Aerial surveys of Greater White-fronted Geese *Anser albifrons frontalis* and other waterfowl in the Rasmussen Lowlands of the Central Canadian Arctic

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Helicopter surveys were carried out in June 1994-95 to determine the numbers and distribution of Greater White-fronted Geese *Anser albifrons frontalis* and other waterfowl in the Rasmussen Lowlands of the Central Canadian Arctic. The results provide information needed for the management of Greater White-fronted Geese as well as for evaluating the biological importance of the Rasmussen Lowlands as a potential 'protected area'. Estimated numbers of waterfowl in the 6,265km^2 survey area were 42,041 Lesser Snow Geese *Anser caerulescens caerulescens*, 23,516 Greater White-fronted Geese, 13,690 King Eiders *Somateria spectabilis*, 6,412 Canada Geese *Branta canadensis hutchinsii*, 5,427 Long-tailed Ducks *Clangula hyemalis* and 3,822 Tundra Swans *Cygnus columbianus*. Smaller numbers of several other species of aquatic and terrestrial birds were observed and minimum population estimates are reported for those species as well. Numbers of Lesser Snow, Greater White-fronted and Canada Geese have increased substantially in the Rasmussen Lowlands since the mid-1970s, but King Eiders and Long-tailed Ducks have declined markedly. The results support previous findings that the Rasmussen Lowlands is a critical breeding and summer area for Greater White-fronted Geese and other arctic-nesting waterfowl, and further strengthen the recommendations that this site should be protected.

Key Words: Greater White-fronted Goose, Canada Goose, Lesser Snow Goose, Tundra Swan, King Eider, Long-tailed Duck, aerial surveys, Rasmussen Lowlands, Central Canadian Arctic

The Arctic Goose Joint Venture (part of the North American Waterfowl Management Plan) identified the Greater White-fronted Goose *Anser albifrons frontalis* (hereafter also referred to as White-fronted Goose) as a priority for research and monitoring, and recommended a 'breeding ground' approach for delineating and monitoring populations of this and other species of arctic-nesting geese (Anonymous 1995). Management of White-fronted Geese following such an approach requires information on the breeding distributions and numbers of geese from different breeding areas in addition to knowledge of migration routes and wintering areas. The Rasmussen Lowlands site ('the Lowlands') has been identified as one of the major breeding areas in the Central Canadian Arctic for White-fronted Geese (Allen & Hogg 1978; Bromley & Stenhouse 1994).

The Lowlands site was largely unknown to ornithologists until the mid-1970s when environmental studies (McLaren *et al.* 1977; Zdan & Brackett 1977; Allen & Hogg 1978) were conducted in the area to determine the potential impacts of a proposed natural gas pipeline, which would have passed through the middle of the Lowlands. These studies identified the importance of the area as a nesting and moulting area for White-fronted Geese, Tundra Swans *Cygnus columbianus*, Lesser Snow Geese *Anser caerulescens caerulescens*, Canada Geese *Branta canadensis hutchinsii*, King Eiders *Somateria spectabilis*, Long-tailed Ducks *Clangula hyemalis* and many species of shorebirds. The findings led to the designation of the Rasmussen Lowlands as a Wetland of International Importance (Ramsar site; IUCN 1987) and as a Canadian Wildlife Service Key Migratory Bird Habitat Site (Alexander *et al.* 1991). As a result, the site has been identified as a potential candidate for protection as a National Wildlife Area (Johnston *et al.* 2000).

The objective of the authors' study was to determine the current numbers and distribution of Greater White-fronted Geese and other waterfowl in the Lowlands. The results are intended to provide information needed for the management of White-fronted Geese, and to help in evaluation of the biological importance of the Rasmussen Lowlands in view of its possible designation as a National Wildlife Area.

Methods

The Rasmussen Lowlands site (68°40'N, 93°00'W) is situated on the mainland of the Central Canadian Arctic (**Figure 1**). It is bordered by the escarpment of the Wager Highlands to the east and by the arctic coast to the west. The land is flat to gently rolling, with some eskers and rock outcrops. Most of the region is poorly drained and numerous lakes and ponds are present. The Lowlands site is located about 900km north of the tree line near the boundary of two major ecological zones: the warmer, well-vegetated southern arctic and the colder, sparsely-vegetated northern arctic (Ecological

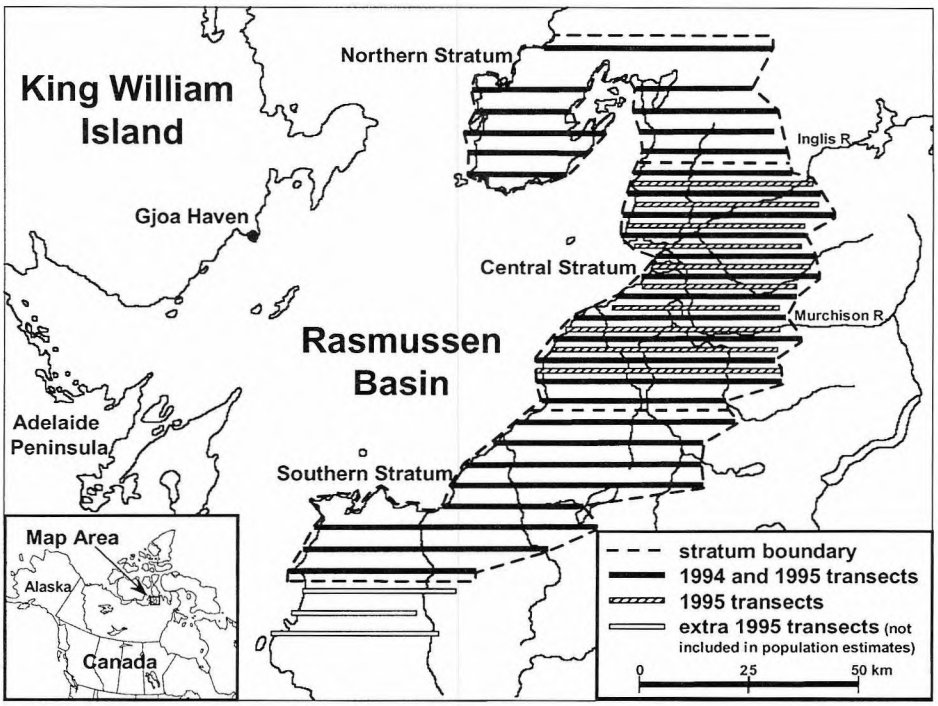

Figure 1. Locations of transects surveyed within three strata in the Rasmussen Lowlands in June 1994-1995.

Stratification Working Group 1996). Sedge-dominated meadows and marshes, which are tundra communities frequently used by geese and other migratory birds in the Canadian Arctic, are widely distributed throughout the Lowlands (Johnston *et al.* 2000).

Aerial surveys were carried out in the Lowlands from 20-24 June 1994 and 20-25 June 1995, following generally accepted procedures for breeding ground surveys of waterfowl (Anonymous 1987; Smith 1995), specifically modified for helicopter surveys in arctic Canada (Hines *et al.* 2000; Hines & Wiebe 2004). Surveys were carried out at a time when most waterfowl were nesting and, thus, widely dispersed as breeding or territorial pairs. The survey procedure involved flying straight transects in a float-equipped Bell 206L helicopter at an altitude of 45m above ground and a ground speed of 80-100km/hr. Transects were oriented in an east-west manner (approximately at right angles to the coastline) and spaced at 5km intervals in areas expected to support higher densities of geese (McLaren *et al.* 1977; Allen & Hogg 1978; Bromley & Stenhouse 1994) and at 10km intervals in areas of lower expected densities. All transects were

divided into 2km segments, which served as a basis for recording data.

Unpredictable weather conditions, a shortage of aircraft and the high cost of conducting helicopter surveys meant that the surveys could not be restricted to a specific time of day. Most transects were surveyed when winds were less than 25km/hr and the ceiling was more than 150m, as recommended by Butler *et al.* (1987, 1988). These specifications could not be met on some transects but it is believed that this did not significantly bias the results.

Surveys were conducted with two observers, one seated in the left front seat and the other in the right rear seat, which was equipped with a bubble window for better viewing. All observations of geese and other highly visible birds within an estimated 200m of the flight path were recorded on audio tape and the resulting data were later transcribed.

The study site was divided into three strata based on expected differences in densities of White-fronted Geese (**Figure 1**). Areas of the Northern, Central and Southern Strata were 1,525km^2, 2,668km^2 and 2,072km^2, respectively. Each year, transects covered approximately 8% of the area of the Northern and Southern Strata. Transects also covered 8% of the Central Stratum in 1994, but in 1995 additional transects were added to the stratum, increasing the area surveyed to 15% (**Figure 1**).

In 1995, three additional transects were surveyed in a 555km^2 area immediately south of the study area to verify that the southern limit of the high waterfowl densities in the Lowlands had been reached. This area was not included in the overall population estimates for the Lowlands.

Lesser Snow Geese typically nest in large colonies and are not easily surveyed using widely spaced aerial transects. Thus, as well as counting the numbers of Snow Geese on the regular transects (all non-breeders in flocks of three or more birds), total counts of nesting Snow Geese were carried out by flying over colonies at a height of 230m and counting all geese within 1km of each side of the helicopter. Transects were spaced at 2km distances so as to provide 100% coverage of the colonies. During both transect and colony surveys, the plumage colour of the birds (blue or white) was recorded whenever all individuals in a flock or pair could be readily identified to colour phase.

The transects were of differing lengths and the ratio method was therefore used to calculate minimum population estimates and densities (± standard errors) for each stratum (Jolly 1969). Population densities for both years were averaged to calculate the mean number of geese in the stratum. The standard error (S.E.) of the mean population estimate for each stratum was determined:

$$S.E. = (V(\sum S_i^2))/n$$

where S_i^2 is the variance of the stratum population estimate in year i and n is

the number of years the stratum was surveyed (ie two years). The total population estimate for the Lowlands was the sum of the individual stratum estimates and the variance for the total population estimate was the sum of all stratum variances.

Female Greater White-fronted and Canada Geese are infrequently seen from the air if they are on nests, so each observation of one or two geese of these species was treated as an indicated breeding pair (ie two birds) in calculating numbers of breeding geese (Anonymous 1987). Calculations of total population size used the number of indicated breeding pairs multiplied by two plus the number of birds in groups of three or more. Estimates of Lesser Snow Geese were not adjusted for visibility because the colonial nature and light plumage of these geese (see Results) made them relatively easy to see from the air and thus relatively few birds were likely to be missed. The number of breeding Snow Geese was the total number sighted less those seen in flocks of three or more birds.

Tundra Swans are highly visible and are unlikely to be missed during the surveys, and calculations of total population size used only the number of swans observed. Indicated breeding pairs were calculated by summing all sightings of one or two swans and then dividing by two (Wilk 1988).

The number of indicated breeding pairs of King Eiders was calculated using the standard operating procedure for waterfowl breeding population surveys that was developed by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service (Anonymous 1987; Dickson *et al.* 1997). This procedure treats lone males, males in flocks of two to four and pairs as indicated breeding pairs. Calculations for the total population size used the number of indicated breeding pairs multiplied by two added to the number of birds in groups of five or more. Thus, observations of one to four females (no male present) and observations of one to four eiders of unidentified sex were not used in the calculations.

Indicated breeding pairs were not calculated for Long-tailed Ducks because the sex of many of the birds could not be distinguished from the air. Calculations for the total population size used only the number of Long-tailed Ducks observed, and thus did not account for nesting females that were missed from the air. Similarly, calculations for other species such as loons, cranes, gulls and terns used only the number of individuals actually seen during the survey.

Adjusting observations to account for 'missed' females will still, in most cases, underestimate the actual population size because there are groups, pairs or lone birds for which none of the individuals were sighted from the air. Based on work carried out in both the Western Canadian Arctic and the Rasmussen Lowlands (Hines *et al.* 2000; Hines & Wiebe 2004), visibility correction factors (VCFs) that had been developed by means of a double-

counting (mark-recapture) approach were used (Caughley & Grice 1982; Pollock & Kendall 1987; Anthony *et al.* 1992). Overall population estimates and variances were then determined by applying the appropriate visibility correction factor to the minimum population estimates and variances as described by Smith (1995). Only minimum population estimates are reported for less commonly sighted species (for which VCFs could not be developed).

Results

Distribution and numbers of waterfowl and other species

White-fronted Geese were widely distributed throughout the Lowlands (**Figure 2**). More than 23,500 White-fronted Geese were present in the 6,265km^2 survey area, with approximately two-thirds of the individuals occurring in the Central Stratum. The densities averaged 2.0 geese/km^2 in the Northern and Southern Strata and 6.1 geese/km^2 in the Central Stratum. Approximately 4,400 pairs (0.7 pairs/km^2) were present in the Lowlands (**Table 1**), with over 70% of these pairs present in the Central Stratum (1.1 pairs/km^2). Overall, Greater White-fronted Geese were the second most abundant species of waterfowl in the survey area.

Lesser Snow Geese were the most abundant species of waterfowl in the survey area. The Inglis River colony was the largest of the three Snow Goose colonies located, with more than 80% of the 6,700 nesting pairs being found there (**Table 2**). Many Snow Geese were found in or near one of the three colonies (**Figure 3**) but other groups of non-breeding Snow Geese were seen elsewhere in the study area. The estimated population size was 42,041 birds. Twenty per cent of the birds in a sample of 1,154 Snow Geese were blue phase birds.

Canada Geese and Tundra Swans were regularly distributed throughout the survey area (**Figures 4 and 5**). Densities of Canada Geese ranged from 0.9-1.3 geese/km^2 in the three strata, and the total population estimate was 6,412 birds, including 2,450 pairs (**Table 1**). Tundra Swans occurred in somewhat lower densities (0.4-0.7 birds/km^2) than Canada Geese. The total population estimate for Tundra Swans was 3,822 and included 1,632 pairs (**Table 1**).

King Eiders were the most commonly observed ducks (**Table 1**). Densities of King Eiders were highest in the northern sections of the survey area (3.3, 2.5 and 1.0 eiders/km^2 in the northern, central and southern strata, respectively). The total population estimate for King Eiders was 13,690 birds and included 6,393 pairs. Densities of Long-tailed Ducks ranged from 0.6-0.7 ducks/km^2 in the three strata, with a total population estimate of 5,427 ducks (**Table 1**).

Data were adequate for estimating minimum population sizes (uncorrected for visibility bias) for several other

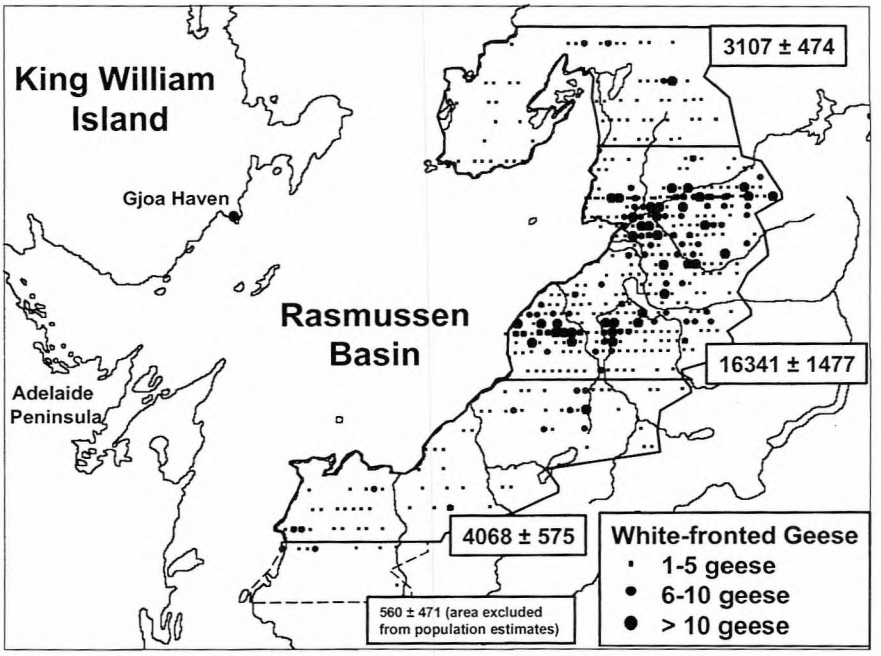

Figure 2. The mean number of White-fronted Geese seen on each 2km segment during helicopter surveys in the Rasmussen Lowlands, Central Canadian Arctic, in June 1994-95. Population estimates ± standard errors for each stratum are indicated in boxes by the strata.

species of birds that occurred at lower densities: Red-throated Loons *Gavia stellata*, Pacific Loons *Gavia pacifica*, Glaucous Gulls *Larus hyperboreus*, Thayer's Gulls *Larus thayeri*, Arctic Terns *Sterna paradisaea*, Jaegers *Stercorarius* spp., and Sandhill Cranes *Grus canadensis* (**Table 1**). In addition, small numbers of the following species were sighted during the surveys: Rock Ptarmigan *Lagopus mutus* (7 in 1994, 34 in 1995), Snowy Owls *Nyctea scandiaca* (5 in 1994, 6 in 1995), Rough-legged Hawks *Buteo lagopus* (2 in 1994, 5 in 1995), Yellow-billed Loons *Gavia adamsii* (2 pairs in 1994) and Northern Pintails *Anas acuta* (a group of 12 in 1994). The data were not sufficient for determining population estimates for the latter species.

Southern limit of high densities of waterfowl

Very few Greater White-fronted Geese, Lesser Snow Geese, King Eiders or Long-tailed Ducks were observed on the three transects added south of the Southern Stratum in 1995 (**Figures 2 and 3**) and densities for these species were much lower in this area than in any of the three strata. In contrast, many Canada Geese and Tundra Swans were observed on the extra three transects (**Figures 4 and 5**) and densities of these two species were similar or higher in this area than in the three survey strata.

Table 1. Estimated numbers and densities ± standard errors (S.E.) of waterfowl and other species observed within the 6,265km^2 survey area in the Rasmussen Lowlands, Central Canadian Arctic in June 1994-1995. Mean estimates have been adjusted by a visibility correction factor (VCF) when possible. Refer to **Table 2** for estimates of Lesser Snow Geese.

Species	Year	Number on Transects	Number of Birds ±S.E.	Density (birds/km^2) ±S.E.
Greater White-fronted Goose	1994	1,312[b]	16,329±1859	2.61±0.30
Anser albifrons frontalis	1995	1,921[b]	15,025±1187	2.40±0.19
	Mean (No VCF)	1,617[b]	15,677±1103	2.50±0.18
	Mean (VCF)a	2,425[b]	23,516±1530	3.75±0.24
Greater White-fronted Goose pairs	1994	224[b]	2,786±257	0.44±0.04
	1995	403[b]	3,109±251	0.50±0.04
	Mean (No VCF)	314[b]	2,947±180	0.47±0.03
	Mean (VCF)a	470[b]	4,421±269	0.71±0.04
Canada Goose	1994	343[b]	4,314±621	0.69±0.10
Branta canadensis hutchinsii	1995	435[b]	4,236±538	0.68±0.09
	Mean (No VCF)	389[b]	4,275±411	0.68±0.07
	Mean (VCF)a	584[b]	6,412±616	1.02±0.10
Canada Goose pairs	1994	131[b]	1,651±230	0.26±0.04
	1995	164[b]	1,616±216	0.26±0.03
	Mean (No VCF)	148[b]	1,634±158	0.26±0.03
	Mean (VCF)a	221[b]	2,450±236	0.39±0.04
Tundra Swan	1994	340	4,254±427	0.68±0.07
Cygnus columbianus	1995	373	3,389±328	0.54±0.05
	Mean (No VCF)	357	3,822±269	0.61±0.04
Tundra Swan pairs	1994	142[c]	1,778±117	0.28±0.02
	1995	162[c]	1,485±141	0.24±0.02
	Mean (No VCF)	152[c]	1,632±92	0.26±0.01
King Eider	1994	672[d]	8,445±786	1.35±0.13
Somateria spectabilis	1995	830[d]	6,928±710	1.11±0.11
	Mean (No VCF)	751[d]	7,687±530	1.23±0.08
	Mean (VCF)a	1,338[d]	13,690±944	2.19±0.15
King Eider pairs	1994	309[d]	3,888±350	0.62±0.06
	1995	392[d]	3,291±353	0.53±0.06
	Mean (No VCF)	351[d]	3,590±249	0.57±0.04
	Mean (VCF)	624[c]	6,393±443	1.02±0.07
Long-tailed Duck	1994	157	1,987±531	0.32±0.08
Clangula hyemalis	1995	236	1,993±416	0.32±0.07
	Mean	197	1,990±337	0.32±0.05
	Mean (VCF)a	536	5,427±920	0.87±0.15

Table 1 continued

Species	Year	Number on Transects	Number of Birds ±S.E.	Density (birds/km^2) ±S.E.
Red-throated Loon	1994	32	407±80	0.06±0.01
Gavia stellata	1995	18	164±49	0.03±0.01
	Mean (No VCF)	25	285±47	0.05±0.01
Pacific Loon	1994	69	870±142	0.14±0.02
Gavia pacifica	1995	56	467±91	0.07±0.01
	Mean (No VCF)	63	669±84	0.11±0.01
Glaucous Gull	1994	92	1,138±322	0.18±0.05
Larus hyperboreus	1995	102	879±216	0.14±0.03
	Mean (No VCF)	97	1,008±194	0.16±0.03
Thayer's Gull	1994	48	593±505	0.09±0.08
Larus thayeri	1995	22	154±81	0.02±0.01
	Mean (No VCF)	35	373±256	0.06±0.04
Arctic Tern	1994	19	236±77	0.04±0.01
Sterna paradisaea	1995	34	259±96	0.04±0.02
	Mean (No VCF)	27	247±62	0.04±0.01
Sandhill Crane	1994	86	1,070±200	0.17±0.03
Grus canadenisis	1995	81	722±92	0.12±0.01
	Mean (No VCF)	84	896±110	0.14±0.02
Jaeger (unidentified to species)	1994	54	681±170	0.11±0.03
Stercorarius spp.	1995	52	506±104	0.08±0.02
	Mean (No VCF)	53	594±100	0.09±0.02

[a] Visibility Correction Factors: Greater White-fronted Goose and Canada Goose 1.5, King Eider 1.781, and Long-tailed Duck 2.727 (Hines *et al.* 2000, Hines and Wiebe 2004).
[b] Sightings of 1-2 geese considered to be a pair.
[c] Sightings of 2 swans considered to be a pair and sightings of 1 swan considered to be 0.5 pair.
[d] Sightings of pairs, lone males and flocks of 2-4 males considered to be pairs. Observations of 1-4 females and 1-4 King Eiders of unidentified sex are excluded.

Table 2. Estimated numbers of Lesser Snow Geese in the Rasmussen Lowlands, Central Canadian Arctic, in June 1994-1995.

Location	Year	Total Birds	Nesting Pairs
Inglis River colony	1994	13,708	5,943
	1995	10,763	5,330
	Mean	12,236	5,637
Shepard Bay colony	1994	8,226	887
	1995	3,179	1,126
	Mean	5,703	1,002
Snow Goose River colony	1994	Not surveyed	
	1995	99	50
	Mean	99	50
Areas outside the colonies	1994	22,109	-
	1995	25,898	-
	Mean	24,004	
Total in Rasmussen Lowlands	1994	44,043	6,820
	1995	39,939	6,506
	Mean	42,041	6,688

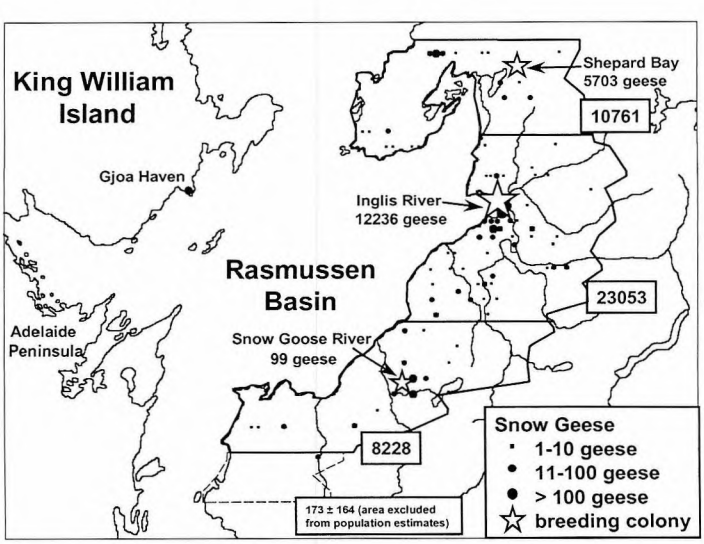

Figure 3. The mean number of Lesser Snow Geese in colonies and seen on each 2km segment during helicopter surveys in the Rasmussen Lowlands, Central Canadian Arctic, in June 1994-1995. Population estimates for each stratum are indicated in boxes by the strata.

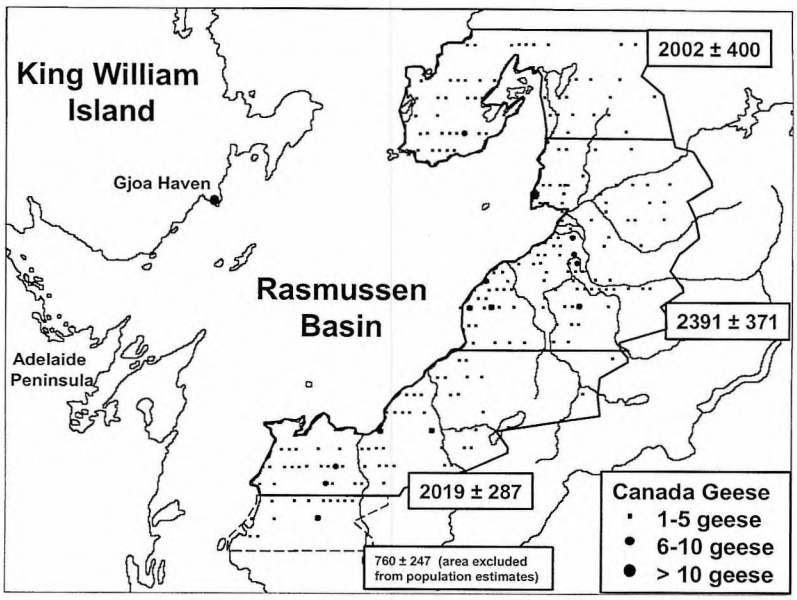

Figure 4. The mean number of Canada Geese seen in each 2km segment during helicopter surveys in the Rasmussen Lowlands in June, 1994-1995. Population estimates ± standard errors for each stratum are indicated in boxes by the strata.

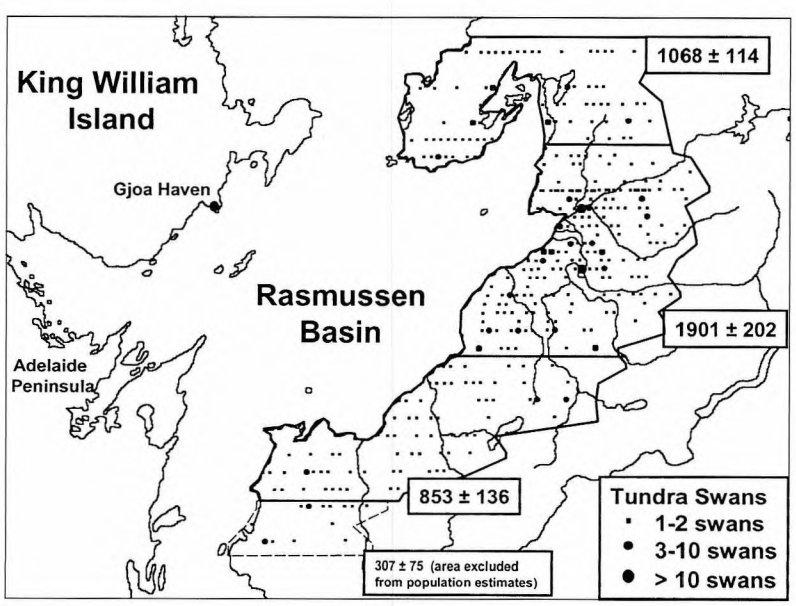

Figure 5. The mean number of Tundra Swans seen in each 2km segment during helicopter surveys in the Rasmussen Lowlands in June 1994-1995. Population estimates ± standard errors for each stratum are indicated in boxes by the strata.

Discussion

Reliability of estimates

Aerial surveys of waterfowl and other wildlife are subject to a number of biases that influence the probability of being sighted. For the species of waterfowl most frequently encountered in the present surveys, attempts were made to overcome this bias by applying visibility correction factors. For reasons discussed elsewhere (Hines *et al.* 2000; Hines & Wiebe 2004), it is probable that the visibility correction factors developed using the 'double counting' or 'mark-recapture' approach would be somewhat low, therefore producing conservative estimates of population size. The only comparable information on visibility bias in helicopter surveys of arctic waterfowl was presented by Bromley *et al.* (1995) for White-fronted Geese and Canada Geese. Bromley *et al.* (1995) indicated that the visibility of nesting geese varied from year to year and was lowest in years of highest nesting success. Recognising that potential form of bias, it was recommended that aerial surveys should be repeated over more than one year and average VCFs (derived from data from several years) should be applied to the mean annual population estimates (Hines *et al.* 2000; Hines & Wiebe 2004). That approach was adhered to in the present study and should limit the influence of annual variation in visibility on estimates of average population size. Although, Bromley *et al.* (1995) did not report VCFs for overall populations, such estimates can be derived from information presented in their Table 2. Average VCFs of 1.5 for Canada Geese and 1.8 for White-fronted Geese calculated from their data are similar or slightly higher than the estimate of 1.5 used for these species in the Rasmussen Lowlands surveys.

The three Snow Goose colonies found in the Lowlands are thought to represent virtually all the nesting population there. Given the high visibility of this species, and the amount of time spent by the authors and their colleagues (Johnston *et al.* 2000) in flights over the lowlands, it is unlikely that any nesting colonies were missed. In addition, repeat surveys of the Snow Goose colonies produced estimates that were within 14% of the mean, suggesting that the 2-km wide transects surveyed from higher altitude (230m above ground) were adequate for counting geese in the colonies.

Waterfowl distribution and abundance

The results of this study improve on and update previous findings (McLaren *et al.* 1977; Zdan & Brackett 1977; Allen & Hogg 1978; Bromley & Stenhouse 1994) that the Lowlands site is an important breeding and summering area for waterfowl and, in particular, supports high numbers of Greater White-fronted Geese. The authors estimated that 23,500 White-fronted Geese (3.4 geese/km^2) were present on their survey area with average breeding densities of 0.7 pairs/km^2. Summer

densities of White-fronted Geese are typically <3 geese/km^2 (Ely & Dzubin 1994), so the densities recorded for the Lowlands are comparable to or higher than for most other arctic areas. The authors' estimates were also higher than the 10,000 geese observed in a 9,825km^2 survey (1.0 geese/km^2 uncorrected for visibility bias) in the Lowlands in the mid-1970s (McLaren *et al.* 1977) but are consistent with other findings that Greater White-fronted Goose numbers have increased since that time (Canadian Wildlife Service Waterfowl Committee 2002). Autumn population inventories indicated that the Mid-continent Population of White-fronted Geese averaged about 0.9 million birds in 1994-95 (Canadian Wildlife Service Waterfowl Committee 2002), suggesting that the Lowlands supported >2% of the overall population during summer.

It was estimated that over 42,000 Lesser Snow Geese, including over 13,000 nesting geese, used the Lowlands in 1994-95. This is a substantial increase from the 5,000-6,000 Lesser Snow Geese that McLaren *et al.* (1977) found there during the mid-1970s, but parallels the large increases that have occurred at other colonies in the Central Canadian Arctic (Abraham & Jefferies 1997; R.H. Kerbes and K. M. Meeres, Canadian Wildlife Service, Saskatoon, SK, pers. comm.). The Mid-continent Population of Lesser Snow Geese was estimated to be close to 4 million nesting birds in 1997-98 and probably numbered 6 million adults if non-breeders are included (R.H. Kerbes and K.M. Meeres, pers. comm.). Therefore, the authors' results suggest that >0.5% of the Mid-continent Population used the Lowlands in summer.

McLaren *et al.* (1977) estimated that fewer than 1,000 Canada Geese used the Lowlands in the mid-1970s whereas the authors' results indicated that there were 6,400 geese present. The Canada Geese encountered during the authors' surveys were probably from the Tallgrass Prairie Population and belong to the race *B. c. hutchinsii* (McLaren *et al.* 1977; Bellrose 1980). The Tallgrass Prairie Population has increased since the 1970s (Sharp & Moser 1998), which corresponds with the authors' finding of increased numbers in the Lowlands. The mean winter estimate for the Tallgrass Prairie Population was approximately 250,000 birds from 1992-93 to 1995-96 (Sharp & Moser 1998), indicating that the Lowlands supported over 2% of this population.

McLaren & McLaren (1984) reported that the Rasmussen Lowlands site is a prime nesting area for Tundra Swans in the mid-1970s. They estimated that 5,500 swans were using a 9,825km^2 area (0.6 swans/km^2) in the Lowlands, which is comparable to the 1994-1995 estimate of 3,800 swans on the authors' 6,250 survey area (also a density of 0.6 swans/km^2). The winter estimate of the Eastern Population of Tundra Swans was approximately 80,000 birds from 1993-1996 (Sharp & Moser 1998). Therefore, 5% or more of the Eastern Population uses the Lowlands.

In striking contrast to the situation with goose populations, King Eider and Long-tailed Ducks numbers have declined greatly in the Lowlands since the mid-1970s. In 1994-1995 it was estimated that 13,690 King Eiders and 5,427 Long-tailed Ducks were present, whereas McLaren *et al.* (1977) found 30,000-35,000 King Eiders and 10,000-15,000 Long-tailed Ducks in the mid-1970s. The decline in numbers may have been even greater than suggested by these estimates because the aerial counts of McLaren *et al.* (1977) were not adjusted for visibility bias (and, thus, could have been >80% higher). Based on ground counts of breeding pairs, Gratto-Trevor *et al.* (1998) also documented a significant decline in King Eider numbers in the Lowlands from the mid-1970s to the mid-1990s. Precise estimates of the numbers of King Eiders and Long-tailed Ducks in the Eastern Canadian Arctic are lacking, but, based on observations of relative waterfowl numbers elsewhere in the arctic, the authors suspect that at least 1% of the eastern Canadian arctic population of King Eiders uses the Lowlands.

Potential for a National Wildlife Area

Johnston *et al.* (2000) recommended that the Rasmussen Lowlands site be considered for designation as a National Wildlife Area because of its richness of shorebird species, its position in an ecological transition zone, its abundance of diverse and suitable bird habitat, and its significant portions (>1%) of specific populations of shorebirds and other species. The authors' results support previous studies that the Lowlands site is an important area for waterfowl and further strengthen the recommendations that the area be considered for protection. In particular, the authors' findings suggest that the Rasmussen Lowlands is used in summer by more than 2% of the Mid-continent Population of Greater White-fronted Geese, over 2% of the Tallgrass Prairie Population of Canada Geese, about 5% of the Eastern Population of Tundra Swans and probably 1% of the eastern arctic population of King Eiders. Based on numbers and densities of shorebirds present in the Rasmussen Lowlands, Johnston *et al.* (2000) proposed a potential boundary for a National Wildlife Area that would include all of this study's Northern and Central Strata, plus most of its Southern Stratum and the escarpment to the east of the study area, a high density nesting area for the tundra race of Peregrine Falcons *Falco peregrinus tundrius* (Shank 1995). Thus, this proposed boundary encompasses the high density areas of White-fronted Geese and King Eiders, the Lesser Snow Goose colonies and most of the areas with high densities of other waterfowl. The authors agree with the suggestion by Johnston *et al.* (2000) that their proposed boundary would be a useful starting point when discussions about the conservation status of the area begin.

Acknowledgements

We greatly appreciate the help of Vicky Johnston and Stephen Pepper who allowed us to use their field camp and facilitated our field work in other ways as well. In addition, we thank J-F. Dufour for help with the manuscript, the Polar Continental Shelf Project (Natural Resources Canada) for providing aircraft and logistic support, and two reviewers for their comments on the manuscript.

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