Annual movements of Interior Canada Geese *Branta canadensis interior* marked in Greenland, revealed by recoveries and re-sightings during 1992–2018

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Abstract

Analysis of 1,360 resightings and 105 recoveries made in continental North America during 1992–2018 of 542 Interior Canada Geese *Branta canadensis interior* marked in central-west Greenland in summers 1992, 1997, 2008, 2009 and 2014 were used to describe their winter quarters and the autumn and spring migration routes. Results showed that the geese arrived simultaneously in Newfoundland and Labrador, northeast Maine and central Nova Scotia in late September/October, but resightings and recoveries from Connecticut in September suggest that many may skip autumn staging and travel directly to be near their ultimate wintering site following arrival in continental North America. Some of the geese remained in northeast Maine and Nova Scotia into December, but the majority continued down into Massachusetts, Connecticut and especially Long Island in New York, which was the main wintering area for the marked individuals, with most occurring there during December–February inclusive. There were also resightings in January/February and recoveries in December/January from sites further south and west in New Jersey, Pennsylvania, Maryland and Delaware. Reports were too few to determine whether they constituted a regular movement, but there was no evidence that hard weather had displaced geese southwest from their core wintering areas, so it seems likely that some Canada Geese from Greenland do migrate to these areas each winter, which may represent

their most distant winter quarters. By March, the Greenland Canada Geese had returned northwards and in the second half of the month aggregated in large numbers in the lower Richelieu Valley in Quebec. Very few birds were reported in Maine or Nova Scotia, in areas used in autumn, and there were no further records in continental North America after the first few days of May. Subtle differences between resightings and recovery distributions suggest differential spatial and temporal bias associated with both methods for describing the migration routes of Greenland's Canada Geese. The Greenland-breeding *interior* race of Interior Canada Geese has close genetic affinities with the Atlantic Population of *B. c. interior* which breeds in northern Quebec and winters mostly in Delaware and Maryland. Despite some winter overlap of the two populations, these results support the continued inclusion of Greenland birds in current management of the North Atlantic Population of the Atlantic Canada Goose *B. c. canadensis*, which breeds in Newfoundland and Labrador and southeast Quebec, in that these populations of *interior* and *canadensis* Canada Geese use similar staging and wintering areas.

Key words: autumn migration routes, hard weather movements, spring migration routes, staging areas, winter distribution.

There remains a lack of information relating to the status, abundance and distribution of the Canada Goose *Branta canadensis* races and populations breeding in west Greenland, which are thought to winter exclusively on the North American continent (Fox *et al.* 1996). Although the smaller Cackling Goose *Branta hutchinsii* seems to have been present during *c.* 1000–1400 years A.D. (Gotfredsen 2002), this species currently remains sporadic and rare in west Greenland, where the dominant form seems to be the Interior Canada Goose *Branta canadensis interior* (Fox *et al.* 2012; Burnham *et al.* 2014). Scribner *et al.* (2003) used telemetry and genetic analysis to show that the Greenland Canada Geese, which they sampled, were associated with the population of *B. c. interior* that breeds in the north of Quebec. These were thought to benefit from extending their range to breed in west Greenland because of the more amenable spring temperatures occurring further north in recent years (Fox *et al.* 2011). This race is now known to occur in Greenland from north of Qaanaaq (just south of 78°N: Vaughan 1988; Best & Higgs 1990) and to breed from 77°N (Burnham *et al.* 2014) as far south as Nuuk (64°N, Boertmann 1994). Aerial surveys suggest greatest concentrations in the interior between Kangerlussuaq (67°N) and southern Disko Bay (68°N) and in lowland areas south of Aasiaat (68°N), Disko Island (70°N), Nuussuaq (70°N) and Svartenhuk (71°N) during both the nesting and post-moulting periods (Malecki *et al.* 2000; Fox & Glahder 2010).

It is important to understand the ecology of the Canada Goose population summering in Greenland, and the role played by factors affecting the population throughout the annual cycle away from the breeding

areas, for informing goose management programmes throughout the wintering range. Management plans have been drawn up for the various Canada Goose populations wintering in North America, including the North Atlantic Population (NAP), which embraces all of the Atlantic Canada Geese, race *Branta canadensis canadensis*, summering in Newfoundland, Labrador, and in parts of southeastern Quebec (Atlantic Flyway Canada Goose Committee 2008a). In 1996, the U.S. Fish and Wildlife Service and Canadian Wildlife Service formally recognised the NAP as a separate population to the Atlantic Flyway Population (AP) of *B. c. interior*, which primarily breeds in northern Quebec (Atlantic Flyway Canada Goose Committee 2008b). Their decision was based upon the fact that breeding ground aerial surveys had shown that Quebec-breeding migrants were reaching critically low levels, while Canada Geese originating from Newfoundland and Labrador were increasing. To make matters more complicated, both the AP and NAP Canada Geese mix on the wintering grounds in the United States with Atlantic Flyway Resident Population (AFRP) Canada Geese, which due to their increasing abundance and nuisance factor have been the focus of attempts to maximise the opportunity for their harvest (Atlantic Flyway Canada Goose Committee 2011). Unfortunately, once mixed with the very many other Canada Geese from the AP, NAP and AFRP of eastern North America outside of the breeding period, it is impossible to identify Canada Geese of Greenland origin to understand their migration routes and distribution. More information about their degree of overlap with other Canada Geese from elsewhere in northeast North America, and the extent to which Greenland birds are being harvested in relation to other Canada Geese along their flyway during the non-breeding season, is needed to inform and assess the current effects of goose management programmes on Greenland-breeding Canada Geese.

To do this, we therefore undertook an analysis of seasonal resightings and recoveries of Canada Geese marked in west Greenland away from their summer quarters during 1992–2014. This updates an initial analysis of sightings and recovery data for Canada Geese marked in west Greenland (Kristiansen *et al.* 1999), and also the telemetry results presented in Scribner *et al.* (2003). We place particular emphasis on identifying key migration routes and stopover areas, as well as on the wintering sites used by these geese.

Methods

In summers 1992, 1997, 2008, 2009 and 2014, non-breeding and family groups of Canada Geese were displaced from waterside feeding areas onto lakes at Isunngua, west Greenland (67°06'N, 50°43'W), during the flightless moult. The birds were then surrounded using inflatable boats and herded into funnel nets erected on land for catching and marking. Most of the adult geese were fitted with metal and yellow plastic leg-rings and with yellow neck-collars bearing the same alpha-numeric codes as the leg-rings, except on occasions when metal rings and/or plastic leg-rings were not available (Table 1). Goslings, generally too small for the collars, were marked

Table 1. Number of Interior Canada Geese caught and marked in Isunngua, central West Greenland, during 1992–2014. In some cases, goslings were too small for collars and even for metal rings and plastic leg-rings; in other cases rings were not available for application in the field; hence the inconsistency in numbers or lack of markers.

Year	Number of adults newly collared	Number of juveniles newly collared	Additional individuals caught, marked and released, including recaptured birds
1992	5		5 adults fitted with leg-rings only.
1997	48	16	2 re-trapped birds from previous years; 43 juveniles fitted with plastic leg-ring only; 18 juveniles with metal ring only.
2008	91		4 re-trapped birds from previous years; 10 adults fitted with plastic leg-rings only; 13 adults without metal rings; 25 leg-ringed juveniles, including 10 juveniles without metal rings.
2009	78		35 re-trapped birds from previous years; 2 adults with metal rings only; 42 plastic and metal leg-ringed juveniles; 23 juveniles with metal rings only.
2014	118		21 re-trapped birds from previous years; 24 plastic and metal leg-ringed juveniles; 22 juveniles with metal rings only.

with plastic leg-rings and/or metal rings (Table 1). Resighting and recovery details were reported to the Bird Banding Laboratory (U.S. Geological Service), the Bird Banding Center (Canadian Wildlife Service) and the Zoological Museum Copenhagen University (administrators of the Greenland bird-ringing scheme), or direct to the Department of Bioscience, Aarhus University. Data presented here are based on 1,360 records from outside of Greenland, out of 1,941 resightings and recoveries made across the flyway from 29 September 1992 (the first recovery date) until 1 May 2018 inclusive.

Results

Overall, 340 adult and 16 first summer Canada Geese were fitted with neck collars in west Greenland during the study, with a further 139 individuals marked with leg-rings and 47 birds with metal rings only.

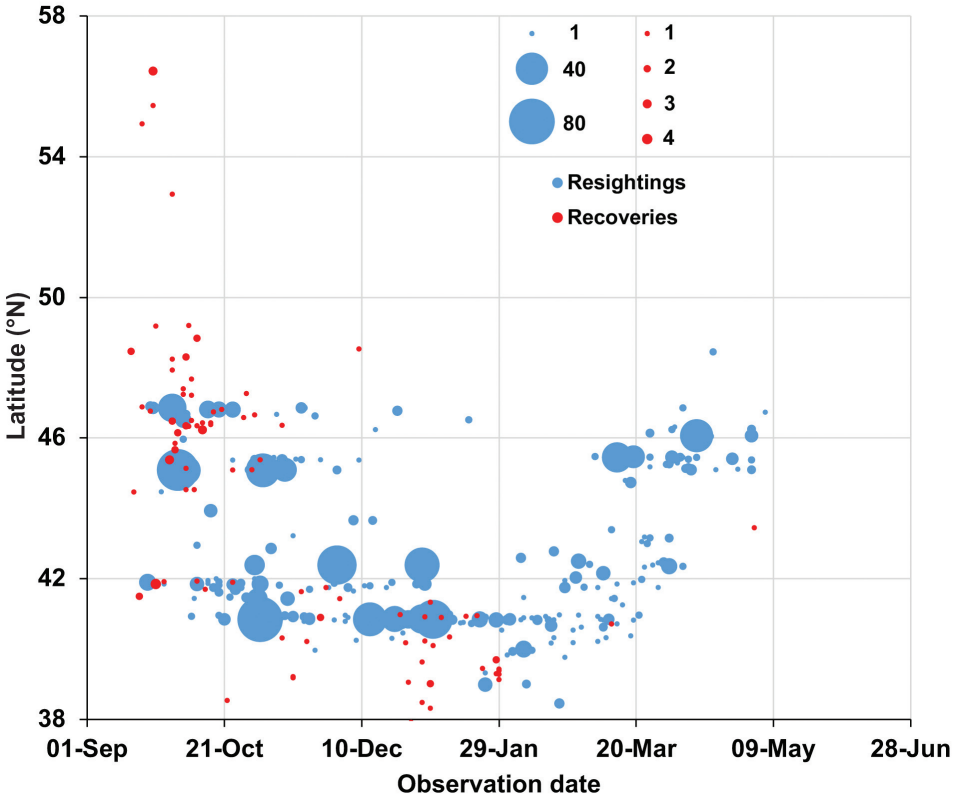

Figure 1. Plot of date for resightings (blue) and recoveries (red) in Canada/United States of America, against latitude of observation, for Canada Geese marked in west Greenland reported during 1992–2014. The size of symbols indicate numbers of observations of different individuals per site per day for each interval. Range = 1–4 records/site for recoveries; 1–79 records/site for resightings.

The distribution of 1,360 resightings and 105 recoveries of these geese at staging and wintering sites in continental North America are shown in Fig. 1. The recoveries included two birds found long dead outside of the hunting season, in Connecticut in March 2015 and on the shores of Lake Ontario, New York State in May 2004.

Autumn migration

In autumn, the most northerly records are of Canada Geese shot in coastal Newfoundland and Labrador in the last 10 days of September, although there are also seven recoveries of geese as far south as Connecticut during this same period (Fig. 2), together with several late September resightings of birds in the northeast part of the state (Fig. 3). Almost half (46%) of combined recoveries and resightings from continental North America in the first half of September came from south of 42°N (Fig. 1), which corresponds to being close to the subsequent wintering areas (Figs. 3–5).

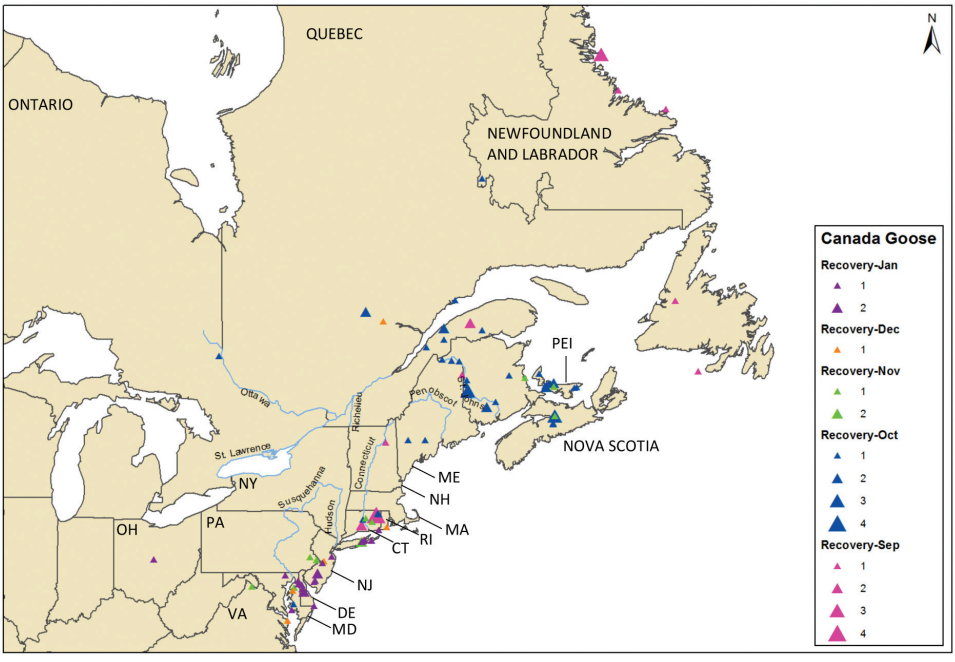

Figure 2. Distribution of 105 recoveries during 1992–2018 of Canada Geese marked in west Greenland during 1992–2014, differentiated by recovery month. Triangle sizes reflect the number of individuals recovered. Standard abbreviations indicate US states where necessary as follows: CT – Connecticut, DE – Delaware, OH – Ohio, NH – New Hampshire, NJ – New Jersey, NY – New York, MA – Massachusetts, MD – Maryland, ME – Maine, PA – Pennsylvania, RI – Rhode Island and VA – Virginia; PEI indicates Prince Edward Island province in Canada.

Another 42% remained on staging areas between 44°–48°N (Fig. 1), where resightings from September until November showed geese remaining around Caribou in northeast Maine and also in mid Nova Scotia (Fig. 3, Fig. 4). Although the resightings would seem to indicate two discrete staging areas (Fig. 3), it is equally clear from the spread of recoveries through Prince Edward Island, both sides of the St Lawrence Seaway, other parts of Maine and New Hampshire (Fig. 2) that Greenland Canada Geese probably migrate on a broader front than these resightings alone would indicate. From mid-October, Greenland Canada Geese appear to be close to their ultimate winter quarters, since reports from Connecticut and Long Island increased from 35% of resightings (n = 17) in early October to 76% (n = 35) in the second half of the month (Fig. 1), and this pattern was also reflected in recovery distributions (Fig. 1). Resightings persist from both northeast Maine and Nova Scotia into November, with a very few reports from Quebec in November and even December, but by these months most marked Greenland Canada Geese are

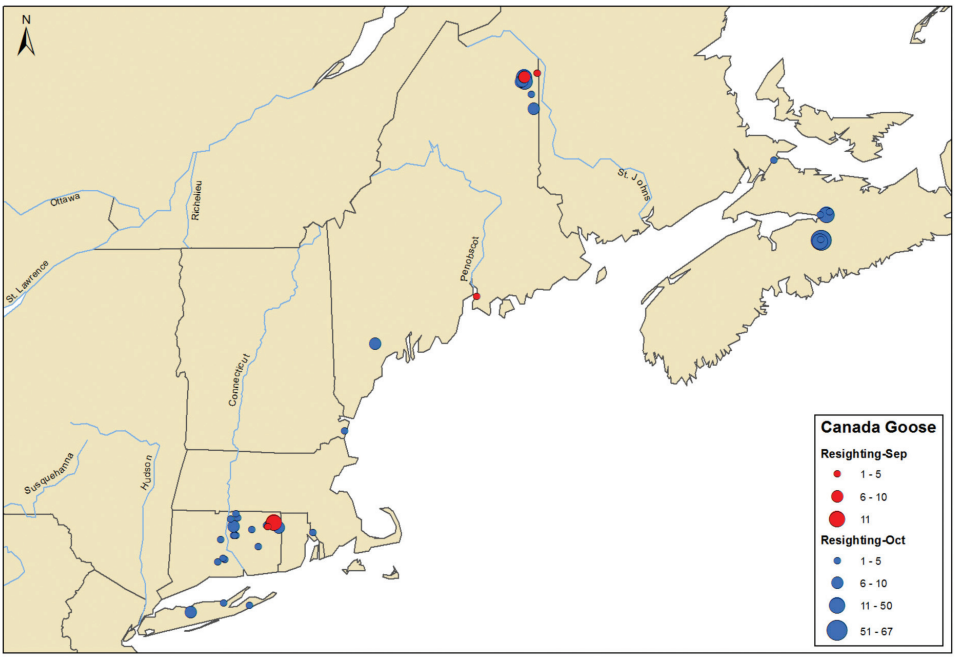

Figure 3. Distribution of 295 September/October resightings made in 1992–2018 of Canada Geese marked in west Greenland during 1992–2014, differentiated by recovery month. Circle sizes reflect the number of individuals reported.

reported from the core of the ultimate wintering area at Long Island, New York, with substantial numbers also still in Massachusetts and Connecticut (Fig. 4).

Winter distribution

Resightings from December, January and February remain concentrated on Massachusetts, Connecticut and Long Island (Figs. 4 and 5), although from December onwards more geese were initially recovered and later resighted further south and west into New Jersey, Pennsylvania, Delaware and Maryland. Despite the total numbers reported in these areas being relatively modest, the numbers recovered here in mid-winter (Fig. 2) confirms that some birds likely shift onwards to these areas at this time but remain undetected by birdwatchers. Unfortunately, we lack sufficient numbers of resightings and recoveries to undertake any detailed analyses of whether these patterns are responses to hard weather in the core wintering areas of Connecticut and Long Island. Sub-zero mean January temperatures recorded at La Guardia Airport in New York during January of 1994, 2003, 2004, 2005, 2009, 2014 and 2015 did not, however, result in significantly greater numbers of geese recovered/resighted south of 40°N compared to further north (Fisher exact

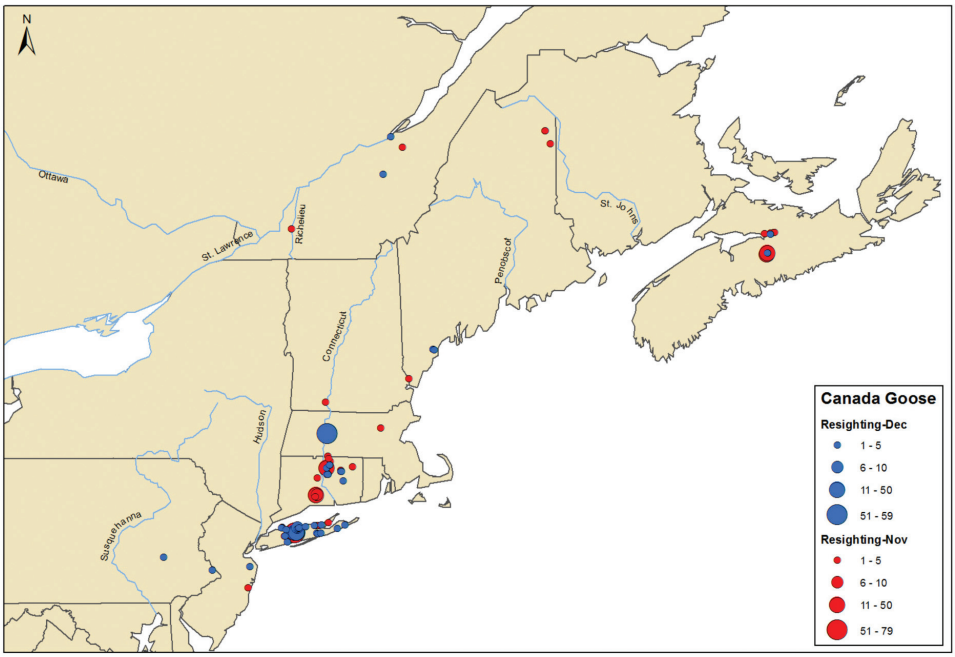

Figure 4. Distribution of 490 November/December resightings made in 1992–2018 of Canada Geese marked in west Greenland during 1992–2014, differentiated by recovery month. Circle sizes reflect the number of individuals reported.

test, $n = 421$, $P = 0.09$, n.s.). However, total numbers were too small south of 40°N in any of the years (overall total $n = 39$) to give confidence in the result.

Spring migration

By March, fewer reports were being received from observers in Long Island and Connecticut, as the Canada Geese move northwards, especially along the Connecticut River (Fig. 6). Already in March, geese begin to use the Richelieu catchment further north, which seems to funnel large numbers of marked geese into areas south of Montreal. Based on resighting data, this area seems to constitute important staging areas for Greenland Canada Geese that may stay until the first few days of May (Fig. 6), after which there were no further records from continental North America. Northeastern Maine and Nova Scotia seem to be of far lesser importance during spring compared to autumn, despite good observer coverage in both areas (Figs. 3 and 6).

Discussion

These results confirm earlier reports (Kristensen *et al.* 1999) that Canada Geese breeding in central west Greenland migrate to overwinter in continental North America, with a winter distribution largely centred on Massachusetts, Connecticut and especially Long Island. There the species seems highly mobile, moving between many different

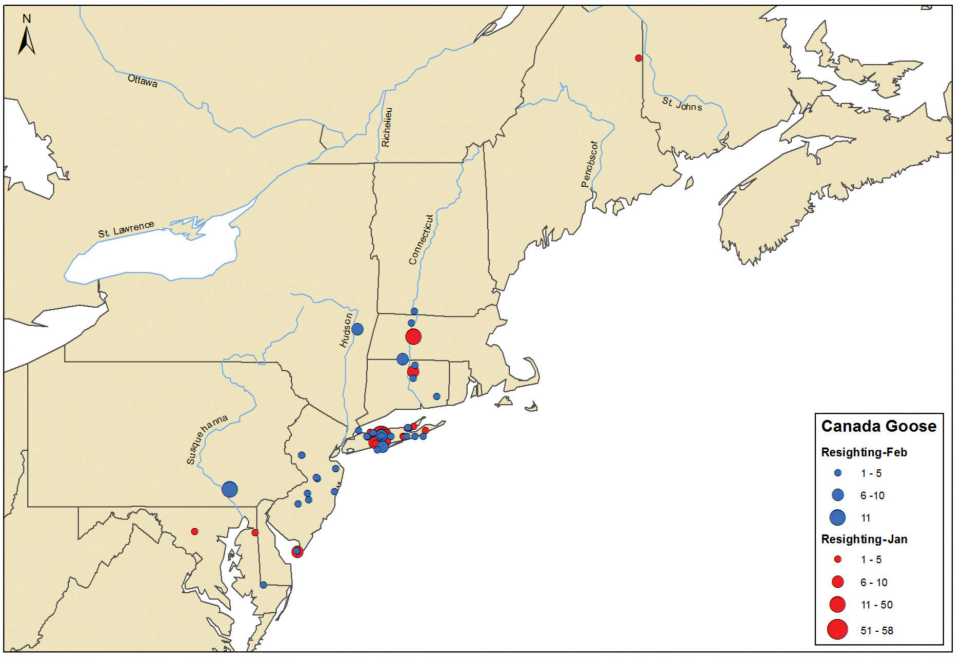

Figure 5. Distribution of 300 January/February resightings made in 1992–2018 of Canada Geese marked in west Greenland during 1992–2014, differentiated by recovery month. Circle sizes reflect show the number of individuals reported.

sites over short periods, although patchy observer cover makes it difficult to generate frequent repeat within-winter resightings of the same individuals. Although we did not ask observers for habitat details associated with resightings, reports and site coordinates viewed on Google Earth indicated that many of the Long Island observations were from playing fields, public parks, baseball pitches and urban lakes, even in quite densely urban areas. This was in considerable contrast to the birds' use of farmland almost everywhere else throughout North America, excluding the recoveries from Newfoundland and Labrador for which we have no habitat details. Relatively small numbers of geese seem to move further to the southwest into New Jersey, Pennsylvania, Delaware and Maryland, based on resightings and recoveries especially from mid-December onwards, but we have no evidence that these movements are linked to hard weather. Interestingly, the only exchanges of Canada Geese with Europe (mostly likely via west Greenland) confirmed by ringing, have involved Maryland, in the southern reaches of the birds' North American range. An adult Canada Goose caught with White-fronted Geese *Anser albifrons flavirostris* on Wexford North Slob, southeast Ireland in November 1993 was recovered in Maryland in January 1995. Also a first-winter Canada Goose caught and fitted with a collar in Maryland

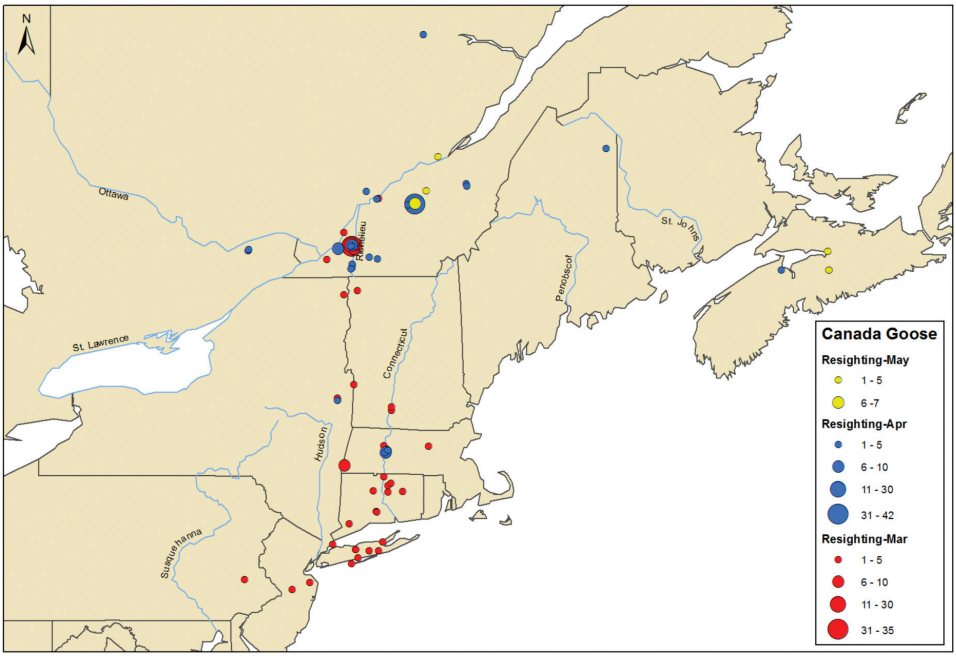

Figure 6. Distribution of 275 March/April/May resightings made in 1992–2018 of Canada Geese marked in west Greenland during 1992–2014, differentiated by recovery month. Circle sizes reflect the number of individuals reported.

in February 1992 was seen in Grampian, northeast Scotland in November 1992 and subsequently shot further south in Perthshire in January 1993 (Appleton *et al.* 1997).

From the recoveries, it is evident that some Greenland Canada Geese made landfall in Newfoundland and Labrador, but we have no resightings of Greenland-marked Canada Geese from there, nor any information on the relative contribution of the local Canada Geese (race *B. c. canadensis*) and Greenland *interior* geese to the hunting harvest in that province. If it were possible to distinguish these races either by size or migration phenology, analysis of tail feathers could determine the age of birds in the hunting kill, offering a potential means of assessing between-year variation in reproductive success among both populations, prior to their migration further south. Two satellite-transmitter tagged Canada Geese marked in Isunngua reported by Scribner *et al.* (2003) took a more westerly route and migrated via southern Baffin to northern Quebec before moving further south, but because of the lack of observers in this part of the Arctic we have no resightings or recoveries from the area. We therefore cannot determine the proportion of the Greenland Canada Geese that migrate via their ancestral breeding areas in northern Quebec, and how that affects their autumn staging routes towards ultimate winter quarters.

Patterns among subsequent resightings suggest that the geese mainly migrate through northeast Maine and central Nova Scotia in autumn, two areas that seem to be of disproportionate importance during September to December. Both areas represent lowland areas of intensive arable agriculture with extensive grasslands, in contrast to the heavily wooded areas in the surrounding regions, so naturally represent highly attractive staging areas for geese. In northeast Maine, Canada Geese have begun to stage in large numbers since the 1980s when there was a wide scale shift from potatoes and oats to more intensive barley production. They glean spilled grain in the extensive barley stubble fields as long as these are available and even benefit from the sprouting grain after these are ploughed, which gives abundant new growth; where these are still in the ground, the geese also feed on waste potatoes, especially after softening as a result of ground frosts (Bill Sheehan *in litt.*). The length of stay of geese is highly dependent on the extent of the available food resource, so birds tend to move on if food is scarce, as in seasons like 2009 with more oats and less barley, which is less attractive to geese (Bill Sheehan *in litt.*). Generally, Canada Geese depart this part of Maine in late October when snow starts to lay, but if there is food and the winter is mild, they can stay until December in some seasons (Bill Sheehan *in litt.*). In central Nova Scotia, the geese resort primarily to freshly cut maize stubble to which they resort from mid to late November in very large concentrations. Prior to the harvest, they tend to be more dispersed and feed in smaller groups on grassland, ignoring winter wheat and soyabean in the area, but potentially reducing resighting probability earlier in the season (Eric Mills *in litt.*). As in Maine, their departure seems to have as much to do with food depletion as severe weather. It is interesting that some individually-marked Isunngua birds are present as far south as Connecticut in late September, at the same time as other birds have been shot in Newfoundland and Labrador. This is despite the fact that birds caught at the same time may remain together in staging areas in Maine and Nova Scotia into November and even December (Greenland White-fronted Goose Study unpubl. data). Reports of shot and resighted early arrivals in September and early October in North America (including those as far south as Connecticut) included birds from both non-breeding flocks and birds marked in families in Isunngua the same year. What determines these differences in autumn staging strategies remains obscure, but it could be illuminating to deploy GPS tags on a series of individuals in Greenland to relate body condition and breeding/social status at capture to subsequent decisions made along the migration route the following autumn. Retrospective analysis shows that the same individuals have been resighted in Maine and Nova Scotia in different autumns, implying that individual Canada Geese do not show site fidelity to one or other of these two staging routes (Greenland White-fronted Goose Study, unpubl. data).

In spring, the lower Richelieu valley seems to be of disproportional importance for Isunngua-marked Canada Geese, as large numbers seem to concentrate here as soon as open water is made available by the

spring thaw, compared with very much lower numbers in Nova Scotia at the same time. At present, we know very little about habitat use in these areas or the reason they are so attractive to spring staging Canada Geese. Future deployment of telemetry devices would be helpful in determining habitat use of Greenland Canada Geese and to show whether these areas constitute their major spring staging areas, or if the apparent concentration of reports is the result of bias in the relative distribution of active observers in particular areas.

Comparing the results from resightings and recovery data relating to Canada Geese marked in Isunngua suggests that there is generally a more widely dispersed pattern of reports amongst the recoveries compared to the resightings. This implies that the distribution of observers reporting collared geese is more clumped than that of the hunters, which may introduce considerable geographical bias of which we should be aware when interpreting these results. Since hunting effort is constrained temporally, and to some extent geographically, potential biases in the recovery data also need to be taken into consideration. There is no spring hunting season for Canada Geese, so we cannot be confident that the bias of resightings from the Richelieu Valley, south of Montreal area is not attributable to uneven observer coverage at this stage of the annual cycle. Even allowing for these sources of bias, we are fortunate to be able to use this uneven distribution of volunteer observers through their reporting of resightings and recoveries to provide vital insights into the annual range and distribution of Greenland marked Canada Geese outside of the summering range, which before the 1990s was completely unknown.

The overall results presented here support the decision of the Atlantic Flyway, the U.S. Fish & Wildlife Service and the Canadian Wildlife Service to include the Greenland-breeding *B. c. interior* within the population management unit for *B. c. canadensis* (NAP) breeding in Newfoundland and Labrador/southeast Quebec. This is because the AP northern Quebec breeding *interior* birds tend to migrate southwards further west in the United States, with conspicuously high autumn recovery rates in Vermont and western parts of New York State (see Figs. 7 and 8 in Atlantic Flyway Canada Goose Committee 2008b), from where we have almost never received recoveries or resightings of Isunngua-marked birds. Equally, relatively few Greenland-marked birds have been reported or seen in Delaware and Maryland, compared to the dense recoveries of marked AP Canada Geese recovered from these areas in mid-winter (see Fig. 8 in Canada Goose Committee 2008b). In contrast, there are very large numbers of resightings of Greenland birds from southern New England and especially Long Island, from which there are very few recoveries of AP Canada Geese (Atlantic Flyway Canada Goose Committee 2008b) but very large numbers of recoveries and resightings of NAP geese (Atlantic Flyway Canada Goose Committee 2008a). Similarly, very few NAP Canada Geese have been observed wintering in New Jersey and further south (Atlantic Flyway Canada Goose Committee 2008a). Greenland-breeding *interior* race Canada Geese have closer taxonomic

affinities with the AP *B. c. interior* geese, which breed in northern Quebec and winter mostly in Delaware and Maryland (Scribner *et al.* 2003). The NAP *B. c. canadensis* breeds in Newfoundland, Labrador and southeast Quebec, stages in Prince Edward Island, Nova Scotia and Maine and winters in southern New England and on Long Island, with fewer birds continuing to the Lower Hudson River Valley and New Jersey (Atlantic Flyway Canada Goose Committee 2008a). The definition of management units for goose populations are, by definition, a human construct, which may not always correspond to biological definitions of these populations. Management of Canada Goose stocks can only be implemented within the confines of their distribution in time and space, for instance through the designation of protected wintering areas and refuges, assessment of hunting kill, and ultimately through the regulation of harvest. Hence, despite some winter overlap of both Interior Canada Goose populations, the results we present here support the justification for including the Greenland birds within the NAP management plan together with the Atlantic Canada Geese (as occurs at the present; Atlantic Flyway Canada Goose Committee 2008a), despite genetic and ecological affinities with AP *interior* birds which breed in northern Quebec.

Acknowledgements

We are very deeply grateful to the very many people who have supported this study. We especially thank all of the 37 expedition members who assisted with the capture of geese in Greenland (mostly funded at their own expense) and the 259 different observers that have either provided data through reading of collars or by reporting recoveries of shot birds (all alas too numerous to mention). Thanks to Kaj Kampp and the Zoological Museum in Copenhagen for the supply of rings and to Naalakkersuisut, the government of Greenland, for permission to catch and mark geese under licence there. We acknowledge financial support from the United States Department of Agriculture Animal and Plant Health Inspection Service in summer 2009 as part of a collaborative project with the Danish National Environmental Research Institute screening for highly pathogenic avian influenza in west Greenland. The Greenland White-fronted Goose Study funded the collars and rings and supported the catching in all other years, we gratefully thank its many supporters that helped to finance these projects. Thanks to Matthew Rogosky, Jennifer Mackay, Rose DeComo and Mary Gustafson at the U.S. Geological Service Bird Banding Laboratory at Patuxent; Kaj Kampp at the Zoological Museum, University of Copenhagen and Linda Laurin at the Canadian Wildlife Service Bird Banding Center for their unswerving support and help over many years in supplying resighting and recovery data. Thanks to the Kangerlussuaq International Science Support facility for serving as a transit base and looking after our gear in Greenland, but especially to Basse Vængtoft for his kindness, logistical help and support there over many years. Although invidious to single out individual observers, we must express our particular gratitude to Bill Sheehan and Eric Mills for their knowledge and insight regarding

geese in their respective areas. We are extremely grateful to Jana Kotzerka for her preparation of the maps. We also thank Min Huang, Larry Griffin and Eileen Rees for their helpful reviews of the paper.

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