increased from 73% to 100%, while the femur marrow fat increased from 76% to 79%. They concluded that pregnancy rates and fat reserves are closely associated and that partial recovery following the starvation conditions of 1973-1974 took 3 years.

Larter and Nagy (2000b), combining data from 1982 to 1999 for Banks Island, found that the summertime extremes in percentage of calves in the population in July and August after June calving was 12.5% to 32.1%. As ratios of calves per 100 adult females, the variation on Banks Island during those years was from 24.0 to 74.3:100 adult females. Calf production was greater than 50 calves per 100 cows in 8 years. Calves per 100 adult females actually varied from none to 96.7 calves during the 1990s (F.L. Miller, pers. comm. 26 Jan 2004).

Larter and Nagy (2000b) estimated calf production and over-winter calf survival over 7 years (1992-1999), a period when the authors did not rate the winters as severe. The lowest calf production followed the 1 winter with increased snow hardness (1993-94). Calf survival was the lowest during the winter following a severe winter but neither calf survival nor calf production were significantly related to snow hardness or snow depth. Larter and Nagy (2000b) concluded that either their data on calf production and survival had not sampled the full range of winter conditions or that snow depth or snow hardness do not adequately sample the winter condition which affects calf production and winter survival.

Reproductive potential

Peary caribou under ideal conditions have similar rates of increase to other caribou based on breeding in consecutive years, single births, and age of first breeding at 2 years. A potential complication for recovering (and small) populations is the age and sex composition of the 'starting' population. A population that has survived a die-off will likely have a high proportion of breeding females. For example, Miller and Gunn (2003b) recorded that 75% of caribou seen on Bathurst Island in 1998 (after the 1994-97 die-off) were breeding age cows compared to 40% before the die-off.

Gunn *et al* (2000b) referred to "the accepted maximum" rate of annual increase of 0.3, or 30% (λ=1.3), a rate that Bergerud (1978) previously proposed for caribou in general. The Bathurst Island complex local population approached this rate, going from 1103 caribou in 1988 to 2667 in 1993 (Miller 1998), a 19% annual rate of increase (λ=1.19) over 5 years. (Caribou on Banks Island and northwestern Victoria Island appear to have increased at higher rates, but those data are suspect, in part because when populations increased on Banks Island they decreased on Victoria Island, and vice versa, suggesting movement between them.) Over longer periods, however, even when conditions remained favourable, Peary and Dolphin and Union caribou experienced lower rates of annual increase:

- Bathurst Island, from 266 caribou in 1974 to 3011 in 1994 (20 years), 13% (λ=1.13).
- Dolphin and Union, from 3424 in 1980 to 27 786 in 1997 (17 years), a 13% annual rate of increase (λ=1.13).

Miller (1998) also reported a 20-year fixed-rate increase of 13% per year for Peary caribou in the Bathurst Island complex and suggested that it is a reasonable expectation for Peary caribou on the Queen Elizabeth Islands under favourable environmental conditions and without die-off events. Gunn *et al.* (1998), reporting results of a modelling workshop, also stated that "*during particularly favourable periods the population could grow as much as [fixed rates of] 15-20%*."

Physiology

Miller (1991) previously reviewed aspects of physiology that are relevant to assessment of conservation status. Physiology in relation to nutrition was discussed above. Gunn and Dragon (1998) provide a good review of caribou and muskox physiology in relation to nutrition and possibly competition with muskoxen.

Movements/dispersal

Peary caribou have flexible and varied migration strategies: some have relatively small home ranges (e.g., Bathurst Island) that expand during severe winters, while others migrate and have seasonal ranges separated by hundreds of km (e.g., the Melville Island complex). There also seem to be a few Peary caribou in any population that make long, irregular movements outside of their normal home ranges, in both good and bad years. Such movements during severe winters can be attributed to a desperate search for food, but such movements in good years are less easily interpreted. The proportion of Peary caribou willing to make such movements, and the environmental or other factors that prompt them to do so are unknown. Uncertainties as to the frequency and scale of these kinds of movements and the motivation of caribou to make them have generated some controversy among biologists and between biologists and Inuit and Inuvialuit.

Maximum distance travelled (vector sum on horizontal plane) by marked caribou in the Melville Island complex during spring migration was 450 km (Miller *et al.* 1977b). Miller and Barry (2003) found mean home ranges of 4 of 17 satellite-collared Peary caribou that remained on Bathurst Island over 1 year to be between 1221 and 2429 km^2 (mean±SE = 1765±160 km^2, 95% CI=1353 to 2178 km^2) during a full year, 1993-1994, a nutritionally and reproductively favourable year. The other 13 caribou used multiple nearby islands, but their home ranges have not yet been reported. Some of the seasonal migrations within the Prince of Wales-Somerset-Boothia complex would have been in the 300-500 km range or longer and within the Bathurst Island complex, 100-200 km. Caribou of the Dolphin and Union herd also seasonally migrate on the scale of 300-500 km (Gunn and Fournier 2000).

Most documented crossings occur in winter over the ice, but crossings have also occurred in summer by swimming at least 2.5 km (Miller 1995).

Peary and Dolphin and Union caribou cows' fidelity to their calving areas has been shown by aerial surveys (Urquhart 1973, Miller *et al.* 1977b) and satellite telemetry (Gunn and Fournier 2000, Gunn *et al.* 2000a). Regular, seasonal movements are reinforced by fidelity of females to calving areas (Gunn and Miller 1986 cited in Miller 1991, Miller and Gunn 2001). Males also make regular use of seasonal home ranges as shown by non-random distribution of antlers (Miller and Barry 1991).

Miller and Barry (2003) also noted that in summer and autumn the caribou used larger sections of their home ranges than in winter and speculated that this reflected the widespread availability of forage, rather than a need to move to find adequate forage. In the same year, Miller (2002) documented a male and a female Peary caribou having home ranges that involved 6 and 5 islands, respectively, with the male making 16 and the female 11 movements among those islands between 1 July 1993 and 30 June 1994. He also reviewed previous studies that showed that, in severe winters, while some caribou remain in their home range on 1 island even to the point of starvation, others will move to other islands.

The basis for reports of inter-island movements varies between direct sightings of caribou and their tracks on the sea-ice to finding caribou on smaller islands (and assuming where they might have come from) to assumptions about movements based on differences in sizes of caribou numbers on neighbouring islands during consecutive surveys. They include:

- among the Melville-Prince Patrick complex of islands (Miller *et al.* 1977b);

- between and among Bathurst Island and nearby islands less than 10 km distant (Miller 1995, 1998, Miller 2002);
- from Bathurst Island to Baring Island (50 km east); then, Baring to Cornwallis Island; then, Cornwallis to Little Cornwallis Island to Milne Island, back to Bathurst Island (Miller 1995, 1997b, 1998, Miller and Barry 2003);
- from Bathurst Island to Lougheed Island, then to Borden Island (280 km northeast of Bathurst Island, requiring sea ice crossings of at least 48 km to Lougheed Island and 100 km to Borden Island) and dying immediately after arrival on Borden Island (Miller 1997b, 1998);
- among Prince of Wales, Russell Island, Somerset Island and nearby smaller islands, Boothia Peninsula (Miller and Gunn 1978, 1980, Miller and Kiliaan 1980, 1981, Miller *et al.* 1982); and
- from Bathurst Island to Cornwallis Island at least twice: during the 1973-1974 starvation year Miller *et al.* (1977a), and again during the 1994-1997 starvation years (Miller 1998, Gunn and Dragon 2002).

In addition to the above documented movements, qaujimajatuqangit suggests that caribou have also moved between the Bathurst Island complex and the Prince of Wales -Somerset complex, and from the Bathurst Island complex to the eastern Queen Elizabeth Islands. Local people believe that such movements are not uncommon and may be prompted by poor range conditions (including those caused by severe winters) or by an inherent need to keep shifting ranges to keep them from becoming overutilized (Ferguson *et al.* 1998). Also, genetic testing suggests past gene flow between the Prince of Wales-Somerset population and the Bathurst Island complex (Zittlau 2003).

T. Mullen, (Nunavut Wildlife Service Resolute Bay, pers. comm. March 20, 2002) reported having seen caribou tracks heading from Cornwallis Island southwards across Barrow Strait and D. Kaomayok (a hunter from Resolute Bay, pers. comm. cited in Gunn and Dragon 1998) suggested that Prince of Wales caribou may have moved to Bathurst Island in the 1990s, as an explanation for their absence on Prince of Wales, although he had no direct observation. However, Canadian Wildlife Service researchers surveying caribou in the Bathurst Island complex at that time did not see any large-bodied caribou typical of the Prince of Wales-Somerset Island deme during that period (Gunn and Dragon 1998); nor did any Inuit hunter report seeing kingailik (Prince of Wales Island) caribou on Bathurst Island (F.L. Miller, pers. comm. January 26, 2004). Also, T. Mullen (pers. comm. March 20, 2002) and N. Amarualik (Resolute Bay Hunters and Trappers Association, pers. comm., March 20, 2002) said that it is a general understanding in among both Resolute Bay and Grise Fiord hunters that caribou have, in the past, gone from Cornwallis Island to Devon and Ellesmere Island.

During the crash of 1994-1997, caribou from Bathurst Island went east at least as far as Cornwallis Island (Miller and Barry 2003), where about 85±25 were shot, leaving about 315 unaccounted for in Miller’s (1998) and Gunn and Dragon’s (2002) live/dead caribou mass balance for 1995. Inuit from Resolute Bay said that many caribou went to Devon and Ellesmere islands during that period (T. Mullen, Nunavut Wildlife Service, pers. comm. March 20, 2002; N. Amarualik, Resolute Bay Hunters and Trappers Association, pers. comm., March 21-22, 2002).

There is some evidence—tracks on the ice and observations of caribou on small islands in Barrow Strait (Miller and Gunn 1978)—that a few animals may make such movements on a small scale at irregular intervals, but no evidence of regular or mass movements. F. Miller (Canadian Wildlife Service, pers. comm. Dec. 21, 2002) attempted to document such observations but found no one who could verify a first-hand observation of caribou or their tracks crossing between these population areas. He searched for tracks and other evidence of such movements along both sides of Barrow Strait, during the times that they were reported to have occurred, and found none.

The ability to shift ranges by inter-island movements in times of environmental stress may be important to Peary caribou survival, and this same ability is essential to restock previously abandoned ranges (Miller 1990a). Miller and Gunn (1978), for example, speculated that recolonization of decimated Bathurst Island population might occur as movements of caribou from Somerset and Prince of Wales islands across Barrow Strait or Viscount Melville Sound.

Miller and Gunn (2003b) concluded that,

> "Inter-island movements could enable temporary predator avoidance and enhance those caribou's use of different ranges on different islands. In turn, this would maximize their use of the best seasonal ranges among a group of islands in times of environmental stress. Thus, those inter-island movements would represent an effective pattern of range–use, even if less so in the few years with the most extremely unfavourable and prolonged range-wide snow and ice conditions…Their seasonal and annual range-use patterns suggest a degree of flexibility and adaptability to a variable and taxing environment and indicate the important role that relatively small islands play in the ecology of Peary caribou."

Nutrition and interspecific interactions

A continuing issue since the Bathurst Island population crash of 1973-1974 has been whether depleted forage due to overgrazing, caused by either overpopulation of caribou or by competition with muskoxen, has caused caribou declines. The sudden population crashes in Bathurst Island complex were clearly caused by deep snow and icing events unrelated to forage conditions—a density-independent mechanism (Miller 1991, 1998). Peary caribou population declines or emigration prompted by overpopulation and/or deteriorating forage—a density-dependent mechanism—have been hypothesized (Ferguson *et al.* 2001), but not documented.

Many authors (see review in Miller 1998:48-54) have found that lichens are often of minor importance in the diets of Peary caribou, relative to caribou on mainland and more southern ranges. Parker (1978), sampling rumen and fecal content on Melville and Axel Heiberg islands, found that willow (*Salix arctica*) is the most important food item, especially in summer. Winter forage items included forbs, grasses, and some sedges, but caribou maintained better nutritive and reproductive condition on a high willow diet. He showed that in favourable winters there is no interspecific competition with muskoxen on the basis of total forage available, but predicted that, in severe winters, there could be competition as both species sought willows on exposed slopes and ridges. He concluded that deep, prolonged, and dense snow cover is the important climatic factor controlling both muskox and caribou populations. Riewe (1973) also found that willow is "vital" to caribou on Ellesmere Island. Other studies have shown that purple saxifrage (*Saxifraga oppositifolia*) is very important, especially in summer when caribou select the flowers (see review by Miller 1991).

Thomas *et al.* (1999), based on their 1974 data, showed that vegetative cover and standing crop in summer and winter were correlated with the density of caribou summer and winter fecal pellet types, demonstrating that caribou seek out these habitat types in both seasons. In summer, caribou pellet densities were greatest in mesic sites where lichens, willow, wood rushes (*Luzula spp.)*, arctic poppy (*Papaver radicatum*) and chickweed (*Stellaria longipes)* were abundant. Winter forage sites were typified by high densities of *Luzula* spp. and lichens. Caribou winter range use on some sites had a significant positive correlation with *Cetraria delisei*, *Thamnolia vermicularis*, *Juncus bigumis, Alopecurus alpinus* and crustose lichens. They also concluded that during the 1973-1974 severe winter when both caribou and muskoxen died, there was no interspecific competition between caribou and muskoxen. The fecal pellet densities of the 2 species were negatively associated and relationships with certain forage species contrasted significantly. Caribou also used predominantly mesic to xeric sites, while muskoxen used primarily wet meadows. They concluded that *Luzula* spp. are survival foods, used in severe winters when more palatable foods are unavailable. *Luzula* is only 28% digestible, compared to *Thamnola vermicularis* (57% to 62%) and *Cetraria* spp. (61% to 81%).

Peary caribou require about 1 kg DM/day (dry matter per day) for maintenance in winter, or 2.0 kg DM/day for good health (Miller 1998, extrapolated this from Alaskan studies that he cited in consultation with the senior author, Robert G. White). The range produces far more than that, even in poor years. Miller (1998, citing unpublished 1974 data from D.C. Thomas, that is now published as Thomas *et al*. 1999) calculated the plant biomass (living parts only of all vascular plants plus lichens, excluding moss, crustose lichens and algae) measured as dry matter (DM) available on eastern Melville Island in spring after the 1973-1974 die-off. The total available was 33.5 gDM/m^2.

Based on the low, 1973 pre-crash density of caribou occupying those ranges on Melville Island that spring, Miller (1998) calculated that they would have required only 0.05 gDM/m^2/year, or < 0.2% of the available forage to survive the previous winter. He also calculated that even at maximum historic density for the Bathurst complex (1961: 3608), with only 5 gDM/m^2, only 2% of the available forage would be required. Therefore, according to Miller (1998), the absolute amount of forage was not limiting and over-utilization of the range was not a factor. His conclusion was that the forage was made unavailable because of snow conditions, particularly those caused by early winter snowfall (1 Sep-30 Nov). This unfavourable condition is particularly severe when associated with rain in late September and/or early October which freezes on, in, or under the snow pack, preventing ungulates from foraging or making their foraging efforts energy-inefficient.

Miller (1998) used the mean home range size for 6 caribou of 1765±160 km^2 in 1993-1994, a favourable year, to calculate that they needed only 5% to 8% of the available land area on Bathurst Island to obtain their nutritional requirements. He made a distinction between density-dependent forage depletion that could theoretically prompt emigration, but which has not occurred on Bathurst or other western Queen Elizabeth Islands, and density-independent, seasonal forage unavailability that does occur, has caused starvation and may prompt limited emigration.

Many Inuit believe that caribou routinely disperse from their previous home ranges because of deteriorating forage conditions. For example, after the Prince of Wales-Somerset population had declined, local Inuit stated that the decline probably was caused by effects of high caribou densities on their forage (S. Idlout pers. comm. in Ferguson *et al.* 2001). During the decline of caribou on Banks Island, there was no statistically significant association between any measure of winter severity and either calf production or overwinter survival, nor was there any evidence of a die-off (Larter and Nagy 2000b). Thus, forage availability may have been a factor, and indeed, local Inuvialuit hunters reported that some caribou were in poor condition in the fall prior to onset of severe winter conditions. Likewise, the declines on northwestern Victoria Island (Gunn 1993, Inuvialuit Game Council 2002b) and Prince of Wales-Somerset islands (Gunn and Dragon 1998) were not known to be associated with any large-scale winter mortality as described for the western Queen Elizabeth Islands (Miller *et al.* 1977a, Miller 1991, Gunn and Dragon 2002). If unfavourable snow conditions and widespread icing on, in, and under the snow cover occurred on northwestern Victoria Island and on Prince of Wales and Somerset islands, they went undetected.

Several instances of range shifts by barren-ground caribou and reindeer on other Arctic islands in response to deteriorating forage supply have been reported (Gates *et al.* 1986, Adamczewski *et al.* 1988, Ouellet *et al.* 1993, Staaland *et al.* 1993, Ouellet *et al.* 1996, Ferguson *et al.* 2000, Ferguson and Messier 2000). Qaujimajatunqagnit also includes several instances of range shifts away from deteriorating range on Baffin Island (Ferguson and Messier 1997, Ferguson *et al.* 1998). These situations, however, with higher amounts of non-lichen forage (grasses and sedges) supporting higher densities of reindeer or caribou, are rather different from the High Arctic range and lower Peary caribou densities; moreover, icing events may have been implicated in some of the range shifts (F. Miller, pers. comm., May 21, 2003).

The available evidence for barren-ground caribou suggests that they switch winter ranges for complex (not well documented although much speculated) reasons that sometimes include forage availability. Range shifts *before* overgrazing can damage the range have often been hypothesized, but would be difficult to demonstrate.

The Dolphin and Union population's use of fall ranges is a more unusual situation. Since the mid-1980s, the caribou have migrated to the south coast of Victoria Island during the rut and then cross on the newly formed sea-ice to the mainland winter range (Nishi and Gunn 2004). However, in recent years, ice formation is later and the caribou staged along the coast are visibly affecting the vegetation, at least in some areas, while they wait for the ice to form (A. Gunn, Government of the Northwest Territories, pers. comm. July 9, 2003). If global warming were to cause this trend to continue, the consequences could be serious.

Behaviour/adaptability

In structured interviews by Inuktitut speakers, residents of both Resolute Bay (Nunavut Tusaavut Inc. 1997) and Holman Island (Elias 1993) mentioned the propensity of Peary caribou to temporarily abandon ranges in response to environmental conditions, such as extreme snow and ice covering forage, and then to return some years later. In such winters, many caribou that did not leave, starved. One of Elias's (1993) interviewees also said that Peary caribou do not flee from snow machines, making them unusually vulnerable to hunters. Another area of vulnerability to hunters, mentioned in the Resolute Bay interviews, is when caribou migrate by swimming between islands (caribou migrating through sea-water are termed "sinmiujut").

Behaviour and adaptability were reviewed by Miller (1991). Peary caribou are found in small group sizes relative to barren-ground caribou. Group sizes increase slightly prior to calving, stabilize or decrease during calving, and then increase into post-calving aggregations as they move inland from coastal areas. Peary caribou crater in the snow pack until threshold hardness (density) is experienced, when they shift to foraging on windswept (hence, snow-free or shallow snow-covered) ridges and hilltops, and in boulder fields where snow is deeper but soft and not crusted by wind. During icing conditions (snow depth >30 cm, temperatures fluctuating above and below 0° C), caribou leave boulder fields and move to snow-free, south-facing ridges, which are also where spring green-up occurs earliest.

The virtual absence of mosquitoes and warble flies allows Peary caribou more uninterrupted foraging leading to accumulation of substantial fat stores, which can amount to 55 mm in subcutaneous deposits on the back. High fat accumulations in the autumn are critical to survival in severe winters. During years of exceptionally severe snow/ice conditions leading to extreme environmental (nutritional) stress, relatively few, or less often, virtually no calves may be produced and/or survive after birth (deaths usually within the first hours, day or < 1 week of life). Some Peary caribou also respond to stress by range shifts on home range or range expansion within a local population's range and less often by long distance emigration or temporary displacement outside their previous home ranges (Miller 1995, 1997b, 1998, Miller 2002, Miller and Barry 2003) as discussed above.

POPULATION SIZES AND TRENDS

Documenting population trends within narrow limits of confidence is difficult because of the irregularity of surveys and the inconsistency of survey coverage and methods. Surveys are expensive because of the vast area involved. Weather conditions can prevent completion of a planned survey. The caribou make it more difficult by moving unpredictably among islands within their ranges, so that investigators have to cover all major islands to be sure they have not missed sizable proportions of the herds. All populations have never been surveyed in 1 year. Only 3 times have most of the western Queen Elizabeth Islands been covered in 1 survey period: 1961, 1972-1974 and 1997. Various authors have used different assumptions in extrapolating to islands not covered in 1 survey to compare with populations estimated in another. Also, some authors included calves while others did not, making it difficult to compare surveys. Finally, aerial surveys of low and clumped caribou densities may have unrealistically wide or narrow confidence intervals, depending on what proportion of the clumps were captured in the transects. The confidence intervals given in the text are ± Standard Error unless otherwise noted. The graphs in this section do not show confidence intervals (which in many cases were not available) and it should not be assumed that each point is significantly different from its neighbours. Cases in which the validity of the trends or of the underlying estimates is in question, are discussed individually.

In 1961 Tener (1963) completed the only survey of the Queen Elizabeth Islands, estimating 25 802 caribou. Therefore, allowing for Peary caribou on Somerset Island and Boothia Peninsula, the total must have exceeded 30 000 Peary caribou. By adding all of the first counts for all populations (which occurred in different years as much as 2 decades apart) a maximum of nearly 50 000 Peary caribou is obtained (Appendix 1). Currently there are about 7000 Peary caribou (Table 10).

Queen Elizabeth Islands

For the western Queen Elizabeth Islands, the population (total caribou, including calves) from Tener’s (1963) 1961 estimate of 24 320 declined to 5244 in 1973 and 2674 in 1974 (Miller *et al.*, 1977a). In 1987 there were about 2100 total caribou and in 1997, 1100 total caribou (Miller and Gunn 2003b). This seemingly constant decline masks quite different trends in the Melville Island complex and the Bathurst Island complex.

Population estimates in the Melville Island complex are complicated because some segments of the local population seasonally migrate between Melville Island and Prince Patrick Island; in addition, there are irregular movements among these and other islands in this complex. Since Tener’s 1961 survey (Tener 1963), the population has declined. It may have had a recovery during 1987-1996 which is not demonstrated in population aerial surveys due the long gaps between surveys, but can be inferred from the estimated 371 carcasses found in 1997 after a die-off the previous winter (Miller 1998, Gunn and Dragon 2002, Miller and Gunn 2003a). Based on aerial population surveys summarized by Gunn and Dragon (2002), however, the Melville Island local population showed an overall steady decline of 7.4% per year between 1961 and 1997

(Figure 8). The smaller local population of the Prince Patrick Island group (including the smaller "satellite" islands of Eglinton, Emerald, Mackenzie King and Brock islands) declined at a rate of 10.7% per year during that time (Figure 8). Surveys in the 1970s and 1980s did not include all of the islands and so resulted in estimates below the trend line. Die-offs resulting from adverse snow conditions in both Melville and Prince Patrick local populations, although not revealed in the long term population trend data from major surveys, have been inferred from carcass counts in 1974, 1995, 1996 and 1997, (Miller and Gunn 2003a). The timing was concurrent with die-offs in the Bathurst Island complex (see below). The last survey of the Melville Island complex, in 1997, found 871±103 for 1+ year old caribou, although only 2 calves were seen and none on the main islands (Gunn and Dragon 2002). Population estimates and trends are given in Appendix 1, Table 5.

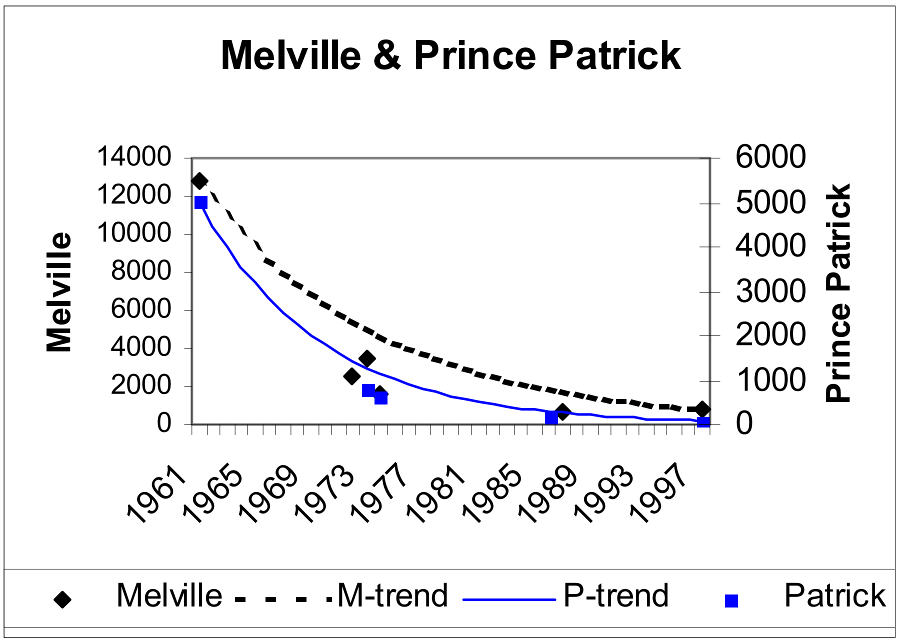

Figure 8. Melville Island and Prince Patrick Island local population declines (all caribou; data from Tener 1963 and Gunn and Dragon 2002).

The caribou in the Bathurst Island complex have been the most studied. The population declined between 1961 and 1973, crashed during 1973-1974, increased at about 13% per year for the next 2 decades (but more sharply during 1988–1994 as noted previously), and then crashed again during 1995-1997. The last published survey of the Bathurst Island complex, in 1997, resulted in an estimate of 78±26 for 1+ year old caribou, which were mostly breeding age cows, suggesting a high potential for recovery (Gunn and Dragon 2002). Severe winter weather characterized by deep snow with icing events caused the crashes; other possible causes such as hunting, predation, competition with muskoxen or forage depletion have been ruled out (F.F. Slaney & Co. Ltd. 1975a, Miller *et al.* 1977a, Ferguson 1987, Miller 1991, Gunn and Dragon 2002, Miller and Gunn 2003b).

In two surveys in May 2001, Ferguson (Nunavut Wildlife Service, pers.comm., November 19, 2002) estimated populations of 240 (95% CI=150-283) and 289 (95% CI=166-503) by distance sampling for 1+ year old caribou on Bathurst Island (21% and 41% of occupied watersheds were surveyed in these 2 surveys). The higher of these is shown in Figure 9 and used in the calculations; however, this estimate is not strictly comparable to the previous estimates because of the different methods used. Population estimates and trends are given in Appendix 1, Table 5.

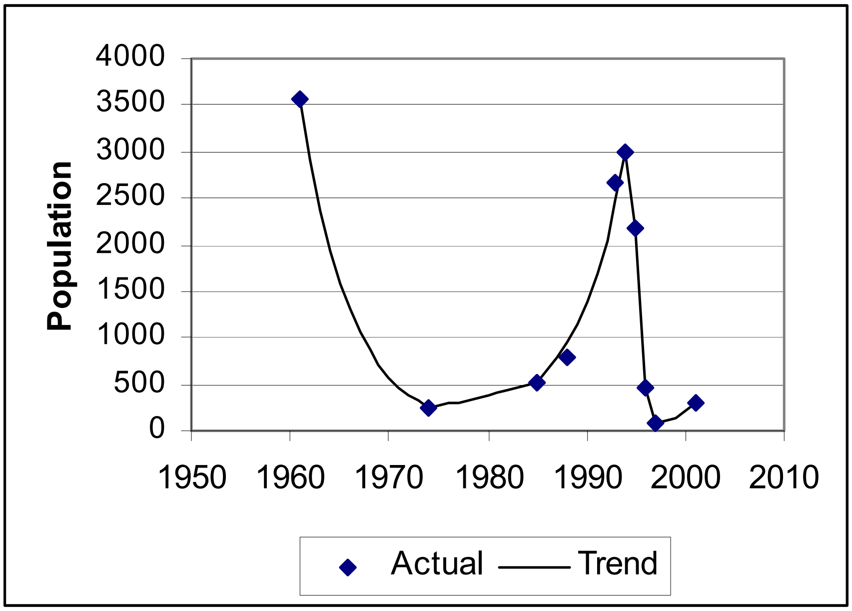

Figure 9. Population of the Bathurst Island complex. Data given by Gunn and Dragon 2002 for 1+ year old caribou have been replaced with estimates for all caribou from F. Miller (CWS, pers. comm., January 12, 2003). The last point is adults only on Bathurst Island only (M. Ferguson, Government of the Northwest Territories, pers. comm., November 19, 2002).

The most complete survey of the eastern Queen Elizabeth Islands complex was carried out in 1961, when Tener (1963) estimated 1482. Although his estimates were conservative, some Inuit in Grise Fiord and Resolute Bay doubt that the population could have been that high (Ferguson *et al.* 2001). Riewe (1973) estimated about 145 caribou on southern Ellesmere Island. In 1989, about 90 caribou were estimated on southern Ellesmere Island (Case and Ellsworth 1991). Gauthier (1996) counted 63 caribou on central Ellesmere and Axel Heiberg islands in 1995 in unsystematic surveys. Ferguson *et al.* (2001) reported no evidence of caribou die-offs on southern Ellesmere Island where local Inuit travel extensively in late winter and spring; however, local Inuit suspect that an apparent decline and unusual distributions during the 1970s were caused by seismic activity over extensive areas, especially in important caribou habitats. Since the mid-1990s, caribou have been found in several areas on southern Ellesmere and northern Devon islands where they had not been seen since the 1960s (Ferguson *et al.* 2001). Caribou have been in good physical condition in recent years, including bulls in late winter. They observed that even some young females were pregnant in late winter. In 2 of 3 recent summers, a geoscientist noticed several caribou on Ellef Ringnes Island (Tener 1963, saw 21 there in 1961 and estimated a population of 114). Although the current population of the complex cannot be reliably estimated, the Peary Caribou Recovery Team estimated around 1480 caribou, based on published and unpublished information (Peary Caribou Recovery Team 2001). Population estimates and trends are given in Appendix 1, Table 5.

Banks Island–northwestern Victoria Island

The population on Banks and northwestern Victoria Island declined in the early 1950s and early 1960s (Elias 1993, Gunn 1993). The Banks Island local population subsequently increased to an estimated 12 098 in 1972 (Urquhart 1973), and was relatively stable to 1982 when Latour (1985) estimated the total number of caribou at 11 034 (9015 1+year old caribou) (P. Latour's data reworked by J. Nagy, Northwest Territories Wildlife Service, pers. comm. February 2, 2004). Caribou numbers on Banks Island then declined between 1982 and 1992 to an estimated 1018 1+year old caribou, 757–1279 95% Confidence Interval (Nagy *et al.* 1996, Larter and Nagy 2000a, J. Nagy, Northwest Territories Wildlife Service, pers. comm. February 2, 2004). The decline appeared to continue during the 1990s based on lower estimates in 1994 and 1998, but there were technical problems including poor weather with the 2 surveys. If real, the rate of decline from 1982 to 1998 was about 17% per year (λ=0.83) (Figure 10). The survey in 2001 had excellent conditions and returned an estimate of 1196 1+year old caribou (1137–1254 95% CI) suggesting that the caribou numbers were stable to slowly increasing during the 1990s (J. Nagy, Northwest Territories Wildlife Service, pers. comm. February 2, 2004) (data in Appendix 1, Table 7).

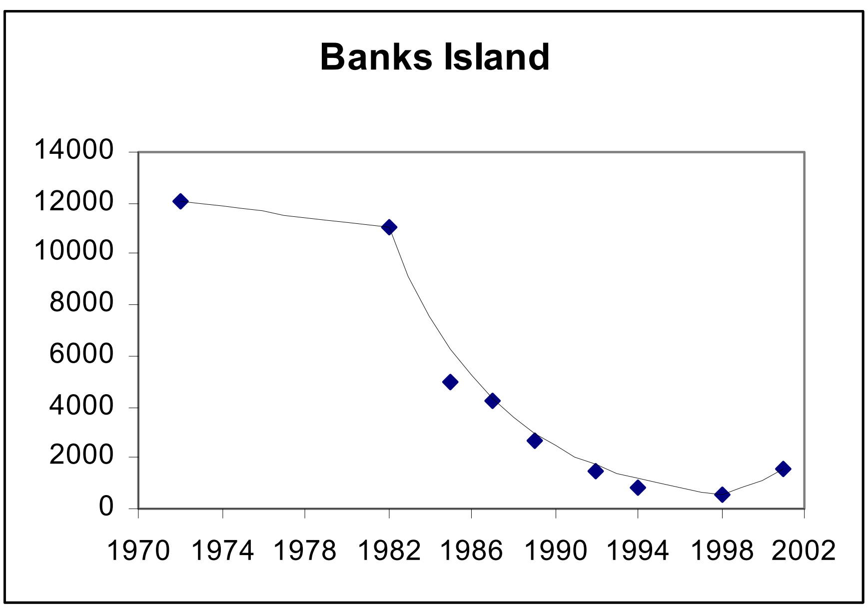

Figure 10. Estimated populations of Peary caribou on Banks Island (total caribou) (John Nagy, pers. comm. February 2, 2004).

Trends for the northwestern Victoria Island local population are given in Appendix 1, Table 7, but not illustrated because of their uncertainty. The low point for the northwestern Victoria Island caribou population was in the early 1960s, coincident with both a freezing rain event and with the introduction of snow machines (Elias 1993) and again in the early 1990s (Gunn 1993). Die-offs occurred in the 1950s, 1977-1978, and 1980s.The decline in Peary caribou of northwestern Victoria Island lagged behind the decline on Banks Island (Elias 1993).

The 1980 estimate of 4512±988 included calves. In 1987 Gunn's (1993) estimate was for 3500 total caribou; confidence limits could not be calculated, but since the estimate was within the confidence interval of the 1980 estimate there was no evidence for a decline. They then declined to an estimated 114 adult caribou in 1993 (Gunn 1993) and in 1994 just 6 caribou were seen (Nishi and Buckland 2000). A weather-related die-off probably occurred in 1993-1994: no carcasses were reported, but it was an exceptionally heavy winter. The population then apparently increased to 508±75 for 1+ year old caribou (633±81 for all caribou) in 1998 (Inuvialuit Game Council 2002b) and 1272±384 1+ year olds, or 1628±501 for all caribou (J. Nagy, Northwest Territories Wildlife Service, pers. comm. January 6, 2003) in 2001.

An increase from 114 in 1993 to either 633 in 1998 or 1628 in 2001 would require a rate of about 40% per year (λ=1.41 and 1.39, respectively), higher than the maximum reproductive potential of caribou discussed above. One explanation is immigration from Banks Island. However, a more likely explanation is that some, perhaps a large proportion, of the northwestern Victoria Island caribou counted in 1998 and 2001 were from the Dolphin and Union herd.

Most of the caribou counted on northwest Victoria in July 2001 were east of Richard Collinson Inlet which is adjacent to ranges used by Dolphin and Union caribou in 1987 and 1996-98 based on satellite telemetry (Gunn and Fournier 2000). To answer the question of whether the 2001 estimate included caribou from the Dolphin and Union herd, John Nagy followed up his 2001 survey results by fitting satellite collars to 10 cows east of Richard Collinson Inlet in August 2003. The 10 collared cows reached the south coast of Victoria Island by early November 2003 and 9 cows crossed to the mainland (1 had died). Those movements strongly suggest that the caribou counted on northwest Victoria Island in 2001 included an unknown number of Dolphin and Union caribou. The Minto Inlet herd still exists as tracks were seen north of Minto Inlet in December 2003 but the extent of recovery of the Minto Inlet caribou is currently uncertain (J. Nagy, Government of the Northwest Territories, pers. com. 25 January 2004; A. Gunn, Government of the Northwest Territories, pers. com. February 20, 2004).

Hunters from Holman, on western Victoria Island, hunt caribou of the Minto Inlet herd (i.e., northwestern Victoria Island) in winter, but the difficulties of distinguishing the Minto Inlet harvest records from the Dolphin and Union harvest records has prevented a detailed analysis of the effects of hunting. More work is needed to provide a basis to distinguish harvest records for the 2 populations on Victoria Island, as well as their respective ranges, particularly calving areas (Nishi and Buckland 2000).

In view of the improbability that the northwestern Victoria Island local population having increased at 40% per year after 1993 and the certainty that at least some of the caribou counted were from the Dolphin and Union herd, the estimates require adjustment. For the purpose of trend and current status calculations, the report writer arbitrarily divided the 2001 estimate by half in Table 7 and Table 10.

Dolphin and Union

Anderson (1922), a mammalogist who studied wildlife in the Coronation Gulf area from 1908 to 1916, estimated that 100 000 to 200 000 caribou migrated across Dolphin and Union Strait. Manning (1960) accepted the more conservative value, based in part on the projected density for the population in the land area of Victoria Island compared to other barren-ground caribou densities. The Dolphin and Union caribou stopped migrating across Dolphin and Union Strait after 1924. However, morphologically similar caribou with a distinct genotype now occupy the island and most now migrate across Dolphin and Union Strait somewhat as before. They may be a relict population currently on the rebound, or they may be the native, resident caribou, or, less likely, a mixture of these 2 plus barren-ground caribou from the mainland.

The first recent estimate was 1000 caribou in 1949, with the summer distribution shown around Prince Albert Sound (Banfield 1950). In 1980, 7936±1100 caribou were estimated on Victoria Island (Jackimchuk and Carruthers 1980), but 4512±988 were Peary caribou on northwestern Victoria Island, leaving 3424±522 Dolphin and Union caribou on the remainder of the island. This estimate, however, is problematic, as discussed below. Later surveyors found 14 529±1016 caribou in 1994 and 27 786±3366 in 1997 (Gunn and Nishi 1998).

Figure 11 shows the population data with a fitted trend line for 1980 to 1997, an annual increase of about 13% (the trend line and rate estimate split the difference between the 1994 estimate, which is too low for the exponential growth model, and the 1997 estimate, which is too high). However, if the annual rates of increase from 1980 to 1994 and from 1994 to 1997 are calculated separately, the former would have been 11% and the latter, 24% (from 14 529 to 27 786, 3 reproductive years, λ=1.24).

Despite the apparent precision of the estimates, these values are problematic. First, the 1980 survey had a low coverage of the island, so that if 1 or more sizeable groups of caribou were missed, the population would have been under-estimated. Second, annual harvests for Cambridge Bay were 2351±59 in 1983 (Jingfors 1986) and 1445±38 in 1994 (Kitikmeot Hunters' and Trappers' Association 1996), and for all communities in the late 1980s to early 1990s, 2000 to 3000 (Gunn and Nishi 1998). A population of only ~3200 caribou could not have supported such a high harvest rate. Therefore, either the 1980 survey underestimated caribou numbers, or the subsequent increase was due partly to immigration. If so, then both the rates of increase for 1980 to 1994 and 1980 to 1997 would have been less than the 11% and 13% per year, respectively, that were mentioned above.

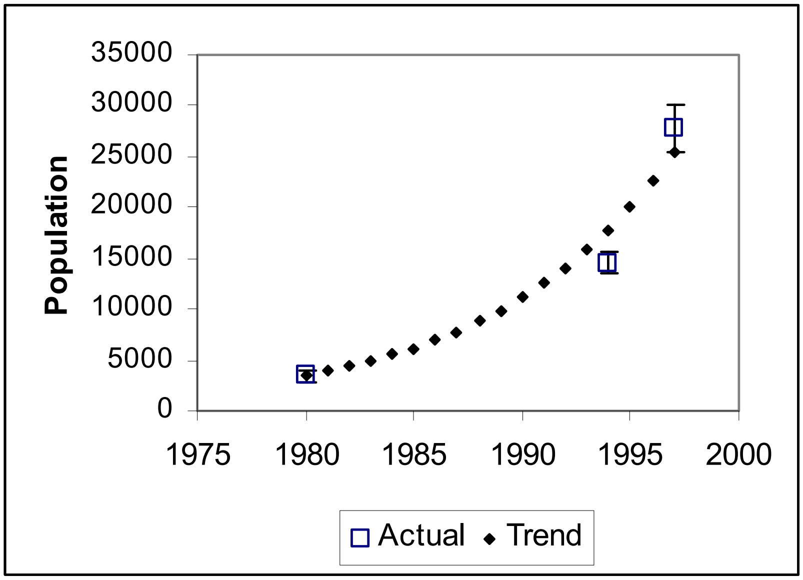

Figure 11. Population estimates and trend of total Dolphin and Union herd caribou with error bars (SE) for the data points (data from Gunn and Nishi 1998).

Elias (1993) reported Aboriginal traditional knowledge that both hunting and weather were factors in the decline in the early 1900s: One elder remembered hunting caribou with bows and arrows from kayaks after herding them into the water. Only after the widespread availability of rifles, and after the 1960s, snow machines, did hunting affect the populations. Several elders reported wastage of meat after high-powered rifles were available and caribou were killed only for their skins. In times of freezing rains in the fall (several elders recalled such an event in the 1960s), the elders thought that the caribou moved away and should have had no trouble finding ice-free vegetation because Victoria Island is so large.

Prince of Wales–Somerset Island

Despite scanty population data, a serious, recent decline is obvious. Aboriginal traditional knowledge shows that Peary caribou on Prince of Wales and Somerset islands declined during the 1930s and were scarce in the mid-1940s (Ferguson *et al.* 2001). The population started to increase in the late 1950s, and was stable through the 1970s. Estimates of adult caribou for 1974 and 1975 were 4540 and 3607, respectively (Fischer and Duncan 1976). Accounting for the percentage of calves they counted in spot-checks on Prince of Wales and Somerset islands, there were 5516 and 4383 total caribou in 1974 and 1975, respectively. In 1980 Gunn and Decker (1984, cited in Gunn and Dragon 1998) estimated 5100 1+ year old caribou (6043 total caribou) on these islands. In 1995 Gunn and Dragon (1998), in response to Inuit concerns about difficulty in finding caribou during winter hunting trips, surveyed the same area covered in 1980, using the same survey methods. The observers, who included an experienced Inuit hunter, counted 7 caribou on Prince of Wales and Somerset islands, too few for a meaningful population estimate. (60±20 is used herein as the estimate for graphing and tabulation purposes as suggested by F. Miller, Canadian Wildlife Service, pers. comm. Dec. 21, 2002). A constant decline from 6043 to 60 adult caribou would be 26% per year (λ = 0.73529). Figure 12 gives the estimates, along with a 26% population decrease curve (from 6043 to 60) for 1980-1995. It may be misleading, however, to display the population decrease curve with the estimated population trend, because the decline may have been sudden, rather than gradual.

In the late 1970s and early 1980s, annual harvests were 150-250 caribou during the time when Resolute hunters voluntarily stopped hunting on Bathurst Island after the 1973–1974 die-off and hunters instead travelled to Prince of Wales and Somerset (Gunn and Decker 1984). Harvests then declined in the late 1980s to annual harvests of 85 to 170 caribou on Prince of Wales and Somerset islands islands (Donaldson 1988 and A. Idlout pers. comm. cited in Ferguson *et al.* 2001). An uncertain factor, however, is the amount of harvest on the Boothia Peninsula, where some Prince of Wales-Somerset caribou winter, by hunters from Taloyoak.

The decline of the Prince of Wales-Somerset population of Peary caribou coincided with increases in the populations of Peary caribou on Boothia Peninsula to the south, the Bathurst Island complex to the north, and the Dolphin and Union herd of barren-ground caribou to the west. It is possible that, instead of decreasing because of internal mechanisms, large numbers of them emigrated. If so, Boothia is the most likely destination, although Gunn and Dragon (1998) found little evidence of immigration during their survey of Boothia in 1995. On the other hand, Inuit hunters from Taloyoak prefer Peary caribou (which they call "kingailik tuktu" meaning "Prince of Wales Island caribou") because the meat is more flavourful and tender (F. Miller, Canadian Wildlife Service, Dec. 21, 2000). The high harvest rates of about 22% per year during the late 1980s from a population of only about 4800 caribou (1985 estimate) suggests such an influx (i.e., the population was being augmented by immigrants from the north). Fisher and Duncan (1976) also thought that caribou from Prince of Wales–Somerset complex migrated to the Boothia Peninsula between 1974 and 1975 because of declining numbers in the former concurrent with increasing numbers in the latter.

Some Inuit from Resolute Bay believed the decline to have been caused by effects of high caribou densities on their forage (Ferguson *et al.* 2001) and at least one thought, without having seen any physical evidence, that some may have emigrated to the Bathurst Island complex (D. Kaomayok of Resolute Bay, cited in Gunn and Dragon 1998). They saw no evidence of unusually severe snow conditions and believed that Peary caribou persisted on Somerset despite Gunn and Dragon's low count in 1995. That count was, however, consistent with an unsystematic survey flown under ideal conditions in May 1996 when Miller (1997a) found only 2 caribou and almost no tracks. Moreover, other Inuit from the same village did not mention competition or forage depletion and felt that the causes might have been wolf predation or disease (F.L. Miller, Canadian Wildlife Service, May 21, 2003, recalling a meeting at Grise Fiord in October 1997 at which several Inuit from Resolute Bay were present).

Gunn and Dragon (1998) reviewed the possible causes of the decline, including inaccurate surveys, emigration and factors affecting deaths and/or births rates such as hunting, predation, winter weather, diseases, and parasites and competition with the muskox population, which was increasing. They had only scanty data on calf production and survival, which, however, did not point to depression from winter severity; nor was there any evidence of a die-off (Inuit hunters from Resolute reported some carcasses in the winter of 1992 but the carcasses were not in poor condition). Although there were no data on wolf populations in the area, Resolute Bay hunters reported increased wolf numbers on Prince of Wales Island during the 1990s and suggested that the 5-fold increase in muskoxen would support a high wolf population. There was no evidence that drier summer weather had reduced plant growth, which is moisture limited, sufficiently to affect the fat reserves needed to survive the winter (Gunn and Dragon 2002). Although they could not attribute all of the decline to any of these, they concluded that (a) harvest could have been a factor in the early 1980s when hunters were taking 150 to 250 caribou per year, and (b) predation or winter malnourishment (perhaps in competition with muskoxen, or associated with climate change) may have hastened the decline. In any case, the numbers are now so low that recovery will be slow and uncertain (Gunn and Dragon 1998).

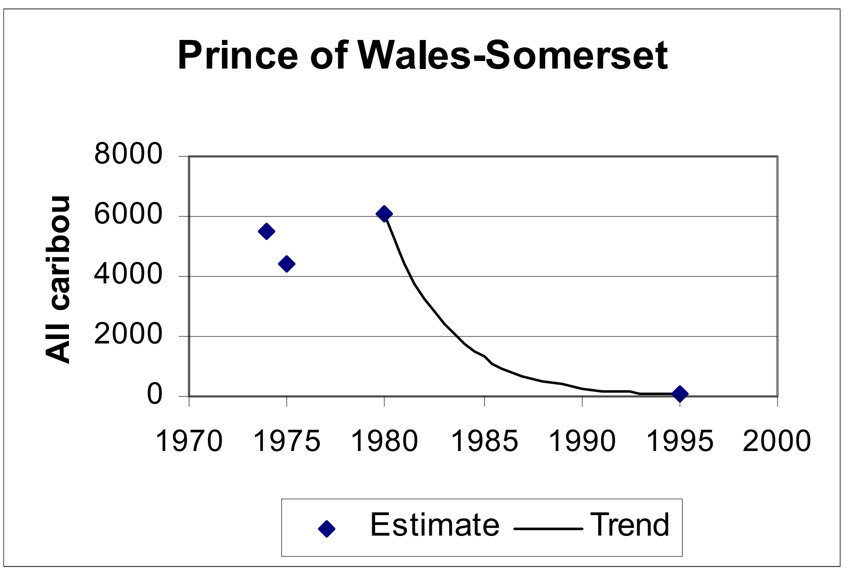

Figure 12. Population estimates and trend for all caribou in the Prince of Wales–Somerset group of islands (data from Gunn *et al.* 2000b).

Boothia

Caribou on the Boothia Peninsula were numerous before the 1930s to 1940s, when the migration through the Boothia Isthmus dwindled, then stopped (Gunn 1998a). Inuit hunters said that caribou were scarce in the 1950s and a Canadian Wildlife Service unsystematic survey found no animals in 1958; however, in 1974 and 1975, Fisher and Duncan (1976) estimated 428 and 1443 adult caribou, respectively on Boothia

Peninsula. Accounting for the percentage of calves they saw in spot-checks, the estimates of total caribou for 1974 and 1975 were 556 and 1890, respectively. In those surveys, barren-ground and Peary caribou were not distinguished, but the population was assumed to be mostly Peary caribou (Gunn 1998a).

The Boothia Peninsula estimates apparently increased from 4831± 543 1+ year old to 6658±1728 total caribou during 1984-1995 (Gunn and Dragon 1998, Gunn *et al.* 2000b), but the wide standard errors belie their statistical significance. Also, the 1985 survey was at the beginning of calving and the few calves seen were not counted, but the 1995 survey was after calving and calves were included, further complicating the comparison (A. Gunn, Government of the Northwest Territories, pers. comm., November 22, 2002). Gunn and Dragon (1998) noted that observers on the 1995 survey did not differentiate between Peary and barren-ground caribou, although both were observed. Barren-ground caribou have apparently been increasing on Boothia (Gunn 1998a) and Peary caribou decreasing (F. Miller, Canadian Wildlife Service, pers. comm. Dec. 21, 2002). The preference for kingailik caribou by Inuit from Taloyoak as noted in the previous section is a possible mechanism for such a shift in caribou subspecies predominance, along with others such as climate change-induced vegetation changes. If only half were Peary caribou in 1995, as estimated by F. Miller (Canadian Wildlife Service, pers. comm. Dec. 21, 2002), then that estimate would fall to 3329, a constant annual decline rate of 3.7% per year from 1985 to 1995 (Figure 13). These estimates, although the best available, are quite unsatisfactory.

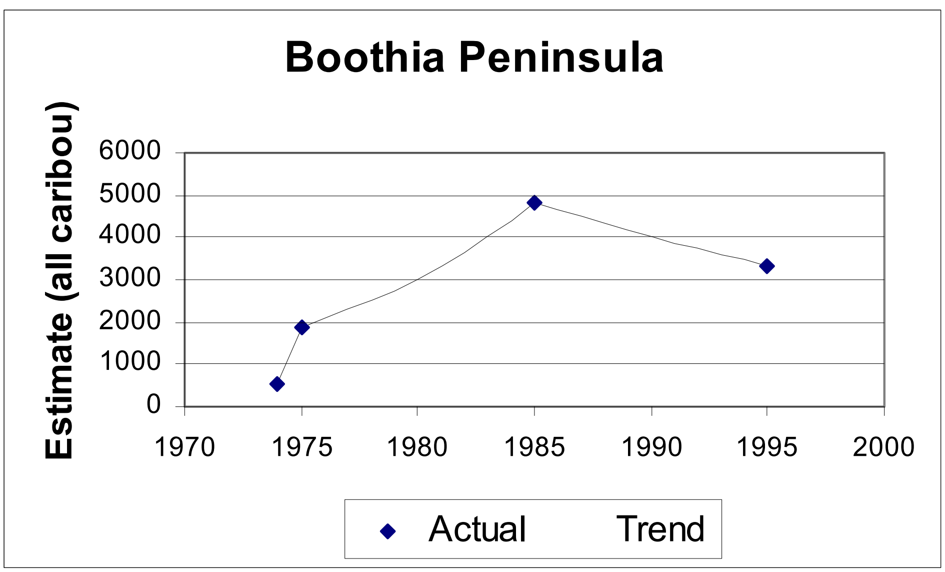

Figure 13. Population estimates and trend on Boothia Peninsula (data from Fisher and Duncan 1976 and Gunn and Dragon 1998) with the 1995 estimate reduced by 50% to account for the barren-ground caribou that were included in the count.

Other islands

King William Island and nearby smaller islands once supported large numbers of caribou that were presumed to be migrants from the mainland, but migrations apparently ceased in the 1930s (Miller 1991). Few caribou have been seen in recent surveys. However, Inuit from Gjoa Haven recognize 2 types of caribou on King William Island: mainland caribou (i.e., barren-ground caribou) and Peary-type caribou that they believe cross over from Victoria Island (i.e., Dolphin and Union caribou); they say that mainland caribou have only been crossing from Queen Maud Gulf within the last few years and are increasing in number annually (Dave White, Government of Nunavut, pers. comm. February 6, 2004).

LIMITING FACTORS AND THREATS

Industrial activities

Miller (1991) concluded that industrial activities have the potential to reduce or prevent access to important habitats, and some Inuit believe that this has been the case at least in some situations (Freeman 1975). However, a study of interactions between seismic operations and ungulate behaviour (F.F. Slaney & Co. Ltd. 1975a, b) found that:

- 15-20 caribou were in the vicinity of seismic vehicles during the mid-winter portion of the study and some of them were seen repeatedly.
- Caribou continued foraging when seismic shots were detonated 3.5 km distant and remained in the vicinity for at least several hours.
- Caribou ceased foraging and walked away when approached by seismic vehicles closer than 0.8 km. Individuals remained for more than 1 day within about 4.0 km sight or sound of seismic activity.
- Caribou moving through the area by-passed the seismic camp within 0.8 km without altering their direction of movement.
- Caribou showed neither preference nor avoidance of seismic lines, which became partially obscured by blowing snow within a few hours.

While some displacement from foraging areas and increased energy expenditure occurred, these were within the ranges of normal activities such as predator avoidance; more intensive disturbance in areas of ungulate concentrations during critical periods, such as late winter and calving times, could be harmful (F.F. Slaney & Co. Ltd. 1975a, b). These recorded observations support Amagoalik's (in Freeman 1975) opinion that seismic activities can disrupt the activities of caribou, but not to the extent that disturbance would cause caribou to abandon the island.

Miller and Gunn (1978, 1980) noted the potential threat of ship traffic interrupting inter-island caribou movements, which are necessary, at some times, both to escape unfavourable environmental conditions and to repopulate previously abandoned ranges. Inuit and biologists, at a Peary caribou population and habitat workshop in Yellowknife, echoed these concerns in regard to migration of the Dolphin and Union herd (Gunn *et al.* 1998). More recently, hunters have voiced similar concerns at meetings of the Kitikmeot Hunters and Trappers Association in regard to shipping traffic associated with the proposed Bathurst Road and Port Development (M. Wheatley, Nunavut Wildlife Management Board, pers. comm. June 30, 2003).

Interspecific competition

Some Inuvialuit of Victoria Island do not believe that competition with muskoxen is a factor in caribou declines, because of different food preferences and different feeding areas (Elias 1993). Residents of Resolute Bay also doubt that there is direct competition, noting that the 2 species do not feed together (Nunavut Tusaavut Inc. 1997). Parker (1978) suggested, based on rumen and fecal samples of both species collected after the 1973-1974 crash in the Western Queen Elizabeth Islands, that, while there was some overlap in forage species, there was no interspecific competition. He found that in severe winters, however, both ungulates sought out willows on exposed slopes or ridges and suggested that when densities are high, they may compete for forage. In contrast, Thomas et al. (1999) found almost no dietary overlap and different use of micro-habitats (caribou used moist and dry sites while muskox preferred wet meadows), and concluded that, at low densities, competition was not a factor. Miller's (1991) review supported the Aboriginal traditional knowledge on this point, stating that caribou and muskoxen use somewhat different habitats, prefer different foods, and segregate their ranges, although there is overlap on all 3 points. In the western Queen Elizabeth Islands, neither the amount or quality of the absolute forage supply nor competition with other grazers made any significant contribution to the documented declines of Peary caribou (Miller and Gunn 2003a).

On Banks Island, the caribou population decreased from about 12 000 in 1972 to about 700 in 1995, while muskox populations increased from about 4000 to about 65 000 (Larter and Nagy 1997). Several studies (Wilkinson and Shank 1974, Wilkinson *et al.* 1976, Shank *et al.* 1978, Oakes *et al.* 1992, Mulder and Harmsen 1995, Smith 1996) examined this issue and found that while overlap of feeding areas and forage species occurred, there was no compelling evidence of large-scale impact of muskoxen on forage conditions that could affect caribou. Larter and Nagy (1997) found that caribou and muskoxen had considerable similarity in their diets, and diet similarity was more pronounced in areas of high muskox densities. Larter and Nagy (1997) also found that deep snow caused muskoxen to crater for forage on the same slopes where caribou foraged and suggested that muskox browsing on willows in such situations could reduce its availability for caribou. In recent years, however, the caribou population trend reversed and began to rise at a high annual rate, while muskox populations have also continued to increase. Consequently, in 3 decades of study, detrimental effects of high muskox densities on caribou have not been demonstrated.

On Prince of Wales and Somerset islands, Gunn and Dragon (1998) found that while the caribou declined, muskoxen increased from about 1155 in 1980 to 6399 in 1995 (Figure 14). (Confidence intervals can not be given because they were calculated separately for Prince of Wales and Somerset surveys; for the Somerset population only 29 muskoxen were seen and no estimate was calculated, so for the graph, 29 was added to the Prince of Wales population for 1980.) The trend lines are based on the exponential model (Appendix 1), but with only 2 estimates at the start and end, sudden changes are equally plausible.

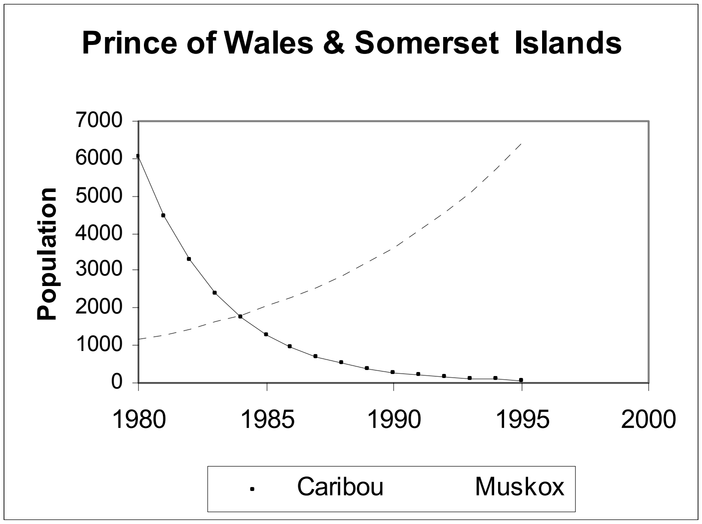

Figure 14. Prince of Wales-Somerset caribou and muskox trends, 1980-1995 (data from Gunn and Dragon 1998).

Gunn and Dragon (1998), reviewing the possible causes of the caribou decline on Prince of Wales and Somerset islands, made the following points about the possibility of competition with muskoxen having affected the caribou adversely:

- There has been a long-standing controversy about the relationship between muskoxen and caribou, particularly among the Banks and Victoria islands Inuvialuit who hunt them and the biologists who study them.
- Muskox-caribou relationships operate at different scales of space and time; on an evolutionary time scale they have long coexisted, but also have evolved in more complex communities of large herbivores and predators.
- In the Arctic Archipelago, their population growth and decline trajectories are spatially inconsistent: mostly synchronous in the western Queen Elizabeth Islands and south central Victoria Island and asynchronous on Banks Island, northwest Victoria Island, and in the Prince of Wales-Somerset islands complex. There are region-wide climatic, terrain and vegetative differences that may contribute to these differences (Banks Island being the only well-vegetated Arctic island).
- Previous studies of muskox-caribou relationships did not specifically address competition. They compared diet or habitat use, but have not addressed behavioural exclusion (or avoidance), although Inuit have often stated that caribou avoid muskoxen or muskox foraging areas and suggested several reasons why this is so.

- The studies of distribution and diet that point to little overlap between caribou and muskox did not deal with high muskox densities or deep snow foraging conditions (e.g. Larter and Nagy 1997). Russell *et al.* (1978 cited in Gunn and Dragon 1998), however, documented little overlap between caribou and muskox seasonal ranges based on distribution of fecal pellets, except on Prince of Wales Island where both herbivores fed in summer on willow-moss-lichen patterned ground, 1 of the most common plant communities.
- Dietary overlap, in itself, is not evidence of competition.
- The time scales of the effects of competition vary. For example, browsing at different seasons can either damage shrubs or stimulate compensatory growth.

The above evidence suggests that in most circumstances there is no substantial competition between muskoxen and caribou for space or forage, but more investigation is needed into the space and time scales of potential competition (Ferguson 1996), as well as the mechanisms of competition (Gunn and Dragon 1998). The possibility remains that when muskoxen are at high densities, the caribou may be at a disadvantage, particularly in severe winters when forage for both species is limited by snow and ice**.** When muskoxen are at high densities, correspondingly higher wolf populations may take enough caribou to depress their numbers and either exacerbate a decline or dampen a recovery.

Predation

Arctic grey wolves (*Canis lupus arctos*) are present throughout Peary caribou and barren-ground caribou range in the Arctic Archipelago (Miller 1992, Miller and Reintjes 1995, Larter and Nagy 1998b). Wolves feed on caribou and muskoxen approximately according to their availability when both prey species are present (Gunn *et al.* 2000b).

Inuvialuit of Victoria Island do not believe that wolf predation is a significant factor in caribou declines on northwest Victoria Island (Gunn 1993). Wolf predation may have been a factor in the 1993-1994 caribou decline because of the high density of wolf dens and large wolf packs (up to 20 wolves per pack) adjacent to the traditional caribou calving and summering grounds on Banks Island (Larter and Nagy 2000b).

Miller and Reintjes (1995), based on 373 reports involving 1203 wolf sightings from 1967 to 1991, documented observations of at least 572 different wolves in 118 separate packs and 116 single wolves throughout the Arctic Archipelago. Most (81%) of the wolves were seen on the Queen Elizabeth Islands, but not all population areas were sampled equally. Pack sizes averaged 4.8±0.28 and ranged from 2 to 15 wolves per pack. Pups averaged 3.9±2.24 SD (range 1-10) per pack. On a decadal scale, the frequency of wolf sightings increased and decreased with the populations of Peary caribou and muskoxen in the Queen Elizabeth Islands. (This association did not hold up, however, in the “southern tier” of islands, most likely due to the relatively small data sets from those regions (F.L. Miller, pers comm. May 21, 2003).

Miller (1998) concluded that if the wolf population responded to the increasing prey base (caribou and muskoxen) in the Bathurst Island complex as expected, then there would have been about 45 wolves there when the populations crashed during 1995-1997. That many wolves would pose "*a serious threat to…the remnant caribou and muskox populations*" Miller (1998 p. 55). Gunn *et al.* (2000b) agreed that wolf predation could accelerate a decline.

Hunting

The southern tier of islands and parts of the eastern High Arctic were more or less continuously occupied by caribou hunting pre-Dorset, Dorset, and Thule cultures from about 4500 ybp onwards (McGhee 1976, 1997). Although the Melville Island complex and the northwestern portions of the Bathurst Island complex were beyond the margins of consistent Inuit occupation, the other parts of the Queen Elizabeth Islands had long periods of occupation interspersed with periods of abandoned or limited use, so that hunting pressure probably ranged from moderate to non-existent in those areas during the latter half of the Holocene. The western Queen Elizabeth Islands were unpopulated prior to 1953 when a community of Inuit was established at Resolute Bay.

Although hunting has not been implicated as a causative factor in any of the die-offs (Gunn *et al.* 2000b), it may have contributed to long-term caribou decline in several cases. The demise, between about 1900 and 1920, of the Dolphin and Union herd, was thought due to hunting following the introduction of firearms (Anderson 1934, Manning 1960). On Banks Island, throughout the 1980s, harvest was female-selective, which likely skewed the population towards males and younger animals (Larter and Nagy 2000b). After 1991, the caribou population on Banks Island continued to decline until 1998 despite severely restricted hunting by Sachs Harbour residents (Larter and Nagy 2000b). More recently, the population increased significantly as noted previously.

Hunting may also have been a factor in the decline of caribou on Victoria Island (both Peary and Dolphin and Union populations), and is of concern on the Boothia Peninsula (Gunn *et al.* 1998).

The harvest of the Dolphin and Union herd is relatively high compared to the 1997 estimated size of the herd. As the herd migrates close to Cambridge Bay and Holman in the fall and over-winters on the mainland, increased access by hunters from other communities including Kugluktuk, Umingmaktok, and Bathurst Inlet contribute to the total harvest. In addition to the subsistence harvest, the herd provides the opportunity for guided hunts when they mass along the north coast of Dolphin and Union Strait prior to fall migration. Currently, 50 tags are allotted (Mathieu Dumond, Government of Nunavut, pers. comm. February 9, 2004). The extrapolated harvest is 2000-3000 caribou (based on the reported harvest from the Kitikmeot Harvest Study (Gunn *et al.* 1986, Nishi and Gunn 2004).

The Dolphin and Union herd is also hunted commercially. Irregularly, a few (currently 30 for Kagluktuk and 40 for Cambridge Bay) commercial caribou tags are issued for the sale of meat. Although the commercial harvest is intended for barren-ground caribou, the hunt occurs in winter when the Dolphin and Union caribou are on the mainland and they account for a large proportion of the harvest. Probably fewer than 100 Dolphin and Union caribou are harvested in these hunts (Mathieu Dumond, Government of Nunavut, pers. comm. February 9, 2004).

Inuit hunters, through their local associations, have voluntarily curtailed hunting of Peary caribou throughout the period of investigation into caribou population declines from 1974 to present (Miller and Gunn 1978, Ferguson 1987, Larter and Nagy 1995, 2000b, Ferguson *et al.* 2001). For example, from 1974 to 1989, the Resolute Bay Hunters and Trappers Organization prohibited hunting of the Bathurst Island local population (the Melville-Prince Patrick herd is too far for access by snow machine). From 1989 to 1996, as the caribou population increased in the Bathurst complex, it allowed limited harvesting in consultation with government biologists. After the 1994-97 die-off, however, it again curtailed the harvest. Inuit hunters from Grise Fiord halted caribou hunting on most of southern Ellesmere Island from 1986 to 1996 while caribou numbers were low, and then began again in response to the increasing caribou population. At times of unavailability of local (Bathurst) caribou, the Resolute Bay hunters made arrangements with Inuit groups at Grise Fiord and Cambridge Bay to hunt in their territories, but this was not a satisfactory solution for several reasons (T. Mullen pers. comm. March 20, 2002; N. Amarualik Resolut Bay Hunters and Trappers Association, pers. comm. March 21, 2002). From these observations it seems clear that excessive hunting can at least exacerbate, if not cause, declines, and would also dampen recovery rates. Peary caribou are under no serious threat from hunting as long as local community associations and biologists continue to cooperate on conservation.

Freezing fall rain and snow/icing events

Weather events that result in a hard glaze of ice forming on the ground, or as a crust or in layers in the snow, are implicated in a number of the major die-offs of Peary caribou. The mechanism is warming in spring or fall when there is already snow on the ground, which then melts or absorbs rain, followed by re-freezing to form a hard crust in the snow or a glaze covering the ground.

These situations contrast with the more usual condition in which temperatures from the first snowfall onward throughout winter remain below freezing and the snow remains powdery. Normally, the wind erodes snow away from topographic elevations and packs it into topographic depressions and the lee sides of geographic features. Both caribou and muskoxen feed on these exposed, snow-free terrain features, but muskoxen have more of an ability to dig craters in the snow and make more use of mesic sites, while caribou make more use of the xeric sites. A hard crust or glaze disadvantages both species; this is why muskoxen and caribou populations decline more or less in synchrony during these events in the areas where they occur, and not in other areas.

Measures of winter severity such as temperature and snowfall are difficult to associate with events such as winter die-offs, but several authors (Miller 1998, Larter and Nagy 2000b, Gunn and Dragon 2002) have found snowfall to be the best predictor.

Miller and Gunn (2003b) summarized the evidence as follows:

> *"We know of four major die-offs and associated subsequent major to near total calf crop losses plus one additional major calf crop reduction on, at least, the WQEI: 1973/74, 1989/90, 1994/95, 1995/96, and 1996/97…. All 5 of those winters and springs experienced significantly greater ($p < 0.005$) than average total snowfall between 1 September-21 June of each year and ranked at the top of 50 years for which weather records exist at Resolute, Cornwallis Island (Miller, 1998: 1st, 1995/96; 2nd, 1994/95; 3rd, 1996/97; 4th, 1989/90; and 5th, 1973/74). It is more the extent and characteristics of the snow cover than snow depth per se which result from heavy snowfall and high winds that cause widespread or in the few worst years range-wide prolonged and extreme relative unavailability of forage. This condition is especially compounded when associated with extensive icing that will 'lock in' the forage even further and prevent the animals from obtaining an adequate supply of food. However, so far, there has been a direct correlation between total snowfall and die-offs, particularly when heavy snowfall occurs in early winter. Therefore, total snowfall is the best indicator that we have to date of the potential for an extremely severe 'weather-year' causing die-offs and calf crop failures. The timing, duration, types, and amounts of icing compound the impact of deep snow and tends to cloud the relative importance of the role of deep snow vs. icing in these drastic die-off years."*

They further noted that the die-offs occurred in the western Queen Elizabeth Islands when the caribou were at low mean overall densities, implying that density-dependent mechanisms such as overgrazing were not involved (Miller and Gunn 2003b):

- 1973-74, 68% reduction at a starting density of 0.04 caribou • km^{-2} (19 199 km^2) and a 46% decline at 0.7 caribou • km^{-2} (61 237 km^2);
- 1994-95, 30% decrease at 0.16 caribou • km^{-2} (19 199 km^2);
- 1995-96, 75% drop at 0.11 caribou • km^{-2} (1 199 km^2); and
- 1996-97, 83% loss at 0.03 caribou • km^{-2} (19 199 km^2).

All 4 of the above Peary caribou die-offs also involved similar high annual rates and timing of deaths among muskoxen (Miller and Gunn 2003b), supporting snow/ice conditions as the causative factor.

Snowfall and snow depth records and notes on their relationship to caribou die-off years are given in Appendix 2. Neither total annual snowfall (Appendix 2, Figure 19) nor total monthly snowfall during September-May (Appendix 2, Figure 20) are exclusively associated with caribou die-off years, but snow depth at month end (Appendix 2, Figure 21) is. Interestingly, snow depth at month end is not correlated with total monthly snowfall. This suggests that snow depth may be a better predictor of die-off years than snowfall (Appendix 2, Figure 22).

The Banks Island-Victoria Island region is in a different climate region from the Queen Elizabeth Islands, with warmer annual mean temperatures and higher precipitation (Maxwell 1980, MacIver and Isaac 1989). Larter and Nagy (2000b) reported that severe winters with heavy snow caused caribou die-offs in 1987-1988, 1988-1989, and 1990-1991. A severe winter with deep, hard snow and freezing rain in autumn also occurred in 1993-1994. The freezing rain effectively eliminated approximately 50% of the available range and the local Inuvialuit voiced concern in November 1993 that the caribou were undernourished (Larter and Nagy, 1995). Although overwinter growth occurred in caribou calves and there was no die-off, during that winter (Larter and Nagy 1995), subsequent analysis showed that in a 5-year period, calf production was highest following the winter with the shallowest snow, and lowest following the winter with the hardest snow (Larter and Nagy 2000b).

To evaluate other possible explanations for caribou scarcity during those years, Miller (1998) and Gunn and Dragon (2002) counted caribou and muskox carcasses along with their population surveys in the Bathurst complex. In June 1995, Miller (1998) counted 1984 live and 56 dead caribou in intensive but unsystematic (hence, no population estimate) searches and estimated that 25% to 30% of the 3000+ Peary caribou there in 1994 had died. However, Resolute Bay hunters reported that significant numbers of caribou moved that fall from Bathurst Island to Cornwallis, where they killed between 50 and 100. In July 1996, Miller (1998) estimated from 143 caribou carcasses counted on transect, that 1143±164 had died the previous winter. He saw no calves that summer, and estimated 452±108 living caribou. This left about 400 caribou unaccounted for by deaths, suggesting that some had also emigrated during 1995-1996, which was confirmed by (a) reports by hunters of more caribou appearing on Cornwallis Island that year, and (b) a movement of a satellite-collared cow leaving from Bathurst to Borden Island, where it died (Miller 1997b, 1998). Miller (1998) estimated, from interviews with a number of Inuit hunters, that 85±25 of those 400 caribou were shot on Cornwallis Island that winter, leaving about 315 unaccounted for.

In 1997 Gunn and Dragon (2002) estimated 78±26 live caribou and 408±53 carcasses in the Bathurst Island complex, suggesting that most of the caribou alive there in 1996 had died by the following spring. They also found that death rates varied by island complex and by island based on the ratio of dead to living caribou in 1997. The Bathurst Island complex had a higher death rate (83%) than the Melville Island complex (30%). Their tabulation of caribou group size further supported the hypothesis that the declines were due to deaths and not emigrations (because when emigrating, usually a herd or family group goes together): the mean group size for the Melville, Prince Patrick and Bathurst groups was 4.3±0.34, compared to 6.7±0.36 in 1974, another die-off year. Although they could not fully discriminate among deaths, reproductive failure or emigrations as the cause of the 1996-1997 decline in the Melville-Prince Patrick complex, a 30% decline was due directly to deaths.

In summary, severe winters characterized by deep snow and icing resulting from rain or unseasonably warm weather, either in fall or spring, have been the cause of the best documented, sudden population declines, notably those that occurred in the western Queen Elizabeth Islands during 1973-1974 and again during 1995-1997. Other declines, including those of the Banks Island-northwestern Victoria Island and Prince of Wales-Somerset Island populations, have been more gradual and without a clear, single cause. In those latter cases, weather played a role in some cases (e.g., Banks Island) and in other cases may have, but the evidence is lacking. Contributing factors in these latter cases included excessive hunting (Banks Island, northwestern Victoria Island, Prince of Wales-Somerset and Boothia Peninsula) and may also have included summer weather effects on plant growth (Prince of Wales-Somerset) or interaction with muskoxen through some as yet undetermined mechanism, possibly related to either predator-prey interactions or competition for space or forage, or both.

Climate change

The susceptibility of Peary caribou to population-wide decimation caused by weather events has led to speculation that climate change has caused the observed 3-decade overall decline in the subspecies (Miller 1991, Ferguson 1996, Gunn 1998b, Miller and Gunn 2003b). Gunn (2003) noted that,

> *"The current patterns of morphological and genetic variation are also a consequence of recent as well as past conditions. The North American Arctic and subarctic climate is strongly regionalized with east-west and north-south gradients in variables such as snow depth which is related to probabilities of incursions of Pacific and/or Atlantic maritime air masses (Maxwell 1981). Annual and seasonal variability is high and unpredictable. Consequently, caribou ranges especially on the Arctic islands are a non–equilibrium ecological system with environmental extremes causing unpredictable declines in relative forage supplies (Caughley and Gunn 1993, Behinke 2000)."*

The notion of caribou existing in a non-equilibrium situation with respect to their range conditions explains their extreme susceptibility to climatic factors that may alter their food supplies or access to them. Brown and Alt (2001) documented extensive high latitude warming in the Northern Hemisphere in recent decades, consistent with predictions of greenhouse gas-forced global warming (Figure 15). These data confirm reports by Inuit from the Queen Elizabeth Islands of warming and associated ecological changes (Nunavut Tusaavut Inc. 1997). Much of the warming and reduction in snow and sea ice has occurred during the 1980s and 1990s, and 1998 was conspicuous for the unprecedented warmth and length of the melt season over the Canadian Arctic. Accompanying the 1998 weather anomalies, Brown and Alt (2001) found changes in:

- Snow melt: The 1998 melt season was characterized by an initial early retreat of the spring snow-line over the entire North American continent in April and May. Early spring warming coupled with below-average winter snow accumulation over western Canada and the Mackenzie Basin, led to a record (1955-2000) early melt of snow over the western Arctic.
- Break-up: In the west, break-up was early and there was twice as much open water in the southern Beaufort Sea as normal; distance to the ice edge was

46% greater than for the previous record year of 1954. Minimum ice extent conditions extended into the Queen Elizabeth Islands where the latest date for minimum ice extent in the 40 years was recorded.

- Active layer: In the west, permafrost temperatures and thaw penetration were generally the highest in the 10-year record and there was evidence of ground ice wedge melt and increased active layer detachment slide activity.

They also found that 1998 was the warmest year in the instrumental record for the Canadian Arctic (since ~1950 for the High Arctic climate station network), and was also the warmest in the instrumental record for the Northern Hemisphere land area (since ~1850). Other years have experienced similar cryospheric conditions to 1998, notably 1962.

Current Environment Canada global warming projections from the Canadian General Circulation Model (CCGM) (Environment Canada 2002) show that both maximum and minimum winter temperatures will rise more than summer temperatures. At Eureka, for example, the maximum extreme temperatures during 1961–1990 remained below freezing from November through April (Figure 16), but with global warming, temperature extremes of 0° C or above may occur in every month except March (Figure 17). (Extreme temperatures are important because although these events are rare, it only takes 1 event to cause the thawing and re-freezing that is associated with caribou die-offs). This would increase the frequency of winter rain and consequent snow/icing events.

Such dramatic climate changes portend equally profound ecological changes that could affect caribou. Effects could include:

- Warmer winter weather could reduce caribou energy expenditure, but is also likely to increase the frequency of rain and consequent snow/icing events, a known cause of starvation and population declines.
- Warmer summer weather could lead to greater plant growth, a benefit to caribou. It could, however, be a disadvantage to Peary caribou if it and other weather-related ecosystem changes allowed barren-ground caribou to invade the Arctic Archipelago. Warmer spring weather and earlier snowmelt can hasten plant green-up and flowering phenology. This may benefit caribou during late 3rd trimester gestation in spring. However, disruption of the synchrony between plant phenology and Peary caribou life cycle could be detrimental (Gunn 1998b)
- Warmer and wetter summer weather could lead to greater exposure to diseases and parasites, which have not previously been implicated in population declines (Miller and Gunn 2003b). Inuit from the Queen Elizabeth Islands report that mosquitoes and black flies have increased along with warmer weather in certain areas (Nunavut Tusaavut Inc. 1997).

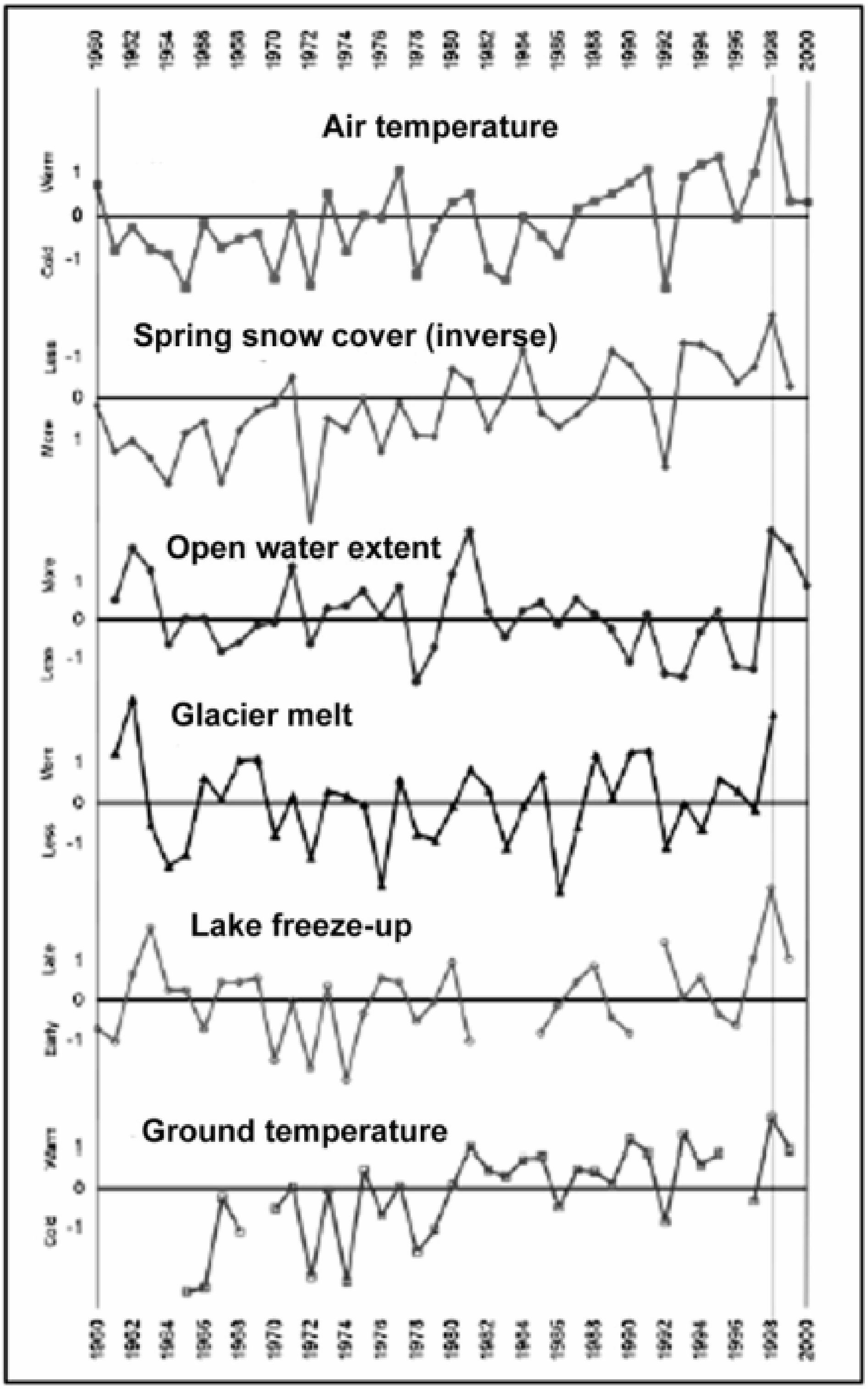

Figure 15. 1998 Departures from normal in selected cryosphere parameters. The thin verticle line highlights 1998 (from Brown and Alt 2001).

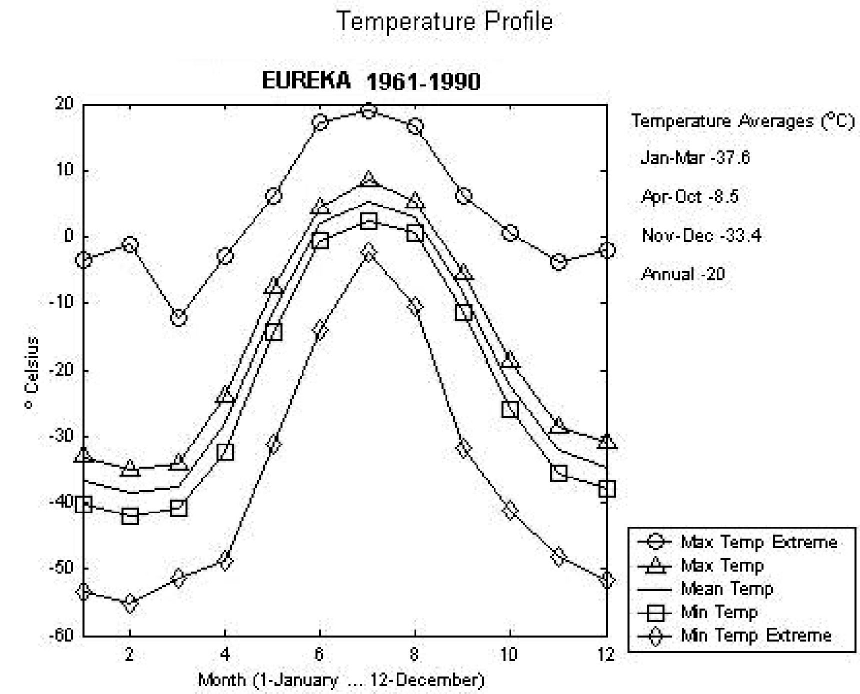

Figure 16. Mean monthly temperature at Eureka, 1961 to 1990 (Environment Canada 2002).

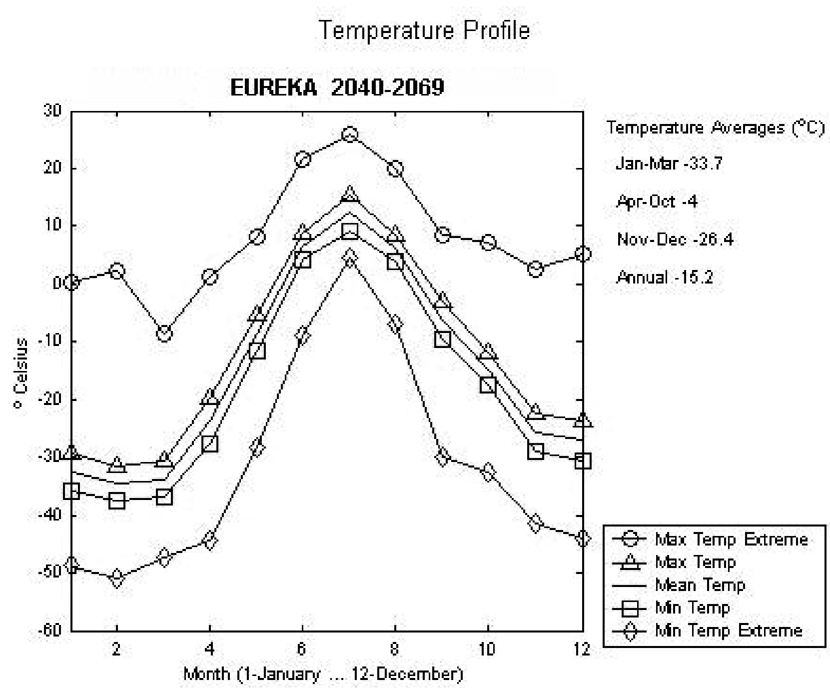

Figure 17. Mean monthly temperature projections for 2040-2069 at Eureka based on General Circulation Model (Environment Canada 2002).

- A greater extent or longer periods of open water in summer, combined with higher evaporation rates, could increase cloud cover, limit solar radiation and reduce plant growth.
- Increased soil temperatures and greater depth of the active soil layer above the permafrost could increase plant productivity with benefits to caribou. Also soil subsidence caused by ice lens melting could increase the availability of seed beds for some plant species, such as grasses and forbs, resulting in changes in plant community structure. Shrub dominance could also move northward with an increased duration of warmer (>5 C°) temperatures.
- Changes in the timing of freeze-up and break-up of sea-ice and a reduction in the extent of sea-ice will disrupt caribou inter-island and island-mainland migrations. Caribou deaths may increase if caribou cross on thin ice.
- In the eastern Queen Elizabeth Islands, Peary caribou could subsist at higher elevation than those currently used if glaciers were to retreat.

In experiments on the effect of global warming on Ellesmere Island, Greg Henry (University of British Columbia, pers. comm., November 20, 2002; unpubl. data) maintained a long-term warming experiment at a site on Ellesmere Island since 1992. He increased summer growing season temperatures by 1°C to 3°C in open-top chambers made of greenhouse grade fibreglass. The higher temperatures were associated with a change in species composition and abundance in all 7 of the tundra plant communities examined. There was an increase in the abundance of non-woody (herbaceous) plants (graminoids and forbs) in all sites and an increase in the only deciduous shrub (*Salix arctica*) in those communities where it dominates. The evergreen shrubs did not show any strong response. He concluded that in terms of Peary caribou forage, climate warming should increase some caribou food species and cause earlier flowering of those species.

If global warming were to prove favourable to barren-ground caribou, their expanding range northward could put Peary caribou at a competitive disadvantage. For example, in the Yukon, some lichens could expand their range northward and this could favour barren-ground caribou, which can prosper on lichens (Harding and McCullum 1997). How Peary caribou, which include little lichen in their diet because of the paucity of lichens on their range, would adapt to a new vegetation profile (species assemblage, forage biomass and phenology) compared to barren-ground is unknown. Miller (1991) suggested that Peary caribou would not compete well with barren-ground caribou.

Unfortunately, the hypothesis of climate change impacts on Peary caribou has not been tested. To do so would require a detailed analysis of weather records focusing on the specific variables that may change (or that have changed) with greenhouse-induced global warming in relation to Peary caribou demographics and associated ecological conditions over the period of record. This should be a priority, because if global warming increases the frequency or severity of spring and fall icing events, Peary caribou could go extinct within a relatively few years. Conversely, if climate turns out not to be implicated, then it becomes urgent to develop and test alternative hypotheses to explain the observed population declines.

Genetic diversity

Mitochondrial DNA shows that Peary caribou have low genetic diversity, the Prince of Wales population having a very low index of gene diversity (0.5714, compared to 0.791 to 1.000 for other North American caribou populations, where 1.0 means that all haplotypes in the sample are different) (Eger *et al.* 1999).

Zittlau (2003), using microsatellite analyses of nuclear DNA, which reflects a shorter evolutionary scale, found considerable genetic variation within the Peary and Dolphin and Union populations, sufficient to recognize distinct genotypes. However, the Canadian Arctic islands samples were significantly less variable than mainland barren-ground and woodland caribou populations. The Bathurst Island complex, Melville Island complex, and Prince of Wales-Somerset populations had the lowest levels of genetic diversity. Each population of Arctic islands caribou that they sampled had experienced recent genetic bottlenecks, raising concerns of increased risk of inbreeding depression as well as a loss of adaptive potential. Zittlau (2003) concluded that,

> *"The Arctic Island caribou populations have already experienced a number of declines and may not be able to adapt to changes in their environment if their genetic diversity is not preserved."*

Parasites and diseases

Few parasites and diseases have been found in Peary caribou and they are not thought to be a serious conservation issue (Miller 1991, Gunn 1993, Gunn and Dragon 1998, Larter and Nagy 1998d, Miller and Gunn 2003b).

Other threats

Dolphin and Union caribou, although relatively numerous are at risk, because of their behaviour of staging along the coast until freeze-up, of reduced forage availability, deaths from drowning through being too anxious to move across the ice, and a high susceptibility to hunting at that time (A. Gunn, Government of the Northwest Territories, pers. comm. June 12, 2003).

SPECIAL SIGNIFICANCE OF THE SPECIES

Peary caribou are endemic to Canada (Table 2). They are an integral component of Inuit culture and economy. Sharing in the hunt, distributing the products (such as meat, skins and antlers), and creating and trading the crafts made from skins and antlers reinforce social structures within and among communities. Sale of the products and crafts provides some income, but more significant potential income from tourism is not likely while populations are so low.

Criterion	Comment
Is the species or subspecies endemic to Canada? Is it a relict?	Endemic to Canada as a viable population; status of former population in NW Greenland uncertain, but most or all individuals there may have been strays from Canada. The DU caribou are endemic.
Does the species fulfill an especially important ecological role (e.g., keystone species, top predator, indicator species, significant prey item)?	1 of 2 large herbivores in the Arctic Archipelago, and the only member of the family Cervidae; a major prey of polar wolves; indicator of Northern Arctic Ecozone health. Peary caribou are adapted to an extreme polar desert environment and could not be replaced by other caribou subspecies. The ecological niche of the DU caribou could probably be filled by Peary Caribou but the current status of adjacent Peary Caribou populations makes it unlikely.
Is it a monotypic genus?	No.
Is the species at risk worldwide?	(only occurs in Canada)
How secure is the taxonomic unit? Are any related forms threatened?	Species secure; some other populations at risk.
Is the gene pool important, apart for survival, per se?	Gene pool of Prince of Wales-Somerset population, and possibly other populations, are constricted.
Is the species of special interest for scientific reasons?	Yes.
Is it of interest to the public? For what reasons? Is it hunted or otherwise harvested?	Yes: An icon of Arctic wildlife to all Canadians and especially important to Inuit, who hunt it for subsistence and products for artistic expression of their cultures. Inuit communities are leading efforts to conserve it within their territories.
Is there any subsistence exploitation? Is it exploited commercially? Is it traded nationally or internationally? Is it used in the pet trade or for horticultural purposes?	Yes. No. No, except for sale of arts and crafts made from products such as fur and antlers. No. The DU herd is an important food and skin supply for local Inuit and Inuvialuit, and the only caribou population accessible for Cambridge Bay. It is important for the tourism, art and craft economy and supports limited commercial harvest and sport hunts.
Is it reared in captivity? Does it have medicinal, ethnobotanical, ethnozoological or culinary characteristics? Is it used for traditional, or recreational purposes or in crafts?	No. Inuvialuit and Inuit say that Peary caribou tastes better than other caribou. Caribou meat as a “country food” source is important economically and nutritionally for local communities. Yes.
Is there adverse public opinion or prejudice against the species?	No.
Can it be confused with a more common species to its detriment?	No.

Table 2. Special significance of Peary and Dolphin and Union caribou.

The caribou of the Dolphin and Union herd represent a unique phenotype, genotype, and ecotype. Taxonomic, behavioural, historical, and qaujimajatuqangit all suggest that they are different from both Peary and barren-ground caribou and likely uniquely adapted to their environment. Except for their distribution, they have similar special significance to Peary caribou as noted in Table 2.

EXISTING PROTECTION OR OTHER STATUS

The conservation status designations of 1991 of Peary caribou and Dolphin and Union caribou are shown in Table 1. They are protected by the terms of the land claim agreements that recognize and specify Aboriginal rights to harvest wildlife, subject to conservation and public safety, and that provide for the establishment of wildlife co-management boards. The boards and their co-management partners, such as regional wildlife organizations (RWOs) and hunters' and trappers' organizations (HTOs – also known as HTAs – hunters' and trappers' associations), have the authority to restrict or prohibit hunting by their members. Experience has shown that both northern boards, with the cooperation of their co-management partners, are willing and able to make such restrictions on the advice of scientists and of their own information, and that hunters obey the restrictions. The agreements provide for government intervention in certain circumstances after due process.

There are no lands where hunting is prohibited by statute.

Industrial operations are normally required to avoid harassment or other disturbance to caribou under the terms of their territorial and/or federal operating permits or licences of occupation.

SUMMARY OF STATUS REPORT

Subspecies and distribution

Peary caribou are distinct from barren-ground caribou and no intermediate forms are recognizable at the subspecies level. Nevertheless, phenotypic and genotypic variations have been documented among the populations discussed in this report and the conservation of this diversity should be a primary goal of conservation and management. Peary caribou occupy the Queen Elizabeth Islands, Banks Island, the northwest corner of Victoria Island, Prince of Wales Island, Somerset Island, numerous smaller islands, and the Boothia Peninsula (and seasonally or irregularly on the mainland south to the Hayes River).

Caribou of the Dolphin and Union herd occupy the remainder of Victoria Island and adjacent parts of the mainland and are phenotypically and genetically distinct from both barren-ground caribou and Peary caribou.

Current population status

The current status of the main Peary caribou populations, not including calves, is shown in Figure 18. Data are from Gunn and Dragon (2002) for the Melville Island complex; Ferguson *et al*. (2001) and M. Ferguson, Nunavut Wildlife Service, pers. comm., Nov. 19, 2002) for Bathurst Island; Peary Caribou Recovery Team 2001 for the eastern Queen Elizabeth Islands; Nagy (unpubl. data) for Banks Island and northwestern Victoria Island; and Gunn and Dragon (1998) for the Prince of Wales-Somerset Island and Boothia populations. (The Prince of Wales-Somerset population has been inflated to 60±20 as noted above and the NW Victoria and Boothia populations bars have been reduced by half to exclude the Dolphin and Union and barren-ground caribou, respectively.)

The best current estimate for total (including calves) Peary caribou is 7890 and range of population estimates for total caribou, using errors measurements (either Standard Error or 95% CI) of the original surveys with modifications as described in the Population Sizes and Trends section is 5971 to 9146.

Recent population trends

To determine recent population trends, the most recent estimates have been compared with 1980 estimates, representing a nominal 3 generations of caribou (7 years/generation=21 years). The most recent populations have also been compared with the first reported estimate to give a measure of change from historic levels. The data used in these calculations are given in Appendix 1, Tables 5 to 10.

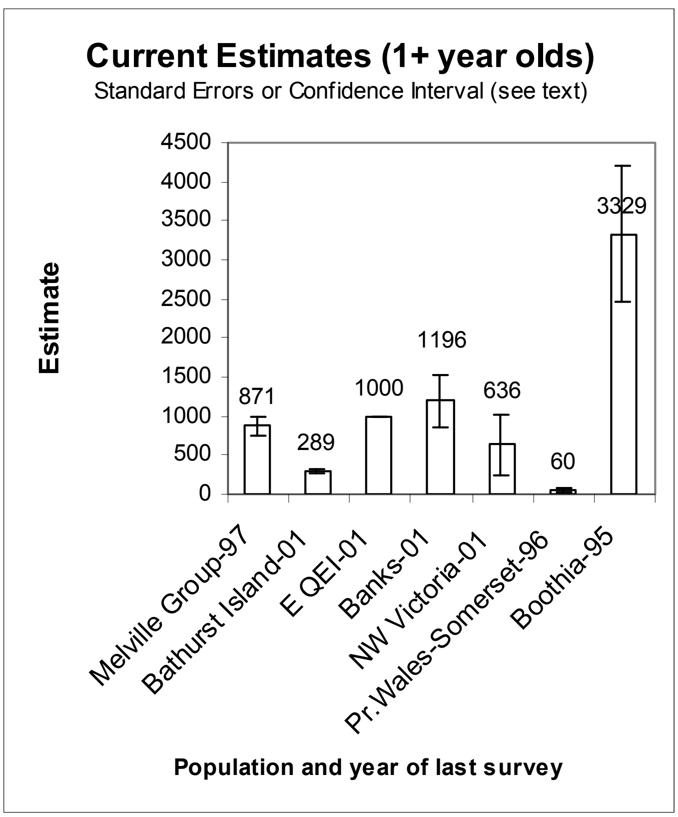

Figure 18. Number of adult caribou in each population as of last survey except for Boothia, which is for total caribou (see text for data sources).

All 4 Peary caribou populations have suffered serious declines. Where multiple-year time series are available, some of the declines have been more or less gradual, in the range of -5% to -22%, except for the Bathurst Island complex local population. It experienced the sharpest and deepest declines twice (1973-1974 and again in 1994-1997). Multi-year increases have also been documented in the Bathurst Island complex (1974-1994), the Boothia Peninsula (1975-1995), the Banks Island–northwestern Victoria Island population (1998-2001) and the Dolphin and Union herd (1980-1998). The Dolphin and Union herd has apparently increased from 3424 in 1980 to about 27 800 in 1997, but there is doubt about the 1980 estimate; the actual population may have been considerably higher. Increases also occurred previous to scientific surveys in the Banks Island-northwestern Victoria Island population and in the Prince of Wales-Somerset and Boothia Peninsula population, according to Aboriginal traditional knowledge. The eastern Queen Elizabeth Island population has also increased according to Inuit from Resolute Bay and Grise Fiord, but was only surveyed in 1961.

Peary caribou and Dolphin and Union caribou have continued their decline from historic levels (Table 3). The current population estimates in the eastern Queen Elizabeth Islands and Boothia Peninsula have a high degree of uncertainty.

Table 3. Summary table: current populations and change since historic levels and since 1980.

Population	First Count	1980	2001	Change since 1980	Change since first count
QEI	25 802	3326	2100	-37%	-92%
Banks/NW Victoria Isl.	16 610	15 751	2401	-85%	-86%
PrW/Som	5516	6043	60	-99%	-99%
Boothia	556	3022	3329	10%	498%
All Peary	48 484	28 142	7890	-72%	-84%
Dol & Union	100 000	3424	27 786	712%	-72%

Data are from Appendix 1, Tables 5 to 10.

Threats

Peary and Dolphin and Union caribou are threatened (Table 4) by:

- Recurring severe winters can decimate populations within 1-3 years. Peary caribou have the ability to reoccupy previously abandoned range through inter-island emigrations.
- Industrial activities including seismic exploration and shipping have the potential to interfere with Peary caribou use of habitat and inter-island migration and Dolphin and Union caribou island-mainland migration.
- Climate change may have negative effects including increased snowfall and greater variability in snow depth and hardness. The latter is the most serious threat to Peary caribou and could eliminate the subspecies.

- Some populations may be below an "effective population size" in terms of genetic diversity caused by genetic bottlenecks following population crashes.

Table 4. Specific threats to Peary and Dolphin and Union caribou by population.

Population	Causes of past declines	Current/Future threats
QEI	Episodic winter snow and ice[1]	Episodic winter snow and ice; climate change; hunting if not regulated
Banks/NW Victoria Isl.	Winter snow and ice; hunting; possibly predation associated with high muskox populations (hypothesized)	Episodic winter snow and ice; climate change; hunting if not regulated
PrW/Som	Main causes unknown; hunting possibly a contributing factor; possibly predation associated with high muskox populations (hypothesized)	Episodic winter snow and ice; climate change; hunting if not regulated
Boothia	Population fluctuations poorly documented; hunting possibly a factor	Episodic winter snow and ice; climate change; hunting if not regulated
Dolphin & Union	Hunting	Episodic winter snow and ice; climate change; hunting if not regulated; shipping; drowning during migration (at special risk from climate change if open water season in Dolphin and Union strait is extended); forage depletion in fall staging areas

[1]Except eastern Queen Elizabeth local populations, about which virtually nothing is known of population changes or their contributing factors.

Conservation and recovery

- Following population declines, recovery of Peary caribou can be as high as 19% per year per year for short periods, but long term (>10 years) rates of increase may be around 13% if no weather-related die-off occur. (e.g., The Dolphin and Union herd has increased at 24% per year for short periods (e.g., 1994–1997).
- Because of the small populations and subspecific genetic and phenotypic differences among them (that may also represent unique adaptations to specific environments), conservation of the full range of genetic diversity among these populations is paramount.

Other status assessments

The World Conservation Union assessed Peary caribou as EN (endangered) in 1996 based on (1) reduction in population by 50% over the previous 10 years and (2) population <2500 and an estimated continuing decline of 20% within 5 years.

TECHNICAL SUMMARY

Rangifer tarandus pearyi

Peary caribou | Caribou de peary | Tuktu

Range of Occurrence in Canada: Northwest Territories and Nunavut

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* Based on surveys and monitoring of radiocollared animals	602 356 km^2
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	No
Area of occupancy (AO) (km²)	Cannot be properly estimated because it may vary over time and there is insufficient information
• *Specify trend in AO*	stable
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	Four metapopulations
• *Specify trend in #*	Stable
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Stable
Population Information	
• *Generation time (average age of parents in the population)*	7 years
• *Number of mature individuals*	7890 (5971 to 9146)
• *Total population trend:*	Decreasing
• *% decline over the last/next 10 years or 3 generations.*	72%
• *Are there extreme fluctuations in number of mature individuals?*	Yes in some populations
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Stable
• *Are there extreme fluctuations in number of populations?*	No
• *List populations with number of mature individuals in each:*	Queen Elizabeth Islands: 2100 Banks Island-Northwest Victoria Island: 1500 Prince of Wales – Somerset: 60 Boothia Peninsula: 3350
Threats (actual or imminent threats to populations or habitats)	
Winter die-offs due to extreme icing events. Climate warming. Potential threats: hunting if unregulated, industrial activity, increased predation if wolf numbers respond to increased muskox numbers, loss of genetic diversity in a few extremely reduced populations.	
Rescue Effect (immigration from an outside source)	None
• *Status of outside population(s)?*	Canadian endemic
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive in Canada?*	
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	not done
Other Status **COSEWIC: 3 units recognized in 1991: 'Banks Island' and 'High Arctic' Endangered, 'Low Arctic" Threatened** **IUCN: Endangered (1996)**	

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2a
Reasons for Designation: This caribou is a Canadian endemic subspecies. Numbers have declined by about 72% over the last three generations, mostly because of catastrophic die-off likely related to severe icing episodes. The ice covers the vegetation and caribou starve. Voluntary restrictions on hunting by local people are in place, but have not stopped population declines. Because of the continuing decline and expected changes in long-term weather patterns, this subspecies is at imminent risk of extinction.	

Applicability of Criteria

Criterion A (Declining Total Population): Endangered because it has declined by more than 50% in 3 generation, based on the population surveys. Decline is expected to continue because of changing climate. (A2a)

Criterion B (Small Distribution, and Decline or Fluctuation): the extent of occurrence is much greater than 20,000 km^2

Criterion C (Small Total Population Size and Decline): Threatened, because there are fewer than 10,000 mature individuals and decline has been much more than 10% over the last 3 generation. (C1)

Criterion D (Very Small Population or Restricted Distribution): there are more than 1000 mature individuals remaining.

Criterion E (Quantitative Analysis): analysis has not been done.

TECHNICAL SUMMARY

Rangifer tarandus groenlandicus

Dolphin and Union caribou — Caribou de la toundra, population de Dolphin et Union — Tuktu

Range of Occurrence in Canada: Northwest Territories and Nunavut

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* Based on surveys and monitoring of radiocollared animals. Victoria Island excluding northwestern Victoria Island (195 417 km^2) and Stefansson Island (4463 km^2). Area of mainland used in winter not included	200 000 km^2
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	Yes; range vacant 1924–1970, re-occupied 1970–1997
• *Area of occupancy (AO) (km²)*	Unknown,
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	One
• *Specify trend in #*	Stable
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Stable
Population Information	
• *Generation time (average age of parents in the population)*	7 years
• *Number of mature individuals*	27 786 (1997)
• *Total population trend:*	Unknown (see note following table)
• *% decline over the last/next 10 years or 3 generations.*	increase
• *Are there extreme fluctuations in number of mature individuals?*	Not in last 3 generations
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Stable
• *Are there extreme fluctuations in number of populations?*	No
• *List populations with number of mature individuals in each:*	Not applicable
Threats (actual or imminent threats to populations or habitats)	
High harvests without recent population estimates. Potential threats: Climate warming may shorten the period when sea ice allows migration to and from mainland, industrial activity including shipping and icebreaking. Potentially vulnerable to icing events and die-offs similar to those that have affected Peary caribou.	
Rescue Effect (immigration from an outside source)	None
• *Status of outside population(s)?*	Canadian endemic
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive in Canada?*	
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	Not available
Other Status **COSEWIC: included in ‘Low Arctic’ caribou, Threatened (1991)**	

Status and Reasons for Designation

<table>
<tr><td>Status: Special Concern</td><td>Alpha-numeric code: Not applicable</td></tr>
<tr><td colspan="2">Reasons for Designation:
This population of caribou is endemic to Canada. Once thought to be extinct, numbers have recovered to perhaps a quarter of the population’s historic size. They have not been censused since 1997 and are subject to a high rate of harvest, whose sustainability is questioned by some. They migrate between the mainland and Victoria Island and climate warming or increased shipping may make the ice crossing more dangerous. The population, however, increased substantially over the last three generations and was estimated at about 28,000 in 1997.</td></tr>
<tr><td colspan="2">Applicability of Criteria

Criterion A (Declining Total Population): Population has increased substantially over the last 21 years (3 generations)
Criterion B (Small Distribution, and Decline or Fluctuation): The extent of occurrence is much greater than 20,000 km^2 and there is no evidence of decline
Criterion C (Small Total Population Size and Decline): There are more than 10,000 mature idividuals and no recent decline
Criterion D (Very Small Population or Restricted Distribution): There are more than 1000 mature individuals.
Criterion E (Quantitative Analysis): analysis has not been done.</td></tr>
</table>

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My great-uncle, Dr. R. M. Anderson (1876–1961), former Chief of the Biology Division of the National Museum of Canada from 1920 to 1946, contributed to Peary caribou knowledge and conservation through his early study and collections of Peary caribou and his life-long time dedication to the conservation of arctic wildlife.

Herodier Kalluk and Simione Amagoalik of Resolute Bay accompanied me throughout many miles of winter darkness while observing the responses of Peary caribou and muskoxen to seismic activities on Bathurst Island in the winter of 1974-1975. Tabitha Mullen, who was 4 years old when I worked with her father, Kalluk, on Bathurst Island, introduced me to the people of Resolute Bay and arranged for me to meet with the members of the Hunters and Trappers Association. Nancy Amarualik of the Hunters and Trappers Association explained the association's biological survey program, her understanding of the caribou and muskox population changes and responses to environmental conditions and the hunting patterns of people from Resolute Bay, Grise Fiord, Gjoa Haven, Cambridge Bay and other communities in the project area. I am grateful to Susan Alley, Peter Amarualik, Roger Salluvinig, Nathaniel Kulluk, Martha Idlout, Ludy Kulluk and Mini Nungat for welcoming me to Resolute Bay and sharing with me their views on how to incorporate Aboriginal traditional knowledge into science assessments.

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Appendix 1. Population Estimates

Table 5. Population estimates for the Melville and Bathurst Island complexes.

Year	Melville[1]		Pr Patrick [1]		BIC	
	Estimated	Calculated	Estimated	Calculated	Estimated	Calculated
1961	**12799**	**12799**	**5001**	**5001**	**3608**[1]	**3608**
1962		11845		4464		2952
1963		10962		3985		2416
1964		10145		3558		1977
1965		9389		3176		1617
1966		8689		2835		1323
1967		8041		2531		1083
1968		7442		2259		886
1969		6887		2017		725
1970		6373		1800		593
1971		5898		1607		485
1972	2500	5459		1435		397
1973	3500	5052	790	1281		325
1974	1600	4675	630	1143	**266**[1]	**266**
1975		4327		1021		291
1976		4004		911		319
1977		3706		813		350
1978		3429		726		383
1979		3174		648		420
1980		2937		579		460
1981		2718		516		504
1982		2516		461		553
1983		2328		412		606
1984		2155		367		663
1985		1994		328	**727**[1]	**727**
1986		1845	181	293		851
1987	729	1708		261		997
1988		1580		233	1103[1]	**1167**
1989		1463		208		1367
1990		1354		186		1601
1991		1253		166		1875
1992		1159		148		2195
1993		1073		132	2667[1]	2571
1994		993		118	**3037**[1,3]	**3011**
1995		919		105		**2183**
1996		850		94		**452**
1997	**787**	**787**	**84**	**84**	**78**[1]	**78**
1998						108
1999						150
2000						208
2001					**289**[2]	**289**

Bold font indicates the years used in trend calculations. Most estimates are for total caribou.

[1]Melville and Prince Patrick, adult caribou (Tener 1963, Gunn & Dragon 2002). The Prince Patrick column includes Eglinton, Emerald, Mackenzie King and Brock Islands. Bathurst, all caribou up to 1997 (Miller, 1998 and Miller and Gunn, 2003b) on all islands except Lougheed. The WQEI column in Table 10 includes Lougheed Island.

[2]Ferguson pers. comm. for 2001: adult caribou on Bathurst Island.

[3]The 1994 estimate, from unsystematic searches, was reported as 3011 by Miller 1998 and 3037 by Miller and Gunn (2003b).

Table 6. Population estimates for the Eastern Queen Elizabeth Islands.

Year	Estimated	Calculated
1961	**1482**[1]	**1482**
1962		1466
1963		1450
1964		1434
1965		1419
1966		1403
1967		1388
1968		1373
1969		1358
1970		1343
1971		1329
1972		1314
1973		1300
1974		1286
1975		1272
1976		1258
1977		1244
1978		1231
1979		1217
1980		1204
1981		1191
1982		1178
1983		1165
1984		1153
1985		1140
1986		1128
1987		1115
1988		1103
1989		1091
1990		1079
1991		1068
1992		1056
1993		1045
1994		1033
1995		1022
1996		1011
1997	**1000**[2]	**1000**

Bold font indicates the years used in trend calculations. Estimates are for total caribou.

[1]Tener (1963): values for Ellesmere, Devon, and Axel Heiberg islands are not based on calculated estimates they are merely "intuitive guesses."

[2]Peary Caribou Recovery Team (2001).

Table 7. Population estimates for Banks Island and northwestern Victoria Island.

	Banks Island[1]		Northwestern Victoria Isl[2]	
Year	Estimated	Calculated	Estimated	Calculated
1972	**12098**	**12098**		
1973		11987		
1974		11877		
1975		11768		
1976		11661		
1977		11554		
1978		11448		
1979		11343		
1980		11239	**4512**	**4512**
1981		11136		4351
1982	**11034**	**11034**		4196
1983		9156		4047
1984		7598		3902
1985	4931	6305		3763
1986		5232		3629
1987	4251	4342	**3500**	**3500**
1988		3603		1978
1989	2641	2990		1118
1990		2481		632
1991		2059		357
1992	1469	1709		202
1993		1418	**114**	114
1994	800	1177	6 caribou[3]	146
1995		976		186
1996		810		238
1997		672		305
1998	**558**	**558**	633[4]	389
1999		791		498
2000		1120		637
2001	**1587**	**1587**	1628[4]	**814**

Bold font indicates the years used in trend calculations. Most estimates are for total caribou.

[1]All caribou; data from Urqhart (1973), Latour (1985), Larter and Nagy (2000b) and Nagy (1996) and revised by J. Nagy (pers. comm. February 2, 2004).

[2]Gunn, Miller & Nishi (2000): all caribou.

[3]Estimate not possible because of the scarcity of caribou.

[4]A survey in 1998 gave 633 caribou and 1 in 2001 gave 1628, but J. Nagy (pers. comm. February 2, 2004) found, by satellite telemetry, that they included some Dolphin and Union caribou. Hence, estimates for 1994, 1998 and 2001 are not possible. For the purpose of trend and current-status calculation, I have arbitrarily divided the 2001 estimate by half here and in Table 10.

Table 8. Population estimates for the Dolphin and Union Herd.

Year	Estimated[1]	Calculated
1980	**3424**	3,424
1981		3,873
1982		4,380
1983		4,954
1984		5,604
1985		6,338
1986		7,169
1987		8,109
1988		9,171
1989		10,373
1990		11,733
1991		13,271
1992		15,010
1993		16,978
1994	14529	19,203
1995		21,720
1996		24,566
1997	**27786**	**27,786**

Bold font indicates the years used in trend calculations. Estimates are for total caribou.

[1]Gunn and Nishi (1998). F. Miller (pers. comm.) has questioned the 1980 estimate and suggested that the poor coverage may have underestimated the population, resulting in a lower rate of increase than indicated for 1980-1994.

Table 9. Population estimates for Prince of Wales Island, Russell Island, Somerset Island, and Northern Boothia Peninsula.

Year	Wales, Russell, Somerset		Boothia	
	Estimated	Calculated	Estimated	Calculated
1974	**5516**[1]	**5516**	**556**	**556**
1975	**4383**[1]	**4383**	**1890**	**1890**
1976		4673		2076
1977		4983		2281
1978		5314		2505
1979		5666		2751
1980	**6043**[2]	**6043**		3022
1981		4443		3320
1982		3267		3646
1983		2402		4005
1984		1766		4399
1985		1299	**4831**[2]	**4831**
1986		955		4655
1987		702		4485
1988		516		4321
1989		380		4163
1990		279		4011
1991		205		3865
1992		151		3724
1993		111		3588
1994		82		3457
1995	**60**[2]	**60**	**3329**[2, 3]	**3331**

Bold font indicates the years used in trend calculations. Most estimates are for total caribou.

[1]Fisher and Duncan (1976): estimates for adults converted to all caribou using the percentages of calves that they reported in spot-checks

[2]Gunn and Dragon (1998); all caribou. In 1995, too few caribou were seen in the Prince of Wales–Somerset complex for a quantitative estimate and an arbitrary 60 is used as described in the text.

[3]The 1995 estimate for Boothia was halved to account for the barren-ground caribou that were counted in the survey but not distinguished, as described in the text.

Table 10. Calculated population trends.

Year	Melville	Pr. Patrick	BIC	ΣWQEI	EQEI	ΣQEI	Banks	NW Vict	ΣBanks +NWV	PrW/Som	Boothia	Σ All Peary	DU
First count	**12,799**	**5,001**	**3,608**	**24,320**	**1,482**	**25,802**	**12,098**	**4,512**	**16,610**	**5516**	**556**	48,484	**100,000**
1961	**12799**	**5001**	**3608**	**24,320**	**1,482**	**25,845**						46,522	
1962	11845	4464	2952	21,401	1,466	22,867						44,639	
1963	10962	3985	2416	18,833	1,450	20,283						42,832	
1964	10145	3558	1977	16,572	1,434	18,007						41,099	
1965	9389	3176	1617	14,584	1,419	16,002						39,436	
1966	8689	2835	1323	12,833	1,403	14,236						37,839	
1967	8041	2531	1083	11,293	1,388	12,681						36,308	
1968	7442	2259	886	9,938	1,373	11,311						34,839	
1969	6887	2017	725	8,745	1,358	10,103						33,428	
1970	6373	1800	593	7,695	1,343	9,039						32,076	
1971	5898	1607	485	6,772	1,329	8,100						30,777	
1972	5459	1435	397	5,959	1,314	7,273	**12,098**					29,532	
1973	5052	1281	325	**5,244**	1,300	6,544	11,987					28,336	
1974	4675	1143	266	**2,676**	1,286	3,962	11,877			**5516**	**556**	27,190	
1975	4327	1021	291	2,575	1,272	3,846	11,768			**4383**	**1890**	26,089	
1976	4004	911	319	2,477	1,258	3,735	11,661			4673	2076	25,033	
1977	3706	813	350	2,383	1,244	3,627	11,554			4983	2281	24,020	
1978	3429	726	383	2,293	1,231	3,523	11,448			5314	2505	23,048	
1979	3174	648	420	2,206	1,217	3,423	11,343			5666	2751	22,115	
1980	2937	579	460	2,122	1,204	3,326	11,239	**4512**	**15,751**	**6,043**	3022	28,142	3,424
1981	2718	516	504	2,042	1,191	3,233	11,136	4351	15,751	4,443	3320	26,747	3,873
1982	2516	461	553	1,964	1,178	3,142	**11,034**	4196	15,487	3,267	3646	25,543	4,380
1983	2328	412	606	1,890	1,165	3,055	9,156	4047	15,230	2,402	4005	24,692	4,954
1984	2155	367	663	1,818	1,153	2,971	7,598	3902	13,203	1,766	4399	22,339	5,604
1985	1994	328	**727**	1,749	1,140	2,889	6,305	3763	11,501	1,299	**4831**	20,520	6,338
1986	1845	293	851	1,683	1,128	2,811	5,232	3629	10,069	955	4654	18,489	7,169
1987	1708	261	997	1,619	1,115	2,734	4,342	**3500**	8,862	702	4484	16,783	8,109
1988	1580	233	1167	1,558	1,103	2,661	3,603	1978	7,842	516	4320	15,340	9,171
1989	1463	208	1367	1,499	1,091	2,590	2,990	1118	5,581	380	4162	12,713	10,373
1990	1354	186	1601	1,442	1,079	2,521	2,481	632	4,108	279	4010	10,919	11,733
1991	1253	166	1875	1,387	1,068	2,455	2,059	357	3,113	205	3864	9,637	13,271
1992	1159	148	2195	1,335	1,056	2,391	1,709	202	2,416	151	3722	8,680	15,010
1993	1073	132	**2667**	1,284	1,045	2,329	1,418	**114**	1,910	111	3586	7,936	16,978
1994	993	118	**3011**	1,235	1,033	2,269	1,177	146	1,532	82	3455	7,337	19,203

Table 10. Calculated population trends.

Year	Melville	Pr. Patrick	BIC	ΣWQEI	EQEI	ΣQEI	Banks	NW Vict	ΣBanks +NWV	PrW/Som	Boothia	Σ All Peary	DU
1995	919	105	**2100**	1,188	1,022	2,210	976	186	1,322	60	3329	6,922	21,720
1996	850	94	**452**	1,143	1,011	2,154	810	238	1,163			7,115	24,566
1997	**787**	**84**	**78**	**1,100**	**1,000**	**2,100**	672	305	1,049			7,313	27,786
1998			108				**558**	389	977			7,517	
1999			150				791	498	947			7,726	
2000			208				1,120	637	1,289			7,942	
2001 Last Count	**787**	**84**	**289**	**1,100**	**1,000**	**2,100**	1,587	**814**	**2,401**	**60**	**3,329**	7,890	**27,786**
Change since 1980	-73%	-85%	-37%	-48%	-17%	-37%	-86%	-82%	-85%	-99%	10%	-72%	712%
Change since first count	-94%	-98%	-92%	-95%	-33%	-92%	-87%	-82%	-86%	-99%	498%	-84%	-72%

Table notes
Actual estimates are shown in **bold** font, between which the trends are calculated as exponential rates of increase or decrease.
Values are for all caribou including calves except as noted below. Data are from Tables 5 to 9 except 1961 first counts for EQEI and WQEI, which are from Tener (1963), the first count for Dolphin and Union, which is from Manning (1960), and the ΣWQEI, which is from Miller and Gunn (i2003b).
The estimates for NW Victoria for 1997 and 2001 have been omitted because they were found to include an unknown number of Dolphin and Union caribou (see text and Table 7).
The "last count" for Prince of Wales–Somerset is a guess, as no quantifiable estimate was possible.
Estimates for the Melville and Prince Patrick islands complexes are for 1+ year old adults.
The Last Count row uses the most recent estimate or sum. The range of estimates for "All Peary" is 5998 to 9092.

Appendix 2. Snowfall and Snow Depth

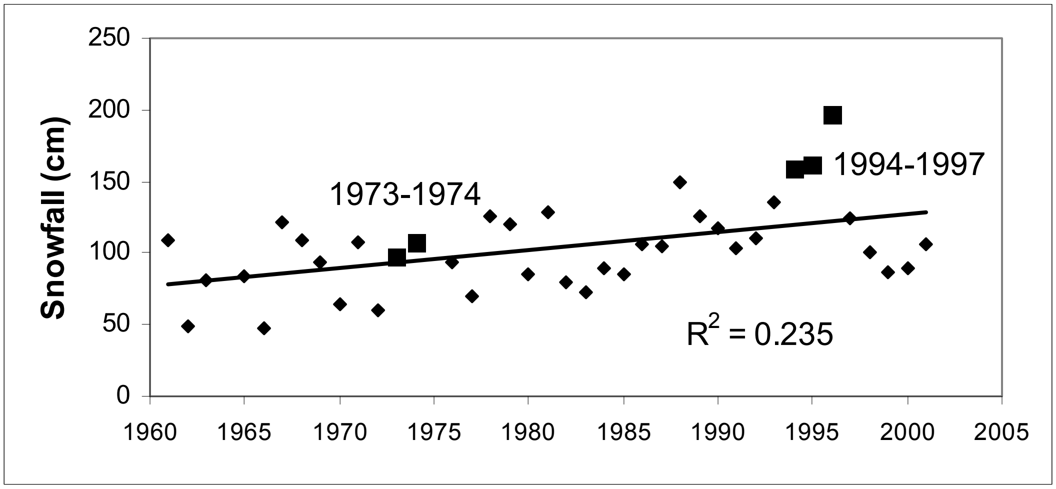

Figure 19. Total yearly (sum of mean monthly) snowfall at Resolute Bay, Nunavut, 1961-2001. Square symbols are snowfall during caribou die-off years. The apparent increasing trend is not statistically significant. The annual average was 104.2 cm.

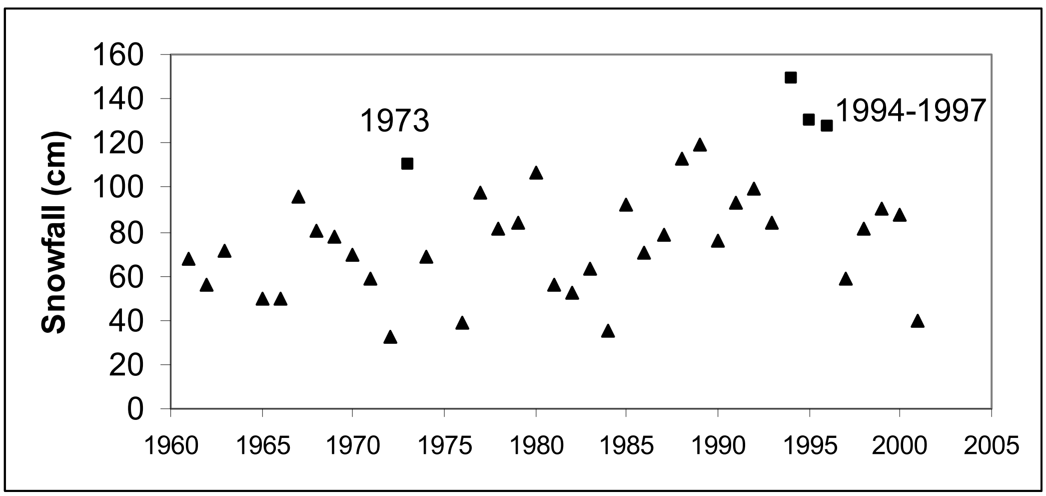

Figure 20. September-May total (sum of mean monthly) snowfall at Resolute Bay, Nunavut, 1961-2001. Square symbols are snowfall during caribou die-off years. The annual average was 78.2 cm.

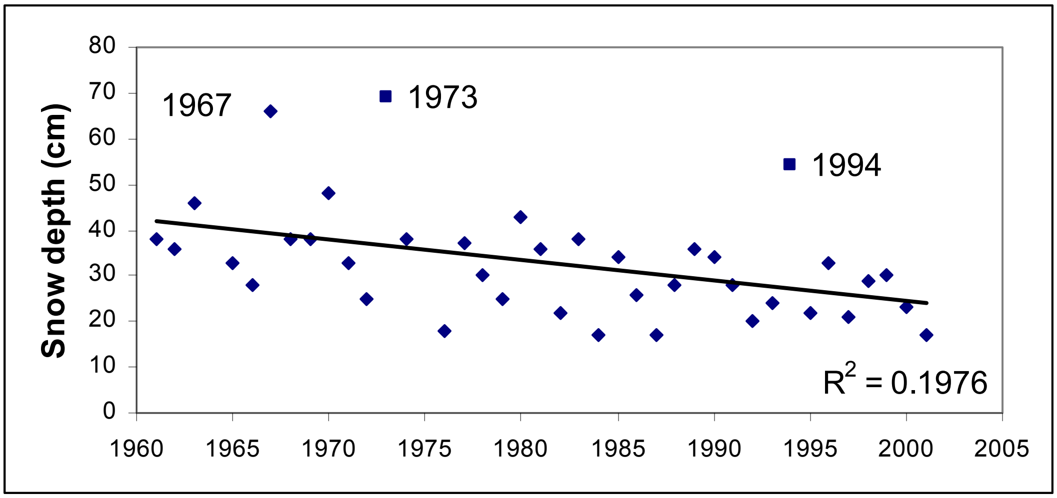

Figure 21. September-May maximum snow depth at month end at Resolute Bay, Nunavut, 1961-2001. Square symbols represent caribou die-off years. The apparent declining trend is not statistically significant.

Since there was no caribou survey in 1967, it is not known when whether there was a die-off that year, but the low caribou numbers found in 1973 show that there was either a die-off or a sharp decline sometime between 1961 and 1973.

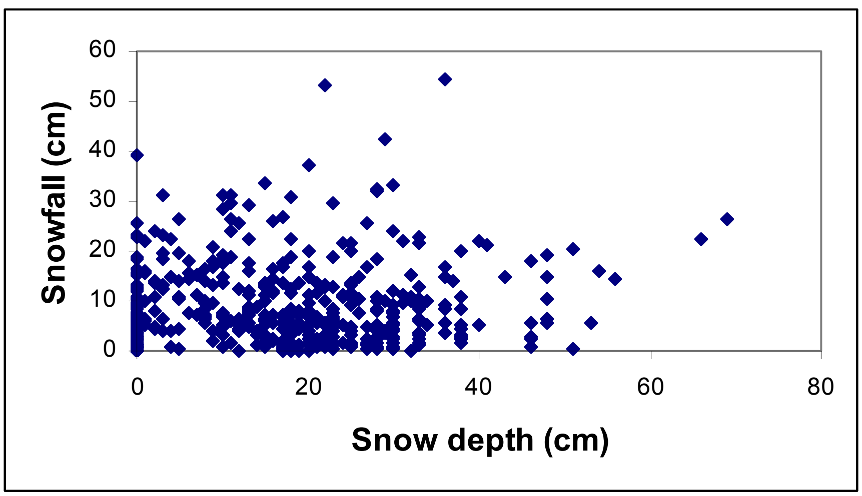

Figure 22. Relationship between mean monthly snowfall and maximum snow depth at month's end, Resolute Bay, Nunavut 1961-2001. No relationship was found.