An aerial survey of nesting Greater White-fronted and Canada Geese in west Greenland

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An aerial survey conducted in early June 1999 in west Greenland, between 62o and 72oN latitude, provided breeding pair estimates of 4,314 (±785 SE) Greater White-fronted Geese (Anser albifrons flavirostris) and 2,631 (±897 SE) Canada Geese (Branta canadensis). Only one pair of Canada Geese and no White-fronted Geese were observed on transects south of 66o 45' N. Mean densities of White-fronted (0.28 pairs/km2) and Canada Geese (0.25 pairs/km2), were highest in the Kangerlussuaq region (66o 55'-67o 30' N). North of this region, primarily in the area from 67o 30' N to the southern portion of Disko Bay (68o 40' N), densities declined to 0.11 pairs/km2 for White-fronted Geese and 0.03 pairs/km2 for Canada Geese. Few breeding pairs (<6, both species combined) were seen on transects north of the south Disko Bay region. However, increased snow cover and inclement weather prevented a full assessment of this more northerly region. At a local scale, the two species were less likely to occur together than expected by chance suggesting some spatial segregation. The importance of the Kangerlussuaq region to breeding Greater White-fronted Geese and the potential for competition with increasing numbers of recently established Canada Geese is discussed.

Key Words: ***Branta canadensis*, *Anser albifrons flavirostris*, aerial survey, breeding pairs, competition**

The Greater White-fronted Goose *Anser albifrons flavirostri* breeds exclusively in west Greenland, primarily between Nuuk (64°N) and Upernavik (73°N) with summer reports as far north as 77°N (Salomonsen 1967; Best & Higgs 1990). In the late 1970s, the global population may have fallen as low as 14,300 individuals and was the cause of conservation concern at that time (Fox *et al.* 1999). The total population currently numbers about 33,000 individuals based on complete annual counts on the wintering range in Britain and Ireland (Fox *et al.* 1999). The increase in population size during the 1980s probably resulted from reduced hunting mortality throughout its winter range (Fox *et al.* 1998). However, since 1995, there has been little change in overall population size and a reduction in the proportion of breeders that return with young to the most important Irish wintering area, Wexford Slobs (Fox *et al.* 1999, unpubl. data). This suggests that there may be some new factor affecting recruitment of new birds into this population.

Prior to 1980, the Canada Goose *Branta canadensis* was regarded as a rare and irregular breeder in Greenland (Salomonsen 1981). By the early 1990s, the species was described as a locally common breeder that was increasing and expanding in west Greenland (Boertmann 1994). Records suggest a primary breeding range between 66° and 70°N (Fox *et al.* 1996). Ring recoveries and resightings of Canada Geese neck-collared in Greenland indicate that these birds are clearly part of the North Atlantic Population (NAP) of Canada Geese. Based on measurements, the majority of these birds are of the *B. c. interior* form that breeds mainly in northern Quebec. These geese migrate through Labrador and Atlantic Canada to wintering areas along the Atlantic coastline of the United States (Kristiansen *et al.* 1999).

Little is known about the distribution or densities of nesting White-fronted or Canada Geese in west Greenland except from localised studies (Fencker 1950; Fox & Stroud 1988; Kristiansen *et al.* 1999). Competitive interactions with increasing numbers of Canada Geese on the breeding grounds may negatively influence breeding productivity in Greater White-fronted Geese where both species occur (J.N. Kristiansen, pers. comm.). On the other hand, numbers of Canada Geese breeding in Greenland are viewed as a potential source of recruitment into the NAP that will help sustain or increase the harvest of these birds in North America.

For these reasons, some assessment of the relative distribution and abundance of both species in West Greenland was deemed necessary and it was proposed that an aerial survey be carried out in summer 1999. The objective was to provide preliminary baseline data upon which to assess the future changes in their distribution and abundance. The results of the survey are reported here.

Methods

Transects were flown using a specially adapted twin-engined Partenavia Observer aircraft equipped with a Plexiglas dome for forward observation and bubble observation windows to either side. Flights were conducted at air speeds of 120-170 km/hr. at altitudes of 24-36 m. Two observers (seated in the right forward seat and rear left seat behind the pilot) recorded the number of single and paired geese sighted within a 200 m transect on each side of the aircraft (verified visually using an inclinometer to measure the angle of observation). An assumption was made that the strong pair bond and attachment to the nest site helped ensure that single and pair sightings both indicated pairs of nesting geese (Malecki *et al.* 1981). One 40 km segment of transect in higher density breeding habitat near Kangerlussuaq was repeated within a 24 hour period to help verify this assumption. All observations of single, paired and geese in flocks were recorded and their positions noted. No attempt was made to correct our estimates for visibility bias.

All flights were flown between 3-10 June 1999, when most females should have completed egg laying and been well into incubation. Harsh weather conditions were encountered with extensive snow cover and sub-zero temperatures that resulted in an apparent delayed (or perhaps failed) nesting season in areas north of Disko Bay. In most other areas, females appeared in the early phases of nest initiation and incubation.

In all, 48 E-W transects varying in length from 4 to 160 km were spaced at intervals of 13-16 km north from 62° N latitude to 72° N (**Figure 1**). Although both species are known to breed and summer north of 72° N, conditions there were unlikely to have supported breeding geese in 1999. It was considered that the transects were probably representative of some 70-80% of the land area used by geese. Our survey covered an area of about 36,260 km^2, omitting large tracts of land where elevation (>600 m a.s.l.) and steep rugged terrain made habitat unsuitable for summering geese. The area was divided into four broad geographical areas for the purposes of analysis, based on encountered goose abundance (see **Figure 1** for details). Means and standard errors for these areas were generated based upon the results from individual transects. Transects were divided into 2.5 km segments and locations of all goose sightings assigned to individual segments by: (1) assuming a constant aircraft speed, (2) dividing the number of 2.5 km segments per transect by the total number of minutes flown per transect, and (3) assigning the number of minutes at which a sighting occurred to the segment corresponding to that time period. Total breeding pair numbers and their corresponding densities were estimated following procedures described by Martin *et al.* (1979).

The aerial survey census was stratified into two levels to assess the degree of spatial overlap in the observed distribution of the two species to assess the potential for competitive interactions. First, the data was tested from each of the 48 transects to see if both species were more or less likely to occur together on a latitudinal scale than would be expected by chance. A simple contingency table of transects was constructed where the two species occurred together, where each of the species occurred alone, and where neither was observed and tested against predictions for association-dissociation distribution using a simple χ^2 test. Secondly, we carried out the same analysis on all 712 count segments to assess whether the two species were more or less likely to occur together at a much smaller spatial scale.

Results

Only one pair of Canada Geese and no White-fronted Geese were encountered on transects flown in Area 1 between 62° and 66°N. In contrast, highest densities of

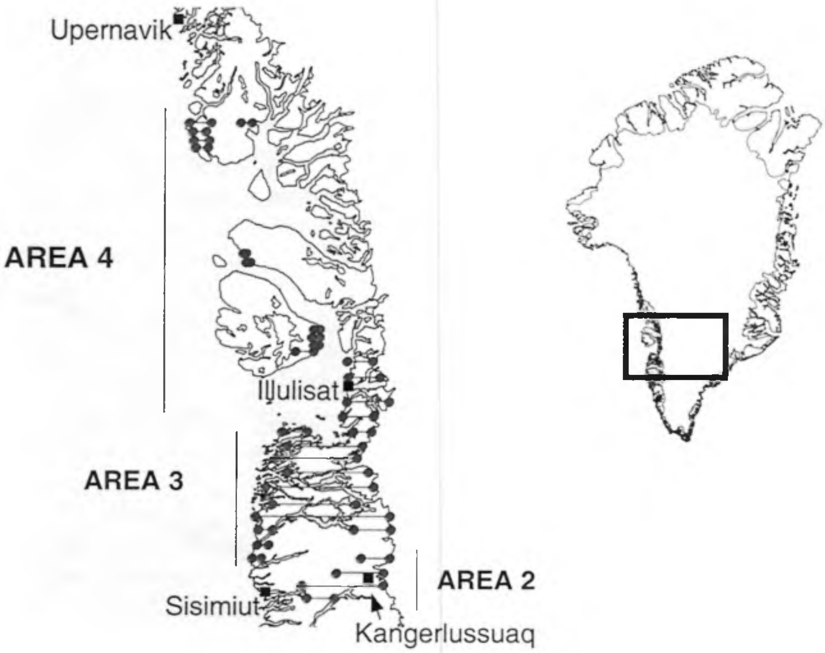

Figure 1. Location of aerial goose count transects flown in southern (lower) and central (upper) West Greeenland during 3-10 June 1999. Transects have been grouped on the basis of encountered densities into the four areas as indicated.

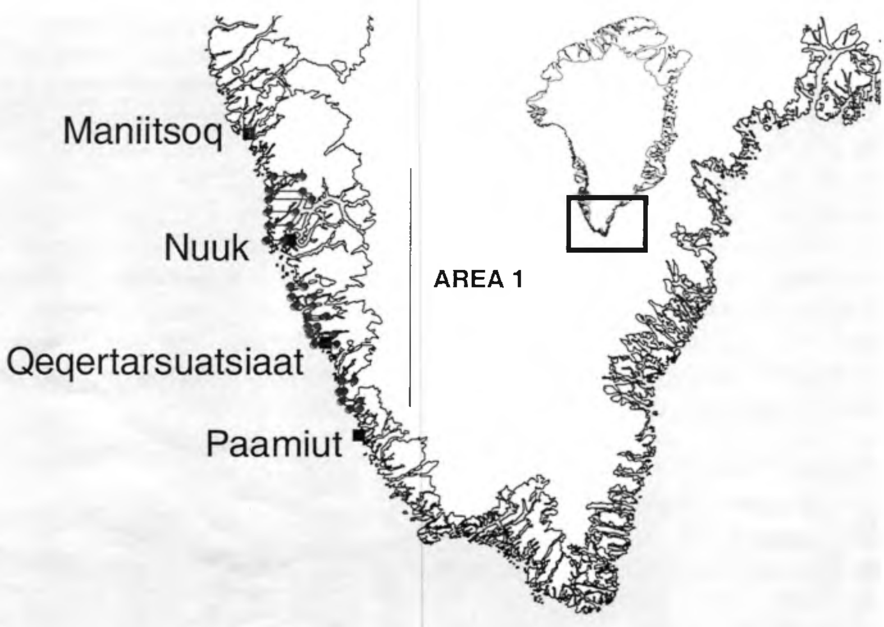

Table 1. Summary of aerial survey data from transects flown in West Greenland, 1999. Data are presented for the numbers of White-fronted (WF) and Canada Geese (CG) encountered during the flights, but breeding pair density is based only on encounters with singles and pairs of geese (group encounters are provided for completeness).

Area	Total Area Covered (km^2)	Transect Area km^2 (Number of Transects)	WF Singles and Pairs	WF No. of Groups (Total Nos)	CG Singles and Pairs	CG No. of Groups (Total Nos)	Breeding Pair Density (km^{-2}) WF	Breeding Pair Density (km^{-2}) CG	Breeding Pair Estimates WF n (±SE)	Breeding Pair Estimates CG n (±SE)
1	6,168	170 (17)	0	0	1	0	0	0.006	0	37 (±0.43)
2	8,192	130 (4)	37	12 (111)	33	3 (15)	0.28	0.25	2,294 (±732)	2,048 (±859)
3	16,364	347 (11)	38	13 (113)	10	1 (5)	0.11	0.03	1,800 (±268)	491 (±248)
4	5,517	105 (16)	4	3 (12)	1	1 (3)	0.04	0.01	220 (±96)	55 (±55)
Totals	**36,241**	**752 (48)**	**79**	**28 (236)**	**45**	**5 (23)**			**4,314 (±785)**	**2,631 (±897)**

both species occurred in Area 2 further north (66°30'-67°30'N). Four transects totalling 130 km^2, within a survey area of approximately 8,192 km^2, of potential breeding habitat (**Table 1**) resulted in 37 single and pair sightings of White-fronted Geese and 33 such sightings of Canada Geese. Resultant densities of 0.28 pairs and 0.25 pairs/km^2, respectively, provided breeding pair estimates of 2,294 (SE ±732) White-fronted and 2,048 (SE ±859) Canada Geese.

Transects in Area 3, along the coast north of Sisimiut and extending inland north of 67° 30'N to the southern edge of Disko Bay (68°45' N) revealed lesser densities of breeding White-fronted and Canada Geese, where densities averaged 0.11 and 0.03 breeding pairs/km^2, respectively. Total estimated pairs were 1,800 (SE ±268) for White-fronted and 491 (SE ±248) for Canada Geese. Even lower densities of both White-fronted Geese (0.04 pairs/km^2) and Canada Geese (0.01 pairs/km^2) were found in Area 4 from Disko Bay northwards (68°45'-71°45' N).

In total, our survey provided breeding pair estimates of 4,314 (SE ±785) White-fronted Geese and 2,631 (SE ±897) Canada Geese. Repetition of a 40km segment of transect on two consecutive days (June 9 and 10) in Area 2 resulted in 13 versus 10 single and pair sightings of Canada Geese and zero versus two such sightings for White-fronted Geese.

The observed pattern of association between the two species on transects differed significantly from complete association (χ^2=9.0, df=1, P<0.01) and dissociation (χ^2=4.0, df=1, P<0.05). There was no significant difference from an even spread of the two species over all transects where one or the other species occurred (χ^2=0.56, df=1, P>0.05). At the individual count unit level, the observed pattern of association between the two species differed significantly from that expected for the prediction of complete association (χ^2=96.6, df=1, P<0.001), but not for complete dissociation (χ^2=0.60, df=1, P>0.05).

Discussion

Greatest densities of both White-fronted and Canada Geese occurred in Area 2, near Kangerlussuaq, where satellite imagery shows that inland areas lose their snow cover more than one month earlier than the coastal areas near Sisimiut (Glahder 1999a). Over half of our estimate of White-fronted Geese and almost 80% of estimated Canada Geese occurred here. Given the extent of late snow cover to the north, it is possible that geese of both species were more concentrated at these latitudes than may be the case in other years. Glahder (1999b) found more geese during the moulting period between 66° and 69° in west Greenland in the cold summer of 1992 than in the warmer season of 1995. Nevertheless, this central area around Kangerlussuaq has proven to be important for spring staging, breeding and moulting Greater White-fronted Geese over a number of years (Glahder 1999a, b). In addition, this area seems to support a substantial proportion of the current Canada Goose breeding population. Thus, the climate of this area, characterised by low winter snow cover and relatively early thaw patterns, may be beneficial to both goose populations.

Densities of both species were similar throughout the area surveyed, showing a high degree of overlap in their use of this area for nesting. The two species showed a distribution that was even throughout those areas where one or the other species occurred, suggesting that both species showed preference for the same latitudes, but they neither segregated nor aggregated within these favoured areas. Nevertheless, at the individual count unit scale, the two species were significantly dissociated, suggesting some segregation between the two species at the local scale, either through behavioural exclusion, different habitat preferences, mutual avoidance or a combination of all three. Ground observations suggest the two species utilise different habitats for nesting and there may also be behavioural mechanisms that result in mutual exclusion during the moult period (J.N. Kristiansen pers. comm.)

Although the global population of the Greater White-fronted Goose numbers about 33,000 individuals, the population is characterised by consistently low productivity. Normally 14-18% of the numbers arriving on the wintering grounds are young hatching year birds, the result of low numbers of families (Fox *et al.*. 1999). This low level of recruitment may result from (i) delayed age of first breeding compared to other races of the same species (Warren *et al.* 1992, 1993), (ii) a relatively small proportion of birds of reproductive age attempting to nest, (iii) high proportions of nesting age females that do attempt to breed being unsuccessful or (iv) low post-fledging survival to the winter quarters. The survey located large groups of White-fronted Geese throughout the surveyed areas and relatively few birds as singles or pairs, hence the estimated 3,500-5,000 pairs suggested by the survey represents approximately half the birds of potentially breeding age. This total may suggest that a low proportion of the number of geese of potential breeding age attempt to breed each year, an assertion supported by the high ratio of birds in flocks compared to those encountered as pairs or singles. However, the late complete snow cover in areas north from Disko Bay may have denied a substantial proportion of the breeding population access to nesting areas normally free of snow at this time of year. This factor may have contributed to the flocks that were seen elsewhere during the survey. Independent observations of the proportion of young in the flocks in the main wintering areas were low on Islay, Scotland (10.4%) and the lowest ever recorded at Wexford in Ireland (5.5%) after the 1999 breeding season (M.A. Ogilvie and A.J. Walsh *in litt.*). Hence, the severe conditions of June 1999 in the north of the breeding range (where most Irish-wintering geese tend to breed, Fox *et al.* 1983) likely affected recruitment throughout the wintering range, but especially at Wexford.

Canada Goose numbers in Greenland have apparently been increasing throughout the 1980s and 1990s. In Isunngua (67°05' N, 50°30' W), for example, ground counts showed a steady increase from *c.*20 individuals in 1988 to *c.*140 by 1997 (Kristiansen *et al.* 1999). Our baseline estimate of roughly 1,700 - 3,500 breeding pairs is therefore not unreasonable. In North America, estimates for the NAP total 29,000 breeding pairs (25,000 pairs in Labrador; 4,000 pairs in Newfoundland, unpubl. aerial survey data). Based on this assessment, Canada Geese breeding in Greenland may make up c.10% of the existing NAP breeding population. Long-term monitoring of this population is of interest for harvest management in North America. In Greenland, this increase in numbers of Canada Geese has some importance for local harvest, but may, in the longer term, be of greater interest because of the potential competitive interactions with the endemic White-fronted Goose population.

Results of the repetition of a 40km segment of transect provide weak evidence that the variability of the observations was not dramatic. No attempt was made to adjust the survey results for visibility bias. It is known that aerial survey may underestimate true population size and that Canada and White-fronted Geese show different detection probabilities from the air (Bromley *et al.* 1995). Visibility estimates from Western Alaska of 0.24 and 0.29 for White-fronted and Canada Geese respectively were similar (Butler *et al.*. 1988). However, there is no doubt that Canada Geese are more conspicuous in the landscape (e.g. by nesting along lake shores and showing less cryptic behaviour compared to White-fronted Geese) and nesting pairs react at greater distances to disturbance than do *Anser* species (Fabricius *et al.* 1974; Bromley *et al.* 1995). Malecki *et al.* (1981) suggest that breeding pair estimates for Canada Geese can be multiplied by about 1.4 to adjust for birds not seen in tundra habitat such as the habitat that was surveyed. However, a similar adjustment for White-fronted Geese may not be appropriate because of differences in degree of cryptic behaviour and coloration, and use of more upland habitat for nesting and feeding. Regrettably, there are no studies known that provide quantitative correction factors for both species to allow estimates of 'true' density on the ground.

The objective of completing a baseline survey of breeding White-fronted and Canada Geese in Greenland was achieved in 1999. The results suggest a concentration of breeding densities in a relatively small part of west Greenland. A great deal of overlap was encountered in the nesting distribution of these two species, but the results hint at segregation at a local scale. This subject is currently the focus of a post-graduate study, which seeks to identify the scale, nature and extent of potential inter-specific competition between these two species. There is growing evidence that the two species do co-exist in some areas, but that Canada Geese are behaviourally dominant over White-fronted Geese, and local displacement has been recorded where there are annual surveys to provide such evidence (J.N. Kristiansen pers. comm.). Preliminary studies suggest there is little overlap in nest site selection, nor timing of breeding of the two populations. However, during the moult period (when both species use the same habitats) both species show considerable overlap in diet in allopatric sites, but reduced overlap in sympatric ones, White-fronted Geese taking less nutritious dietary items at sites where both occur (J.N. Kristiansen pers. comm.). Given that highest densities of both species occurred in and around Kangerlussuaq (Area 2), the low productivity of Greater White-fronted Geese, the high breeding output of Canada Geese in west Greenland (unpubl. data) and its increasing population trend, there is considerable potential for competition for resources and behavioural exclusion that may prove detrimental to the endemic White-fronted Goose. Harvest management of NAP Canada Geese in both Greenland and North America may provide a means for maintaining an equitable balance if the signs are that this should occur.

Quite why there should be such competitive interactions in this region of recent overlap remains unclear, given that the two species breed sympatrically elsewhere in their range in North America, without apparent adverse effects on either species (e.g. Mickelson 1975; Carrier *et al.* 1999). Nevertheless, the growing evidence of spatial segregation, behavioural dominance and degree of foraging overlap suggest the potential for effects at the population level. Future monitoring of population trends based on repeated breeding pair survey estimates provides the means for monitoring the population changes of these two species of geese in Greenland.

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