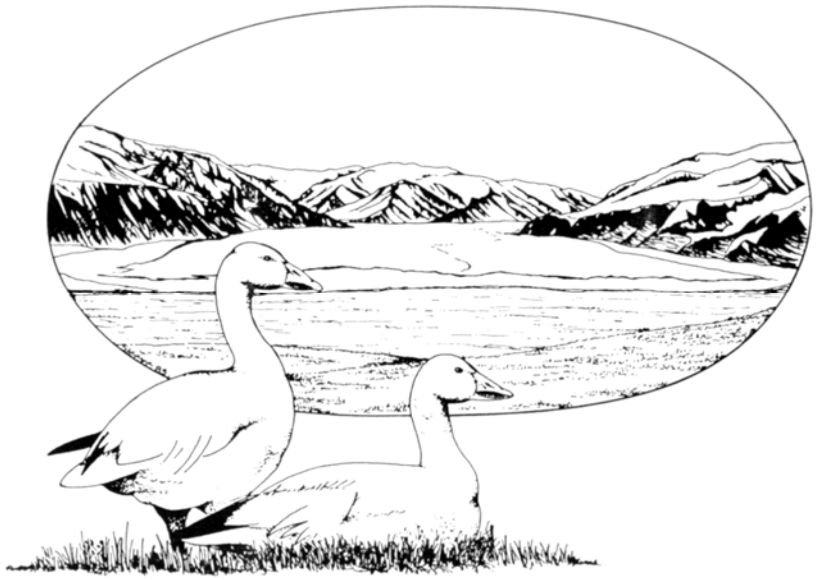
POPULATION STUDY OF GREATER SNOW GEESE AND ITS NESTING HABITAT ON BYLOT ISLAND, NUNAVUT IN 2014: A PROGRESS REPORT



Gilles Gauthier — Département de biologie & Centre d'études nordiques, Université Laval, Québec

Marie-Christine Cadieux — Département de biologie & Centre d'études nordiques, Université Laval, Québec

Mark Dionne — Canadian Wildlife Service, Environment Canada, Québec

Joël Bêty — Département de biologie & Centre d'études nordiques, Université du Québec à Rimouski

Dominique Berteaux — Département de biologie & Centre d'études nordiques, Université du Québec à Rimouski

22 January 2015

INTRODUCTION

In 2014, we continued our long-term study of the population dynamics of Greater Snow Geese (*Chen caerulescens atlantica*) and of the interactions between geese, plants and their predators on Bylot Island. Like many other goose populations worldwide, Greater Snow Geese have increased considerably during the late XXth century. The exploding population has imposed considerable stress on its breeding habitat, while extensive use of agriculture lands provides an unlimited source of food during winter and migratory stopovers for them. Remedial management during autumn, winter and spring has been undertaken since 1999 in Canada and 2009 in the United States to curb the growth of this population. A synthesis report produced in 2007 evaluated the initial success of these special conservation measures. However, both the Avian Monitoring Review Steering Committee Final Report and the Greater Snow Goose Action Plan released in 2012 by the Canadian Wildlife Service called for a continued monitoring of the dynamic of this population and of its habitats. In response to those needs, the long-term objectives of this project are to (1) study changes in the demographic parameters of the Greater Snow Goose population, and especially the effects of the spring conservation harvest, (2) determine the role of food availability and predation in limiting annual production of geese, and (3) monitor the impact of grazing on the Arctic vegetation.

OBJECTIVES

Specific goals for 2014 were as follows:

1) Monitor productivity (egg laying date, clutch size and nesting success) of Greater Snow Geese on Bylot Island.

2) Mark goslings in the nest to provide a sample of known-age individuals to be used to assess the growth of goslings by their recapture in late summer.

3) Band goslings and adults, and neck-collar adult females at the end of the summer to continue the long-term study of demographic parameters such as survival and breeding propensity.

4) Monitor the abundance of lemmings and study their demography along with factors affecting their cyclic fluctuations of abundance.

5) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).

6) Monitor the breeding activity of foxes at dens.

7) Capture and mark adult Arctic Foxes and their pups with ear-tags to study their movements and demography.

8) Sample plants in exclosures to assess annual production and the impact of goose grazing on plant abundance in wet meadows.

9) Maintain our automated environmental and weather monitoring system.

FIELD ACTIVITIES

Field camps. — In 2014, we operated two camps on Bylot Island: the main field station, located at 6 km from the coast in the largest glacial valley on the island ("Qarlikturvik Valley", 73° 08' N, 80° 00' W), was occupied from 12 May to 22 August. However, arrival of the goose study team, which normally occurs around 1 June, was delayed by a week due to bad weather. A secondary camp, located in a narrow valley 30 km south of the main field station and 5 km from the coast ("Camp-2 area", 72° 53' N, 79° 54' W) was occupied from 21 May to 22 July (Fig. 1). Finally, 8 fly camps were also established for 3-9 days at various times throughout the island, west of Pointe Dufour.

Field parties. — The total number of people in both camps ranged from 2 to 18 depending on the period. Members of our field party included project leaders Gilles Gauthier, Joël Bêty, Dominique Berteaux, Mark Dionne and several graduate students whose thesis projects addressed many of the objectives mentioned above: Cynthia Resendiz (PhD, objectives 1, 2 and 3), Vincent Marmillot (MSc, objectives 1), Dominique Fauteux (PhD, objective 4), Audrey Robillard (PhD, objective 5), Andréanne Beardsell (MSc, objective 5), Yannick Seyer (MSc, objective 5), Florence Lapierre-Poulin (MSc, objective 6), Clément Chevalier (PhD, objective 7). Several other students assisted them in the field, including: Audrey Lauzon, Christine Lambert, Marine Serra-David, Magaly Oakes and Frédéric Dulude-de Brouin. Other people in the field included Marie-Christine Cadieux, a research professional in charge of goose banding and plant sampling (objectives 3 and 8); Denis Sarrazin, research professional responsible of the maintenance of the weather stations (objective 9); Christian Marcotte, a wildlife technician, from the Canadian Wildlife Service (CWS, Quebec region) and Jean-François Therrien, a biologist from the Hawk Mountain Sanctuary (Pennsylvania, USA).

Several other people also used our camps during the summer. They were Jean-François Lamarre (PhD student), Pascal Royer-Boutin (MSc student), Eric Reed (biologist from the CWS, Gatineau region), Fanny Senez-Gagnon and Don-Jean Léandri-Breton who studied shorebirds, lapland longspurs and insects under the supervision of Joël Bêty; the field party of Daniel Fortier (Université de Montréal) and Esther Lévesque (Université du Québec à Trois-Rivières), which included Étienne Godin (PhD student), Stéphanie Coulombe (MSc student), Audrey Veillette (MSc student), Maxime Tremblay (MSc student), Laurent Gosselin and Sabine Veuille, who studied the permafrost and the geomorphology of the island; the field party of Isabelle Laurion (Institut National de la Recherche Scientifique), which included Frédéric Bouchard (post-doc fellow) and Vilmantas Preskienis (PhD student), who studied the carbon cycle in ponds; and Florent Dominé (Takuvik, Université Laval/CNRS) and Mathieu Barrère (PhD student) who studied the snow physical and chemical properties. Debbie Gardiner from Parks Canada inspected both camps during the summer. Lucas Habib (acting manager of *Sirmilik National Park*), Jena Merkosak and Randy Quaraq also visited our main field station in early August.

Environmental and weather data. — Environmental and weather data continued to be recorded at our four automated stations. Our network includes 3 full stations, two at low and one at high elevation (20 m and 312 m ASL, respectively) where air and ground temperature, air humidity, precipitations, snow depth on the ground, solar radiation, wind speed and direction are recorded on an hourly basis throughout the year (Fig. 1). A fourth station measures soil surface temperature in areas grazed and ungrazed by geese (i.e. exclosures). All automated stations were visited during the summer to download data and were found to be operating normally. Daily precipitation was also recorded manually during the summer. Finally, snowmelt was monitored by measuring snow depth at 50 stations along two 250-m transects and by visually estimating snow cover in the Qarlikturvik Valley, both at 2-day intervals.

Monitoring of goose arrival and nesting. — We monitored goose arrival in the Qarlikturvik Valley by counting goose pairs every two to three days from our arrival on the island on 8 June until the end of snowmelt on sample plots. Nest searches were carried out within walking distance (~6 km) of both the main field station and the Camp-2 between 8 and 18 June. Nests were found by systematic searches conducted over various areas in the field. At Camp-2, where the bulk of the goose colony is located, nest searches were conducted in two ways: 1) over an intensively-studied core area (ca 50 ha) located in the centre of the colony every year, and 2) within a variable number of 1 and 2-ha plots randomly located throughout the colony. Nest density was calculated over a fixed 20-ha area within the intensively-studied core area. We also attempted to find the nests of as many neck-collared females as possible through intensive searches on foot throughout the nesting colony. All nests were revisited at least twice to determine laying date, clutch size, hatching date and nesting success. During the hatching period, we visited a sample of nests almost daily to record hatch dates and to web-tag goslings.

Goose banding. — From 6 to 16 August, we banded geese with the assistance of a helicopter. Goose flocks of a few hundred birds were rounded up and driven by people on foot into a holding pen made of plastic netting. All captured geese were sexed and banded with a metal band, and all recaptures (web-tagged or leg-banded birds) were recorded. A sample of young and adults was measured (mass and length of culmen, head, tarsus and 9th primary) and some adult females were fitted with coded yellow plastic neck-collars.

Small mammals. — We sampled the annual abundance of lemmings at two sites in the Qarlikturvik Valley (one in wet meadow habitat and one in mesic habitat) and one site at the Camp-2 (mixed habitat) in July using snap-traps. At each site, we used 240 traps set at 80 stations spaced 15-m apart along two to four parallel transect lines 100 m apart and left open for 3 days. We used Museum Special traps baited with peanut butter and rolled oats. We also sample lemming abundance and demography using live-traps. We trapped on 2 permanent grids (330 × 330 m) in the Qarlikturvik Valley (one in wet meadow habitat and one in mesic habitat) with 144 traps per grid and on a 3rd grid (200 × 340 m; 96 traps) in mesic habitat where a predator exclosure experiment was set up in 2012 (the grid is surrounded by a chicken wire fence and covered by criss-crossing fishing line on top). We used Longworth traps baited with apples and set at each grid intersection every 30-m. We trapped for 3 consecutive days during 3 periods (mid-June, mid-July and mid-August) on each grid. All trapped animals are identified, sexed, weighed and marked with electronic PIT tags (or checked for the presence of such tags). Finally, we sampled the abundance of lemming winter nests along 60 500-m transects randomly distributed in 3 different habitats of the Qarlikturvik Valley: wetlands, mesic tundra and streams in mesic tundra.

Breeding activity of foxes at dens and marking. — All known fox dens located within a 600 km^2 area were visited one to five times during the summer and inspected for signs of use and/or presence of reproductive adults with pups. We attempted to live-trap adults with padded leghold traps at locations where foxes were seen hunting or travelling. At reproductive dens, we noted the species (Arctic Fox, *Vulpes lagopus*, or Red Fox, *Vulpes vulpes*) and minimum litter size, and, whenever possible, we live-trapped pups with Tomahawk collapsible cage traps. Cage traps were kept under continuous surveillance and leghold traps were visited at least every 6 hours. Captured foxes were measured, weighed and tagged on both ears using a unique set of coloured and numbered plastic tags. In addition, some adult Arctic Foxes were fitted with ARGOS satellites collars. Samples of winter and summer fur, blood, and scats were also collected for genetic and diet analyses.

Monitoring of other bird species. — We monitored the nesting activity of Snowy Owls (*Bubo scandiacus*), Long-tailed and Parasitic Jaegers (*Stercorarius longicaudus* and *S. parasiticus*), Glaucous Gulls (*Larus hyperboreus*), Rough-legged Hawks (*Buteo lagopus*) and Lapland Longspurs (*Calcarius lapponicus*). Nests were found through systematic searches of suitable habitats or opportunistically and revisited to determine their fate (successful or not) until fledging.

Monitoring of plant growth and goose grazing. — The annual plant production and the impact of goose grazing was evaluated in wet meadows dominated by graminoid plants at 2 sites (Fig. 1): the Qarlikturvik Valley (brood-rearing areas), and the Camp-2 area (nesting colony). At each site, 12 exclosures (1×1 m) were installed in late June in two groups of 6 in the same general area every year. At Camp-2, one of the groups of 6 exclosures was moved about 200 m in 2011 due to the natural drainage of some wetlands. Plant biomass was sampled in ungrazed and grazed areas (i.e. inside and outside exclosures) at the end of the plant-growing season between 10 and 15 August. Plants were sorted into sedges (*Eriophorum scheuchzeri* and *Carex aquatilis*) and grasses (*Dupontia fisheri*). Use of the area by geese was monitored by counting faeces on 1×10 m transects located near each exclosure every 2 weeks in the Qarlikturvik Valley and once at the end of the season at the Camp-2 area.

PRELIMINARY RESULTS

Weather conditions. — Temperatures in spring were generally cool. Air temperature averaged -0.19°C between 20 May and 20 June (0.19°C below normal), the period of goose arrival and egg-laying, and 1.04°C (0.406°C below normal) during 1-15 June, which is the critical period of egg formation and egg-laying. The snow pack at the end of winter was thin (snow depth was 5 cm on 8 June) which resulted in a rapid snowmelt in the lowlands (Fig. 2). Temperature up to mid-July was mild and sunny whereas the end of July and August was generally cool with extensive cloud cover and frequent rainfall (48.5 mm). Overall, precipitations during the summer were low (cumulative rainfall: 57.0 mm, long-term average: 88.4 mm).

Goose arrival and nesting activity. — The number of geese counted on the hills surrounding the Qarlikturvik Valley (main field station), usually the first area used by geese upon arrival, was very low at our first count on 8 June (43 pairs) and increased only slightly over the next few days to peak at 114 pairs on 17 June, a low number (Fig. 3). Due to our delayed arrival to the main field station, it is possible that we missed the peak arrival of geese at those sites. In years of early snowmelt like 2014, geese move rapidly from the first snow-free areas on hill sides to lowland areas and the nesting colony. Census done in the Camp 2 area yielded higher numbers during the same period, with up to 652 pairs present in the colony on 18 June, consistent with this hypothesis.

Nest density in the center of the colony was high for the second year in a row (7.89 vs. 8.85 nests/ha in 2013) and above the long-term average (Table 1). However, many geese were also found nesting away from the colony in the camp 2 area due to the exceptional nesting activity of Snowy Owls on the island in 2013 (see *Monitoring of other bird species* below). Therefore, we were also able to monitor goose nesting in the Qarlikturvik Valley in association with owls. There was a high spatial variation in laying dates between the two areas as geese started laying on average on 9 June (n = 68) in the Qarlikturvik Valley, whereas those nesting in the main colony started laying around 11 June (n = 355), which is one day earlier than the long-term average on Bylot Island (Table 1). This was probably due to a combination of differences in topography and timing of snowmelt between the colony and the nesting sites of Snowy Owls because owls prefer to nests along ridges that are freed of snow earlier than the lowlands of the Camp-2 colony. As expected, clutch size was higher in nests located in the Qarlikturvik Valley (4.28, n = 76), where laying was earlier, than at the main colony (3.77, n = 410).

Nesting success of geese. — Nesting success (proportion of nests hatching at least one egg) was high this year (88% in the colony and 100% in the Qarlikturvik Valley), a value above the long-term average (Table 1). This was largely due to a relatively low activity of Arctic Foxes and avian predators around goose nests, which destroyed fewer nests than last year. During the summer, 144 neck-collared birds were sighted in the colony. Peak hatch was on 9 July in the colony and 6 July in the Qarlikturvik Valley, which is earlier than the long-term average for the latter (Table 1). We tagged 2727 goslings in nests at hatch (2494 in the Camp-2 area and 233 at the main field station). Overall, nesting conditions of geese in 2014 were therefore above average.

Density of broods. — The density of goose faeces at the end of the summer in wet meadows of the Qarlikturvik Valley was high (9.2 ± 2.4 [SE] faeces/m^2; long-term average: 6.2; Fig. 4). Accumulation of faeces began in mid-July, when newly-hatched broods started to move in the valley and increased steadily thereafter until mid-August. Faeces density at the end of the summer was also high in the wet meadows of the nesting colony at Camp-2 (6.8 ± 3.0 faeces/m^2; long-term average: 3.9).

Goose banding. — The banding operation was difficult this year due to bad weather prevailing throughout the banding period. We conducted 5 drives in our core banding area, i.e. in the lowlands and hills bordering the main field station to the south and north (< 8 km), and 1 additional drives further away, between the Camp 2 and the Qarlikturvik Valley. We banded a total of 2001 geese, including 203 adult females marked with neck-collars and 48 young that had been marked with web-tags at hatch. In addition, we recaptured 128 adults that were banded in previous years. The young:adult ratio among geese captured at banding was much higher than last year (1.19:1) and above the long-term average (Table 1). Mean brood size toward the end of brood-rearing (2.58 young, n = 67; counts conducted from 1 to 4 August) was similar to last year and to the long-term average. By combining information on brood size and young:adult ratio at banding, we estimated that 92% of the adults captured were accompanied by young, a high value (Table 1). Overall, these results are indicative of a good production of young on Bylot Island by the end of the summer.

Small mammals. — During our survey using snap traps, we cumulated 1435 trap-nights at our 2 trapping sites of the Qarlikturvik Valley from 23 to 28 July, and 720 trap-nights at the Camp-2 from 13 to 15 July. In the Qarlikturvik sites, we caught 1 Collared Lemming (*Dicrostonyx groenlandicus*) and 20 Brown Lemmings (*Lemmus trimucronatus*), which yielded a combined index of abundance of 1.54 lemming/100 trap-nights, a high value (Fig. 5). The estimated abundance was also high in the Camp-2 area, as 3 Collared Lemmings and 6 Brown Lemmings were caught, for an index of 1.34 lemming/100 trap-nights. The live-trapping survey conducted throughout the summer in the Qarlikturvik Valley area revealed the same picture. Overall, we captured 478 Brown Lemmings and 40 Collared Lemmings, for an index of 16.6 lemming/100 trap-nights, a very high number compared to last year (0.03 lemming/100 trap-nights). A formal estimation of density using capture-recapture analytical methods indeed showed that both lemming species were in the peak phase of abundance of their cycle in 2014 (Fig. 6). Finally, the number of lemming winter nests found along our 60 transects was also high as 206 were found in 2014 compared to 19 in 2013.

Breeding activity of foxes at dens and marking. — We found 6 new fox dens on the island in 2014, bringing the total to 109 known denning sites still intact. Among these dens, we found signs of activity (fresh digging and/or footprints) at 44 of them, a high number. The breeding activity of foxes was high as we found 28 different litters (26% of known denning sites) of Arctic Fox, a marked increase following two years of low reproductive activities (8 and 2 litters found in 2012 et 2013, respectively), and one litter of Red Fox. The high breeding activity of the Arctic Fox is typical of what we normally observed in years of high lemming abundance (average: 19%). Minimum litter size of Arctic Fox varied between 3 and 15 pups (9 pups on average). A total of 73 Arctic Foxes (17 adults and 56 juveniles) and 4 Red Foxes (1 adult and 3 young) were captured during trapping sessions. Fifty-seven Arctic Foxes (7 adults and 52 juveniles) captured were new individuals and one adult Red Fox and 14 Arctic Foxes (10 adults and 4 young) had been marked in previous years. All new individuals were marked with ear-tags. Among the adults captured, 9 Arctic Foxes were also fitted with satellite collars to study their home ranges and movements at large spatial scale over the entire annual cycle.

Monitoring of other bird species. — We found 41 active nests of Glaucous Gulls (vs. 23 in 2013), 5 nests of Parasitic Jaegers (vs. 2 in 2013), 77 nests of Long-tailed Jaegers (vs. none in 2013), 31 nests of Rough-legged Hawks (vs. none in 2013) and 98 nests of Snowy Owls (vs. none in 2013). The increase in the nesting activities of all avian predators is typical of what we encountered in a high lemming year. We found 82 nests of Lapland Longspurs compared to 119 in 2013. Average clutch size was 2.7 eggs for gulls (vs. 2.6 in 2013), 1.8 eggs for Long-tailed Jaegers, 2.0 eggs for Parasitic Jaegers (same as in 2013), 5.0 eggs for hawks, 6.1 for owls and 5.3 eggs for longspurs (vs. 5.0 in 2013). Nesting success was very good for owls and hawks (96% and 87%, respectively) and moderate for gulls and jaegers (46% and 52%, respectively). Fledging success (proportion of nests successful in fledging at least one young) was also moderate for longspurs (55% vs. 12% in 2013).

Plant growth and grazing impact. — Plant production in wet meadows of the brood-rearing area was above the long-term average but lower than in recent years (Fig. 7). Above-ground biomass of graminoid plants in the Qarlikturvik Valley reached 56.7 ± 6.0 [SE] g/m^2 in ungrazed areas in mid-August compared to 63.5 ± 9.4 in 2013 (long-term average since 1990: 50.4 g/m^2). Nonetheless, biomass of both *Eriophorum* and *Dupontia* was higher compared to last year (Fig. 7) because an unusually large of biomass of *Carex aquatilis* had been found in our plots in 2013 (16.4 ± 7.6 compared to 3.6 ± 1.0 g/m^2 this year). At the nesting colony (Camp-2 area), graminoid biomass had also decreased compared to recent years (74.9 ± 9.7 g/m^2, Fig. 8). Four exclosures had to be eliminated because they fell down during the summer, allowing access by the geese. Biomass of both *Eriophorum* (41.4 ± 4.7 g/m^2) and *Dupontia* (32.9 ± 7.1 g/m^2) decreased compared to last year. The change in the location of half of the exclosures at Camp-2 in 2011 prohibits a comparison of long-term trend in plant production after that date at this site (Fig. 8).

Grazing pressure was moderate in the wet meadows of the Qarlikturvik Valley in 2014 as geese had removed 23% of the above-ground biomass (difference between paired grazed and ungrazed plots) by mid-August (long-term average: 30%; Fig. 7). Similar to most previous years, grazing pressure was higher on *Eriophorum* (28% of biomass removed) than on *Dupontia* (18% of biomass removed). At the Camp-2 area (nesting colony), the grazing pressure was low this year with 8% of the graminoid biomass removed by geese (long-term average at this site: 25%; Fig. 8). Geese had no impact on the *Eriophorum* production at this site but grazed 35% of *Dupontia* biomass.

CONCLUSIONS

The production of young geese on Bylot Island was very good in 2014. Despite cool temperature at the time of laying, the snowmelt was early due to a thin snow cover last winter, which allowed the geese to nest near their usual date in the colony or even earlier for those that nested away from it. It also appears that the breeding effort of the population was high as judged by the high density of nests in the core area of the colony and the large number of individuals that nested in a dispersed fashion around Snowy Owls. We found a record number of Snowy Owl nests on the island in 2014 (three time higher than the previous highest number), which provided numerous opportunities for geese to nest in association with them. The clutch size was near average or higher than normal depending of the area and predation on goose eggs was very low, resulting in a high reproductive success. The low predation was due to the high abundance of lemmings, following 2 low years, which allowed predators like foxes to feed mainly on those small mammals rather than on geese. Moreover, geese nesting in association with Snowy Owls benefitted from the “predator-free” area maintained by these birds around their nest. Nonetheless, the cool, cloudy and wet conditions that prevailed during the brood-rearing period may have reduced the survival of goslings, which are vulnerable to exposure when they are young.

Based on the young:adult ratio recorded at banding on Bylot Island, we anticipated a good percentage of young in the fall flock with a predicted value of 28%, higher than the long-term average (23%). The percentage of young measured during juvenile counts conducted in southern Quebec this fall was 22% (*n* = 28,184), a slightly lower value than anticipated. This suggests that breeding conditions encountered by geese on Bylot Island were better than those prevailing elsewhere in the eastern Canadian Arctic in 2014. We should remember that Bylot Island accounts for only ~15% of the annual breeding population of greater snow geese. Information relayed to us by researchers working at other sites in the eastern Arctic (e.g. Mary River, Igloolik) indicated a moderate to low abundance of lemmings, which suggests that the spatial extent of the lemming peak recorded on Bylot Island may not have been as large as some other peaks in the past. This could also explain why the density of owls was so high on Bylot Island in 2014 as low lemming abundance in surrounding areas may have attracted more owls in search of good breeding conditions than usual. It is thus possible that low lemming abundance at other greater snow goose colonies may have resulted in a higher predation rate than on Bylot Island and thus contributed to a reduction in overall productivity of the population. Another possibility is that mortality could have been higher than anticipated during the fall migration between the Arctic and southern Québec.

Above-ground graminoid production in the wet meadows of the Qarlikturvik Valley was good in 2014, though not as much as in recent years. Production actually decreased for the second consecutive year. Because annual growth of Arctic plants is sensitive to summer temperature, the cool temperature that prevailed over the past 2 years during much of July, the period of maximum growth for plants, may explain the recent reduction in plant production. The impact of low temperature on plant growth in the current year may also be carried over into the next year if it reduces the accumulation of belowground reserves, which are important for the regrowth of plants like *Eriophorum* and *Dupontia* in subsequent years. This recent decreasing trend in plant production was also present at Camp-2 though in this case it may have been amplified by the extremely high biomass of *Eriophorum* recorded in 2011 and 2012, which was due to a massive flowering event of this plant. Flower abundance of *Eriophorum* was indeed an order of magnitude higher in 2011 than in preceding years at this site. In the Qarlikturvik Valley, plant biomass nonetheless remained above the long-term average in 2014. At Camp-2, the change in sampling site in 2011 prevents a comparison of the current biomass with the long-term average.

The goose grazing pressure on Bylot Island was moderate in 2014 despite a good production of young locally. A possible explanation for this moderate impact could be that a large number of geese nested away from the main colony, clustered around Snowy Owls territories dispersed over much of the South Plain of Bylot Island. This may have prompted some geese to use different brood-rearing areas as well, away from the traditional areas, thereby leading to a reduced grazing impact in those areas. At Camp-2, evaluation of the goose grazing impact was also hampered by the loss of one-third of the exclosures, which reduced sample size. Nonetheless, the moderate goose grazing impact combined with the generally good plant production that continued to prevail in 2014 suggest that feeding conditions of geese on Bylot Island have remained good in recent years.

PLANS FOR 2015

The long-term objectives of our work are to study the population dynamics of Greater Snow Geese, and the interactions between geese, plants, and their predators on Bylot Island. A major focus of the project is to monitor changes in demographic parameters (such as survival rate, hunting mortality, breeding propensity, reproductive success, and recruitment) and habitat (annual plant production and grazing impact) in response to the spring conservation harvest and other special management actions implemented since 1999 in Canada and since 2009 in the United States. Other aspects of the project include *i*) understanding better the links between events occurring during the spring migration and the subsequent breeding success of geese; *ii*) determining the long-term effects of geese on the arctic landscape; *iii*) assessing how climate change may be affecting the carrying capacity of the habitat for geese, *iv*) studying indirect interactions between snow geese and lemmings via shared predators; *v*) studying the ecology of the main predator of geese, Arctic Foxes; and *vi*) assessing the impact of climate change on goose reproduction and molt. In 2015, we anticipate to:

1) Monitor productivity (egg laying date, clutch size and nesting success) and nesting distribution of Greater Snow Geese on Bylot Island.
2) Mark goslings in the nest to provide a sample of known-age individuals to assess the growth and pre-fledging survival of goslings by their recapture in late summer.
3) Band goslings and adults, and neck-collar adult females at the end of the summer to continue the long-term study of demographic parameters such as survival and breeding propensity.
4) Monitor the abundance of lemmings and study their demography.
5) Monitor the breeding activity of other bird species, in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).
6) Monitor the breeding activity of foxes at dens and study their movements and demography.
7) Sample plants in exclosures to assess annual production and the impact of goose and lemming grazing on plant abundance in wet meadows.
8) Maintain our automated environmental and weather monitoring system.

In 2015, at least 7 graduate students will be involved in the Bylot Island snow goose project. **Cynthia Resendiz** (PhD) will continue her study on the effects of climate change on snow goose reproduction. **Dominique Fauteux** (PhD) will complete his study on the role of predation in the cyclic dynamic of lemming populations. **Andréanne Beardsell** (MSc) will complete her study on the nesting ecology of Rough-legged Hawks. **Yannick Seyer** (MSc) will continue his study on the migratory and reproductive strategies of the Long-tailed Jaegers. **Florence Lapierre-Poulin** (MSc) will continue her study on the vulnerability of fox dens to climate change. **Guillaume Slevan-Tremblay** (MSc) will start a study on the grazing impact of lemmings on the tundra vegetation. Finally, a new PhD student should start a study on the effects of predators and food on the reproductive success of snow geese.

Table 1. Productivity data of Greater Snow Geese nesting on Bylot Island over the past decade.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Average[2]
Number of nest monitored	346	393	494	466	405	372	382	375	451	**491**	--
Nest density (nb/ha)	5.55	2.14	4.07	6.36	4.94	2.95	4.89	5.24	8.85	**7.89**	4.57
Median date of egg-laying	12 June	14 June	16 June	10 June	12 June	13 June	13 June	12 June	13 June	**11 June**	12 June
Clutch size	3.60	3.68	3.91	4.10	3.38	3.68	3.74	3.80	3.58	**3.85**	3.71
Nesting success[1]	66%	42%	82%	74%	74%	80%	90%	54%	67%	**91%**	67%
Median date of hatching	8 July	10 July	11 July	6 July	9 July	10 July	8 July	9 July	10 July	**8 July**	9 July
Number of geese banded	5304	4603	4260	3395	5417	4267	3802	2512	4865	**2001**	3536
Ratio young:adult at banding	1.03:1	0.74:1	1.11:1	1.11:1	1.07:1	1.18:1	1.19:1	0.92:1	1.10:1	**1.19:1**	1.04:1
Brood size at banding	2.42	2.20	2.90	3.07	2.35	2.39	2.80	2.54	2.51	**2.58**	2.52
Proportion of adults with young at banding	86%	67%	77%	72%	91%	98%	85%	73%	88%	**92%**	83%

[1] Mayfield estimate
[2] Period 1989-2014

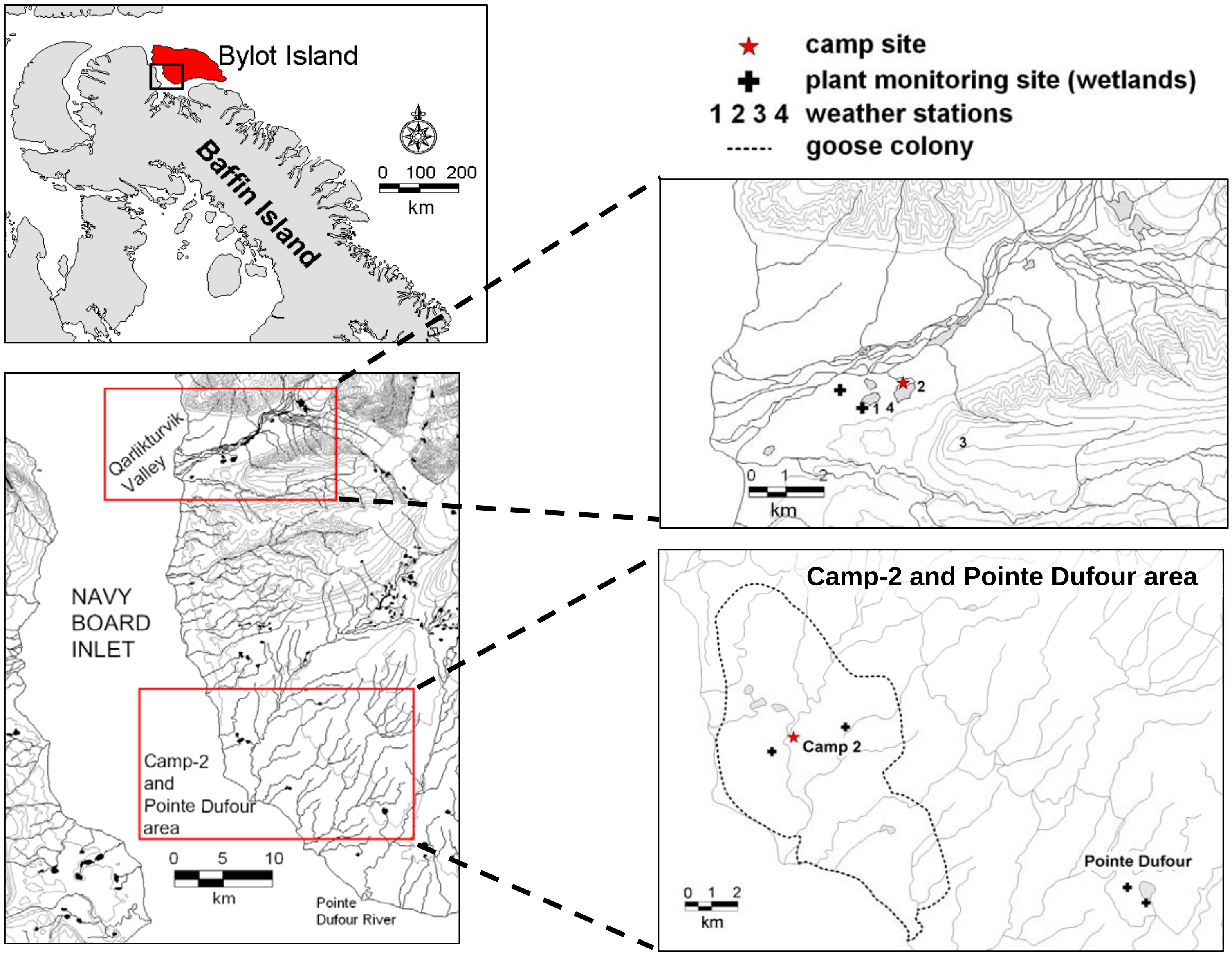


Figure 1. Location of the two main study sites (Qarlikturvik Valley and the Camp-2 area) on the South Plain of Bylot Island, Nunavut. Enlarged maps on the right present these study sites in more details, including camp locations, extent of the goose colony, vegetation sampling sites and our four weather stations. Vegetation was last sampled at Pointe Dufour in 2008.

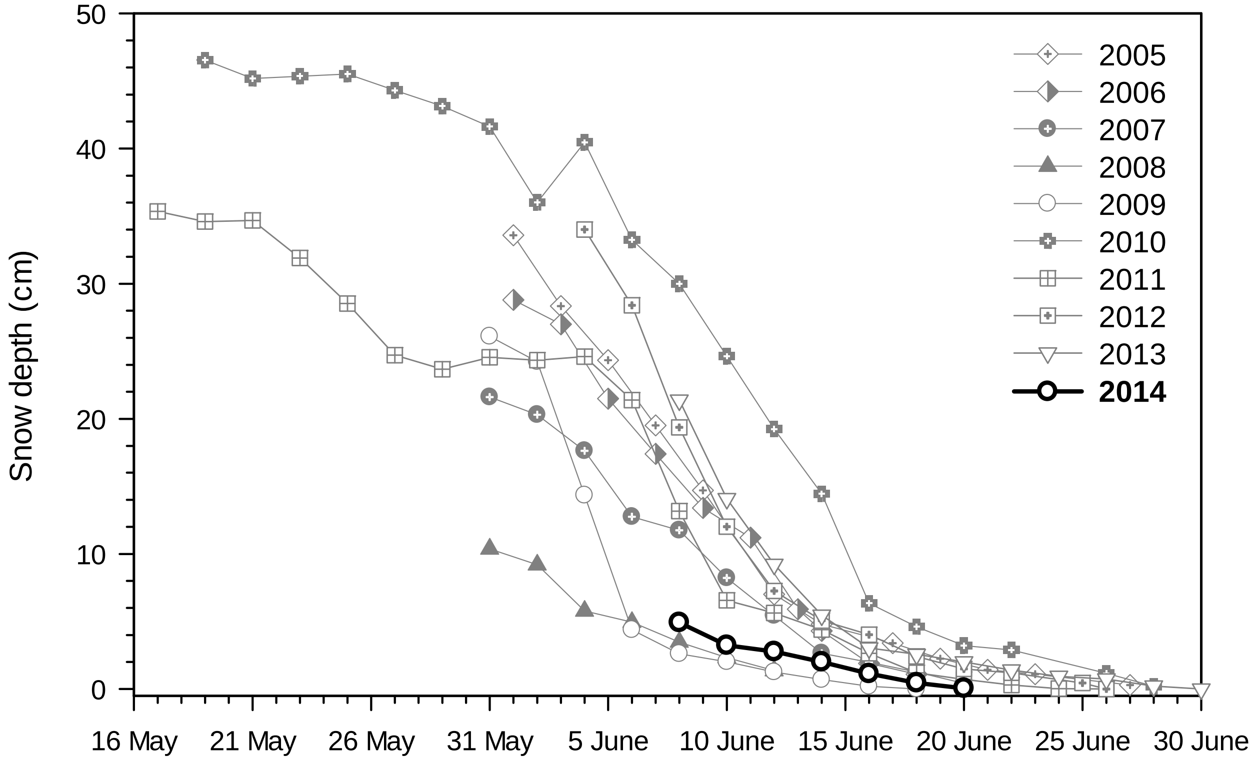


Figure 2. Average depth of snow along 2 transects showing the rate of snowmelt in the lowlands of Bylot Island over the past decade (*n* = 50 stations).

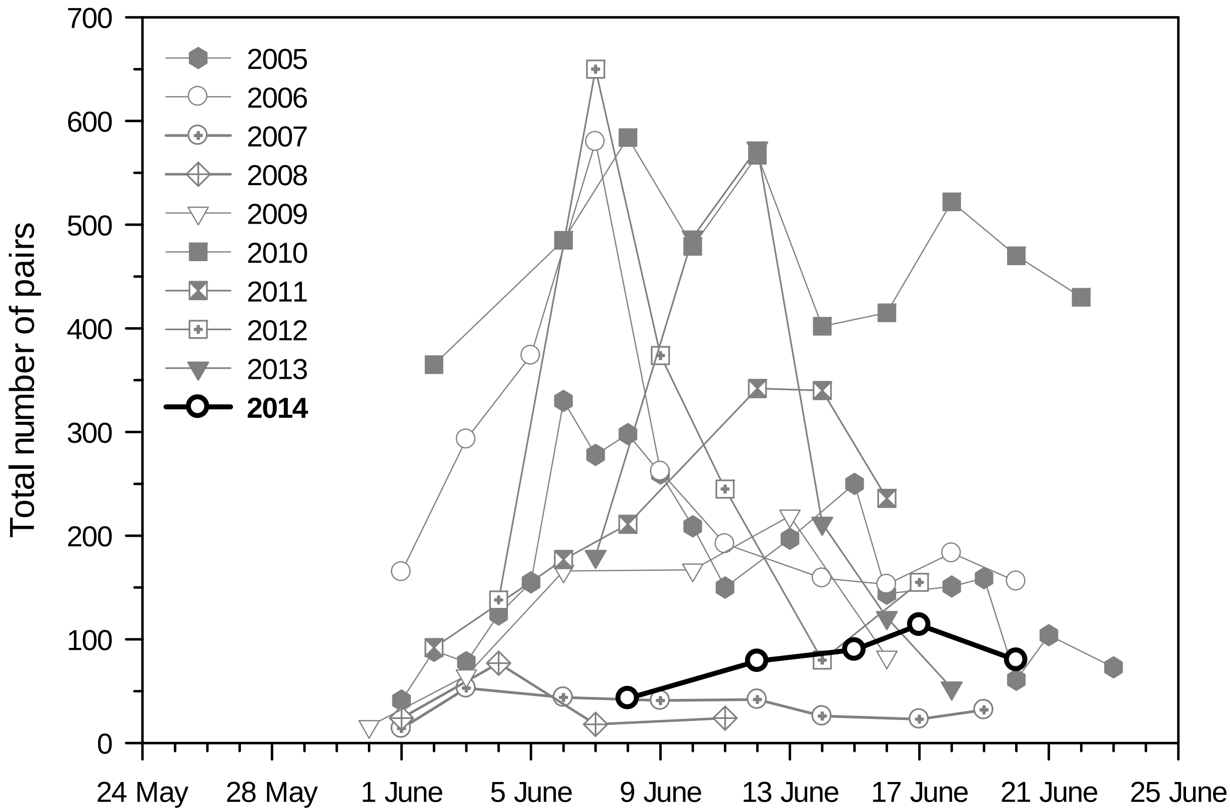


Figure 3. Total number of goose pairs counted in the Qarlikturvik Valley from arrival of our crew on Bylot Island until the end of snowmelt over the past decade.

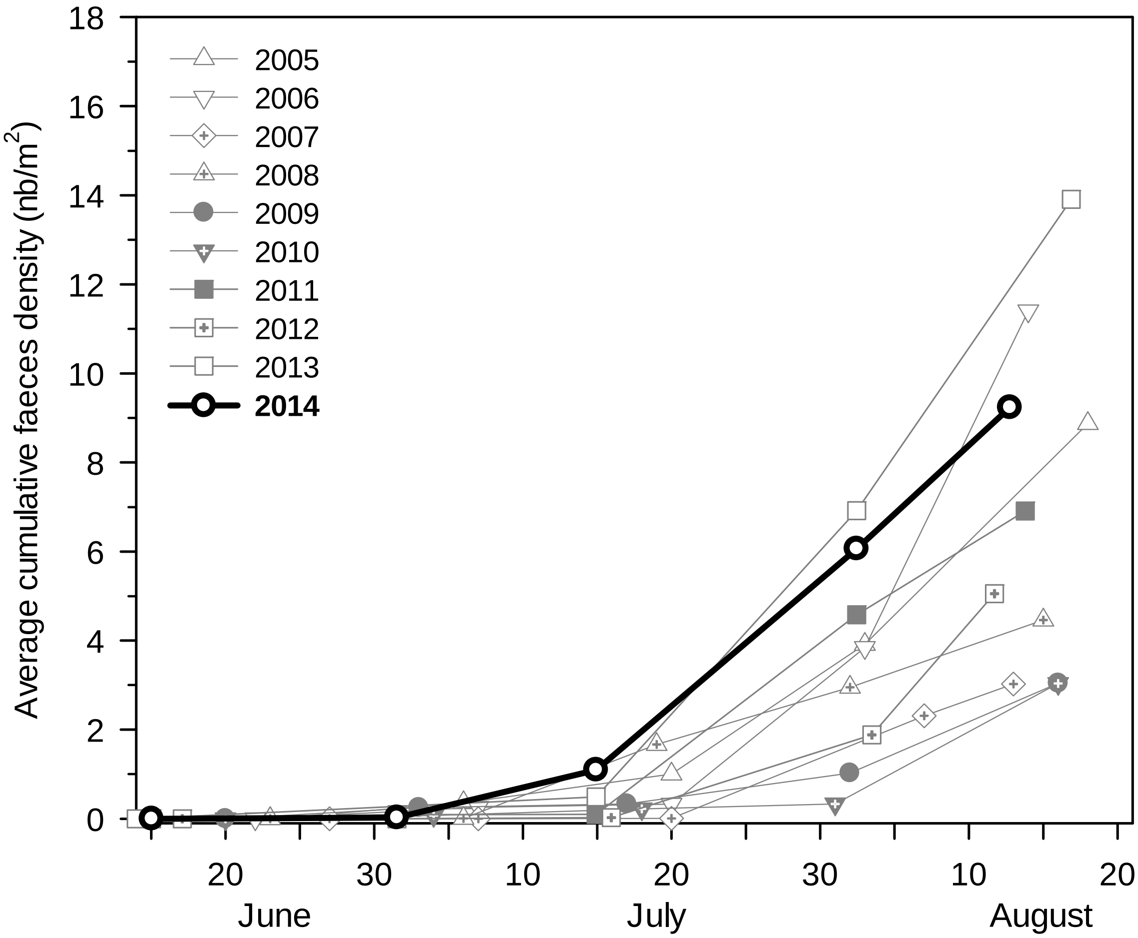


Figure 4. Average cumulative faeces density showing the use of the Qarlikturvik Valley by Greater Snow Goose families on Bylot Island throughout the summer over the past decade (*n* = 12 transects of 1 x 10 m; except 2013 where *n* = 5).

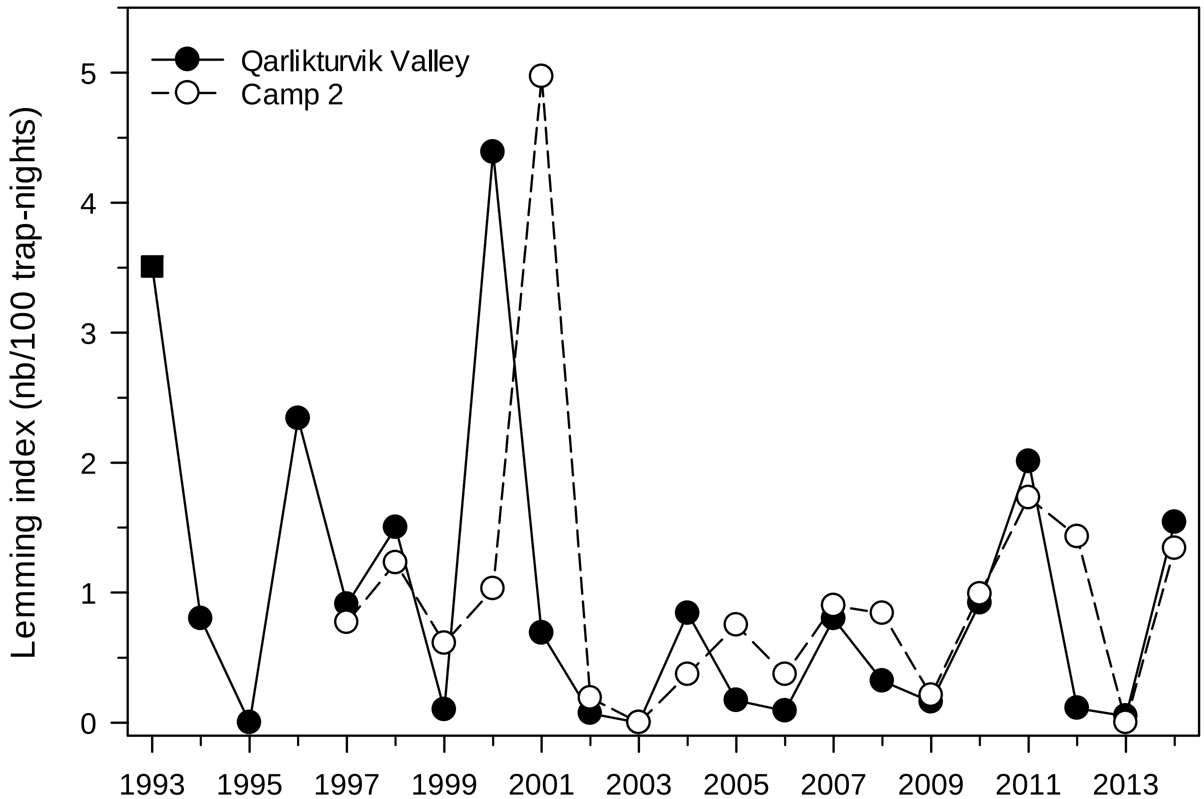


Figure 5. Annual index of lemming abundance based on snap-trapping at two study areas (Qarlikturvik Valley and Camp 2) located 30 km apart on Bylot Island.

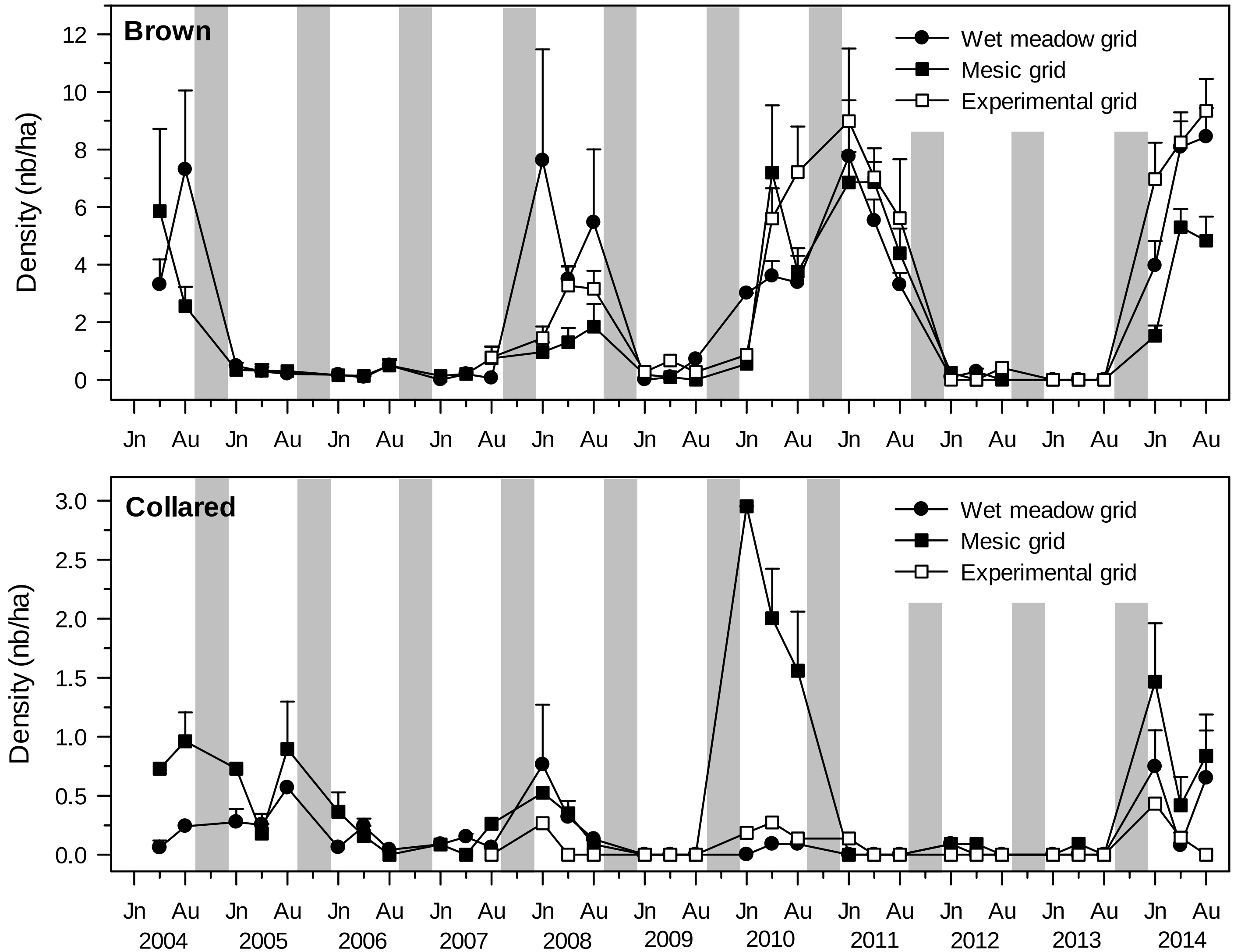


Figure 6. Annual summer density (+ SE) of Brown and Collared Lemmings on 3 trapping grids located in the Qarlikturvik Valley of Bylot Island (snow cover was increased from 2008 to 2011 and predators were excluded from 2012 to 2014 on the experimental grid). The gray area indicates winter. Jn = mid-June, Au = mid-August.

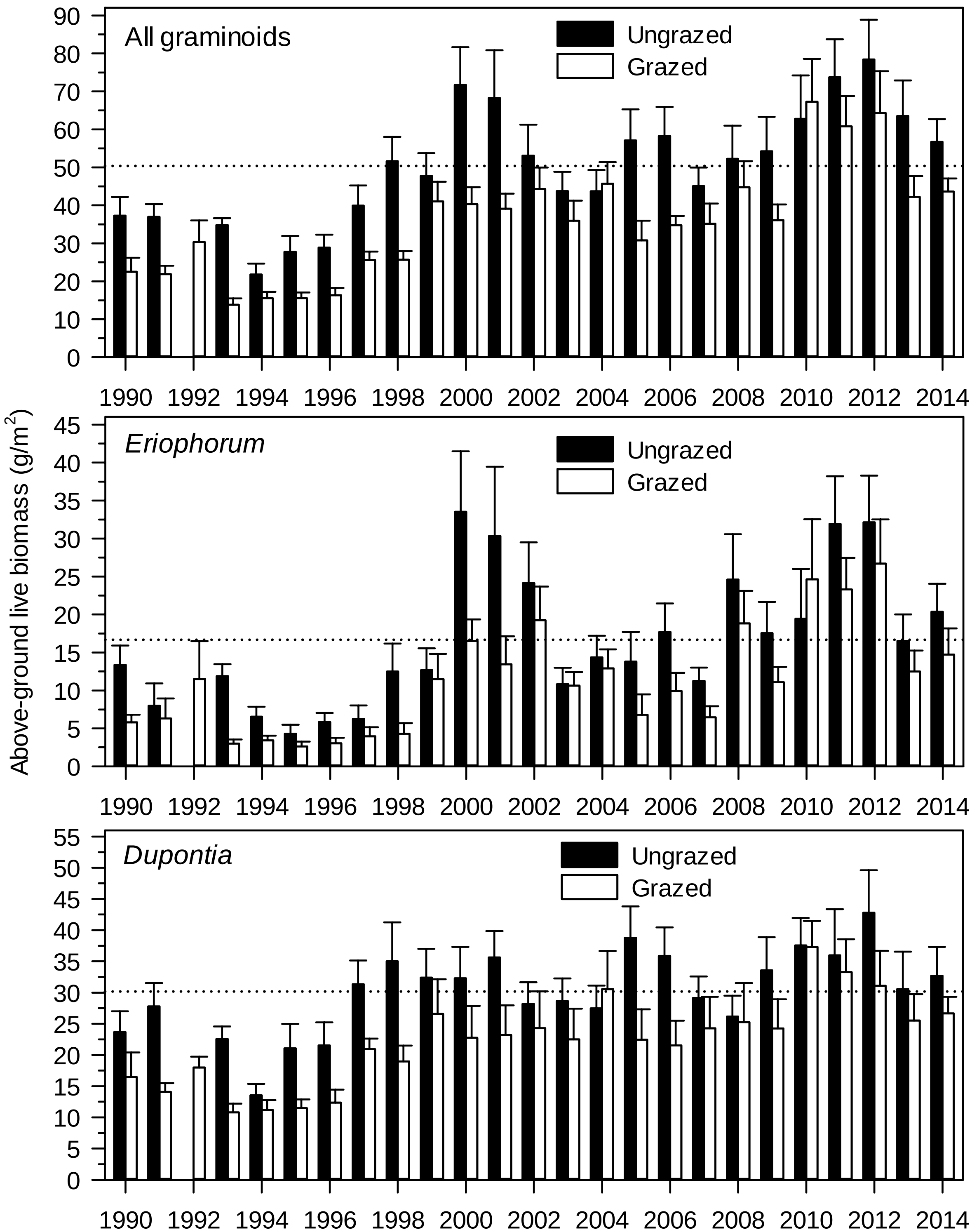


Figure 7. Live above-ground biomass (mean + SE, dry mass) of graminoids on 10-11 August in grazed and ungrazed wet meadows of the Qarlikturvik Valley, Bylot Island (n = 12, except in 2013-2014, n = 11). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data from ungrazed area in 1992. The dashed line is the long-term average for ungrazed area.

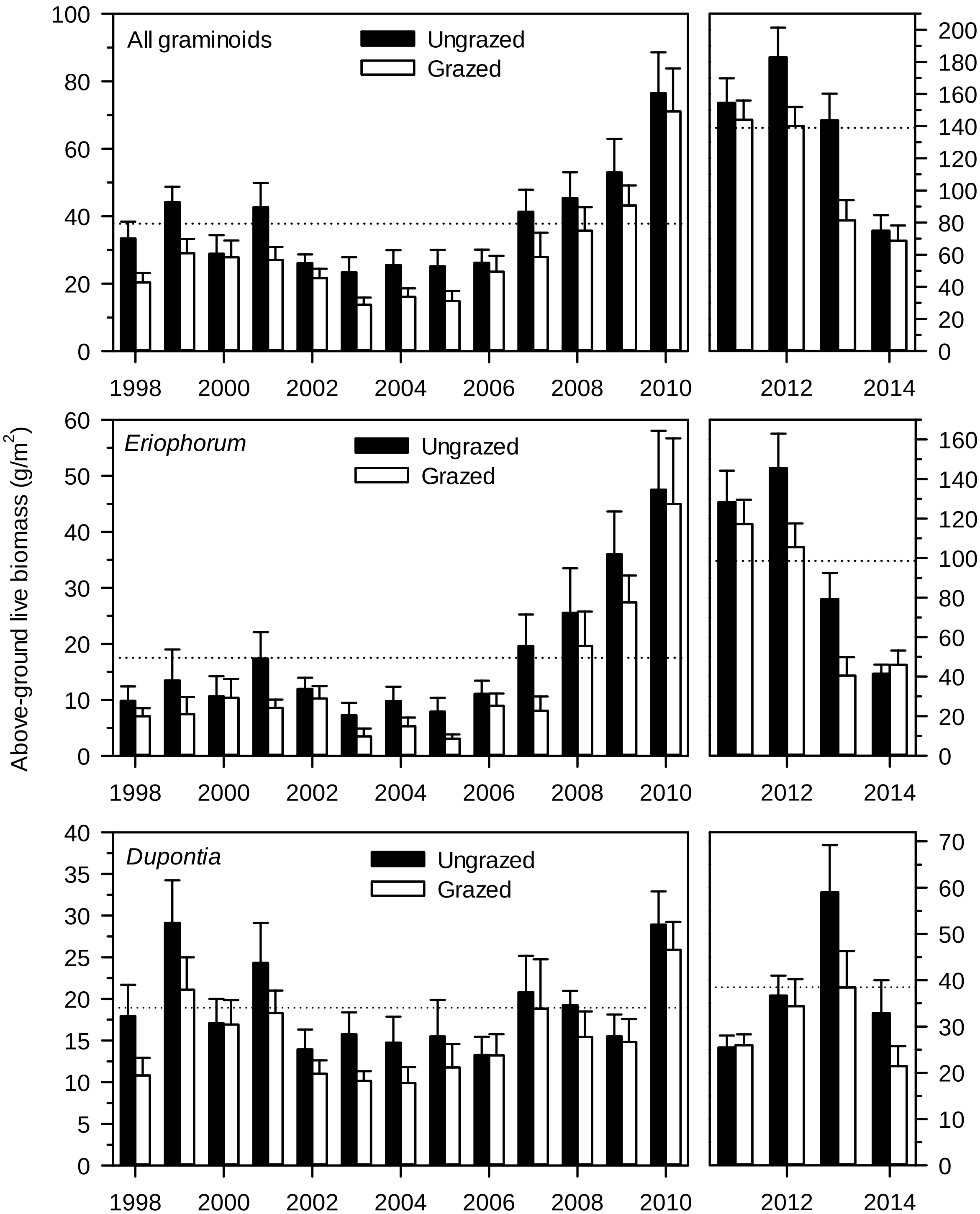


Figure 8. Live above-ground biomass (mean + SE, dry mass) of graminoids on 15 August in grazed and ungrazed wet meadows of the Camp-2 (goose colony), Bylot Island (n = 12, except in 2008 and 2014 n = 8, and 2012-2013 n = 10). Total graminoids include *Eriophorum scheuchzeri, Dupontia fisheri* and *Carex aquatilis*. Half of the exclosures had to be moved to a new site in 2011, which explains why the figure was split and the long-term average for ungrazed area (dashed line) calculated separately before/after 2011.

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