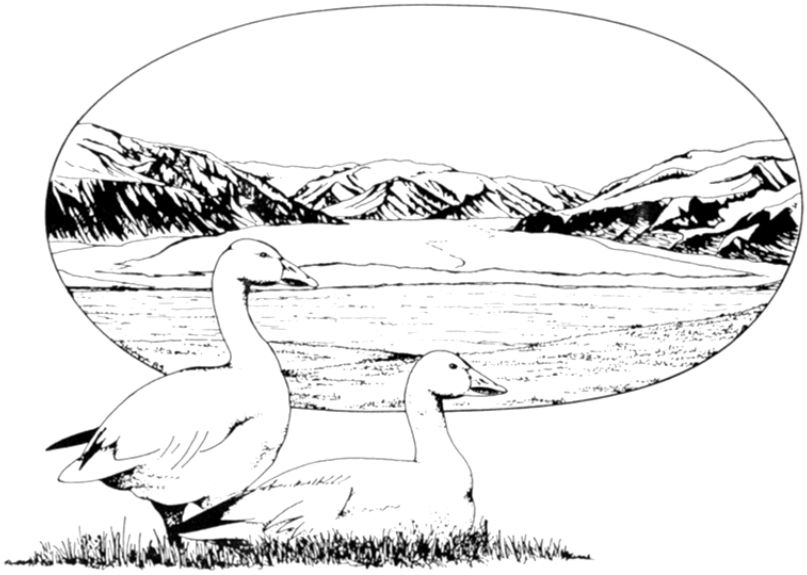
POPULATION STUDY OF GREATER SNOW GEESE AND ITS NESTING HABITAT ON BYLOT ISLAND, NUNAVUT IN 2022: A PROGRESS REPORT



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INTRODUCTION

In 2022, 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 20th century. The exploding population has imposed major 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 actions during fall, winter and spring have 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) monitor changes in the demographic parameters of the Greater Snow Goose population, and especially the effects of the spring conservation harvest on those parameters, (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 2022 were as follows:

1) Monitor the productivity (egg laying date, clutch size and nesting success) and nesting distribution of Greater Snow Geese on Bylot Island.
2) Study the migration phenology of geese and its impact on reproductive success.
3) 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.
4) Band goslings and adults at the end of the summer to continue the long-term study of demographic parameters such as survival and breeding propensity.
5) Monitor the abundance of lemmings and study their demography in relationship with snow conditions and the impact of predation on their cyclic fluctuations of abundance.
6) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owl, jaegers, Glaucous Gull, Peregrine Falcon and Rough-legged Hawk).
7) Monitor the breeding activity of foxes at dens.
8) Capture and mark adult foxes and their pups to study their movements, demography and foraging activity.
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 2022, we operated two camps on Bylot Island: the main field station, located 6 km from the coast in the largest glacial valley on the island (Qarlikturvik Valley, 73° 08' N, 80° 00' W), was occupied from 10 May to 20 August. 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 22 May to 20 July (Fig. 1). Finally, 11 fly camps were also established for periods ranging from 4 to 7 days at various times throughout the island, west of Dufour Point.

***Field parties.* —** The total number of people in both camps ranged from 4 to 16 depending on the period. Members of our field party included project leaders Pierre Legagneux, Joël Bêty, Dominique Berteaux, Josée Lefebvre, Dominique Fauteux and several graduate students whose thesis projects addressed many of the objectives mentioned above: Frédéric LeTourneux (PhD, objectives 1, 2 and 3), Frédéric Dulude-de Broin (PhD, objectives 7 and 8), Mathilde Poirier (PhD, objective 5), Gabriel Bergeron (PhD, objectives 5 and 6), Ilona Grenztmann (PhD, objectives 1, 3 and 4), Camille Gaudreau-Rousseau (PhD, objective 5), David Bolduc (MSc, objective 5), Thierry Grandmont (MSc, objective 2), Matthieu Weiss-Blais (MSc, objective 1), Jeanne Clermont (PhD, objective 8), Mathieu Archambault (MSc, objective 7). Other students assisted them in the field, including Azénor Bideault, Marylou Beaudoin, Ludovic Landry-Ducharme and Louis-Pierre Ouellet. Other people in the field included Marie-Christine Cadieux, a research professionnal in charge of goose banding and plant sampling (objectives 4 and 9); Denis Sarrazin, research professionnal responsible of the maintenance of the weather stations (objective 10); and Christian Marcotte and Simon Bourbeau, wildlife technicians from the Canadian Wildlife Service (CWS, Quebec region). Finally, we hired one person from Pond Inlet to work with us during goose banding: James Akpaleeapik (8-15 August).

Several other people also used our camps during the summer. They were Louis Moisan (PhD student), Madeleine-Zoé Corbeil-Robitaille (MSc student), Laurence Gagnon (MSc student) Éliane Duchesne (research assistant), Joassie Otoovak (Pond Inlet field assistant) and Dominique Gravel (researcher at Université de Sherbrooke), who studied shorebirds, lapland longspurs, cackling geese and insects under the supervision of Joël Bêty; the field party of Daniel Fortier (Université de Montréal), which included Élisabeth Hardy-Lachance (MSc student), who studied the permafrost and geomorphology; the field party of Esther Lévesque, Christophe Kinnard and Vincent Maire (Université du Québec à Trois-Rivières), which included Charlotte Marquis (MSc student), Stéphanie Desjardins (MSc student) and Virginie Favreau, who studied plant ecology and hydrology; the field party of Isabelle Laurion and Jérôme Comte (Institut National de la Recherche Scientifique), which included Martial Leroy (PhD student), Emily Hallett (PhD student), Peter Douglas and Cynthia Kallenbach (researchers at McGill University), Melanie Burnett (PhD student at McGill University), Roxane Maranger (researcher at Université de Montréal), Melissa Lafreniere (researcher at Queen's University), Cedelle Pereira (MSc student at Queen's University) and Kimia Motevalli (PhD student at Université Laval), who studied the carbon cycle in ponds; the field party of Florent Dominé (Takuvik, Université Laval/CNRS) with Félix Lévesque-Desrosiers (MSc student) who studied the snow physical properties; Angela Gallego-Sala (University of Exeter, UK) who studied the carbon cycle in peatlands.

Other people from Pond Inlet also visited the camp for knowledge exchange or helped us with research activities. Tess Espey and Darrell Makin from Parks Canada inspected both camps during the summer. Sheatie Tagak and Simon Komangapik guided the research teams of Christophe Kinnard and Gilles Gauthier in snowmobiles to bring them to the main field station in early May. Darrell Makin and Patricia Panipakoocho (Parks Canada), Elijah Panipakoocho (Pond Inlet elder) and Jeannie (college student interested in environmental sciences) visited the main field station in early June during a knowledge sharing day organized by Mathilde Poirier (PhD student, Université Laval) and Parks Canada. Five community members from HTO (Jonathan Pitseolak and Phanuel Enooagak), Joint Park Management Committee (Jessie Oolateeta), Parks Canada (Caleb Little) and the Hamlet Office (Joshua Arreak) visited both our camp in early July. Brendon Anderson (Visitor Safety Specialist from Parks Canada) also spent one day in August at the main field station.

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, solar radiation, wind speed and wind 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 across the valley every two to three days from our arrival on the island on 27 May until the end of snowmelt. Nest searches were carried out within walking distance (~6 km) of both the main field station and the Camp 2 mostly between 11 and 25 June. Nests were found by systematic searches conducted over various areas in the field. At Camp 2, where the main goose colony is located, nest searches were conducted using two methods: 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 4-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. Nests of other goose species, and in particular Cackling Geese (*Branta hutchensii*), were also systematically recorded during our field activities throughout Bylot Island.

Tracking of geese radio-marked in the south. **—** During spring staging in Quebec, we banded 594 snow geese captured with cannon-nets and we equipped 41 adult females with GPS/GSM transmitters mounted on neck collars. We were also able to monitor 37 additional females equipped with similar transmitters in previous years. On Bylot Island, we conducted intensive ground surveys (mostly from 11 to 18 June) of the breeding colony to find the nests of radio-marked geese and monitor their nests until hatching.

***Goose banding.* —** From 9 to 15 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 (body mass and length of culmen, head, tarsus and 9th primary). We also collected cloacal and blood samples on geese to study their aging process.

***Small mammals.* —** We sampled lemming abundance and demography using live-traps. We trapped on two 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 2012-2013 (the grid is surrounded by a chicken wire fence and covered by criss-crossing fishing line on top). The fishing line covering the grid to prevent avian predators to enter inside the enclosure was removed in summer 2022 but the fence remained in place. We also trapped at one other site at Camp 2 (270 × 270 m grid with 100 traps; mixed habitat). We used Longworth traps 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 grids of the Qarlikturvik Valley and during one period in mid-July at Camp 2. Traps were checked at 12-h intervals and all captured animals were identified, sexed, weighed and marked with electronic PIT tags or ear-tags (or checked for the presence of such tags). Finally, we sampled the abundance of lemming winter nests along 154 500-m transects randomly distributed in different habitats (wetlands, mesic tundra, streams in mesic tundra and willow shrubs) between the main field station and Dufour Point.

***Breeding activity of foxes at dens and marking.* —** All known fox dens located within a 600 km^2 area ranging from the Qarlikturvik Valley in the north to Dufour Point in the south and from the coast to approximately 10 km inland. Dens were visited one to five times during the summer and inspected for signs of use and/or presence of reproductive adults with pups. Automated cameras were deployed at dens showing signs of activity. We attempted to live-trap adults with cages and padded leghold traps at locations where foxes were seen hunting or travelling. At each den, we noted the species (Arctic Fox, *Vulpes lagopus*, or Red Fox, *Vulpes vulpes*), the presence of previously marked adults, and monitored for the presence of pups to determine minimum litter size. Cages 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. Samples of winter and summer fur and claws 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*), Peregrine Falcons (*Falco peregrinus*), Rough-legged Hawks (*Buteo lagopus*) and Lapland Longspurs (*Calcarius lapponicus*). Gull and Long-tailed jaeger nests were only monitored in the Qarlikturvik Valley and the Camp-2 area, but nests of other avian predators were monitored throughout the same 600 km^2 area than for foxes. 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 11 and 13 August. Plants were sorted into sedges (*Eriophorum scheuchzeri* and *Carex aquatilis*) and grasses (*Dupontia fisheri*), dried and weighed. 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 cool. Air temperature averaged -6.1°C (3.6°C below normal) between 20 May and 5 June, the period of goose arrival, and 1.9°C (0.7°C below normal) during 5-20 June, which is the most critical period for egg formation and egg-laying. Snowpack at the end of the winter was near normal (snow depth was 32.2 cm on 16 May; Fig. 2). However, cool temperature in spring and snow fall in early June delayed snowmelt to the end of June, which was later than normnal. Temperature throughout most of the summer were warm and the sky mainly clear and sunny. Rainfall was well below average and concentrated mostly in June (cumulative rainfall from 1 June to 17 August: 42 mm, long-term average: 76 mm).

Goose arrival and nesting activity. **—** The first geese were detected on the hills surrounding the Qarlikturvik Valley, usually the first area used by geese after arrival, around 27 May. This number increased over the next few days to peak at 504 pairs on 4 June, a high number (Fig. 3). When compared to other years, goose arrival on Bylot Island tended to be early in 2022. The subsequent decline in goose numbers was due to the movements of geese to the nesting colony and potentially to moulting sites, away from the Qarlikturvik Valley.

Nest density in the center of the colony (4.1 nests/ha) and outside the colony (1.3 nests/ha) was much lower than the long-term average (Table 1). Egg-laying date in the colony (median: 15 June) was 3 days later than the long-term average but average clutch size was 3.7, which is similar to the long-term average (Table 1). Only one nest was found in the Qarlikturvik Valley, which is predominantly a brood-rearing area for geese. Across the island, we found 61 nests of Cackling Geese compared to 76 in 2019 (Table 1).

Nesting success of geese. **—** Nesting success (37%; proportion of nests hatching at least one egg) was very low and well below to the long-term average (Table 1). This was largely due to a relatively high activity of Arctic Foxes and avian predators around goose nests, which destroyed more nests than in normal years. During the summer, 20 neck-collared birds were sighted in the colony. Peak hatch was on 12 July, which is 3 days later than the long-term average (Table 1). We tagged 627 goslings in nests at hatch in the Camp 2 area and none in the Qarlikturvik Valley. Overall, nesting parameters of geese in 2022 were lower than normal.

Density of broods. **—** The density of goose faeces on transects was very low at the end of the summer in wet meadows of the Qarlikturvik Valley (2.2 faeces/m^2; long-term average: 6.5; Fig. 4). Accumulation of faeces began after mid-July and increased only slightly until mid-August, which suggests a very low abundance of broods throughout the brood rearing period. Similarly, faeces density at the end of the summer was below average in the wet meadows of the nesting colony at Camp 2 (3.1 faeces/m^2; long-term average: 4.1).

Tracking of geese radio-marked in the south. **—** We were able to monitor departure date of 78 adult females from southern Quebec and the migration pattern and breeding decisions in the Arctic for 66 of them. Birds left Quebec around 19 May and arrived in Nunavut between 27 May and 12 June. Among those, six females arrived on Bylot Island around 11 June but all of them left soon after (before 28 June) to move further south to moult. Only three out of the 66 females that migrated to the Arctic attempted to nest and only one was seen with young in the fall. These females were also tracked during the fall migration and arrived in Quebec between 14 September and 6 October. Two of them were shot during the fall hunting season. Most geese were in Pennsylvania and New Jersey on 25 January 2023.

Goose banding. **—** The banding operation was difficult this year due to bad weather and mechanical problems with the helicopter in August. We conducted 5 drives between the Camp 2 area and the Qarlikturvik Valley. We banded a total of 662 geese, including 34 young that had been marked with web-tags at hatch. In addition, we recaptured 46 adults that were banded in previous years. We collected cloaca and blood samples from 26 goslings and 38 adults. The young:adult ratio among geese captured at banding (0.53:1) was much lower than last year and well below the long-term average (Table 1). Mean brood size toward the end of brood-rearing (2.28 young, n = 111; counts conducted between 31 July and 12 August) was also below the long-term average. By combining information on brood size and young:adult ratio at banding, we estimated that only 47% of the adults captured were accompanied by young, a very low value (Table 1). Overall, these results are indicative of a very low production of young on Bylot Island by the end of the summer.

Small mammals. **—** During our live-trapping survey, which cumulated 6,912 12-hr trapping sessions throughout the summer, we only captured 5 Brown Lemmings and 3 Collared Lemmings, a very low number. A formal estimation of density using capture-recapture methods confirmed that Brown Lemmings, which had reached a record high abundance in summer 2021 (>15 lemmings/ha), had crashed to extremely low values (<0.5 lemmings/ha) throughout the summer 2022 (Fig. 5). The live-trapping survey conducted at Camp 2 also indicated a very low lemming abundance with no lemmings captured during 500 12-hr trapping sessions. Finally, the number of lemming winter nests found along our transects confirmed a decrease in lemmings during winter as we counted 105 nests in 2022 compared to 431 in 2019.

Breeding activity of foxes at dens and marking. — A total of 128 known fox denning sites were monitored in 2022. Among these dens, we found signs of activity (fresh digging and/or footprints) at 58 of them, a high number. However, no litter were seen this year, a rare event but nonetheless typical of what can be observed in years of very low lemming abundance. A total of 27 adult Arctic Foxes and 1 adult Red Fox were captured during the summer, including 3 Arctic Foxes marked in previous years. Five Arctic Foxes marked in previous years were also sighted but not recaptured. All new individuals were marked with ear-tags.

Monitoring of other bird species. **—** We found 32 active nests of Glaucous Gulls (vs. 36 in 2019), 2 nests of Parasitic Jaegers (vs. 5 in 2019), no nest of Long-tailed Jaegers (vs. 37 in 2019), 3 nests of Rough-legged Hawks (vs. 42 in 2019), 5 nests of Peregrine Falcons (vs. 3 in 2019) and no nest of Snowy Owls (vs. 10 in 2019). The low nesting activity of avian predators is typical of what we encountered in a year of low lemming abundance. We found 122 nests of Lapland Longspurs compared to 67 in 2019. Average clutch size of gulls was slightly lower than 2019 (2.6 eggs vs 2.8 in 2019) as well as for longspurs (5.5 eggs vs. 6.0 in 2019). Nesting success was low for gulls (25%) and unknown for hawks, falcons and jaegers. Fledging success (proportion of nests successful in fledging at least one young) was also low for longspurs (34%).

Plant growth and grazing impact. **—** Plant production in wet meadows of the brood-rearing area was lower than in 2019 and similar to the long-term average (Fig. 6). Above-ground biomass of graminoid plants in the Qarlikturvik Valley reached 50.6 g/m^2 in ungrazed areas in mid-August compared to 56.0 in 2019 (long-term average since 1990: 51.0 g/m^2). Biomass of both *Eriophorum* and *Dupontia* also decreased slightly compared to 2019 (Fig. 6). At the nesting colony (Camp 2 area), graminoid biomass was higher compared to 2019 (80.5 vs 60.9 g/m^2 in 2019, Fig. 7). Above-ground biomass of *Eriophorum* in the exclosures was similar to 2019 but biomass of *Dupontia* increased compared to 2019.

Grazing pressure was relatively low in the wet meadows of the Qarlikturvik Valley in 2022 as geese had removed 27% of the above-ground biomass (difference between paired grazed and ungrazed plots) by mid-August (long-term average: 32%; Fig. 6). Grazing pressure was lower on *Eriophorum* (17% of biomass removed), the preferred plant of geese, than *Dupontia* (24% of biomass removed). Grazing pressure at the Camp 2 area (nesting colony) was lower than at the Qarlikturvik Valley (15% of the graminoid biomass removed by geese) and lower than the long-term average (27%; Fig. 7). Geese removed 9% of the *Eriophorum* biomass and 19% of the *Dupontia* biomass at this site.

CONCLUSIONS

All indicators of goose reproduction on Bylot Island were poor in 2022. Overall, 2022 was the worst breeding season of the past two decades for geese on Bylot Island, similar to 1999. Even if geese arrived relatively early and in large numbers on the island, their numbers rapidely decreased and nesting effort (indexed by nest density in the colony) was very low with delayed egg-laying and reduced clutch size. This was partly the consequence of the late spring and late snow melting, one of the latest on record. These conditions likely induced a strong reduction of breeding propensity (less than 5% of our GPS tracked birds initiated reproduction). This contrasts with values obtained in previous years (2019-2021) with similar devices when breeding propensity was 52% on average (range 46-67%). Among those that did nest, predation rate on nests was extremely high. Predation was also likely high during brood-rearing, resulting in a record low density of broods at the end of the summer.

Very late snow-melt in spring is typically the main cause of breeding failure events in arctic-nesting geese (this was also the case in 1992 for instance). When such situations occur, food availability is very low during the pre-laying period and nesting sites are not available, which increase energy demand, potentially reduce endogeneous body reserves and jeopardize reproduction. Nesting success was also very low, a consequence of a high activity of predators and of the low density of geese in the colony, which reduced the predator-swamping effect associated with high goose density. The high activity of foxes in the colony, and of avian predators as well, was likely a consequence of the low lemming abundance on the island this year, as their populations were in the low phase of their cycle. When lemmings are scarce, goose eggs become a major source of food for local predators. Although no fox den had pups this year, adult foxes are known to remain on their territory during the summer and forage around even when lemmings are low. The proportion of young recorded in our catches at banding suggested that production on Bylot Island was very low in 2022. Based on the young:adult ratio recorded at banding, we predicted a percentage of young in the fall flock of 2%. This prediction was supported by the percentage of young measured during juvenile counts conducted in southern Quebec this fall, which was estimated at 3% (n = 24,908). A proportion of young lower than 10% in the fall flock is considered indicative of widespread breeding failure over the whole breeding area.

An emerging phenomenon on Bylot Island is the growing number of nesting Cackling geese. In our study area, the first nest was found in 1996. Until 2010, their presence was relatively rare (<10 nests annually). However, as we noticed a rapid increase in their number, we started to search more systematically the study area in 2014. In 2022, we found 61 cackling nests, which was slightly lower than in 2019 (76 nests). Moreover, the nesting success of cacklings was very low in 2022 (31%), compared to previous years (typically >90%), possibly also due to a high redation rate.

Above-ground graminoid production in wet meadows of the Qarlikturvik Valley, a prime brood-rearing area, was average this year, though less so in the nesting colony. Faeces counts revealed that use by broods was very low at both sites due to the low abundance of broods this year, which resulted in a low impact of goose grazing at both sites. Annual change in plant production in wetlands seem to be more related to variations in summer temperature, often with a 1 or 2-year lag, than to variations in goose grazing pressure.

PLANS FOR 2023

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*) studying indirect interactions between snow geese and lemmings via shared predators; *iii*) studying the ecology of the main predator of geese, the Arctic Fox; and *iv*) assessing the impact of climate change on goose reproduction and the carrying capacity of the habitat for geese. In 2023, 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) Study the migration phenology of geese and its impact on reproductive success.
3) 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.
4) Band goslings and adults at the end of the summer to continue the long-term study of demographic parameters such as survival and breeding propensity.
5) Monitor the abundance of lemmings and study their demography in relationship with snow conditions and the impact of predation on their cyclic fluctuations of abundance.
6) Monitor the breeding activity of other bird species, in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls, Peregrine Falcons and Rough-legged Hawks).
7) Monitor the breeding activity of foxes at dens
8) Capture and mark adult foxes and their pups to study their movements, demography and foraging activity.
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.

In 2023, at least 4 graduate students will be involved in the Bylot Island snow goose project. **Ilona Grentzmann** (PhD) will continue her study on the effect of senescence on the population dynamics and physiology of snow geese. **Gabriel Bergeron** (PhD) will continue his study on seasonal Arctic food-web modeling. **Camille Gaudreau-Rousseau** (PhD) will start her study on the vulnerability of lemmings to predation by ermine in different phases of the cycle. **Matthieu Weiss-Blais** (MSc) will continue his study on nest attendance of snow geese during incubation and its impact on the risk of predation by arctic foxes.

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

	2013	2014	2015	2016	2017	2018	2019	2020	2021	**2022**	Average[2]
Number of nests monitored	451	491	347	337	342	277	422	580[3]	487[3]	**332**	--
Nest density in the core of the colony (n/ha)	8.85	7.89	9.26	5.50	8.14	3.46	5.70	8.35[3]	9.09[3]	**4.09**	4.90
Nest density in random plots (n/ha)	3.39	3.39	2.73	3.70	3.41	3.35	4.38	4.41[3]	4.15[3]	**1.28**	2.48
Median date of egg-laying	13 June	11 June	12 June	13 June	11 June	14 June	7 June	12 June[4]	13 June[4]	**15 June**	12 June
Clutch size	3.58	3.85	3.48	3.36	3.53	3.50	4.04	3.67[4]	2.75[4]	**3.74**	3.71
Nesting success[1]	67%	91%	77%	73%	56%	50%	82%	64%[3]	--	**37%**	66%
Median date of hatching	10 July	8 July	9 July	9 July	8 July	11 July	4 July	11 July[4]	10 July[4]	**12 July**	9 July
Ratio young:adult at banding	1.10:1	1.19:1	0.99:1	0.91:1	0.88:1	0.94:1	1.20:1	--	1.02:1	**0.53:1**	1.02:1
Brood size at banding	2.51	2.58	2.08	2.35	2.14	2.34	2.65	--	2.51	**2.28**	2.48
Proportion of adults with young at banding	88%	92%	95%	78%	83%	81%	91%	--	81%	**47%**	82%
Number of Cackling goose nests found	10	22	11	28	40	61	76	--	--	**61**	29[6]

[1] Mayfield estimate.
[2] Period 1989-2019 and 2022. Data from 2020 and 2021 are not included in the long-term average (except banding data) because different protocols were used during the covid19 pandemic.
[3] These values were estimated from analyses of satellite images.
[4] These values are only based on the GPS-tracking of 4 females that nested on Bylot Island.
[6] Period 2010-2019 and 2022.

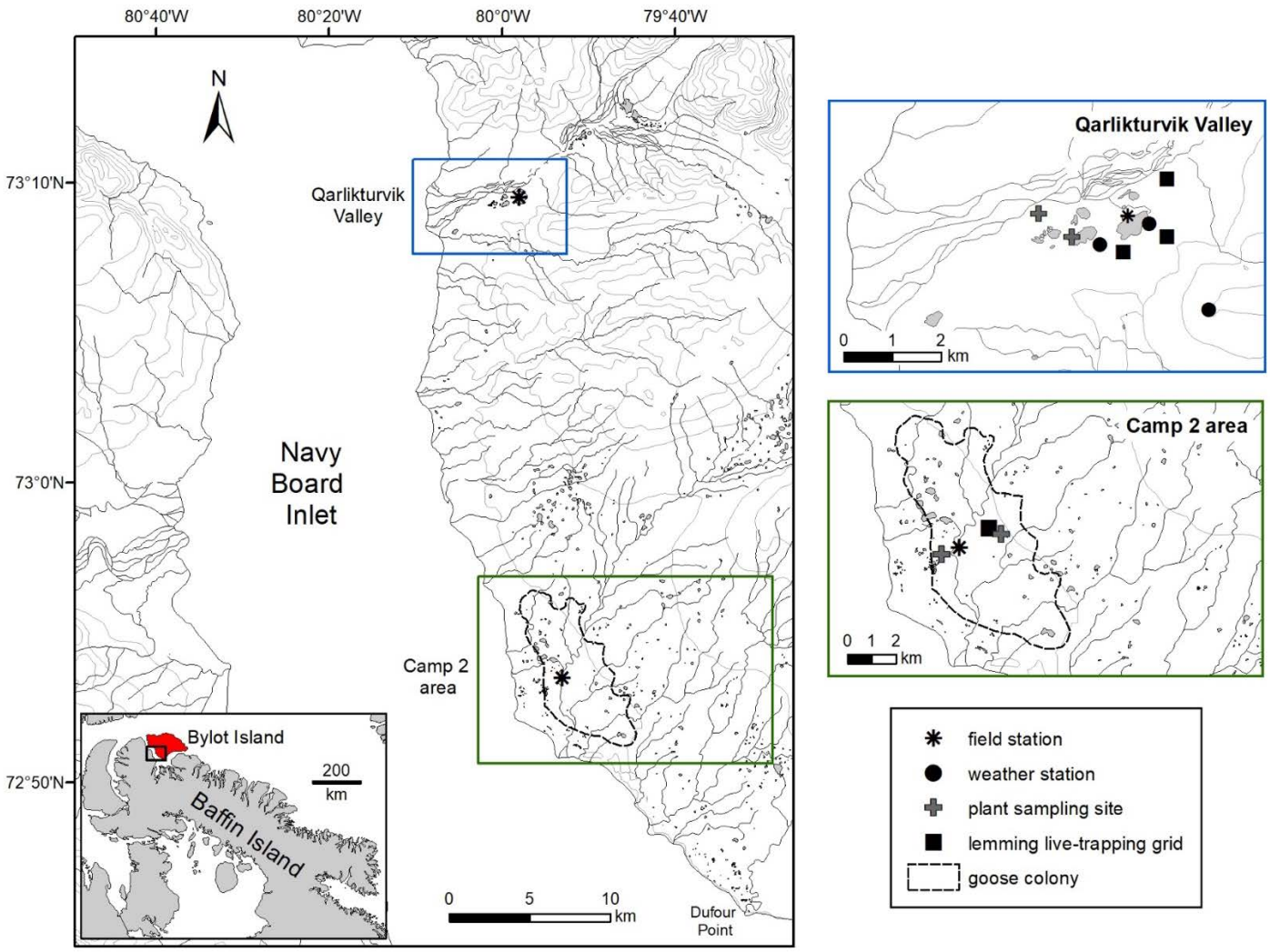

Figure 1. Location of the two main study sites (Qarlikturvik Valley and the Camp 2 area) on the South Plain of Bylot Island, Nunavut. Enlarged maps on the right present these study sites in more details, including locations of our field stations, automated weather stations, wetland sampling sites for plants, lemming live-trapping grids and the extent of the main snow goose colony. The Qarlikturvik Valley is predominantly a brood-rearing area for geese.

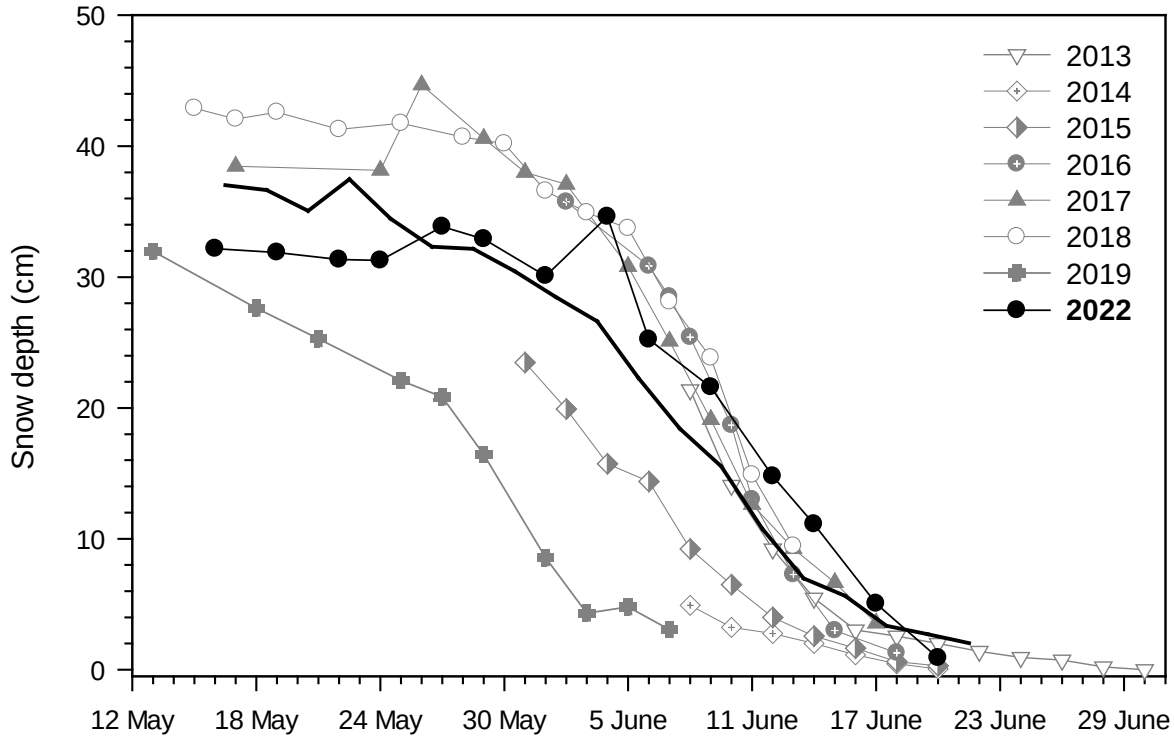

Figure 2. Average snow depth along two transects showing the rate of snowmelt in the lowlands of Bylot Island in spring over the past decade (n = 50 stations). The thick solid line represents the average snowmelt rate since 1995. No field data available in 2020 and 2021 due the covid19 pandemic.

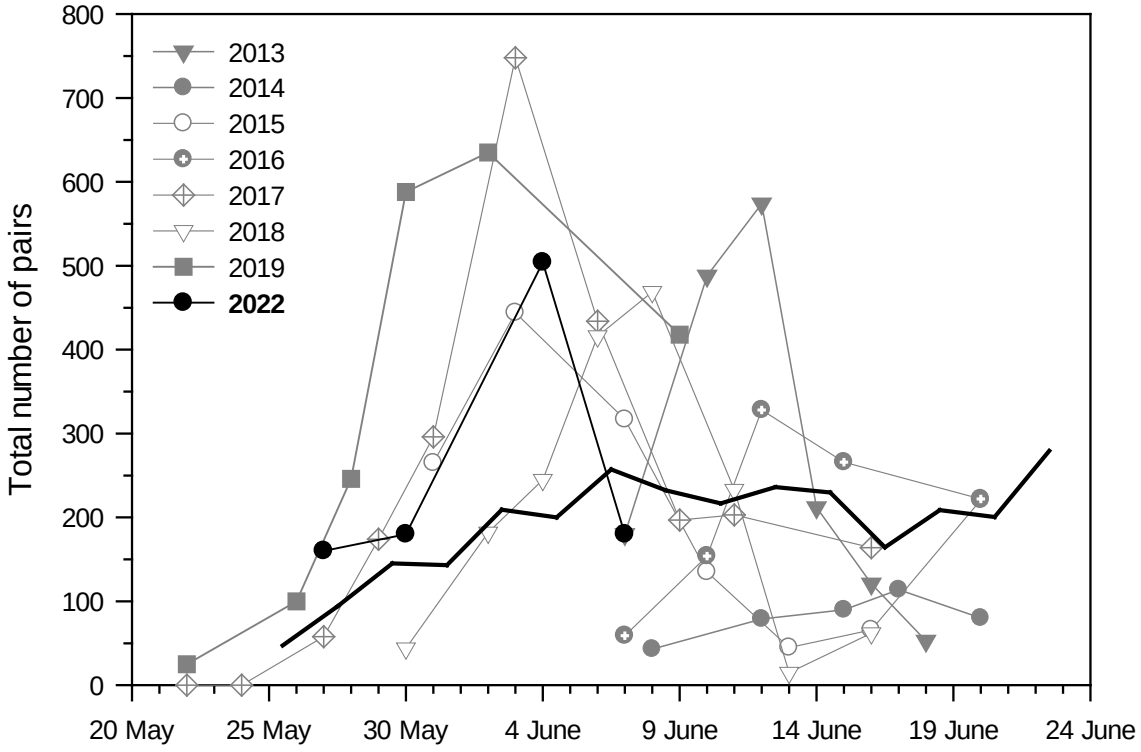

Figure 3. Total number of goose pairs counted in the Qarlikturvik Valley from arrival of our crew on Bylot Island in late May until the end of snowmelt over the past decade. The thick solid line represents the average number of goose pairs counted since 1996. No field data available in 2020 and 2021 due the covid19 pandemic.

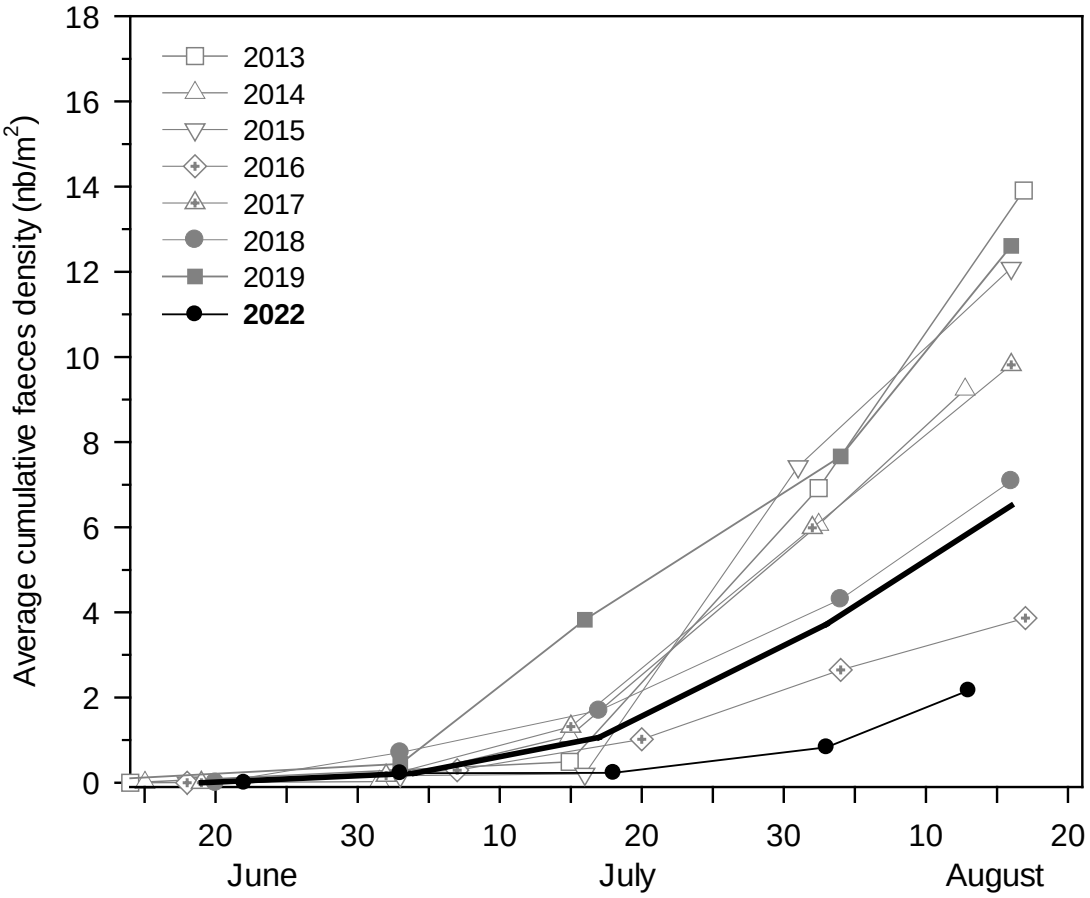

Figure 4. Average cumulative faeces density showing the use of the Qarlikturvik Valley by Greater Snow Goose families on Bylot Island throughout the summer over the past decade (n = 12 transects of 1 x 10 m; except 2013 n = 5 and 2016 n = 11). The thick solid line represents the average cumulative faeces density since 1990. No field data available in 2020 and 2021 due the covid19 pandemic.

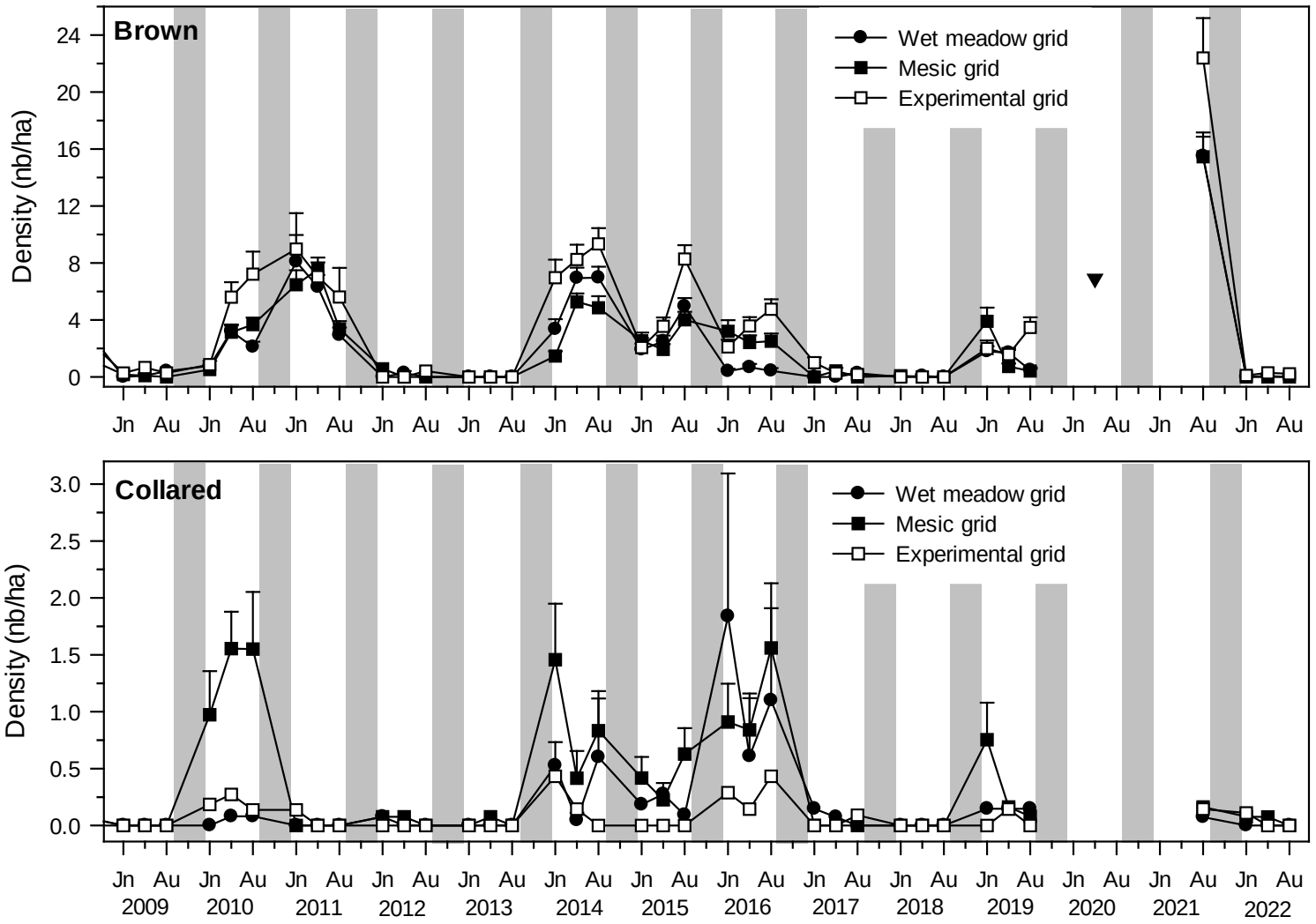

Figure 5. Annual summer density (+ SE) of Brown and Collared Lemmings on three trapping grids located in the Qarlikturvik Valley of Bylot Island over the past 14 years (snow cover was increased from 2008 to 2011 and predators were excluded from 2012 to 2022 on the experimental grid). The gray area indicates winter. Jn = mid-June, Au = mid-August. Lemming density in 2020 (both specied combined; black triangle) was inferred based on the density of snowy owls estimated through satellite images.

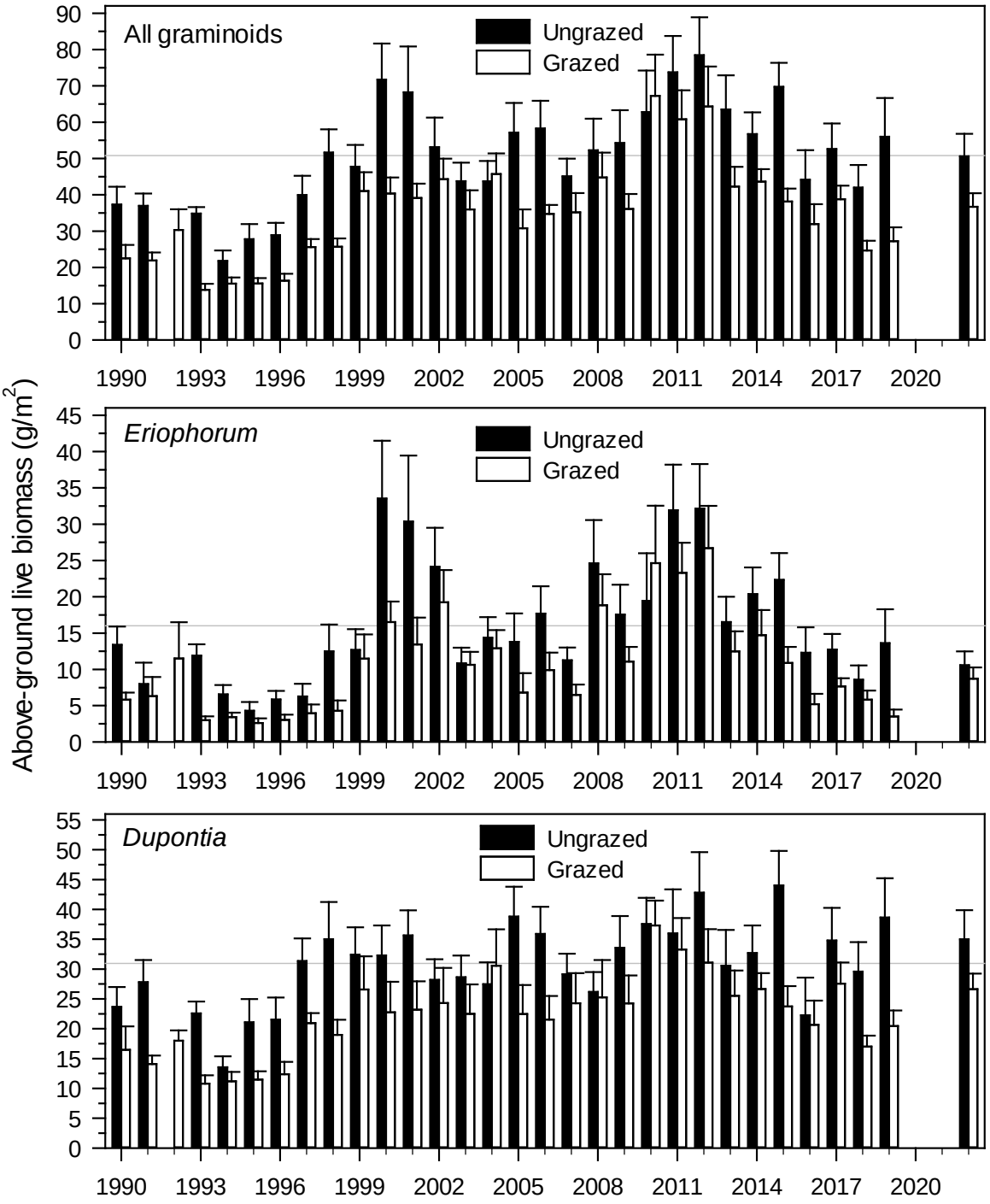

Figure 6. Live above-ground biomass (mean + SE, dry mass) of graminoids around 11 August in grazed and ungrazed wet meadows of the Qarlikturvik Valley, Bylot Island (n = 12, except in 2013, 2014 and 2016, n = 11). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data from ungrazed area in 1992. The solid gray line is the long-term average for ungrazed area. No field data available in 2020 and 2021 due the covid19 pandemic.

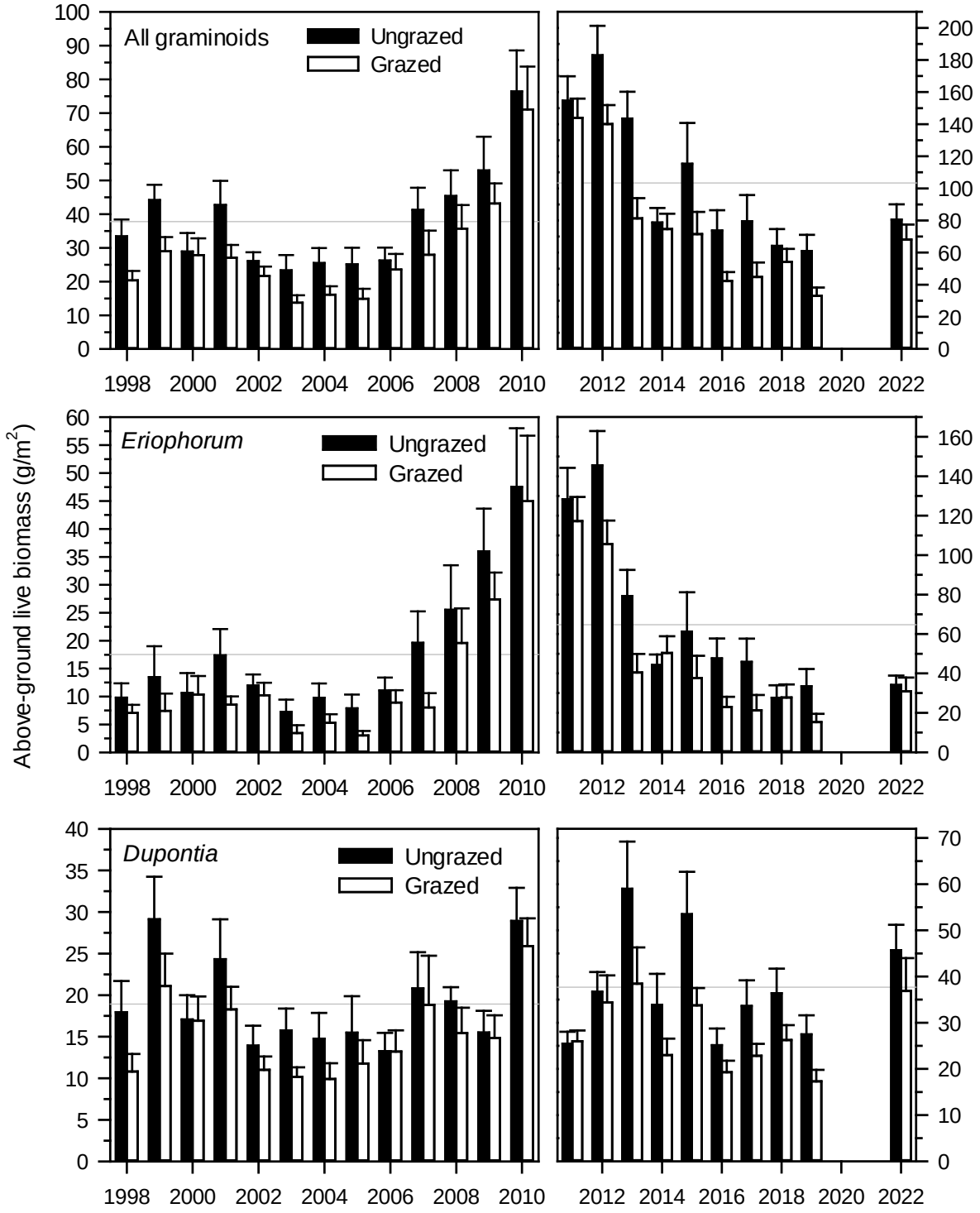

Figure 7. Live above-ground biomass (mean + SE, dry mass) of graminoids around 13 August in grazed and ungrazed wet meadows of the Camp 2 (goose colony), Bylot Island (n = 12, except in 2008 and 2014 n = 8, and 2012, 2013 and 2015 n = 10). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia 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 (solid gray line) calculated separately before/after 2011. No field data available in 2020 and 2021 due the covid19 pandemic.

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Papers in refereed journals

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C.221. Hutchison, C., P. Legagneux, F. Guichard, J. Bety, D. Berteaux, G. Gauthier, D. Fauteux, A, Allard & D. Gravel. 2020. Arctic seasonal models: evidence for hierarchical temporal processes in food-webs. *Arctic Change 2020 Conference*, Quebec City, QC.
C.220. Godin, E., W.F. Vincent, G. Gauthier & C. Barrette. 2020. Merged Observatory Data for Arctic Air Temperature (MODAAT) in action: Comparison of temperature data from a High Arctic automated weather station with reanalysis estimates from the ERA5-Land model. *Arctic Change 2020 Conference*, Quebec City, QC.
C.219. Gauthier, G. & J.F. Therrien. 2020. Recent rends in snowy owl breeding and lemming populations on Bylot Island, Nunavut, Canada. *5th meeting of the International Snowy Owl Working Group*, Pasvik, Norway.
C.218. Curk, T., I. Pokrovsky, N. Lecomte, O. Kulikova, T. Aarvak, G. Gauthier, K.O. Jacobsen, I.J. Øien, R. Solheim, K. Wiebe, M. Wikelski, J.F. Therrien & K. Safi. 2020. Snowy owls with contrasting migration patterns exhibit different proximate responses to food resources. *5th meeting of the International Snowy Owl Working Group*, Pasvik, Norway.
C.217. Therrien, J.F., K. Wiebe, K.O. Jacobsen, I.J. Øien, R. Solheim, T. Aarvak, S. Weidensaul, D. Brinker, B. Sittler, O. Gilg, A. Aebischer, J. Lang, D. Holt & G. Gauthier. 2020. Fledging dispersal and survival in snowy owls. *5th meeting of the International Snowy Owl Working Group*, Pasvik, Norway.
C.216. Beardsell, A., D. Gravel, D. Berteaux, G. Gauthier, V. Careau, J. Clermont, C.C. Juhasz, N. Lecomte, P. Royer-Boutin & J. Bêty. 2020. Assessment of functional responses using a mechanistic approach in a generalist predator of the arctic tundra. *Predator-Prey Interactions meeting*, Ventura CA.
C.215. Gousy-Leblanc, M, G. Yannic, J.F. Therrien, G. Gauthier, S. Weidensaul, D. Brinker & N. Lecomte 2019. Population genetic structure of an arctic breeder, the snowy owl. *ArcticNet Scientific Meeting*, Halifax, NS.
C.214. Lamarre J.-F., G. Gauthier, O. Love, E.T. Reed, O.W. Johnson, K. Overdujin, R. Lanctot, S.T. Saalfeld, J. Liebezeit, R. McGuire, M. Russell, L. McKinnon, L. Kolosky, P.A. Smith, S. Flemming,

N. Lecomte, M.-A. Giroux, S.Bauer, T. Emmenegger & J. Bêty. 2019. Timing of breeding site availability drives migration schedule in a long distance trans-hemispheric migrant. *ArcticNet Scientific Meeting*, Halifax, NS.

C.213. Gauthier, G. & J.-F. Therrien. 2019. Long-term ecological monitoring of the tundra ecosystem: role and conservation perspectives for birds of prey. *Raptor Research Foundation annual scientific conference*, Fort Collins, CO.

C.212. Lamarre, J.-F., G. Gauthier, O. Love, E. Reed, O.W. Johnson, K. Overdujin, R. Lanctot, S.T. Saalfeld, J. Liebezeit, R. Bentzen, M. Russell, L. McKinnon, L. Kolosky, P. Smith, S. Flemming, N. Lecomte, M.-A. Giroux, S. Bauer & T.J. Emmenegger. 2019. Timing of breeding site availability drives migration schedule in a long distance trans-hemispheric migrant. *8th Western Hemisphere Shorebird Group meeting*, Panama City, Panama.

C.211. Kalhor, D., A. Pusenkova, M. Poirier, G. Gauthier, T. Galstian & X. Maldague. 2019. Using near infrared for studying lemming subnival behavior in the arctic. *15th International Workshop on Advanced Infrared Technology and Applications*, Firenze, Italy.

C.210. Fauteux, D., G. Gauthier, J. Bêty, D. Berteaux, M.J. Mazerolle, N. Coallier & M.-C. Cadieux. 2019. Evaluation of invasive and non-invasive methods to monitor lemming abundance in the Canadian Arctic. *Arctic Science Summit Week*, Arkhangelsk, Russia.

C.209. Chagnon-Lafortune A, N. Casajus, R.I.G. Morrison, P.A. Smith, N. Lecomte, I. Tulp, M.C.Y. Leung, L. McKinnon, D. Berteaux & J. Bêty. 2018. Large-scale effect of temperature on arthropod availability for birds. *ArcticNet Scientific Meeting*, Ottawa, ON.

C.208. Léandri-Breton, D.-J., J.-F. Lamarre, & J. Bêty. 2018. Daring crossing or cautious detour? Contrasting transatlantic migration strategies in a small migratory bird breeding in the Canadian Arctic and wintering in Africa. *ArcticNet Scientific Meeting*, Ottawa, ON.

C.207. Fauteux, D., E. Schmidt, J.-F. Therrien, G. Gauthier & Y. Seyer. 2018. Enhancing terrestrial predators' diet assessments with rodent mandibles. *ArcticNet Scientific Meeting*, Ottawa, ON.

C.206. Gérin-Lajoie J, G. Gauthier, J. Bêty & G. MacMillan. 2018. A visual tool in Participatory Action Research for consulting Inuit communities about their environmental concerns and research interests. *ArcticNet Scientific Meeting*, Ottawa, ON.

C.205. Berner, L. P. Jantz, R. Massey, P. Burns, G. Gauthier, B. Forbes, M. Macias-Fauria, B. Gagliote, L. Andreu-Hayles, R. D'Arrigo & S. Goetz. 2018. Rapid warming leads to greening of the tundra biome. *American Geophysical Union annual meeting*, Washington DC, USA.

C.204. Gauthier G. & J. Lefebvre. 2018. Projecting the population dynamic of greater snow geese into an uncertain future: the interplay between management actions and climate change. *Fourteenth North American Arctic Goose Conference and Workshop*, Lincoln, Nebraska, USA.

C.203. LeTourneux, F., G. Gauthier, R. Pradel & J. Lefebvre. 2018. Impact of recent changes in hunting regulation on seasonal survival of male and female greater snow geese. *Fourteenth North American Arctic Goose Conference and Workshop*, Lincoln, Nebraska, USA.

C.202. Berteaux, D. 2017. Effects of climate shifts on arctic biodiversity. *37th Annual Conference of the International Association for Impact Assessment*, Montreal, QC.

C.201. Berteaux, D. 2017. Satellite tracking of arctic foxes on the Canadian Arctic sea ice: fine-scale genetic structure of the arctic fox population of Bylot Island (Nunavut, Canada). *Arctic Change 2017 conference*, Quebec, QC.

C.200. Legagneux, P., M-A. Giroux, P. Archambault, F. Barraquand, D. Berteaux, J. Bêty, G. Gauthier, D. Ehrich, T. Hoye, R. Ims, N. Lecomte, M-J. Naud, T. Roslin, N.M. Schmidt, P. Smith, S. Sokolov, N.G. Yoccoz & D. Gravel. 2017. ArcticWEB, a pan-Arctic network to monitor and model Arctic trophic interactions. *Arctic Change 2017 conference*, Quebec, QC.

C.199. Juhasz, C.C., N. Lecomte, G. Gauthier. 2017. Direct and indirect effects of climate on a simplified trophic network in the Arctic tundra. *Arctic Change 2017 conference*, Quebec, QC.

C.198. Fauteux, D., G. Gauthier, N. Coallier, J. Bêty & D. Berteaux, 2017. Evaluation of iseveralmethods to monitor lemming abundance: simple can also be good. *Arctic Change 2017 conference*, Quebec, QC.

C.197. Chevalier, C., G. Gauthier & D. Berteaux. 2017. Weather variability has no direct impact on adult survival in a High Arctic carnivore *Arctic Change 2017 conference*, Quebec, QC.

C.196. Lamarre, J.-F., J. Bêty. E. Reed, R. Lanctot, O. Love, G. Gauthier, O.W. Johnson, J. Liebezeit, R. Bentzen, M. Russell, L. McKinnon, L. Kolosky, P. Smith, S. Flemming, N. Lecomte, M.-A. Giroux, S. Bauer & T. Emmeneger. 2017. Year-round variation in migratory connectivity in American Golden-Plover (*Pluvialis dominica)*. *Arctic Change 2017 conference*, Quebec, QC.

C.195. Poirier, M., G. Gauthier, F. Dominé & M. Barrère. 2017. Physical properties of snow guide the movements of lemmings under the snowpack. *Arctic Change Conference*, Quebec, QC.

C.194. Seyer, Yannick, G. Gauthier, J. Bêty & N. Lecomte. 2017. Connectivity between the Canadian Arctic and the west coast of Africa: the journey of the Long-tailed jaeger. *Arctic Change Conference*, Quebec, QC.

C.193. Slevan-Tremblay, G., G. Gauthier & E. Lévesque. 2017. Impact of lemming grazing on Arctic willows under experimentally reduced predation. *Arctic Change Conference*, Quebec, QC.

C.192. Juhasz, C.C., A. Lycke, V. Carreau, G. Gauthier, J.-F. Giroux & N. Lecomte. 2017. Picking the right cache: hoarding-site selection for egg predators in the Arctic. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.191. Therrien J.F., A. Beardsell, G. Gauthier, N. Lecomte & J Bêty. 2017. Reproductive and movement ecology of rough-legged hawks breeding in the high arctic. *Raptor Research Foundation Annual Conference*. Salt Lake City, Utah, USA.

C.190. Couchoux, C., J. Clermont, S. Lai, F. Lapierre-Poulin, C. Chevallier & D. Berteaux. 2017. Implementing measures of individual behavioural variation in the Arctic ecosystem: can we assess personality in arctic foxes? *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.189. Darbon, C., S. Lai & D. Berteaux. 2017. Influence of the distribution of medium-sized prey species on the presence of red foxes in the south plain of Bylot Island, Nunavut, Canada. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.188. Thierry, A.-M., J. Bêty & D. Berteaux. 2017. Competition between Arctic and red foxes at the expanding front of the red fox in the Canadian Arctic. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.187. Lapierre-Poulin, F., D. Fortier & D. Berteaux. 2017. Developing a vulnerability index to climate change for arctic fox dens. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.186. Chevallier, C., G. Gauthier & D. Berteaux. 2017. Weather variability has no direct impact on adult survival in Arctic foxes. *5th International Conference in Arctic Fox Biology*. Rimouski, QC.

C.185. Devost, E, N. Casajus, S. Lai & D. Berteaux. 2017. FoxMask image analysis software, assisting ecologists in facing big data challenges. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.184. Berteaux. D. 2017. Satellite tracking of Arctic foxes on the Canadian Arctic sea ice. *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.183. Lapierre-Poulin, F., D. Fortier & D. Berteaux. 2017. Are arctic fox reproductive dens vulnerable to climate change in the Canadian High Arctic? *5th International Conference in Arctic Fox Biology.* Rimouski, QC.

C.182. Lai, S., A. Quiles, J. Lambourdière, D. Berteaux & A. Lalis. 2017. Fine-scale genetic structure of the arctic fox population of Bylot Island (Nunavut, Canada). *5th International Conference in Arctic Fox Biology*. Rimouski, QC.

C.181. Chevallier, C., D. Berteaux & G. Gauthier. 2017. Are demographic parameters of adult Arctic foxes resource-dependent? *5th International Conference in Arctic Fox Biology*. Rimouski, QC.

C.180. Fauteux, D., G. Gauthier, R. Boonstra, R. Palme & D. Berteaux. 2017. Top-down regulation of lemmings by Arctic foxes and other predators: observations and experiments on Bylot Island. *5th International Conference in Arctic Fox Biology*. Rimouski, QC.

C.179. Gauthier G., D. Fauteux, J. Bêty, D. Berteaux, M. Mazerolle & M.-C. Cadieux. 2017. Evaluation of invasive and non-invasive methods to monitor lemming abundance in the Canadian Arctic. *5th International Conference in Arctic Fox Biology*. Rimouski, QC.

C.178. Therrien J.-F., G. Gauthier, A. Robillard, T. McDonald, N. Smith, S. Weidensaul, D. Brinker, J. Bêty & N. Lecomte. 2017. The irruptive nature of snowy owls: going full cycle. *World Owl Conference*. Évora, Portugal.

C.177. Lefebvre, J., G. Gauthier, J.-F. Giroux, A. Reed, A. Béchet & E. Reed. 2017. Managing an overabundant population: the Greater Snow Goose in North America. *Dutch scientific goose meeting*. Leeurwarden, Netherlands.

C.176. Gauthier, G. A. Robillard, J.-F. Therrien & J. Bêty. 2017. What can we learn from isotopic analyses of snowy owl feathers? *4th meeting of the International Snowy Owl Working Group*, Milton, Massachussetts, USA.

C.175. Robillard A., G. Gauthier, J.-F. Therrien & J. Bêty. 2017. Wintering strategies, habitat use and site fidelity of snowy owls in eastern North America. *4th meeting of the International Snowy Owl Working Group*. Milton, Massachussetts, USA.

C.174. Juhasz, C.-C., N. Lecomte & G. Gauthier. 2016. How predator-prey interactions can mediate effects of climate on prey nesting success: the case of an Arctic nesting bird. *ArcticNet Scientific Meeting*, Winnipeg, MB.

C.173. Resendiz, C. & G. Gauthier. 2016. Heterogeneous long-term effects of a changing environment on the reproductive success of greater snow geese. *ArcticNet Scientific Meeting*, Winnipeg, MB.

C.172. Fauteux, D., G. Gauthier, D. Berteaux, R. Palme, C. Bosson & R. Boonstra. 2016. Lethal and non-lethal effects of predation on arctic lemmings. *Fifeteenth International Conference on Rodent Biology*, Olomouc, Czech Republic.

C.171. Giroux, M.-A., N. Lecomte, D. Gravel, D. Berteaux, G. Gauthier, P. Legagneux & J. Bêty. 2015. Bridging the gap between monitoring and modeling approaches to better understand arctic food webs under global pressures. *ArcticNet Scientific Meeting*, Vancouver, BC.

C.170. Seyer, Y., G. Gauthier & J. Bêty. 2015. From the Canadian Arctic to the western coast of Africa: The trans-equatorial migration of the Long-tailed jaeger. *ArcticNet Scientific Meeting*, Vancouver, BC.

C.169. Slevan-Tremblay, G., G. Gauthier & E. Lévesque 2015. Validation of a non-destructive method to estimate grazing impact of lemmings in the Arctic tundra. *ArcticNet Scientific Meeting*, Vancouver, BC.

C.168. Resendiz, C. & G. Gauthier. 2015. To change or not to change? Variations in components of the Greater Snow Goose reproductive success over a 26-year period. *ArcticNet Scientific Meeting*, Vancouver, BC.

C.167. Giroux, M.-A., N. Lecomte, D. Gravel, J. Bêty, G. Gauthier & D. Berteaux. 2015. Can animal migration explain the dominance of top-down forces in many Arctic food webs? Insights from empirical and theoretical approaches. *100th Ecological Society of America Annual Meeting*, Baltimore, MD.

C.166. Fauteux, D., G. Gauthier & D. Berteaux. 2015. Socio-economic relationships between Inuit and lemmings and the scientific methods employed to monitor lemmings. *International workshop on small mammal population outbreaks and their consequences*, Frasne, France.

C.165. Gauthier, G. 2015. Goose, plant and predator interactions in arctic systems: how will climate change things? *Thirteenth North American Arctic Goose Conference and Workshop*, Winnipeg, MB.

C.164. Lamarre, J.-F., G. Gauthier, P. Legagneux, E.T. Reed & J. Bêty. 2015. Snow goose colony: a risky nesting area for shorebirds. *Thirteenth North American Arctic Goose Conference and Workshop*, Winnipeg, MB.

C.163. Marmillot, V., G. Gauthier, M.-C. Cadieux & P. Legagneux. 2015. Plasticity in speed and timing of flight feather molt in the greater snow goose, a high-arctic-nesting species. *Thirteenth North American Arctic Goose Conference and Workshop*, Winnipeg, MB.

C.162. Resendiz, C. & G. Gauthier. 2015. Temporal trends and spatial variation in components of reproductive success of Greater Snow Geese on Bylot Island. *Thirteenth North American Arctic Goose Conference and Workshop*, Winnipeg, MB.

C.161. Gauthier, G. & D. Berteaux. 2014. Monitoring of terrestrial wildlife on Bylot Island in a global warming context: what did we learn after 20 years? *Arctic Change 2014 conference*, Ottawa, ON.

C.160. Robillard, A., J.-F. Therrien, G. Gauthier & J. Bêty. 2014. Fall migration and winter habitat use of an Arctic top predator: the Snowy Owl. *Arctic Change 2014 Conference*, Ottawa, ON.
C.159. Fauteux, D., G. Gauthier & D. Berteaux. 2014. Seasonal demography of a cyclic lemming population in the Canadian Arctic. *Arctic Change 2014 Conference*, Ottawa, ON.
C.158. Royer-Boutin, P., D. Berteaux, G. Gauthier & J. Bêty. 2014. Effects of lemming cycles on reproductive success of arctic-nesting birds using different antipredator strategies. *Arctic Change 2014 conference*, Ottawa, ON.
C.157. Beardsell, A., G. Gauthier, D. Fortier, J.-F. Therrien & J. Bêty. 2014. Factors affecting nest occupancy and reproductive success of rough-legged hawks: a trade-off between predation risk, microclimatic conditions and nest stability? *Arctic Change 2014 conference*, Ottawa, ON.
C.156. Seyer, Y., G. Gauthier, J. Bêty & J.-F Therrien 2014. Migratory strategies and reproduction of the Long-tailed Jaeger in the Canadian Arctic. *Arctic Change 2014 conference*, Ottawa, ON.
C.155. Lapierre-Poulin, F., D. Fortier & D. Berteaux. 2014. Are arctic fox reproductive dens vulnerable to permafrost degradation? *Arctic Change 2014 conference*, Ottawa, ON.
C.154. Morin, C. & D. Berteaux. 2014. Seasonal migratory prey and cyclic variation in small mammal abundance affect Arctic fox litter size. *Arctic Change 2014 conference*, Ottawa, ON.
C.153. Chevallier, C., D. Berteaux & G. Gauthier. 2014. Estimating the age structure of an arctic carnivore population by comparing tooth wear and cementum line. *Arctic Change 2014 conference*, Ottawa, ON.
C.152. Berteaux, D. & G. Gauthier. 2014. Long-term monitoring of the Bylot Island tundra ecosystem: what did we learn? *Arctic Biodiversity Congress*, Trondheim, Norway.
C.151. Gauthier, G. 2014. Population dynamic and management of the greater snow goose population in North America. Symposium *The Changing World of the Goose*. Wageningen, Netherlands.
C.150. Gauthier, G., J.-F. Therrien & J. Bêty. 2014. Movements and breeding dispersal of Snowy Owls in eastern North America: a specialized predator exploiting a pulsed resource. *Third meeting of the International Snowy Owl Working Group*, Salekhard, Russia.
C.149. Robillard, A., J.-F. Therrien, G. Gauthier & J. Bêty. 2014. Winter ecology of Snowy Owls: post-reproductive movements and determinants of winter irruptions in North America. *Third meeting of the International Snowy Owl Working Group*, Salekhard, Russia.
C.148. Gauthier, G. 2013. Lemming population ecology on Bylot Island: Interaction between snow and predation. *Lemming and Snow Workshop*, University of Tromsø, Tromsø, Norway.
C.147. Beardsell A., G. Gauthier G., D. Fortier D. & J. Bêty. 2013. Breeding ecology of rough-legged hawks (*Buteo lagopus*) in the High Arctic: are nesting structures vulnerable to climate change? *Ninth ArcticNet Scientific Meeting*, Halifax, NS.
C.146. Robillard, A., J.-F. Therrien, G. Gauthier & J. Bêty. 2013. Multi-scale influence of small mammal summer densities on snowy owl winter irruptions in North America. *Ninth ArcticNet Scientific Meeting*, Halifax, NS.
C.145. Fauteux, D., G. Gauthier & D. Berteaux. 2013. Ten years of monitoring lemming demography in the Canadian High Arctic. *Ninth ArcticNet Scientific Meeting*, Halifax, NS.
C.144. Lamarre, J.-F., J. Bêty & G. Gauthier. 2013. Predator-mediated interactions between shorebirds and colony-nesting snow geese on Bylot Island, Nunavut. *5th Western Hemisphere Shorebird Group conference*, Santa Marta, Colombia.
C.143. Perkins, M., L. Ferguson, R.B. Lanctot, I.J. Stenhouse, D.C. Evers, N. Basu, J. Bêty, S. Brown, R. Gates, S. Kendall, J.-F. Lamarre, J. Liebezeit & B. Sandercock. 2013. Quantifying mercury exposure for multiple shorebird species across the North American Arctic using blood and feather samples. *34th Annual Meeting of the Society of Environmental Toxicology and Chemistry*, Nashville, TN.
C.142. Lai, S., J. Bêty & D. Berteaux. 2013. Where do arctic foxes go in winter? A 6-year study using satellite telemetry on Bylot Island, Canada. *Fourth International Conference in Arctic Fox Biology*. Westfjords, Iceland.
C.141. Rioux, M.-J., S. Lai, J. Bêty & D. Berteaux. 2013. Spatial winter dynamics in arctic fox pairs at Bylot Island. *Fourth International Conference in Arctic Fox Biology*, Westfjords, Iceland.

C.140. Berteaux, D. 2013. Range margins of Arctic and Red fox in a rapidly changing Arctic, *8th Annual Meeting of the Canadian Society of Ecology and Evolution*, Kelowna, BC.
C.139. Berteaux, D. 2013. État et tendances de la biodiversité arctique. *Chantier arctique français*, Paris, France.
C.138. Legagneux, P., G. Gauthier, P.L.F. Fast, N. J. Harms, H. G. Gilchrist, C. Soos & J. Bêty. 2013. Empirical and experimental evidence of carry-over effects on waterfowl reproduction. *Canadian Society of Zoologists Annual Meeting*, Guelph, ON.
C.137. Souchay, G., G. Gauthier & R. Pradel. 2013. A new approach to account for temporary emigration using a multi-event framework. *EURING analytical conference*, Athens, GA.
C.136. Van Oudenhove, L., G. Gauthier, & J.D. Lebreton. 2013 Modelling climatic effects on the population dynamic of a long-distance, arctic-nesting migrant. *EURING analytical conference*, Athens, GA.
C.135. Legagneux, P., C. Juillet, P.L.F. Fast, G. Gauthier & J. Bêty. 2013. Experimental evidence of carry-over effects on greater snow goose reproduction and its management implications. *6th North American Duck Symposium and Workshop*, Memphis, TN.
C.134. Bêty, J. 2013. Understanding individual variation in reproductive strategies: the challenge of integrating physiology, optimization model and environmental stressors. *6th North American Duck Symposium and Workshop*, Memphis, TN.
C.133. Lefebvre, J., M. Huang, J.-F. Giroux, M. Bélisle, J. Bêty & C. Dwyer. 2013. Satellite telemetry improves our understanding of habitat use patterns and population estimates of greater snow geese. *6th North American Duck Symposium and Workshop*, Memphis, TN.
C.132. Bilodeau, F., S. Lai, G. Gauthier & D. Berteaux. 2012. Are tundra lemming populations controlled from the bottom-up or the top-down? *Eighth ArcticNet Scientific Meeting*, Vancouver, BC.
C.131. Fauteux, D., G. Gauthier, D. Berteaux & R. Boonstra. 2012. Direct and indirect effects of predation on lemmings in the High Arctic. *Eighth ArcticNet Scientific Meeting*, Vancouver, BC.
C.130. Doucet, C., G. Gauthier & J. Bêty. 2012. Synchrony between breeding phenology of an arctic-nesting insectivore and its food resources: investigating the effect of mismatch on juvenile growth rate. *Eighth ArcticNet Scientific Meeting*, Vancouver, BC.
C.129. Gauthier, G. 2012. Long-term changes in the Bylot Island tundra food web: a 20-year case study in the Canadian High Arctic. *Conference Tundra Change – The ecological dimension*. Aarhus, Denmark.
C.128. Fauchald, P., D. Ehrich, J. Schmidt, K. Klokov, F. S. I. Chapin, D. Berteaux & V. Hausner. 2012. The importance, management and status of harvested animals in the Arctic tundra ecosystems. *4th International Conference EcoSummit*, Columbus, OH.
C.127. Gauthier, G., D. Berteaux, P. Legagneux, D.G. Reid, C.J. Krebs & J. Bêty. 2012. The role of predators in controlling the tundra food web: New evidence from the ArcticWOLVES project. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.126. Fast, P.L.F., M. Doiron, G. Gauthier, J.A. Schmutz, D.C. Douglas, J. Madsen, J.Y. Takekawa, J. Yee & J. Bêty. 2012. Linking animal migration, spring weather and timing of breeding in an arctic herbivore. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.125. McKinnon, L., C.A. Corkery, E. Bolduc, C. Juillet, J. Bêty & E. Nol. 2012. Assessing the vulnerability of Arctic-nesting shorebirds to climate induced changes in food resource peaks. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.124. Juillet, C., R. Choquet, G. Gauthier, R. Pradel & J. Lefebvre. 2012. Carry-over effects of spring hunt and climate on recruitment to the natal colony in a migratory species. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.123. Lai, S., D. Berteaux and J. Bêty 2012. Movement tactics and habitat selection of overwintering arctic foxes in the Canadian high Arctic. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.122. Lamarre, J.-F., J. Bêty & G. Gauthier. 2012. Shorebird predation risk in the high-Arctic, do geese have a role to play? *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.

C.121. Berteaux, D., G. Gauthier, J. Bêty, A. Franke & G. Gilchrist. 2012. Effects of climate change on the canadian arctic wildlife. *International Polar Year Conference: From Knowledge to Action*. Montréal, QC.
C.120. Therrien, J.-F., G. Gauthier & J. Bêty. 2011. Avian predators play a key role in population regulation and energy flux of the Arctic tundra food web. *Annual Meeting of the Raptor Research Foundation*, Duluth, MN.
C.119. Bêty, J. 2011. Sensitive Arctic birds under the spotlights: global change and recent discoveries. *Society of Canadian Ornithologists Annual Meeting*, Moncton, NB.
C.118. Legagneux, P., P. Fast, G. Gauthier & J. Bêty. 2011. Manipulating individual state during migration provides evidence for carry-over effects modulated by environmental conditions. *Society of Canadian Ornithologists Annual Meeting*, Moncton, NB.
C.117. Bêty, J. 2011. Ecology and evolution of arctic migrants: fundamental questions and recent results. *Royal Swedish Academy of Sciences and Wenner-Gren Foundations*, Sweden.
C.116. Gauthier, G. 2011. Lemmings: a keystone species of the tundra food web vulnerable to climate change. *6th Annual Meeting of the Canadian Society of Ecology and Evolution*, Banff, AB.
C.115. Tarroux, A., D. Berteaux & J. Bêty. 2011. The marine side of a terrestrial mammal: trophic niche and diet specialization of arctic foxes. *Estación Biológica de Doñana – CSIC*, Sevilla, Spain.
C.114. Gauthier, G. & M.-C. Cadieux. 2011. Goose-plant interactions on Bylot Island in the context of global warming. *Twelfth North American Arctic Goose Conference*, Portland, OR.
C.113. Legagneux, P., P. Fast, G. Gauthier & J. Bêty. 2011. Migratory connectivity in Greater Snow Geese: carry-over effects of a manipulation of spring body condition. *Twelfth North American Arctic Goose Conference*, Portland, OR.
C.112. Fast, P., C. Redjadj, G. Gauthier & J. Bêty. 2011. Using isotopes to assess the importance of stopover sites to fuel migration and reproduction in Snow Geese. *Twelfth North American Arctic Goose Conference*, Portland, OR.
C.111. Doiron, M., G. Gauthier & E. Lévesque. 2011. Climate change and the ecological mismatch between Greater Snow Goose breeding and plant phenology. *Twelfth North American Arctic Goose Conference*, Portland, OR.
C.110. Desnoyers, M. & G. Gauthier. 2011. Travelling in greater snow goose flocks: do you know with whom you're travelling? *Twelfth North American Arctic Goose Conference*, Portland, OR.
C.109. Horrigan, E., R.L. Jefferies & G. Gauthier. 2011. Vegetation responses to simulated snow goose herbivory in two arctic ecosystems. *Twelfth North American Arctic Goose Conference*, Portland, OR.
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C.86. Gauthier, G. 2009. Impact of climate change on arctic terrestrial food webs: examples from the Bylot Island long term study. *Canadian Society of Ecology and Evolution Annual Meeting*, Halifax, NS.

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Graduate student theses

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T.73. Bergeron, G. 2022. Approche simplifiée par états et transitions saisonniers pour modéliser un système prédateurs-proies complexe de l'Arctique. MSc thesis, Département de biologie, Université de Sherbrooke.

T.72. Gignac, C. 2022. Réponse à long terme des communautés végétales aux changements climatiques et à l'herbivorisme par la Grande Oie des neiges dans les milieux humides de la toundra du Haut-Arctique canadien. MSc thesis, Département de phytologie, Université Laval.

T.71. Valcourt, M. 2022. Influence multi-échelles de l'habitat sur la répartition des lemmings dans le Haut Arctique canadien. MSc thesis, Département de biologie, Université Laval, Québec.

T.70. Seyer, Y. 2022. Mouvements annuels, reproduction et compétition alimentaire chez un prédateur aviaire de la toundra, le labbe à longue queue. PhD thesis, Département de biologie, Université Laval, Québec.

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T.68. Duchesne, E. 2020. Effet des interactions indirectes engendrées par un prédateur commun sur les variations spatio-temporelles d'abondance des espèces dans une communauté de vertébrés. MSc thesis, Département de biologie, Université du Québec à Rimouski.

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T.64. Lapierre-Poulin, F. 2018. Vulnérabilité des tanières du renard arctique aux risques géologiques reliés aux changements climatiques. MSc thesis, Département de biologie, Université du Québec à Rimouski.

T.63. Léandri-Breton, D.-J. 2018. Stratégies migratoires et vulnérabilité à la prédation chez des pluviers nichant dans l'Arctique. MSc thesis, Département de biologie, Université du Québec à Rimouski.

T.62. Chevallier, C. 2018. Démographie et dynamique de la population de renards arctiques (*Vulpes lagopus*) de l'Île Bylot, Nunavut, Canada. PhD thesis, Département de biologie, Université du Québec à Rimouski.

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