STATUS OF WOLVES IN THE CANADIAN ARCTIC ARCHIPELAGO

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ABSTRACT. Three subspecific forms of the gray wolf (Canis lupus spp.) have been recognized in the Canadian Arctic Archipelago: C. l. arctos Pocock, the Canadian Polar wolf; C. l. bernardi Anderson, the Banks Island tundra wolf; and C. l. manningi Anderson, the Baffin Island tundra wolf. All existing data indicate that wolf numbers and densities are low throughout the archipelago, although those values apparently are higher in the Baffin Island region and the southern tier of Arctic Islands than on the Queen Elizabeth Islands. The genetics and thus taxonomical characteristics of C. l. arctos on the Queen Elizabeth Islands and C. l. manningi on Baffin Island have possibly remained relatively stable with little or no interchange over recent time. The genetics of wolves on the southern tier of Arctic Islands have likely been highly dynamic, however, with sporadic ingress of wolves from the Queen Elizabeth Islands and at least sporadic invasions by mainland wolves. The large item prey base in the Canadian Arctic Archipelago is restricted to caribou (Rangifer tarandus spp.) and muskoxen (Ovibos moschatus). Reasonable gross approximations of "theoretical maximum carrying capacities" based on one wolf per 100 ungulate prey are currently only ca. 200 C. l. arctos on the Queen Elizabeth Islands; ca. 1100 C. l. arctos on the southern tier of Arctic Islands, probably together with some races from the mainland; and ca. 2100 C. l. manningi in the Baffin Island region. Currently, only tentative conclusions can be drawn about the status of arctic island wolves within those three major regions of the Canadian Arctic Archipelago. (1) Wolves classified as C. l. bernardi appear to have become extinct on Banks Island some time between 1918 and 1952. (2) Supposition about C. l. bernardi having also occurred on at least northwestern Victoria Island remains unsubstantiated by fact, as bernardi is still known only from its type locality on SW Banks Island. (3) The validity of bernardi as a distinct subspecies of Canis lupus remains debatable; that is, did those eight wolves from Cape Kellett represent a valid subspecies or were they merely immigrants from the mainland. (4) Wolves (C. l. manningi) appear to be generally common at low densities within much of the Baffin Island region but their overall number does not appear to approach their extrapolated current "theoretical maximum carrying capacity" of ca. 2100. (5) Wolves (C. l. arctos) generally occur at low densities and are often rare or absent in large areas throughout the southern tier of Arctic Islands; thus, those wolves do not appear to even closely approach their currently extrapolated "theoretical maximum carrying capacity" of ca. 1100. (6) Wolves (C. l. arctos), with a few local exceptions, generally occur at low densities and are rare or absent over large areas throughout the Queen Elizabeth Islands; however, they currently may be near or at their extrapolated low "theoretical maximum carrying capacity" of 200.

RÉSUMÉ. Trois sous-espèces de loup gris (Canis lupus spp.) ont été reconnues dans l'archipel Arctique canadien : C. l. arctos Pocock, ou loup polaire canadien; C. l. bernardi Anderson, ou loup arctique de l'île Banks; et C. l. manningi Anderson, ou loup arctique de l'île de Baffin. D'après toutes les données existantes, le nombre et la densité des loups sont faibles partout dans l'archipel. Les effectifs semblent toutefois être plus élevés dans la région de l'île de Baffin et dans le tiers méridional de l'archipel Arctique que dans les îles de la Reine-Élisabeth. Les caractères héréditaires et, par le fait même, taxinomiques de C. l. arctos dans les îles de la Reine-Élisabeth et de C. l. manningi dans l'île de Baffin sont peut-être demeurés relativement stables, les modifications interchromosomiques récentes ayant été peu nombreuses ou inexistantes. La transmission des caractères héréditaires au sein de la population de loups du tiers méridional de l'archipel Arctique semble cependant avoir été très dynamique : la région a été visitée de façon sporadique par les loups des îles de la Reine-Élisabeth et elle a été envahie à l'occasion par les loups du continent. Les principales proies du loup dans l'archipel Arctique canadien se limitent au caribou (Rangifer tarandus spp.) et au boeuf musqué (Ovibos moschatus). À l'heure actuelle, les approximations brutes raisonnables des « capacités limites maximales théoriques », fondées sur un loup pour cent ongulés, sont les suivantes : environ 200 C. l. arctos seulement sur les îles de la Reine-Élisabeth; environ 1100 C. l. arctos dans le tiers méridional de l'archipel Arctique, probablement mêlés à certaines races du continent; et environ 2100 C. l. manningi dans la région de l'île de Baffin. Pour le moment, on ne peut que formuler des conclusions provisoires sur la situation du loup dans ces trois grandes régions de l'archipel Arctique. 1) C. l. bernardi semble avoir disparu de l'île Banks entre 1918 et 1952. 2) L'hypothèse voulant que C. l. bernardi ait également fréquenté au moins la partie nord-ouest de l'île Victoria n'a pas été prouvée, car bernardi n'est encore connu que d'après sa localité type du sud-ouest de l'île Banks. 3) La validité de l'hypothèse voulant que bernardi soit une sous-espèce de Canis lupus distincte est encore discutable; en effet, on peut se demander si les huit bernardi en provenance du cap Kellett forment réellement une sous-espèce ou s'ils ont tout simplement émigré du continent. 4) Il semble que la densité des loups (C. l. manningi) soit généralement faible dans la plus grande partie de l'île de Baffin, mais le nombre total ne paraît pas approcher de la « capacité limite maximale théorique » actuelle, qui a été extrapolée à environ 2100. 5) Les loups (C. l. arctos) atteignent habituellement une faible densité. Comme ils sont souvent rares ou même absents dans de vastes régions de tiers méridional de l'archipel Arctique, ils semblent être très loin de leur « capacité limite maximale théorique » actuelle, qui a été extrapolée à environ 1100. 6) La densité des loups (C. l. arctos) est généralement faible, à part quelques exceptions locales. Ces loups sont rares ou inexistants dans de vastes régions des îles de la Reine-Élisabeth. Toutefois, à l'heure actuelle, ils pourraient avoir atteint ou être sur le point d'atteindre leur faible « capacité limite maximale théorique » extrapolée à 200.

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INTRODUCTION

The Canadian Arctic Archipelago (CAA) is the most remote and isolated region of North America. It is a niveous land, characterized by the extremes of harsh, prolonged, wintry weather followed by brief, cool polar summers. The arctic archipelago is locked in sea ice and thus fastened to the Canadian mainland for most of each year. In this setting, a meagre array of only 10 species of terrestrial mammals have adapted to the severities of the polar environment to live on the arctic archipelago year-round (Macpherson 1965).

Five species of land carnivores occur in viable populations the year-round. The gray wolf (Canis lupus spp.) is the only large land carnivore found throughout the Canadian Arctic Islands, although the ice-bound waters of the arctic archipelago are the marine domain of the polar bear (Ursus arctos). The smaller land carnivores are the arctic fox (Alopex lagopus) and ermine (Mustela erminea), which both occur throughout the Arctic Islands. The wolverine (Gulo gulo) and red fox (Vulpes vulpes) occur regularly on Baffin Island and are rare visitors on southern Arctic Islands.

Four herbivores occur throughout the CAA: caribou (Rangifer tarandus spp.), muskox (Ovibos moschatus), arctic hare (Lepus arcticus), and varying lemming (Dicrostonyx torquatus). A fifth herbivore, the brown lemming (Lemmus trimucronatus), is found regularly only on the southern Arctic Islands and in the Baffin Island region of the archipelago.

Summertime brings a wide range of migratory birds to nesting grounds in the CAA: most notably, sea birds, shorebirds and waders, waterfowl, and birds of prey. About 64 avian species are known to breed on the Arctic Islands of Canada (Quellet 1990). Bird life in winter is sparse and mainly limited to the gyrfalcon (Falco rusticolus), raven (Corvus corax), rock ptarmigan (Lagopus mutus), and snowy owl (Nyctea scandiaca), with the rock ptarmigan usually being the most common avian winter resident.

With the exceptions of the southern and especially the southeastern coastal areas, the most recent prolonged period of occupation of much of the CAA by indigenous peoples was several hundred years before present (ca. 1400-1600 AD), well before European settlement in Canada. Currently, most people in the CAA are Inuit and live in small, coastal settlements (Table 1). There are also people living at government weather stations, Distant Early Warning (DEW) Line sites, two mines, and a Canadian military installation. Summertime sees an influx of southerners: mainly researchers and government employees and some developers and tourists. Year-round residents on the Canadian Arctic Islands number about 11 500, with ca. 80% of them living in the Baffin Island region (Northwest Territories data book 1990/91).

Wolves on the Arctic Islands are typically white or whitish in appearance. The white wolves of Ellesmere Island have received detailed photographic coverage in two popular books (Mech 1987, Brandenburg 1991). The prevailing white colouration of some individuals is altered by a greater prevalence of black-tipped hairs on the dorsum and especially along the median dorsal line and across the upper side of the tail near the base. Even otherwise completely white wolves tend to have a small blackish area across the upper side of the tail associated with a clump of stiff, black-tipped hairs that surround the precaudal gland located on the back ca. 7 cm above the base of the tail (e.g., Mech 1970). I have seen some wolves (possibly immature animals) on the Arctic Islands, however, that could best be described as reddish-buff, greyish, dusky, or, on one occasion, even black.

The least known of the arctic mammals is the wolf: wolves are curious but usually fleeting visitors to isolated camps, seemingly, appearing out of nowhere. Their apparent elusiveness as they are swallowed up in the vast tracts of land, together with the general absence of people and the formidable logistics and costs associated with studying wolves on the Canadian Arctic Archipelago explains the overall lack of information. Their ecology, population dynamics, abundance, distributions, and movements are scarcely known. Therefore, the following status report is out of necessity both in part speculative and tentative. My objectives in this paper are (1) to compile information on arctic-island wolves and their ungulate prey previously scattered throughout the literature, (2) to provide a starting point for the evaluation of the status of wolves on the Arctic Islands of Canada, and (3) to offer an initial analysis of the status or potential status of those wolves by examining the size of the ungulate prey base. I draw heavily on my empirical knowledge of the arctic archipelago and its wildlife, particularly the two species of arctic ungulates that constitute the staples in the diets of high-arctic wolves.

STUDY AREA

The CAA forms the northern apex of the North American continent (Dunbar and Greenaway 1956), and with a landmass of over 1.3 million km^2, it equals one-seventh of the land area of Canada. The CAA spans nearly 60 degrees of longitude (66-126° W) and 22 degrees of latitude (61-83° N), with a maximum east-west breadth of ca. 2700 km and a maximum north-south extent of ca. 2400 km. Three of the world's 10 largest islands occur there: Baffin Island (507 451 km^2), the 5th largest; Victoria Island (217 290 km^2), the 9th largest; and Ellesmere Island (196 240 km^2), the 10th largest (Hurtig 1985).

The tundra vegetation is composed of lichens, bryophytes, graminoids, herbs, cushion plants, and prostrate shrubs; on some areas of southern islands, dwarfed or low, erect shrubs occur (e.g., Savile 1961;

Porsild 1964; Babb and Bliss 1974; Bliss 1975, 1986, 1990; Edlund 1983, 1990; Thomson 1990). Bliss (1990) estimated that the landscape areas within the CAA were 44% "Polar desert"; 40% "Polar semidesert"; 10% ice (glaciers and permanent snowfields); and 6% meadow. Bliss (1990) and Edlund (1990) discuss ecosystems and bioclimatic zonation in the CAA, respectively.

Extremely cold polar winters and brief, cool polar summers characterize the climate (McKay 1990). Spring and autumn are brief in all but the most southerly portions of the archipelago. Perhaps the most impressive aspect of the high latitudes is the continual 24 hours of darkness during much of the winter (the "Polar night"), followed in summer by the continual daylight (above ca. 67°N latitude) for weeks or months, as you approach the North Pole.

The CAA is usually thought of as a region of fairly uniform climatic conditions, but in reality, many areal and seasonal variations occur (Maxwell 1980, 1981, 1982). The Canadian Arctic Islands have been divided into five climatic regions and 15 subregions (Maxwell 1981). Winter comes any time from late August to early September (late Sep on southern Baffin Island) and ends in mid to late June of each year. Mean monthly temperatures are above 0°C for only 2 (Jul. & Aug.) or 3 (Jun, Jul. & Aug.) months of the year, except on southern Baffin where mean monthly temperatures remain above 0°C from June through September. Extreme temperatures range from ca. 29 to -9°C in July to ca. 4 to -53°C in January, based on 30-yr (1951-80) records (Canadian Climate Program 1982). Both total annual rainfall and snowfall are highly variable throughout the archipelago: it can snow on any day of the year; but rain is rare in winter, except on southern areas of Baffin Island. Precipitation increases from north to south and west to east across the climatic regions of the archipelago (Maxwell 1981). Most of the annual precipitation falls as snow, with September and October being the months with the most snow. Total snowfall is light during the deep cold of November through March. Snowfall then increases in April to June, but usually not to the autumnal level.

Land mammals can move freely among the islands of the archipelago on the sea ice for at least 8 to 9 months each year (e.g., Miller et al. 1977b, 1982, Miller 1990a) and between the southern islands and the mainland for 7-8 months. Open channels and strong currents between Baffin Island and the more westerly islands make inter-island movements across the sea ice in those areas less likely, infrequent, or at best, sporadic. The winter is, however, largely a time of easier travelling on wind-packed snow and prey are often weakened by the hardships of winter. Severe winters leading to caribou or muskox deaths provide carcasses to be scavenged.

Abiotic and biotic components of the CAA vary markedly both by latitude and longitude; therefore, I have divided the CAA into three "eco-regions" (Figs. 1-3): the Queen Elizabeth Islands, with five "eco-areas" - Eastern, Southwestern, South-central, North-central, and Northwestern (Table 2, Fig. 1); the Southern Tier of Arctic Islands, with three "eco-areas" - Western, Eastern, and South-central (Table 2, Fig. 2); and Baffin Island region, with two "eco-areas" - Southern and Northern (Table 2, Fig. 3). The "eco-regions" are tied to the three major geographic areas of the CAA, their associated climate, and in general, their vegetation-cover. The "eco-areas" are related more to the vegetation-cover in terms of their capabilities of supporting arctic ungulates and, thus, indirectly to their potential for supporting wolves.

The CAA was first occupied by people of Siberian origin, "Palaeoeskimos", who appear suddenly in the archaeological record about 4000 years ago (McGhee 1990). The High Arctic islands were then apparently abandoned about 3500 years ago when the climate deteriorated until about 2500 years ago. At the latter time, the "Dorset culture" spread from Baffin Island northward to Ellesmere Island and westward across most of the Arctic Islands to Banks Island. The northwestern Queen Elizabeth Islands, however, were never occupied by the Dorset people (McGhee 1990). Those people were then killed or driven to extinction about 1000 years ago by invading "Neoeskimos" from Alaska. The Neoeskimos spread throughout arctic Canada, extending the "Thule" culture from Alaska to Greenland, and are the ancestors of the present Canadian Inuit (McGhee 1990).

The Thule were a whale-hunting culture, tied to coastal winter settlements, who followed the extension of the bowhead whale's (Balaena mysticetus) range eastward in association with a general climatic warming (e.g., McGhee 1990; Arnold and McCullough 1990). Climatic cooling about 500-600 years ago, culminating in the "Little Ice Age" (ca. 1600-1850 AD), led to the impoverishment of the Thule Inuit economy and culture. The Palaeoeskimos, and the Thule Inuit who abandoned the High Arctic Islands between 1400-1600 AD (e.g., Savelle and McCartney 1990), never were numerous in the CAA, especially on the Queen Elizabeth Islands. They lived first in small, widely scattered, temporary camps and later in small, isolated, coastal winter settlements, and still later reverted to the old ways with the deterioration of the arctic climate (ca. 1600-1850 AD). Baffin Island apparently has always been the most populated area, followed by the south coasts of the southern tier of Arctic Islands. Thus, occupation of the Queen Elizabeth Islands by humans was only temporary, at extremely low-densities, and mainly in the southern and eastern sections.

What impact those people had on wolves is unknown but it was probably little at regional levels, as the people were greatly restricted in space at any one time and they had only the bow and arrow for hunting and a few traps and killing devices. Dog, and possibly wolf, bones do

occur in association with Neoeskimo sites (e.g., Arnold and McCullough 1990). Skeletal remains of dogs have been found at two Greenland Palaeoeskimo sites: Qaja and at Qegertasussuk (Møhl 1972 and Meldgaard and Grønnow 1986, respectively, In: Schledermann 1990: 57).

The first European presence in the CAA came in the form of exploration for a northwest passage to the orient starting in the late 1500s AD and continuing into the early 1800s. Subsequently, they came mainly in search of Franklin and his lost crews in the mid 1800s AD. All that was contained in their journals about wolves on the archipelago are brief accounts, usually of human-wolf encounters and wolf hunting of ungulates. Although wolves were encountered in low numbers throughout the CAA, large numbers of wolves were implied only for northern Banks Island (e.g., M'Clure 1856). Very few wolves were killed by the explorers, however, and the impression is that considerable literary licence was applied in relating accounts about wolves, particularly human-wolf encounters. Seemingly, this apparent elaboration occurred because the journals of explorers were published for public consumption of adventure and travels in unknown lands. Also, the disdainful European view of the dreaded wolf was pervasive throughout those tales.

The Hudson's Bay Co. and some "free-traders" and whalers carried out trading activities along the south coasts of the southern Arctic Islands and in the Baffin Island region, where Inuit clans occurred during the late 20th and early 21st centuries. The Queen Elizabeth Islands were unoccupied for several hundred years and were not resettled with Inuit until the mid 1950s. Four Canadian Government weather stations were established on the Queen Elizabeth Islands in the late 1940s. There was little scientific or nonrenewable resource exploration until the 1950s. Exploration (and scientific) activities peaked in the 1970s, then declined throughout the 1980s to the present.

MATERIALS AND METHODS

1. Data Sources

Journal accounts of 19th and 20th century explorers in the Canadian Arctic Archipelago were searched for information on past numbers of wolves on the Canadian Arctic Islands (Parry 1821, Franklin 1823, Richardson 1829, Parliamentary papers 1852, Kennedy 1853, Belcher 1855, Bellot 1855, M'Clure 1856, Armstrong 1857, M'Dougall 1857, M'Clintock 1859, 1861, Collinson 1889, Bernier 1910, Stefansson 1921, Noice 1924, and Moore 1936). Literature pertaining to the taxonomical classification of the three forms of gray wolf found, or previously found, on the Canadian Arctic Islands was examined (Pocock 1935, Anderson 1943, 1946, Manning and Macpherson 1958, 1961, Nowak 1979, 1983). An assortment of wolf sightings and fragmentary information on various aspects of the biology and ecology of wolves on the Arctic Islands of Canada can be found scattered throughout the literature: i.e., excluding taxonomical references, for

the Queen Elizabeth Islands Eco-region, Bruggemann (1953, 1954), MacDonald (1953, 1954, 1960), Degerbøl (1957), Macpherson (1961), Corbett and Downe (1966), Stott (1968), Freeman (1971), Beak (1975b), Pluritec (1975), Riewe (1975, 1976), Russell (1976), Miller and Gunn (1977, 1978, 1980), Miller and Russell (1978), McLaren (1981), Gray (1983, 1987), Kiliaan and Thomas (1983), and Meldgaard (1986); for the Southern Tier of Arctic Islands Eco-region, Manning (1952, 1953, 1956), Hohn (1953), McEwan (1953, 1956), Macpherson (1960), Usher (1970), Hagen (1970), Broughton (1971), Bouckhout (1972), Beak (1975a), Hubert (1975), Russell (1977), and Heard (1983); and for the Baffin Island Eco-region, Miller (1955), Ellis (1957), and Wood (1974). Few internal reports or published articles have the arctic-island wolf as the main theme or, if a multi-topic paper, even as one of their main themes; e.g., those few that do, excluding taxonomical references, include McEwan (1956), Lauer and Baker (1969), Lauer et al. (1969), Gray (1970, 1983, 1987), Theberge (1973), Riewe (1975), Grace (1976), Smith (1976), Miller and Gunn (1977), Miller and Russell (1978), Miller (1978), Munthe and Hutchinson (1978), Graves (1980), Heard (1983), Mech (1987, 1988, 1990), and Brandenburg (1991). A considerable body of information has accumulated on wolf interactions and encounters with their prey and humans: Tener (1954), Gray (1970, 1983, 1987), Grace (1976), Smith (1976, 1980), Miller (1978), Munthe and Hutchinson (1978), Mech (1987, 1988), Brandenburg (1991).

2. The Canadian Polar Wolf

Canis lupus arctos, Pocock, Proc. Zool. Soc. London, Pt. 3, p. 682, September 1935. C. l. arctos is described as a medium-sized wolf but smaller than coastal mainland arctic races and with a narrower brain case (Pocock 1935, Young and Goldman 1944).

2.1. Type locality

Melville Island, District of Franklin, Northwest Territories, Canada.

2.2. Type specimen

No. 55.11.26.4, Brit. Mus., adult, probably male, skull only; collected by Sir E. Belcher's expedition, 1853-54.

2.3. Distribution

Melville Island and probably neighbouring islands; north and east to Ellesmere Island.

2.4. Common names

American arctic wolf, Pocock (1935:682), indiscrimately called "the Melville Island wolf" (Pocock 1935:683) when discussing the earliest

reference to the American arctic wolf by Parry (see Richardson, 1829:67-78). Most recently referred to as the Canadian Polar wolf by Anderson (1946:52).

2.5. Marginal records

Pocock (1935:682), in addition to the type specimen, examined an old skull from Discovery Bay, Ellesmere Island. Manning and Macpherson (1958:55) subsequently examined 53 specimens: 8 adult males, 3 adult females, 1 subadult (sex?), 1 skull from the Thomsen River, and 5 cubs, all from Banks Island; 7 adult males and 3 adult females from Prince Patrick Island; and 18 adult males, 5 adult females, 1 subadult (sex?), and 1 (sex or age?), all from Ellesmere Island noted as "C. l. actos"? by Manning and Macpherson. Nowak (1979:138) examined 21 skulls: Ellesmere Island, 1 Bear Peninsula, 6 Eureka Sound, 2 Grise Fiord, 1 Hare Fiord, and 8 Slidre Fiord, Foshiem Peninsula; Graham Island, 1 Norwegian Bay; and Prince Patrick Island, 1 Cherie Bay and 1 Mould Bay.

2.6. Remarks

Manning and Macpherson (1958:54) speculated that on geographical grounds, Greenland wolves likely could be very similar to those on Ellesmere Island. Thus, they (Manning and Macpherson 1958:54) suggested that if, in the future, a racial division proves desirable between Banks Island wolves and those on Ellesmere Island (and by association, Prince Patrick Island and Melville Island wolves), the dividing line should lie east of Melville Island. More recently, in their review of the wolf in Greenland, Dawes et al. (1986:121) concluded that, "It is unlikely that the Greenland wolf [(C. l. orion)] has at any time developed subspecies characteristics distinct from its Canadian counterpart [(C. l. arctos)]". Dawes et al. (1986) suggested that when wolf populations on Greenland were in decline or extirpated, North and East Greenland would be recolonized by wolves (C. l. arctos) from Ellesmere Island.

Manning and Macpherson (1961:208-209) concluded that there may be a close genetic relationship between the Prince of Wales Island wolf population and that of Ellesmere Island, based on a single skull (adult male ?) found on northeast Prince of Wales Island (Inner Browne Bay area). They speculated that gene flow could have been maintained between the Ellesmere Island population and that of the mainland by way of Prince of Wales and Somerset islands (Manning and Macpherson 1961:209). They concluded, however, that "it seems more likely that the Ellesmere Island-Prince of Wales Island wolves are the primitive high arctic stock and the Banks Island population has become differentiated comparatively recently, possibly by genetic drift acting on established or mutant genes at a time of low population. The broad, almost deformed P3 of some Banks Island skulls lends support to this theory." (Manning and Macpherson 1961:209).

It appears in retrospect that movement of wolves from the mainland, particularly from the Boothia Peninsula, in association with springtime caribou migrations to Somerset and Prince of Wales islands (cf. Miller et al. 1982, Miller 1990b) could have been a likely invasion route for the progenitors of arctic-island wolves. On occasion, some of those ancestral wolves could have lingered on those islands in autumn and then continued northward to Devon Island and thence to Ellesmere Island in search of more abundant prey, especially in winter after the relatively large migratory caribou herds had left Prince of Wales and Somerset islands and returned to the mainland.

3. The Banks Island Tundra Wolf

Canis lupus bernardi, Anderson, J. Mamm. 24:389, 17 August 1943. C. l. bernardi is considered a relatively large but rangy wolf, with a long narrow skull (Anderson 1943, Young and Goldman 1944).

C. l. banksianus, Anderson, J. Mamm. 24:390, 17 August 1943 (synonym used inadvertently in table of cranial measurements).

3.1. Type locality

Cape Kellett (ca. 72° N, 125° W), SW Banks Island, District of Franklin, Northwest Territories, Canada.

3.2. Type specimen

No. 2796, Nat. Mus. Can., adult male, collected by Peter Bernard, 27 February 1916. The type specimen was subsequently listed as a subadult of undetermined sex by Manning and Macpherson (1958:55), apparently, on the basis of the formation of the angle of the mandible.

3.3. Distribution

Originally given as Banks Island and probably on at least NW Victoria Island (I assume that the speculation about NW Victoria Island was related to the Inuit's knowledge of caribou and muskoxen movements between NE Banks Island and NW Victoria Island). Actually, this form is known only for the type locality.

3.4. Common names

Banks Island tundra wolf, Anderson (1943:389); and Banks Island wolf, Anderson (1946:53).

3.5. Marginal records

Anderson (1943:389-392) clearly states that he examined, "Six skins and 8 skulls from the type locality."(p. 392), including the type specimen. However, he makes mention of only 2 adult males, 2 adult females, 1 subadult male, 1 subadult female, and 1 cub (p. 389); while he gives a sample size of 3 adult males and 2 adult females in his Table 1, (p. 390). He then gives measurements from 2 skins, "one male and one female which did not reach the museum". Subsequently, Manning and Macpherson (1958:55) report examining 1 adult male, 1 adult female, 6 subadults (sex?), and 1 skull from Cape Cardwell. Nowak (1979:138-139) reports examining 8 skulls from Banks Island: 1, no precise locality; 3, North Adam River; 1, Big River; 1, Egg River; and 2, 40 km E. of Sachs Harbour. There appears to be considerable disagreement over the sex and age of the various specimens between examinations in 1943 and 1958 (cf. Manning and Macpherson 1958). The only possible marginal record is an exceptionally old (est. 100 yr) broken skull picked up at an Inuit camp on Thomsen River, Banks Island, that appeared to agree best with 1914-16 Banks Island bernardi series (Manning and Macpherson 1958:54); however, they subsequently classified the specimen as a "questionable subadult arctos" (Manning and Macpherson 1958:55).

3.6. Remarks

Manning and Macpherson (1958:36-56) reexamined the original eight skulls classified by Anderson (1943) as C. l. bernardi (which they called the 1914-16 series) and compared them to a 1953-55 series of 16 specimens also from Banks Island (along with two old skulls from Inuit ruins), and several series of skulls from the Queen Elizabeth Islands and the mainland. They found that (1) in general, the appearance of the skulls of the 1953-55 series resemble skulls from the Queen Elizabeth Islands, especially those from Prince Patrick Island (p. 36); (2) the 1914-16 series of narrow skulls are strikingly different from the 1953-55 series of broad skulls (p. 40); and (3) the results of the comparison (p. 41, Table 25) strongly suggests that the 1914-16 and 1953-55 series are from different populations - the 1953-55 series being most closely related to wolves from Prince Patrick Island which they assume, because of geographical position, are similar to those wolves on Melville Island (the type locality for C. l. arctos).

Manning and Macpherson (1958:53) concluded that C. l. bernardi had been replaced on Banks Island by wolves of the C. l. arctos form; most likely, in a then recent invasion of Banks Island from Melville Island or northern Victoria Island (supposedly from Prince Patrick Island via Melville Island or Victoria Island). It should be noted, however, that Nowak (1979:96) commented that although he agreed with Manning and Macpherson (1958:43) that the 1953-55 series of wolf skulls from Banks Island differ from Anderson's (1943) description of C. l. bernardi, he was not so certain that those 1953-55 specimens could be "assigned to C. l.

arctos with confidence", as suggested by Manning and Macpherson. Manning and Macpherson (1958:53-54) speculated that the 1914-16 series of eight wolves all from the Cape Kellett region of SW Banks Island might actually have been mainland wolves that crossed the ice to Banks Island, possibly from Cape Bathurst or Cape Parry. Therefore, they reasoned that "the name bernardi must remain in doubt", at least until more specimens are examined from adjacent coastal mainland areas. Finally, they concluded that bernardi could not be considered a synonym of arctos but may subsequently be proven to be a synonym of one of the mainland barren ground races.

Thus, even though C. l. bernardi currently must be considered extinct, the mystery remains as to whether C. l. bernardi was swamped by the subspecies C. l. arctos from the Queen Elizabeth Islands or were themselves not a distinct new form but only immigrants from the mainland (cf. Manning and Macpherson 1958: 53-54).

4. The Baffin Island Tundra Wolf

Canis lupus manningi, Anderson J. Mamm. 24:392, 17 August 1943. C. l. manningi is smaller than other arctic races and with a much smaller and less massive skull than arctos (Anderson 1943, Young and Goldman 1944).

4.1. Type locality

Hantzsch River, east side of Foxe Basin, west side of Baffin Island, District of Franklin, Northwest Territories, Canada. Although Anderson (1943:392), and apparently everyone using the information after him, gave the location of the type specimen as ca. 67° N, 24° W, the longitude of ca. 24° W is obviously in error. The longitudinal location of 24° W at 67° N latitude falls in the Atlantic Ocean beyond the southeast coast of Greenland in the Denmark Strait off the NW corner of Iceland. An approximate location of 72° W longitude at 67° N latitude would be the correct location for the type specimen (T.H. Manning, pers. commun., 1992: in the early 1930s, maps of Baffin Island were too inaccurate to use latitude/longitude locations).

4.2. Type specimen

No. 17236, Nat. Mus. Can., young adult female; collected by T.H. Manning (original no. 70.) on 7 December 1938.

4.3. Distribution

All of Baffin Island from Hudson Strait to Pond Inlet; probably also on Bylot Island.

4.4. Common name

Baffin Island tundra wolf.

4.5. Marginal records

Anderson (1943:392-393) examined 12 specimens from Baffin Island in addition to the type specimen: 1, Ashe Inlet, Hudson Strait; 4, Foxe Basin; 3, Pangnirtung, Cumberland Sound; 2, Piling 69°N, Foxe Basin; and 2, Salmon River, Pond Inlet, ca. 72° 30'N. Nowak (1979:139) only examined 3 specimens from Baffin Island: 2 from no precise locality and 1 from Pangnirtung Fiord.

4.6. Remarks

Nowak (pers. commun., 1992) examined only 1 adult male skull in his revision, suggesting that C. l. manningi should be included in C. l. nubilus, which ranged from the central states northward through Canada. Nowak (pers. commun., 1992) has also included the mainland race C. l. hudsonicus in his C. l. nubilus classification. Dawes et al. (1986:122) believed that, "..., the wolves that periodically visit central West Greenland are almost certainly immigrants from Baffin Island,....".

5. Evaluation Procedure

In the absence of essentially any systematic and quantitative data on past, recent, or current numbers of wolves on the CAA, I have opted for examining the "theoretical maximum carrying capacities" for wolves on the Canadian Arctic Islands in terms of their available ungulate prey base. I have approximated the possible trends in wolf numbers (trend directions and magnitudes) over the last 3 decades (ca. 1961-90) from changes in the reported estimated numbers of caribou and muskoxen and from hearsay evidence. When survey estimates do not extend back to 1960, literature relating to generalized trends and relative numbers of caribou and muskoxen in those areas was used to support generalizations about likely changes in wolf numbers over the entire time period. Those extrapolations allow only approximations of the potential status of wolves on the Canadian Arctic Islands. They do, however, permit some insight into the status or possible status of those wolves when considering the need for their conservation. The approach is simplistic but, I believe, it is a biologically sound, general starting point for an otherwise undocumented subject.

Wolves are large carnivores that require considerable amounts of meat for their sustenance. I calculated a mean rate of kill from Keith (1983:76, Table 10) of 32.3 days time lapse · $wolf^{-1}$ · $ungulate^{-1}$ and assumed that it applied roughly to the entire year. Thus, I obtained an average of 11.3 ungulates killed · yr^{-1} · $wolf^{-1}$. The body weights of

caribou and muskoxen mostly fall intermediate to those ungulate species reported by Keith (white-tailed deer, Odocoileus virginianus; elk, Cervus elaphus; and moose, Alces alces). Most importantly, no data exist for evaluating the probable ratios of ungulate prey used by arctic-island wolves by species (caribou vs. muskoxen) or by sex/age classes of either species. Therefore, I did not calculate an "ungulate biomass index" as I had no way of assigning any level of confidence to such a refinement of this exercise. I believe, based on existing data, that any rate of annual kill by wolves in excess of 10% (excluding newborn calves and other additional natural mortality, even in the absence of human hunting) would likely tax ungulate populations on the Arctic Islands beyond their sustainable capacities. Thus, I chose an annual mean rate of kill of 10% at an overall mean density of 100 ungulates · $wolf^{-1}$ as a reasonable measure to use in my calculation of the "theoretical maximum carrying capacities" for wolves on the Canadian Arctic Islands. The ratio of one wolf per 100 ungulates is in agreement with the equilibrium value of one wolf per 100 deer suggested by Pimlott (1967:276). If the reader wishes to reevaluate the findings herein, he or she can simply adjust the annual rate of ungulates killed by wolves or the mean overall density of the available ungulate prey base to suit their particular purpose or beliefs.

This paper compiles sources for estimates of caribou and muskoxen on the Canadian Arctic Islands together with hereunto widely scattered references to arctic-island wolves. The extrapolations of past and present populations of ungulate prey available to arctic-island wolves are drawn from a wide array of sources: Queen Elizabeth Islands Eco-region, Wychoff (1952), Tener (1960, 1961, 1963, 1965), Macpherson (1961), Beak (1975b), Elliot (1976), Fischer and Duncan (1976), Gray (1977), Miller et al. (1977a), Riewe (1978), McLaren and Green (1982), McLaren (1983), Henry et al. (1986), Ferguson (1987), and Miller (1987a, 1987b, 1988, 1989, 1990b, 1991); Southern Tier of Arctic Islands Eco-region, Urquhart (1973), Beak (1974, 1975a, 1975b), Kevan (1974), Elliot (1976), Fischer and Duncan (1976), Jackimchuk and Carruthers (1980, 1983), Vincent (1979, 1980), Vincent and Gunn (1981), Latour (1982, 1985), Gunn and Miller (1983), Gunn and Decker (1984), McLean et al. (1986), McLean and Fraser (1989, 1991), McLean (1990), Fraser et al. (1991), and Gunn (1991); and the Baffin Island Eco-region, Manning (1943), Wright (1944), Macpherson (1963), Clark (1971), Elliot (1976), Williams and Heard (1986), and M.A.D. Ferguson, Reg. Wildl. Biol., Dep. Renewable resourc., Govern. NWT, Pond Inlet (pers. commun., 1992).

Systematically collected aerial survey data for estimating sizes of caribou and muskox populations on the Queen Elizabeth Islands are most complete and current for the islands within the Southwestern and South-central eco-areas (see Table 2 for grouping of islands by Eco-region and Eco-area). Aerial survey results for the remainder of the Queen Elizabeth Islands (Northwestern, North-central, and Eastern eco-areas) are fewer over time and dated, but they are usable along with supplemental

information.

On the southern Arctic Islands, aerial survey data for caribou and muskoxen are detailed and current for Banks Island only among the three islands of the Western Eco-area (see Table 2). The largest Western Eco-area island of Victoria is also the largest southern Arctic Island and has been aerially surveyed essentially in its entirety for caribou and muskoxen only once (1980). More recent estimates of muskox numbers obtained by aerial survey are available, however, for much of Victoria Island. The current estimate of caribou on Victoria Island must be inflated by about 3-fold beyond the 1980 estimate in order to agree with current rates of harvest that the population could sustain. Stefansson Island has never been aerially surveyed for caribou or muskoxen. Recent aerial survey information for the South-central Eco-area of the southern Arctic Islands indicates that few caribou and even fewer muskoxen now occur on King William Island and the satellite islands of the area. Aerial survey results for caribou and muskoxen on the Eastern Eco-area of the southern Arctic Islands are few and are now dated. There are, however, no other data or hearsay information to indicate that those population sizes have changed markedly during recent years; so, those estimates are applied directly herein.

Baffin Island has never received an adequate, island-wide, systematic aerial survey for caribou (this includes Bylot and the other satellite islands, see Table 2). Wright (1944:9), using information from Manning (1943:51) and unpublished Canadian Wildlife Service data, speculated that the total caribou population numbered about 25 000 in the 1940s. Subsequently, Macpherson (1963:9) guessed, from essentially Wright's (1944) same data base, that there could be 25-30 000 caribou on Baffin Island and that the population was "increasing rapidly" in the 1960s. In 1985, the best informed guess was that there were about 100 000 caribou on Baffin Island, based solely on observations of then recent range expansion (Williams and Heard 1986: >40 000 on northern Baffin and >60 000 on southern Baffin). Most recently, and still based only on continuing range expansion and apparent higher densities, the current impression is that there are 120-300 000 caribou on Baffin Island (M.A.D. Ferguson, Reg. Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Pond Inlet, pers. commun., 1992). I selected the mid-point value of 210 000 as the current size of the caribou population on Baffin Island because of the wide range of the current estimate and the fact that the estimate was arrived at mainly by conjecture. Most importantly, any increase from the 1985 impression of 100 000 caribou beyond the mid-point value of 210 000 caribou is highly improbable, if not impossible, for the species when free-ranging and actively hunted. I also assumed that the 2:3 ratio suggested for caribou on northern vs. southern Baffin Island in the mid 1980s is still meaningful for the current distribution, and I divided the numbers of caribou accordingly (see Table 3).

RESULTS AND DISCUSSION

1. Queen Elizabeth Islands Eco-region

All of the islands lying north of the M'Clure Strait-Viscount Melville Sound-Barrow Strait-Lancaster Sound water passage in the CAA (ca. north of 74°N latitude) are collectively known as the Queen Elizabeth Islands (Fig. 1). Only two Inuit settlements currently exist in the region: Resolute Bay on the south coast of Cornwallis Island and Grise Fiord on the south coast of Ellesmere Island (Table 1). Hunters from Holman and Arctic Bay hunt on occasion within this region. An active mine site, Polaris, is located on the west-central coast of Little Cornwallis Island. There are also two staffed, nonsettlement weather stations: one at Mould Bay on the east-central coast of Prince Patrick Island and one at Eureka on the west-central coast (Fosheim Peninsula) of Ellesmere Island. The Canadian military maintains an installation at Alert on the north coast of Ellesmere Island.

Peary caribou (R. t. pearyi) and muskoxen are the two major prey available to wolves. There is indirect evidence that at least some wolves have learned to hunt seals at breathing holes in the sea ice (Stirling and Archibald 1977: ringed seals (Phoca hispida) or bearded seals (Erignathus barbatus). Some wolves also are known to scavenge on seal carcasses left on the sea ice from polar bear kills (Stirling and Archibald 1977). Arctic hares could be locally and seasonally important in the diets of wolves, at least in years of hare population highs, especially on the eastern islands of Ellesmere and Axel Heiberg (cf. Tener 1954). Arctic foxes, lemmings, and a wide variety of birds and their eggs could also contribute to the wolves' sustenance.

Constituting ca. 32% of the CAA, most of the collective landmass of the Queen Elizabeth Islands Eco-region has no value in terms of forage production for caribou, and particularly for muskoxen. Much of the region remains permanently covered by snow and ice, and land areas above 900 m elevation (above mean sea level) have no value as grazing sites for arctic ungulates, while most range between 600 and 900 m elevation has little or no value. Many other extensive areas are essentially unvegetated due to unsuitable substrata (calcareous bedrock) or water regimes which are either too wet or too dry. Most importantly, periods of widespread, severe forage unavailability due to unfavourable snow/ice conditions are experienced on much of the existing better range sites. Such prolonged, widespread, wintertime forage unavailability has in the past (e.g., Parker et al. 1975, Miller et al. 1977a), and will in the future, lead to major or catastrophic winter die-offs (due to extreme undernutrition) of both caribou and muskoxen on the Queen Elizabeth Islands. This ongoing calamitous condition suggests to me that it is unlikely that the C. l. arctos population on the Queen Elizabeth Islands will ever normally exceed 300-400 1+ yr-old wolves for any extended number of consecutive years

(based on my assumption that 24 000 caribou and 16 000 muskoxen approximate the greatest sustainable number of ungulates on the Queen Elizabeth Islands).

Some statistics for wolves on southwestern and south-central Queen Elizabeth Islands can be obtained from a systematically collected aerial survey data base between 1972-74 and 1985-88 (Tables 4, 6). The survey results as they pertain to wolves are highly variable between and among years and are suspect in all years for reasons disussed in Miller and Russell (1978). No wolves were seen in 2 out of the 10 surveys and pups were seen in only 1 of the 7 summer surveys (Table 4). The estimated mean overall density for 1+ yr-old wolves averaged 0.6 ± 0.2 (SE) · 1000 km^{-2}. Those rates of wolf sightings were low on the southwestern and south-central Queen Elizabeth Islands compared to some reported for the Canadian mainland by Heard (1992) and they declined markedly for those areas from 1972-74 to 1985-88 (Table 6). When the reported values from Heard (1992: Table 2) for Melville, Bathurst, and Prince Patrick islands are combined (i.e., 73 wolves seen and 660 hours flown) to compare with the southwestern and south-central Queen Elizabeth Islands from Table 6, however, the resultant sighting rate from Heard's (1992) data equals only 111 wolves · 1000 h^{-1}. This condition seemingly illustrates the possible variation that can occur for essentially the same areas when different data sets are used. The ungulate prey base theoretically available to wolves during that time span averaged 217 ± 91.4 (SE) ungulates · $wolf^{-1}$ and one wolf was seen on average per 1827 ± 654.2 (SE) km^2 of survey area. Perhaps, all that can be drawn with confidence from those limited data is that wolves were not plentiful on the survey areas in those years and also that they appear to have declined there between 1974 and 1985. Of particular importance is the fact that those survey areas represent much of the best ungulate range on the Queen Elizabeth Islands.

Only ca. 6% of the extrapolated size of the entire ungulate prey base on the CAA currently occurs within this region. Thus, the Queen Elizabeth Islands currently could support only ca. one-sixteenth of the "theoretical maximum carrying capacity" for wolves on the CAA (Table 3). The potential "theoretical maximum carrying capacity" for wolves in the Queen Elizabeth Islands Eco-region has declined by one-third over 3 decades (1961-90), based on an extrapolation of aerial survey results for caribou and muskoxen from 1961 to 1990. I believe, based on the existing pertinent literature and on my own empirical observations over the past 20 years, that the "maximum carrying capacity" for ungulates on the Queen Elizabeth Islands would approximate 40 000 1+ yr-old animals of which at least 60% would be caribou (3 caribou for every 2 muskoxen). Therefore, it seems reasonable to assume that even when the ungulate prey base reaches maximum sustainable numbers, the number of wolves would not reach even 500 1+ yr-old wolves on the Queen Elizabeth Islands.

Thus, it appears that fixed stringent limitations on the maximum population size of C. l. arctos on the Queen Elizabeth Islands makes the welfare of those wolves an ongoing concern. C. l. arctos on the Queen Elizabeth Islands most likely represents the purest stock of arctic-island wolves on the archipelago. They compose a clearly recognizable subspecies that warrants recognition as a potentially "Threatened" or possibly "Endangered" form of North American gray wolf. Providing some form of protection for C. l. arctos on the Queen Elizabeth Islands is problematical because one of its principal prey items, the Peary caribou, is recognized as an "Endangered" form of wildlife in Canada (Miller 1990b). Wolf protection is still further complicated by the fact that caribou are generally the preferred source of fresh red meat in the diets of high arctic Inuit, so most Inuit hunters view wolves mainly as competitors for caribou (and occasionally for muskoxen). Additionally, a prime wolf pelt has considerable cash value in a cash-hungry economy, and wolf fur is also sought for domestic use as trim on clothing.

1.1. Eastern Queen Elizabeth Islands Eco-area

This complex is formed by the three largest islands in the Queen Elizabeth Islands Eco-region and represents 71% of the entire collective landmass of the Queen Elizabeth Islands (Tables 2, 3: Ellesmere, Devon, and Axel Heiberg islands). One of the two Inuit settlements on the Queen Elizabeth Islands is located in this area (Table 1: Grise Fiord). Hunters from Resolute Bay and Arctic Bay hunt on occasion within this area. Much of the terrain on those three islands is permanently covered in snow and ice. Land areas above 600 m elevation together with unvegetated sites at lower elevations constitute well over half of the entire landmass within this area. However, the remaining land area still equals about one-third of the entire landmass within the Queen Elizabeth Islands; so, the usable landbase is appreciable in terms of the numbers of caribou and muskoxen that it should be capable of supporting.

The vegetation-cover is variable at lower elevations: often rich in kind and degree, especially along stream banks, and on slopes and low plateaus; while other sites are moderately well-vegetated; and some are poorly vegetated (e.g., Tener 1954, 1960, 1965, Edlund and Alt 1989, Edlund 1990). The quantity and quality of the vegetation together with the relatively large portion of usable range suggests that this area should support much larger ungulate populations than have ever been reported there, (e.g., Tener 1963). There is, however, no evidence that those islands have ever supported large, high-density ungulate populations commensurate with the total usable range available, especially with regard to caribou.

Extrapolation of existing data combined with considerable hearsay information over the past 20 years (ca. 1971-90), from several long-time arctic researchers working in this eco-area, suggests that currently extrapolated numbers for both caribou and muskoxen should be somewhat

greater than those estimated during the first and only island-wide aerial survey of those three islands in summer 1961 (Tener 1963). Currently, there appears to be ca.17 muskoxen for every one caribou in this area.

About 44% of the extrapolated size of the ungulate prey base on the Queen Elizabeth Islands currently occurs within this area (Table 3). Thus, this area supports nearly half of the currently estimated "theoretical maximum carrying capacity" for wolves in the Queen Elizabeth Islands Eco-region (Table 3). The potential for further increase in ungulate numbers is unknown. The existing limited data suggest, however, that the potential is not great, even though the usable landbase is there. The Eastern Eco-area is, however, of major importance to C. l. arctos on the Queen Elizabeth Islands. The large land area together with a relatively large number of ungulates, albeit at very low overall mean densities (except in a few locations), affords support for a proportionately large number of the wolves. These low-density wolf and ungulate populations, seemingly, help assure that no single detrimental factor is likely to impact on wolves throughout this entire area, except possibly through widespread contagious canid diseases. Serious environmental or human-induced reduction of even this low-density ungulate prey base on a range-wide basis is, however, still a possibility.

1.2. Southwestern Queen Elizabeth Islands Eco-area

This complex of five islands is ca. 15% of the entire landmass of the Queen Elizabeth Islands (Tables 2, 3: Melville, Prince Patrick, Eglinton, Byam Martin, and Emerald islands). There are no Inuit settlements within this area, but springtime sport hunts have been and could be carried out for muskoxen on Melville Island by Inuit guides from Sachs Harbour, Banks Island, and Holman on Victoria Island. Hunters from Resolute Bay also hunt on occasion along the SE corner of Melville Island.

This area contains much of the best year-round range for caribou and muskoxen within the Queen Elizabeth Islands. Many of the Peary caribou summer mainly on Melville Island and winter mainly on Prince Patrick and Eglinton islands. This area currently supports the 2nd largest ungulate prey base in the Queen Elizabeth Islands Eco-region and has the greatest overall mean density of ungulates, which is 3.9 times greater than the overall mean density for ungulates within the Northwestern Eco-area and 3.1 times greater than the overall mean density for ungulates within the North-central Eco-area. Most importantly, this area has the known potential to support at least 50% of all the ungulates present at any one time on the Queen Elizabeth Islands (cf. Tener 1963) and in the past was the most important area for caribou (at least from the 1950s to 1987) and apparently the second most important area for muskoxen. Muskoxen currently outnumber caribou within this area by ca. 7 to 1.

Approximately 39% of the extrapolated prey base of this Eco-region occurs within this area at present. Thus, the occurrence of

potential prey on a proportional landmass basis is greater within this area than within any of the four other eco-areas of the Queen Elizabeth Islands ($P<0.005$). Although this area is currently the second most important for supporting wolves on the Queen Elizabeth Islands, 3 decades ago, it was by far the most important area within the Queen Elizabeth Islands - and likely will be again some time in the future, when overall caribou numbers on the Queen Elizabeth Islands again near their peak. Since 1961, this area has experienced a 51% decline in the capacity of its ungulate prey base to support wolves (ca. 13-fold decrease in caribou and a 7-fold increase in muskoxen). Therefore, there is a potential for at least a 50% increase in the "theoretical maximum carrying capacity" for wolves within this area.

1.3. South-central Queen Elizabeth Islands Eco-area

This complex of seven islands represents ca. 6% of the entire landmass of the Queen Elizabeth Islands (Tables 2, 3: Bathurst, Cornwallis, Vanier, Cameron, Alexander, Massey, and Little Cornwallis islands). One Inuit settlement is located within this area (Table 1: Resolute Bay). Hunters from Grise Fiord also hunt on occasion along the E coast of Cornwallis Island.

Most of the better year-round range for caribou and muskoxen is apparently restricted to Bathurst Island. Good summer range is also found on the major satellite islands of Bathurst Island. Although this area is roughly the same size as the North-central Eco-area, it currently supports an ungulate prey base that is more than twice as large. Thus, the ungulate prey base is over-represented on a proportionate landmass basis compared to those in the Northwestern, North-central, and Eastern eco-areas (only the Southwestern Eco-area is proportionately greater). Most importantly, this area has the potential to support a much larger year-round prey base than either the Northwestern or the North-central eco-areas. Currently, ca. 11% of the extrapolated prey base of the Queen Elizabeth Islands Eco-region occurs within this area, with ca. 3 caribou for every 2 muskoxen. This area is currently also the third most important for muskoxen on the Queen Elizabeth Islands.

The South-central Eco-area currently could support about one-tenth of the estimated "theoretical maximum carrying capacity" for wolves within the Queen Elizabeth Islands Eco-region (Table 3). This area has experienced at least a 60% decline over 3 decades (1961-90) in the capacity of its ungulate prey base to support wolves. Therefore, there is a potential for at least a 60% increase in the "theoretical maximum carrying capacity" for wolves within this area.

1.4. North-central Queen Elizabeth Islands Eco-area

This complex of eight islands represents ca. 6% of the entire landmass of the Queen Elizabeth Islands (Tables 2, 3: Ellef Ringnes, Amund

Ringnes, Cornwall, Graham, Lougheed, Meighen, King Christian, and North Kent islands). No Inuit live or currently hunt in this eco-area.

Most of the range within this area is unsuitable for year-round occupation by caribou, and especially by muskoxen. Relatively high-density populations of caribou could summer there, but most would likely have to migrate to wintering areas in other eco-areas of the Queen Elizabeth Islands Eco-region. Caribou represent more than 90% of the ungulate prey base, as the area cannot support a muskox population of any appreciable size. Only slightly less than 5% of the extrapolated ungulate prey base on the Queen Elizabeth Islands currently occurs within this area (Table 3), with ca. 9 caribou for every one muskox. Thus, it appears that the North-central Eco-area can support only ca. 5% of the current "theoretical maximum carrying capacity" for wolves within the Queen Elizabeth Islands Eco-region (Table 3).

The North-central Eco-area currently serves and has most likely served in the past as an "extremely low-density reservoir-area" for C. l. arctos on the Queen Elizabeth Islands. However, this area does have the potential for serving as a summer range for some denning packs of wolves during times when a relatively high-density caribou population on the adjacent Southwestern Eco-area or South-central Eco-area extend their spring migrations there (as apparently took place in the 1950s and 1960s).

The greatest value of this area to wolves in the past was most likely its relatively total isolation from humans. A weather station was established at Isachsen on Ellef Ringnes Island in 1948 (converted to an unoccupied automatic recording station in 1989) and subsequently a variety of small scientific field parties and nonrenewable resource exploration teams have frequented the area from the 1950s to present, especially during the 1970s. The number of caribou estimated in 1961 (Tener 1963) suggests that the potential for a 2-fold increase above the current estimated number of wolves (Table 3) is possible, at least in summertime.

1.5. Northwestern Queen Elizabeth Islands Eco-area

This complex of three islands represents only 2% of the entire landmass of the Queen Elizabeth Islands (Tables 2, 3: Mackenzie King, Borden, and Brock islands). At present, no Inuit live or travel in this area. The area is characterized by the extreme poverty or paucity of its flora and fauna. Much of the area is underlain by the "Beaufort Formation" (Tozer and Thorsteinsson 1964) and the overall vegetation-cover is more sparse than within the other four eco-areas of the Queen Elizabeth Islands Eco-region. Woody plants are essentially absent (Edlund 1990). The potential for year-round support of caribou within this area is extremely low and is essentially totally lacking for muskoxen (Miller et al. 1977a). Seasonal summer use by caribou can be high, however, when the mean density of caribou is high within the Southwestern Eco-area (cf. Tener 1963, Miller et al. 1977a). All evidence to date indicates that the

occurrence of muskoxen within this area can only be considered as a "pioneering" effort by muskoxen most likely from the Southwestern Eco-area or less likely from the South-central Eco-area.

Only ca. 1% of the extrapolated ungulate prey base on the Queen Elizabeth Islands currently occurs within this eco-area (Table 3), with ca. 14 caribou for every one muskox and most likely only during the summertime. Therefore, it is unlikely that even a single pack of wolves could remain resident year-round. It is likely, however, that at least one pack could den within this area, at least in years when caribou summered there in sufficient numbers. If wolf denning did take place, it most likely would occur on Mackenzie King Island, where the terrain has more relief and the potential summer grazing is at least as good as on Borden or Brock islands.

Thus, the Northwestern Eco-area likely only serves as an area of sporadic seasonal range expansion for C. l. arctos during times of relatively high caribou densities within the adjacent Southwestern Eco-area. If wolves did live year-round within this area, it is estimated that the area could support only ca. 1% of the current "theoretical maximum carrying capacity" for wolves within the Queen Elizabeth Islands Eco-region. Caribou estimates for the three islands within this area in summer 1961 (Tener 1963) suggest that a potential 14-fold increase above the currently estimated number of wolves (Table 3) is possible, at least in summertime.

2. Southern Tier of Arctic Islands Eco-region

The southern Arctic Islands includes all of the islands lying south of the M'Clure Strait-Viscount Melville Sound-Barrow Strait-Lancaster Sound water passage in the CAA (Fig. 2: ca. south of 74° N latitude), but excluding the Baffin Island Eco-region. There are currently only four Inuit settlements within the entire region (Table 1). All four are on coastal sites: Sachs Harbour on southern Banks Island; Holman on west-central Victoria Island; Cambridge Bay on southeastern Victoria Island; and Gjoa Haven on the south of King William Island. Hunters from Resolute Bay and Arctic Bay, as well as the mainland settlements of Coppermine, Spence Bay, and Umingmaktok (Bay Chimo) hunt on occasion within this region.

Two major prey items are available to wolves: a transitional form of arctic-island caribou (R. t. groenlandicus x pearyi) and muskoxen. Seals, at least as carrion, could be important in winter. In some winters, extremely high numbers of arctic foxes over most of the region could contribute notably to the diets of wolves, especially trapped foxes (e.g., McEwan 1955). Arctic hares could be of secondary importance, particularly on Banks and Victoria islands. Lemmings and a wide array of birds and their eggs could also be seasonally well-represented in the diets of wolves on the southern Arctic Islands.

Representing ca. 28% of the landmass of the CAA, range on the southern Arctic Islands is, in general, superior to that on the Queen Elizabeth Islands for year-round use by caribou and muskoxen. Several large tracks of land are of particular importance to relatively high densities of muskoxen. As in the Queen Elizabeth Islands Eco-region, there is, however, evidence that large areas of the southern Arctic Islands can suffer significant losses of the ungulate prey base from winter die-off due to widespread forage unavailability brought on by prolonged periods of unfavourable snow/ice conditions (e.g. McEwan 1955, Manning and Macpherson 1958, Morrison 1978, Vincent 1979).

The potential "theoretical maximum carrying capacity" for wolves in the Southern Tier of Arctic Islands Eco-region has apparently increased by 3.3 times, mostly in the Western Eco-area, during the past 2 or 3 decades. To date, however, there appears to be no evidence to support a corresponding incease in the wolf populations within this eco-region. Why wolves apparently have not responded sooner to the significant increases in ungulate prey remains unanswered. Although Inuit hunters and trappers vigorously pursue wolves, there is no evidence to indicate or even suggest that their efforts have been, are, or would be limiting wolf numbers within this region (although local reductions near settlements are possible). For example, the Sachs Harbour hunters and trappers have reported killing only 19 wolves, or ca. 6 wolves annually between 1989 and 1991 (P. Clarkson, Reg. Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Inuvik, pers. commun., 1992). Only recently have hunters from Holman on Victoria Island reported seeing greater numbers of wolves and hunters from Sachs Harbour on Banks Island reported increasing wolf numbers and a kill of 36 wolves in autumn 1992 (A. Gunn, Senior Caribou Biol., Dep. Renewable Resourc., Govern. NWT, Yellowknife, pers. commun., 1993).

The genome of wolves in the Southern Tier of Arctic Islands Eco-region likely has been, and still is, in continual flux due largely to sporadic but relatively frequent invasion of those islands by mainland wolves. Prior to the 1940s, tens, if not hundreds, of thousands of barren-ground and intergrade caribou crossed the sea ice annually in spring from mainland winter ranges to calve and summer on the southern Arctic islands, usually returning in autumn to the mainland (e.g., Hoare 1927; Manning 1960). Those migrations of caribou were undoubtedly accompanied by many mainland wolves. On occasion, some of those wolves might have remained on some of the southern islands where prey was plentiful and they and their offspring became year-round island residents. Over time, some of them could have mixed with the original resident island wolves (most likely *C. l. arctos*) and gave rise to transitional forms, much as the mainland caribou did with the island caribou (e.g., Manning 1960; Banfield 1961). Seasonal migrations of caribou from the mainland to summer ranges on the southern Arctic Islands restarted in the 1980s, now include 1000s of caribou, and those migrations have been accompanied both to and from the islands by wolves (A. Gunn, Reg. Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Coppermine, pers. commun., 1991).

The possibility of contagious canid disease (rabies or canine distemper) sporadically or periodically markedly reducing wolf numbers on the southern Arctic Islands cannot be ruled out, especially if arctic foxes are the source carriers for such disease (Gunn et al. 1991). Disease alternatingly or in combination with widespread loss of ungulate prey likely are the long-term limitations or regulation of wolves within this region.

Currently, about one-third of the ungulate prey base available to wolves on the CAA is found on the southern Arctic Islands. The literature suggests that value represents a ca. 70% increase in ungulates within the Southern Tier of Arctic Islands Eco-region in the last 2 or 3 decades. What directions these ungulate populations will take in the future are unknown. It is most likely, however, that the Southern Tier of Arctic Islands Eco-region will remain a major region for wolves on the CAA but the taxonomic status and genetic variation among those wolves resident there are essentially unknown.

2.1. Western Southern Tier of Arctic Islands Eco-area

This complex is formed by the two largest islands within the Southern Tier of Arctic Islands Eco-region, a major satellite island (Table 2, Fig. 2: Victoria, Banks, and Stefansson islands), and some lesser satellite islands. Three of the four Inuit settlements on the southern Arctic Islands are located in this eco-area (Table 1: Sachs Harbour, Holman, and Cambridge Bay). Hunters from Coppermine and Umingmaktok also hunt on occasion in this eco-area.

Extensive year-round range for ungulates on the southern Arctic Islands is likely at its best both in terms of quality and quantity within the Western Eco-area. The existing data suggest a ca. 75% increase in the ungulate prey base during the last 2 or 3 decades, but that could be an overestimate caused by the lack of sufficient data for Victoria Island (particularly prior to 1980). This overall increase has come about solely through rapid increases in the numbers of muskoxen, and on Banks Island, at least, equally rapid decreases in the number of caribou. Currently, there appears to be on the average at least ca. 4 muskoxen for every one caribou in this area.

The Western Eco-area represents ca. 80% of the entire collective landmass of the southern Arctic Islands and nearly 89% of the ungulate prey base currently occurs there. Thus, this area should be capable of supporting nine-tenths of all the wolves that the entire Southern Tier of Arctic Islands Eco-region currently could sustain (Table 3). There is no evidence, however, to suggest that there are currently anywhere near 1000 wolves within the Western Eco-area.

Wolves are considered rare on Banks Island (Urquhart 1973, Kevan 1974, Latour 1985, McLean et al. 1986, McLean and Fraser 1989) and also on

Victoria Island (Heard 1983, Gunn 1991). Observation of wolves obtained from systematic aerial survey of muskoxen and caribou on Banks Island between 1985-91 suggests that wolves are uncommon (Tables 5,6). The rates of wolf sightings by all measures are relatively low compared to some reported for the mainland by Heard (1992). Heard's (1992: Table 2) Banks Island extrapolated value of 105 wolves seen per 1000 h^{-1} varies somewhat from those obtained for Banks Island in Table 6; again, this illustrates the possible variation from the use of different data sets for the same area. Those 1985-91 aerial survey results are suspect, however, for many reasons (cf. Miller and Russell 1978) and thus, can only be used with total confidence to indicate that the mean density of wolves on Banks Island does not necessarily agree with the estimated total size of the ungulate prey base recently available there (Table 3). The total number of muskoxen and caribou on Banks Island in 1991 should theoretically support 500-600 wolves at 1 wolf : 100 $ungulates^{-1}$. Thus, either such aerial surveys grossly underestimate the number of wolves present or the wolves are being suppressed for unknown reasons.

It is difficult to speculate on future changes in the numbers of wolves within this area because the ungulate prey base is at an all-time documented high and future population trends cannot be predicted. The Western Eco-area should, however, remain by far the most important area for wolves within the entire Southern Tier of Arctic Islands Eco-region. This area also will likely remain a gateway for invasion by mainland wolves.

2.2. Eastern Southern Tier of Arctic Islands Eco-area

This complex is formed by two large islands, two major satellite islands (Table 2, Fig. 2: Prince of Wales, Somerset, Russell, and Prescott islands), and some lesser satellite islands. There are no Inuit settlements within this area, but the area is visited by Inuit hunters from Resolute Bay, Cornwallis Island, and less frequently from Spence Bay on the mainland Boothia Peninsula and Cambridge Bay, Victoria Island.

The Eastern Eco-area represents ca. 16% of the entire collective landmass of the Southern Tier of Arctic Islands Eco-region and ca. 11% of the ungulate prey base on the southern Arctic Islands currently occurs there, with nearly equal representation by muskoxen and caribou. Thus, about one-tenth of the wolves currently sustainable on the southern Arctic Islands should be within this area (Table 3).

Much of the range within this area will support moderate-density populations of caribou and muskoxen. Existing data suggest that Prince of Wales Island serves mainly as summer range and Somerset Island (and the Boothia Peninsula) as winter range for caribou. Most of the muskoxen occur year-round on Prince of Wales Island. Muskoxen have increased in recent years on Somerset Island and herds have been seen on western and

northern Boothia Peninsula, suggesting that recolonization is still occurring.

Future trends in wolf numbers within this area cannot be predicted but, if ungulate populations do not fail, wolves should remain well-represented there. This area probably experiences relatively frequent invasion by mainland wolves following annual springtime migrations of caribou off the Boothia Peninsula to Prince of Wales Island or Somerset Island. Hunters from Spence Bay comment on increases in both caribou and wolves since the 1970s (A. Gunn, Reg. Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Coppermine, pers. commun., 1992).

2.3. South-central Southern Tier of Arctic Islands Eco-area

This complex is composed of only one relatively large island, three major satellite islands (Table 2, Fig. 2: King William, Royal Geographical Society, Matty and Jenny Lind islands), and some lesser satellite islands. It represents only ca. 4% of the entire collective landmass of the Southern Tier of Arctic Islands Eco-region. Currently, there is only one Inuit settlement within this area (Table 1: Gjoa Haven).

Year-round range for ungulates in the South-central Eco-area is generally the poorest within the Southern Tier of Arctic Islands Eco-region and holds not even 1% of the current ungulate prey base (Table 3), with more than 9 caribou for every one muskox. Prior to the 1930s, however, King William Island served as summer range for high-density populations of migratory caribou from the mainland (Hoare 1927). There is, however, no evidence that adequate winter range for caribou at any meaningful density exists on King William Island or anywhere else within the South-central Eco-area. Also, this area apparently cannot support muskoxen year-round at any meaningful level.

Thus, the future of wolves on this area is seemingly governed by the possible resumption of migrations of caribou from the mainland, although the probability of that occurrence is unknown. Therefore, the South-central Eco-area can only be thought of as an extremely low-density reservoir area for arctic-island wolves but more importantly, as a likely gateway for invading mainland wolves.

3. Baffin Island Eco-region

The Baffin Island Eco-region forms much of the southeastern flank of the CAA and includes Baffin Island, its principal satellite island of Bylot, and 10 other major satellite islands (Table 2, Fig. 3). Many lesser satellite islands also lie in the coastal waters of this region.

Iqaluit (Frobisher Bay) on the southern coast of Baffin Island is the largest settlement in the region and on the entire CAA (Table 1). The other six settlements on Baffin Island are all coastally located:

northern, Arctic Bay; northeastern, Clyde River, Pond Inlet; southeastern, Pangnirtung; southern, Lake Harbour; and southwestern, Cape Dorset (Table 1). There are other Inuit, some of whom hunt on Baffin Island, who live in Igloolik on Igloolik Island just off the northeast coast of the Melville Peninsula and on Broughton Island just off the southeast coast of Baffin Island (Table 1). Inuit from the mainland settlements of Hall Beach and Repulse Bay on the Melville Peninsula also hunt on occasion within this region (Table 1).

The only major prey item for wolves (C. l. manningi) within this region is a form of barren-ground caribou (R. t. groenlandicus). Seals, arctic hares, arctic foxes, red foxes, lemmings, and a wide array of birds and their eggs could also contribute, at least seasonally, to the diets of wolves. Wolverines would be a rare dietary item at most.

The Baffin Island Eco-region represents ca. 41% of the CAA. Although much of the range in this region is unsuitable for year-round use by caribou, the vastness of the remaining usable range apparently allows relatively high-density populations of caribou to build up. Current conjecture suggests that the mean density of caribou on Baffin Island is somewhere between ca. 24 and 59 caribou · 100 km^{-2}. Thus, the current "theoretical maximum carrying capacity" for wolves should fall somewhere between at least 1200 and 3000 wolves within the entire Baffin Island Eco-region.

It is unknown how accurate the recent and current impressions are about the size and distribution of the caribou population or how much more the caribou population can or will grow on Baffin Island. If the current size is indeed closely approaching, at, or beyond 300 000 caribou, it seems most likely that the population will begin to decline in the not too distant future, as the history of caribou is one of cyclic-like ups and downs. This would cause the wolves to follow those decreases and increases of caribou, possibly after a short time lag, as there are no alternate ungulate prey on Baffin Island. It seems reasonable to assume, however, that barring cataclysmic loss of the caribou or contagious endemic disease among the wolves, C. l. manningi should continue to be well-represented for the foreseeable future within the Baffin Island Eco-region.

Whether C. l. arctos from the Queen Elizabeth Islands or the southern Arctic Islands, C. l. orion from Greenland, or some mainland race (possibly, C. l. hudsonicus or C. l. labradorius) has in the recent past, or will in the near future, invade this region remains debatable. It seems, however, that one or more of these scenarios is probable. Most recently, R.M. Nowak (pers. commun., 1992) has indicated that he believes that C. l. manningi should be included together with the mainland race C. l. hudsonicus in the subspecies C. l. nubilus. Therefore, the taxonomic status and genetics of wolves within the Baffin Island Eco-region need

further evaluation, including DNA analyses.

3.1. Southern Baffin Island Eco-area

This eco-area encompasses the south half of Baffin Island; three major satellite islands (Table 2, Fig. 3: Prince Charles, Air Force, and Spicer islands); and some lesser satellite islands. Four Inuit settlements currently occur on Baffin Island within this eco-area (Table 1: Cape Dorset, Iqaluit (Frobisher Bay), Lake Harbour, and Pangnirtung), their populations representing ca. 47% of all the people living on the CAA and ca. 71% of all the people on Baffin Island. Inuit from the settlements of Broughton Island, Hall Beach, Igloolik, and Repulse Bay on the mainland (Melville Peninsula) have hunted within the Southern Eco-area.

Baffin Island was divided in half arbitrarily. This division was made mainly because recent and current impressions hold that the caribou occur at a ratio of 2:3 on northern versus southern Baffin Island (Williams and Heard 1986). Possibly, suitable range for caribou in the Northern Eco-area is either less extensive or of poorer quality than range in the Southern Eco-area, but this remains unsubstantiated.

The ungulate prey base is set, in this evaluation, at 60% of all the extrapolated caribou currently assumed to be within the entire Baffin Island Eco-region. Thus, the current "theoretical maximum carrying capacity" for wolves within the Southern Eco-area is three-fifths of all the wolves supposedly, currently sustainable within the entire Baffin Island Eco-region (Table 3).

The future of wolves within this area remains unpredictable. Foregoing possible catastrophic events, wolves seemingly should continue to be well-represented at slightly higher rates in the Southern Eco-area than in the Northern Eco-area. Thus, in the absence of undue human interference, the Southern Eco-area has the potential of remaining the highest density wolf area within the entire CAA.

3.2. Northern Baffin Island Eco-area

This complex includes the northern half of Baffin Island, along with the principal satellite island of Bylot, seven other major satellite islands (Table 2, Fig. 3: Rowley, Jens Munk, Bray, Foley, Sillem, Koch, and Crown Prince Frederick islands), and some lesser satellite islands. Three of the seven Inuit settlements now found of Baffin Island along with the mine-site settlement at Nanisivik are in this eco-area (Table 1: Arctic Bay, Clyde River, Pond Inlet). This area also includes the settlements of Broughton Island and Igloolik (Table 1). Hunters from Hall Beach also hunt on occasion in this area.

The ungulate prey base is set, in this evaluation, at 40% of the extrapolated number of caribou assumed to be within the Baffin Island Eco-region. Thus, the current "theoretical maximum carrying capacity" for wolves within the Northern Eco-area is two-fifths of all the wolves supposedly, currently sustainable within the Baffin Island Eco-region (Table 3).

The future of wolves within this area is unpredictable. It seems reasonable to assume, however, that in the absence of significant environmental changes, wolves will continue to be well-represented throughout the Northern Eco-area.

4. Conservation and Management Implications

Like all other interrelationships in the natural world, the importance of wolf predation on caribou and muskoxen on the Arctic Islands is interwoven in a maze of ecological intricacies. Thus, it is most unlikely that we will ever fully understand with complete confidence the importance of wolf predation on these ungulates, especially under changing densities of the predator and the prey species and particularly in association with unfavourable environmental conditions. It is reasonable to assume, however, that only caribou and muskoxen are the staples in the diets of arctic-island wolves and that wolf populations on the Arctic Islands could not persist in the absence of sufficient ungulate prey.

The arctic-island wolf represents an important component in the biodiversity of the Canadian Arctic Archipelago and as a distinct subspecies of the North American gray wolf, *C. l. arctos* warrants protection as a valuable part of Canada's natural heritage. This issue now becomes complicated, however, for several reasons: (1) the Peary caribou on the Queen Elizabeth Islands is classified as an "Endangered" form of wildlife in Canada; (2) the Banks Island caribou population is also classified as "Endangered", and caribou on the other southern Arctic Islands (excluding Baffin) are classified as "Threatened"; and (3) Inuit living on the Arctic Islands have a strong desire to hunt and eat caribou as their favourite food, and have shown no interest in replacing caribou with muskoxen. Thus, the goal of caribou conservation on the archipelago must be two-fold: first, to preserve these distinct forms of caribou as unique parts of Canada's natural heritage; and, secondly, to provide caribou populations that are capable of sustaining meaningful rates of annual harvest by native people.

If caribou were the only ungulate that occurred on each of the Arctic Islands, the problem of wolf predation on caribou would seemingly be much more simplistic, as it likely would have been self-corrective with declining numbers of the prey. Muskoxen do occur throughout most of the archipelago (except the Baffin Island region), however, and currently in much greater numbers than caribou. On Banks Island there are ca. 50 muskoxen estimated for every one caribou and on the Queen Elizabeth

Islands muskoxen are on average 4 times more common than caribou. This means that disproportionate predation on caribou is very likely, if wolves for any reason select for caribou over muskoxen. This is especially true, if such predator selection results in particularly heavy predation on newborn caribou calves in addition to disproportionately high predation on other caribou. Wolves probably often preferentially prey on caribou whose body weight is much less than that of adult muskoxen (of either sex), as wolves supposedly prefer medium-sized prey to larger ones when both are available (e.g., Pimlott et al. 1969, Potvin et al. 1988). High numbers of muskoxen, especially with an abundance of calves and yearlings present, could support wolves which preferentially kill caribou whenever possible. Thus, alternative preferential predation could become a key factor in accelerating a decline or impeding a recovery of caribou in areas with high densities of muskoxen.

In this situation the biologist is faced with the dilemma of needing to do everything possible to not only preserve the caribou populations but also to promote their growth as rapidly as possible to meet demands for subsistence utilization by Inuit living on the Arctic Islands; while on the other hand, recognizing the wolf's place in this ecosystem and its eminence as a symbol of Canada's wilderness.

Caribou on the Queen Elizabeth Islands and Banks Island have declined to dangerously low numbers, where rates of utilization at the desired levels are not biologically possible for the caribou to sustain and the very survival of those caribou populations is in question. In this state of anxiety, biologists are considering such desperate measures as "supplemental winter feeding of artificial foods" and "ex situ breeding programs" to save those caribou populations from possible extinction. In this extreme setting, biologists are also considering the localized and judicious reduction of wolf numbers as a valid conservation tool in areas chosen for prime importance to caribou. Reduction of wolves could be carried out in a manner that would not be meaningful at the level of the regional wolf population but would be significantly beneficial to the caribou populations over the short-term on some areas of their range. The long-term goal would be maintenance of healthy, balanced populations of wolves, caribou, and muskoxen, wherever they occur in common, throughout the entire Canadian Arctic Archipelago.

5. Summary Discussion

Brief accounts of wolf sightings, wolf hunting of ungulates, and wolf-human encounters can be found in the following journals of 19th century explorers: Parry (1821), Franklin (1823), Belcher (1855), M'Clure (1856), Armstrong (1857), M'Dougall (1857), M'Clintock (1859, 1861), Collinson (1889), Nares (1878), and Greely (1886). Some similar observations are reported by the following 20th century explorers: Bernier (1910), Stefansson (1921), Noice (1924), and Moore (1936). None of those observations provide meaningful insight into any quantitative

evaluation of past numbers of wolves on the Canadian Arctic Islands. They do suggest, however, that wolves where common wherever there were sufficient numbers of caribou or muskoxen. Some of the events reported by those explorers do point out the boldness of those wolves, at least, when apparently pressed and competing for a common food source (a hunter-killed caribou or muskox). Even though the wolves showed little or no fear of humans and often came close by, few wolves were reported killed (cf. M'Clure 1856:258-259). If wolves were truly abundant, this condition seems strange, as the seamen reportedly tried to dispatch wolves whenever possible, as they thought of wolves as loathsome creatures that mercilessly dogged their prey, often feeding on the downed animal before it was even dead.

Most likely wolf numbers on the CAA have always been regulated by ongoing fluctuations in the numbers of ungulate prey available to the wolves. The history of caribou and muskox populations on the CAA is, however, highly dynamic due largely to sporadic widespread forage unavailability for the ungulate prey base brought on by unfavourable snow/ice conditions in winter or springtime. Thus, both caribou and muskoxen are subject to major winter die-offs, sometimes at cataclysmic levels (such as in the winter of 1973-74 on the Queen Elizabeth Islands). Such large-scale winter die-offs apparently occur at various levels of severity every several years on major portions of the CAA. Therefore, the maintenance of both caribou and muskox populations on the CAA appears to be markedly and negatively influenced by extremely severe environmental stresses in a density-independent manner. Thus, changes in the sizes of wolf populations on the CAA could be rather volatile within a period of only a few years due to the relative unavailability of their ungulate prey. This is especially true for wolves on the Queen Elizabeth Islands, where mean ungulate densities are relatively low at the best of times.

The only limiting factor that likely could have impacted significantly on wolves either sporadically or periodically on local, extended, or essentially range-wide bases is contagious endemic canid diseases. A canine distemper outbreak was detected in dogs and arctic foxes throughout the Canadian Arctic and Greenland in the late 1980s (Leighton et al. 1988). No data exists, however, for the frequency or intensity (importance) of such diseases among arctic-island wolves.

Palaeoeskimos and Neoeskimos likely killed wolves whenever the opportunity presented itself. The low numbers of people occupying widely scattered encampments or coastal settlements most likely minimized their impact on the overall number of wolves. Indigenous people may have reduced wolves locally, when caribou and muskoxen were scarce and wolves attempted to rob Eskimo food caches. Mortality of wolves from humans probably would have been greatest in the Baffin Island and southern Arctic Islands eco-regions when occupied by Palaeoeskimos or Neoeskimos; and present-day Inuit have been the greatest cause of wolf mortality.

Present-day Inuit hunters and trappers kill wolves whenever possible. Inuit on the CAA often view the wolf as an unwelcome "successful competitor" for a common food source, mainly caribou, and also as a destroyer of saleable furs, as wolves destroy foxes in traps (e.g., McEwan 1955). The hunting of wolves is culturally prestigious and economically rewarding so opportunities are rarely missed.

On the other hand, there are vast areas of the arctic archipelago that are virtually untrodden, even by the Inuit who are reknowned arctic travellers. Most hunting and trapping activities (with the exception of some longer spring hunts) remain relatively close to the settlements out of necessity or by preference, even though modern snowmobiles and all-terrain vehicles permit extended excursions. When a wolf track is cut by a snowmobile-mounted hunter or trapper, the animal (or animals) are most always doggedly pursued, and usually only lack of fuel, extremely severe weather, or exceptionally rough terrain or ice would prevent the demise of the quarry.

Longer treks are taken on occasion, particularly in association with polar bear hunts and especially during guided sport hunts. Such hunts can be positioned long distances from the settlement by aircraft, although actual hunting activities and return to the settlement are usually by snowmobiles or, in the case of nonresident sport hunts, by dog teams. The presence of dogs in areas remote to the settlements and fresh meat attract the ever curious wolves and the investigating wolves are killed by the native guides, whenever possible. Some of those occasions have been particularly devastating, when most or all of the pack members were killed. For example, on Melville Island, 12 and 5 wolves were shot in 1982 and 1984, respectively, after the wolves approached tethered dog teams that Inuit guides were using for transporting polar bear sport hunters (A. Gunn, Reg. Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Cambridge Bay, pers. commun., 1985). That kill of 17 wolves represented 85% of the 20 wolves seen: the entire pack of 12 and 5 of a pack of 8. This type of heavy kill is, however, rare and associated with the strong attraction of inexperienced wolves to a novel stimulus (dogs) in areas remote from settlements.

From the 1940s through the 1950s and in some areas on into the 1970s, wolves were often readily killed by chance encounters with people in the field or actively sought on some occasions by personnel from weather stations, DEW Line sites, oil exploration companies, and some few members of scientific parties. For example, at the Eureka weather station between 1947 and 1954, wolves were seen and recorded on 102 occasions, 58 of them were shot at, 31 were known killed, and 7 were known to be injured (Grace 1976:149). More recently, from the 1980s onward, changing attitudes among the people involved in work on the CAA, stricter regulations by companies and agencies involved, and better enforcement of hunting restrictions has markedly reduced the killing of wolves by people not resident in the CAA.

Generally, non-natives usually have little or no influence on wolf numbers on the CAA. Scrap foodstuff thrown on dumps at exploration camps, remote weather stations, DEW Line sites, and military installations provide an unnatural supply of food for wolves that frequent such sites, especially in winter. In the 1970s, a dump at Rea Point on eastern coastal Melville Island within the Southwestern Eco-area of the Queen Elizabeth Islands Eco-region attracted as many as 35-40 wolves at a time in the winter period. This condition, at first, may appear beneficial strictly in terms of maintenance of wolf numbers. Subsequently, however, the ingress of wolves and the higher rates of survival of wolves could markedly impact on the existing ungulates at levels that the ungulates could not sustain.

Perhaps, the most likely detrimental impact on wolves frequenting sites of human habitation would be through significantly increased contact with domesticated dogs. Such contacts could eventually lead to mixed breedings and the introduction of undesirable genes from dogs into the wolf blood line, at least temporarily. More and more dogs are brought into the archipelago: to settlements as pets and for dog teams; and to remote camps as a "warning device" against polar bears. Some of those dogs possibly harbour diseases that are not commonly found in the Arctic. The dogs could also serve as a source of infection for canid diseases which wolves would not normally contract, except at very high densities which are seldom experienced under natural conditions.

My review of the caribou-muskox prey base suggests that, simplistically, the most 1+ yr-old wolves that currently could be supported on the Arctic Islands would be ca. 200 for C. l. arctos on the Queen Elizabeth Islands, ca. 1100 wolves on the southern Arctic Islands (some C. l. arctos but also some of unclear taxonomy), and ca. 2100 wolves in the Baffin Island region, currently classified as C. l. mannningi. There is no way to do more than guess at the present numbers but there is no known reason to believe that wolves are currently even approaching, let alone exceeding, those maximums, except on the Queen Elizabeth Islands where there currently might be about 200 wolves present. There is also no reason to doubt that the fortunes of the arctic-island wolf tracks the fate of its ungulate prey populations. Ultimately, the fate of arctic-island wolves will be determined by the long-term success of their major ungulate prey items - the caribou and the muskox. At least this will be true in the absence of unforseen catastropic environmental events, either natural or human-induced.

CONCLUSIONS

1. The most northerly form of the gray wolf (Canis lupis spp.) in North America is the arctic-island form C. l. arctos on the Queen Elizabeth Islands of the Canadian Arctic Archipelago.

2. The heartland of arctos is the Queen Elizabeth Islands but there is no reason to believe that some individuals of this form do not range over the southern Arctic islands in the archipelago, with the possible exception of the Baffin Island region.

3. Wolves (C. l. arctos) with a few local exceptions, generally occur at low densities and are rare or absent over large areas throughout the Queen Elizabeth Islands; however, they currently may be near or at their extrapolated "theoretical maximum carrying capacity" of ca. only 200. The Queen Elizabeth Islands represent a discrete and unique high arctic eco-region in Canada. Phenotypically and, apparently, genetically the arctic-island form of the North American gray wolf (C. l. arctos) is a clearly recognizable subspecies. However, their current overall number is low and future numbers are not likely to exceed 500 (1+ yr-old) wolves even under the most favourable of sustainable prey densities. There is also a strong liklihood of future, large-scale nonrenewable resource exploitation on the Queen Elizabeth Islands. Therefore, Canis lupus arctos on the Queen Elizabeth Islands warrants recognition as a potentially "Threatened", if not "Endangered", form of North American gray wolf in Canada.

4. Wolves (C. l. arctos), and probably also wolves from mainland races, occur at low densities and are often rare or absent in large areas throughout the southern tier of Arctic Islands; thus, those wolves do not appear to even closely approach their extrapolated current "theoretical maximum carrying capacity" of ca. 1100. The taxonomic position of all wolves on the southern Arctic Islands is unclear (cf. Manning and Macpherson 1958, Nowak 1979, pers. commun., 1992) and needs further investigation, including examination of DNA to shed light on current and, if possible, past occurrences.

5. The possible presence of arctos within the Baffin Island region has gone undetected to date: further investigation is needed.

6. Baffin Island and its immediate satellite islands are supposedly occupied by a different subspecific form of gray wolf, the Baffin Island tundra wolf (C. l. manningi). Most recently, Nowak (pers. commun., 1992) has concluded that C. l. manningi on Baffin Island should be lumped with the mainland race (C. l. nubilus). Therefore, examination of old and new wolf specimens from Baffin Island, including the use of new DNA procedures, could be fruitful in clarifying the taxonomic position of Baffin Island wolves.

7. Wolves currently classified as (C. l. manningi) occur at low densities within much of the Baffin Island region but their overall number does not appear to approach their extrapolated

current "theoretical maximum carrying capacity" of ca. 2100.

8. The validity of bernardi as a distinct subspecies of Canis lupus remains debatable (Manning and Macpherson 1958); that is, did those eight wolves from Cape Kellett represent a valid subspecies or were they merely immigrants from the mainland.

9. Wolves classified as C. l. bernardi appear to have become extinct on Banks Island between 1918 and 1952 (Manning and Macpherson 1958).

10. Supposition about the occurrence of C. l. bernardi at least on northwestern Victoria Island (Anderson 1943) remains unsubstantiated by fact, as bernardi is still known only from its type locality on SW Banks Island.

11. The islands of Banks, Victoria, King William, Prince of Wales, and Somerset, are likely invaded from time to time by mainland gray wolves (hudsonicus or mackenzii): cf. Manning and Macpherson (1958) and Nowak (1979).

12. Such invading waves are most likely during periods of "caribou highs", when large numbers of caribou migrate in spring from winter ranges on the Canadian mainland to calve and summer on some of the southern Arctic Islands in the archipelago, returning in autumn migration after freeze-up to the mainland.

13. Whether intermingling and subsequent interbreeding between mainland and island wolves occurs at such times is, to date, undocumented but an ongoing possibility.

14. Interbreeding between mainland and island wolves is unlikely, however, unless mainland wolves remain year-round on some of the islands, for unknown reasons, as they would otherwise only be summer visitors to the island and still on the mainland during the spring breeding period.

15. Although detailed quantitative data are lacking, wolves throughout the Canadian Arctic Archipelago are held at relatively low densities in direct response to the limited and clumped distributions of low-density populations of their principal prey, caribou and muskoxen.

16. Although seasonal availability of seals, hares, foxes, lemmings, and birds might contribute significantly to the diets of wolves, in most or all years and at least locally, wintertime availability of prey at significant levels would be determined mainly or solely by the accessibility of caribou or muskoxen.

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Table 1. Current distribution and sizes of settlements on the Canadian Arctic Archipelago[a], based on Government of the Northwest Territories 1988 estimates

Eco-region[b] (Eco-area[c])	Island	Settlements		Location[d] (lat./long.)	Total population[e]	% Inuit[e]
		English name	Inuit name			
QEI (E)	Ellesmere	Grise Fiord	Aujuittuq	7625/8254	76	92
(S-C)	Cornwallis	Resolute Bay	Qausuittuq	7442/9450	166	68
STI (W)	Banks	Sachs Harbour	Ikaabuk	7159/12514	171	89
	Victoria	Holman	Uluqsaqtuuq	7044/11745	316	95
		Cambridge Bay	Ikaluktutiak	6907/10503	1027	72
(SC)	King William	Gjoa Haven	Ursuqtuq	6838/9552	706	96
BI (S)	Baffin	Cape Dorset	Kingait	6414/7632	970	93
		(Frobisher Bay)	Iqaluit	6345/6831	3039	60
		Lake Harbour	Kimmirut	6251/6953	341	94
		Pangnirtung	Panniqtuup	6609/6543	1070	94
	Broughton	Broughton Is.	Qikiqtarjuaq	6733/6402	451	94
BI (N)	Baffin	Arctic Bay	Ikpiarjuk	7302/8510	535	95
		Clyde River	Kangiqlugaapik	7028/6836	474	96
		Nanisivik	Nanisivik	7302/8433	317	39
		Pond Inlet	Mittimatalik	7242/7759	885	94
	Igloolik	Igloolik	Iglulik	6923/8148	922	93

Continued

Table 1. Continued.

Eco-region[b] (Eco-area[c])	Island	Settlements		Location[d] (lat./long.)	Total population[e]	% Inuit[e]
		English name	Inuit name			
Mainland	Melville Pen.	Hall Beach	Sanirajak	6846/8113	476	94
		Repulse Bay	Naujat	6632/8615	454	95
	Boothia Pen.	Spence Bay	Taoyoak	6932/9331	540	92
	Bathurst In.	(Bay Chimo)	Umingmaktok	6650/10802	80	100
	Coronation G.	Coppermine	Kugluktuk	6750/11506	956	92

[a] The mainland settlements of Hall Beach, Coppermine, Repulse Bay, Spence Bay, and Umingmaktok (Bay Chimo) are included in this consideration because Inuit hunters from those settlements can and do on occasion hunt caribou and kill wolves on islands within the Baffin Island region and within the southern tier of Arctic Islands.
[b] Eco-regions equal (1) Queen Elizabeth Islands (QEI); (2) Southern Tier of Arctic Islands (STI); and (3) Baffin Island (BI).
[c] Eco-areas where settlements occur equal: (E), Eastern; (N), Northern; (S), Southern; (S-C), South-central; and (W), Western.
[d] Locations are given by latitude and longitude (e.g., 7442/9450 = 74° 42' N, 94° 50' W and 7159/12514 = 71° 59' N, 125° 14' W).
[e] Data source: Northwest Territories data book 1990/91. 1990. Outcrop Publishers Ltd., Yellowknife. pp. 238.

Table 2. Islands of the Canadian Arctic Archipelago classed by "Eco-region" and "Eco-area", Northwest Territories, Canada

Islands[a]	Size (km^2)	Eco-region[b]	Eco-area
Ellesmere	196 240	QEI	Eastern
Devon	55 250		
Axel Heiberg	43 180		
Melville	42 220		Southwestern
Prince Patrick	15 830		
Eglinton	1550		
Byam Martin	1160		
Emerald	550		
Bathurst	16 090		South-central
Cornwallis	7000		
Vanier	1130		
Cameron	1060		
Alexander	490		
Massey	440		
Little Cornwallis	410		
Ellef Ringnes	11 300		North-central
Amund Ringnes	5260		
Cornwall	2260		
Graham	1380		
Lougheed	1300		
Meighen	960		
King Christian	650		
North Kent	590		
Mackenzie King	5050		Northwestern
Borden	2800		
Brock	1160		

Continued

Table 2. Continued

Islands[a]	Size (km^2)	Eco-region[b]	Eco-area
Victoria	217 290	STI	Western
Banks	70 030		
Stefannson	4460		
Prince of Wales	33 340		Eastern
Somerset	24 790		
Russell	940		
Prescott	410		
King William	13 110		South-central
Royal Geographical Society	610		
Matty	480		
Jenny Lind	411		
Southern Baffin[c]	253 725	BI	Southern
Prince Charles	9521		
Air Force	1720		
Spicer	458		
Northern Baffin[c]	253 726		Northern
Bylot	11 067		
Rowley	1090		
Jens Munk	919		
Bray	689		
Foley	637		
Sillem	482		
Koch	458		
Crown Prince Frederick	401		

Continued

Table 2. Continued

[a]Richards Island (2165 km^2) near the mouth of the Mackenzie River and Wales Island (1137 km^2) in Committee Bay were not included in this consideration because of their closeness to the mainland.
[b]Eco-region: QEI - Queen Elizabeth Islands; STI - Southern Tier of Arctic Islands; and BI - Baffin Island.
[c]Baffin Island = 507 451 km^2.

Table 3. Approximations of mean density of ungulate prey base, theoretical maximum carrying capacity for wolves at current ungulate stocking rate, and resultant number of kilometres per wolf by "Eco-region" and "Eco-area", Canadian Arctic Archipelago

Eco-area by (Eco-region)[a]	Size (km^2)	Ungulate prey base: % of Canadian Arctic Archipelago	Ungulate prey base: Size of prey base[b]	Ungulate prey base: Mean density (· 100 km^{-2})	Theoretical maximum carrying capacity for wolves[c]	km^2/wolf
(QEI)	(415 310)	(31.6)	(20 500)	(4.9)	(205)	(2026)
E	294 670	22.4	9000	3.0	90	3274
SW	61 310	4.7	8000	13.0	80	766
S-C	26 620	2.0	2200	8.3	22	1210
N-C	23 700	1.8	1000	4.2	10	2370
NW	9010	0.7	300	3.3	3	3003
(STI)	(365 880)	(27.8)	(111 300)	(30.4)	(1113)	(329)
W	291 780	22.2	99 000	33.9	990	295
E	59 480	4.5	12 000	20.2	120	496
S-C	14 620	1.1	300	2.0	3	4873
(BI)	(534 893)	(40.6)	(210 000)	(39.3)	(2100)	(255)
S	266 061	20.2	126 000	47.4	1260	211
N	268 832	20.4	84 000	31.2	840	320
Totals (CAA)	(1 316 083)	(100.0)	(341 800)	(26.0)	(3418)	(385)

Continued

Table 3. Continued

[a]Eco-region - QEI = Queen Elizabeth Islands, STI = Southern Tier of Arctic Islands, BI = Baffin Island; Eco-area - NW = Northwestern, SW = Southwestern, N-C = North-central, S-C = South-central, E = Eastern, W = Western, N = Northern and S = Southern.
[b]Data sources for determination of approximate extrapolations are given in Materials and Methods.
[c]Based on the assumption that the prey base could sustain a maximum number of wolves at the ratio of 1 wolf:100 ungulates (see Materials and Methods for details).

Table 4. Estimated wolf densities, extrapolated rates of ungulate prey availability per wolf, range (km^2) per wolf, and resultant number of wolves on entire survey area, western and central Queen Elizabeth Islands, Northwest Territories, Canadian Arctic Archipelago, data obtained by systematic aerial surveys, 1972-74 and 1985-88

Year	Season (months)	Size of survey area (km^2)	Area surveyed (km^2)	Mean density of wolves (· 1000 km^{-2})	Ungulates/ wolf[b]	km^2/ wolf	Extrapolated number of wolves on survey area
1972[a]	Mar.-Apr.	44 930	11 295	1.5	56	664	68
1972	Aug.	26 240	6597	0.0	-	-	-
1973	Mar.-Apr.	91 430	22 413	0.5	715	2037	45
1973	Jul.-Aug.	61 310	16 090	1.6[c]	223	644	95
				2.1[d]	170	473	130
1974	Mar.-Apr.	50 400	12 743	1.1	54	910	55
1974	Jul.-Aug.	67 800	16 637	0.0	-	-	-
1985[e]	Jul.	20 855	6566	0.8	76	1313	16
1986[f]	Jul.	17 930	5005	0.2	155	5005	4
1987	Jul.	43 380	12 093	0.2	783	6046	7
1988	Jul.	26 896	8238	0.6	105	1648	16

Continued

Table 4. Continued

[a]Data sources for 1972-74 are Miller and Russell (1978) and Miller et al. (1977a) and for 1985-88 Miller (1987a, 1987b, 1988, 1989; and unpubl. data, 1985, 1986, 1987, 1988).
[b]Summertime estimates from Miller et al. (1977a) are used for calculating mean densities for caribou and muskoxen because they are considered the most accurate population estimates for both of those species in each year.
[c]Wolf density is based on 1+ yr-old wolves only, excludes 9 pups.
[d]Wolf density based on all wolves seen: 25 1+ yr olds and 9 pups.
[e]A resurvey of 502 km^2 was also carried out in July 1985 and no wolves were seen.
[f]Resurveys totalling 9121 km^2 were also carried out during July 1986 and no wolves were seen.

Table 5. Estimated wolf densities, extrapolated rates of ungulate prey availability per wolf, range (km^2) per wolf, and resultant number of wolves on entire survey area, Banks Island, Northwest Territories, Canadian Arctic Archipelago, data obatined by systematic aerial surveys, 1985-91[a]

Year	Season (months)	Size of survey area (km^2)	Area surveyed (km^2)	Mean density of wolves (· 1000 km^{-2})	Ungulates/ wolf[b]	km^2/ wolf	Extrapolated number of wolves on survey area
1985	Jul.	70 028	7050	1.3[c]	385	770	91
1985				1.8[d]	278	556	126
1987	Jun.		4219	0.0	-	-	-
1989	Jun.		6810	1.5[c]	408	667	105
1989				2.2[d]	278	455	154
1990	Sep.		3198	0.6	1185	1667	42
1991	Jun.-Jul.		6766	0.2	4050	5002	14

[a]Data sources: McLean et al. (1986), McLean (1990), McLean and Fraser (1989, 1991), Fraser et al. (1991), and unpublished data provided by B.D. McLean, Dep. Renewable Resourc., Govern. NWT, Inuvik, NWT, for years 1985, 1987,1989, 1990, 1991.
[b]Total numbers of ungulates extrapolated for 1987 by taking the mid value of 1985 and 1989 and for 1990 by taking the mid value between 1989 and 1991.
[c]Wolf density is based on 1+ yr-old wolves only, excludes 4 pups in 1985 and 5 pups in 1989.
[d]Wolf density based on all wolves seen: 13 in 1985 and 15 in 1989.

Table 6. Relative wolf densities based on the number of wolves seen per 1000 km^{-1} flown and per 1000 h^{-1} of aerial survey[a]

Years	Survey seasons (months)	Distances flown (km)	Number of wolves seen	Number of wolves · 1000 km^{-1} flown	Estimated flying hours[b]	Sighting rate wolves · 1000 h^{-1}
Southwestern & south-central Queen Elizabeth Islands						
1972-74	Mar.-Apr.	28 870	42	1.45	192	219
	Jul.-Aug.	24 440	25[c]	1.02	163	153
			34[d]	1.39		208
1985-88	Jul.	31 900	13[e]	0.41	213	61
Banks Island						
1985, 1987	Jun.-Sep.	28 040	22[c]	0.78	187	118
1989-91			31[d]	1.10		166

[a] Data sources: Miller and Russell (1978), McLean et al. (1986), Miller (1987a, 1987b, 1988, 1989), McLean (1990), McLean and Fraser (1989, 1991), Fraser et al. (1991), and unpublished data provided by B.D. McLean, Regional Wildl. Biol., Dep. Renewable Resourc., Govern. NWT, Inuvik, NWT, for years 1985, 1987, 1989, 1990, 1991.
[b] Estimated at an average of 150 km · h^{-1} for all surveys.
[c] Only 1+ yr-old wolves included (pups excluded).
[d] All wolves, including pups.
[e] No pups seen during aerial surveys in summers 1972, 1974, 1985-88 (pups were seen by ground observers in summers 1973 and 1974 only).

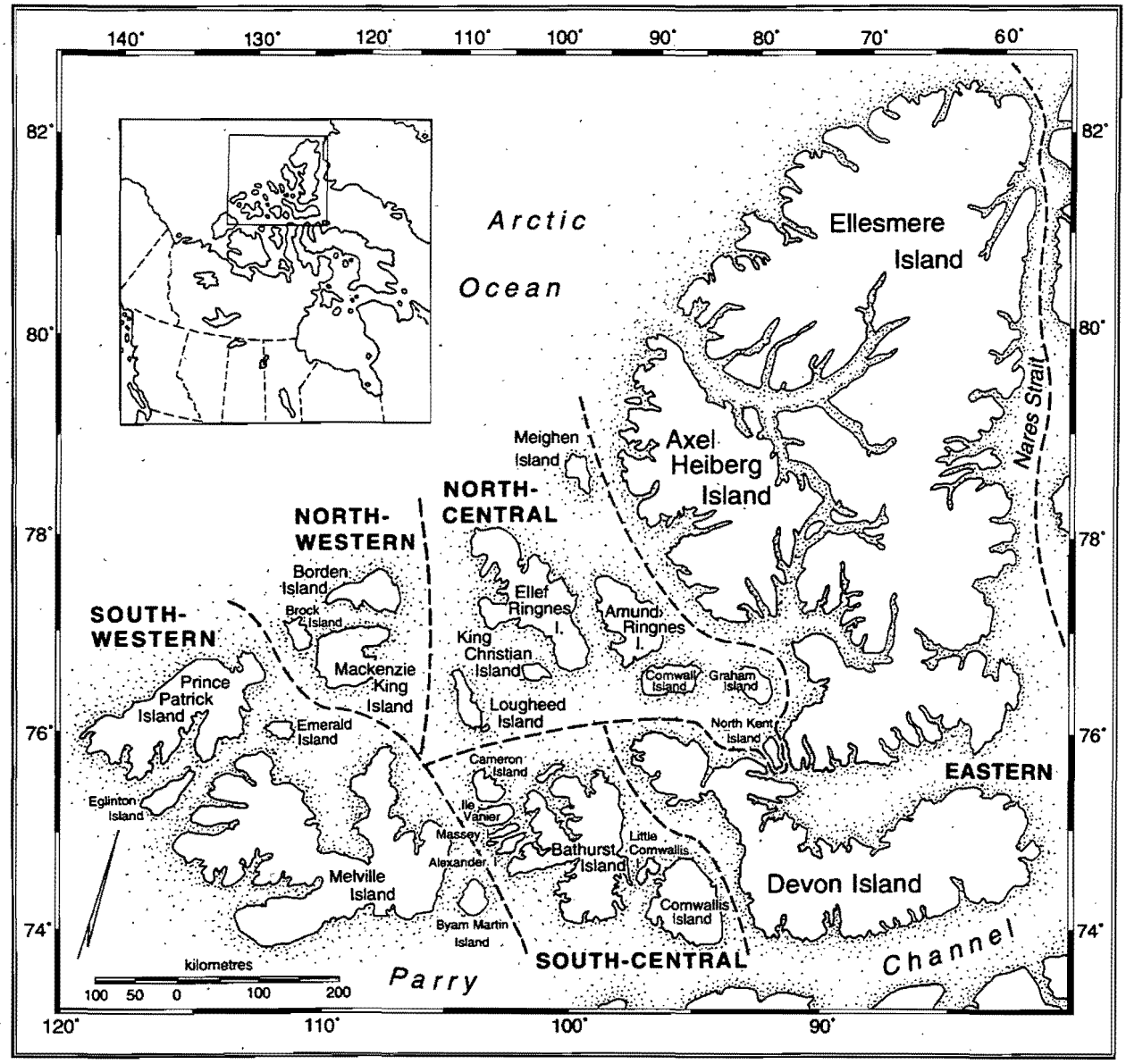

Fig. 1. Current range of the Canadian High Arctic form of gray wolf (Canis lupus arctos), Queen Elizabeth Islands Eco-region, NWT, Canadian Arctic Archipelago (given by 5 eco-areas)

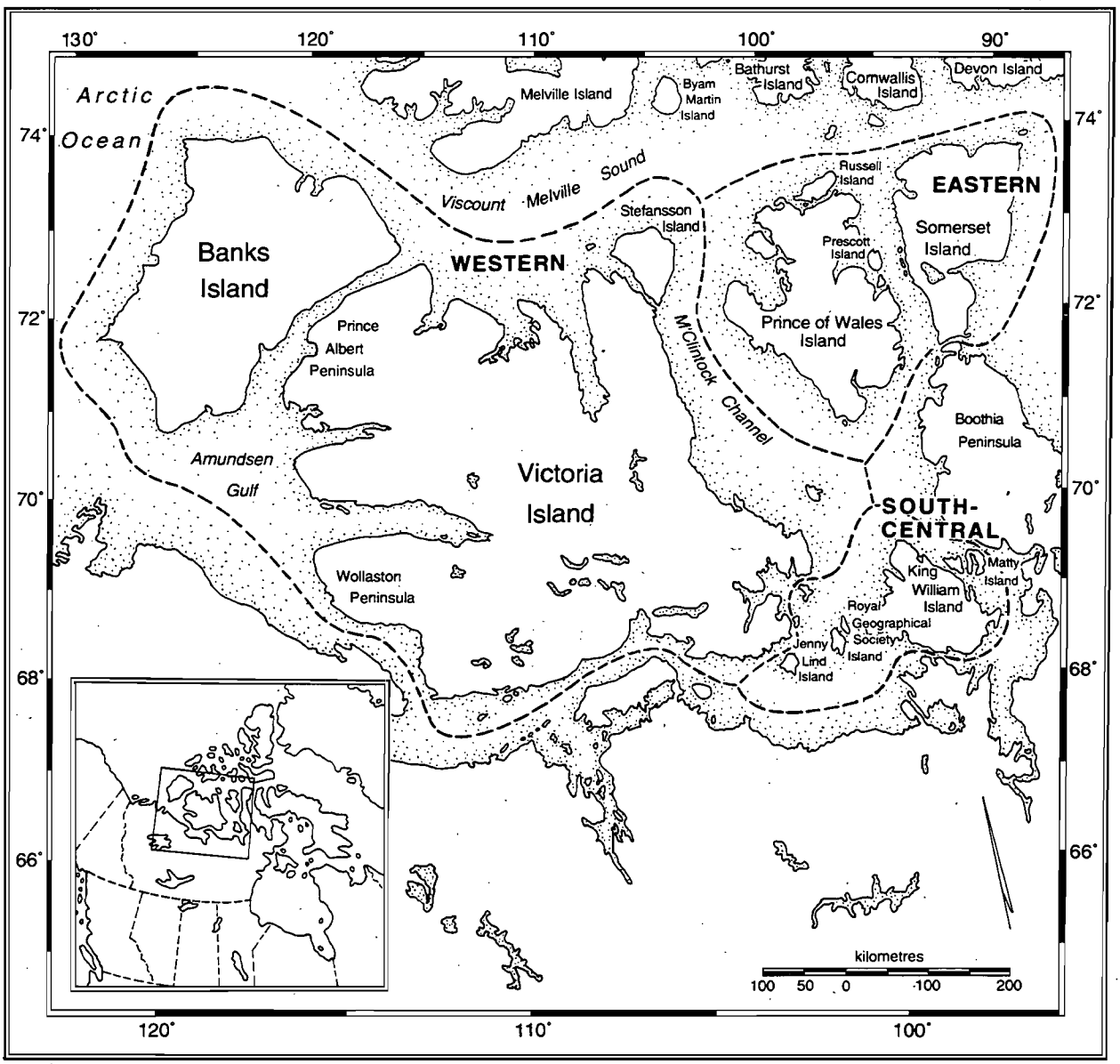

Fig. 2. Current range of the Canadian High Arctic form of gray wolf (Canis lupus arctos) and past range of the Banks Island tundra wolf (C. l. bernardi) apparently now extinct on its former range on Banks Island and supposedly also on northwestern Victoria Island, Southern Tier of Arctic Islands Eco-region, NWT, Canadian Arctic Archipelago (given by 3 eco-areas)

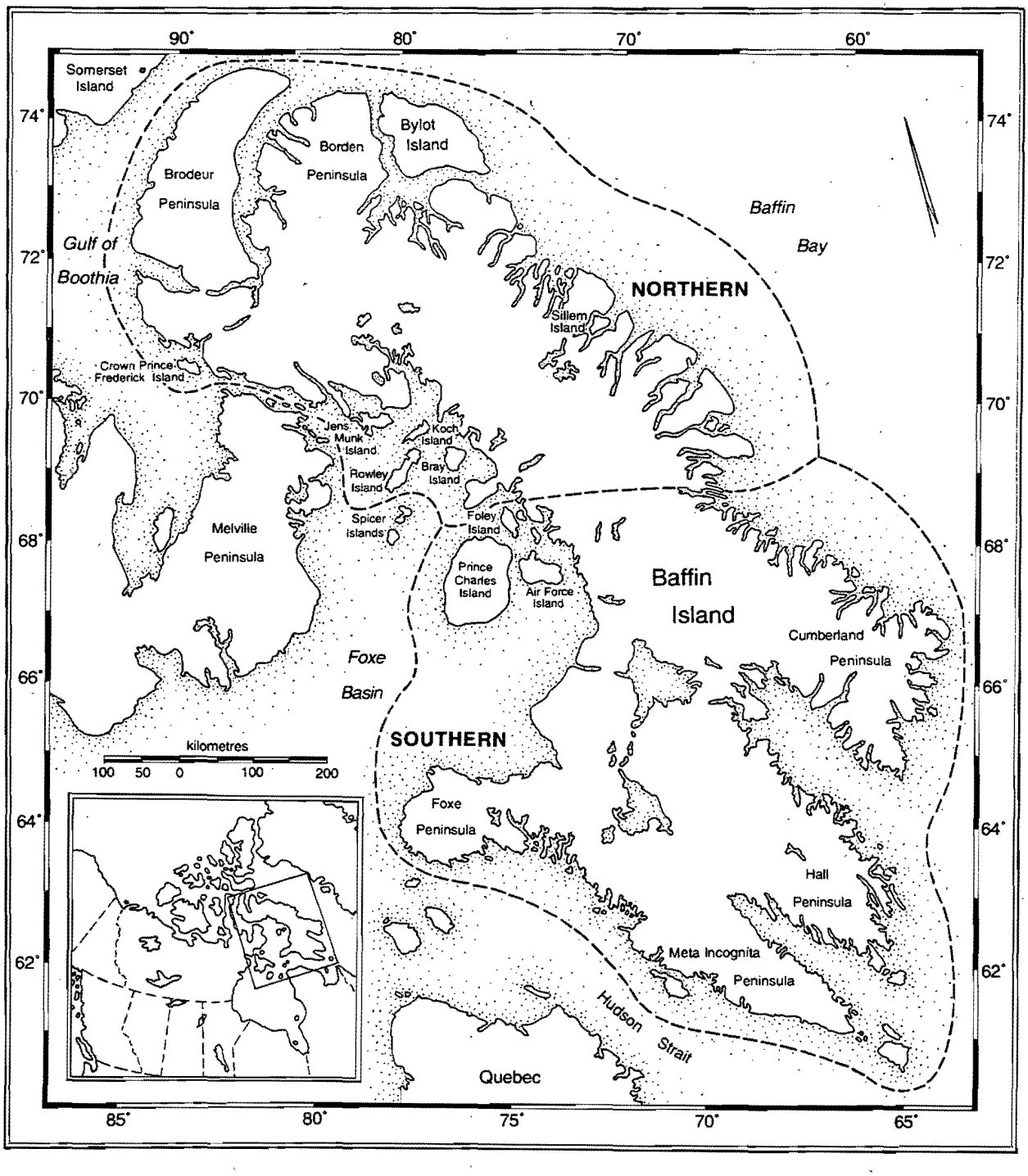

Fig. 3. Current range of the Baffin Island tundra wolf (Canis lupus manningi), Baffin Island Eco-region, NWT, Canadian Arctic Archipelago (given by 2 eco-areas)