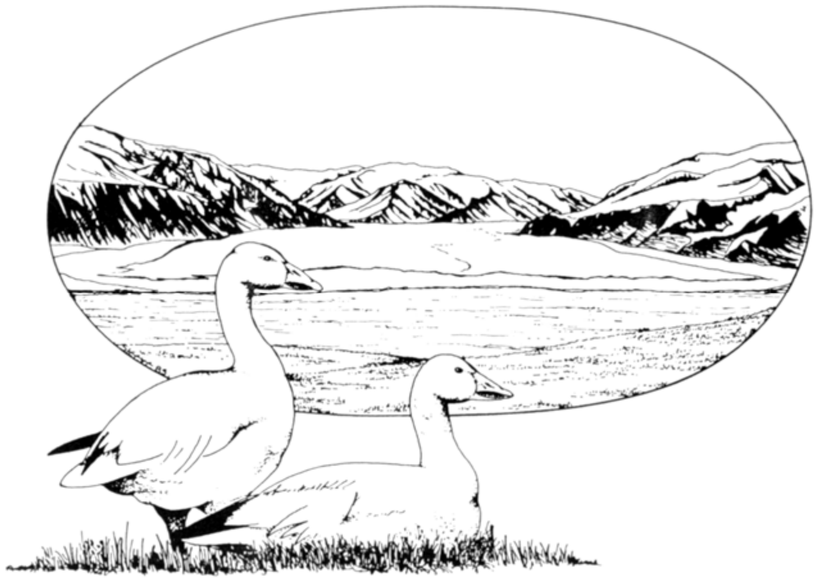
POPULATION STUDY OF GREATER SNOW GEESE AND ITS NESTING HABITAT ON BYLOT ISLAND, NUNAVUT IN 2012: A PROGRESS REPORT



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INTRODUCTION

In 2012, 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 2012 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) Study factors affecting the molt (chronology, plumage quality) of adults during the summer such as timing of breeding, food availability, body condition and the hormonal status.
5) Monitor the abundance of lemmings and study their demography and factors affecting their cyclic fluctuations of abundance.
6) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).
7) Monitor the breeding activity of foxes at dens.
8) Capture and mark adult Arctic Foxes and their pups with ear-tags to study their movements and demography.
9) Sample plants in exclosures to assess annual production and the impact of goose grazing on plant abundance in wet meadows.

10) Maintain our automated environmental and weather monitoring system.

FIELD ACTIVITIES

Field camps. — In 2012, 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 21 August. A secondary camp, located in a narrow valley 30 km south of the Base-camp and 5 km from the coast (“Camp-2 area”, 72° 53' N, 79° 54' W) was occupied from 24 May to 21 July (Fig. 1). Finally, 14 fly camps were also established for 4-11 days at various times throughout the island, west of Pointe Dufour. In mid-June, we were able to replace our radio-repeater that had been destroyed in 2011, which greatly improved communications in the field.

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 and Dominique Berteaux and several graduate students whose thesis projects addressed many of the objectives mentioned above: Guillaume Souchay (PhD student, objectives 1, 2 and 3), Dominique Fauteux (PhD, objective 5), Vincent Marmillot (MSc, objectives 1 and 4), Audrey Robillard (PhD, objective 6), Sandra Lai (PhD, objectives 7 and 8), Clément Chevalier (PhD, objectives 7 and 8) and Camille Morin (MSc, objective 7). Several other students assisted them in the field, including: Isabeau Pratte, Andréanne Beardsell, David Gaspard, Coralie Henry-Brouillette, Nicolas Trudel, Marie-Jeanne Rioux, Nicolas Bradette and Sylvain Christin. Other people in the field included Marie-Christine Cadieux, a research professional in charge of goose banding and plant sampling (objectives 3 and 9); Denis Sarrazin and Jonathan Roger, research professionals responsible of the maintenance of the weather stations (objective 10); Josée Lefebvre, a biologist from the Canadian Wildlife Service (CWS, Quebec region) and Louise van Oudenhove, a post-doctoral fellow at Université Laval. Finally, we hired 2 persons from Pond Inlet to work with us: Trevor Arreak (marking goslings in nests: 4-14 July and goose banding: 5-14 August) and Ezra Arreak (goose banding: 5-14 August).

Several other people also used our camps during the summer. They were Jean-François Lamarre (MSc student), Catherine Doucet (MSc student), Eric Reed (biologist from the CWS, Gatineau region), Marie-Christine Frénette, Marion Trudel and Pascal Royer-Boutin 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), Naïm Perreault and Jonathan Lasnier, who studied the permafrost and the geomorphology of the island. Finally, several other persons visited our camp during the summer. Tyler Harbidge (manager of *Sirmilik National Park*) inspected both camps during the summer. Paul Ashley and Sarah Chisholm also came to our field station to establish a long-term monitoring program to evaluate the impact of the presence of the station on the environment in the park. Finally, a meeting of the Sirmilik Park Planning Team was held at the field station to discuss with researchers the future park zoning. The Planning Team was represented by Maryse Mahé, Tyler Harbidge and Margaret Nowdlak from Parks Canada, Josée Lefebvre from the Canadian Wildlife Service and Abraham Kublu from the Inuit Qikiktani Association.

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 370 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 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 are 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 are 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 5 to 14 August, we banded geese with the assistance of local Inuit people and 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. Finally, we collected some blood samples from adult females during banding to determine if hormone levels could provide an index of the impact of environmental factors on the stress level of molting adults.

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 or 4 days. We used Museum Special traps baited with peanut butter and rolled oats. Since 2004, we also sample lemming abundance 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 was 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 520 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, and plant biomass was sampled in ungrazed and grazed areas (i.e. inside and outside exclosures) at the end of the plant-growing season on 9 and 10 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. — Temperature in spring was generally mild. Although air temperature averaged -0.45°C between 20 May and 20 June (0.46°C below normal), the period of goose arrival and egg-laying, it averaged 2.02°C (0.59°C above 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 relatively thick (snow depth was 34 cm on 4 June) but the mild weather in June resulted in a normal snowmelt in the lowlands (Fig. 2). However, the summer was generally cool and unusually foggy with frequent precipitations (cumulative rainfall: 153 mm, long-term average: 93 mm). This summer was the wettest recorded since 1995.

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 moderate at our first count on 3 June (138 pairs) but increased very rapidly afterward. Number of geese peaked at 650 pairs on 6 June, a very high number (Fig. 3). This suggests that goose arrival on Bylot Island was relatively early this year. The subsequent decline in goose numbers was due to the movements of geese to the nesting colony, away from the Qarlikturvik Valley.

Median egg-laying date in the colony was 12 June, which is the long-term average egg-laying date on Bylot Island (Table 1). Nest density in the colony was slightly higher than last year (5.24 nests/ha vs. 4.89 in 2011) and above the long-term average. No nests were found in the Qarlikturvik Valley (predominantly a brood-rearing area) compared to 19 in 2011. Overall, average clutch size was 3.80, slightly higher than the long-term average (Table 1).

Nesting success of geese. — Nesting success (proportion of nests hatching at least one egg) was low this year in the colony (54%, a value below the long-term average, Table 1). This was largely due to a high activity of Arctic Foxes and avian predators around goose nests, which destroyed many nests. During the summer, 99 neck-collared birds were sighted, similar to last year (89). Peak hatch was on 9 July, which is the long-term average (Table 1). We tagged 1412 goslings in nests at hatch, all in the Camp-2 area. Overall, nesting conditions of geese in 2012 were therefore moderate.

Density of broods. — The density of goose faeces at the end of the summer in wet meadows of the Qarlikturvik Valley was moderate (5.1 ± 0.6 [SE] faeces/m^2; long-term average: 5.7; Fig. 4). Accumulation of faeces began in mid-July, when newly-hatched broods started to move in the valley from the colony further south and increased steadily thereafter until mid-August. Faeces density at the end of the summer was low in the wet meadows of the nesting colony at Camp-2 (2.8 ± 0.3 faeces/m^2; long-term average: 3.7).

Goose banding. — The banding operation was difficult this year due to bad weather and the small size of family groups. Though numerous, these groups were also more dispersed than usual. We conducted 6 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 3 additional drives further away, between the Camp 2 and the Qarlikturvik Valley. We banded a total of 2512 geese, including 339 adult females marked with neck-collars and 43 young that had been marked with web-tags at hatch. In addition, we had 201 recaptures of adults banded in previous years. The young:adult ratio among geese captured at banding was relatively low (0.92:1) and below the long-term average (Table 1). Mean brood size toward the end of brood-rearing (2.54 young, n = 155; counts conducted from 30 July to 4 August) was lower than last year but similar to the long-term average. By combining information on brood size and young:adult ratio at banding, we estimated that 73% of the adults captured were accompanied by young, a relatively low value (Table 1). Overall, these results are indicative of a moderately low production of young on Bylot Island by the end of the summer. Finally, we collected 186 blood samples from adult females to examine hormone levels during molt.

Small mammals. — During our survey using snap traps, we cumulated 1908 trap-nights at our 2 trapping sites of the Qarlikturvik Valley from 23 to 30 July, and 713 trap-nights at the Camp-2 from 15 to 17 July. In the Qarlikturvik sites, we caught 2 Collared Lemmings (*Dicrostonyx groenlandicus*) and no Brown Lemming (*Lemmus trimucronatus*), which yielded a combined index of abundance of 0.11 lemmings/100 trap-nights, a low value (Fig. 5). The estimated abundance was higher in the Camp-2 area, as 6 Collared Lemming and 4 Brown Lemmings were caught, for an index of 1.43 lemmings/100 trap-nights. The live-trapping survey conducted throughout the summer in the Qarlikturvik Valley area revealed the same picture. Overall, we captured 19 different lemmings (15 Brown and 4 Collared), including 7 that were captured more than once, for an index of 0.57 lemmings/100 trap-nights (excluding recaptures), a very low number compared to last year (12.6 lemmings/100 trap-nights). A formal estimation of density using capture-recapture analytical methods indeed showed that both lemming species were in the low abundance phase of their cycle in 2012 (Fig. 6). The number of lemming winter nests found along our 60 transects was also low as only 49 were found in 2012 compared to 347 in 2011.

Breeding activity of foxes at dens and marking. — We found 3 new fox dens on the island in 2012, bringing the total to 105 known denning sites still intact. Among these dens, we found signs of activity (fresh digging and/or footprints) at 12 of them, a low number. The breeding activity of foxes was low as we found 8 different litters (8% of known denning sites) of Arctic Fox, a considerable decrease over last year (28 litters found in 2011), and 1 litter of Red Fox. The low breeding activity of the Arctic Fox is typical of what we normally observed in years of low lemming abundance (average: 4%). Minimum litter size of Arctic Fox varied between 1 and 7 pups (5 pups on average). A total of 42 Arctic Foxes (34 adults and 8 juveniles) and 2 Red Foxes (1 adult and 1 juvenile) were captured during trapping sessions. Thirty-six Arctic Foxes (28 adults and 8 juveniles) and 1 juvenile Red Fox captured were new individuals and 8 adults had been marked in previous years. All new individuals were marked with ear-tags. Among the adults captured, 11 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 22 nests of Glaucous Gulls (vs. 27 in 2011), 6 nests of Long-tailed Jaegers (vs. 60 in 2011), 2 nests of Parasitic Jaegers (vs. 4 in 2011), 10 nests of Rough-legged Hawks (vs. 15 in 2011) but no nest of Snowy Owls (as in 2011). The decrease in the nesting activities of several avian predators is typical of what we encountered in a low lemming year. We found 137 nests of Lapland Longspurs compared to 122 in 2011. Average clutch size was 2.2 eggs for gulls (vs. 2.6 in 2011), 1.8 eggs for jaegers (vs. 2.0 in 2011), 4.0 eggs for hawks (vs. 4.5 in 2011) and 4.8 eggs for longspurs (vs. 5.4 in 2011). Nesting success (proportion of nests successful in fledging at least one young) was low for gulls (20% vs. 89% in 2011), and longspurs (6% vs. 67% in 2011). Success was unknown for jaegers and hawks.

Plant growth and grazing impact. — Plant production in wet meadows of the brood-rearing area was well above the long-term average and was the highest value ever recorded at the site for a second consecutive year (Fig. 7). Above-ground biomass of graminoid plants in the Qarlikturvik Valley reached 78.4 ± 10.5 [SE] g/m^2 in ungrazed areas in mid-August compared to 73.7 ± 10.5 in 2011 (long-term average since 1990: 49.5 g/m^2). At the nesting colony (Camp-2 area), graminoid biomass in 2012 reached another surprisingly high value following the same trend as last year (182.9 ± 16.8 vs. 154.6 ± 15.2 g/m^2 in 2011) and was more than three times higher than the long-term average (Fig. 8). It is noteworthy that for a second year in a row, the record primary production detected at Camp-2 was largely due to *Eriophorum* since *Dupontia* biomass only slightly increased compared to the previous year. The exceptional biomass of *Eriophorum* recorded in 2011 was associated with a massive flower production that year (about 8 times higher than the long-term average). *Eriophorum* flower density in 2012 decreased but was still the second highest value recorded and above the long-term average (Fig. 9).

Grazing pressure was moderate in the wet meadows of the Qarlikturvik Valley as geese had removed 18% of the above-ground biomass (difference between paired grazed and ungrazed plots) by mid-August (the same value as in 2011; long-term average: 30%; Fig. 7). In contrast to previous years, grazing pressure was lower on *Eriophorum* (17% of biomass removed) than on *Dupontia* (27% of biomass removed). At the Camp-2 area (nesting colony), the grazing pressure was relatively high this year with 23% of the graminoid biomass removed by geese, the highest value recorded over the last 5 years (long-term average at this site: 25%; Fig. 8). Geese removed 27% of the *Eriophorum* production at this site but only 6% of *Dupontia* biomass.

CONCLUSIONS

The production of young geese on Bylot Island was rather low in 2012 and high predation rate appears to be the main contributing factor. Relatively mild temperature at the time of laying and a normal snow-melt in early June allowed geese to nest at their usual date and to lay a good clutch size. It also appears that the breeding effort of the population was near normal as judged by the density of nests in the core of the colony. However, after 2 years of high density, lemming populations crashed in 2012, providing little food for predators such as foxes, gulls and jaegers. After two years of good reproduction due the high lemming abundance, these predators were thus numerous and turned to geese as alternative prey (Morrissette et al. 2010). Consequently, geese experienced a high predation rate on their eggs, which resulted into a low nesting success. The low reproductive success of other tundra birds like gulls and longspurs is another indication of a high predator pressure on these alternative prey. Goslings also likely suffered high predation during brood-rearing. The cool and wet conditions that prevailed during most of the summer may have also contributed to a reduced survival of goslings, which are vulnerable to exposure when they are young. These conditions contrasted with the warm and sunny conditions encountered during the previous two summers.

Based on the young:adult ratio recorded at banding on Bylot Island, we anticipated a percentage of young in the fall flock around 18%, below the long-term average (23%). However, the percentage of young measured during juvenile counts conducted in southern Québec this fall was only 12% ($n = 25,817$), a lower value than anticipated. This suggests that breeding conditions encountered by geese elsewhere in the Eastern Canadian Arctic in 2012 were worse than those prevailing on Bylot Island. In 2011, we had indications that the high abundance of lemmings encountered on Bylot Island was fairly widespread across the Eastern Canadian Arctic, and thus we can presume that the crash in lemming populations was equally widespread in 2012 because lemming peaks rarely last more than one year. Thus, high predation rate on goose eggs and young probably prevailed across the breeding range of Greater Snow Geese. The cool and wet weather, which was also generalized over Eastern Nunavut in 2012, is probably also another contributing factor.

Above-ground plant production in the wet meadows of Bylot Island was again exceptionally good in 2012. For a second year in a row, it was the highest value recorded in over 20 years of monitoring in the Qarlikturvik Valley. This high production is indicative of a long-term trend in increasing plant production observed at our site, which is likely due to the on-going warming occurring on Bylot Island (Gauthier et al. 2011). At the nesting colony (Camp-2), an unusual situation prevailed for a second year in a row as above-ground plant production was again twice as high as the one recorded in the Qarlikturvik Valley brood-rearing area. This is surprising because over the past decade, plant production at the nesting colony has been on average 40% lower than in the Qarlikturvik Valley. In 2011, the high plant production recorded at the nesting colony was due to a large increase in *Eriophorum* biomass and was associated with a massive flowering by this species, the abundance of flowers being an order of magnitude higher than in previous years. *Eriophorum* flowering decreased in 2012 but was still about 4 times higher than the highest value observed for the period 2001-2009. Last year, we suggested that the low goose grazing pressure recorded at this site in recent years combined to the warm summer temperature that prevailed may have caused this mast flowering. A similar situation was observed in permanent exclosures when goose grazing was suppressed for several years in the Qarlikturvik Valley (Gauthier et al. 2004). This occured because chronic goose grazing reduces below-ground reserves in *Eriophorum* (Beaulieu et al. 1996), which suppresses flowering in most tillers. We expect that flowering rate of *Eriophorum* should continue to decrease next year, as well as total above-ground biomass.

The goose grazing pressure in the Qarlikturvik Valley was moderate in 2012. Even though the absolute amount of biomass consumed by geese in wetlands of Bylot Island has not changed over the past two decades, the relative impact of goose grazing on graminoids has experienced a decreasing trend due to the long-term increase in plant production (G. Gauthier et al., in preparation). This appears to be a consequence of the strong summer warming trend observed in the area in recent years. At the nesting colony (Camp-2), grazing pressure in 2012 was similar to the Qarlikturvik Valley but higher than in recent years and concentrated on *Eriophorum*, the plant preferred by geese.

Finally, recent studies suggested that thermal erosion of ice-wedges by spring run-off is causing a degradation of tundra polygons on Bylot Island, with the ensuing drainage of wetlands and loss of wet sedge meadows (Perreault 2012). As these are prime brood-rearing habitats for geese, there is growing concerns that such phenomenon could result in habitat loss for geese, especially as climate continues to warm. This aspect deserves more studies in the near future.

PLANS FOR 2013

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 2013, 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 level of intestinal parasite infestations in goslings and study their impact on survival.
5) Study factors affecting the molt (chronology, plumage quality) of adults during the summer such as timing of breeding, food availability, body condition and the hormonal status.
6) Monitor the abundance of lemmings and study their demography.
7) Monitor the breeding activity of other bird species, in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).
8) Monitor the breeding activity of foxes at dens and study their movements and demography.
9) Sample plants in exclosures to assess annual production and the impact of goose and lemming grazing on plant abundance in wet meadows.
10) Maintain our automated environmental and weather monitoring system.

In 2013, at least 6 graduate students will be involved in the Bylot Island snow goose project. **Vincent Marmillot** (MSc) will complete his study of factors affecting molt in snow geese. **Clément Chevalier** (PhD) will study the population dynamic of Arctic Foxes with a special emphasis on annual variation on survival. **Dominique Fauteux** (PhD) will continue to study the role of predation in the cyclic dynamic of lemming populations. **Audrey Robillard** (PhD) will study the inter-annual movements of predatory birds (primarily Snowy Owls and Long-tailed Jaegers) and habitat use by wintering owls. **Cynthia Resendiz** (PhD) will start a study on the effects of climate change on snow goose reproduction. Finally, **Andréanne Beardsell** (MSc) will start a study on the nesting ecology of Rough-legged Hawks.

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

	2003	2004	2005	2006	2007	2008	2009	2010	2011	**2012**	Average[2]
Number of nest monitored	585	676	346	393	494	466	405	372	382	**375**	--
Nest density (nb/ha)	10.53	1.12	5.55	2.14	4.07	6.36	4.94	2.95	4.89	**5.24**	4.17
Median date of egg-laying	9 June	11 June	12 June	14 June	16 June	10 June	12 June	13 June	13 June	**12 June**	12 June
Clutch size	3.90	3.65	3.60	3.68	3.91	4.10	3.38	3.68	3.74	**3.80**	3.71
Nesting success[1]	82%	78%	66%	42%	82%	74%	74%	80%	90%	**54%**	66%
Median date of hatching	6 July	7 July	8 July	10 July	11 July	6 July	9 July	10 July	8 July	**9 July**	9 July
Number of geese banded	5259	3617	5304	4603	4260	3395	5417	4267	3802	**2512**	3544
Ratio young:adult at banding	1.31:1	0.94:1	1.03:1	0.74:1	1.11:1	1.11:1	1.07:1	1.18:1	1.19:1	**0.92:1**	1.04:1
Brood size at banding	2.74	2.50	2.42	2.20	2.90	3.07	2.35	2.39	2.80	**2.54**	2.52
Proportion of adults with young at banding	96%	75%	86%	67%	77%	72%	91%	98%	85%	**73%**	82%

[1] Mayfield estimate
[2] Period 1989-2012

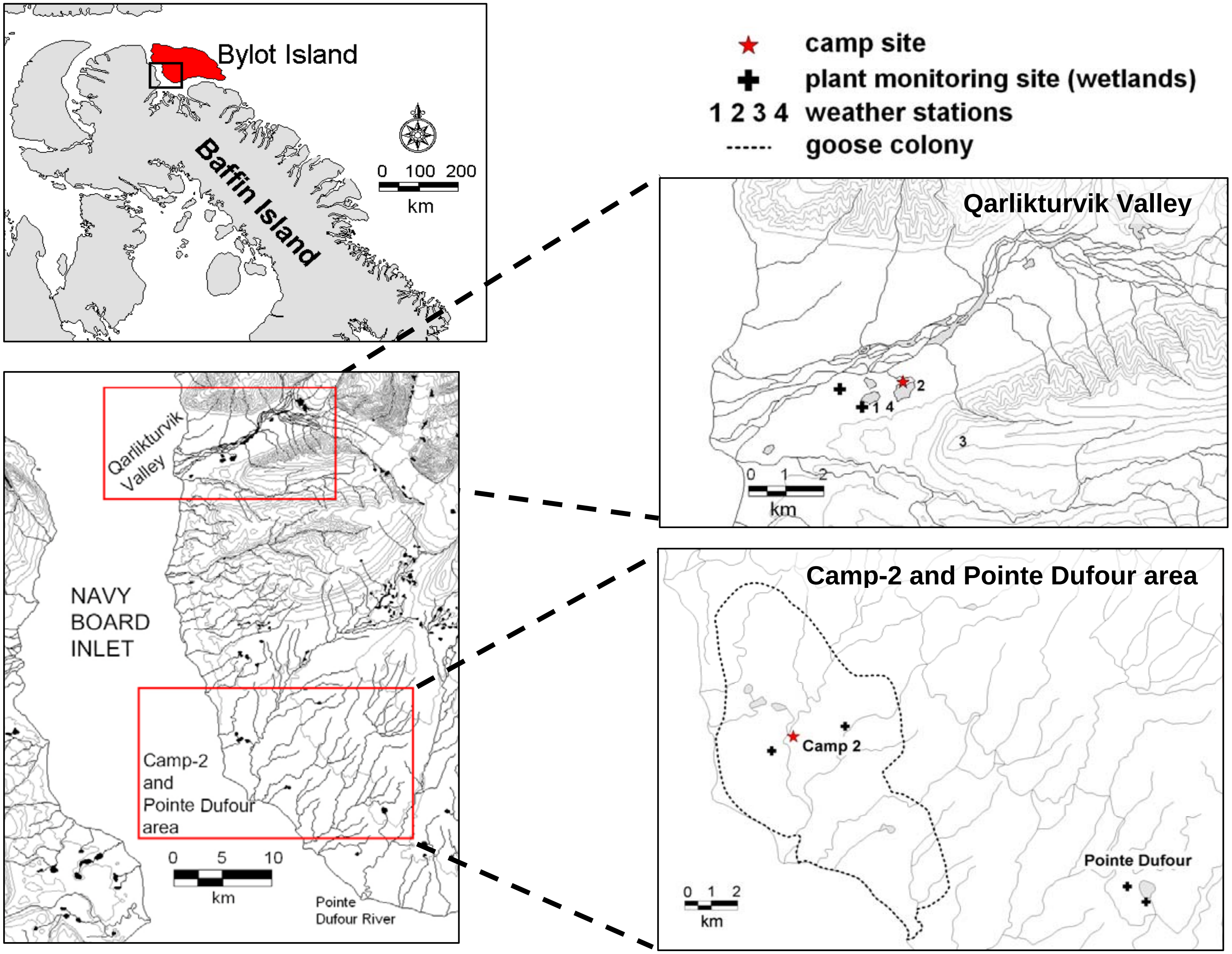

Figure 1. Location of the two main study sites (Qarlikturvik Valley and the Camp-2 area) on the South Plain of Bylot Island, Nunavut. Enlarged maps on the right present these study sites in more details, including camp locations, extent of the goose colony, sampling sites and our four weather stations. Pointe Dufour was not sampled in 2012.

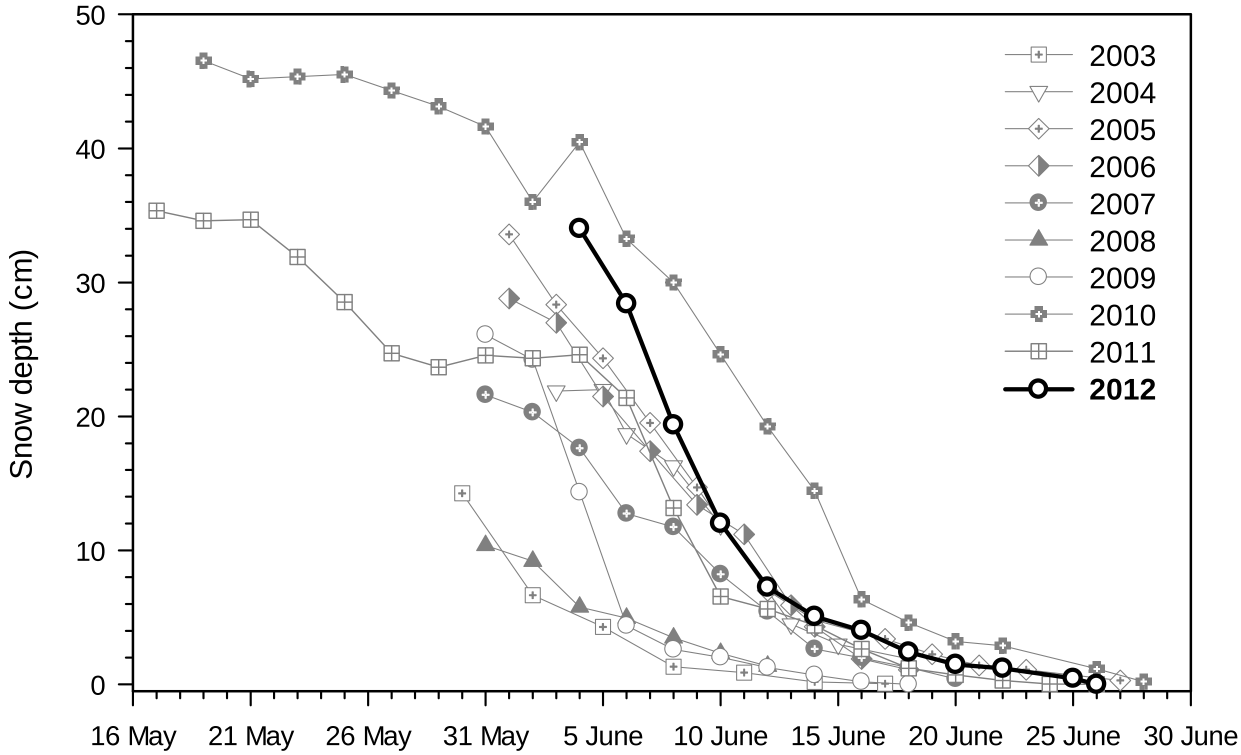

Figure 2. Average depth of snow along 2 transects showing the rate of snowmelt in the lowlands of Bylot Island over the past decade (n = 50 stations).

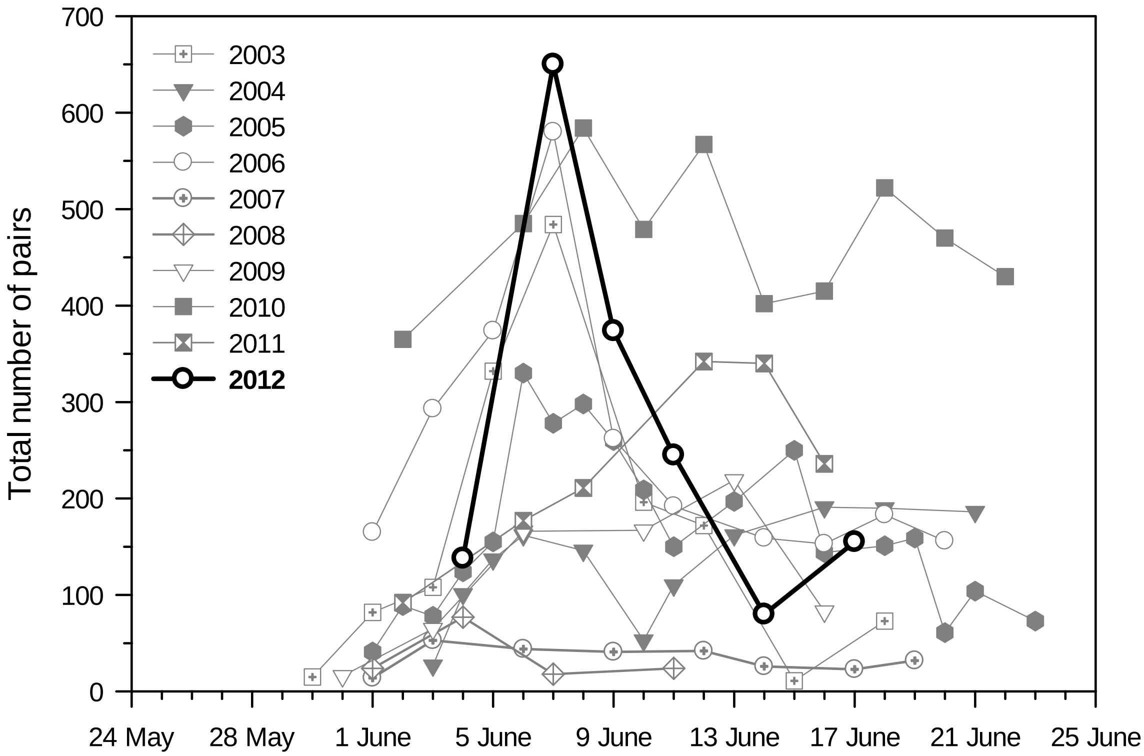

Figure 3. Total number of goose pairs counted in the Qarlikturvik Valley from arrival of our crew on Bylot Island until the end of snowmelt over the past decade.

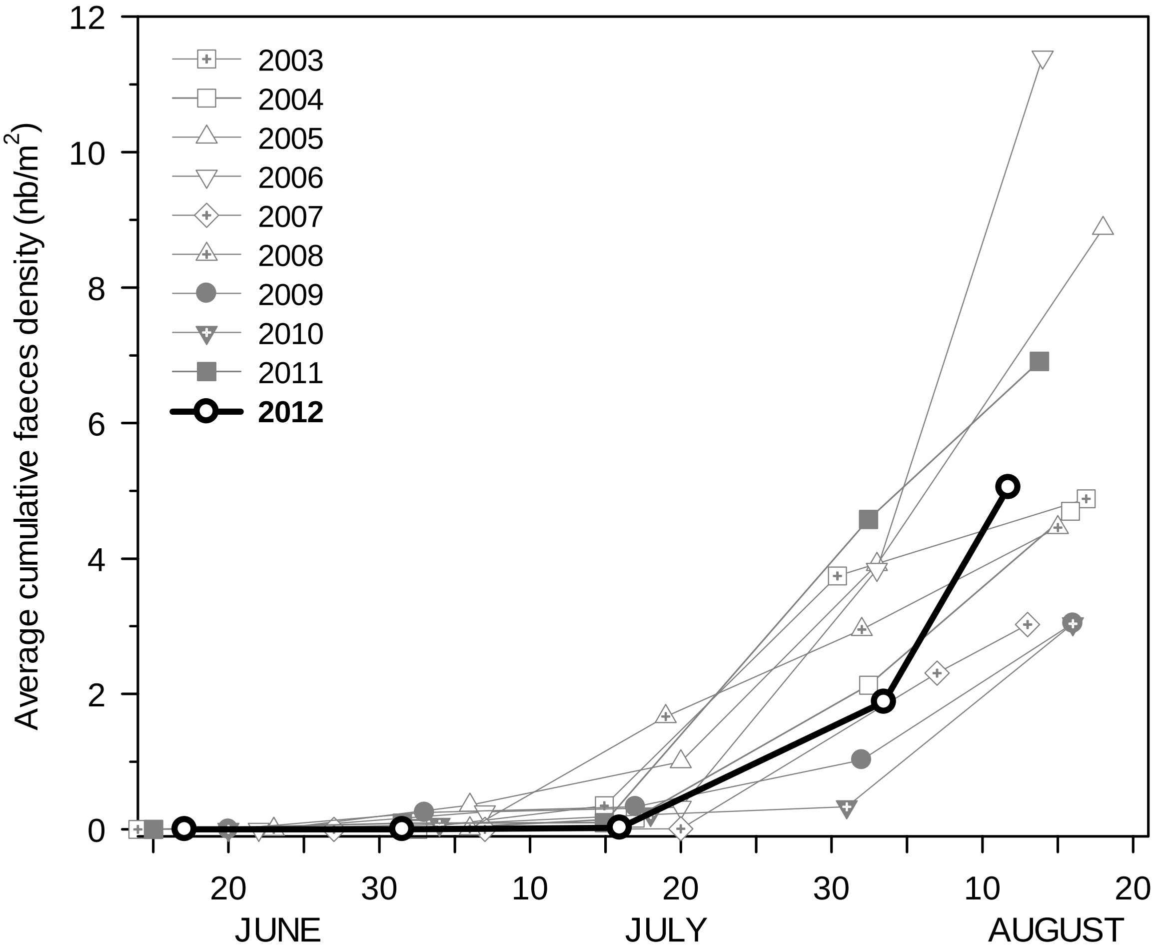

Figure 4. Average cumulative faeces density showing the use of the Qarlikturvik Valley by Greater Snow Goose families on Bylot Island throughout the summer over the past decade (n = 12 transects of 1 x 10 m).

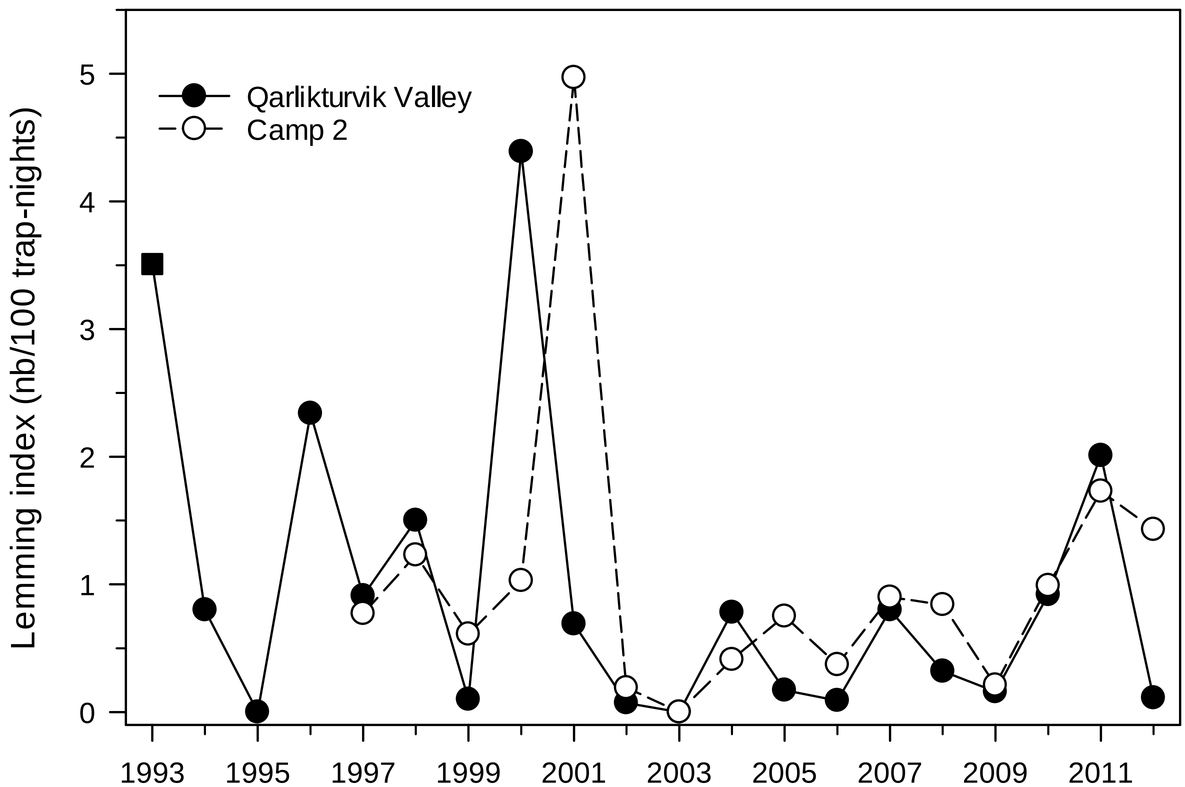

Figure 5. Annual index of lemming abundance based on snap-trapping at two study areas (Qarlikturvik Valley and Camp 2) located 30 km apart on Bylot Island.

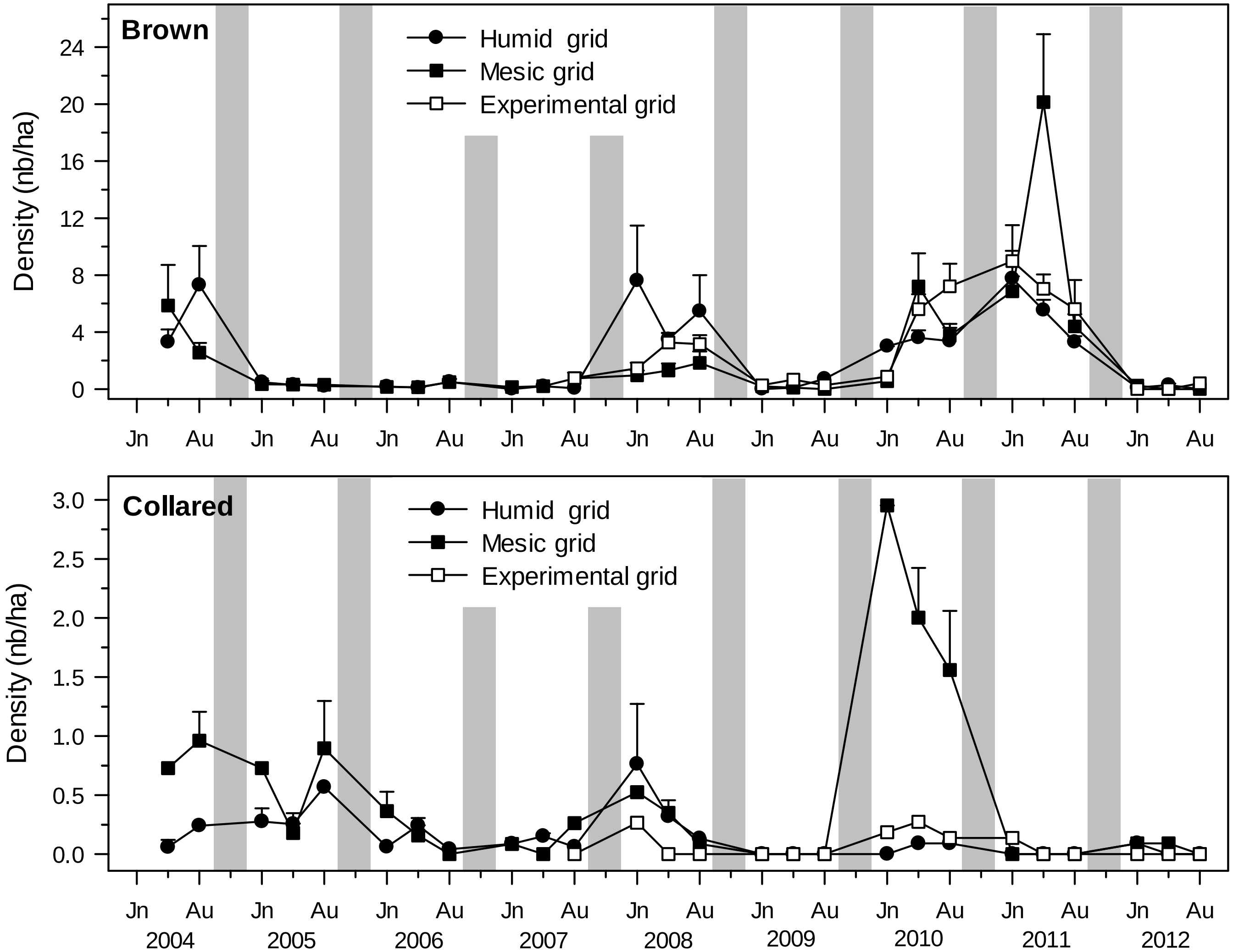

Figure 6. Annual summer density (+ SE) of Brown and Collared Lemmings on 3 trapping grids located in the Qarlikturvik Valley of Bylot Island (snow cover was increased on the experimental grid from 2008 to 2011). The gray area indicates winter. Jn = mid-June, Au = mid-August.

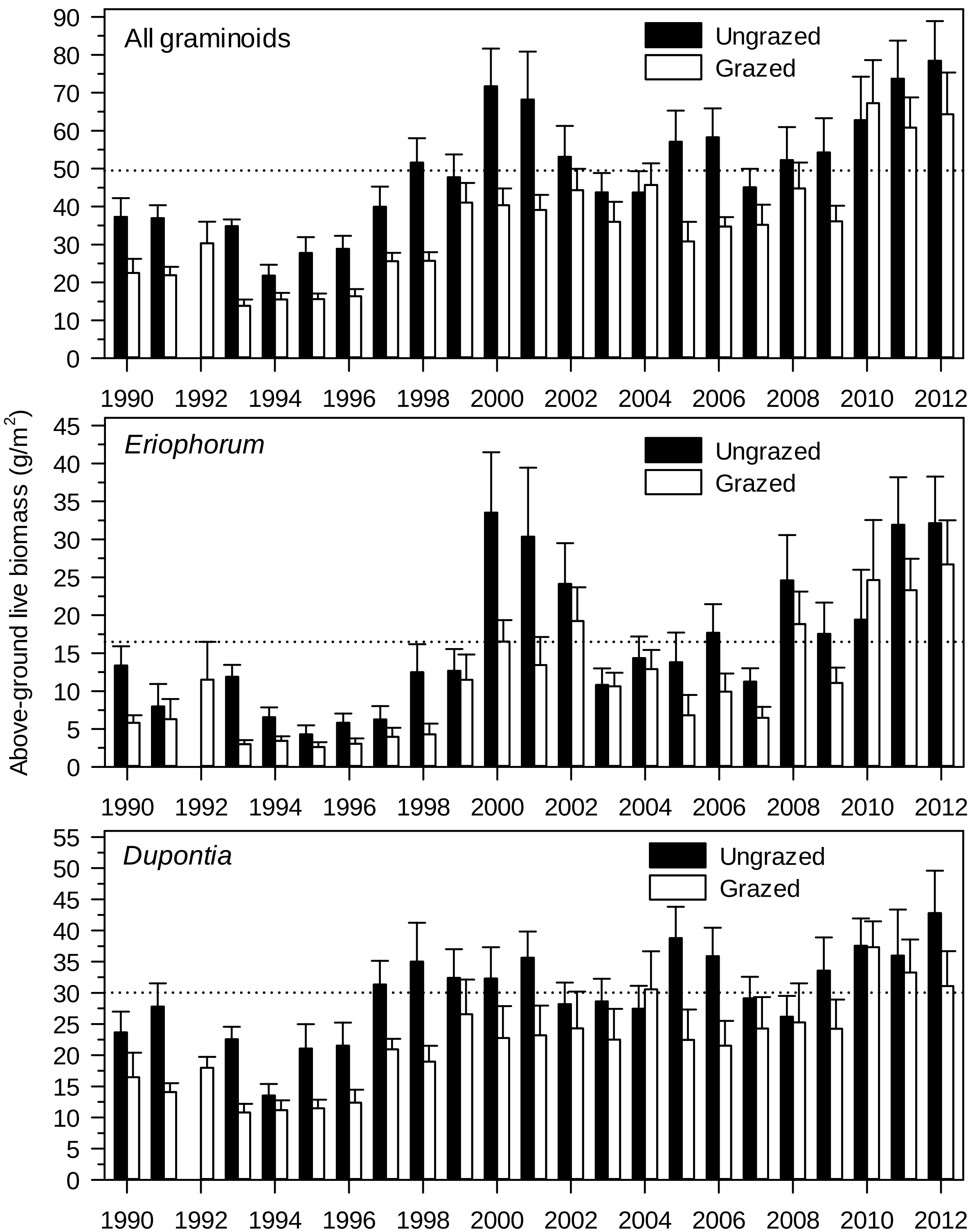

Figure 7. Live above-ground biomass (mean + SE, dry mass) of graminoids on 9 August in grazed and ungrazed wet meadows of the Qarlikturvik Valley, Bylot Island (*n* = 12). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data from ungrazed area in 1992. The dashed line is the long-term average for ungrazed area.

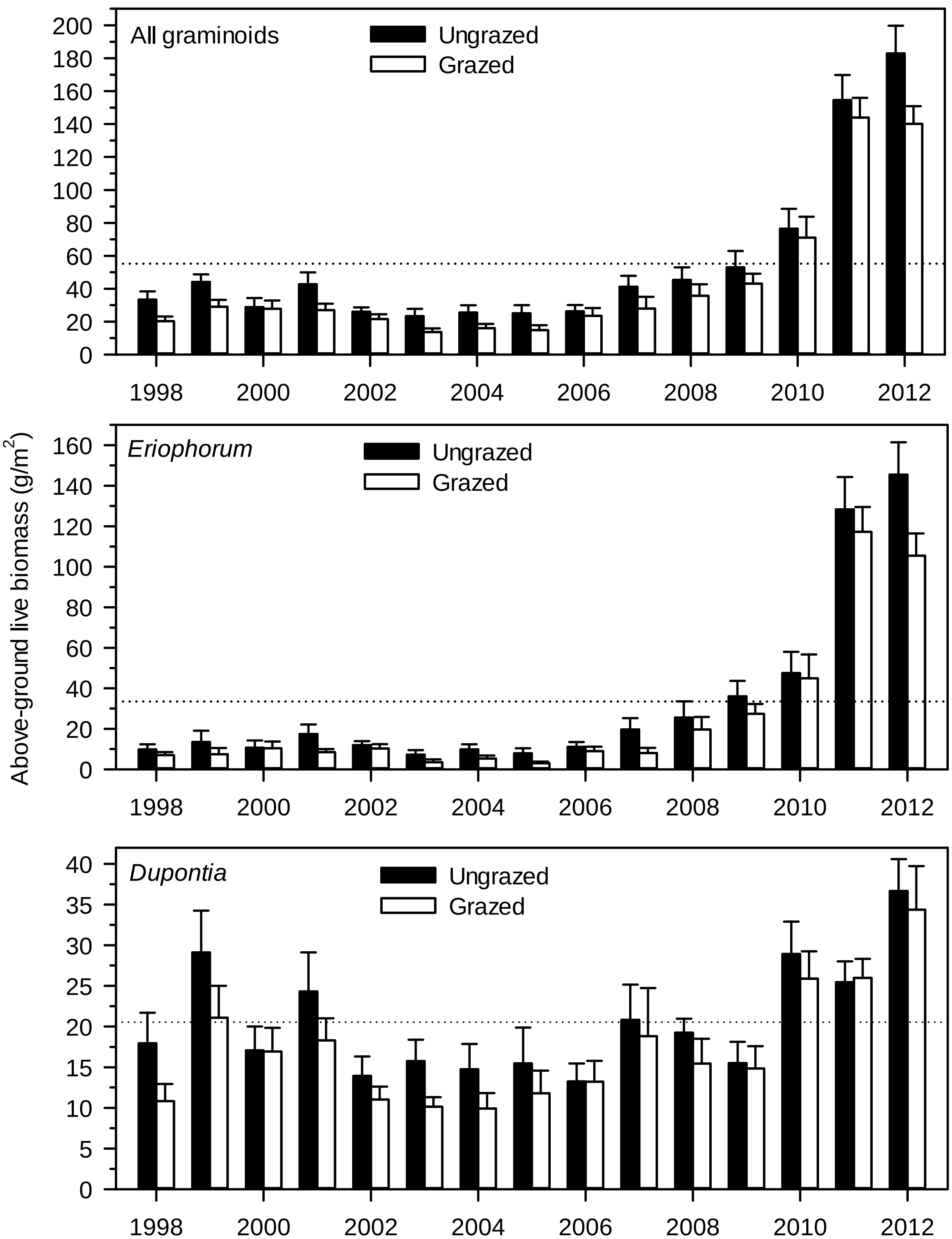

Figure 8. Live above-ground biomass (mean + SE, dry mass) of graminoids on 10 August in grazed and ungrazed wet meadows of the Camp-2 (goose colony), Bylot Island (*n* = 12, except in 2008 (*n* = 8) and 2012 (*n* = 10)). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. The dashed line is the long-term average for ungrazed area.

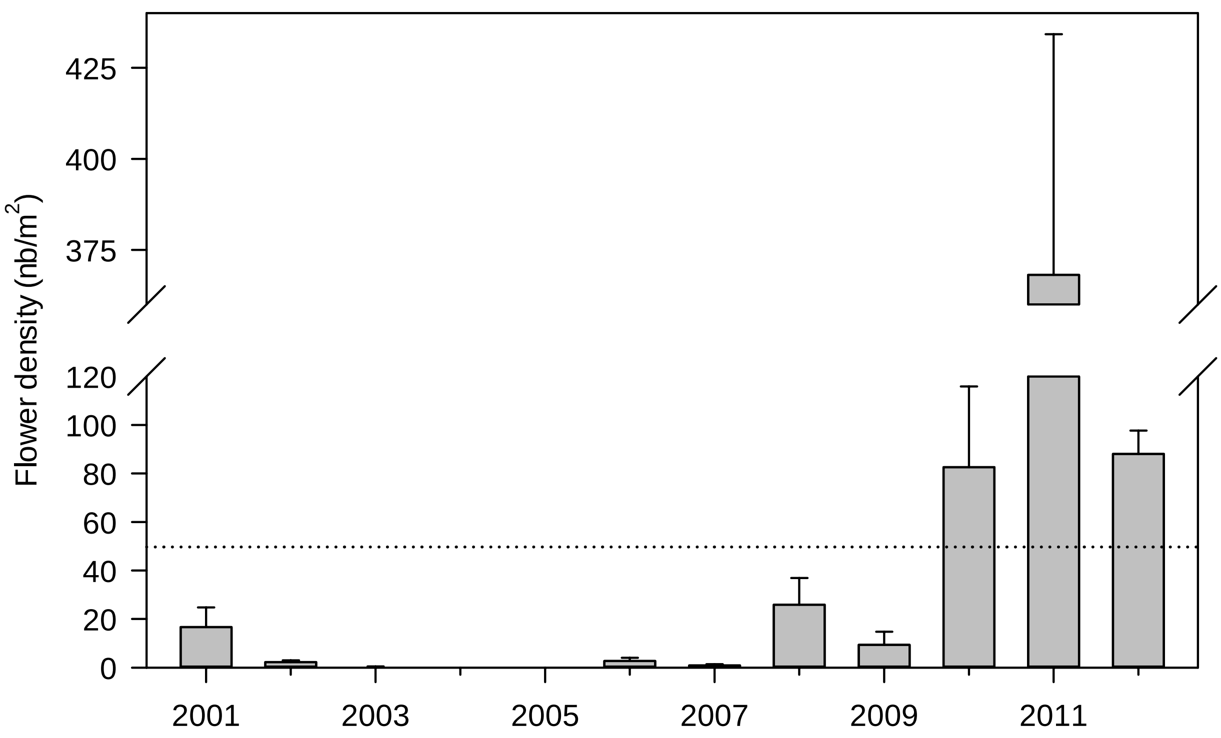

Figure 9. Flower density (mean + SE) of *Eriophorum* in ungrazed wet meadows of the Camp-2 (goose colony), Bylot Island (*n* = 12, except in 2008 (*n* = 8) and 2012 (*n* = 9)). The dashed line is the long-term average.

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