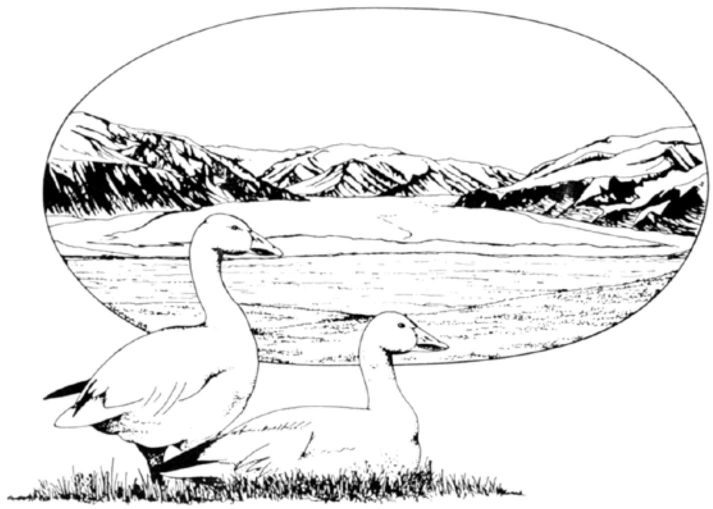
POPULATION DYNAMICS OF GREATER SNOW GEESE: DEMOGRAPHIC AND HABITAT MONITORING DURING A PERIOD OF INCREASED HARVEST

2020 - A PROGRESS REPORT



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INTRODUCTION

Like many other goose populations worldwide, Greater Snow Geese (*Anser caerulescens atlanticus*) have increased considerably during the late 20th 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 actions during autumn, 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 goals 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.

Original activities planned for this project in 2020 included studying of goose migration and reproduction, goose banding, monitoring of lemming abdundance, monitoring of avian predators and fox reproduction, sampling plant production in wetlands and monitoring weather and snow melt on Bylot Island, Nunavut. However, in 2020 all Arctic fieldwork was canceled in Nunavut because of the COVID-19 pandemic. In response to this exceptional situation, we developped an alternative plan that relied on biologging and remote sensing technologies to infer some of the key parameters related to the population dynamic of Greater Snow Geese and thus achieve some of our initial objectives.

OBJECTIVES

Our revised, specific goals for 2020 were as follows:

1) Measure the snowmelt on Bylot Island, an important determinant of goose reproductive effort in the Arctic.
2) Study the migration phenology of Greater Snow Geese and its impact on reproductive success.
3) Estimate the breeding phenogly, nesting density and nesting success of Greater Snow Geese.
4) Estimate the breeding activity of Snowy Owls (*Bubo scandiacus*) and use this information to infer lemming abundance, a key variable affecting goose nesting success.

STUDY SITES

Our main field research activities are conducted primarily at two sites on Bylot Island, Nunavut: the Qarlikturvik Valley, which is the largest glacial valley on the island and a prime brood-rearing area (73°08' N, 80°00' W), and the Camp 2 area, located in a narrow valley 30 km south of the Qarlirturvik Valley at the core of the main goose nesting colony (72°53' N, 79°54' W). Our analyses using remote sensing data in 2020 focused on the same sites. Fieldwork was also conducted in spring 2020 at Île-aux-Oies (47°08' N, 70°28' W), a site located in the heart of the goose staging area in southern Quebec, where adult female Greater Snow Geese were equipped with GPS transmistters.

METHODS

Environmental and weather data. — Since we were unable to retrieve data from our automated weather stations on Bylot Island during the summer, we extrapolated mean daily air temperature from the Copernicus ERA5-Land hourly reanalysis dataset (https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=overview). ERA5 combines model data with observations from across the world into a globally consistent dataset at a 0.1^o x 0.1^o scale. A comparison of hourly temperature between data collected at the Bylot Island weather tation and the ERA5 reanalysis data showed that both datasets was highly correlated (R^2 = 0.93). To make the 2020 data comparable to previous years, we transformed the ERA5 data using predictive equations derived from the analyses of the two datasets over the period 2017-2019.

We studied the snowmelt in the lowlands of the Qarlikturvik Valley (the site of our long-term field monitoring, Fig. 1) using data recorded by MODIS (Moderate Resolution Imaging Spectroradiometer), an instrument on board the Terra satellite that collects the reflectivity of the earth surface daily with a 500-m spatial resolution. We used the MOD10A1 product (version 6), a dataset containing fractional snow cover from 0 to 100% for each 500-m pixel (search.earthdata.nasa.gov/search). Data was downloaded for the period of 15 May to 30 June 2020 and provided a daily value of fractional snow cover for each pixel covering the Qarlikturvik Valley. Pixels with a fractional snow cover >40% were identified as 'snow' pixels while pixels with a fractional snow cover ≤40% were considered 'snow-free'. The ratio between the number of snow pixels and the total number of pixels covering our study area provided us with a snow cover for the valley. We discarded days where <30% of the study area was visible to the MODIS sensors due to cloud cover. To approximate snow cover for days with missing data, we performed a linear interpolation between days with valid MODIS data (number of consecutive days without data ranged from 0 to 11 days anually). To validate our remote-sensing snow-cover estimate, we compared the date of 50% snow cover inferred from the MODIS data with the same date estimated by our field monitoring of snow cover (visual evaluation recorded every 2-3 days) over the period 2000 to 2019.

Tracking of GPS-marked geese. — Since 2019, we have equipped with GPS/GSM transmitters 17 adult female Greater Snow Geese captured during spring staging in Quebec. Five of the 10 transmitters deployed in 2019 were still working in spring 2020 and we equipped an additional seven females with the same transmitters (OrniTrack-N44 – solar powered neck collar GPS-GSM tracker). Hence, we were able to monitor the migration pattern of 12 adult females from southern Quebec to the Arctic in 2020. Four of these 12 birds had been previously banded on Bylot Island and were used to determine their arrival dates at this site, and to estimate their laying and hatching dates and clutch size.

Nesting attempt and laying date were determined by analyzing the movements of GPS-marked birds once they had reached the Arctic. Geese usually wander around when feeding during the pre-laying period. When the goose movements started to be clustered (within a radius of ~75 m) around one location (presumed to be the nest location), this date was chosen as the laying date. When the bird movements started to be even more concentrated around this location (within a radius of ~25 m), this date was used as an estimation of the start of incubation. When the locations suddenly started to be spread over a wide area again, this date was considered to be the departure date from the nest. If the inferred duration of the incubation period (difference between the departure and incubation start dates) was close to the average length of the incubation period of snow geese (i.e., 23 days), the breeding attempt was deemed to be successful, and if shorter it was considered a failure. Considering that parents leave the nest with their young about 24 hours after hatching, hatching date was estimated as the day before the inferred departure date in successful nests considered. Clutch size was estimated using the following equation: hatch date – incubation length (23 d) – laying date.

Monitoring of goose nesting activity. — A validation study conducted on a satellite image taken in 2015 showed that high resolution satellite images could be used to identify nesting Greater Snow Geese (see Appendix 1) and we applied this method in 2020. We acquired three high-resolution (30 cm), orthorectified and georeferenced WorldView-3 images of portions of Bylot Island on two different dates in 2020. Image 1 was taken on 17 June 2020 and images 2 and 3 on 2 July 2020 (Fig. 1). Images 1 and 2 covered the main snow goose colony at the beginning and the end of the incubation period in a typical year, while Image 3 covered the Qarlikturvik Valley and nearby areas, which is the main study area for monitoring avian predators and lemmings, also during the late incubation period of geese.

Goose detection was carried out on Images 1 and 2 over the same two areas where goose nesting activity was monitored in the field in previous years. The first one is a 20-ha area located in the centre of the colony and is intensively studied every year (this area largely encloses the one used in the pilot study in 2015; see above and Appendix 1). The second area is composed of a variable number of 1 and 2-ha plots randomly located throughout the colony. Detection of geese was carried out manually on enlargement of these images by three observers independently, and each white dot was digitized in a GIS software. To determine goose pairs, we performed independent cluster analyses on the white dots detected in June and July (see Appendix 2, section 2.1). Two white dots that were ≤15 m from each other were considered a nesting pair. We then merged the positions of goose pairs detected in June and July over the same area and identified pairs that were close enough (~20 m) to be considered the same nesting pair (for details, see Appendix 2, section 2.2). We then obtained a number of pairs present on both the June and July images and of pairs only present on the June or on the July image. We summed all these numbers and, assuming that each of those pairs was associated with a nest, we calculated nest density over the 20-ha area monitored every year and random plots located throughout the colony (see Appendix 2, section 2.3).

Nesting success was determined by comparing goose nesting pairs detected on the images in June and July. When the same nesting pair was detected in both images, we considered that their nest had survived over the time period between the two images. A nest was considerend to have failed when a nesting pair detected in June could not be matched on the July image. As this estimation of nesting success spanned the period between the two satellites images (15 days), we adjusted it to the whole nesting period (27 days) to make it comparable to other years (see Appendix 2, section 2.4).

Monitoring Snowy Owl nesting activity and lemming estimation. — The search for potential Snowy Owls nests was carried out on the WorldView-3 Image 3 taken in 2020 (see Fig. 1) within a 59-km^2 area of the Qarlikturvik Valley traditionally searched for the presence of Snowy Owls in the field over the period 1993-2019. It was not possible to differentiate owls from geese on the image due to their similar body size. However, we took advantage from the fact that when Snowy Owls are nesting on Bylot Island, their nests are almost always surrounded by an aggregation of snow goose nests (Tremblay et al. 1997, Bêty et al. 2001). Using the same approach as in the goose colony, one observer manually digitized white dots (geese) detected of the image in a GIS software and we performed a cluster analysis on the white dots detected to identify potential goose nesting pairs (see Appendix 3, section 3.1 for details). We performed a second cluster analysis on these goose pairs to identify aggregations of goose nests that could be associated with Snowy Owl nests (for details, see Appendix 3, sections 3.2 and 3.3). We used the number of goose nest aggregations identified by this analysis as an estimate of Snow Owl nests and divided it by the size of the surveyed area to obtain their density.

The estimated density of Snowy Owl nests was used to infer lemming density. Therrien et al. (2014) showed a strong relationship between owl nests and lemming densities on Bylot Island. We updated this relationship based on data collected over the period 1993-2019 and used it for our estimation (equation: owl density = $0.2232/(1+e^{-(\text{lemming density}-5.2693)/1.3746})$.

PRELIMINARY RESULTS

Environmental and weather data. — Temperatures in spring 2020 were cool on Bylot Island. Air temperature averaged -0.7°C (0.7°C lower than normal) between 20 May and 20 June, the period of goose arrival and egg-laying, and 1.0°C (0.5°C lower than normal) during 1-15 June, which is the most critical period for egg formation and egg-laying (Fig. 2). An almost complete snow cover persisted in the Qarlikturvik Valley until mid-June (snow cover was >95% until 14 June; Fig. 3). This, combined with the cool temperature, resulted in a late snowmelt compared to other years and especially 2019, which had a very early melt. Snow cover reached 50% on 16 June (long-term average: 13 June; Fig. 4). However, once initiated, snow melt was very rapid and occurred over about 2 to 3 days (from 90% to 10% snow cover).

Spring migration phenology of geese. — All twelve adult females equipped with a GPS/GSM transmitter left the staging area along the St. Lawrence River around 19 May 2020 and spent the summer in Nunavut except one bird that left southern Quebec on 7 June and travelled to Nunavik. Among the females that migrated to the Arctic, one settled on Melville Peninsula, 5 on Baffin Island, 4 on Bylot Island and 1 on Ellesmere Island. All birds that settled on Bylot Island had been banded there in the past and they arrived around 5 June (± 2 days), which is near the normal arrival date of geese in the Qarlikturvik Valley (peak arrival is typically around 7 June).

Goose nesting activity. **—** All four geese equipped with a GPS/GSM transmitter that reached Bylot Island attempted nesting in 2020. Their egg-laying date was 13 June which is close to the long-term average (12 June; Table 1). Among these birds, three had a successful breeding attempt and their clutch hatched around 11 July (long-term average: 9 July). Based on the laying and hatching dates of these birds and goose incubation period (23 days), it was estimated that average clutch size was 4.00, which is higher than the long-term average (Table 1). However, one has to consider that these parameters are based on a very small sample size compared to the data obtained from field monitoring of these parameters in previous years.

Based on the analyses of satellite images, estimated nest density in the center of the colony was higher than last year (8.4 vs. 5.7 nests/ha in 2019) and above the long-term average (Table 1). In the random plots distributed throughout the colony, nest density was similar to last year (4.4 vs. 4.4 nests/ha in 2019) and also above the long-term average (Table 1). A high number of goose nests (489 vs 27 in 2019) were also found in the Qarlikturvik Valley (predominantly a brood-rearing area). This increase was likely due to the presence of nesting Snowy Owls in the area (see below). We also note that the number of goose nests identified in the Qarlikturvik Valley was higher than in other years with a high density of owls (e.g., 142 in 2000 and 159 in 2004), probably because the search for goose nesting pairs on the satellite images was more thorough than nest searches conducted in the field.

Nesting success of geese. **—** Nesting success, (proportion of initiated nests hatching at least one egg) was estimated at 64% (possible range: 62 to 69%) in 2020, which is close to the long-term average (Table 1) but much lower than 2019. This is indicative of a moderate activity of predators around goose nests, which destroyed more nests compared to last year.

Monitoring of Snowy Owls. **—** Based on the number of aggregations of goose nesting pairs detected in the Qarlikturvik Valley area, we estimated that 10 nests of Snowy Owls (possible range: 9 to 14) were present in 2020 compared to 5 in 2019 over the same area. This yields a density of 0.17 nest/km^2 compared to the long-term average of 0.13 nests/km^2 in years when nesting Snowy Owls were detected. Based on this density of Snowy Owl nests, we estimated the mid-summer density of lemmings at 6.9 lemmings/ha. This density is much higher than last year (1.4 lemmings/ha) and is typical of lemming densities encountered in years of peak abundance in the past (Fig. 5).

Autumn migration phenology of geese. **—** We successfully tracked the autumn migration of all 12 adult females marked with GPS/GSM transmitters from Nunavut/Nunavik to southern Quebec. Birds that nested on Bylot Island left the island between 13 August and 12 September 2020 while the other females that spent the summer in Nunavut left between 13 August and 18 September. All birds arrived along the St. Lawrence river between 26 September and 3 October and were resighted but none of them were seen with young (including those that nested on Bylot Island). They left for their wintering grounds in the United-States between 24 November and 23 December. These females wintered in Maryland, Delaware, New Jersey, New York and Pennsylvania. Seven out of the twelve geese were harvested between 10 December 2020 and 24 March 2021.

CONCLUSIONS

The cancellation of the 2020 field season on Bylot Island due to the COVID-19 pandemic was a significant challenge and forced us to find alternative methods to monitor the reproductive activity of Greater Snow Geese. The opportunity to mark some birds with GPS/GSM transmitters during their spring staging in southern Quebec allowed us to track their migration to the Arctic and to infer reproductive parameters for a few of them that nested on Bylot Island. Unfortunately, sample size was very small here. However, we showed that remote sensing can be a valuable tool to monitor several aspects of the reproduction of geese and this is our most significant achievement. By comparing field data acquired in 2015 in a core area of the colony with a satellite image taken in the same year, we were able to validate our identification of nesting snow geese on satellite images and to confirm that it can be quite accurate. The detailed analysis of high-resolution satellite images taken at the right time and the algorithm that we developed to treat this information further showed that we could obtain reliable information on the nesting density and even the nesting success of snow geese. In addition, the propensity of snow geese to nest in association with Snowy Owls in the High Arctic allowed us to estimate owl nesting density. This, in turn, enabled us to infer the density of lemmings, an important parameter related to goose nesting success due to shared predators (primarily Arctic Foxes, *Vulpes lagopus*) between geese and lemmings. Nonetheless, in 2020 some activities such as the goose banding in August could not be replaced by remote sensing or other alternative methods.

The numerous indicators of goose reproduction that we could estimate on Bylot Island yielded mixed signals, with some being positive and other negative. The most unfavourable factor for goose reproduction in 2020 was the cool spring and late snow-melt. Temperature were below average during the pre-laying period of geese although they were closer to normal during egg-laying. Snow-melt was also quite late and started about a week later than normal, although it proceeded very rapidly once initiated. These weather conditions, however, contrasted with 2019, which was one of the warmest spring and earliest snowmelt on record. The arrival date and nesting phenology of geese was apparently near normal and clutch size possibly higher than normal, but this must be interpreted with great care as it is based on an extremely small sample size of GPS-marked birds (n = 4).

The nesting density of geese in the core area of the colony and in the random plots monitored was found to be high, about 70% higher than the long-term average. The may seem at odds with the late snowmelt because these conditions are typically associated with a reduced reproductive effort of geese. However, it is also possible that late snowmelt reduced nest site availability and forced geese to concentrate nesting in a limited number of snow-free patches such as the 20-ha plot monitored annually and located in the centre of the colony, a site that tends to be snow-free relatively early. Moreover, body condition of geese measured in 2020 at the end of staging in southern Quebec was among the highest recorded over the past 20 years, probably due to a reduced activity of hunters in spring due to the COVID-19 lockdown (Letourneux et al. 2021). The arrival of geese in good body condition at Bylot Island may have attenuated the negative impact of the late snowmelt on their nesting activity and allowed geese to breed in good numbers. Nonetheless, considering that we used a different method to estimate nesting density in 2020 (satellite images) compared to other years, there is still the possibility that some unknown biases could have inflated our estimation of nesting density in 2020. Nonetheless, values observed in the core of the colony were not unrealistically high as similar or higher nesting densities had been observed in previous years (Table 1).

A high density of nesting geese combined with a high lemming abundance are factors normally conducive to high nesting success. When lemmings are high, predators like Arctic Foxes divert their attention from goose eggs to that prey and high nesting density can dilute the impact of predators at the population level. Nesting associations of geese with Snow Owls provide a refuge from predators and also favour high nesting success. Despite a high nesting density and the presence of Snowy Owls, nesting success of geese in 2020 appeared to be lower than in 2019 and near or slightly below the long-term average, suggesting a moderate to high activity of predators in the colony. In 2019, fox reproduction was good on Bylot Island as lemming density had started to bounce back following two years of extremely low values. With lemming densities apparently increasing further in 2020, we can surmise that survival of foxes produced in 2019 was good and fox breeding activity was high for a second consecutive year. Therefore, a high fox density may explain the nesting success observed in 2020 in the goose colony, an area where relatively few owls nest as most of them usually nest away from the main goose colony, most notably in the Qarlikturvik Valley.

The combination of the different indices of Greater Snow Goose reproductive success collected on Bylot Island suggests a moderately high production of young until the hatching period. In comparison, the percentage of young measured during juvenile counts conducted by the Canadian Wildlife Service in southern Quebec in autumn 2020 was moderate at 16% (*n* = 21,406. J. Lefebvre, personal communication), as well as the average brood size at 2.28 (n = 946). This is much lower than in 2019 (32% of young in the flock and an average brood size of 2.55) and slightly lower than the average since the beginning of the spring harvest in 1999 (20% of young and 2.24 young per brood). We therefore note some discrepancy between indices of goose reproductive success on Bylot Island derived from remote sensing and observations conducted during autumn staging in southern Quebec, which can be explained by several factors. First, young survival during brood rearing and the autumn migration may have been low, either due to high predation pressure after hatching or poor weather, and thus may have reduced overall production. Second, our observations are based on a single colony that accounts for ~15% of the total breeding population and it is possible that reproductive success at other colonies was lower than on Bylot Island. Finally and perhaps most importantly, the very high production of young in 2019 led to a large cohort of 2-year old birds in the population in 2020, a cohort still too young to breed. Presence of these birds in the autumn flock likely contributed to reduce the ratio of young to adults in the population in 2020. This is a common phenomenon as the proportion of young in the flock is always pulled down in the year following a very good production like in 2019.

In conclusion, we believe that the work conducted in 2020 with remote sensing tools yielded very satisfactory results. Although it cannot totally replace field work conducted *in situ*, we show that it provides a good alternative when ground work is impossible as in 2020. Nonetheless, we believe that additional field validation of the estimation of goose nesting activity with satellite images is advisable considering that our validation is based on a single year and *a posteriori*. This method also faces additional sources of uncertainty such as criteria used to match nesting pairs between two images and it would be useful to improve further these criteria. The detection of Snowy Owl nests based on goose nest aggregations identified on satellite images has not yet been validated and thus remain a weak part of our analysis. It would be important to validate this method in the field, such as by visiting in 2021 the centroid of goose nest aggregations identified in 2020 to confirm the presence of a Snowy Owl nest based on prey remains and regurgitation pellets usually present around these nests.

PLANS FOR 2021

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 reproduction of geese; *ii*) determining the long-term effects of geese on the arctic landscape; *iii*) studying indirect interactions between snow geese and lemmings via shared predators; *iv*) studying the ecology of the main predator of geese, the Arctic Fox; and *v*) assessing the impact of climate change on goose reproduction and the carrying capacity of the habitat for geese. In 2021, we hope to resume field work in order to:

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

2) Validate further remote sensing tools used to monitor snow geese and Snowy Owl reproductive activities in 2020.

3) Study the migration phenology of geese and its impact on reproductive success.

4) 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.

5) 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.

6) 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.

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.

9) Capture and mark adult foxes and their pups to study their movements, demography and foraging activity.

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

11) Maintain our automated environmental and weather monitoring system.

In 2021, 6 graduate students will be involved in the Bylot Island snow goose project. **Frédéric LeTourneux** (PhD) will complete his study of the impact of recent management actions on the survival and population dynamics of snow geese. **Mathilde Poirier** (PhD) will complete her study on the population dynamics of lemmings and the interaction between lemmings and snow. **Gabriel Bergeron** (MSc) will continue his study of the role of predator-prey interactions in the population dynamics of lemmings. **Thierry Grandmont** (MSc) will continue a study on the timing of snow goose migration and its effect on reproduction. **Ilona Grentzmann** (PhD) will start a study on the effect of senescence on the population dynamics and physiology of snow geese. Finally, **David Bolduc** (MSc) will start a study on the impact of the ermine on lemmings. However, if access to the field remains limited due the pandemic, we will again use remote sensing tools to monitor goose reproduction.

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

	2011	2012	2013	2014	2015	2016	2017	2018	2019	**2020**	Average[2]
Number of nests monitored	382	375	451	491	347	337	342	277	422	**580**	--
Nest density in the core of the colony (n/ha)	4.89	5.24	8.85	7.89	9.26	5.50	8.14	3.46	5.70	**8.35**	4.93
Nest density in random plots (n/ha)	1.77	1.62	3.39	3.39	2.73	3.70	3.41	3.35	4.38	**4.41**	2.54
Median date of egg-laying	13 June	12 June	13 June	11 June	12 June	13 June	11 June	14 June	7 June	**13 June**[3]	12 June
Clutch size	3.74	3.80	3.58	3.85	3.48	3.36	3.53	3.50	4.04	**4.00**[3]	3.71
Nesting success[1]	90%	54%	67%	91%	77%	73%	56%	50%	82%	**64%**	67%
Median date of hatching	8 July	9 July	10 July	8 July	9 July	9 July	8 July	11 July	4 July	**11 July**[3]	9 July

[1] Mayfield estimate.
[2] Period 1989-2019. Data from 2020 is not included in the long-term average because different protocols were used in 2020.
[3] These values are only based on the GPS-tracking of 4 females that nested on Bylot Island.

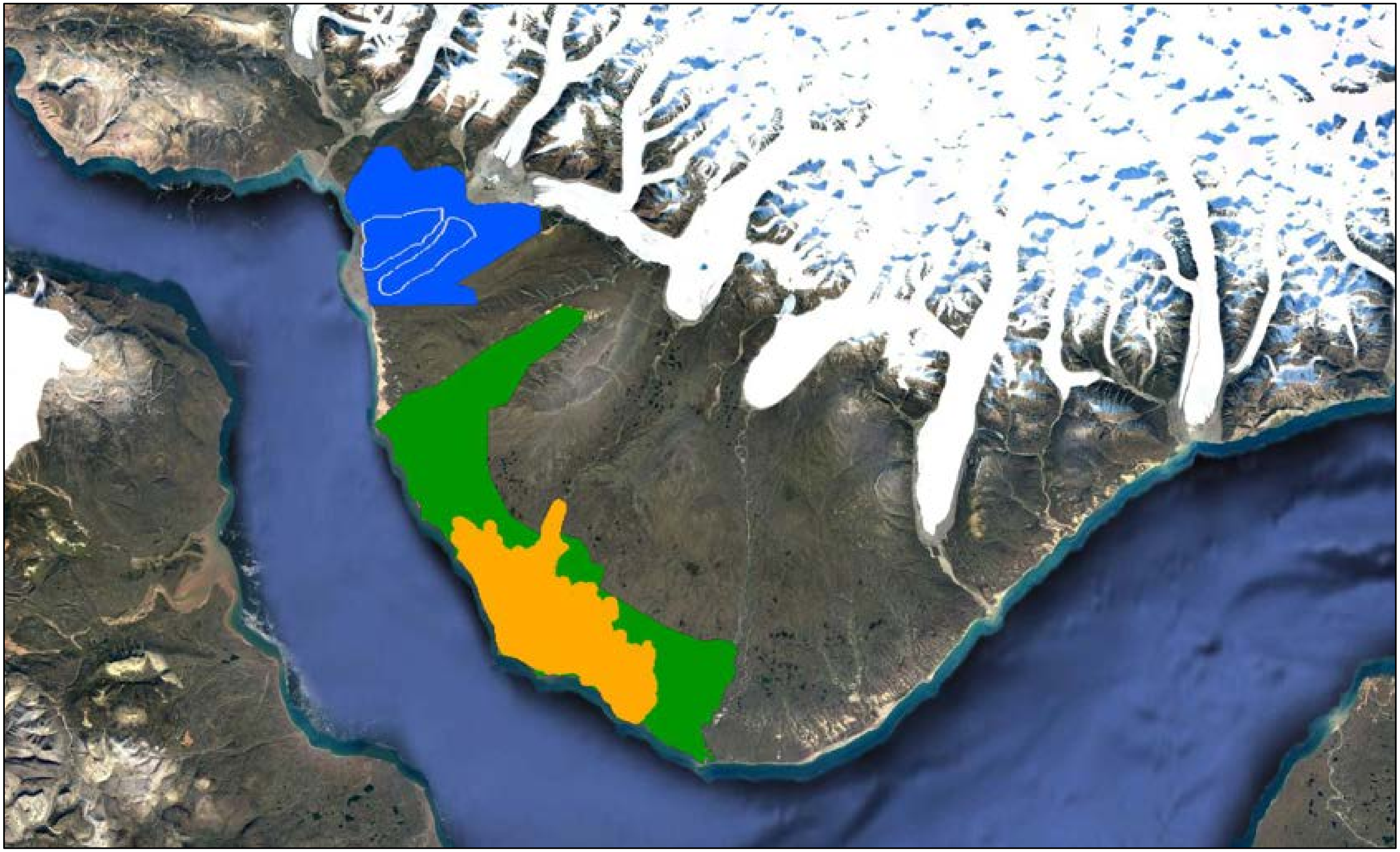

Figure 1. Location and coverage of the three high-resolution (30 cm) images acquired from the WorldView-3 satellite during summer 2020. The blue polygon is centered on the Qarlikturvik Valley (Image 3 taken on 2 July 2020) whereas the goose nesting colony is outlined by the orange polygon (Image 1 taken on 17 June 2020), also covered by the larger green polygon (Image 2 taken on 2 July 2020). The MODIS image (500-m resolution) was obtained for the Qarlikturvik Valley and the polygons used for the analyses are presented in white.

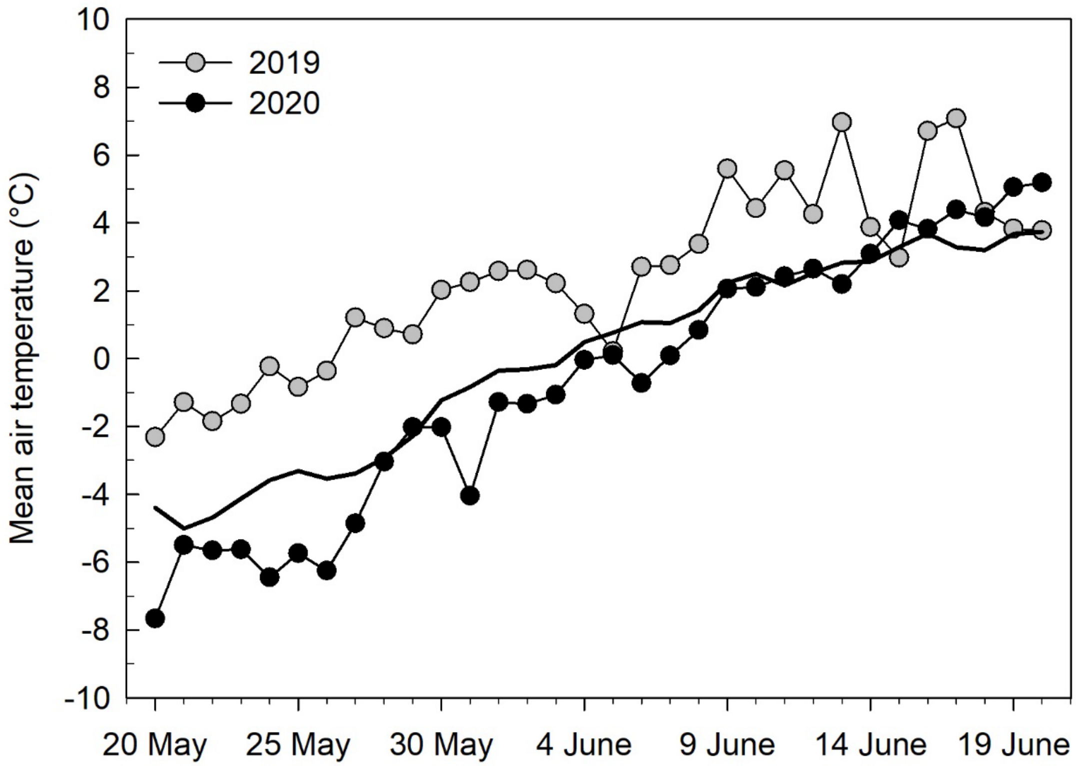

Figure 2. Daily air temperature in spring on Bylot Island. The thick solid black line represents the average air temperature since 1994. Data for 2020 are based on reanalysis estimates from the Copernicus ERA5-Land model. These values were adjusted based on the relationship between hourly air temperature recorded at our weather station on Bylot Island and the one estimated by the ERA5 reanalysis for our study site from 2017 to 2019 (see methods).

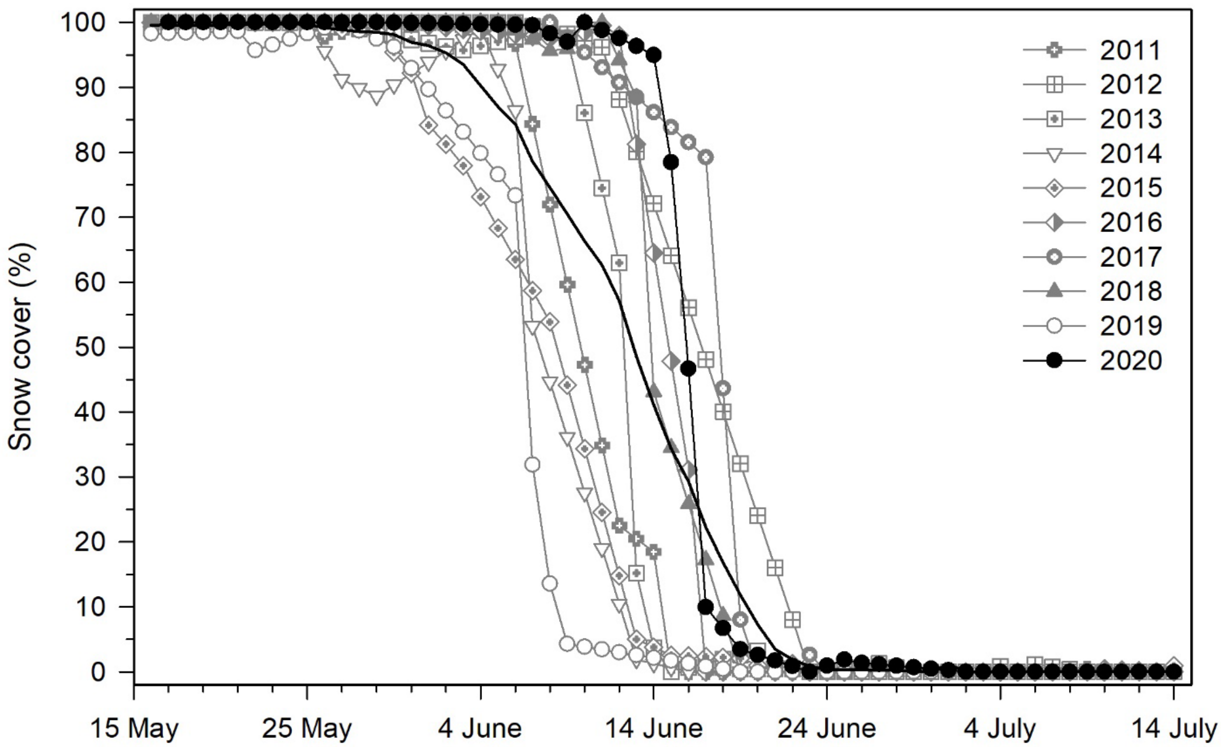

Figure 3. Annual daily snow cover of the lowlands of the Qarlikturvik Valley of Bylot Island estimated from the MODIS satellite data during the snow-melt season for the period 2011 to 2020. The thick solid black line represents the average snow cover since 2000.

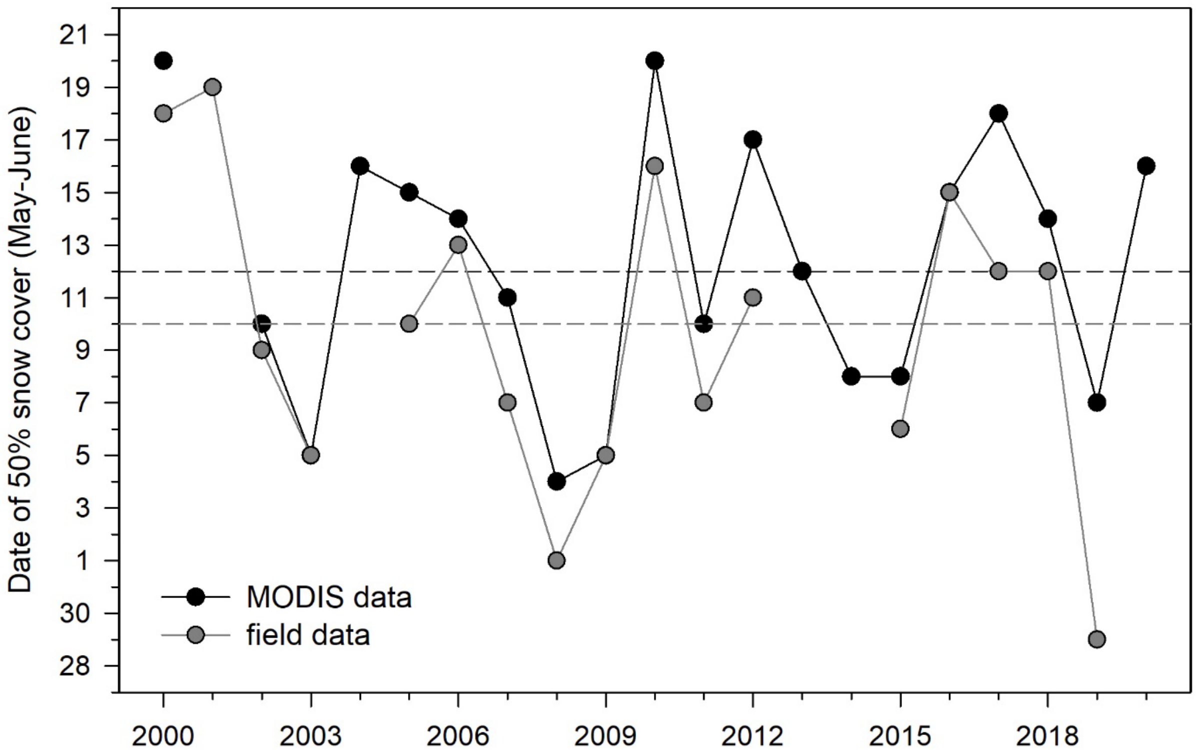

Figure 4. Date of 50% snow cover in the lowlands of the Qarlikturvik Valley of Bylot Island estimated from the MODIS satellite data (black dots) and field data (grey dots) over the period 2000 to 2020. The dashed gray line represents the average date of snowmelt observed from our field records and the dashed black line from the MODIS data. Annual date of 50% snow cover is highely correlated between the two datasets (R^2 = 0.79).

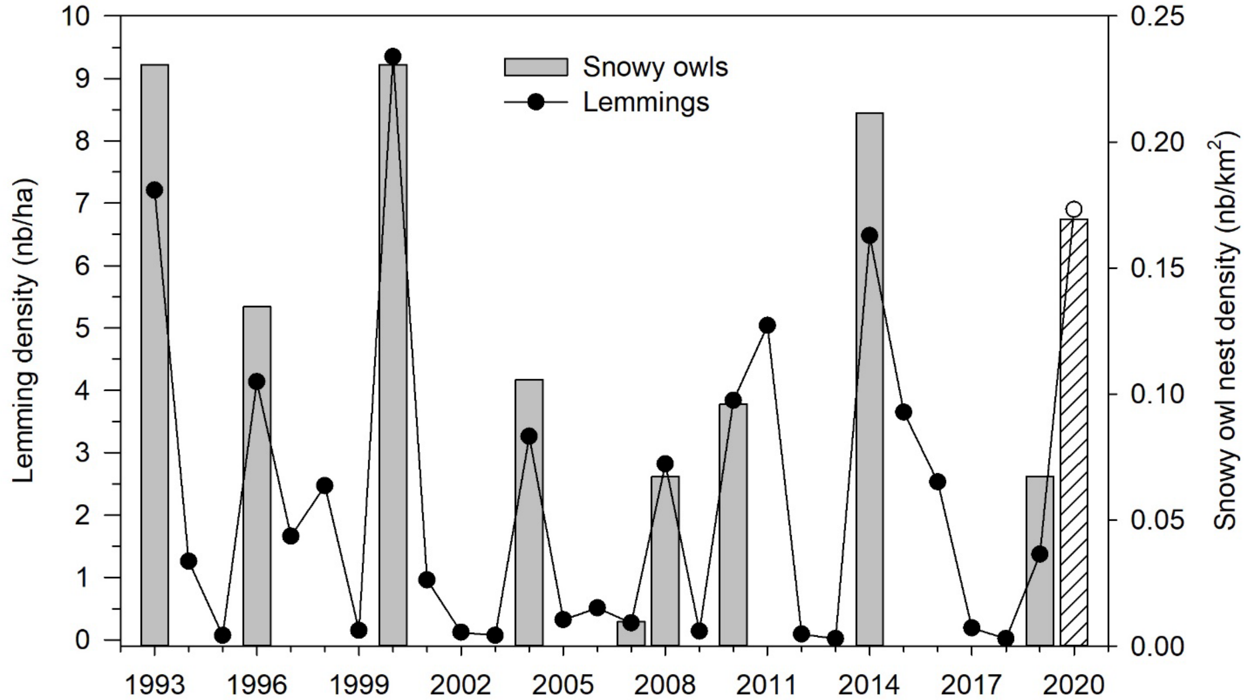

Figure 5. Annual variations in mid-summer lemming density and Snowy Owl nest density in the Qarlikturvik Valley of Bylot Island from 1993 to 2020. Snowy Owl data for 2020 are derived from a satellite image analysis and lemming density for 2020 is estimated from the relationship between owl nests and lemming densities in previous years (see methods).

APPENDIX 1
VALIDATION STUDY CONDUCTED FROM AN IMAGE TAKEN IN 2015

We conducted a pilot study to assess the reliability of high-resolution (30-cm) images from the satellite to detect Greater Snow Geese on Bylot Island. We acquired an orthorectified, georeferenced satellite image taken in 2015 of a portion of the goose colony monitored in the field in that year. A 13-ha portion of the area intensively monitored annually in the goose colony was captured by the WorlView-3 satellite on 27 June 2015, typically about two-third of the goose incubation period on Bylot Island. The satellite image was imported in a GIS softwarte and divided into thirteen cells of 100 × 100 m. Individual geese were clearly visible as white dots on enlargement of the image although we could not exclude the possibility that sometimes two geese side-by-side could appear as a single dot. In a first step, three observers (MCC, MBB and ED) independently identified all the white dots (i.e. geese) manually and digitized their position. Two geese within 15 m from each other were considered a nesting pair. This threshold distance was based on an analysis of the nearest neighbor of nests monitored in the goose colony between 2016 and 2019 (n = 611), which indicated that 75% of goose nests were separated by ≥15m. Only nests known to be present on 27 June were considered in this analysis to avoid potential biases related to a decrease in goose nest density over time due to predation. When combining the results of the three independent observers, we identified 116 goose nesting pairs on the surveyed area whereas 91 goose nests had been found in the field, suggesting an overall detection rate of 127% of real nests. When plotting the position of nests located in the field over the goose nesting pairs identified on the image, we found a perfect match for 83 of the 91 real nests (Fig A1.1). For 33 of the nesting pairs identified on the image, we could not clearly associate a nest found in the field, whereas for 8 nests we had not detected a nesting pair nearby.

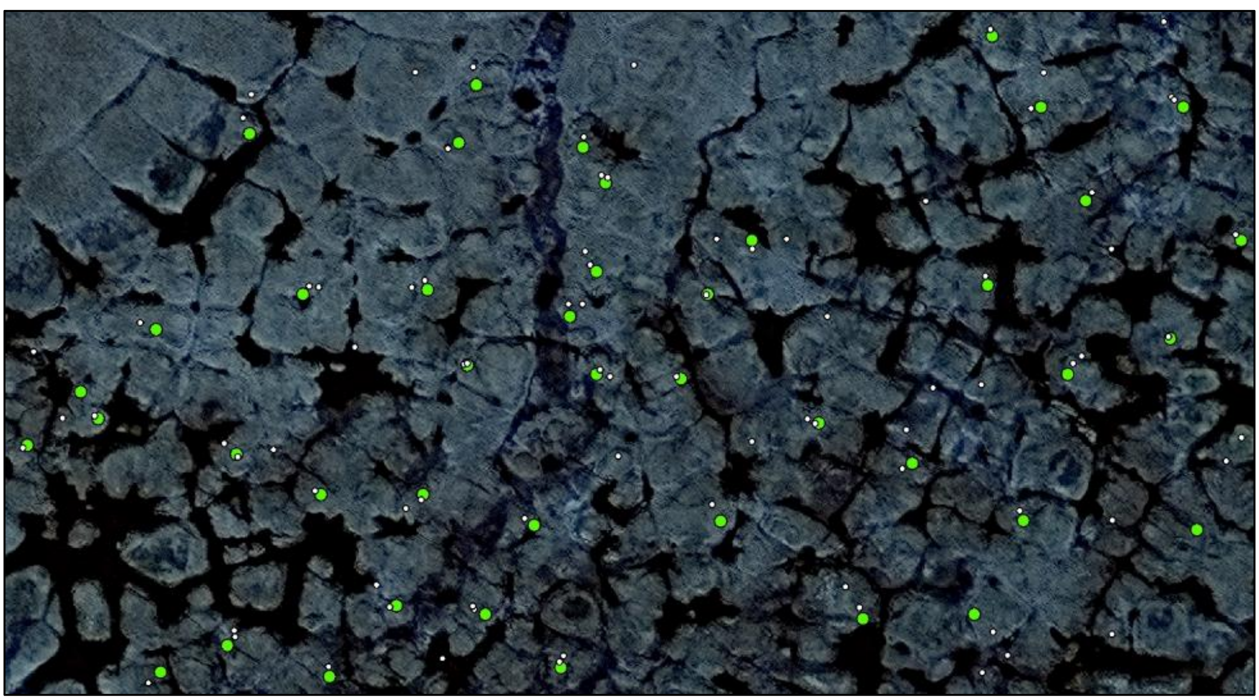

Figure A1.1 Portion of the 2015 satellite image showing the geese detected by the three observers (white dot) relative to the actual location of nests surveyed in the field (green dot).

APPENDIX 2
DETAILED METHOD USED TO ESTIMATE GOOSE NEST DENSITY AND NESTING SUCCESS BASED ON SATELLITE IMAGES

2.1. Pairing of geese detected on satellite images

The satellite images that we acquired for the 2020 field season were imported in a GIS software and divided into 100 × 100 m cells. Geese were clearly visible as white dots on enlargement of the images (Fig. A2.1) although we could not exclude the possibility that sometimes two geese side-by-side could appear as a single dot. In a first step, three observers (MCC, MBB and ED) independently identified all the white dots (i.e., geese) manually and digitized their position (Fig. A2.2A). For each image, the distance between all geese detected was calculated (Fig. A2.2B) and these distances were used to compute a cluster tree for both June and July. The two clusters were cut at 15 m to determine goose pairs (Fig. A2.2C and A2.2D). This meant that two geese detected on the satellite images that were ≤15 meters from each other were considered a nesting pair, otherwise, we assumed that only one individual of the pair was detected or that both individuals were too close to each other to be detect as separate geese. This threshold distance was based on an analysis of the nearest neighbor of nests monitored in the goose colony between 2016 and 2019 (n = 611) which indicated that 75% of goose nests were separated by ≥15m.

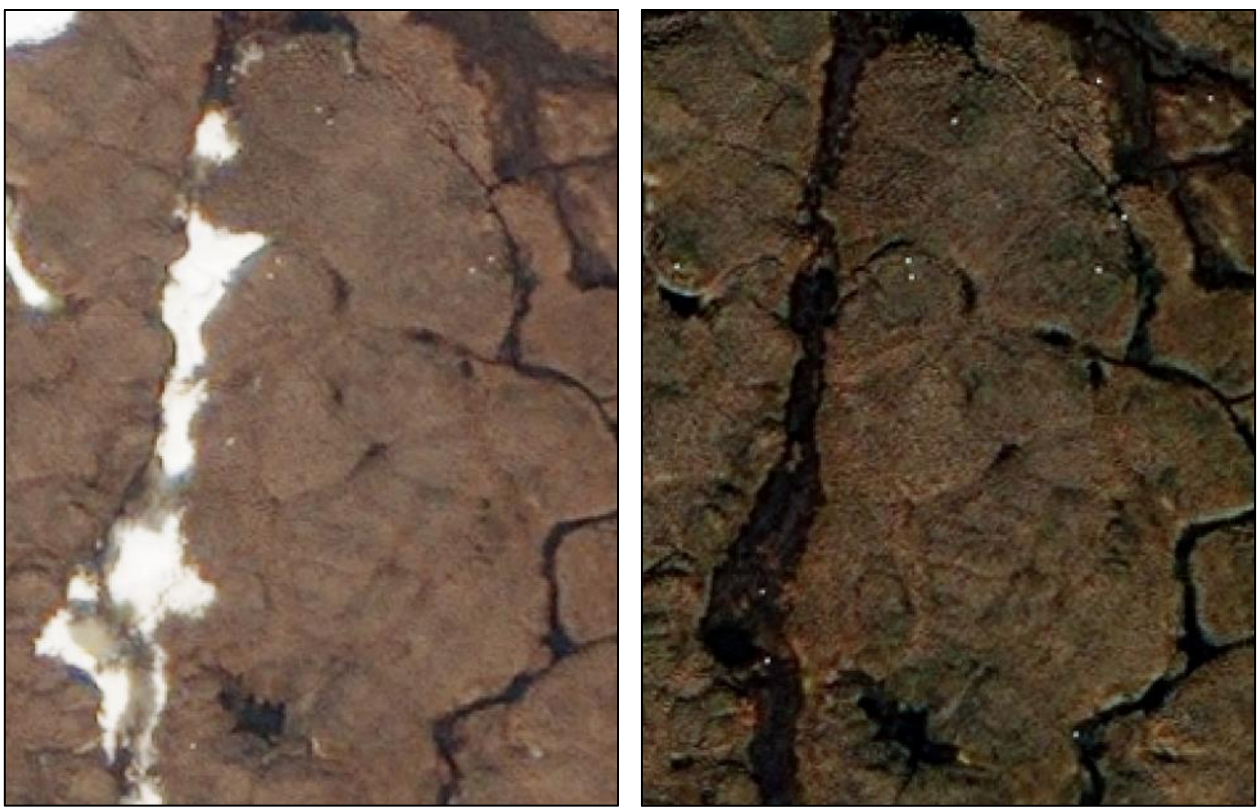

Figure A2.1. Comparison of an identical portion of the satellite images acquired on 17 June (left) and 2 July 2020 (right) showing geese as white dots in the Bylot Island goose colony.

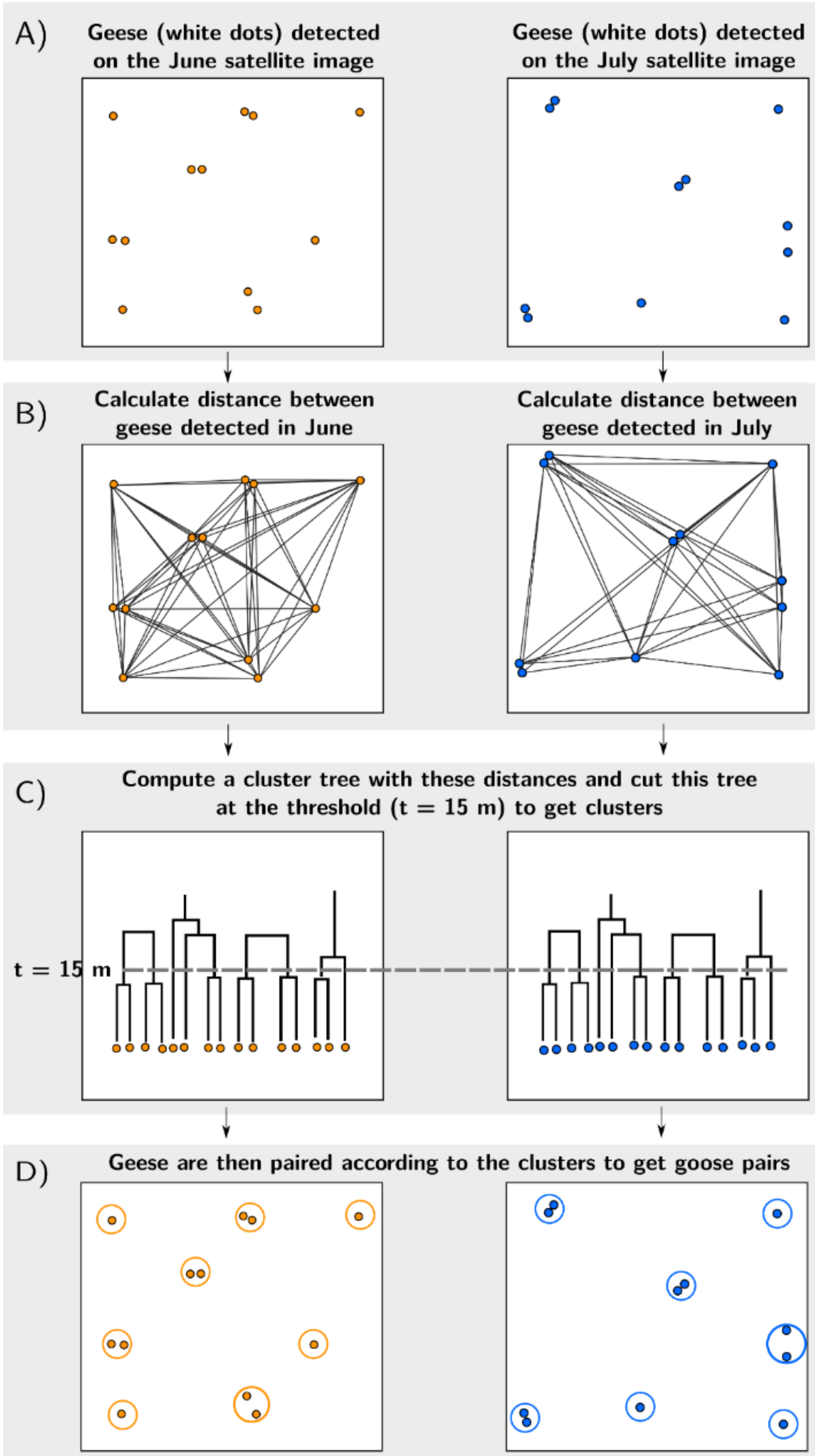

Figure A2.2. Diagram illustrating the method used to pair geese (or white dots) detected on the satellite images.

2.2. Comparison and matching of goose pairs on the June and July images

To estimate nest density and nesting success, we had to be able to locate the same nesting pairs on both images (17 June and 2 July). We compared the locations of nesting pairs detected on both satellite images to determine which ones were actually the same. To do so, we first calculated the centroid of the position of the two pair members in June and July and assumed that this represented an approximation of the nest location of this pair (Fig. A2.3A). We then matched the centroid positions detected in June with those detected in July, starting with the smallest centroid-to-centroid distance and gradually increased this value as we matched more pairs (Figs. A2.3B and A2.3C). All June and July nesting pairs were paired in this manner, until remaining pairs had a centroid-to-centroid distance over the selected threshold values of 15, 17.5 and 20 m (see below for details; Fig. A2.3D). Remaining nesting pairs above this threshold were not matched because they were considered too far from each other to be the same pair in the June and July images.

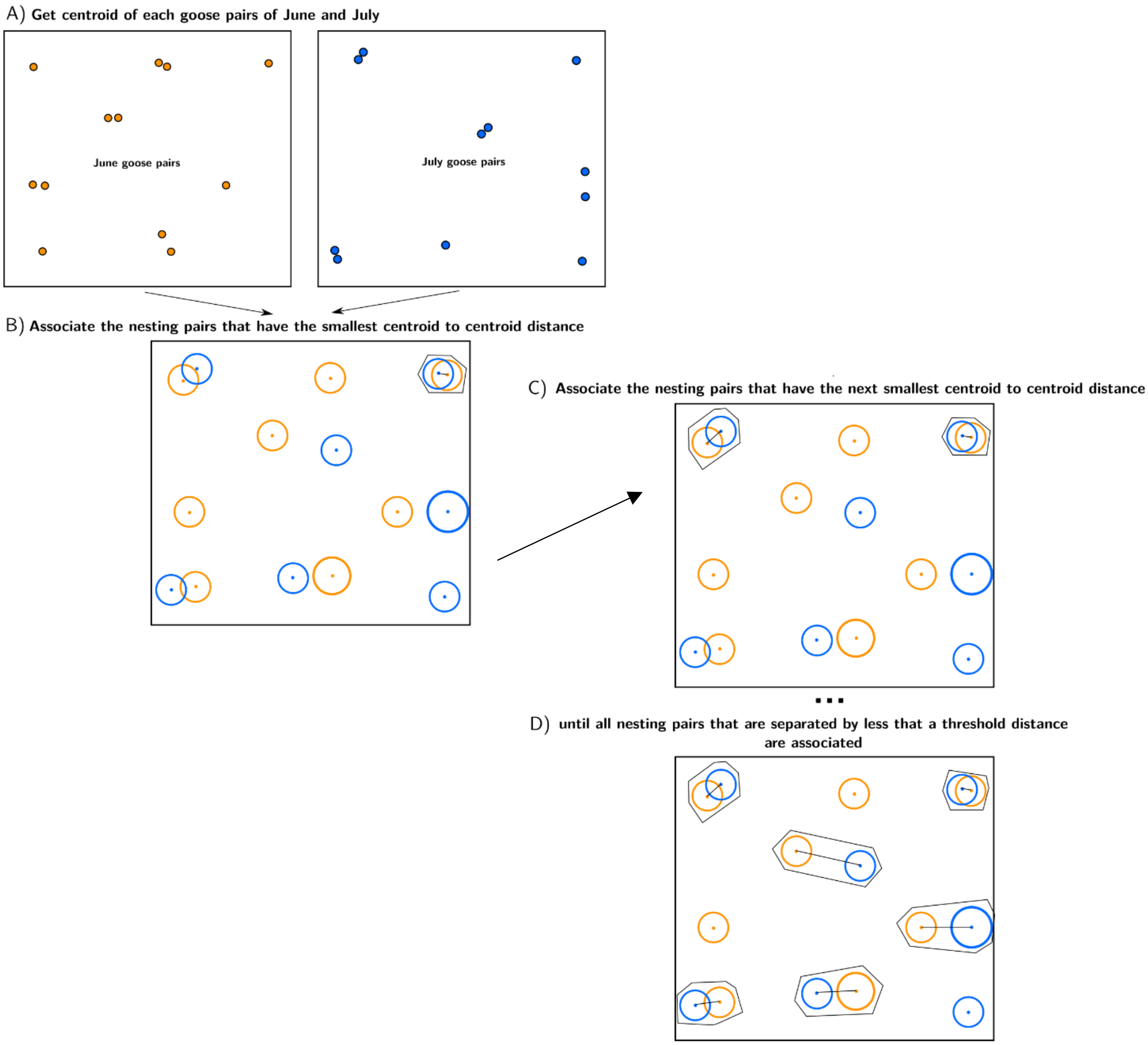

Figure A2.3. Diagram illustrating the method used to match goose nesting pairs detected in June with those detected in July.

Threshold values used to determine the maximum distance that a nesting pair could have moved between the June and July images were based on a fine scale analysis of the locations of four adult females equipped with a GSM/GPS collar that nested on Bylot Island in 2020. The longest distances between a nest and the position of the female will occur during incubation recesses. We determined nest location by using all night (00:00-06:00) GPS locations from 16 June to 2 July. We used night locations because nest recesses are less frequent (Poussart et al. 2001). The center of all those clustered locations was used as the nest location for the four GPS-tracked females. Considering the accuracy of locations obtained by the transmitter (±4 m), we assumed that all positions >10 m from the estimated nest location (the maximum distance found within the night cluster) occured during incubation recesses. The median of the distances between the female and its nest during presumed incubation recesses was 17.6 m, hence the threshold selected to match nesting pairs based on their position on the June and July images. The values of 15 and 20 m were selected as an upper and lower bound to this threshold considering that 85% of the distances recorded on these females where withing these two boundaries.

2.3. Goose nest density

To obtain an estimate of the total number of goose nests initiated in the surveyed area of the colony, we summed the number of nesting pairs matched between June and July with the number of nesting pairs detected only on the June or July images (Fig. A2.4A and A2.4B). We presumed that nesting pairs only detected in June were mostly associated with nests that had failed before the second image whereas those detected only in July could be mostly associated with nests initiated very late. The estimation of nest density with this method is affected by the threshold used to match nesting pairs between the June and July images but variations are slight. Using the selected threshold of 17.5 m, we obtain a nest density of 8.35 nests/ha, a value that changed to 8.38 and 8.16 nests/ha when using a 15 m or a 20 m threshold, respectively.

2.4. Goose nesting success

To estimate nesting success, we assigned an outcome to each nest detected in June based on the matching process previously performed. When a nesting pair found on the June image could be matched with one on the July image, we considered that their nest had survived over the time period between the two images. When a nesting pair detected in June could not be matched on the July image, we considered that their nest had failed in between (Fig. A2.4C). Nesting pairs detected only on the July image were excluded from this analysis because we could not confirm their presence on the June image.

The estimation of nesting success obtained by the analyses of the satellite images did not cover the whole nesting period but only the time period between the two images (15 days). In order to compare the nesting success of geese in 2020 to the one determined annually based on field monitoring, it was necessary to adjust the results derived from the satellite images for the whole nesting period, i.e., 27 days (sum of laying and incubation periods). To extrapolate to the whole nesting period, we had to assume that nest failure rate was constant over time. We thus adjusted the nesting success estimate from the satellite images (expressed as a proportion) as follows:

$$\textit{Nesting success} = (\textit{nesting success estimated over 15 days})^{27/15}$$

As with nest density, the estimation of nesting success with this method is affected by the threshold used to match nesting pairs between the June and July images. Using the selected threshold of 17.5 m, we obtain a nesting success for the whole nesting period of 64%, a value that changed to 62% and 69% when using a 15 m or a 20 m threshold, respectively.

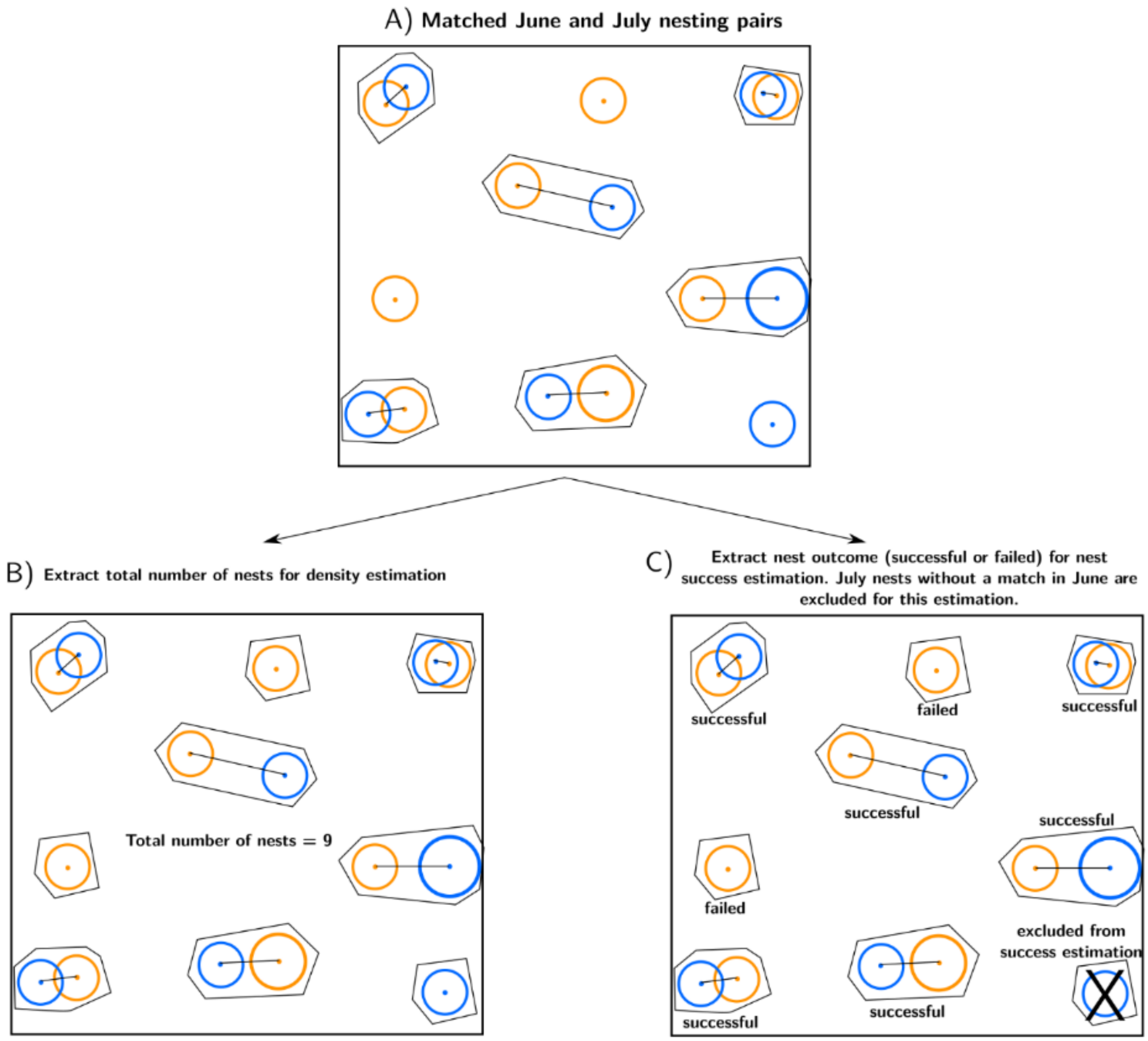

Figure A2.4. Diagram illustrating the method used to estimate goose nest density and nesting success. Nesting pairs detected on the June image are in orange while those detected on the July image are in blue.

APPENDIX 3
DETAILED METHOD USED TO ESTIMATE THE NUMBER OF SNOWY OWL NESTS

3.1. Analysis of the satellite image

The search for potential Snowy Owl nests was carried out by one observer (MCC) on the satellite Image 3 of the Qarlikturvik Valley of Bylot Island taken on 2 July 2020 (see Fig. 1). A search for nesting owls was conducted over a 59-km^2 area, which has been searched every year in the field for presence of this species since 1993. Within this area, 25 km^2 were systematically searched, paying special attention to nesting sites previously used by owls over the period 1993-2019 and other suitable habitats such as ridges. To maximize the coverage of the whole area, a number of 500 × 500 m cells were also systematically distributed in low quality nesting areas for owls and searched (Fig. A3.1). It was not possible to differentiate owls from geese on the image due to their similar body size. However, we took advantage from the fact that when Snowy Owls are nesting on Bylot Island, their nests are almost always surrounded by an aggregation of snow goose nests, which benefit from a predator exclusion area created by owls within a few hundred meters of their nest (Tremblay et al. 1997, Bêty et al. 2001). Using the same approach as in the goose colony (see Appendix 2, section 2.1), the observer manually digitized white dots (geese) detected on the image in a GIS software. We performed a cluster analysis on the white dots detected to identify potential goose nesting pairs as in the analysis done in the goose colony (see Appendix 2, section 2.1).

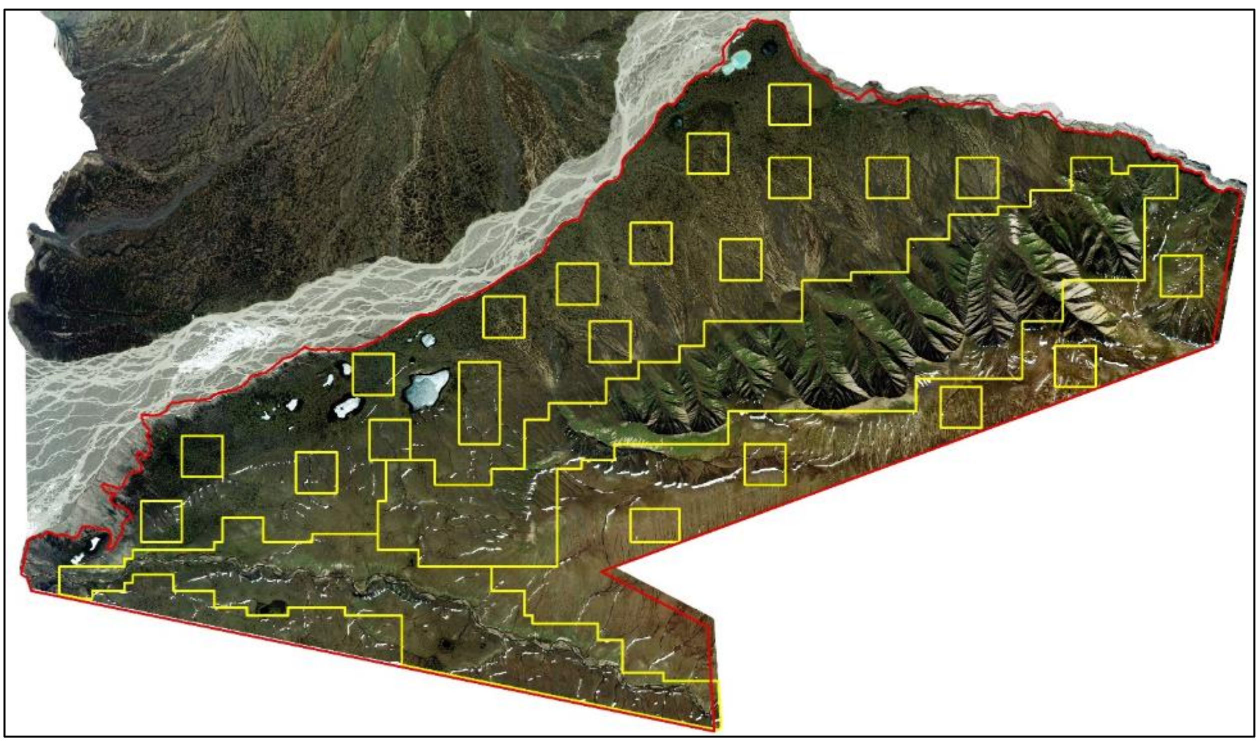

Figure A3.1. Portion of satellite Image 3 (see Fig. 1) showing the Qarlikturvik Valley where a search for potential Snow Owls nests was carried out. The yellow lines enclosed areas that were systematically searched by the observer and the red line delimits the 59-km^2 search area.

3.2. Parametrization of the cluster analysis of nesting aggregations of snow geese

We performed a second cluster analysis on goose pairs detected on the satellite image to identify nesting aggregations that could be associated with Snowy Owl nests. We used historic data on the spatial distribution of goose nests in the Qarlikturvik Valley during seven years with presence of owls between 1993 and 2014 to determine patterns of goose nest agregations around Snowy Owl nests that were closely monitored in the field. Aggregations containing ≤3 goose nests were excluded because they were rarely associated with a Snowy Owl nest.

We ran a separate cluster analysis in each year to identify goose nest aggregations. Identification of aggregations critically depends on the distance threshold used as cut-off point in this analysis. The distance threshold is the maximum possible distance between two nests belonging to the same cluster. We varied the distance threshold applied from 250 to 4000 m and attempted to find the one that yielded the most realistic results. To do so, we compared the number of goose nest aggregtions identified by the cluster analysis for each threshold value with the real number of Snowy Owl nests censused in each year. We expected that these numbers should be similar considering that all Snowy Owl nests had a goose nest aggregation around them. This is what we found when the threshold value varied from 1250 to 1750 m (Figs. A3.2 and A3.3). Using lower threshold values yielded a higher number of goose nest agregations than the numbr of owl nests censused in the field, whereas the converse was true for higher threshold values.

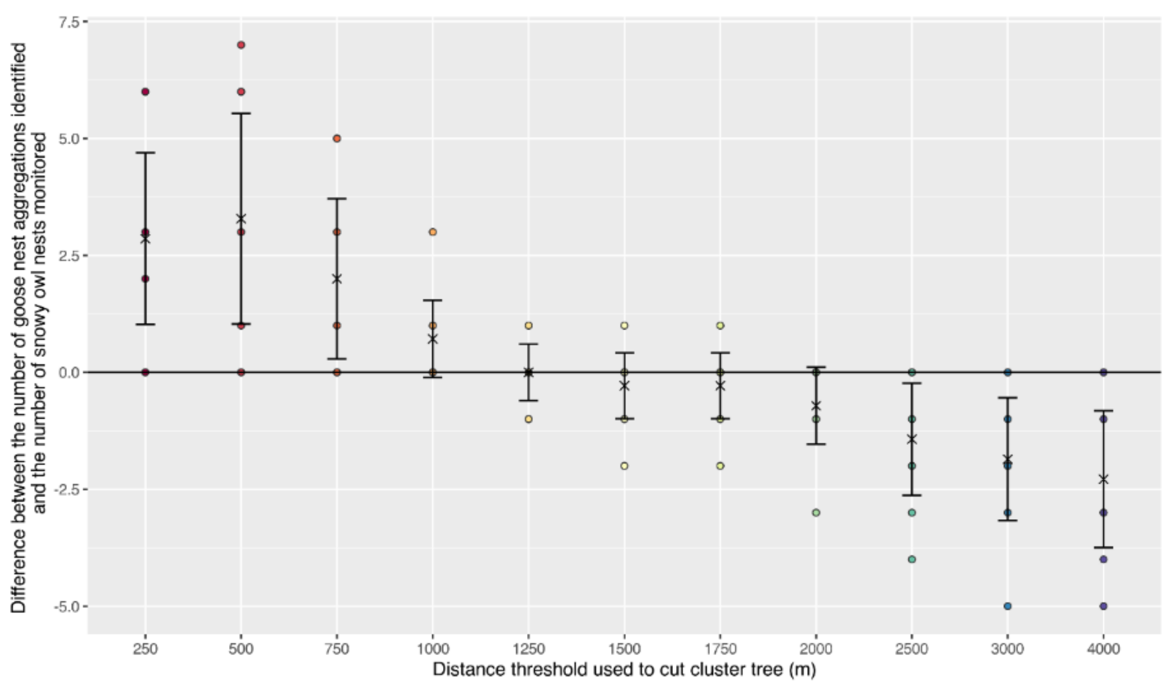

Figure A3.2. Differences between the number of goose nest aggregations identified by the cluster analysis and the number of Snowy Owl nests censused in six different years according to different threshold distance values between goose nests in the cluster analysis. The x represents the mean values and error bars represents the 95% confidence intervals. Each dot represents an individual value (i.e., a different year).

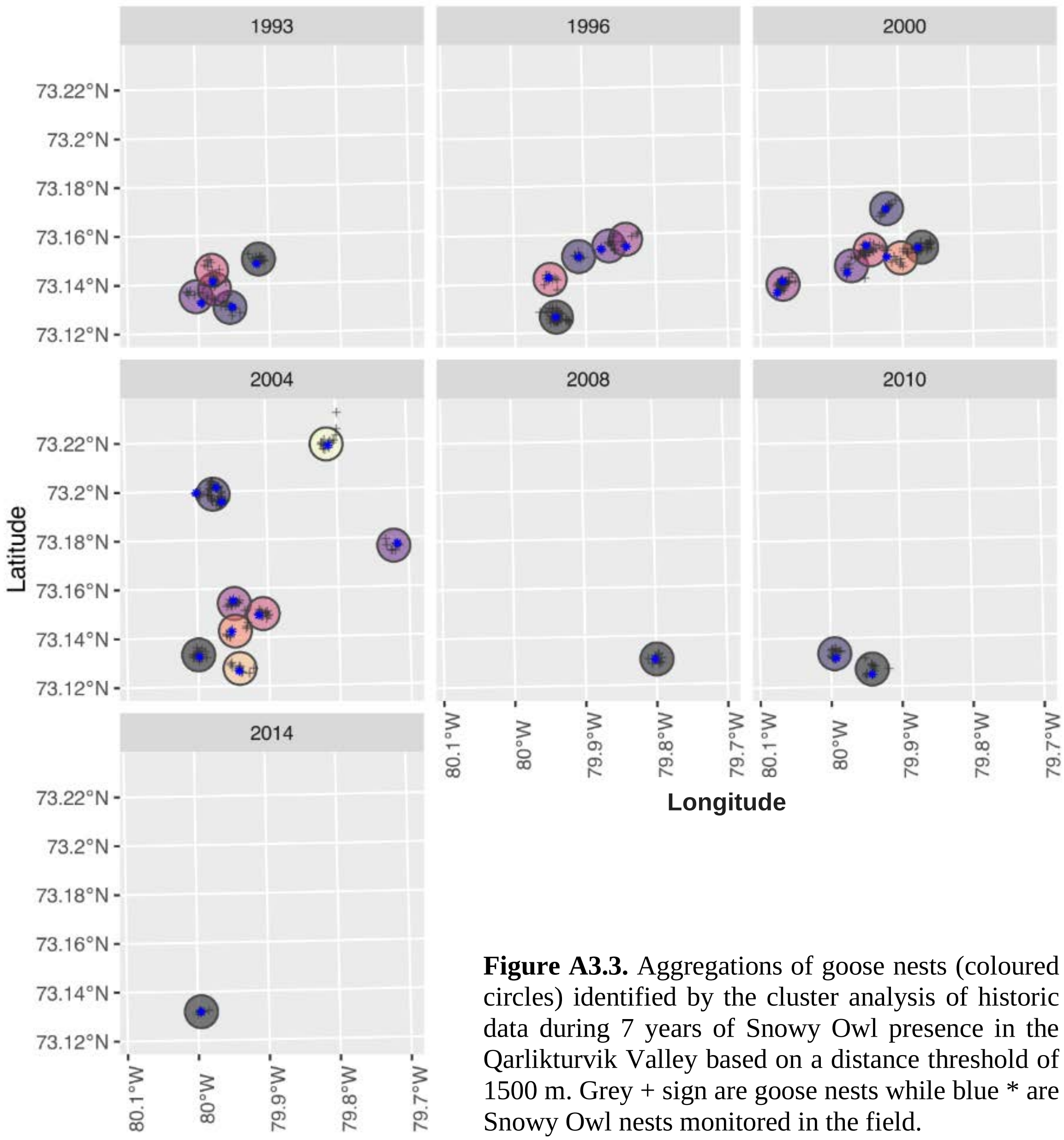

Figure A3.3. Aggregations of goose nests (coloured circles) identified by the cluster analysis of historic data during 7 years of Snowy Owl presence in the Qarlikturvik Valley based on a distance threshold of 1500 m. Grey + sign are goose nests while blue * are Snowy Owl nests monitored in the field.

We also examined the distance between each Snowy Owl nest censused in the field and the centroid of the nearest aggregation of goose nests identified by the cluster analysis for each threshold value (Fig A3.4). We found that the three threshold values previously determined (1250 to 1750 m) yielded realistic (i.e., close to 0 on average) distances between the locations of the centroid of goose nests aggregations and owl nests.

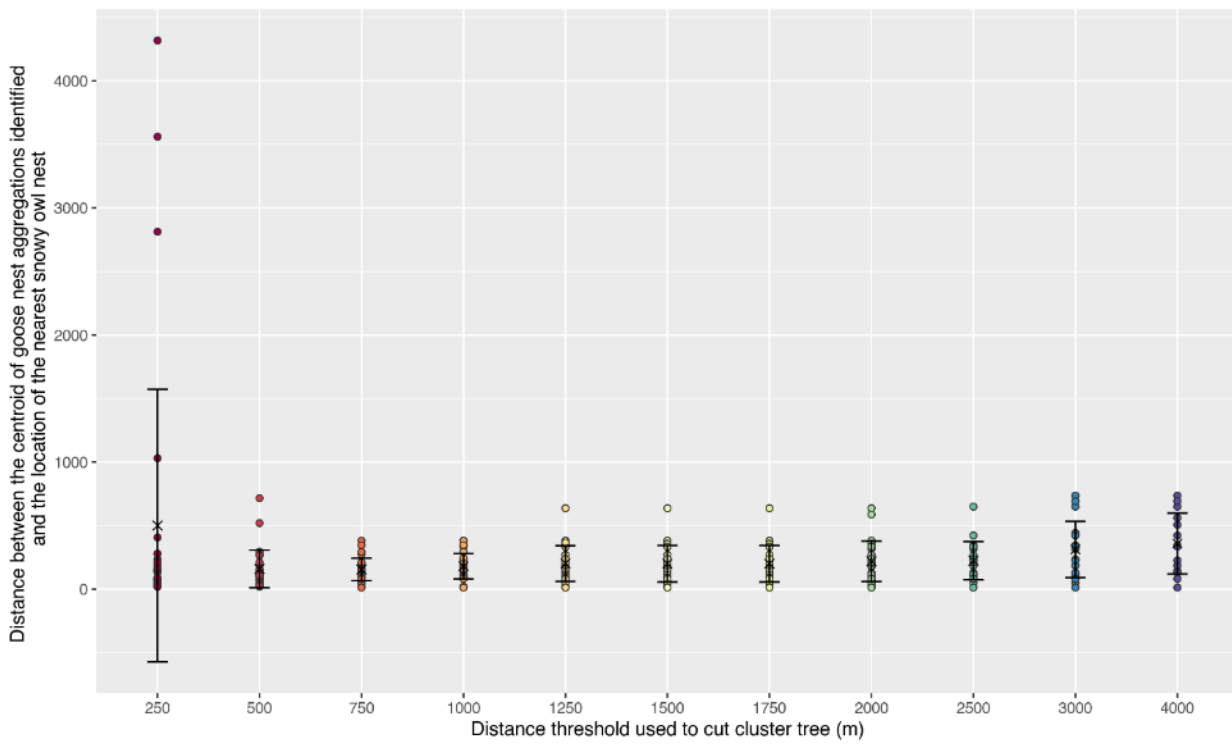

Figure A3.4. Distance (in m) between the centroid of individual goose nests aggregations identified in the cluster analysis and the location of the nearest Snowy Owl nest censused in seven different years according to different threshold distance values between goose nests in the cluster analysis. The x represents the mean values and error bars represents the 95% confidence intervals. Each dot within each treshold value represents an owl nest.

3.3. Estimating the number of Snow Owl nests

We applied the same cluster analysis that we ran on the historic data (see Appendix 3, section 3.2) to the goose nesting pairs identified on the satellite image of the Qarlikturvik Valley in 2020. However, we increased the minimum number of goose nesting pairs required to identify an aggregation of nests. We had retained aggregations of >3 goose nests in the historic data because in some years, search of goose nests around owl nests was not exhaustive. In contrast, the search of goose nesting pairs on the satellite images was very thorough and likely more exhaustive than in the field. Therefore, to avoid detecting an unrealistic high number of aggregations of goose nesting pairs in 2020, we increased this minimum value to 8 because, in the historic data, most owl nests censused were surrounded by 8 or more goose nests. We evaluated the sensitivity of our estimation of the number of goose nest aggregations to the distance threshold specified in the cluster analyses by using the three values previously identified (1250, 1500 and 1750 m) and to the minimum number of goose nesting pairs in an aggregation by varying this number from 7 to 9. Based on these criteria, we estimated between 9 and 14 potential Snowy Owl nests over the 59 km^2 monitoring area (Table A3.1). We chose to report the value associated with the midpoint of the parameter values used in the sensitivy analysis (distance threshold of 1500 m and aggregations with a minimum of 8 nesting pairs), which is 10 owl nests. The spatial distribution of the aggregations of goose nesting pairs identified in 2020 by the cluster analysis based on these parameter values is shown in Fig. A3.5.

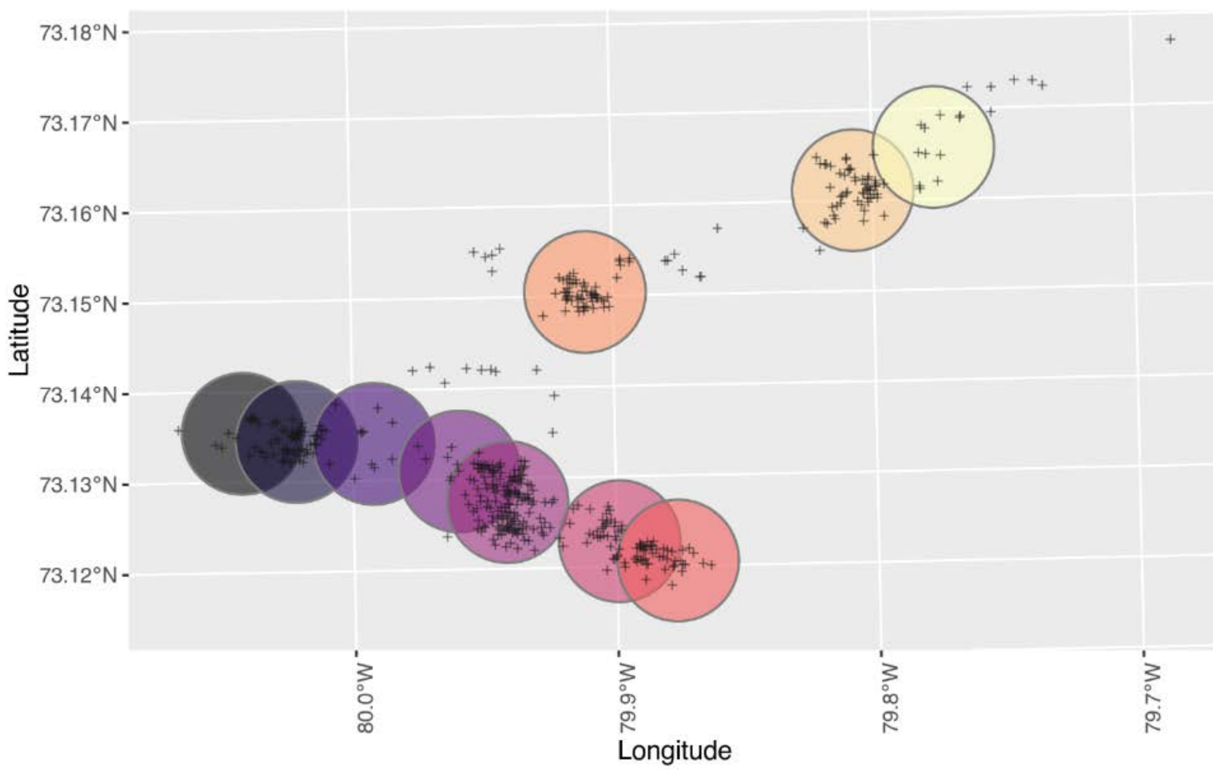

Figure A3.5. Aggregations of goose nesting pairs (colored circles) identified in the Qarlikturvik Valley area in 2020 by the cluster analysis when using a distance threshold of 1500 m and a minium of 8 goose pairs by aggregations. Grey + represents individual nesting pair identified on the satellite image.

Table A3.1. Number of potential Snowy Owl nests present in the Qarlikturvik Valley of Bylot Island in 2020 according to two sets of parameter values retained for the analysis.

Minimum number of goose nests in an aggregation	Maximum possible distance between nesting pairs belonging to the same cluster		
	1250 m	1500 m	1750 m
7	14	12	11
8	12	10	9
9	11	10	9

APPENDIX 4
PUBLICATIONS FROM OUR WORK ON BYLOT ISLAND (1990-2021)

Papers in refereed journals

J.214. Barrio, I.C., D. Ehrich, E.M. Soininen, V.T. Ravolainen, C.G. Bueno, O. Gilg, A.M. Koltz, J. Bêty et al. 2121. Developing common protocols to measure tundra herbivory across spatial scales. **Arctic Science** (*in press*).

J.213. Frederick, C., C. Girard, G. Wong, M. Lemire, A. Langwieder, M.-C. Martin & P. Legagneux. 2021. Communicating with Northerners on the absence of SARS-CoV-2 in migratory snow geese. **Ecoscience** (*in press*).

J.212. Meyer, N., L. Bollache, M. Galipaud, J. Moreau, F.X. Dechaume-Moncharmont, E. Afonso, A. Angerbjörn, J. Bêty et al. 2021. Behavioural responses of breeding arctic sandpipers to ground-surface temperature and primary productivity. **The Science of the Total Environment** 755:142485.

J.211. Nishizawa, K., L. Deschamps, V. Maire, J. Bêty, E. Lévesque, R. Kitagawa, S. Masumoto, I. Gosselin, A. Morneault, L. Rochefort, G. Gauthier, Y. Tanabe, M. Uchida & A.S. Mori. 2021. Long-term consequences of goose exclusion on nutrient cycles and plant communities in the High-Arctic. **Polar Science** 27 :100631.

J.210. Beardsell, A., D. Gravel, D. Berteaux, G. Gauthier, J. Clermont, V. Careau, N. Lecomte, C.-C. Juhasz, P. Royer-Boutin & J. Bêty. 2021. Derivation of predator functional responses using a mechanistic approach in a natural system. **Frontiers in Ecology and Evolution** 9:630944.

J.209. Grenier-Potvin, A., J. Clermont, G. Gauthier & D. Berteaux. 2021. Prey and habitat distribution are not enough to explain predator habitat selection: addressing intraspecific interactions, behavioural state and time. **Movement Ecology** 9:12.

J.208. Poulin, M.-P., J. Clermont & D. Berteaux. 2021. Extensive daily movement rates measured in territorial arctic foxes. **Ecology and Evolution** 11:2503-2514.

J.207. LeTourneux, F., T. Grandmont, F. Dulude-de Broin, M.C. Martin, J. Lefebvre, A. Kato, J. Bêty, G. Gauthier & P. Legagneux. 2021. COVID19-induced reduction in human disturbance enhances fattening rate of an overabundant goose species. **Biological Conservation** 255:108968.

J.206. McCabe, R.A., J.-F. Therrien, K. L. Wiebe, G. Gauthier, D. Brinker, S. Weidensaul & K. Elliott. 2021. Landscape cover type, not social dominance, is associated with the winter movement patterns of snowy owls in temperate areas. **Ornothology** 138:1-12.

J.205. Meyer N., L. Bollache, F.X. Dechaume-Moncharmont, J. Moreau, E. Afonso, A. Angerbjörn, J. Bêty et al. 2020. Nest attentiveness drives nest predation in arctic sandpipers. **Oikos**. 129:1481-1492.

J.204. Reséndiz-Infante, C. & G. Gauthier. 2020. Temporal changes in reproductive success and optimal breeding decisions in a long-distance migratory bird. **Scientific Reports** 10:22067.

J.203. Davidson, S.C., G. Bohrer, E. Gurarie, S. LaPoint, P.J. Mahoney, N.T. Boelman, J.U.H. Eitel, L.R. Prugh, L.A. Vierling, J. Jennewein, E. Grier, O. Couriot, A.P. Kelly, A.J.H. Meddens, R.Y. Oliver, R. Kays, M. Wikelski, T. Aarvak, J.T. Ackerman, J.A. Alves, E. Bayne, B. Bedrosian, J.L. Belant, A.M. Berdahl, A.M. Berlin, D. Berteaux, J. Bêty, G. Gauthier et al. 2020. New ecological insights from the Arctic Animal Movement Archive (AAMA). **Science** 370:712-715.

J.202. Robillard, A., G. Gauthier, J.F. Therrien & J. Bêty. 2020. Linking winter habitat use, diet and reproduction in snowy owls using satellite tracking and stable isotope analyses. **Isotopes in Environmental & Health Studies** 57:166-182.

J.201. Seyer, Y., G. Gauthier, D. Fauteux & J.F. Therrien. 2020. Resource partitioning among avian predators of the Arctic tundra. **Journal of Animal Ecology** 89:2934-2945.

J.200. Berner, L.T., R. Massey, P. Jantz, B. Forbes, M. Macias-Fauria, I. Myers-Smith, T. Kumpula, G. Gauthier, L. Andreu-Hayles, B.V. Gaglioti, P. Burns, P. Zetterberg, R. D'Arrigo & S.J. Goetz. 2020. Summer warming drives widespread but not uniform greening in the Arctic tundra biome. **Nature Communications** 11:4621.

J.199. Kankaanpää T., E. Vesterinen, B. Hardwick, N.M. Schmidt, T. Andersson, P.E. Aspholm, I. Barrio, N. Beckers, J. Bêty et al. 2020. Parasitoids indicate major climate-induced shifts in Arctic communities. **Global Change Biology** 26:6276-6295.

J.198. Chevallier, C., G. Gauthier, S. Lai & D. Berteaux. 2020. Pulsed food resources affect reproduction but not adult apparent survival in arctic foxes of the High Arctic. **Oecologia** 193:557-569.

J.197. Hutchison, C., F. Guichard, P. Legagneux, G. Gauthier, J. Bêty, D. Berteaux, D. Fauteux & D. Gravel. 2020. Seasonal food webs with migrations: Multi-season models reveal indirect species interactions in the Canadian Arctic tundra. **Philosophical Transactions of the Royal Society A – Physical Sciences A** 20190354.

J.196. Curk, T., I. Pokrovsky, N. Lecomte, T. Aarvak, D.F. Brinker, K. Burnham, A. Dietz, A. Dixon, A. Franke, G. Gauthier, K.-O. Jacobsen, J. Kidd, S.B. Lewis, I.J. Øien, A. Sokolov, V. Sokolov, R. Solheim, S. Weidensaul, K. Wiebe, M. Wikelski, J.F. Therrien & K. Safi. 2020. Arctic avian predators synchronise their spring migration with the northern progression of snowmelt. **Scientific Reports** 10:7220.

J.195. Reséndiz-Infante, C., G. Gauthier, & G. Souchay. 2020. Consequences of a changing environment on the breeding phenology and reproductive success components in a long-distance migratory bird. **Population Ecology** 62:284-296.

J.194. Weiser, E.L., R.B. Lanctot, S.C. Brown, H.R. Gates, J. Bêty et al. 2020. Annual adult survival drives trends in Arctic-breeding shorebirds but knowledge gaps in other vital rates remain. **Condor**. 122:1-14.

J.193. Schmidt, E., D. Fauteux, J.F. Therrien, G. Gauthier & Y. Seyer. 2020. Improving diet assessment of Arctic terrestrial predators with the size of rodent mandibles. **Journal of Zoology** 311:23-21.

J.192. Léandri-Breton, D.-J., Bêty, J. 2020. Vulnerability to predation may affect species distribution: plovers with broader arctic breeding range nest in safer habitat. **Scientific Reports** 10: 5032.

J.191. Ehrich, D., N.M. Schmidt, G. Gauthier, R. Alisauskas, A. Angerbjörn, K. Clark, F. Ecke et al. 2020. Documenting lemming population change in the Arctic: Can we detect trends? **Ambio** 49:786-800.

J.190. Gallant, D., N. Lecomte & D. Berteaux. 2020. Disentangling the relative influences of global drivers of change in biodiversity: A study of the twentieth-century red fox expansion into the Canadian Arctic. **Journal of Animal Ecology** 89: 565–576.

J.189. Léandri-Breton, D.-J., J.-F. Lamarre & J. Bêty. 2019. Seasonal variation in migration strategies used to cross ecological barriers in a Nearctic migrant wintering in Africa. **Journal of Avian Biology** 50: e02101.

J.188. Juhasz, C.-C., B. Shipley, G. Gauthier, D. Berteaux & N. Lecomte. 2019. Direct and indirect effects of regional and local climatic factors on trophic interactions in the Arctic tundra. **Journal of Animal Ecology** 89:704-715.

J.187. Larsson, P., J. von Seth, I.J. Hagen, A. Götherström, S. Androsov, M. Germonpré, N. Bergfeldt, S. Fedorov, N.E. Eide, N. Sokolova, D. Berteaux et al. 2019. Consequences of past climate change and recent human persecution on mitogenomic diversity in the arctic fox. **Philosophical Transaction of the Royal Society – Biological Sciences** 374: 20190212.

J.186. Seyer, Y., G. Gauthier, L. Bernatchez & J.-F. Therrien. 2019. Sexing a monomorphic plumage seabird using morphometrics and assortative mating. **Waterbirds** 42:380-392.

J.185. Rheubottom S.I., I.C. Barrio, M.V. Kozlov, S. Sokovnina, J.M. Alatalo, T. Andersson, A.L. Asmus, C. Baubin, F.Q. Brearley, D.D. Egelkraut, D. Ehrich, G. Gauthier et al. 2019. Hiding in the background: community-level patterns in invertebrate herbivory across the tundra biome. **Polar Biology** 42:1881-1897.

J184. Poirier, M., G. Gauthier & F. Domine. 2019. What guides lemming movements through the snowpack? **Journal of Mammalogy** 100:1416–1426.

J.183. Weiser E.L., R.B. Lanctot, S.C. Brown, H.R. Gates, R.L. Bentzen, J. Bêty et al. 2018. Environmental and ecological conditions at Arctic breeding sites have limited effects on true survival rates of adult shorebirds. **Auk** 135:29-43.

J.182. Weiser E.L., S.C. Brown, R.B. Lanctot, H.R. Gates, K. Abraham, R.L. Bentzen, J. Bêty et al. 2018. Effects of environmental conditions on reproductive effort and nest success of Arctic-breeding shorebirds. **Ibis** 160:608-623.

J.181. Weiser E.L., S.C. Brown, R.B. Lanctot, H.R. Gates, K. Abraham, R.L. Bentzen, J. Bêty et al. 2018. Life-history tradeoffs revealed by seasonal declines in reproductive traits of Arctic-breeding shorebirds. **Journal Avian Biology** 49:e01531.

J.180. Dominé, F., G. Gauthier, V. Vionnet, D. Fauteux, M. Dumont & M. Barrère. 2018. Snow physical properties may be a significant determinant of lemming population dynamics in the high Arctic. **Arctic Science** 4:813-826.

J.179. Juhasz, C.C., A. Lycke, V. Careau, G. Gauthier, J.-F. Giroux & N. Lecomte. 2018 Picking the right cache: Caching-site selection for egg predators in the Arctic. **Polar Biology** 41:2233-2238.

J.178. Fauteux, D., G. Gauthier, D. Berteaux, R. Palme & R. Boonstra. 2018. Predator-induced stress does not reduce fecundity in High Arctic lemmings. **Oecologia** 187:657-666.

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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.

C.108. Gauthier, G. & D. Berteaux. 2010. Is the tundra food web controlled by top predators? New evidence from the ArcticWOLVES project. *Seventh ArcticNet Scientific Meeting*, Ottawa, ON.

C.107. Bilodeau, F., G. Gauthier & D. Berteaux. 2010. Life under the snow: the effect of the snow cover on lemming population dynamics. *Seventh ArcticNet Scientific Meeting*, Ottawa, ON.

C.106. Chalifour, E., J. Bêty, M. Bélisle, J. Lefebvre & J.-F. Giroux. 2010. Molt migration of Greater Snow Geese. *Seventh ArcticNet Scientific Meeting*, Ottawa, ON.

C.105. Tarroux, A., D. Berteaux & J. Bêty. 2010. Surviving the arctic winter: insights into the foraging tactics of an arctic terrestrial predator. *Seventh ArcticNet Scientific Meeting*, Ottawa, ON.
C.104. Fast, P. 2010. Studies of migratory connectivity and nest choice in Arctic waterfowl. *Max Planck Institute for Ornithology*, Seewiesen, Germany.
C.103. Gauthier, G., J.-F. Therrien, J. Bêty, F. Doyle & D. Reid. 2010. Surprising migratory movements and site fidelity unraveled by satellite-tracking of snowy owls. *25th International Ornithological Conference*, Sao Paulo, Brazil.
C.102. Legagneux, P., G. Gauthier, D. Berteaux, J. Bêty, M.-C. Cadieux, G. Szor, F. Bilodeau, E. Bolduc, L. McKinnon, A. Tarroux, J.-F. Therrien, M.-A. Valiquette, L. Morissette & C.J. Krebs. 2010. Modeling temporal trophic dynamics of a terrestrial arctic ecosystem. *IPY Oslo Conference*, Oslo, Norway.
C.101. Doiron, M., G. Gauthier & E. Lévesque. 2010. Plant-herbivore interactions and climate change: the case of the Greater Snow Goose. *IPY Oslo Conference*, Oslo, Norway.
C.100. Legagneux, P., P. Fast, G. Gauthier & J. Bêty 2010. Effect of spring condition manipulation on reproductive success in the greater snow geese *Chen caerulescens*. *5th annual meeting of the Canadian Society of Ecology and Evolution*, Quebec, QC.
C.99. Therrien, J.-F., G. Gauthier & J. Bêty. 2010. The lemming buffet: is there anything left after owls and jaegers have eaten? *5th annual meeting of the Canadian Society of Ecology and Evolution*, Quebec, QC.
C.98. Desnoyers, M. & G. Gauthier. 2010. Le voyage organisé, un aspect inconnu du comportement grégaire de la grande oie des neiges *Chen caerulescens*. *5th annual meeting of the Canadian Society of Ecology and Evolution*, Quebec, QC.
C.97. Gauthier, G., D. Berteaux, J. Bêty, P. Legagneux, L. McKinnon, J.-F. Therrien, A. Tarroux, M.-C. Cadieux, C.J. Krebs, D. Reid, & D. Morris. 2010. The role of predators in structuring the Arctic terrestrial food web: preliminary results from the ArcticWOLVES project. *IPY Canada Early Results Workshop*, Ottawa, ON.
C.96. Doiron, M., G. Gauthier, & E. Lévesque. 2010. Impacts of climate change on a High Arctic herbivore: The case of the Greater Snow Goose. *IPY Canada Early Results Workshop*, Ottawa, ON.
C.95. Therrien, J.-F., G. Gauthier, J. Bêty D. Reid and F. Doyle. 2010. Long-distance movements of two avian predators, the Snowy Owl and Long-tailed Jaeger, tracked via satellite. *IPY Canada Early Results Workshop*, Ottawa, ON.
C.94. Reid, D., C.J. Krebs, G. Gauthier, A. Kenney, S. Gilbert, E. Hofer, D. Duchesne, M. Leung & F. Bilodeau. 2010. Snow depth and small mammal winter habitat choice: a tundra fencing experiment. *IPY Canada Early Results Workshop*, Ottawa, ON.
C.93. Lai, S., D. Berteaux & J. Bêty. 2009. From land to sea ice with the arctic fox, following the movements of a terrestrial mammal in the Canadian High Arctic. *Sixth ArcticNet Scientific Meeting*, Victoria, BC.
C.92. Tarroux, A., D. Berteaux & J. Bêty. 2009. Nomades de l'Arctique: Capacité de déplacement à grande échelle chez le renard polaire. *Sixth ArcticNet Scientific Meeting*, Victoria, BC.
C.91. Tarroux, A., D. Berteaux & J. Bêty. 2009. The marine side of a terrestrial mammal: trophic niche and diet specialization in arctic foxes. *Sixth ArcticNet Scientific Meeting*, Victoria, BC.
C.90. Therrien, J.-F., G. Gauthier & J. Bêty. 2009. The lemming buffet: is there anything left after owls and jaegers have eaten? *Sixth ArcticNet Scientific Meeting*, Victoria, BC.
C.89. Fast, P., C. Redjadj, G. Gauthier & J. Bêty. 2009. Fuelling up before the flight: Assessing the importance of stopover sites in an Arctic migrant using stable isotopes. *Sixth ArcticNet Scientific Meeting*, Victoria, BC.
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Graduate student theses

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T.65. Juhasz, C.-C. 2020. Impacts de la variabilité climatique sur les interactions prédateur-proie en Arctique. PhD thesis, Département de biologie, Université de Moncton.

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.

T.61. Lai, S. 2017. Écologie spatiale du renard arctique sur l'Île Bylot, Nunavut, Canada. PhD thesis, Département de biologie, Université du Québec à Rimouski.

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T.56. Marmillot, V. 2015. Effets des conditions environnementales, de la condition corporelle et du statut hormonal sur la mue de la grande oie des neiges (*Chen caerulescens atlantica*). MSc thesis, Département de biologie, Université Laval, Québec.

T.55. Doiron, M. 2014. Impacts des changements climatiques sur les relations plantes-herbivores dans l'Arctique. PhD thesis, Département de biologie, Université Laval, Québec.

T.54. Doucet, C. 2014. Synchronie entre la reproduction et l'abondance des ressources: effet sur le succès reproducteur d'un insectivore nichant dans l'Arctique. MSc thesis. Département de biologie, Université du Québec à Rimouski.

T.53. Christin, S. 2014. Évaluation empirique de la précision du suivi télémétrique Argos dans le Haut-Arctique et implications pour l'estimation des domaines vitaux. MSc thesis, Département de biologie, Université du Québec à Rimouski.

T.52. Rioux, M.-J. 2014. La dynamique socio-spatiale hivernale chez les couples de renard arctique (*Vulpes lagopus*) dans le haut-arctique canadien. MSc thesis, Département de biologie, Université du Québec à Rimouski.

T.51. Bilodeau, F. 2013. Effet du couvert nival, de la nourriture et de la prédation hivernale sur la dynamique de population des lemmings. PhD thesis, Département de biologie, Université Laval, Québec.

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T.49. Bolduc, E. 2013. Abondance et phénologie des arthropodes terrestres de l'Arctique canadien: modélisation de la disponibilité des ressources alimentaires pour les oiseaux insectivores. MSc thesis, Département de biologie, Université du Québec à Rimouski.

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T.47. Perreault, N. 2012. Impact de la formation de ravins de thermo-erosion sur les milieux humides, Ile Bylot, Nunavut, Canada. MSc thesis, Département de chimie-biologie, Université du Québec à Trois-Rivières.
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T.40. Duchesne, D. 2009. Sélection de l'habitat, reproduction et prédation hivernales chez les lemmings de l'Arctique. MSc thesis, Département de biologie, Université Laval.
T.39. Marchand-Roy, M. 2009. L'effet fertilisant de la Grande Oie des neiges: cinq ans de suivi de l'azote et du phosphore dans les polygones de tourbe de l'Île Bylot au Nunavut. MSc thesis, Département de phytologie, Université Laval.
T.38. Cameron, C. 2009. Régimes d'appariement du Renard Arctique (*Vulpes lagopus*). MSc thesis, Département de biologie, Université du Québec à Rimouski.
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