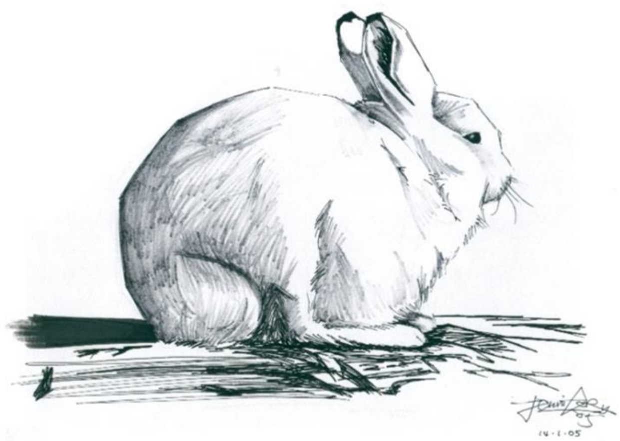
WILDLIFE MONITORING AND ECOLOGICAL RESEARCH AT CFS ALERT

SUMMARY FIELD REPORT 2019



19 November 2019

Université du Québec à Rimouski
Affiliation: Department of National Defence / 8 Wing Environment

	FIELDWORK DATES
PRINCIPAL INVESTIGATORS	
Dominique Berteaux (Professor - HareForce)	9 May - 22 May, 12 Jul - 24 Jul
François Vézina (Professor - SnowBird)	15 May - 12 Jun, 12 Jul - 24 Jul, 4 Sep - 21 Sep
RESEARCH TEAM	
Kevin Young (PhD student – SnowBird)	15 May - 21 Sep
Francis Robitaille (BSc student – SnowBird)	15 May - 19 Aug
Sandra Lai (Postdoctoral researcher – HareForce)	9 May - 12 Jun, 12 Jul - 8 Aug
Jacob Caron Carrier (MSc student – HareForce)	9 May - 8 Aug
Émilie Desjardins (MSc student – SnowBird and HareForce)	11 Jun - 14 Sep
Marie-Jeanne Rioux (Coordinator – SnowBird and HareForce)	22 Jun - 12 Jul
Marie-Pier Poulin (Bsc student – SnowBird and HareForce)	24 Jul - 14 Sep
Ryan O'Connor (Postdoctoral researcher - SnowBird)	Coordination of snow bunting project from UQAR

TOTAL PERSON NIGHTS (9 May 2019 to 21 September 2019): 635

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Abstract

A biodiversity/wildlife research program is conducted by Université du Québec à Rimouski at CFS Alert with the support of the Department of National Defence (8 Wing Trenton Environmental Management). 2019 was the second year of field activities.
Highlights for this second field season are:

- The summer 2019 was unusually warm at Alert (as everywhere else in the Arctic), with a record temperature of 21°C on 14 July. Several snow banks melted completely. Effects on wildlife are unclear.
- We completed the vegetation surveys required to produce a vegetation map for the station premises.
- We confirmed or reported for the first time the breeding of several species on DND property:
  - Arctic fox (4 litters)
  - Ermine (1 litter)
  - Snowy owl (9 clutches)
- We confirmed or reported for the first time the use of the area for rearing of several species on DND property:
  - Snow goose (around 10 families)
  - Red phalarope (20 to 25 juveniles)
  - Lapland longspur (2 juveniles)
  - Iceland gull (Thayer's subspecies) (2 juveniles)
  - Gyrfalcon (3 juveniles)
- We documented the presence of 3 species of conservation concern on DND property:
  - Red knots breed and rear their young on DND property.
  - Peary caribou rear their young on DND property.
  - Polar bear mothers bring their young along the shore of Alert during summer.
- We tracked seasonal hare movements using GPS and Argos collars. Preliminary data show large-scale movements occurring during fall and directed towards Lake Hazen in Quttinirpaaq National Park.
- We observed a very high lemming abundance this summer, which likely explains the successful reproduction of a high number of terrestrial and avian predators. In May and September, we observed many lemmings resting or traveling near their burrow entrance on top of the snow layer, which is unusual and not understood. In July, we tested two methods (pee cards and snap traps) to index lemming abundance at Alert.
- We observed early breeding activity in snow buntings, with birds defending territories up to 2 weeks ahead of previous years.
- We collected new physiological data on thermal tolerance of snow buntings in support of two ongoing research projects.
- We documented thermal micro-environments in habitats used by snow buntings and found that temperatures experienced by the birds can vary considerably among locations while being very different from that registered by the Alert weather station.

- We confirmed that we can capture and study juvenile shorebirds and juvenile snow buntings in the weeks before departure for their first migration in life.
- We found that juvenile shorebirds captured late in the season are structurally small and develop large flight muscles before departure, possibly to improve shivering heat production as temperature decline or in prevision of long non-stop flights.
- We confirmed with visual observations and automatic cameras that shorebirds and other birds such as long-tailed jaegers did not gather around the sewage outfall in late May/early June as usual, but that shorebird numbers did build up after breeding in August. This continuous monitoring will be useful to obtain demographic data on some species of conservation concern and to document year-to-year variation.
- We monitored human activity by installing GPS on BV 206 vehicles to record their movements inside DND property. This will be combined to vegetation data to evaluate potential risks of damage to sensitive and fragile habitats.
- We refined the *Alert Wildlife Research Protocols*, a 70-pages document summarizing goals and protocols for our second year of wildlife research at Alert. We refined many protocols to track annual variation in meteorological conditions, lake ice conditions, plant flowering time, wildlife abundance, wildlife reproduction, and wildlife use of the various habitats available on DND property.

Introduction

The Université du Québec à Rimouski and the Department of National Defence (8 Wing Trenton Environmental Management) have signed a Memorandum Of Understanding in April 2018 to establish a biodiversity/wildlife research program at the Canadian Forces Station Alert, Ellesmere Island, 82°30’N.

Alert is located 817 km from the North Pole and is the northernmost permanently inhabited place in the world. Building from the research interests of Université du Québec à Rimouski and the needs for Federal statutory and regulatory compliance related to the Species at Risk Act, we determined five related long-term research objectives:

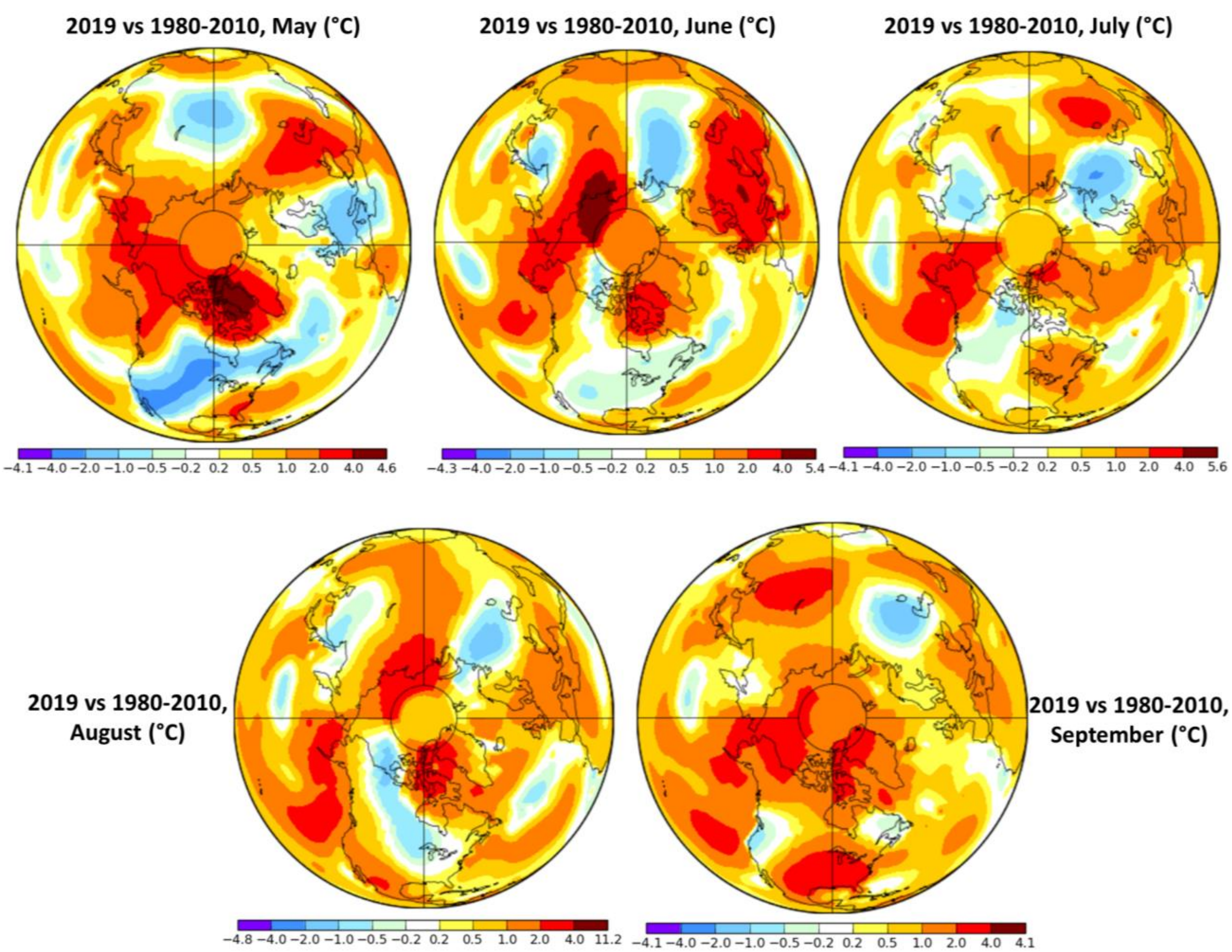
1- Eco-physiology of migratory birds
2- Behavioural ecology of northern mammals
3- Ecology of the polar desert ecosystem
4- Biodiversity monitoring
5- Management plans for Species at Risk and other listed species.

This report summarizes field activities carried out during 2019, our second year of operation, and preliminary objectives for 2020. When available, preliminary data illustrate results from our work. All field activities were performed on DND property, as shown by the purple rectangle in the 1:50 000 map below. All research activities were integrated into a single project, but specific projects were under the responsibility of D. Berteaux (HareForce team) or F. Vézina (SnowBird team), depending on expertise.

1. Environmental variables

1.1 Meteorology

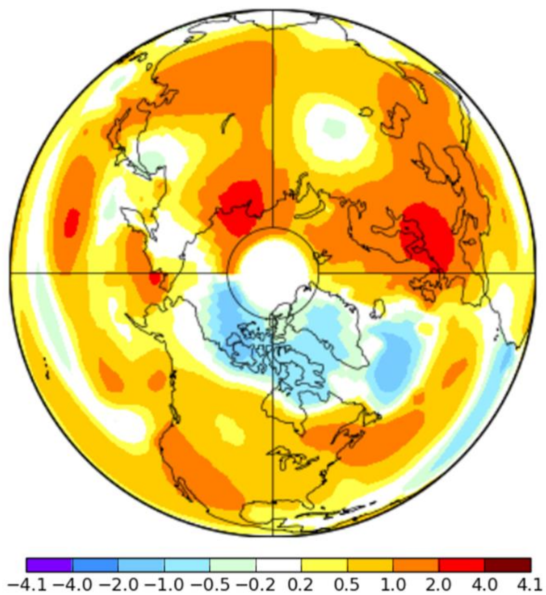
The summer 2019 was warmer than usual at Alert and in most of the Canadian Arctic Archipelago. This is clearly shown by the maps below, where average 2019 air temperatures in May-June-July-August-September are compared to average air temperatures during the 1980-2010 reference period. Alert temperatures were >2°C warmer than the reference period in most summer months. (data source: https://data.giss.nasa.gov/gistemp/maps/)



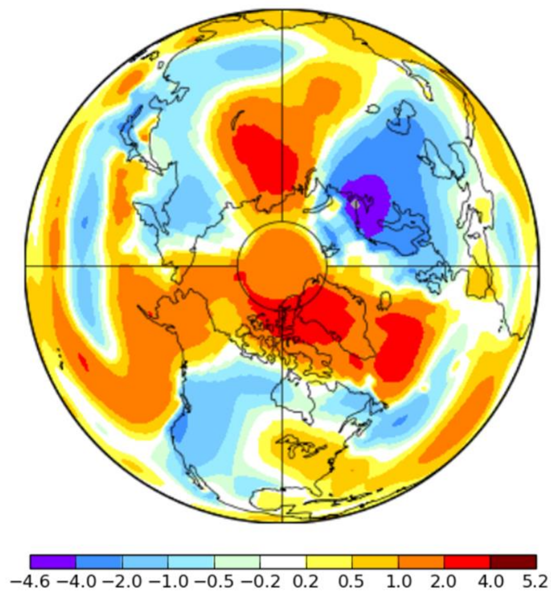
Since we were not at Alert in 1980-2010, it seems impossible to assess the ecological effects of this 2°C increase in air temperatures. However, there is perhaps a way around this, because the summer 2018 had looked rather cold to us. Could it be that the summer 2018 offers a good representation of the temperatures that occurred during the 1980-2010 reference period?

The map on the left below shows that summer temperatures during 2018 were indeed similar to the average summer temperatures for 1980-2010. The map on the right confirms that summer temperature for 2019 were roughly 2°C higher than 2018 temperatures.

2018 vs 1980-2010, June-Sep (°C)



2019 vs 2018, July (°C)



The comparison of our 2018 field observations with those made in 2019 suggests that an increase of 2°C has clear effects on the ecology of the polar desert. In particular, plant growth and snowbank melt were much greater in 2019 compared to 2018. In addition, an unusual snowmelt event has been recorded in late September (see below), which was not detected in the last 15 years of ECCC data. Higher plant growth is beneficial to herbivores, but a snowmelt in September can form ice crusts on the ground and be detrimental to herbivores by blocking access to their food. Our field protocols cannot yet quantify these ecological effects, but we will adapt them so they can do so in the years to come.

Plans for 2020

In addition to archiving data collected at Alert by the weather stations operated by ECCC, Natural Resources Canada, and the Airport, we will measure microclimate temperatures experienced by animals in 2020. These microclimate temperatures can be very different from temperatures recorded by weather stations and will help us understand the links between climate and wildlife at Alert.

1.2 Snow cover and snow banks

Our study of snow cover has two main objectives: 1) monitoring snow accumulation and disappearance every summer; 2) monitoring the melt of designated snow banks every summer.

Goals for 2019

1. To monitor snow accumulation and disappearance in designated areas using automatic cameras;
2. To choose relevant snow banks and monitor their melt using automatic cameras.

Field activities

Camera monitoring — We monitored snow melt at two areas using 3 Reconyx cameras programmed to take two pictures every day (00:00 and 12:00) starting from 10 May (see map **Fig 3.1.2**). Two cameras were placed on a pole, one pointing towards Cairn Butte and the other towards the mouth of Pullen Creek. One more camera was placed on a T-post to monitor snow cover in the Delta area (Lower Dumbell lake).

In addition, we selected 6 snow banks to be monitored in Joliffe Bay, Upper Dumbell Lake, Cairn Butte, Alert Inlet South, Ravine Bay East, and Kirk Lake (see map **Fig 3.1.2**). Cameras were programmed to take two pictures every day (00:00 and 12:00).

Preliminary results

Camera monitoring — The cameras performed well and collected pictures according to plans. Snow melt (< 5% of snow on the ground) was complete around 14 June for the slopes towards Cairn Butte (29 June in 2018) and around 24 June for the slopes towards the mouth of Pullen Creek (7 July in 2018). The Delta river started to flow in Lower Dumbell Lake on 12 June and snow started to melt rapidly on 14 June (**Fig 1.2.1**). Snow melt was completed in the Delta by 17 June.

Figure 1.2.1. Pictures from the camera monitoring snow melt of the Delta area showing the rapid melt on 14 June (picture on the left, 2019-06-13 00:00; picture on the right, 2019-06-14 00:00).

The snow banks of Upper Dumbell Lake, Alert Inlet South, Joliffe Bay and Ravine Bay East completely melted on 23 July, 26 July, 4 August and 6 August, respectively. Before our departure, the snow banks of Cairn Butte and Kirk Lake, last visited on 26 August and 2 September respectively, were not completely melted (although the one at Cairn Butte was almost completely gone). The rate of melting will be analysed later.

Plans for 2020

We will continue using Reconyx cameras to monitor snow melt around Alert Inlet and the Delta. We will analyse satellite maps to determine other important snow banks to monitor during summer.

1.3 Ice cover

Our study of ice cover has one main objective: 1) monitoring ice phenology (break-up and freeze-up) of the main water bodies near CFS Alert every summer.

Goals for 2019

1. To obtain data on ice phenology;
2. To compare two protocols (visual monitoring and camera monitoring) for the long-term monitoring of ice phenology.

Field activities

Visual monitoring — From 9 May to 20 September, we visually estimated, every third day, ice stage and percentage of ice cover (see p. 8-10 in the Alert Wildlife Research Protocols) of 4 water bodies (Alert Inlet North, Alert Inlet South, Dumbell Bay, and Upper Dumbell Lake). We also estimated ice stage and percentage of ice cover opportunistically on 5 more water bodies (Lower Dumbell Lake, Kirk Lake, Colan Bay North, Colan Bay South, and Joliffe Bay) over that same period.

Camera monitoring — We placed Reconyx cameras to monitor ice cover of 5 water bodies: Cape Belknap (ocean), Upper Dumbell Lake, Lower Dumbell Lake, Colan Bay, and Kirk Lake (see map on **Fig 3.1.2**).

Preliminary results

Visual monitoring — Visual monitoring every 3 days was suitable to follow ice phenology of the 4 main water bodies (**Fig 1.3.1**). Other water bodies were monitored less frequently and most stage transitions and final break-up were missed. This justifies the use of cameras to monitor water bodies further away from the Station.

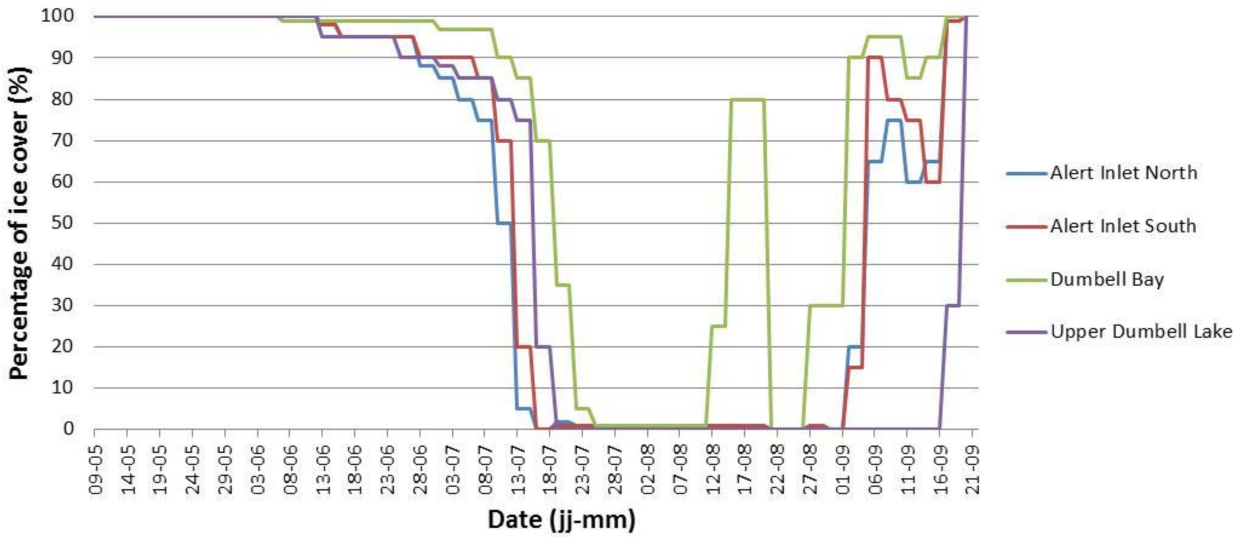


Figure 1.3.1. Chronology of ice cover melt of the 4 main water bodies. Note that Dumbell Bay has a more variable percentage of ice due to wind-generated movements of sea ice in the bay.

Camera monitoring — The cameras performed well and collected pictures according to plans. Analyses of pictures and comparison with visual monitoring will be conducted before the next field season.

Plans for 2020

If the two methods (visual and camera monitoring) yield similar results, we may consider using only Reconyx cameras to record ice break-up and freeze-up of these water bodies.

1.4 Plant communities

Our study of plant communities has three main objectives: 1) inventorying the plant species present in the study area; 2) surveying vegetation to identify the main plant communities representing the various wildlife habitats available on DND property; 3) surveying the phenology of four common species in the arctic.

Goals for 2019

1. To identify Alert plant species;
2. To carry out vegetation surveys for plant community mapping;
3. To monitor plant reproductive phenology.

Field activities

Vegetation surveys — We conducted vegetation surveys on 201 homogeneous areas based on a stratified random sampling (**Fig 1.4.3**). To determine survey sites, we used a satellite picture (taken on 2 and 13 August 2015) transformed with a Soil-Adjusted Vegetation Index (SAVI) and classified areas in 6 categories (water/snow, bare soil, xeric habitat, xeric-mesic habitat, mesic habitat and wetland) using unsupervised hierarchical clustering in ArcGIS. We then divided the area in a 2 km x 2 km grid and generated random points distributed within the grid and performed vegetation surveys for one random point in each class (except for the water/snow class) inside each grid cell. These 201 vegetation surveys were carried out from 3 July to 2 September.

Each vegetation survey consisted in five 1-m^2 quadrats positioned at 5 m from a center point and placed at equal distance from each other (Bay 1998). A quadrat was delimited by a 1m x 1m wooden frame and distended ropes formed a grid pattern in two layers with 100 intersections per layer (**Figs 1.4.1 and 1.4.2**). The frame was placed horizontally, a pin was lowered along each rope intersection and plant species touching the pin were recorded. An index of cover for each plant species will be calculated from these data. Species that were present but not touched will be assigned an index of <1% cover. This method is called pointing-analysis or ITEX and has become a standard in this type of research. The plant communities were characterised by the cover occupied by plant species, moss and lichen. The type of rocks, landform, soil moisture, topography and surface roughness were also recorded. Biological data such as presence of animal tracks, faeces, casts, grazed plants, lemming holes and winter nests were also noted. All this information will be used to classify and name plant communities or habitats.

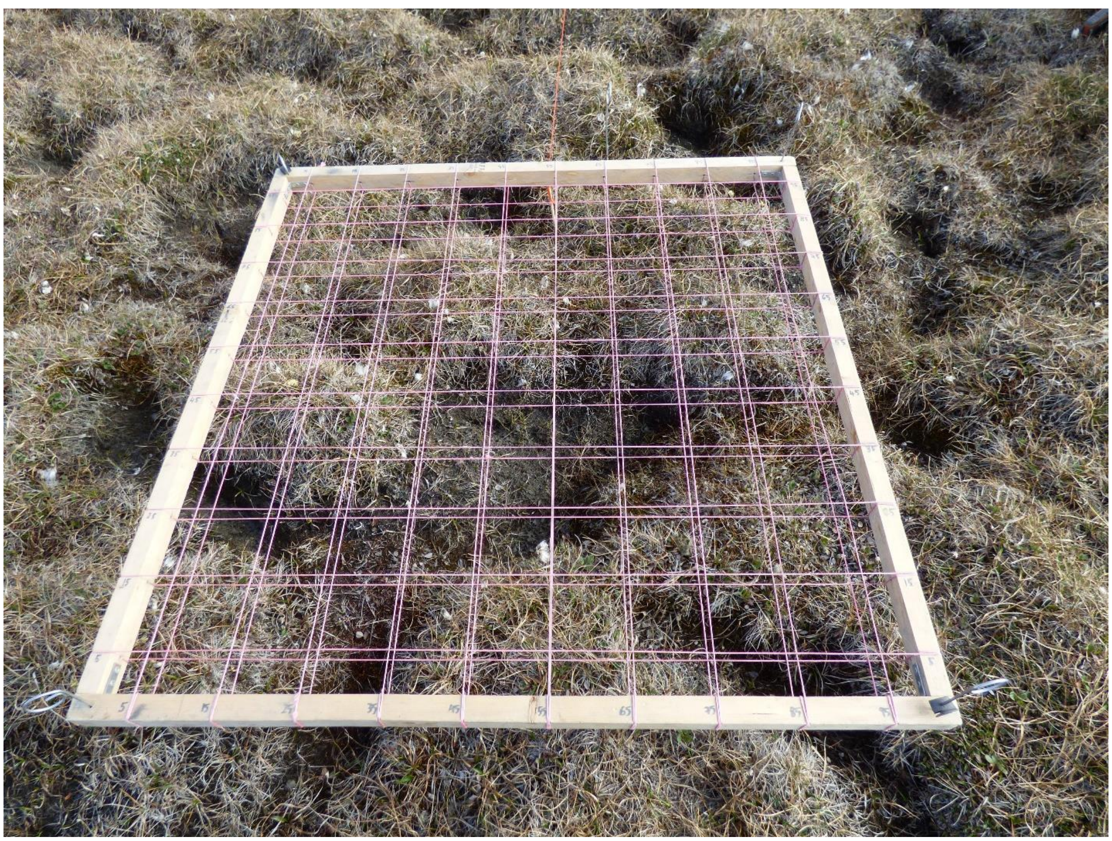


Figure 1.4.1. Top view of a quadrat. Intersections of ropes indicate where vegetation will be assessed with a pin lowered along the rope crossing.

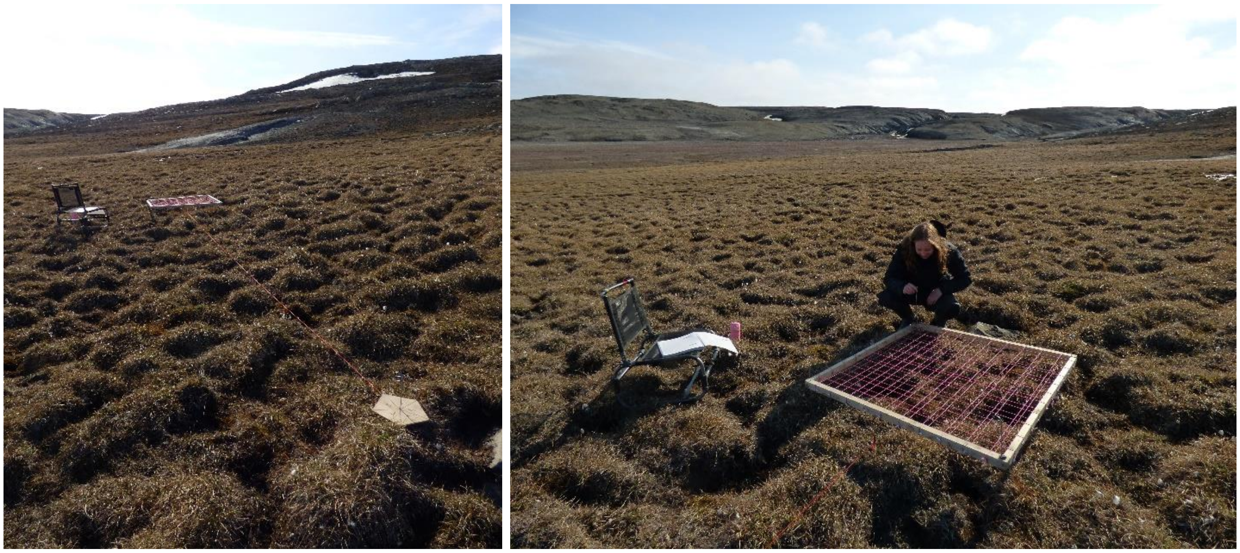


Figure 1.4.2. Setting up one of 5 quadrats during a vegetation survey.

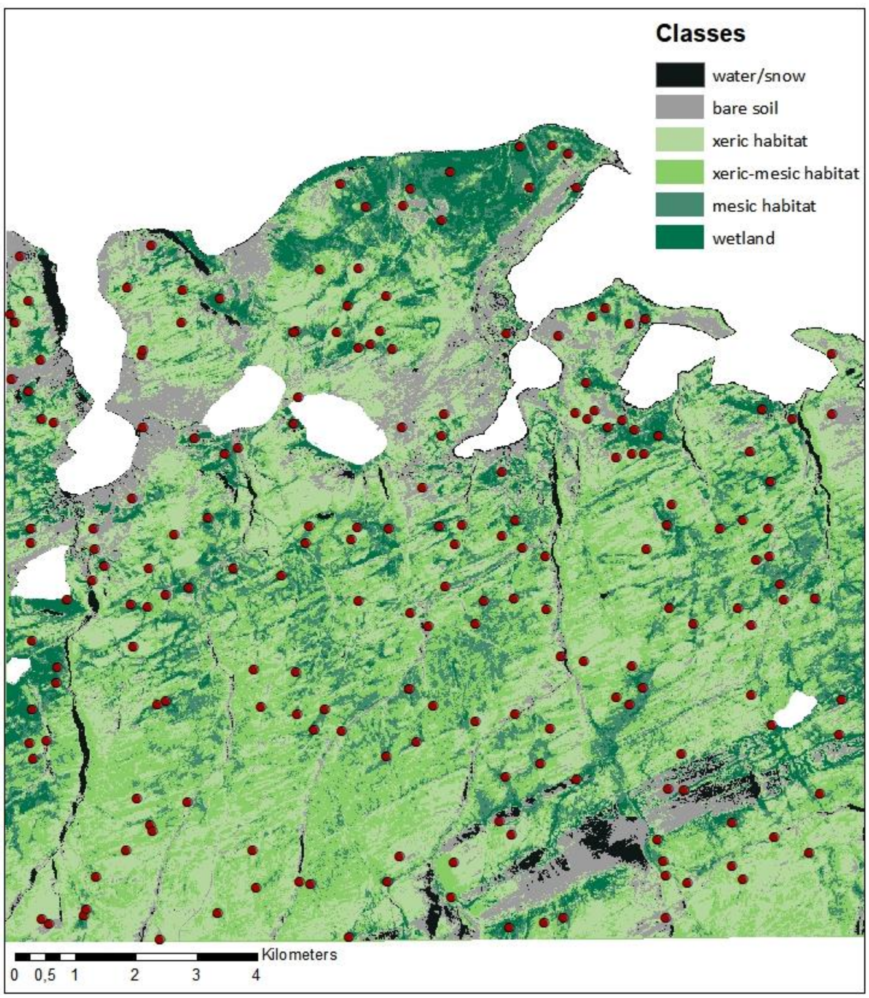


Figure 1.4.3. Satellite picture and topographic map of CSF Alert with the locations (red dots) where vegetation surveys were conducted.

Plant phenology — We identified two areas (Suicide Point and along Upper Dumbell Lake) where the densities of *Dryas integrifolia, Papaver radicatum, Salix arctica* and *Saxifraga oppositifolia* was high enough to allow annual survey of flowering phenology. We marked the plots (measuring a few m^2 each) with metal bars in each corner, as shown in **Fig.1.4.4**. Each plot includes at least 50 flowers of the same species (except for *S. arctica* where >100 flowers are needed to properly record phenology). We have four plots per species: two around Suicide Point and two along Upper Dumbell Lake (**Fig. 1.4.5**). We recorded the number of buds, flowers, and fruits (senescent flowers) for each species, weekly from end of May to beginning of September.

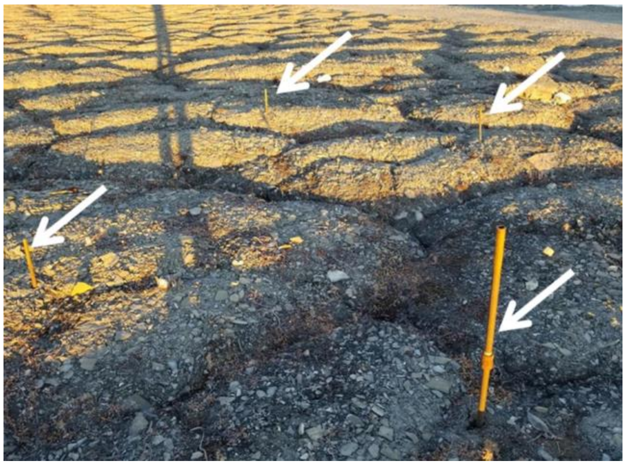


Figure 1.4.4. Phenology plot with a metal stake at each corner.

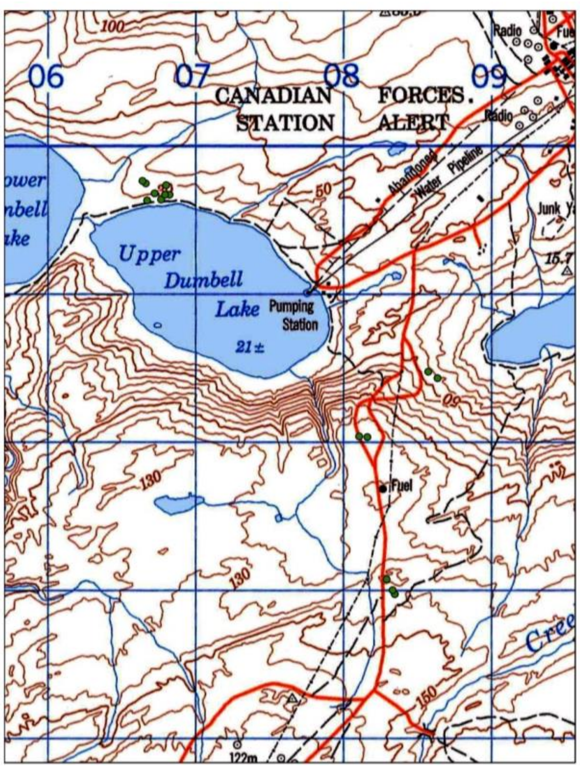


Figure 1.4.5. Locations (green dots) of the plant phenology survey plots

Preliminary results

Vegetation surveys — We collected data on species cover, soil, rocks and animal presence at 201 vegetation survey plots. We identified 57 species of plants at Alert (**Table 1.4.1**), 13 more than in 2018.

Table 1.4.1. List of plant species recorded at CFS Alert during the summer of 2019.

Family	Species
Asteraceae	*Taraxacum phymatocarpum*
Brassicaceae	*Braya arctica*
	Cardamine bellidifolia
	Cochlearia groenlandica
	Draba alpina
	Draba corymbosa
	Draba lactea
	Draba subcapitata
Caryophyllaceae	*Cerastium alpinum* subsp. *alpinum*
	Cerastium regelii
	Minuartia rossii
	Minuartia rubella
	Silene uralensis subsp. *uralensis*
	Stellaria longipes subsp. *longipes*
Cyperaceae	*Carex atrofusca*
	Carex aquatilis var. *minor*
	Carex fuliginosa
	Eriophorum angustifolium subsp. angustifolium
	Eriophorum scheuchzeri
Equisetaceae	*Equisetum arvense*
	Equisetum variegatum subsp. *variegatum*
Juncaceae	*Juncus biglumis*
	Luzula nivalis
Papaveraceae	*Papaver radicatum* subsp. *radicatum*
Poaceae	*Alopecurus magellanicus*
	Arctagrostis latifolia subsp. *latifolia*
	Deschampsia brevifolia
	Festuca brachyphylla
	Festuca edlundiae
	Festuca hyperborea
	Festuca viviparoidea subsp. *krajinae*
	Phippsia algida
	Pleuropogon sabinei
	Poa abbreviata subsp. *abbreviata*
	Poa arctica subsp. *caespitans*
	Poa pratensis subsp. *colpodea*

	Puccinellia angustata
	Puccinellia arctica
	Puccinellia bruggemannii
	Puccinellia phryganodes
	Trisetum spicatum
Polygonaceae	*Bistorta vivipara*
	Oxyria digyna
Ranunculaceae	*Ranunculus aquatilis* var. *subrigidus*
	Ranunculus hyperboreus
	Ranunculus sabinei
	Ranunculus sulphureus
Rosaceae	*Dryas integrifolia* subsp. *integrifolia*
	Potentilla pulchella
Salicaceae	*Salix arctica*
Saxifragaceae	*Micranthes nivalis*
	Saxifraga cernua
	Saxifraga cespitosa
	Saxifraga flagellaris subsp. *platysepala*
	Saxifraga oppositifolia subsp. *oppositifolia*
	Saxifraga tricuspidata
Scorphulariaceae	*Pedicularis hirsuta*

Species name based on: Brouillet, L., F. Coursol, S.J. Meades, M. Favreau, M. Anions, P. Bélisle & P. Desmet. 2010+. VASCAN, the Database of Vascular Plants of Canada. http://data.canadensys.net/vascan/, accessed on 07/05/2019.

Plant phenology — The first flowers appeared on 5 July for *Dryas integrifolia*, 12 July for *Papaver radicatum*, 14 June for *Saxifraga oppositifolia* and 21 June for *Salix arctica*. In 2018, dates of flowering were 15 July for *Dryas integrifolia*, 29 June for *Papaver radicatum*, 13 June for *Saxifraga oppositifolia* and 27 June for *Salix arctica*. In 2018, we were not monitoring plant phenology in the same survey plots as in 2019 (they were not installed yet) but only noted the first flowers blooming in the study area. Therefore, the dates from 2018 and 2019 are not entirely comparable, but we can still see some noticeable differences.

Fig 1.4.6 shows the complete phenology of each species. Most of the poppy buds were eaten by hares and lemmings, which is why we only counted two flowers.

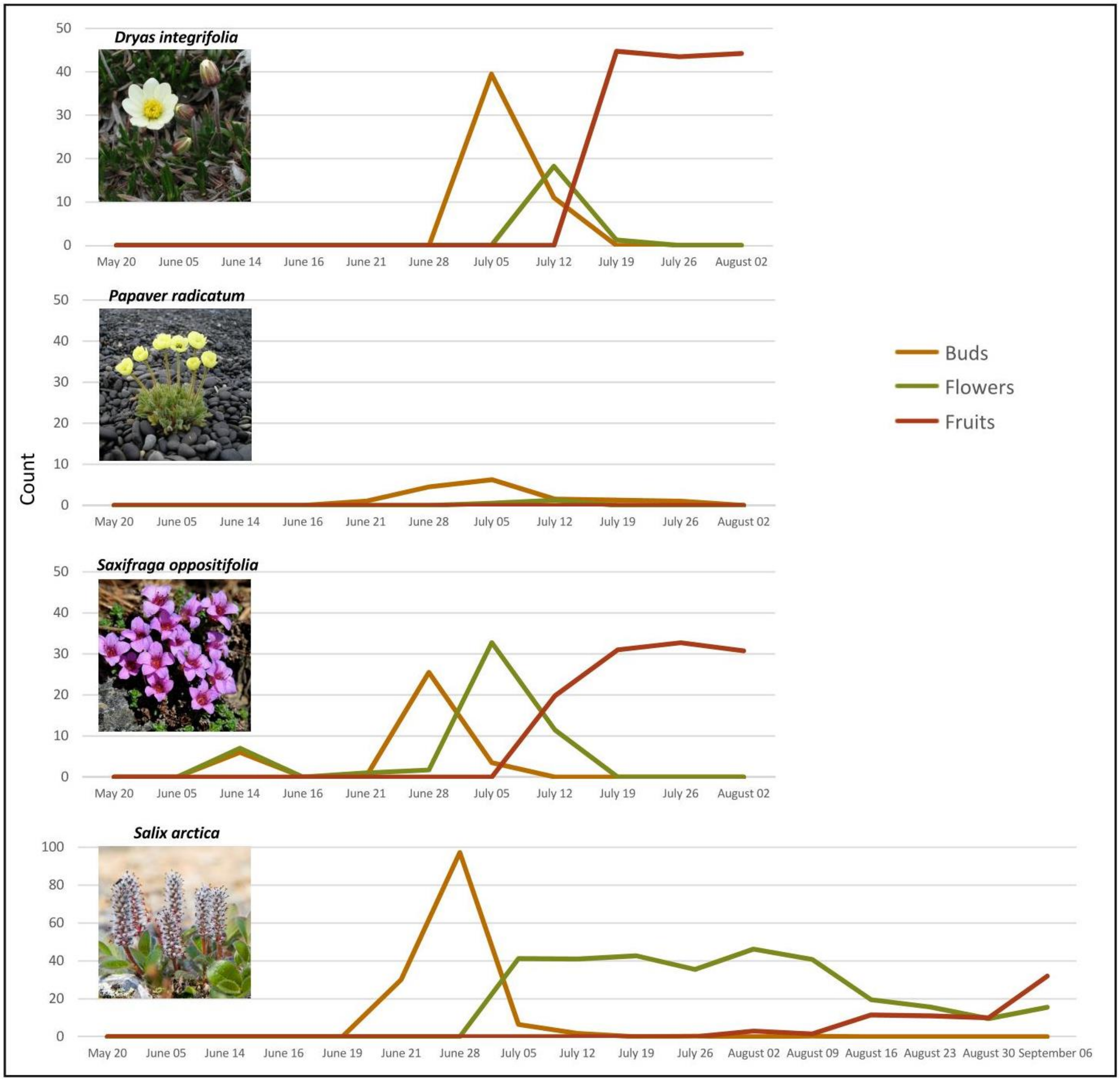


Figure 1.4.6. Phenological calendars of the four species (*Dryas integrifolia*, *Papaver radicatum*, *Saxifraga oppositifolia* and *Salix arctic*) during the summer 2019.

Plans for 2020

We will conduct vegetation surveys along the human infrastructures (road, antennas, sewage, and buildings) to inventory the presence of non-native plants.

Plant reproductive phenology will be monitored again in the permanent plots once a week from May to September. However, starting next year, we will use exclosures to reduce the effect of herbivores on the data.

2. Wildlife species

2.1 Arctic hares

Our study of arctic hares has two main objectives: 1) monitoring population dynamics (abundance, reproduction, survival); 2) tracking adult hare movements to understand space and habitat use.

Goals for 2019

1. To obtain an estimate of hare abundance in the study area;
2. To capture and tag individuals for population dynamics and movement studies;
3. To measure movements and space use by adult hares with GPS collars fitted during summer and using Argos satellite collars during the rest of the year.

Field activities

Monitoring of hares — We monitored hares near the Station, starting from the beginning of Caribou road to the end of the Air Strip (Beacon road). We did 4 visual counts of hares from 10 observation points along the roads (see p. 13-14 in the Alert Wildlife Research Protocols).

We trapped adult hares using Tomahawk collapsible cages, homemade wood cages, including new dismountable wood cages to allow captures away from the Station (model designed and made by Dr. Berteaux), and a throw net. We trapped almost every night from 15 May to 26 July. Although not targeted, some leverets were caught in Tomahawk cages. Upon capture, hares were measured, weighted and ear-tagged using unique 4-color codes (adults) or 2 metal tags (leverets). Tagging will also allow determination of survival, mortality, site fidelity, dispersal and social behaviours.

Movements and space use — We deployed university-made GPS collars and 2 Axy-Trek collars (GPS and accelerometer) to track hares during the summer. 25 Argos satellite collars were also used to follow the movements of adult hares during the rest of the year (**Fig 2.1.1**).

Figure 2.1.1. Adult hare wearing a university-made GPS collar (indicated by arrow on the left picture) and an Argos satellite collar (right picture).

Preliminary results

Monitoring of hares — The four visual counts yielded variable results and indicated a low abundance of hares in the surveyed area (Range = 3-17 adults per count; Mean = 10.2 ± 7.2 adults). We counted juveniles during 3 out of 4 counts (Range = 4-9 leverets per count; Mean = 6.3 ± 2.5 juveniles), but distinction between adults and juveniles became difficult during the last count (3 August). The observation point yielding the highest counts relative to the others was #5, which was the area towards Pusher Shack and Joliffe Bay.

Conversely, a relatively high number of hares were observed further away from the Station. Observations made during trapping activities indicated that hare density was the highest around Kirk Lake and Crystal Mountain in May. Later in the season, hare density and breeding activities were very high in the Joliffe Bay and Pusher Shack areas (this was also apparent from the hare count protocol).

Captures and breeding activities — We captured 35 adult hares (10 males, 25 females). Out of 28 tagged in 2018, two hares (1 male, 1 female) were recaptured this summer and one female was found dead (cause and date of death undetermined). One of the females marked in 2017 (recaptured and breeding in 2018) was resighted at the Station but was predated by wolves 3 days later. The total number of captures, including recaptures, was 49. We also captured and tagged 12 leverets (6 males, 5 females, 1 unchecked).

As already observed in the past years, there seems to be an unbalanced sex ratio in adults, with almost twice as many females captured than males. The sex ratio was however balanced for leverets, indicating that sex ratio unbalance in adults is not due to more females being born than males. Hypotheses explaining the biased adult sex ratio include sex heterogeneity in habitat use, sex differences in trappability, or differential mortality between males and females.

All females were pregnant or lactating upon capture. The first leverets were observed on 23 June (27 June in 2018). We found the nursing spot of 5 females (3 tagged, 2 untagged), with maximum number of leverets observed per litter ranging from 4 to 9 (Mean = 6.6 ±1.9). Overall, the breeding success of hares appeared to be high in 2019.

Movements and space use — University-made GPS collars were deployed on 15 individuals and 9 were recovered (2 males, 7 females). Collars were on individuals during 2 to 25 days (Mean = 10 ± 8.3 days), for a total of 90 hare-days. Axy-Treks were deployed and recovered on 2 individuals (1 male, 1 female), yielding 21 days and 15 days of data. Finally, 25 Argos collars were deployed (4 males and 21 females). As of today (19 Nov), 2 mortalities (1 male, 1 female) have occurred.

The 25 hares fitted with Argos collars have revealed an unsuspected behaviour. We have found that most hares leave Alert to the southwest in September, traveling 100-150 km within a few weeks to reach the Lake Hazen Basin (**Fig. 2.1.2**).

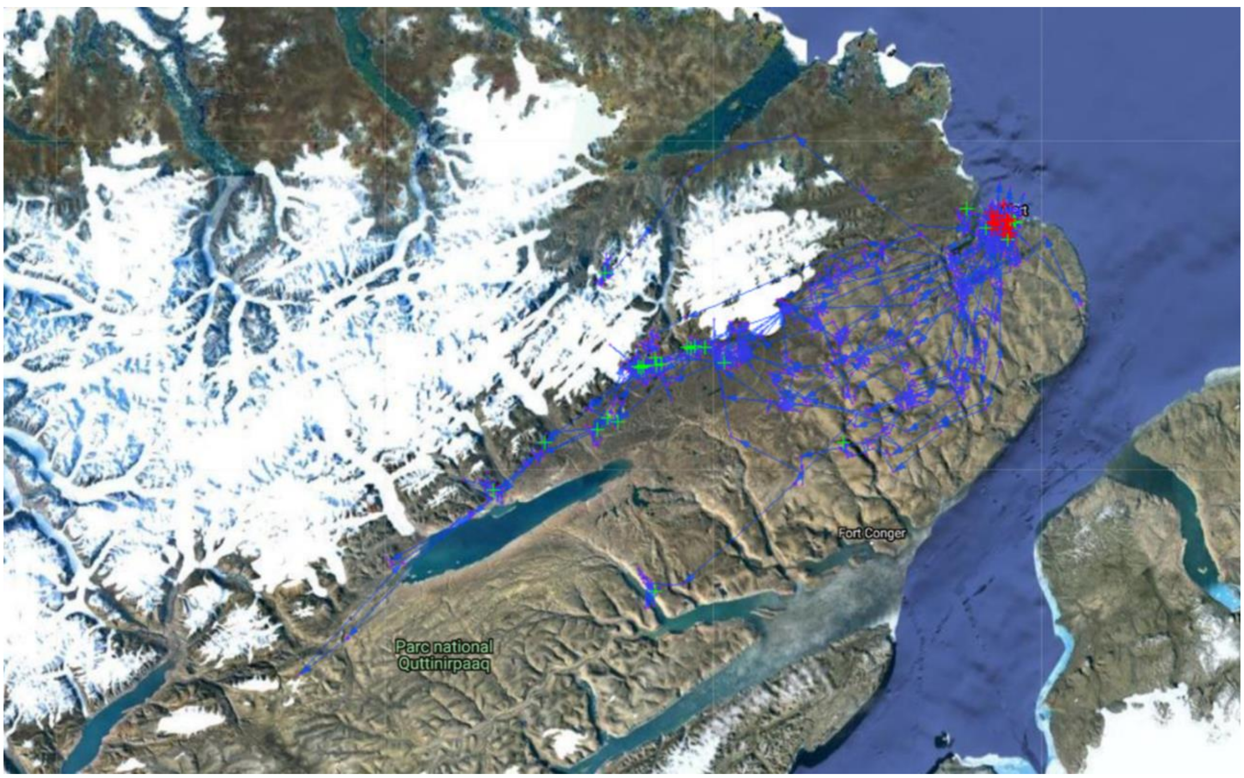


Figure 2.1.2. Map of hare locations in summer 2019 (red crosses) and late October 2019 (green crosses), showing that most of them have moved to the same locations, although through various routes (travel paths in blue).

The Lake Hazen Basin is a polar desert oasis where vegetation is lusher than in the surrounding (**Fig. 2.1.3**), and our hypothesis is that hares spend the winter in this location to benefit from a higher food supply. However, alternative hypotheses should be investigated. For example, it could also be that in winter the local climate is more favourable near Lake Hazen than at Alert, or that predators are fewer or easier to escape. We do not know if these hares will come back to Alert next spring but our hypothesis is that they will do so. Our collars last >1 year and they should thus inform us about this potential northbound spring migration.

Figure 2.1.3. Map of Lake Hazen Basin showing the Normalized Difference Vegetation Index (greener spots indicate a higher plant biomass).

Plans for 2020

We will continue trapping, tagging and performing behavioural observations. We will deploy 30 GPS-Iridium collars to expand the study of hare space and habitat use. These new collars will be more precise than the collars used in 2019, allowing more detailed testing of hypotheses.

2.2 Collared lemmings

Our study of collared lemmings has one main objective: 1) monitoring the relative abundance of lemmings across years and across habitats at Alert.

Goals for 2019

1. To test a new technique (chew cards) to obtain an estimate of lemming abundance in two different habitats;

2. To compare different techniques for estimating lemming abundance.

Field activities

Chew cards — On 15 July, we deployed 240 chew cards on 4 transect lines established within 2 km of CFS Alert in 2018. These cards were deployed during 4 days, for a total of 960 chew card-nights.

Snap traps — On 19 July, we deployed 240 snap traps on the same 4 transect lines used for the chew card experiment. These traps were deployed during 3 days, for a total of 720 snap trap nights.

Preliminary results

Chew cards — Lemming density was very high in 2019, as confirmed through visual observations. In May, we observed many lemming tracks and lemmings resting or traveling near their burrow entrance on top of the snow layer, which is unusual and not understood (**Fig 2.2.1**). This was again observed in September, when the snow cover returned. Yet lemmings did not leave any tooth mark on our chew cards. We conclude that this technique is not suitable to index collared lemming abundance at Alert.

Figure 2.2.1. Lemming standing near its burrow entrance. Several lemming tracks, as well as faeces, can be seen on top of the snow layer.

Although the chew card technique was a failure, we noticed that lemmings often left some urine on our white plastic chew cards. This urine was orange in colour and was thus easy to detect on chew cards (**Fig. 2.2.2**). Therefore we recorded all traces of urine found on chew cards to test whether these signs of lemming presence could serve to index lemming abundance. If they can be used for such a purpose, then the *chew card* technique could be modified into a *pee card* technique.

Figure 2.2.2. Chew card with traces of lemming urine.

Snap traps — We trapped a total of 50 lemmings with the snap traps, a very high number compared to similar sampling at other sites. We conclude that lemming densities were very high at Alert in 2019, as anticipated from visual observations.

A very interesting observation is that, in both habitats, the trapping stations were lemmings were caught seemed to be the same stations where *pee cards* registered some urine traces. Although a quantitative analysis still has to correlate results from snap traps with those from *pee cards*, we are confident *pee cards* will become a valid technique to index lemming abundance.

Plans for 2020
We will abandon chew cards in 2020 but will continue to use both *pee cards* and snap traps, which should allow us to confirm correlations between the two techniques. If such is the case, we will publish the *pee card* technique and gradually abandon the snap trapping.

2.3 Mammalian predators

Our study of mammalian predators has three main objectives: 1) determining which mammalian predators are present in the study area and where; 2) monitoring their reproductive efforts; 3) determining their prey base.

Goals for 2019

1. To record all mammalian predator sightings in the study area;
2. To find and monitor reproductive dens.

Field activities*Predator sightings* — We recorded all mammalian predator sightings (arctic wolf, arctic fox, ermine), including the number of animals (sex if known), the date and the location. We included polar bear sightings, even though they are not terrestrial mammals.

Camera monitoring — We recorded all predators present in the pictures taken by the Reconyx cameras (see section 3.1). Cameras were also placed near two arctic fox dens to obtain data on litter size, presence of adults and prey provisioning.

Preliminary results

Predator sightings and camera monitoring — The main terrestrial arctic predators (arctic wolves, arctic foxes and ermines) were observed by our team this summer.

<u>Arctic wolf</u>

The wolf pack was composed of one female and one male. The female is the same individual from last year (recognizable by the small scar on her muzzle). The male is most probably the alpha male that joined the pack last July. Station personnel indicated that the third individual (presumably the female's offspring from 2017) had been sighted with the two others in spring, but we did not see it. In May, the known wolf den was not used but we noticed the female appeared pregnant. On 8 June, the female was observed still pregnant at the Station and some activity (fresh tracks in the snow) was seen at the den around that time. On 30 June, 3 pups were observed at the den. On 2 July, the whole litter of 6 pups was seen at the den. On 10 August, the wolf pair brought their 6 pups to the Station and they remained there until the end of our field season (21 September). On 20 September, Station personnel reported seeing one pup being eaten by two of its siblings (this was later confirmed by our team). The cause of death was unknown but that pup was reportedly the smallest one in the litter.

In addition to the usual wolf pack, a third lone wolf, described as "big with short greyish hair in the face", was seen at the Station on 25-28 August and 10 September. That individual seriously bit one person from the DRDC team working at the antennas, which led to his evacuation from CFS Alert. This event may have been prompted by the fact that this person and other people from that team had previously fed the wolf with ham sandwiches (as reported later to the SWO). This incident highlights the importance of enforcing strict rules at the Station regarding interactions with wildlife.

<u>Arctic fox</u>

Five active fox dens were found on DND property, in addition to the old den found in 2018. Four fox litters were observed, with one litter using two of the dens we found (**Table 2.3.1**). Litter size ranged from 2 to 11 cubs. We noted a relatively high proportion of foxes of the “blue” color morph, which was believed to be quite rare in Canada. That color morph is however common in Western Greenland, especially at Thule. The “blue” allele (*B*) being dominant over the “white” allele (*w*), blue cubs in a litter indicate that at least one of the parents is a blue fox (homozygote *BB* or heterozygote *Bw*).

Den FOX02 was found very early (5 June) and a camera was placed near the den to monitor activity. The litter emerged on 19 June (11 cubs). The blue male was not seen very often after emergence and may have died since only the female was seen providing the cubs afterwards. This litter was moved on 12 July, 2 days after a wolf visited the den. Another den about 1.5 km away from this den was found on 5 August (FOX04). Due to the proximity to FOX02, that den was most probably the rearing den of this litter. More information on prey provided to pups will be analysed subsequently.

Other fox litters were discovered in August, when cubs were almost independent, and less information is available on these litters. Den FOX03, found on 4 August, had 2 cameras placed for monitoring during one week.

In addition to the adults associated with the dens, as observed last year, one adult fox appeared on Reconyx pictures from Suicide Point and two adult foxes were seen at the Air Strip. One fox was sighted in Alert Creek and another one in West Crystal Mountain Plain. These sightings may indicate that other couples are denning on DND property.

Table 2.3.1. Summary of the activity at arctic fox dens in 2019.

Den	Area	Status	Parents	Cubs
FOX01	Joliffe Bay	Inactive		
FOX02	Kirk Lake	Active	1 white female; 1 blue male	Min. 11 cubs (7 blue + 4 white)
FOX03	Winchester Hills	Active	2 white	4 white cubs
FOX04	Kirk Lake	Active (presumed rearing den of FOX02)	1 white	4 cubs (2 blue + 2 white)
FOX05	East Crystal Mountain Plain	Active	Not seen	1 white + 1 blue
FOX06	Dean Hill	Active	Not seen	2 blue

Ermine

One ermine family was seen in Joliffe Bay (4 pups with their mother). Ermines do not have permanent dens and are therefore harder to track than foxes. Five other sightings of adults were recorded.

Polar bear

Polar bears were seen regularly along the shore (from Joliffe Bay to Mushroom Point) throughout the summer. Our team recorded 6 sightings, including 3 of a mother with 1-2 yearlings. We also recorded 17 sightings from Station personnel during our field season (polar bear alerts announced on the radio or people reporting directly to us).

As of 12 November, we also obtained 18 Polar Bear Sighting Logs from the SWO. These seem to only include sightings which were on Station grounds. For example, several polar bear sightings were reported to us by the Last Ice team when they were going to their offshore ice camp but were not entered in the SWO's Polar Bear Sighting Logs.

Plans for 2020

We will continue to monitor the presence of terrestrial predators. Arctic fox dens will be visited at the beginning of the field season to determine activity and automatic cameras may be used to monitor them.

A high interest was generated from the wolf litter and we suspect the wolf den was visited by Station personnel despite that this is forbidden. Therefore, we will not reveal the location of the arctic fox dens to avoid any disturbance at the dens.

2.4 Caribou and muskoxen

Our study of Peary caribou and muskoxen has 3 main objectives: 1) determining when, where and at what abundance Peary caribou and muskoxen use the study area; 2) locating their preferred habitats; 3) understanding their relations with wolves and humans in the study area.

Goals for 2019

1. To record caribou and muskox sightings in the study area;
2. To test a protocol (transects and observation points) to counts individuals.

Field activities

Caribou and muskox sightings — We recorded all opportunistic caribou and muskox sightings, including the number of animals (sex if known), the date and the location.

Observation points — Using ATVs, we traced and refined 5 routes coupled with observation points for caribou and muskox counts (and also wildlife sightings) that cover a large fraction of the study area.

Preliminary results

Caribou and muskox sightings — Caribou, including fawns (1-2), were observed 6 times in the study area (number of individuals: 1-8) and muskoxen, including calves (3-4), were observed 23 times (number of individuals: 1-15).

Caribou
Caribou were observed along the Gaw Lab road, in front of Crystal Mountain and around Alert Inlet. On 6 June, the Gaw Lab operator (Melody Fraser) reported a fresh caribou leg surrounded by wolf tracks on the road between the Gaw Lab parking and the Gaw Lab. On 15 July, during one the hottest day on record for Alert (21°C), a group of caribou were observed in the water at Self Pond, apparently cooling off. On 12 August, we observed two caribou jumping and swimming in Alert Inlet to escape the alpha wolf that was chasing them.

Muskox
One particular muskox herd (10-12 adults and 3-4 calves) was observed regularly on DND property, mostly east of Pullen Creek and near Crystal Mountain, from mid-July to the end of August. Muskox bulls were observed head-butting around 19-23 August, indicating the onset of the rutting season.

Observation transects — Five observation transects covering 5 areas were determined and tested for counting caribou and muskoxen, as well as other species (**Fig 2.4.1**). We conducted counts along these transects every 2 weeks (5 transects = 1 count), for a total of 4 counts.

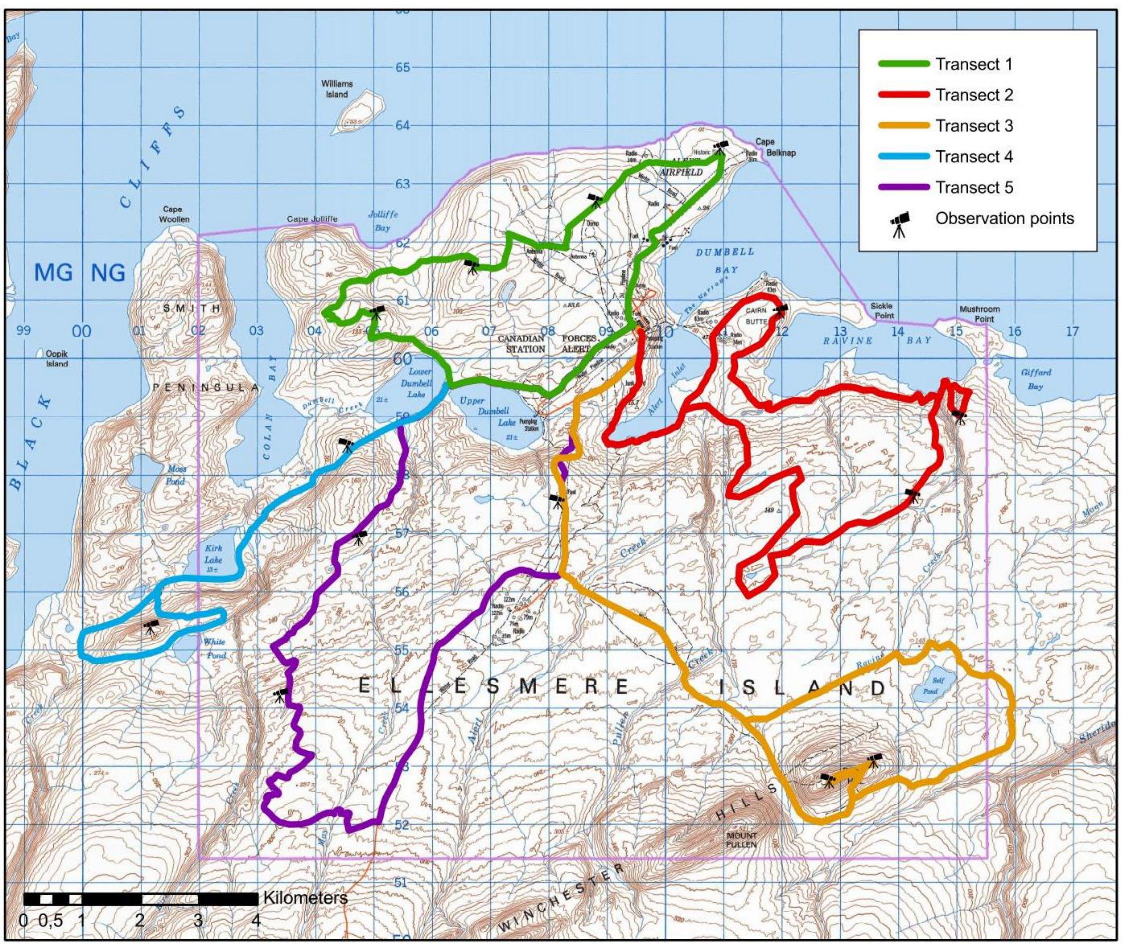


Figure 2.4.1 Five observation transects for wildlife sightings.

We recorded 5 muskox sightings (1 sighting per round of transects and the same herd seen from 2 transects during the 4th count) and no caribou sighting. A total of 22 other species were recorded during the counts. Notably, two arctic fox dens were found while conducting transects.

Plans for 2020

We will continue to monitor the presence of caribou and muskoxen opportunistically and through regular counts from the 5 observation transects. We will evaluate the use of wildlife transects to estimate the relative abundance of other species (birds and mammals) in the 5 areas covered.

2.5 <u>Snow buntings</u>

Our snow bunting studies aim to: 1) understand phenotypic (body and physiological) changes occurring upon arrival to Alert and through to departure, 2) determine whether mildly warm, but rising, environmental temperatures constrain thermoregulation and breeding capacity in these declining cold-specialist songbirds, 3) find their main breeding locations at Alert and 4) determine where is the wintering grounds for the Alert population.

Goals for 2019

1. To determine arrival and departure dates of snow buntings at Alert
2. To complement data collected in previous years on physiological changes (e.g., body condition, cold endurance and heat tolerance) in buntings across the following three life-history stages: (A) arrival and the period preceding breeding, (B) territory defense, (C) nestling provisioning (peak of energy demand at the warmest time of summer)
3. To determine return rates of birds banded on previous years
4. To improve our technique for nest detection
5. To develop catching techniques and evaluate how many juvenile birds can be captured after the breeding season
6. To measure operative temperature and microclimate variation in buntings' habitats and breeding territories

Field activities

Captures and sampling — Snow bunting captures first occurred on 18 May and finished on 19 August. Early captures were made around the sewage outfall on birds noticeably still in winter flock formation. Birds were later captured defending breeding territories that were scattered across the tundra. Then, breeding individuals were captured while feeding nestlings. We also collected blood samples for additional analyses pertaining to a genomics project in collaboration with Dr. Oliver Love from the University of Windsor. This project seeks to determine, through DNA, the genetic divergence of 9 bunting populations distributed across their circumpolar breeding range.

Preliminary results
Monitoring of snow buntings — The first snow buntings were reported by Alert personnel on 30 April, 6 days later than 2018 (24 April). The last group of buntings was observed by our team on 9 September, after the first snow fall permanent snow cover.

Captures and sampling — From our experience, birds are typically observed in flocks throughout May and can be captured in large numbers by mid May to early June as they aggregate around the station (note that this also coincides with the arrival of our team in previous years). However, 2019 has been very different from our previous experience, likely due to warmer spring conditions and early snow melt, which advanced breeding activities considerably.

While we typically capture >100 individuals in late May and early June, only 5 birds were caught during this period in 2019 (18 May to 20 May) as buntings scattered in the tundra early. 26 birds were caught during territory defence with the first capture occurring on 23 May (12 days earlier than 2018) and the last on 22 June. Egg laying is estimated to have begun around 24 June. 8 nests were found this year (**Fig 2.5.1**) and 9 birds were caught during nestling provisioning (5 July to 22 July). All captured birds were temporarily brought back to the laboratory for data collection on body condition (i.e. body mass, visual fat scores and ultrasound measurements of flight muscle thickness) and metabolic performance (i.e., cold endurance and heat tolerance). This data will complete datasets used by MSc J. Drolet and PhD A. Le Pogam.

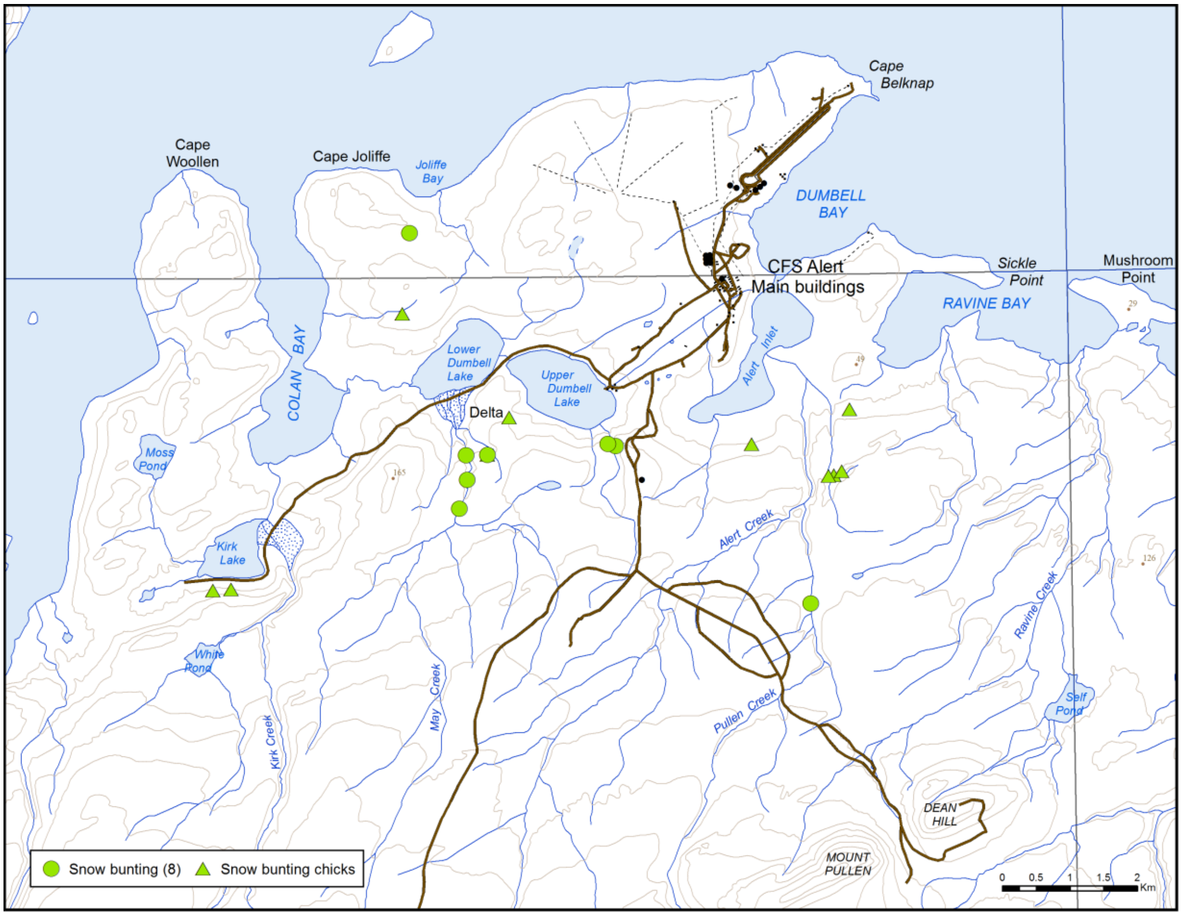


Figure 2.5.1. Locations of snow bunting nests and sightings of fledged juveniles in 2019.

The 2019 season confirmed that we can easily capture juvenile snow buntings later in the season, before their departure. This is important because no studies have examined this life stage, most likely because other research teams are not staying that late on Arctic field sites. 19 juvenile buntings were captured between 23 July and 18 August.

In total, 59 snow buntings were caught in 2019 and, since 2015, 346 birds have been captured and banded at Alert. 40 blood samples were collected in 2019 for DNA analysis.

Return rates and nest detection — Most recaptures of buntings occur within year, during the spring period when birds come to our feeders and seed patches. Within-year recaptures can be quite high (up to 40 in 2017) but, since birds spread early on the tundra, our team made only 4 recaptures in 2019. It is currently unknown whether the first birds arriving at Alert in late April and May stay in the area or continue on their migration. Birds captured at that period have rarely been seen later on breeding territories, but they could also simply scatter on a wider area than what our team has been able to monitor. Without tracking data, we cannot determine where these birds originate or where they are going.

At first sight, inter-annual return rates appear to be low for Alert buntings. So far, only 3 birds captured in previous years have been recaptured in subsequent years (2 in 2019, including one recaptured in both 2017 and 2018). However, studies conducted at other sites show that about 1/3 of birds captured at their nests can be found breeding in following years and so far our sample of individuals captured while feeding nestlings is only 23. This is in part due to lack of time for searching for nests (e.g. priority to laboratory measures in previous years or other logistical constraints such as fuel rationing in 2019). Establishing return rates for birds actively breeding at Alert is crucial to evaluate our capacity to track migration as there are currently no satellite devices small enough to be carried by these declining birds. Current techniques require the use of data loggers, which must be retrieved in subsequent years to download data.

Operative temperature and microclimate variation – Preliminary analyses from the 2019 field season reveal that the operative temperatures (i.e., air temperature corrected for heat exchange due to radiation, wind and the physical properties of the animal, measured with 3-D printed buntings) snow buntings experience in the wild can significantly differ from air temperatures recorded at a standardized weather station (**Fig. 2.5.2**). This difference varies greatly depending on time of day (i.e. operative temperature is much higher during the day relative to that of air compared to the night, despite 24h daylight). Additionally, analyses show that operative temperatures recorded over the same temporal period but from separate sites exhibit fine spatial variation (**Fig. 2.5.2**). These findings suggest that individual birds can experience different energetic demands on the same day depending on their territory.

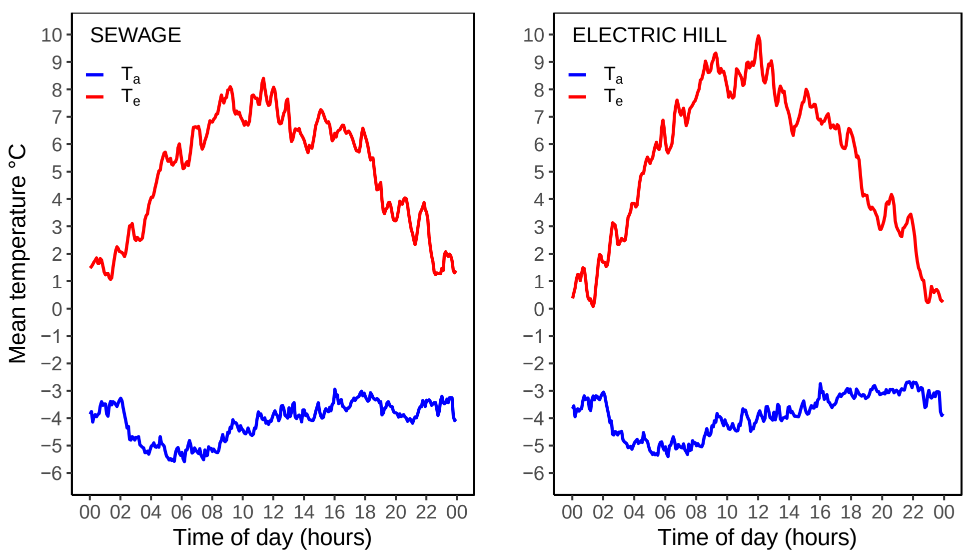


Figure 2.5.2. Mean operative (T_e) and air (T_a) temperatures recorded over the period from 22-29 May 2019 at two separate sites. T_e was recorded using 3-D printed snow bunting models and T_a was derived from a nearby weather station. Data represent average values for each 5-minute time stamp. The higher T_e values result from the input of solar radiation on the 3-D printed snow bunting models.

Moreover, within the same territory snow buntings can experience varying operative temperatures depending on whether they occupy highly reflective snow-covered ground or dry ground (**Fig. 2.5.3**). These data further emphasize how spatially fine microclimates can be and even within a breeding territory. The full data set for 2019 is currently being processed.

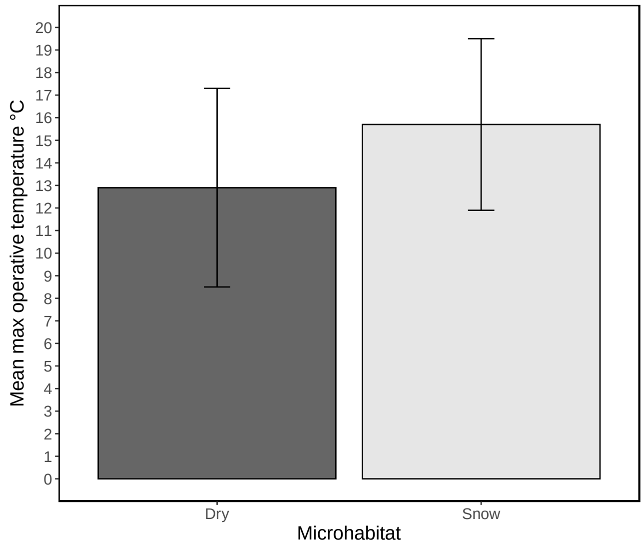


Figure 2.5.3. Daily mean maximum operative temperatures measured over the period from 22-29 May 2019. Data from the sewage and electric hill sites were combined and separated based on whether data were collected on dry ground or snow-covered ground. The daily maximum operative temperature values were higher on snow-covered ground due to the increased reflection of solar radiation. Error bars represent standard deviation.

Plans for 2020

In 2018, MSc student Justine Drolet collected essential data (completed in 2019) to establish thermal tolerance limits in snow buntings. From her data (**Table 2.5.1**) we were able to estimate the temperature at which birds would be expected to risk overheating due to periods of sustained exercise (e.g., when provisioning nestlings). However, it is currently unknown if, and by how much, these thresholds vary among years (2019 data being processed).

Table 2.5.1. Estimated temperature threshold for overheating in snow buntings

Period	Estimated temperature threshold for overheating in birds maintaining constant exercise
Arrival	10.37°C
Territory defense	13.62°C
Breeding	15.65°C

In 2020, we will translate laboratory measurements (2018 and 2019 data) into predictions based on operative temperature data collected in the field. Specifically, we will integrate operative temperatures measured within nesting territories (3-D model birds, Kestrel data loggers) with thermal tolerance limits to determine whether snow buntings have to lower reproductive effort (and success) to avoid overheating when operative temperatures approach or exceed their thermal limits. We will use radio frequency identification systems with an antenna placed at the entrance of each nest cavity (tested successfully at Alert in 2019), to obtain provisioning rates and body temperature patterns of adults. Body temperature will be measured using temperature-sensitive passive integrated transponder tags under the skin of birds. This is a crucial step towards understanding how increasing temperatures from climate change may impact the reproductive success and overall fitness of this severely declining cold-specialist.

2.6 Red knots and Ruddy turnstones

Our study of shorebirds has four main objectives: 1) monitoring the condition on arrival and before departure of the two most common species, ruddy turnstones (*Arenaria interpres*) and special concern red knots (*Calidris Canutus*); 2) finding and monitoring the most commonly used shorebirds breeding habitats; 3) monitoring shorebirds breeding success; 4) estimating survival from return rate of banded birds.

Goals for 2019

1. To capture, band and obtain condition (health) data for shorebirds on arrival (at and around the sewage outfall);
2. To test new capture techniques for red knots at and around the sewage outfall;
3. To determine the proportion of birds banded on arrival or before that breeds at Alert;
4. To improve monitoring protocols for determining breeding success of shorebird nests;
5. To determine whether shorebirds can be captured before departure, at the end of summer at and around the sewage outfall;
6. To monitor sightings of Alert bird in winter in prevision of deployment of ICARUS tags.

Field activities

Captures and nest monitoring — This year, snow melt was already underway at the time of shorebirds arrival and the birds did not congregate at the sewage as they have in previous years. We searched for nests at several sites by foot and opportunistically on ATV while on established trails (along Alert Bay, Dumbell Lakes delta, Joliffe Bay, Kirk Lake, Crystal Mountain area, Suicide Point area). We collected field sightings of adult birds with chicks recording their locations and activities. We caught several ruddy turnstones around the sewage outfall in early September.

Preliminary results

Arrival period – The first shorebirds were observed at Alert around the quarry and sewage on 25 May and the first captures happened on 2 June. While we typically capture >100 birds in the first 2 weeks following the arrival of first individuals, this year the birds spread on the tundra immediately on arrival, likely due to the early snowmelt, and much fewer birds congregated at the sewage outfall in comparison to previous years. In fact, this was an unprecedented event never observed by R.I.G. Morrison. Consequently, we were only able to capture and band 2 ruddy turnstones and 1 red knot in potter traps from 2 June to 4 June. Given the low numbers and birds spending limited time at the sewage outfall, we were unable to test alternative capture methods during this period.

Breeding period – We conducted searches from June 10 through the month of July. Systematic search efforts for shorebird nests were generally unsuccessful and most nests were found opportunistically (but note that movements were also limited during this period by fuel rationing). We found 6 ruddy turnstone nests, 3 red knot nests (**Figure 2.6.1**). None of these individuals were banded. Tracking breeding success for those nests proved difficult due to lack of time and fuel rationing (**Table 2.6.1**). We observed several juvenile birds foraging with adults later in the season (**Figure 2.6.1**).

Table 2.6.1. Red knots and ruddy turnstone nests in 2019 and their observed breeding success.

Species	Number of nests	Success
Red knot	3	2 hatched; 1 unknown
Ruddy turnstone	6	3 hatched; 3 unknown

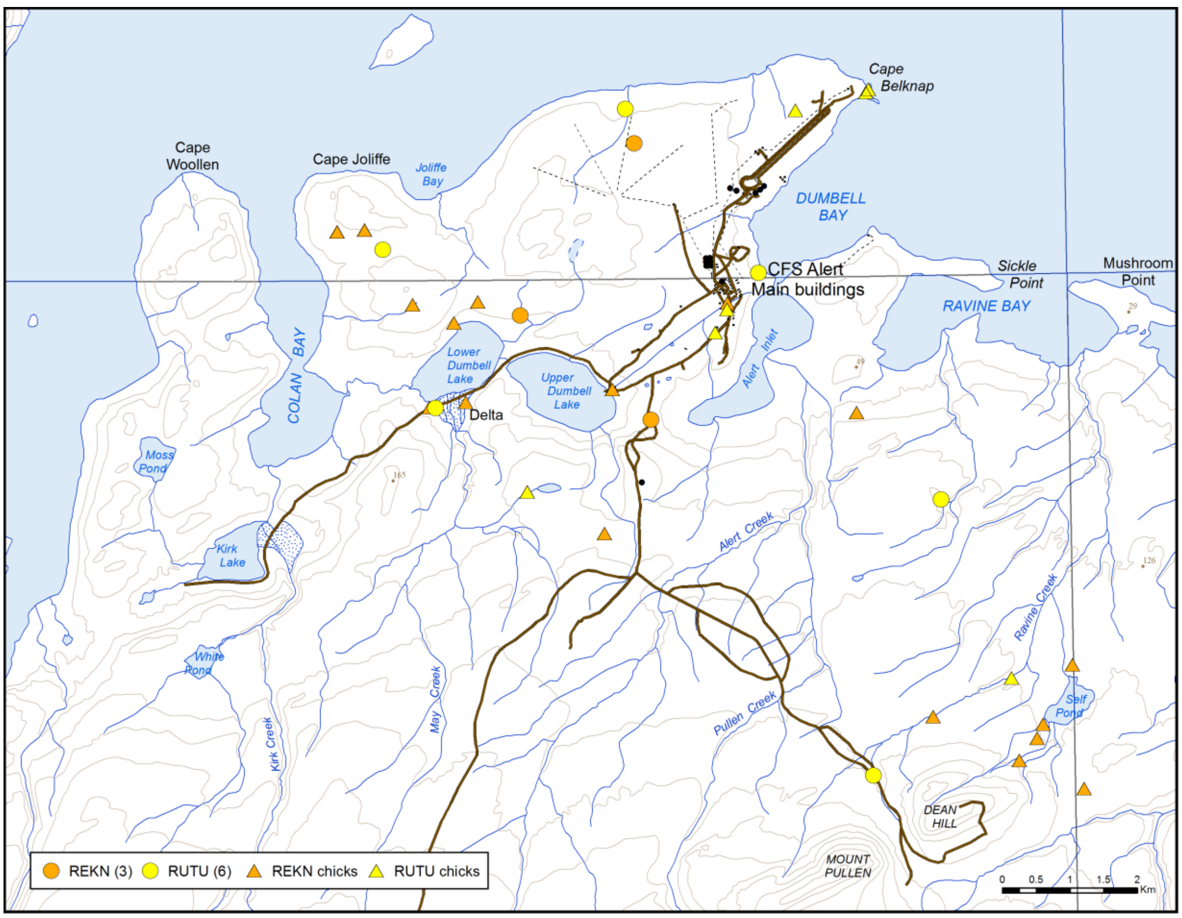


Figure 2.6.1. Locations of red knot (REKN) and ruddy turnstone (RUTU) nests and sightings of fledged juveniles in 2019.

Pre-departure period – We caught and banded 102 ruddy turnstones and recaptured 16 of those individuals during the pre-departure period from 29 July to 1 September. Adults were abundant in the sewage outfall area in late July and early August with most having left after the first week of August. Juveniles remained in the sewage outfall area in declining numbers into the first week of September, after which the sewage became snow covered. During this period, we confirmed that we can catch large numbers of juvenile turnstones fueling for their first migration. This is due to the construction and testing of a large funnel trap that produced the majority of captures in mid-late August.

Preliminary analyses of the data indicate that juvenile ruddy turnstones caught later have larger pectoral muscles (**Figure 2.6.2**) and are structurally smaller (**Figure 2.6.3**) than birds caught earlier during the pre-departure period. The apparent growth of flight muscles could reflect a preparation for the upcoming long distance flight, the result of increasing shivering with cooling temperatures in the fall, or some combination of these. Additionally, larger pectoral muscles in structurally small turnstones later in the fall may indicate that late born birds may have to trade off growth for increased muscle size to cope with migration preparation in the cold.

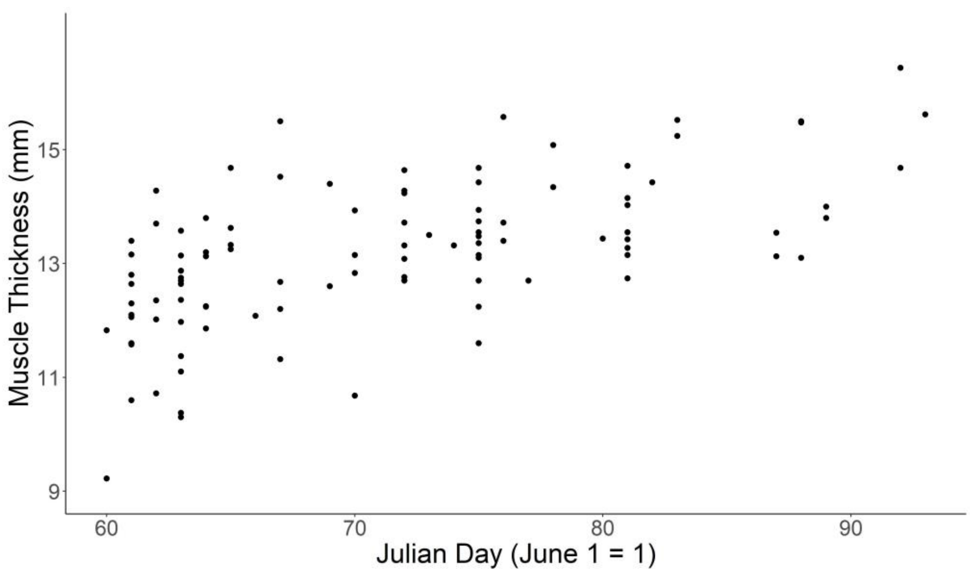


Figure 2.6.2. Pectoral muscle thickness of ruddy turnstones captured between 29 July and 1 September measured by ultrasonography. Birds caught later in the season had larger pectoral muscles than individuals caught earlier in the season.

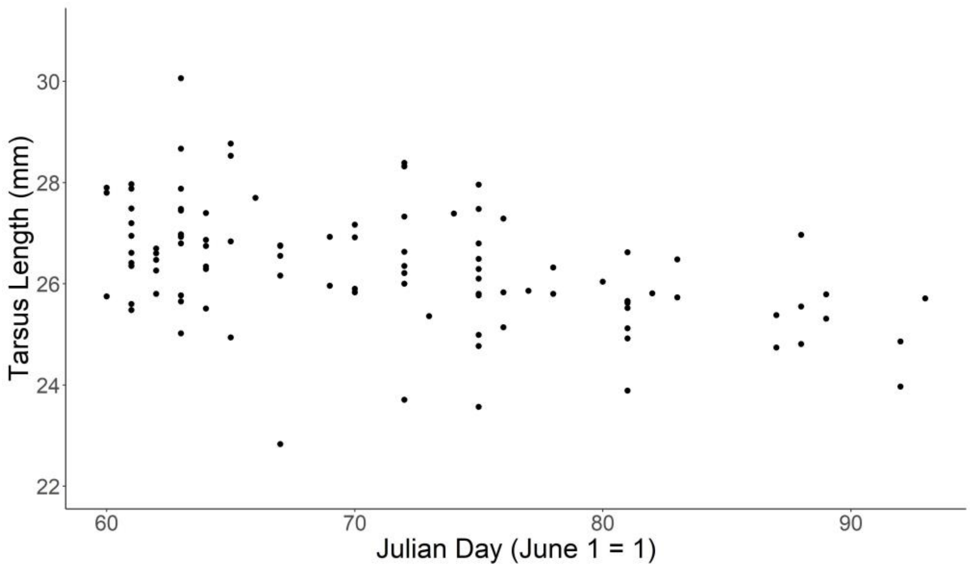


Figure 2.6.3. Tarsus length of ruddy turnstones captured between 29 July and 1 September. Birds caught later in the fall had shorter tarsi than individuals caught earlier in the fall, indicating smaller skeletal size.

Red knots were rarely present in the sewage outfall area during pre-departure in 2019 but were observed in late July and early August feeding in mixed flocks with ruddy turnstones around the Dumbell Lakes and other areas. Consequently, we were unable to capture red knots during this period in the sewage outfall area.

Sightings of Alert shorebirds during winter – So far we have received reports of 15 sightings of shorebirds from observers in Europe (capturing, noting or photographing bird flag numbers), including 14 turnstones and 1 red knot (but only 6 knots were released with a flag since 2015). 13 of these observations (87%) where made at or below 55°N, the northernmost latitude monitored by the ICARUS system. This confirms that deploying ICARUS tags on Alert shorebirds should allow us to monitor location of birds throughout winter.

Plans for 2020

Our objectives for 2020 will be to continue to improve the monitoring of shorebirds in part by launching a 2 new PhD projects (Kevin Young, and switch to PhD for Émilie Desjardins). Nest searches will be integrated into a random or semi-random protocol and nest monitoring will be shared among all team members to improve efficiency.

We aim to reproduce the success of our capture efforts from the fall of 2019 in the spring and fall of 2020, using the new funnel trap, to study the arrival and departure periods of shorebirds in Alert. These understudied periods are critical because physiological condition is likely to affect the capacity of these animals to reproduce and migrate. This will involve short-term experiments in our laboratory on physiological changes, metabolic and performance adjustments and response to various diets.

We are planning to test a new generation of GPS tags on shorebirds (including SAR Red knot) departing alert in 2020. ICARUS tags are monitored by the International Space Station. As the ISS is not flying over Alert, these tags would remain passive (non emitting) while at Alert and begin emitting data only once the birds reach a latitude monitored by the ISS (~55°N). On their return in 2021, we should be able to track birds in the field, using handheld receivers. This work will be conducted in collaboration with Dr. Chis Guglielmo of the University of Western Ontario.

Given that juvenile turnstones can be captured at the end of summer before their first migration in life, these individuals could potentially be used as models to monitor for contaminants in blood and feathers. Their level of contamination (if any) would be reflecting the Alert site as these birds would not have been exposed to any other contaminant in life.

2.7 Other bird species

Our study of other bird species has three main objectives: 1) monitoring the bird species observed at Alert; 2) determining which species breed on DND property (other than snow buntings, red knots and ruddy turnstones); 3) monitoring breeding success of observed nests.

Goals for 2019
1. Generate a list of species;
2. Position nests on a map to gather data on the location of species best breeding habitats;
3. Monitor breeding success (hatching) of all nests found.

Field activities
Visual observations — All team members reported their bird observations.

Nest monitoring — All nests discovered on DND property have been geo-located by GPS. When possible, nests have been monitored at least a second time to determine hatching success (at least one egg hatched).

Preliminary results
Visual observations — In total, 22 avian species have been observed at Alert during the season 2019, as listed below:

Rock ptarmigan	Common ringed plover	Long-tailed duck
Glaucous gull	Baird's sandpiper	Long-tailed jaeger
Thayer's gull	Red phalarope	Common raven
Sabine's gull	Snow bunting	Snowy owl
Arctic tern	Lapland longspur	Gyrfalcon
Red knot (Special Concern)	Brant goose	Red-throated loon
Ruddy turnstone	Snow goose	
Sanderling	King eider	

It is worth mentioning the presence of a higher than usual number of snowy owls (including breeders), common ravens and gyrfalcons this summer. The ivory gull (Special Concern) was not observed this summer.

Nest monitoring — The nests of 8 avian species (other than snow buntings, red knots and ruddy turnstones) have been found during the 2019 season (**Fig 2.7.1**; **Table 2.7.1**). In addition, we observed several families (adults with young) or juveniles alone (**Fig 2.7.2**; **Table 2.7.2**). Notably, juveniles of lapland longspurs, red phalaropes, Thayer's gulls and gyrfalcons have been seen for the first time at Alert this summer. For these species, actual nesting on DND property remains to be confirmed but is very possible.

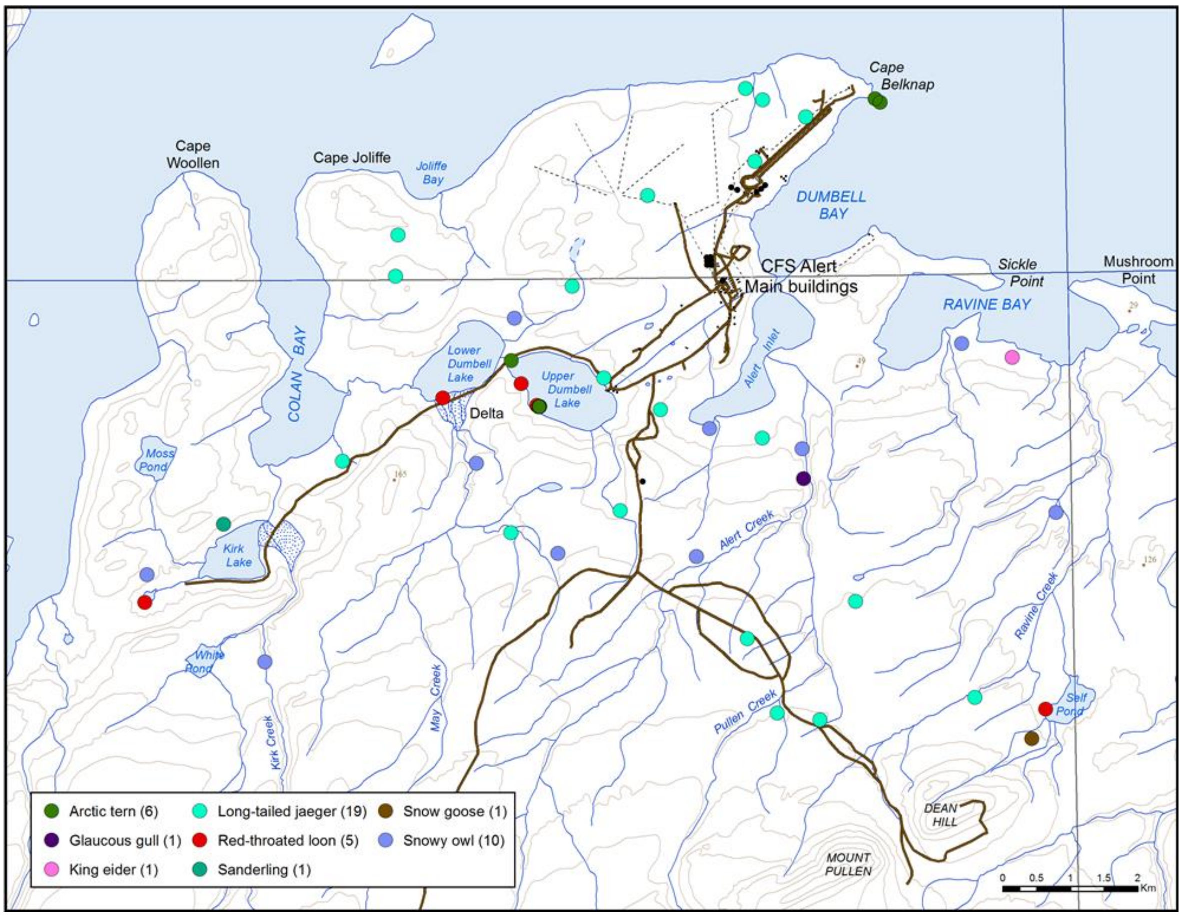


Figure 2.7.1. Locations of nests of other bird species found by our team in 2019.

Table 2.7.1. Species for which nests were found in 2019 and their observed breeding success.

Species	Number of nests	Location of nests	Success
Long-tailed jaeger*	19	Various locations	13 hatched; 3 probably hatched (chicks not seen but adults defending); 3 unknown

Red-throated loon*	5	Upper Dumbell Lake, Tern island, Lower Dumbell Lake, Pond O, Self Pond	3 hatched; 2 unknown
King eider	1	Alert Inlet	Hatched (5 of 6 eggs hatched)
Snow goose	1	Self Pond	Hatched (2 of 3 eggs hatched)
Arctic tern*	6	Beacon road (2); Tern island (3); Upper Dumbell Lake (1)	6 hatched
Glaucous gull	1	Pullen creek	Hatched (3 nestlings)
Snowy owl	10	Various locations	1 nest failed (or was relocated); 1 predated by wolves; 3 hatched; 5 were already hatched when found Mean clutch size: 5.5; Range: 3-9
Sanderling	1	Kirk Lake	Unknown

** Long-tailed jaegers, red-throated loons and arctic terns only lay 2 eggs.*

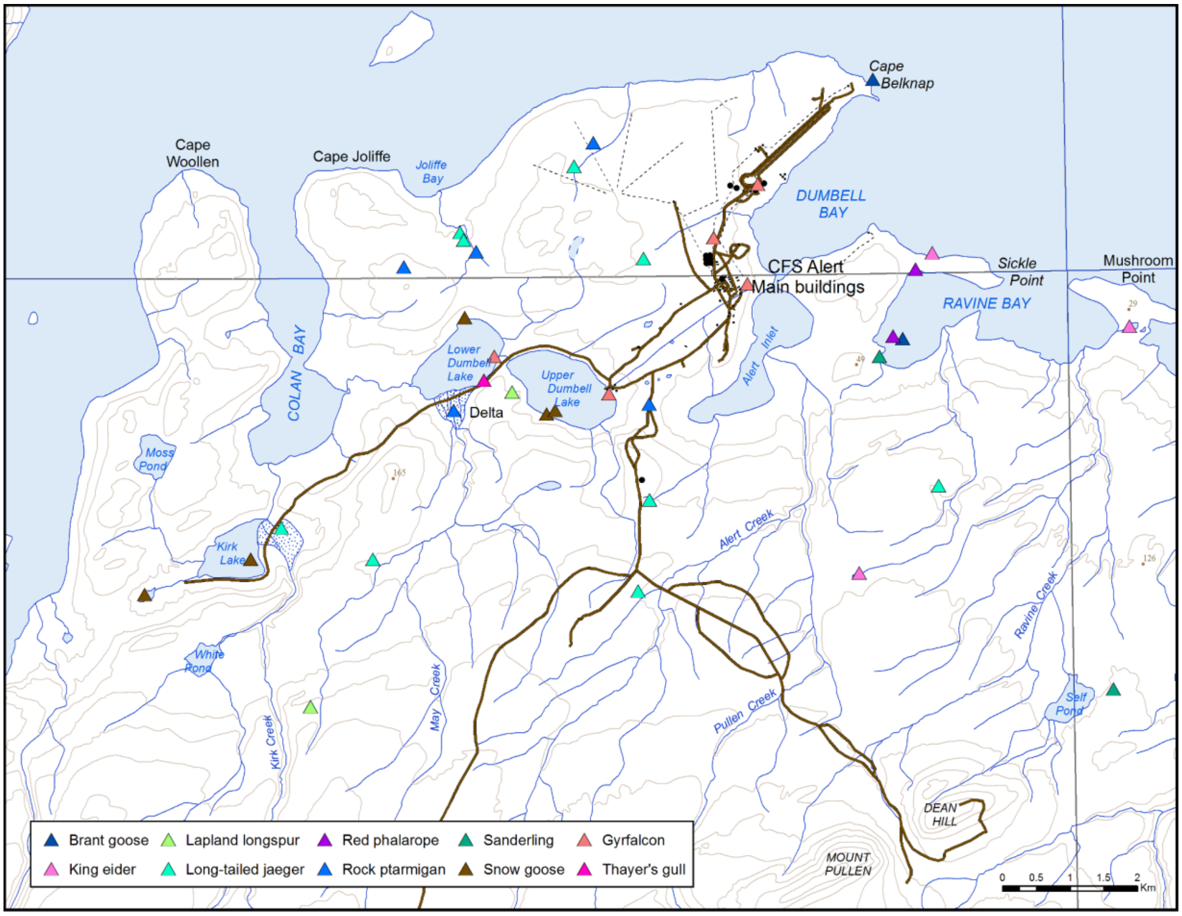


Figure 2.7.2. Locations of fledged juveniles of other bird species observed by our team in 2019.

Table 2.7.2. Families or juveniles observed in 2019.

Species	**Number of observations**	**Location of clutches**	**Number of juveniles**
Long tailed-Jaeger	10	Various locations	Mean clutch size: 1.4 Range: 1-2
Rock ptarmigan	5	Joliffe Bay (2, possibly same clutch); Delta (1); Pusher Shack (1); Suicide Point (1)	Mean clutch size: 9.4 Range: 8-11
Brant goose	2	Cape Belknap (6 families); Ravine Bay (2 families)	Mean clutch size: 3.9 Range: 3-5
King eider	3	Ravine Bay (1 family); Mushroom Point (3 families); Pond W (1 family)	Mean clutch size: 3.4 Range: 1-6
Snow goose	6	Lower Dumbell Lake (1 family); Upper Dumbell Lake (1 family; 1 group); Kirk Lake (6-7 families, seen 2 times); Pond O (1 family)	Mean clutch size: 3.2 Range: 1-7 *Clutch size is difficult to estimate when

			several families are together
Lapland longspur (juveniles)	2	Kirk Creek (1); Delta hills (1)	Total number : 2
Red phalarope (juveniles)	2	Ravine Bay (5; Group of 15-20)	Total number: 20-25
Sanderling (juveniles)	2	Ravine Bay (13), Alert Creek (1)	Total number: 14
Iceland gull (Thayer's subspecies)	1	Lower Dumbell Lake (2)	Total number: 2
Gyrfalcon	8	Station, Dumbell Lakes	Total number: at least 3

Plans for 2020

Nests were found opportunistically and were scattered over the study area, which complicated their monitoring and led to uncertainty regarding the fate of some nests. We will evaluate the use of permanent transects to search systematically for nest of species that breed at high densities in years of abundant resources, such as jaegers. This will allow for the close monitoring of nests of target species.

2.8 Arthropods

Our study of arthropods has for main objective to obtain data on arthropod phenology and abundance as this is the main food source for several bird species during breeding, including snow buntings and shorebirds.

Goals for 2019

1. To install two arthropod monitoring stations representative of a wet and dry environment;
2. To test a monitoring protocol commonly used at other sites for comparison purpose.

Field activities

Monitoring of arthropods — Two monitoring stations were installed in the study area. Each of them had 5 arthropod traps placed 10 meters away from each other (for a 40 m total transect). One station was installed on the plateau south of the Station in a xeric habitat (82° 28,182' N, 62° 25,836' W). The other station was installed within 1 km of the xeric site in a humid habitat (82° 28,153' N, 62° 23,583' W) (**Figure 2.8.1**). Traps were installed on 18 June in both the xeric and humid areas. Traps were emptied every second day at approximately the same time in late afternoon or at night.

Samples were brought back to the lab and prepared for future analyses and long-term storage in glass vials.

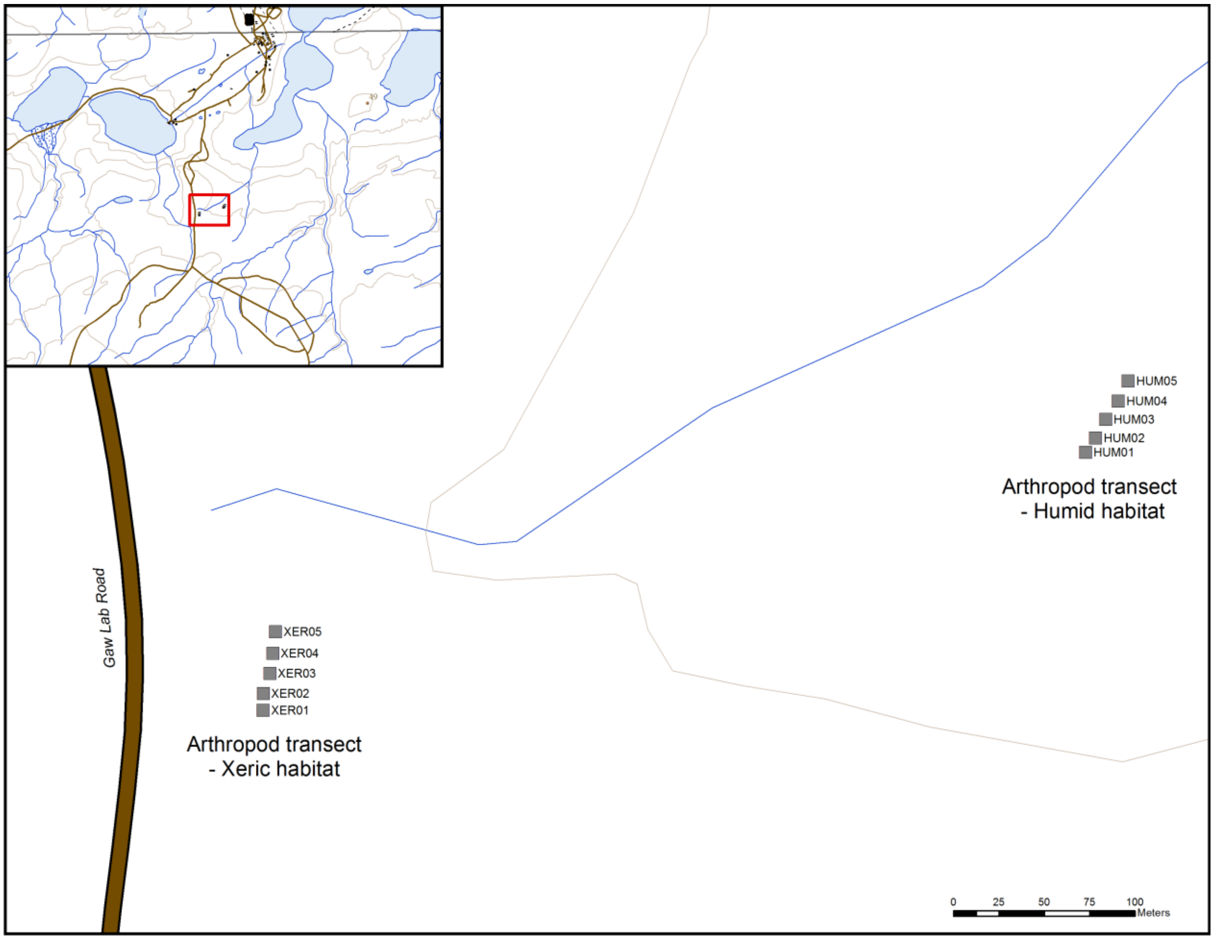


Fig 2.8.1. Position of xeric and humid arthropod monitoring stations

Preliminary results

Monitoring of arthropods — In total, we had 36 harvests for the xeric traps and 36 harvests for the humid traps. These samples are currently being processed.

Plans for 2020

We will continue monitoring arthropod phenology in 2020.

3. Ecosystem monitoring

3.1 Monitoring of wildlife: Cameras and sightings

Our wildlife monitoring has three main objectives: 1) monitoring the diversity and abundance of vertebrates present in the study area; 2) documenting the timing of their presence; 3) locating their preferred habitats.

Goals for 2019
1. To record wildlife sightings, including the number of animals, the date and the geographic area;
2. To identify areas that may represent biodiversity hotspots to monitor.

Field activities
Camera monitoring — The sewage is highly used by animals. We placed four Reconyx cameras on permanent metal stakes at the sewage (**Fig 3.1.1**). These cameras were motion-triggered and collected data from 10 May to 9 September. One camera was left to take pictures during winter.

We also placed Reconyx cameras to monitor shorebird and waterfowl activity at ponds and in locations that may be visited by wildlife (**Fig 3.1.2**):
- Met Shack pond (3 cameras)
- Lake Road pond
- Pond G
- Pond P
- Pond W
- Pond X
- Pond Q
- Delta canyon
- Suicide Point
- around Dean Hill (Crystal Mountain, 3 locations)

In addition to the one camera left at the sewage, we placed Reconyx cameras at 6 other locations to monitor wildlife presence during winter (**Fig 3.1.2**):
- Memorial road (pointing towards the sea in a North-West direction)
- Delta (Lower Dumbell Lake)
- Pusher Shack
- Quarry
- Beacon road
- Suicide Point

Figure 3.1.1. Reconyx cameras placed at the sewage.

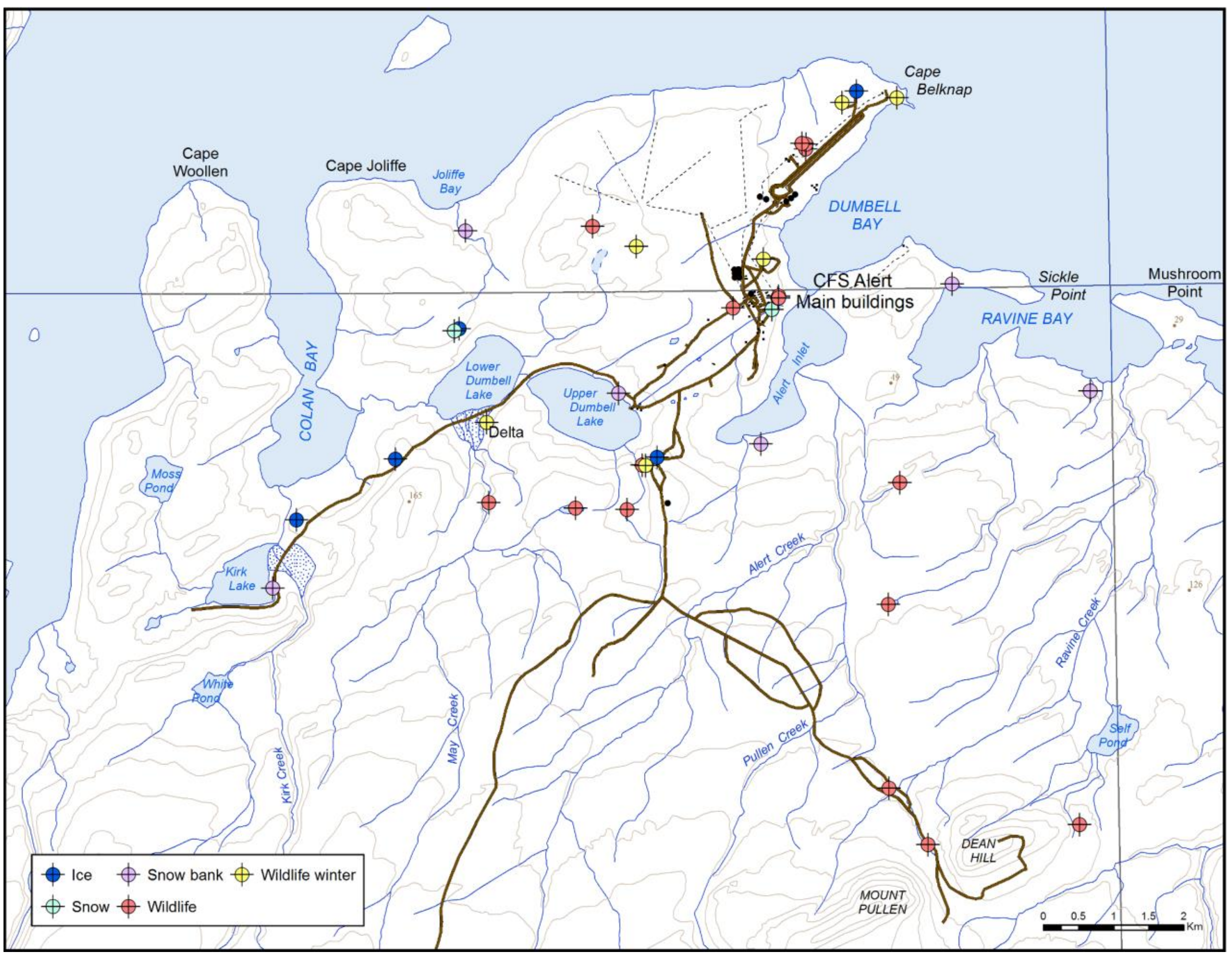


Figure 3.1.2. Location of Reconyx cameras placed in the study area for monitoring snow cover (3), ice cover (5), snow bank melting (6), wildlife presence in summer (17) and winter (7).

Daily observations — Incidental observations were noted as described in the Daily observations protocol (see p. 54-55 in the Alert Wildlife Research Protocol).

Participative science — We encouraged people at the Station to report their wildlife sightings to us using data sheets pinned on the common board.

Preliminary results

Camera monitoring — The cameras at the sewage took > 92K pictures between 10 May and 9 September. In contrast to previous years, shorebirds and jaegers were present in much lower numbers in the spring at the sewage. This low occurrence of birds is unprecedented (never observed by R.I.G Morrison in the past) and likely the result of early snow melt, offering access to breeding areas to freshly arriving birds. Pictures are currently being processed.

Other cameras worked well. We encountered a few problems with animals in some areas. They were interested in the cameras and knocked over a few of them (**Fig 3.1.3**).

Figure 3.1.3. Examples of pictures taken by Reconyx cameras that were found displaced.

Daily observations — Interesting results were reported in previous sections.

Participative science — CFS Alert personnel reported 75 wildlife observations on data sheets, including valuable observations of uncommon species and juveniles. Some of these observations allowed us to focus our efforts in specific areas. Note that personnel also regularly reported sightings verbally to team members. Those are also archived as much as possible.

Plans for 2020

Data from 2018 confirmed that Reconyx cameras at the sewage are useful to monitor arrival of birds, and timing of activity (e.g. night vs day time). 2019 data from the other cameras will help us select relevant locations to install cameras again next summer. We will try to devise a way to anchor and make the cameras less conspicuous to animals to prevent damage by wildlife.

Daily observations and participative science will continue as in 2019.

3.2 Monitoring of herbivory: Herbivore turd transects

The herbivore turd transects have one main objective: 1) determining herbivore presence and abundance based on faeces counts in different habitats.

Goals for 2019

1. To repeat faeces counts in the herbivore turd transects started in 2017;
2. To add more turd transects

Field activities

Herbivore turd transects — We repeated the counts in the 6 herbivore turd transects placed in summer 2017. We added 4 new transects in some xeric and humid habitats.

Preliminary results

Herbivore turd transects — We confirmed the results from 2018. In short, most turd transects accumulated some fresh faeces during the preceding 12 months. Humid habitats accumulated more faeces than xeric habitats, and most faeces were from arctic hares. This confirms that 1- turd transects accumulate enough faeces during 12 months to provide an index of habitat use by herbivores, 2- habitats differ in how much they are used by herbivores, 3- in 2018-2019, arctic hares were the main herbivores grazing in the habitats covered by our turd transects.

Plans for 2020

We will revisit the 14 turd transects now in place and will decide, after analyzing our data from 2017-2019, what is the best long-term sampling strategy to monitor herbivore abundance at Alert based on turd transects.

3.3 Monitoring of predation: Artificial nests

The artificial nest experiment has two main objectives: 1) estimating predation pressure on ground-nesting birds at CFS Alert; 2) comparing the predation pressure between Alert and other Arctic sites.

Goals for 2019

1. To conduct the artificial nest experiment during the early and late incubation periods.

Field activities

Artificial nest experiment — We randomly placed 50 artificial nests (4 quail eggs; 25 nests covered with vegetation and 25 uncovered) from the start of Caribou Road to the end of Beacon Road. The experiment was started on 25 June during the early incubation period (check at 48h and 96h) and on 11 July during the late incubation period (checks at 48h and 96h).

Preliminary results

Artificial nest experiment — No nest was predated during the early incubation period and again no nest was predated during the late incubation period. This suggests a low predation pressure on bird nests at CFS Alert.

Plans for 2020

We will conduct the artificial nest experiments again next year.

3.4 Monitoring of human activities

Measuring the extent of habitat destruction and disturbance of wildlife by the station personnel is critical to make management recommendations. Bandvagn 206 ("BV" below) can damage wet habitats during the snow-free period. Hence, in summer 2019, we used GPS trackers to record the movement paths of BVs.

Goals for 2019

1. To record the tracks of all the BVs used on the DND property during all summer, when the vegetation is exposed.

Field activities

We installed I-Got-U tracking loggers on 5 BVs used during the summer (from 10 July to 7 September). GPS localisations were recorded every 2-5 minutes. Every week, the I-Got-U loggers were recovered to be charged and to download the data. They were then placed back on the BVs. This was done during the night when the BVs were not used.

Preliminary results

We got the GPS locations every 2-5 minutes on the 5 BVs during 9 weeks of utilization. From these data, we traced a line between each consecutive point to get the tracks (**Fig. 3.4.1**).


Figure 3.4.1. Tracks of the 5 Bandvagn 2016 used from 10 July to 7 September 2019.

Plans for 2020

We will repeat the same protocol in 2020, but we will begin recording GPS movements earlier in the summer (beginning of June). We will then combine those GPS tracks with vegetation maps to identify affected areas and make recommendations to protect wetlands important for wildlife.

Conclusions

Despite 2019 being only the second year of biodiversity monitoring at Alert, we can surely say that great progress has been made since the launch of the project and that this field season has been a success. Our work was marked by several advancements in research protocols and capture techniques, and allowed to identify refinements to adopt for 2020, in the science but also in the logistics and in our collaboration with station personnel.

The project grew substantially via the support provided by the Department of National Defence (8 Wing Trenton Environmental Management) and CFS Alert personnel, and through the strengthening of a partnership with Defense Research and Development Canada (DRDC) for logistical aspects (fuel and storage room for ATVs, snowmobile access) and through our continuing collaboration with Environment and Climate Change Canada (fine temporal scale weather data from Alert station and Gaw Lab, access to a truck for specific types of work). While this was profitable for the project, it was above all greatly beneficial for developing collaborative skills in students that are training to become accomplished field biologists.

The 2019 field season was marked by warmer temperatures than usual, breaking an all-time record for Alert on 14 July (21°C). The warm spring presumably led to an unprecedented scattering of shorebirds and other migratory birds on their arrival. The year was also marked by a very high lemming density, a good reproductive season for all species and high numbers of avian predators nesting on station premises.

Our team attained most of the objectives we aimed for. Among our achievements this year, we were able 1) to complete the vegetation survey started in 2018, which is a crucial step towards the Biodiversity Management Plan. We also 2) confirmed or documented for the first time the use of DND property for breeding or rearing of arctic foxes, ermines, red phalaropes, Lapland longspurs, Thayer's gulls, gyrfalcons, snowy owls and snow geese. We further 3) began the first ever year-round satellite tracking study of arctic hares. We 4) developed a new capture method for shorebirds, witch should allow for resuming research on SAR red knots. We further 5) confirmed that we can study physiological changes occurring in juveniles of ruddy turnstones and snow buntings in the weeks before departure, a critical time for these animals that has yet to be described. Finally, we 6) obtained fine scale thermal environment data for cold specialized snow buntings, an important step towards understanding the consequences of Arctic warming in this declining species.

Scientific research on arctic wildlife is important to address conservation issues in fragile environments such as the polar desert of Alert, but also for developing knowledge in these remote and largely inaccessible environments. Our continuing work, in collaboration with DND, 8 Wing Environment and CFS Alert personnel will close several important gaps in knowledge on this front, in addition to providing rare but crucial training opportunities for young scientists and professionals on issues important for all Canadians.