Potential factors influencing increasing numbers of Canada Geese *Branta canadensis* in west Greenland

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Abstract

This paper reviews the increase in abundance of Canada Geese *Branta canadensis*, particularly those of the subspecies *interior*, in west Greenland over the last 20 years. Potential reasons for the increase, such as displacement from traditional breeding areas on mainland North America and regional variation in the breeding success of the population are discussed. Breeding biology of Canada Geese nesting in Isunngua, west Greenland (67°N) was monitored for the first time in 2010. The geese had identical mean first egg dates (27 May 2010) but greater mean clutch size compared to those nesting 1,300 km further south at Ungava (58°N) in the same year (4.57 and 3.80 eggs, respectively). Mean May temperatures in Isunngua were on average 2°C higher than in Ungava during 1979–2010, suggesting that females may have been able to enhance reproductive investment in Isunngua relative to Ungava in those years. Moreover, although data are currently only available for one year in Greenland, nesting success there was as high as in other parts of the Canadian range of this subspecies. Compared to the traditional Canadian nesting grounds, milder spring conditions, potentially lower predation rate, availability of abundant food and lack of competition for nest sites may have combined to help explain the rapid expansion of this goose population in west Greenland.

Key words: *Branta canadensis interior,* clutch size, nest sites, nest success, timing of nesting, Ungava.

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A *Branta* genus goose species, presumably a smaller subspecies of Canada Goose *Branta canadensis*, may have co-existed with Greenland White-fronted Geese *Anser albifrons flavirostris* on their west Greenland breeding areas in historical times. Gotfredsen (2002) documented bone remains of a small *Branta* goose in the interior from Nuuk since at least *c.* 1000–1400 A.D. and from the interior of Sisimiut District since at least *c.* 1200–1300 A.D., which she considered most likely to be from Canada Geese. However, despite it being known that Canada Geese have been breeding near Sarqaqdalen since the mid-1940s (Salomonsen 1950), even by the 1960s the species apparently remained a relatively scarce breeder throughout Greenland (Salomonsen 1967). No birds were seen during extensive goose surveys in Eqalummiut Nunaat in central west Greenland (67°30'N) during summer 1979 (Fox & Stroud 1981), although a single early migrant passed through in May and two were seen in that area in June 1984 (Greenland White-fronted Goose Study (GWGS), unpubl. data). Salomonsen (1967) considered that two small races of Canada Geese occurred in Greenland during the 1960s, but made no mention of the presence of larger races of Canada Geese at that time.

Since the late 1980s, summering and breeding Canada Geese have become increasingly common in west Greenland, but evidence from observations, capture and marking, satellite telemetry, genetic analysis and resightings from the staging and wintering grounds confirm that most of the Canada Geese present in summer at around 67°N are of the larger subspecies *interior* (which breed from Ontario to northern Québec) and that these geese winter along the Atlantic Coast in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York and Pennsylvania (Fox *et al.* 1996; Kristiansen *et al.* 1999; Scribner *et al.* 2003; Stroud 2011; see Fig. 1 for locations). Subspecies occurring further north in Greenland have not been studied in detail in recent years and their identity therefore remains unknown (Lyngs 2003).

Canada Geese have mostly been recorded in Isunngua, Eqalummiut Nunaat, Naternaq (Lersletten, just south of Ilulissat), Qeqertarsuaq (Disko Island), the Nuussuaq Peninsula and Sigguup Nunnuua/ Svartenhuk (Fox & Glahder 2010; Fig. 1). In addition, a few breeding pairs and several summer visitors have been reported from Nuuk and Maniitsoq. Spring and autumn migrant Canada Geese were recorded annually in Paamiut in southernmost Greenland (Boertmann 1994), although recent summer aerial surveys have failed to find them here (Malecki *et al.* 2000; Fox & Glahder 2010). Small numbers of breeding and moulting birds have been recorded as far north as Avanersuaq in northwest Greenland (Boertmann & Glahder 1999; Lyngs 2003). Estimates in 2007 suggested in excess of 41,500 Canada Geese in west Greenland (Fox & Glahder 2010).

The apparently rapid colonisation of west Greenland by increasing numbers of the larger *interior* Canada Geese is of conservation interest because the region was formerly occupied solely by Greenland White-fronted Geese that winter in Ireland and Britain (Bennike 1990; Fox *et al.* 1996; Kristiansen *et al.* 1999). Both species are

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Figure 1. Map showing the locations of places, U.S. states (identified by conventional two letter abbreviations) and regions mentioned in the text.

migratory herbivores of similar body shape, giving rise to considerable interest in the potential for inter-specific competition (Kristiansen & Jarrett 2002; Levermann & Raundrup undated), especially given the decline in the Greenland White-fronted Goose population since 1999 (Fox *et al.* 2009). During the moult period, Greenland White-fronted Geese maintained a poorer diet in sympatry than in allopatry with Canada Geese, and both species selected similar food plant species when separated from each other in a study at Isunngua (Kristiansen & Jarrett 2002), although there was no evidence for competition during moult at a larger site on Disko (Boertmann & Egevang 2002; Levermann & Raundrup undated).

But why should such increasing numbers of *interior* Canada Geese have suddenly occurred in west Greenland in recent years? This paper presents material from a literature review relating to the racial composition and abundance of Canada Geese in west Greenland and speculates on the potential factors influencing the apparent increase in numbers in west Greenland during the last 20 years. We also present the first, limited data on breeding biology of *interior* Canada Geese collected in Greenland in summer 2010, supplemented by more detailed information from other parts of the North American breeding grounds.

Methods

Status of different Canada Goose races in west Greenland

A literature survey was undertaken to ascertain and summarise published information on the relative abundance of different Canada Goose races in Greenland, with particular reference to the Greenlandic, Danish and North American ornithological literature.

Recent changes in abundance of Canada Geese in west Greenland

We present material on the changes in abundance and distribution of Canada Geese in west Greenland since the mid-1980s for which some data are available, drawing heavily on expedition reports and unpublished sources, in an attempt to describe the increase in numbers and, where possible, to determine the Canada Goose race involved. Evidence from Canada is also considered, with the aim of understanding factors on traditional breeding areas which could have led to the colonisation and subsequent increases in Canada Geese summering in west Greenland.

Canada Goose breeding biology in west Greenland in 2010

Isunngua, Sisimiut Kommune is an area of low arctic continental tundra northeast of the airport at Kangerlussuaq, west Greenland (67°05'N, 50°32'W), directly west of the Greenland ice cap. The landscape comprises a gently sloping heavily glaciated plateau, between 200 and 600 m elevation, with many glacial lakes, marshes and streams down to sea level. Terrestrial vegetation is dominated by Greyleaf Willow *Salix glauca* and Dwarf Birch *Betula nana* scrub, with open Small-reed *Calamagrostis* sp. grasslands (Thing 1984).

Between 16 May and 11 June 2010 we searched for Canada Goose nests by walking

around all lakes and marshes within a *c.* 60 km^2 area. The lake terrain was separated into four circuits (mean = 15 km) with each circuit covered at least twice at approximately 5-day intervals. At each nest site located, nest characteristics were recorded, including distance from water (m), height above water (m), number of eggs and a visual assessment of the broad vegetation type (most plants not being in leaf) immediately surrounding the nest. The latitude and longitude of each nest was also recorded along with its altitude (m) onto a GPS. These positions were input into a geographical information system (GIS) so that nearest neighbour distances between occupied nests could be calculated. Canada Geese have been marked with yellow neck-collars and leg bands in Isunngua in recent years and any marked individuals associated with breeding attempts were recorded on finding the nest so that breeding success could be checked later in the season.

Results

Status of different Canada Goose races in west Greenland

The long-standing presence of a small *Branta* species (almost certainly a small-race Canada Goose; Gotfredsen 2002) in west Greenland, based on bone remains, fits with more recent observations reported in the literature. Salomonsen (1950, 1967) stated that small-race Canada Geese (both *parvipes* and *hutchinsii*) occurred in west Greenland. He described the first substantiated record, a pair of the *hutchinsii* race which summered on Disko Island in 1863 and returned in 1864, whereupon the male was shot (the skin is still in the Zoological Museum in Copenhagen; Salomonsen 1950). Hannibal Fencker reported a small group of breeding *hutchinsii* in Sarqaqdalen on Nuussuaq which persisted between 1944 and 1949 and even hybridised with local White-fronted Geese (Salomonsen 1950, 1967). Palmer (1976) reported a goose ringed in Kingsville, Ontario (a known wintering area for *interior*) shot in Uummannaq as early as July 1964, although Salomonsen (1967) considered it more likely to be *parvipes* or *moffitti,* but the race and size of this particular bird was never determined. Cryptically, Salomonsen (1967) suggested that numbers of Canada Geese reported in the vicinity of Isunngua and south of Ilulissat were likely of the *parvipes* race, but mentions no more about these in subsequent publications.

More recent confirmation that small-race Canada Geese continued to breed in west Greenland comes from an authenticated observation of a pair of *parvipes* with a nest of 6 eggs from Stordal on Disko Island in July 1979 (Pedersen 1984). Unfortunately, neither the flock of 75–100 Canada Geese seen in Ilulissat in September 1985 (Anonymous 1985) nor small numbers from Avanersuaq in 1984 and 1986 (Vaughan 1988) were assigned to size class or race. Similarly, six seen in Naternaq in 1989 and 11 in the same area in 1992 during aerial surveys were not attributable to size class, but none was seen during ground surveys in 1991 (A.D. Fox & D.A. Stroud, unpubl. data). Ground surveys in July of 1999 and 2000 found 25 and eight respectively in Naternaq that were considered to be *interior* race (C. Glahder, *in litt.*). Aerial surveys of Nuussuaq and northwest Disko Island in

2003 found large numbers of Canada Geese which could not be assigned to race/size (Boertmann 2004; J. Madsen, pers. comm.). Bennike (1990) reported the widespread occurrence of small-race Canada Geese from Svartenhuk, Nuussuaq and the west coast of Disko during his expeditions to the areas in the summers of 1989 and 1990 which he "with hesitation" assigned to *hutchinsii*. He considered that there had been an increase in the numbers of Canada Geese over the previous decades in these areas where it was at that time (as now) the commonest breeding goose species. One of his observed birds bore a yellow collar (at a time when none had been marked in Greenland), but because the characters could not be read, details of the bird's capture and race could not be determined. Thirty-five to 40 *hutchinsii* were seen in eastern Svartenhuk in summer 1989 (H. Ettrup, *in litt.*), while Best & Higgs (1990) also reported 10 small-race Canada Geese associating with a single larger paler bird further north in Avanersuaq (Thule District) in summer 1989. Small-race Canada Geese therefore were present locally in west Greenland north of Disko from *c.* 69°N for a considerable time and have persisted at least until 1990.

In contrast, there were no authenticated records of the larger race *interior* breeding in Greenland until a pair was found nesting in Lille Narssaq, Nuuk District with four eggs on 4 June 1976. The male was shot and the specimen, together with three of their eggs, is now in the Zoological Museum in Copenhagen (Pedersen 1980). More recently, there have been many more reports of summering and breeding large-race birds that are usually assigned to the *interior* form, especially amongst those observed and captured for ringing in Isunngua (GWGS 1993; Boertmann 1994; Fox *et al.* 1996; Kristiansen *et al.* 1999). The likely presence of *interior* on Disko Island was confirmed by Frimer & Nielsen (1990), who considered a nesting pair on the eastern side of the island to be of this race, although "this could not be confirmed with certainty". The photograph associated with the article (p. 155) suggests this is not one of the smaller races and is indeed most likely to be *interior*.

It is important to remember that many of these areas used by the geese are very remote and rarely visited by biologists, so the few reports of Canada Geese in west Greenland over the last seven decades are tantalising, not least for their lack of racial definition. However, the very limited evidence suggests that numbers of small-race Canada Geese occurred in west Greenland at least until the early 1990s, especially from Disko northwards. Lack of ornithological activity on the ground in these areas precludes confirmation that this is still the case, although an aerial survey found that very large numbers of post-moulting Canada Geese remained in these areas in 2007 (*e.g.* Fox & Glahder 2010). More convincing is the lack of firm evidence of the presence of *interior* or other larger races until the 1960s and 1970s, as well as the apparent absence of large numbers of any Canada Geese in west Greenland south of Ilulissat in the late 1970s and early 1980s. As we shall see below, this is not the case now, and all the evidence from observations and captures suggest that these are mostly of the *interior* race (Fox *et al.* 1996).

Recent changes in abundance of Canada Geese in west Greenland

Apart from the sources mentioned above, there are very few quantitative accounts of Canada Goose abundance in west Greenland before 1988. In that year, Fox & Stroud (1988a) undertook an aerial survey of four areas: Naternaq, Eqalummiut Nunaat, Isunngua and an extensive area to the south of Isunngua, during which 1,892 geese were recorded, all but one (a Snow Goose *Chen caerulescens*) being Greenland White-fronted Geese. Five days of subsequent ground searches in Isunngua found 167 White-fronted Geese and 12 (probably *interior*) Canada Geese, including two well-grown Canada Goose goslings. Aerial surveys of more extensive areas of west Greenland in the first few days of August 1992 found over 500 Canada Geese in six count areas. Repeat surveys at the same time of year in summer 1995 (although with slightly differing coverage) located over 1,300 in the same areas (Table 1). Breeding pair surveys undertaken in June 1999 and 2005 showed a general increase in Canada Goose numbers in most areas, but especially in the northern part of the range (Table 2). Finally, ground counts of *interior* Canada Geese from the same area of Isunngua area showed that, from the original 12 birds seen in 1988, numbers had increased to between 75 and 100 by the late 1990s (Kristiansen & Jarrett 2002) and to 430–450 in 2008–2010 (Stroud 2011).

Breeding biology of *interior* Canada Geese in Isunngua

Thirty-four Canada Goose nests were found during the surveys made at Isunngua between 16 May and 11 June 2010, of which

Table 1. Summary of regional counts made of Canada Geese from aerial surveys flown in west Greenland in the first two weeks of August in 1988 (Fox & Stroud 1988b), 1992 and 1995 (C. Glahder, *in litt.*) and 15 and 18 July 2003 (Boertmann 2004). Survey coverage was more restricted in 1988 than in 1992/1995, and the coverage of Disko (Qeqertarsuaq) was substantially less in 2003 than in 1992 and 1995. Nevertheless, counts are illustrative in confirming absences in earlier times. "nc" = regions not counted.

Region	1988	1992	1995	2003
Eqalummiut Nunaat	0	5	0	nc
Naternaq	0	11	117	nc
Isunngua	0	17	nc	nc
Disko	nc	101	342	506
Nuusuaq	nc	0	176	558
Svartenhuk	nc	397	727	nc

Table 2. Summary of counts made of Canada Geese during aerial surveys flown in west Greenland in early June of 1999 (Malecki *et al.* 2000) and 2005 (C.M. Glahder & A.D. Fox, unpubl. data). Numbered areas are those sets of flown transects defined in Malecki *et al.* (2000). Survey coverage and methods were more or less identical in both years, but colder weather and more extensive snow in 1999 than 2005 could have affected goose distributions, especially in the north of the range.

Count areas (after Malecki *et al.* 2000)	**1999**	**2005**
Area 2: Isunngua and northwards	81	60
Area 3: Eqalummiut to Naternaq	25	56
Area 4: Ilulissat, Disko, Nuusuaq and Svartenhuk	5	85
Total	111	201

28 contained eggs. Mean initiation date was 27 May (range = 23 May – 1 June, n = 9) and mean clutch size was 4.57 eggs (range = 3–6, n = 21) for nests with known final clutch sizes. Too few nests of known age were found to permit an analysis of the relationship between clutch initiation date, clutch size and hatching success.

Nests were located from 233–490 m above sea level (median = 360 m, n = 32), all on lake shores or islands (mean distance from water = 1.84 m, s.d. = 1.90 m, range = 0.3–10 m; and mean height above water level = 0.81 m, s.d. = 0.66 m, range = 0.1–2 m; n = 32 in each case). Lake size varied greatly (mean = 8.5 ha, s.d. = 10.5 ha, range = 0.09–34.6 ha). Most nests (57%, n = 29) were constructed from grass/moss vegetation, the remainder were in *Betula* sp. scrub or grass. Nests were on average 420 m (s.d. = 411) from each other (median = 250 m, range = 100–2,030 m).

Initial egg survival was high, with 21 nests maintaining their clutch sizes (total = 96 eggs) over 206 exposure days (because no nests/eggs were lost we were unable to undertake a Mayfield (1961) analysis). At least 26 nests were still active on 6 June and, in cases where they were revisited thereafter, up to 11 June when fieldwork finished.

At least 13 nests were tended by pairs in which at least one of the adults was marked with a neck collar, and of these, there were 10 pairs where both had collars. Eight of these identifiable pairs were not seen in July, whereas five pairs were seen at higher altitude lakes during 15–28 July. In four cases, broods of 1–3 young were seen, with the other pair thought not to have young. If all eggs hatched for these five pairs seen with or without young then there was a failure rate of between 25–100% at the gosling stage, with a mean failure rate of 53% of the eggs overall. Because the broods had moved up to

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4 km (straight line distance) from their hatch sites, it cannot be assumed that the breeding attempts of the eight marked pairs that were not seen in July had failed, as they may have been rearing their broods on lakes that were not surveyed at that time. The mean brood size of all marked birds encountered in July was 2.92 goslings (n = 13 families), a success rate of 64% if these broods hatched from nests with mean clutch sizes. Other pairs seen without young may have failed in their breeding attempt or might not have attempted to nest.

Discussion

Because of the remoteness of the terrain and difficulties in determining the racial characteristics of Canada Geese in Greenland, the abundance and distribution of the subspecies present there now and in the past remains uncertain. Literature records leave little doubt that small-race Canada Geese have been breeding in west Greenland for several centuries and may potentially persist in the north of their range in Greenland to this day. Ground observations are required to corroborate which subspecies are present in currently known large concentrations of Canada Geese on Disko, Nuussuaq and Svartenhuk. There is more convincing evidence for the arrival of individuals of the larger race, *interior,* at a more recent stage. The first breeding pair was recognised in the south of Greenland in 1976, but aerial surveys in the late 1980s suggest at that time there were very few in west Greenland between 64° and 67°N where the subspecies is now very common and widespread (Fox & Stroud 1988a; Fox & Glahder 2010). Aerial surveys during the moult in 1992 and 1995 suggested general increases in Canada Goose numbers in all areas, but surveys of breeding numbers carried out in June 1999 and 2005 showed greatest increases in Canada Goose numbers north of Disko Bay within west Greenland, although whether these involved purely small-race birds or a mixture it is not possible to say. What is more certain is that numbers of *interior* Canada Geese in Isunngua have increased steadily since their first detection in 1988 and it is likely that this increase is reflected more widely between 64°and 67°N in west Greenland.

So what is behind the apparent arrival of *interior* Canada Geese in west Greenland and the recent spread of their numbers there? Could birds from this race have colonised Greenland in recent years, expanding their number opportunistically, despite longer occupation by smaller forms of the same species further north in Greenland?

Within North America, Canada Goose clutch size declines with increasing latitude (Dunn & MacInnes 1987). The *interior* Canada Geese of Isunngua potentially could originate from stock breeding in eastern Hudson Bay as far as northernmost Québec (as far north as 62°30'N) and east into Ungava Bay (Scribner *et al.* 2003). Canada Geese breeding in this area of west Greenland (67°N) therefore should have smaller clutch sizes and breed less successfully than on the original, more southerly, breeding grounds. Two Canada Geese marked in west Greenland staged in Ungava in spring before returning to the breeding grounds (Scribner *et al.* 2003), so these individuals must have lengthened their spring migration route by *c.* 1,300 km, with

potential fitness costs arising from delaying the start of breeding and with considerable additional energetic costs and enhanced risks of prolonged spring migration.

However, mean first egg dates in Greenland in 2010, were identical to ancestral Canada Goose populations breeding in Ungava, Québec (27 May 2010; Cotter 2010) and mean clutch size in Greenland was greater than in Québec in 2010 (4.57 *versus* 3.80 eggs, Cotter 2010; although mean clutch size varied from 3.04–4.71 eggs in Ungava Bay during 1996–2010; J. Rodrigue, *in litt.*). Geese of the same stock initiated breeding at the same time by continuing 1,300 km north, and females were apparently able to enhance reproductive investment under otherwise similar conditions in spring 2010. This paradox may be explained by comparing the mean May temperatures for the two areas (Fig. 2), a mean of 2°C warmer in interior west Greenland than in northern Québec. Hence, by flying north, in most years (24 out of 31 springs between 1979 and 2010), *interior* Canada Geese can arrive in warmer conditions than formerly encountered on the traditional nesting grounds of this population. Ironically, despite the apparent risk, this may mean that females can recoup stores of energy faster in west Greenland for the same date than can locally breeding females in Québec. This may contribute to the explanation for the lack of difference in first egg dates and the greater clutch sizes in Greenland during 2010. Although we must be cautious about comparing data from just one season, clutch size in Isunngua was also greater than in *interior* geese nesting in the north of its continental North American range (57–58°N) but similar to those further

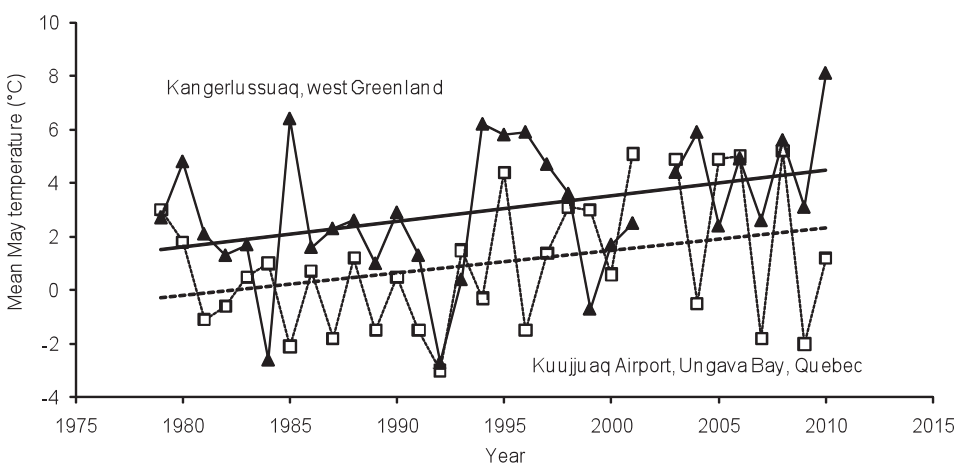

Figure 2. Mean May temperatures for Kangerlussuaq, west Greenland (solid triangles, 67°01'N 50°42'W, downloaded from: http://www.tutiempo.net/en/Climate/Sdr_Stroemfjord/42310.htm) and from Kuujjuaq Airport, Quebec (open squares, 58°06'N 68°41'W, downloaded from http://www.tutiempo.net/en/Climate/Kuujjuaq/719060.htm). Lines show fitted regression models to both sets of data; the solid line indicates Kangerlussuaq, the dashed line, Kuujjuaq.

Table 3. Comparison of mean clutch size amongst studied populations of *interior* Canada Geese in mainland Canada (with source and details of study sites; see Fig. 1 for locations).

Study site	Latitude	Height (metres a.s.l.)	Mean clutch size	Source
Isunngua, west Greenland	67°N	360	4.57	This study
Cape Churchill, Manitoba, Canada	58°N	10	4.10	Malecki (1976)
North Indian Lake, Manitoba, Canada	57°N	230	4.10	Raveling (1977)
Sutton River, Ontario, Canada	55°N	45	5.50	Hanson (1965)
Kinoje Lake, Ontario, Canada	51°N	67	4.57	Raveling & Lumsden (1977)

south (51–55°N; Table 3). This project in Greenland did not attempt to follow nesting rigorously through to hatching, but visits to the same area during the moult period gave some opportunity to assess production of young by nesting individuals, identified by their neck collars, seen earlier in the season. Nest survival in the first two weeks of incubation appeared high, with no known egg or nest losses during the period of observations (which compares with 95% nest survival in 2010 in Ungava; Cotter 2010). It would be interesting to gather larger sample sizes for clutch size and nest success to compare survival rates between *interior* geese in Canada and Greenland and to understand what effects any differences in predator diversity and abundance, nesting habitat and climate may have in the two countries. However, there is no indication that nest survival is any worse in Greenland than in Canada based on data from 2010.

Nest sites were exclusively associated with water; *interior* Canada Goose nests in Isunngua were without exception within 10 m of open water, and very close to water level. This was also the case for *hutchinsii* Canada Geese breeding amongst *frontalis* White-fronted Geese on Kent Peninsula (Bromley *et al.* 1995) where almost all Canada Goose nests were associated with open water. The consistency in the nest dimensions and topography recorded in the current study with the attributes of 14 nests found after the 1998 breeding season by Kristiansen & Jarrett (2001) is noteworthy. Kristiansen & Jarrett (2001) recorded a mean nest distance to water of 1.91 m, mean nest height above the water surface of 0.82 m, mean nest altitude of 461 m a.s.l. and mean lake size of 6.6 ha, compared with 1.84 m, 0.81 m, 352 m and 8.5 ha, respectively for the same measures in 2010. In contrast, Greenland White-fronted Geese do not

habitually nest close to water (mean = 108 m and 70 m from water, n = 8 and n = 6, in 1979 and 1984 respectively in studies from Eqalummiut Nunaat; Fox & Stroud 1988b), but more often on gently sloping hills or tops of elevations to provide all-round visibility (Salomonsen 1950). In this respect, there is little likelihood for direct competition for nest sites between the two species in this part of the range. It should be noted, however, that in recent years Isunngua has only held 0.3% of the total population of Greenland White-fronted Geese, and that the landscapes used by the geese are different further north in west Greenland (*e.g.* Egevang & Boertmann 2001). For both of these reasons, caution should be exercised as to the extent to which findings from Isunngua can be taken as reflecting conditions further north in the range.

Breeding densities of *interior* Canada Geese in coastal parts of Ungava Bay in Canada fell sharply between 1993 and 1994, increased after 1998, and recently declined again since the peak in 2002, this latter decline being due to very high nest predation by Black Bears *Ursus americanus*, densities of which have increased especially around Kuujjuak (Harvey & Rodrigue 2010; J. Rodrigue, *in litt.*). In previous years, nest densities were highest southeast of Kuujjuak, but recent increases in bear densities (based on aerial survey observations and Inuit accounts) correlate inversely with nesting goose numbers. Currently, more geese nest around Aupaluk (150 km north of Kuujjuak) where bears are largely absent but where summer temperatures are lower, from which recent nest data are derived (J. Rodrigue, *in litt.*). Hence, predation pressure may have contributed to redistributing breeding birds within Ungava to less favourable breeding areas, where numbers have increased in recent years to capacity levels determined locally by the habitat, but where lower temperatures may also be influencing the birds' breeding success (J. Rodrigue, *in litt.*).

Densities of nesting pairs in the coastal zones along Hudson Bay further west in Québec have increased more dramatically (Harvey & Rodrigue 2010), but there are no Black Bears in this area. This region is very distant and there is no evidence that these increases are related to increases in the numbers summering in west Greenland.

The preliminary results presented here show that *interior* race Canada Geese colonising west Greenland from Québec have encountered new nesting habitat that is potentially warmer than the traditional nesting areas at the same time of year, suggesting there are advantages to individuals in continuing to Greenland to breed in these new territories, before taking other factors (such as extent of food supply and abundance and especially the density and diversity of predators, including the absence of Black Bears in Greenland) into account. This hypothesis is supported by the fact that in the same year, first egg dates were the same in Greenland as 1,300 km further south in Canada and clutch sizes were larger. Although we lack detailed studies of nest survival and gosling production, these do not seem substantially different from those in Canada, although locally within Ungava Black Bears have had a dramatic effect on nest survival and subsequently on breeding distributions.

Quite why Greenland Canada Geese were less abundant in the 1940s and 1950s than is

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currently the case is not clear, especially if the species, albeit a different race, has long been established in west Greenland (Gotfredsen 2002). They are certainly more visible and easier to catch that White-fronted Geese (authors, pers. obs.), which may have made them easier prey to native people in the past. Although the population may have been smaller in former times, this may also be due to the fact that spring conditions in Québec have been far more severe in earlier times than they are now, with May temperatures 2°C cooler 30 years ago (Fig. 2). The results presented here from this limited west Greenland study area suggest that Canada Geese suffer no competition for nesting sites from the endemic Greenland White-fronted Geese. Thus it seems that conditions are very amenable for Canada Geese breeding in west Greenland, which may explain their dramatic increase from relatively few birds in the late 1980s to over 41,500 in 2007 (Fox & Glahder 2010).

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