LTEMP

Long-term Ecological Monitoring Program

Nunavut Wildlife Cooperative Research Unit
Government of Nunavut
University of Alberta

2019 - Nov
Annual Report

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Alastair Franke
Kevin Hawkshaw
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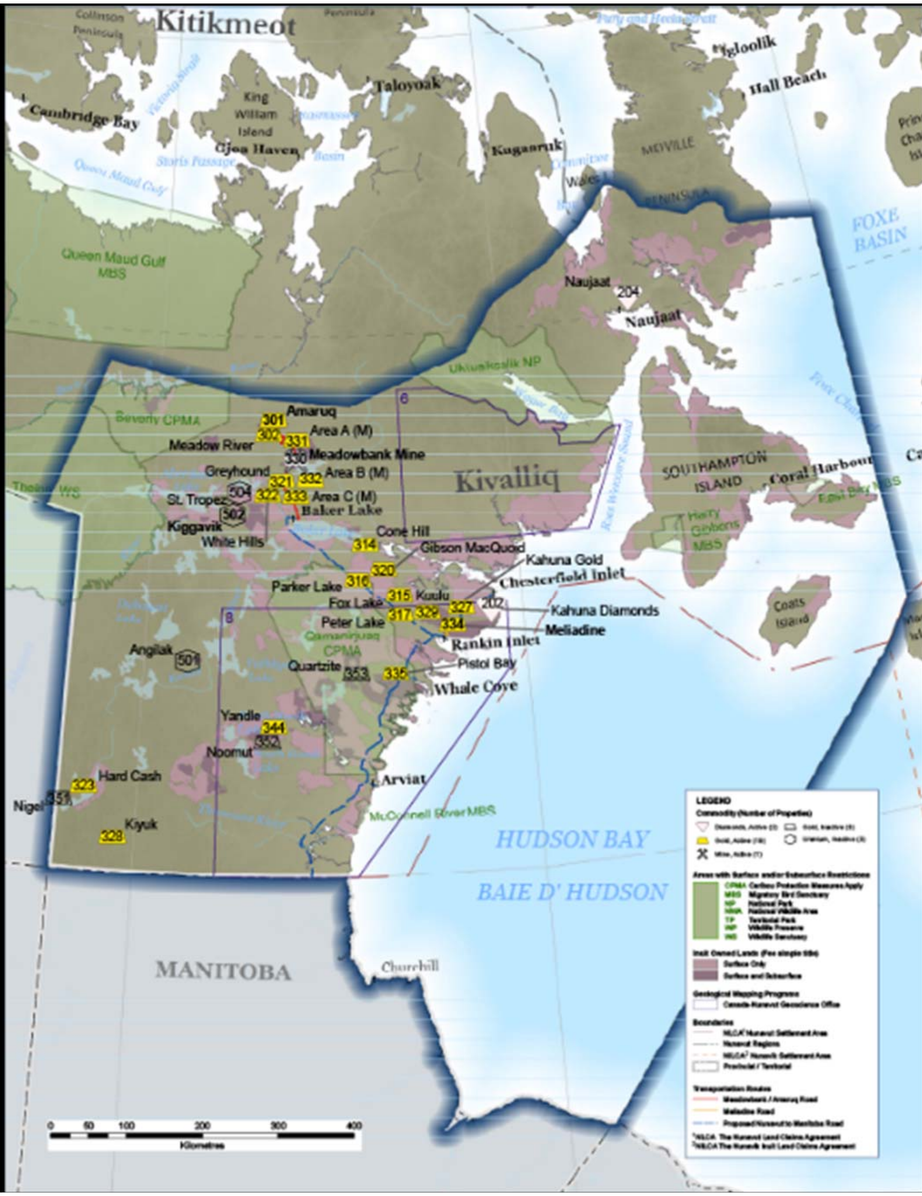
Nick Gulotta

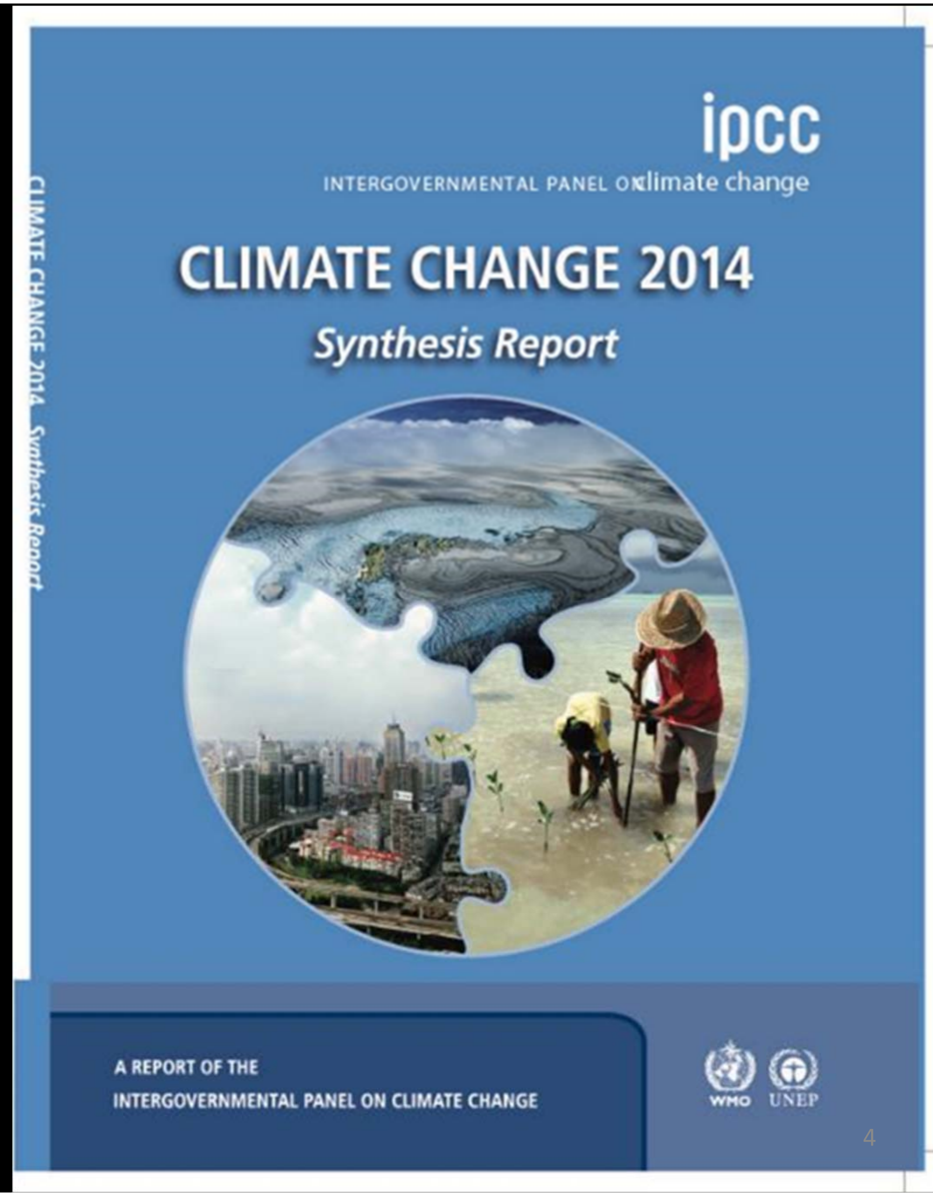
Disclaimer: This draft report has been prepared for the Government of Nunavut and presents preliminary findings that may change with further analysis. The views and interpretations in this report article are those of the authors and do not necessarily represent the views of the Government of Nunavut. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the Government of Nunavut.

Background

- GN established the Long-Term Ecological Monitoring Program (LTEMP) in 2012 to monitor ecosystem-level changes associated with climate and economic development.
- Fieldwork occurred 2012-2013 and 2015-2016. Due to high turnover of staff, the DOE decided to collaborate with academic partners to build long-term capacity to carry out the project.
- A Memorandum of Understanding with the University of Alberta, Department of Biological Sciences, and A. Franke was developed to facilitate the partnering of academic researchers with Government of Nunavut-led research projects, such as LTEMP.

- Goal: monitor ecosystem within summer range of the Qamanirjuaq caribou herd.
- Primary concerns: 1) documenting long-term changes due to climate change, and 2) establishing base-line conditions (mineral-rich region).
    - intensive monitoring is conducted annually near the community of Rankin Inlet
    - extensive monitoring in the calving grounds of the Qamanirjuaq caribou herd
- is currently the only ecosystem-level monitoring program in the territory.
- NGMP is a significant, long-term funding partner (2019/20 – 2021/22).
- NAC and KivIA support ETP student employment through an internship program.
- Two Inuit beneficiaries are employed each year
    - involved in all aspects of the field program
    - transfer of local knowledge and Inuit Qaujimajatuqangit
- The LTEMP is an ideal candidate for which community-based monitoring could be fully integrated.


Kitikmeot
Cambridge Bay
King William Island
Gjoa Haven
Taloyoak
Kugaaruk
Igloolik
Hall Beach
MELVILLE PENINSULA
FOXE BASIN
Queen Maud Gulf MBS
Naujaat
Naujaat
Ukkusiksalik NP
Amaruq
Area A (M)
Meadow River
Meadowbank Mine
Greyhound
Area B (M)
St. Tropez
Area C (M)
Baker Lake
Kiggavik
Kivalliq
SOUTHAMPTON ISLAND
Coral Harbour
Cone Hill
White Hills
Gibson MacQuoid
Kahuna Gold
Chesterfield Inlet
Parker Lake
Fox Lake
Kuulu
Peter Lake
Kahuna Diamonds
Meliadine
Rankin Inlet
Angilak
Quartzite
Pistol Bay
Whale Cove
Coats Island
Yandle
Noomut
Hard Cash
Arviat
Nigel
Kiyuk
HUDSON BAY
BAIE D' HUDSON
MANITOBA
Churchill
LEGEND
Kilometres


ipcc
INTERGOVERNMENTAL PANEL ON climate change
CLIMATE CHANGE 2014
Synthesis Report
CLIMATE CHANGE 2014 Synthesis Report
A REPORT OF THE
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
WMO
UNEP

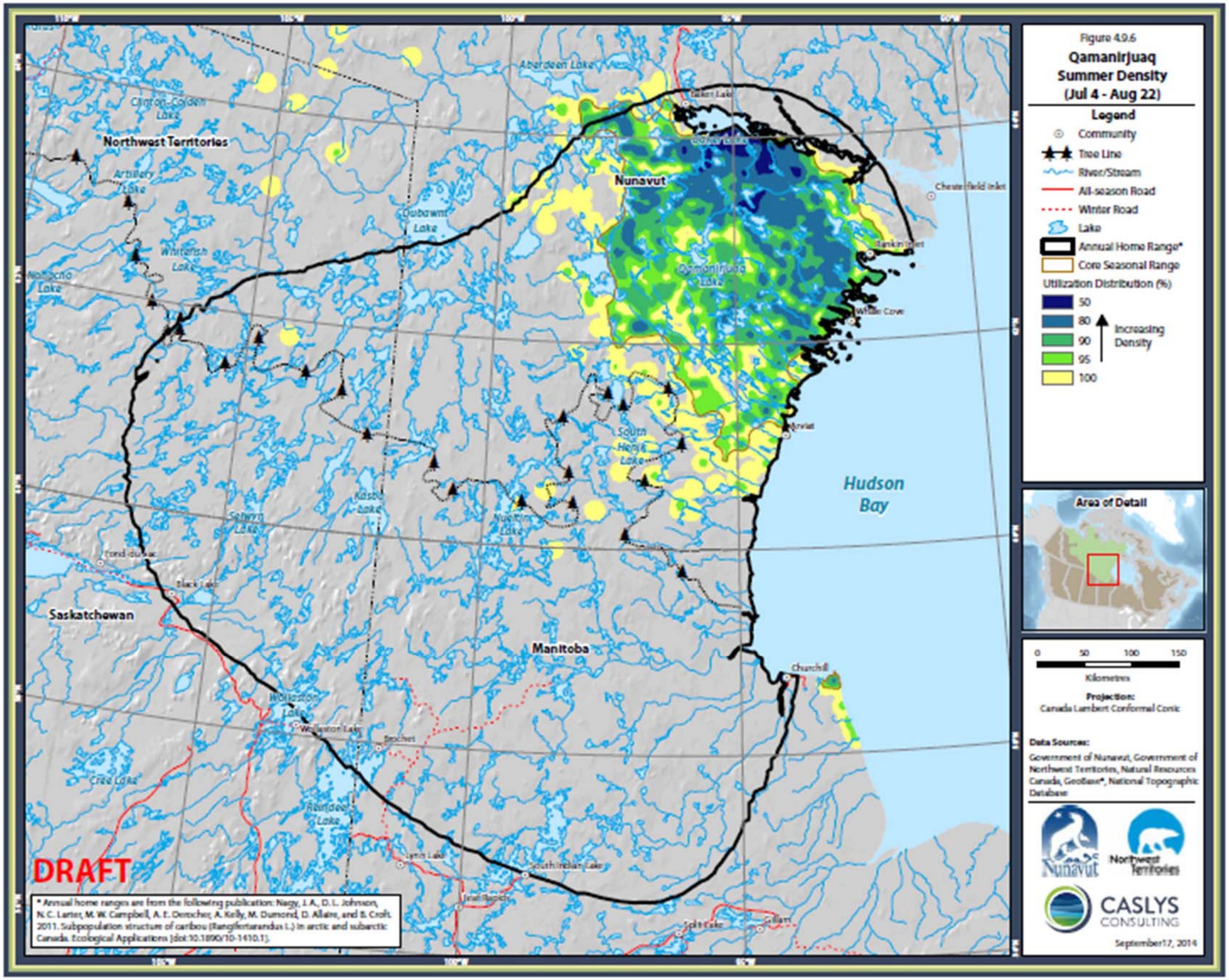


Figure 4.9.6
Qamanirjuaq
Summer Density
(Jul 4 - Aug 22)
Legend
Community
Tree Line
River/Stream
All-season Road
Winter Road
Lake
Annual Home Range*
Core Seasonal Range
Utilization Distribution (%)
50
80
90
95
100
Increasing Density
Area of Detail
0 50 100 150
Kilometres
Projection:
Canada Lambert Conformal Conic
Data Sources:
Government of Nunavut, Government of Northwest Territories, Natural Resources Canada, GeoBase®, National Topographic Database
Nunavut
Northwest Territories
CASLYS CONSULTING
September17, 2014
Northwest Territories
Nunavut
Saskatchewan
Manitoba
Hudson Bay
Aberdeen Lake
Dubawnt Lake
Kasba Lake
South Henik Lake
Nueltin Lake
Wollaston Lake
Reindeer Lake
Selwyn Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Arviat
Churchill
DRAFT
* Annual home ranges are from the following publication: Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft. 2011. Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications [doi:10.1890/10-1410.1].

ENU nature climate change

Perspective | Published: 14 May 2018

Future climate risk from compound events

Jakob Zscheischler, Seth Westra, Bart J. J. M. van den Hurk, Sonia I. Seneviratne, Philip J. Ward, Andy Pitman, Amir AghaKouchak, David N. Bresch, Michael Leonard, Thomas Wahl & Xuebin Zhang

Nature Climate Change 8, 469–477(2018) | Cite this article

An Author Correction to this article was published on 20 June 2018

This article has been updated

But with many interacting factors, monitoring ecosystem change is difficult.

Abstract

Floods, wildfires, heatwaves and droughts often result from a combination of interacting physical processes across multiple spatial and temporal scales. The combination of processes (climate drivers and hazards) leading to a significant impact is referred to as a 'compound event'. Traditional risk assessment methods typically only consider one driver and/or hazard at a time, potentially leading to underestimation of risk, as the processes that cause extreme events often interact and are spatially and/or temporally dependent. Here we show how a better understanding of compound events may improve projections of potential high-impact events, and can provide a bridge between climate scientists, engineers, social scientists, impact modellers and decision-makers, who need to work closely together to understand these complex events.

Global Change Biology

Global Change Biology (2015) 21, 4651–4661, doi: 10.1111/gcb.13051

Contrasting effects of warming and increased snowfall on Arctic tundra plant phenology over the past two decades

ANNE D. BJORKMAN[1,2], SARAH C. ELMENDORF[3,4], ALISON L. BEAMISH[1,5], MARK VELLEND[6] and GREGORY H. R. HENRY[1]

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Phenology does not advance

Abstract

Recent changes in climate have led to significant shifts in phenology, with many studies demonstrating advanced phenology in response to warming temperatures. The rate of temperature change is especially high in the Arctic, but this is also where we have relatively little data on phenological changes and the processes driving these changes. In order to understand how Arctic plant species are likely to respond to future changes in climate, we monitored flowering phenology in response to both experimental and ambient warming for four widespread species in two habitat types over 21 years. We additionally used long-term environmental records to disentangle the effects of temperature increase and changes in snowmelt date on phenological patterns. While flowering occurred earlier in response to experimental warming, plants in unmanipulated plots showed no change or a delay in flowering over the 21-year period, despite more than 1 °C of ambient warming during that time. This counterintuitive result was likely due to significantly delayed snowmelt over the study period (0.05–0.2 days/yr) due to increased winter snowfall. The timing of snowmelt was a strong driver of flowering phenology for all species – especially for early-flowering species – while spring temperature was significantly related to flowering time only for later-flowering species. Despite significantly delayed flowering phenology, the timing of seed maturation showed no significant change over time, suggesting that warmer temperatures may promote more rapid seed development. The results of this study highlight the importance of understanding the specific environmental cues that drive species' phenological responses as well as the complex interactions between temperature and precipitation when forecasting phenology over the coming decades. As demonstrated here, the effects of altered snowmelt patterns can counter the effects of warmer temperatures, even to the point of generating phenological responses opposite to those predicted by warming alone.

Keywords: Arctic tundra, Bayesian hierarchical modeling, climate change, flowering time, interval censoring, plant phenology, seed maturation

Community-level phenological response to climate change

Otso Ovaskainen, Svetlana Skorokhodova, Marina Yakovleva, Alexander Sukhov, Anatoliy Kutenkov, Nadezhda Kutenkova, Anatoliy Shcherbakov, Evegeniy Meyke, and Maria del Mar Delgado

PNAS August 13, 2013 110 (33) 13434-13439; https://doi.org/10.1073/pnas.1305533110

Edited by William H. Schlesinger, Cary Institute of Ecosystem Studies, Millbrook, NY, and approved July 9, 2013 (received for review March 25, 2013)

Article Figures & SI Info & Metrics PDF

Phenology advances

Abstract

Climate change may disrupt interspecific phenological synchrony, with adverse consequences to ecosystem functioning. We present here a 40-y-long time series on 10,425 dates that were systematically collected in a single Russian locality for 97 plant, 78 bird, 10 herptile, 19 insect, and 9 fungal phenological events, as well as for 77 climatic events related to temperature, precipitation, snow, ice, and frost. We show that species are shifting their phenologies at dissimilar rates, partly because they respond to different climatic factors, which in turn are shifting at dissimilar rates. Plants have advanced their spring phenology even faster than average temperature has increased, whereas migratory birds have shown more divergent responses and shifted, on average, less than plants. Phenological events of birds and insects were mainly triggered by climate cues (variation in temperature and snow and ice cover) occurring over the course of short periods, whereas many plants, herptiles, and fungi were affected by long-term climatic averages. Year-to-year variation in plants, herptiles, and insects showed a high degree of synchrony, whereas the phenological timing of fungi did not correlate with any other taxonomic group. In many cases, species that are synchronous in their year-to-year dynamics have also shifted in congruence, suggesting that climate change may have disrupted phenological synchrony less than has been previously assumed. Our results illustrate how a multidimensional change in the physical environment has translated into a community-level change in phenology.

nature climate change
LETTERS
PUBLISHED ONLINE: 6 JULY 2015 | DOI: 10.1038/NCLIMATE2697

Climate sensitivity of shrub growth across the tundra biome

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Shrub proliferation

Rapid climate warming in the tundra biome has been linked to increasing shrub dominance[1–4]. Shrub expansion can modify climate by altering surface albedo, energy and water balance, and permafrost[2,5–8], yet the drivers of shrub growth remain poorly understood. Dendroecological data consisting of multi-decadal time series of annual shrub growth provide an underused resource to explore climate–growth relationships. Here, we analyse circumpolar data from 37 Arctic and alpine sites in 9 countries, including 25 species, and ~42,000 annual growth records from 1,821 individuals. Our analyses demonstrate that the sensitivity of shrub growth to climate was: (1) heterogeneous, with European sites showing greater summer temperature sensitivity than North American sites, and (2) higher at sites with greater soil moisture and for taller shrubs (for example, alders and willows) growing at their northern or upper elevational range edges. Across latitude, climate sensitivity of growth was greatest at the boundary between the Low and High Arctic, where permafrost is thawing[4] and most of the global permafrost soil carbon pool is stored[9]. The observed variation in climate–shrub growth relationships should be incorporated into Earth system models to improve future projections of climate change impacts across the tundra biome.

The Arctic is warming more rapidly than lower latitudes owing to climate amplification involving temperature, water vapour, albedo and sea ice feedbacks[5,7]. Tundra ecosystems are thus predicted to respond more rapidly to climate change than other terrestrial ecosystems[4]. The tundra biome spans Arctic and alpine regions that have similar plant species pools and mean climates, yet vary in topography, seasonality, land cover and glaciation history. Concurrent with the recent high-latitude warming trend[7], repeat photography and vegetation surveys have shown widespread expansion of shrubs[1–3], characterized by increased canopy cover, height and abundance. However, climate warming[7] and shrub increase[2,10] have not occurred at all sites. Models predict that warming of 2–10 °C (ref. 11) could convert as much as half of current

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Global Change Biology
Global Change Biology (2009) 15, 2681–2693, doi: 10.1111/j.1365-2486.2009.01935.x

Herbivores inhibit climate-driven shrub expansion on the tundra

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*Department of Ecology and Environmental Science, Umeå University, S-901 87 Umeå, Sweden, †Department of Biology, University of Turku, FI-20014 Turku, Finland, ‡Department of Natural Sciences, Finnmark University College N-9509 Alta, Norway, §Abisko Scientific Research Station, Abisko, Sweden, ¶Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK, ‖National Centre for Advanced Bio-Protection Technologies, Lincoln University, PO Box 84, Canterbury, New Zealand

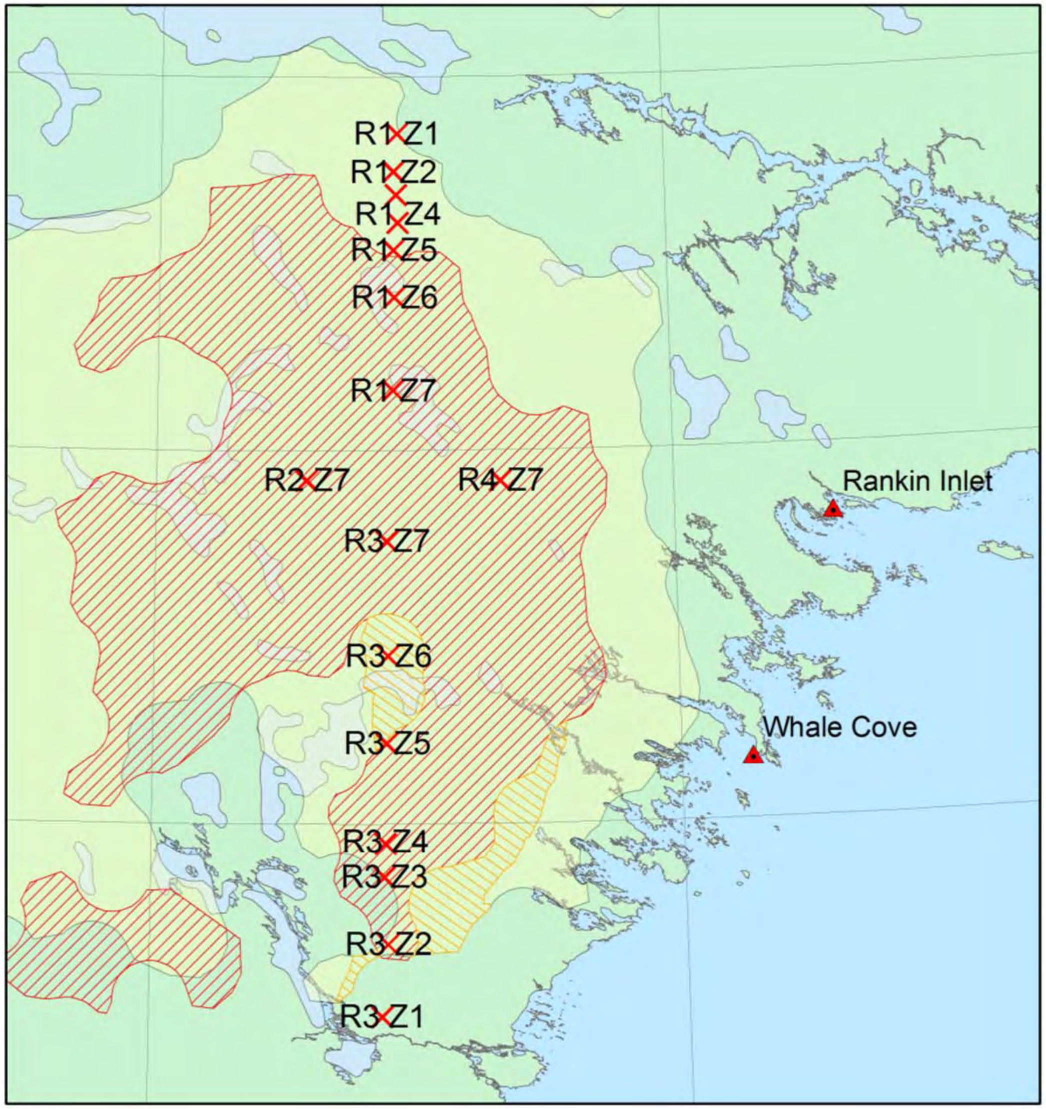
Shrub proliferation suppressed by herbivory

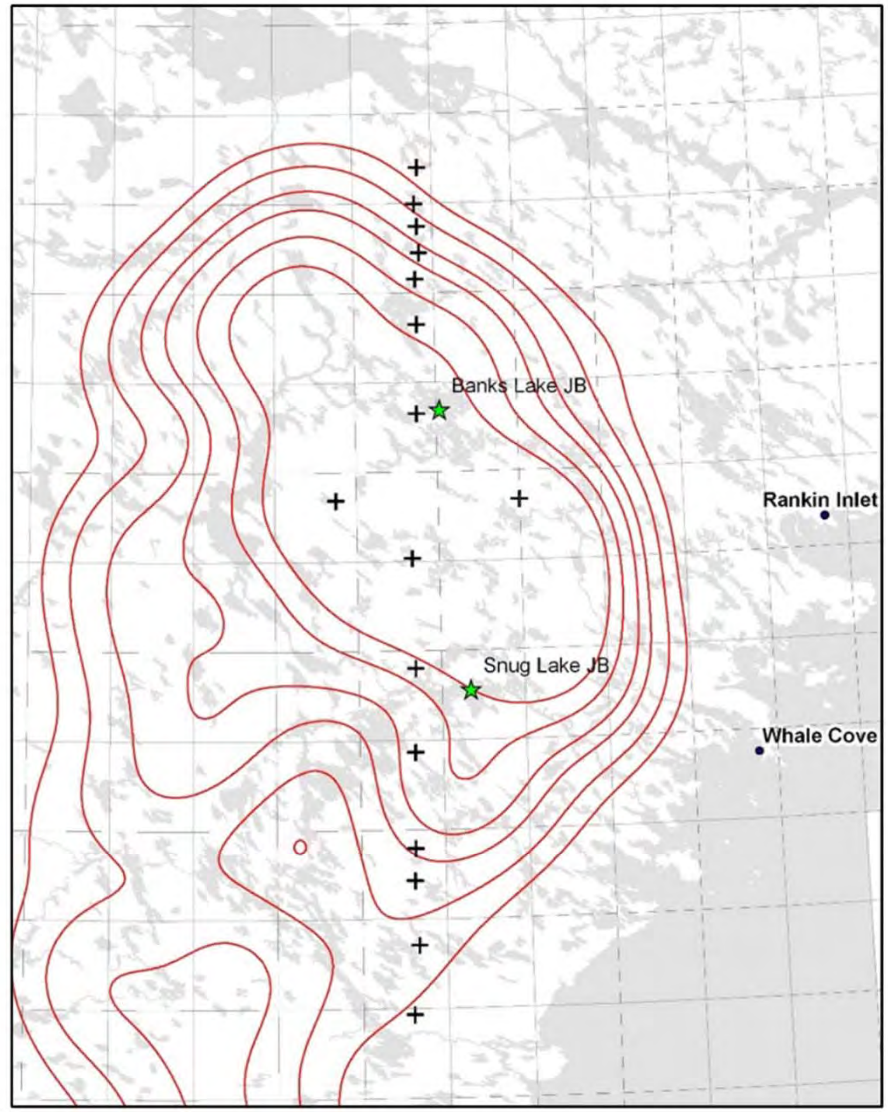
Abstract

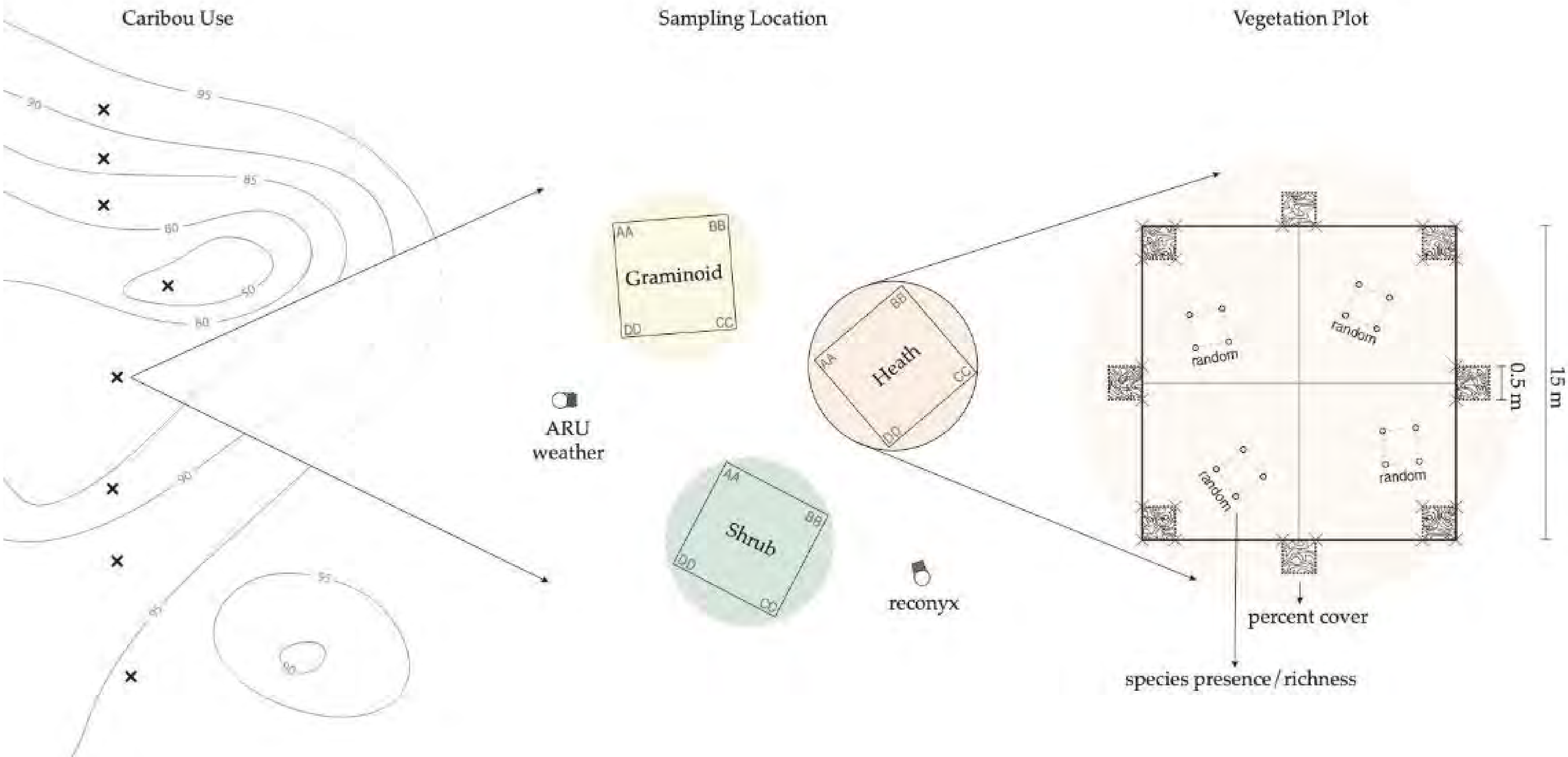
Recent Pan-Arctic [illegible] as a response to a warmer climate. However, herbivores can also influence the abundance of shrubs in arctic ecosystems. [illegible] changes in plant community composition during the last 10 years in permanent plots inside and outside exclosures with different mesh sizes that exclude either only reindeer or all mammalian herbivores including voles and lemmings. The exclosures were replicated at three forest and tundra sites at four different locations along a climatic gradient (oceanic to continental) in northern Fennoscandia. Since the last 10 years have been exceptionally warm, we could study how warming has influenced the vegetation in different grazing treatments. Our results show that the abundance of the dominant shrub, *Betula nana*, has increased during the last decade, but that the increase was more pronounced when herbivores were excluded. Reindeer have the largest effect on shrubs in tundra, while voles and lemmings have a larger effect in the forest. The positive relationship between annual mean temperature and shrub growth in the absence of herbivores and the lack of relationships in grazed controls is another indication that shrub abundance is controlled by an interaction between herbivores and climate. In addition to their effects on taller shrubs (>0.3 m), reindeer reduced the abundance of lichens, whereas microtine rodents reduced the abundance of dwarf shrubs (<0.3 m) and mosses. In contrast to short-term responses, competitive interactions between dwarf shrubs and lichens were evident in the long term. These results show that herbivores have to be considered in order to understand how a changing climate will influence tundra ecosystems.

Keywords: *Betula nana*, exclosures, global warming, herbivores, lemmings, reindeer, shrubs, snow, tundra, voles

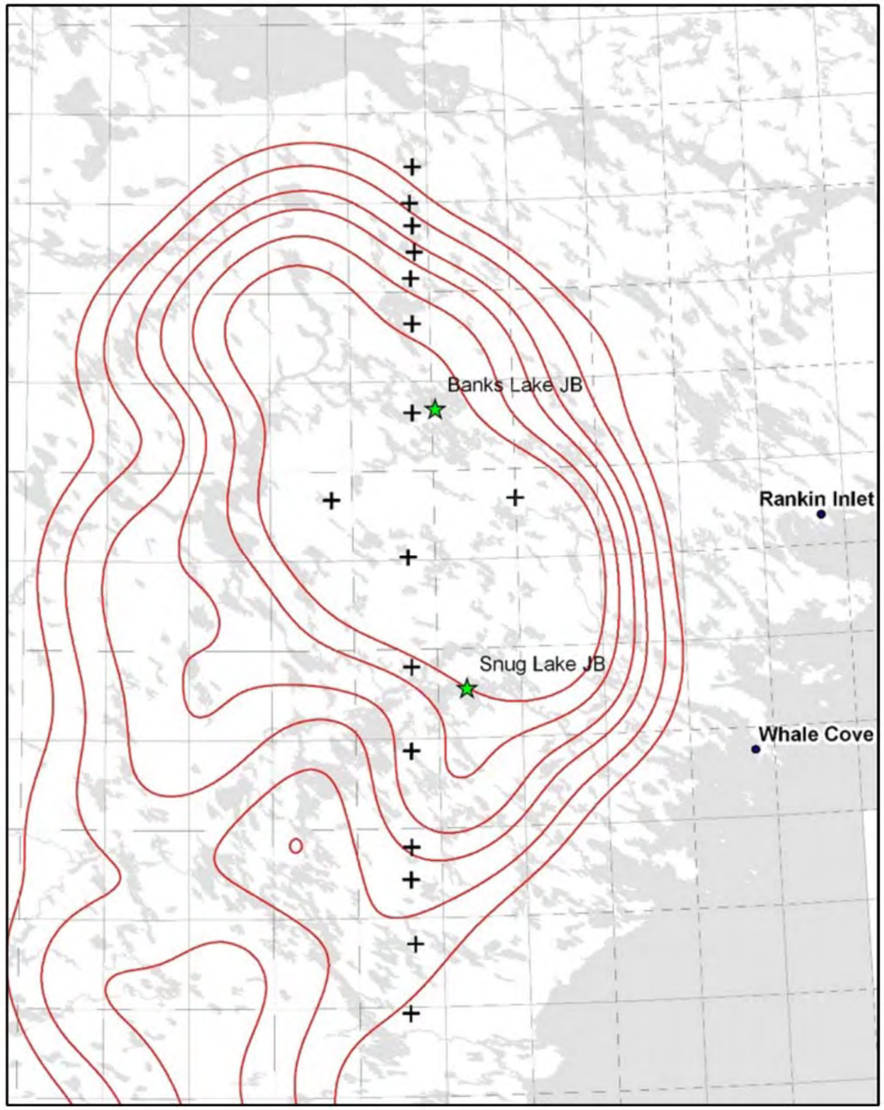
Received 15 October 2008 and accepted 16 February 2009

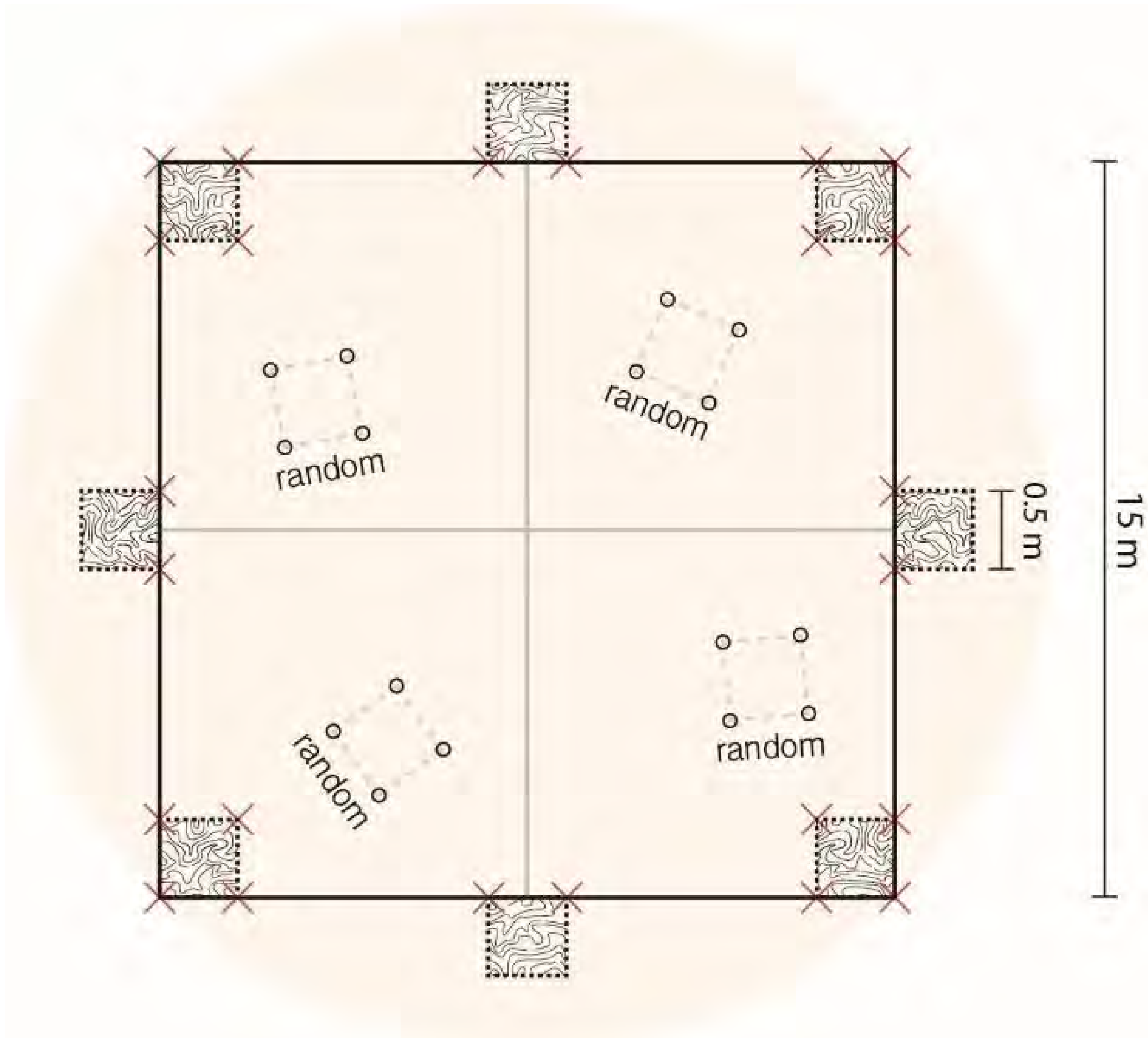

R1Z1
R1Z2
R1Z4
R1Z5
R1Z6
R1Z7
R2Z7
R4Z7
R3Z7
R3Z6
R3Z5
R3Z4
R3Z3
R3Z2
R3Z1
Rankin Inlet
Whale Cove


Banks Lake JB
Snug Lake JB
Rankin Inlet
Whale Cove

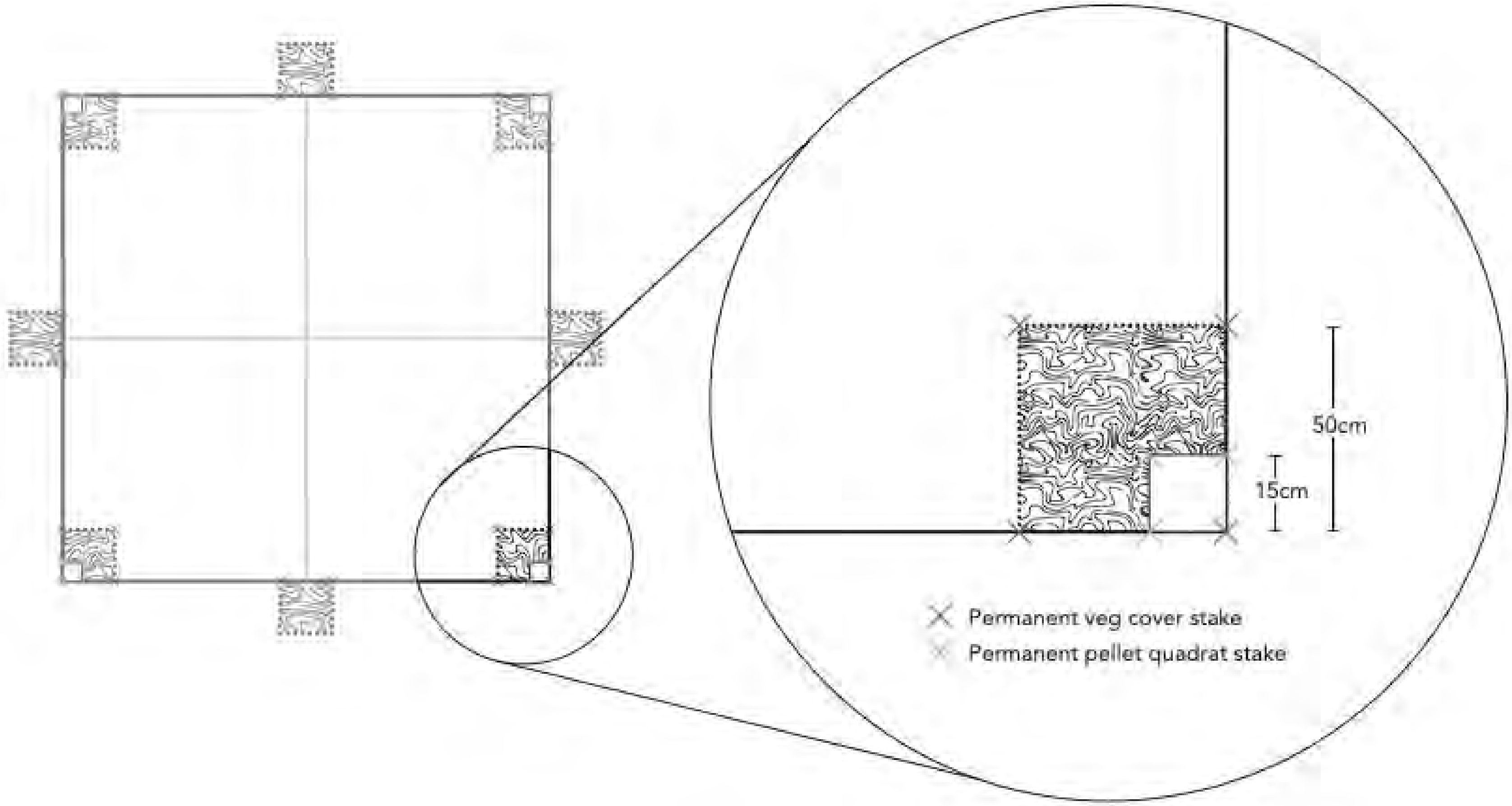


Caribou Use
Sampling Location
Vegetation Plot
95
90
85
80
50
Graminoid
Heath
Shrub
AA
BB
CC
DD
ARU
weather
reconyx
random
0.5 m
15 m
percent cover
species presence/richness

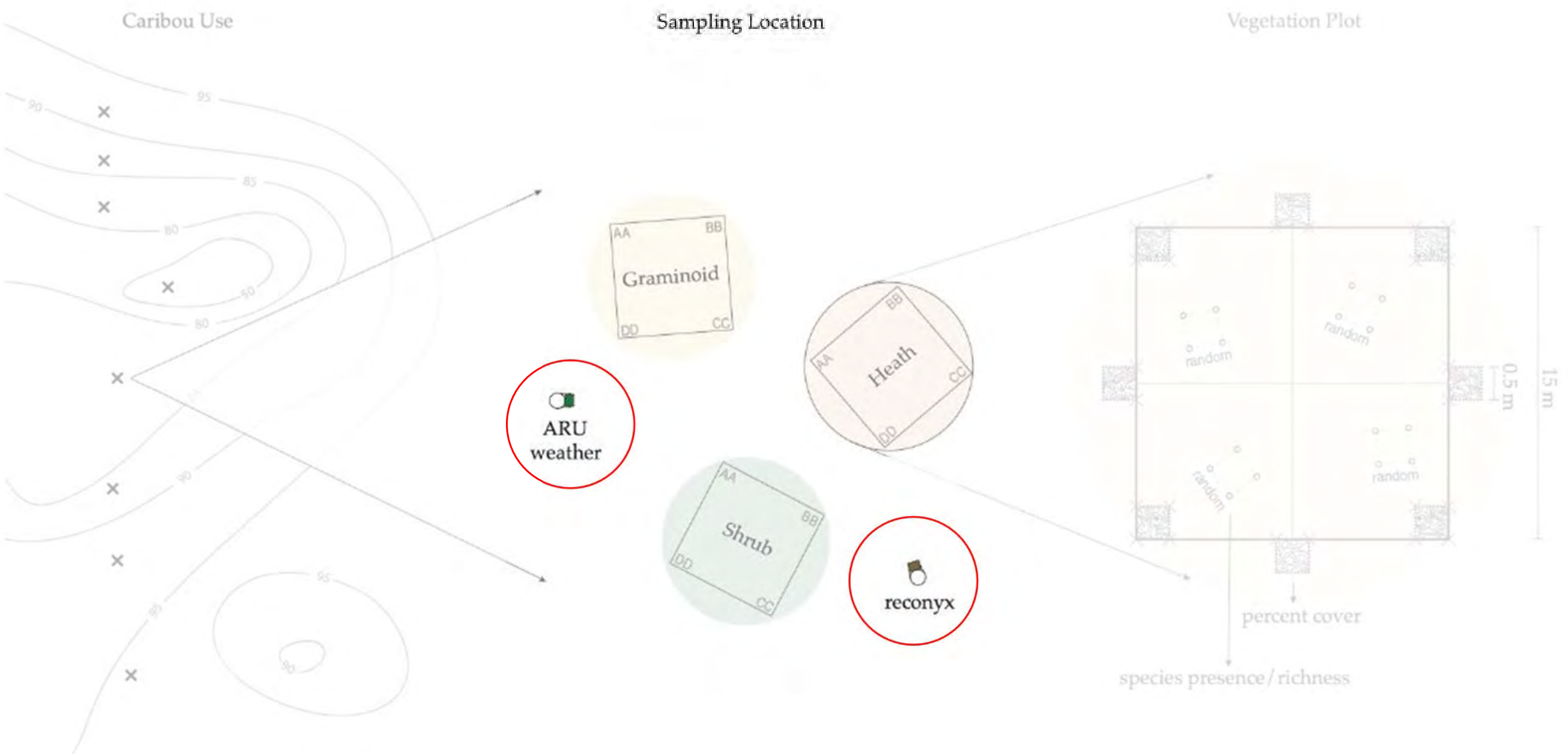

Banks Lake JB
Snug Lake JB
Rankin Inlet
Whale Cove



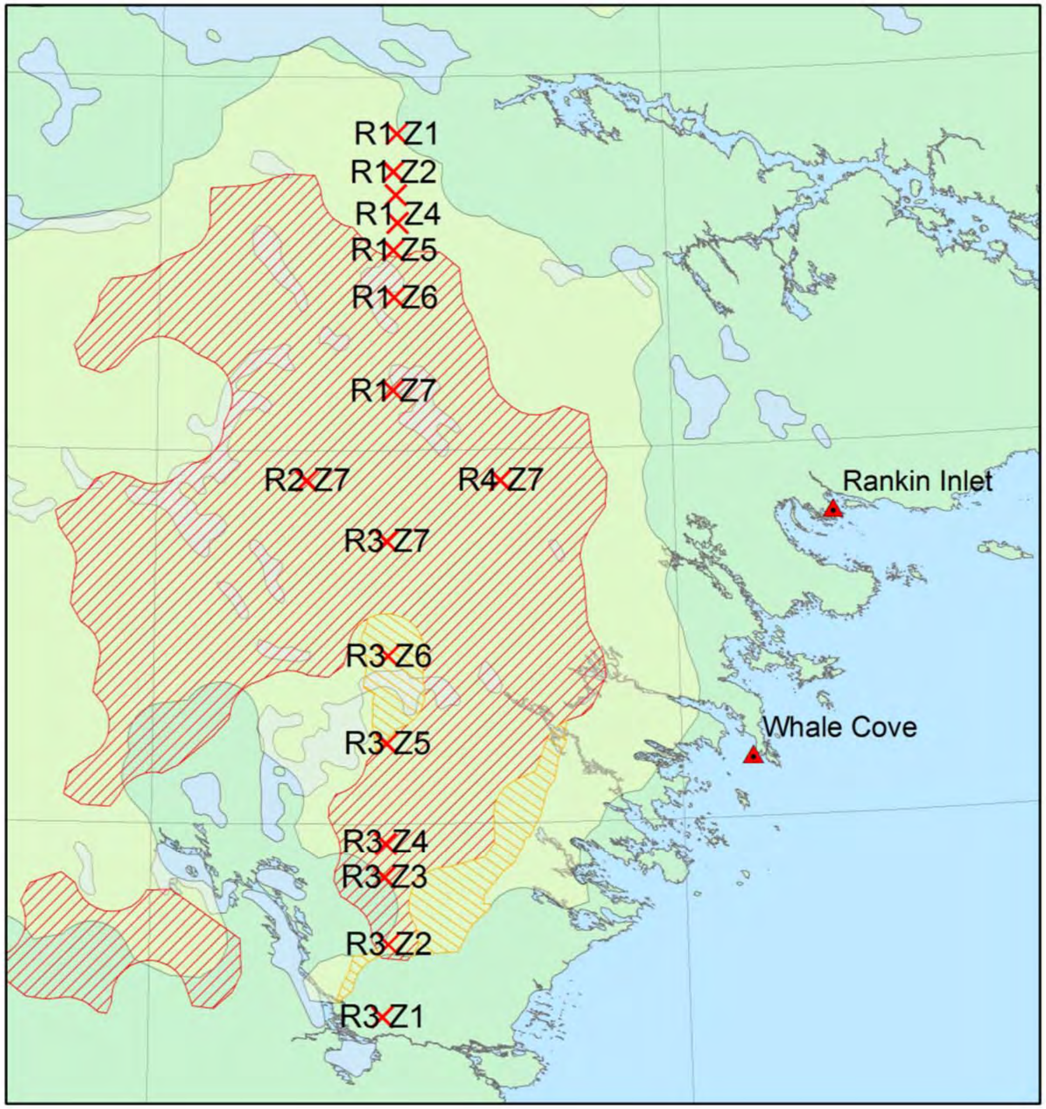
random
random
random
random
0.5 m
15 m

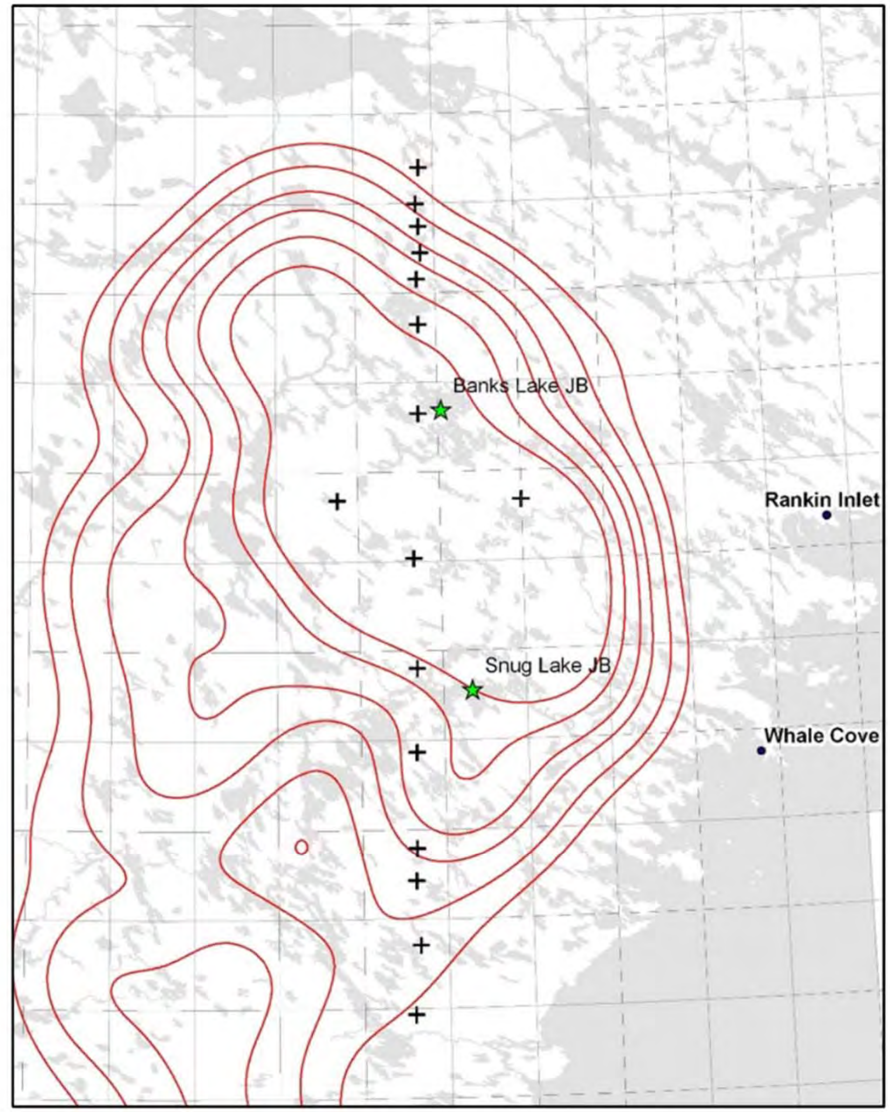


50cm
15cm
Permanent veg cover stake
Permanent pellet quadrat stake



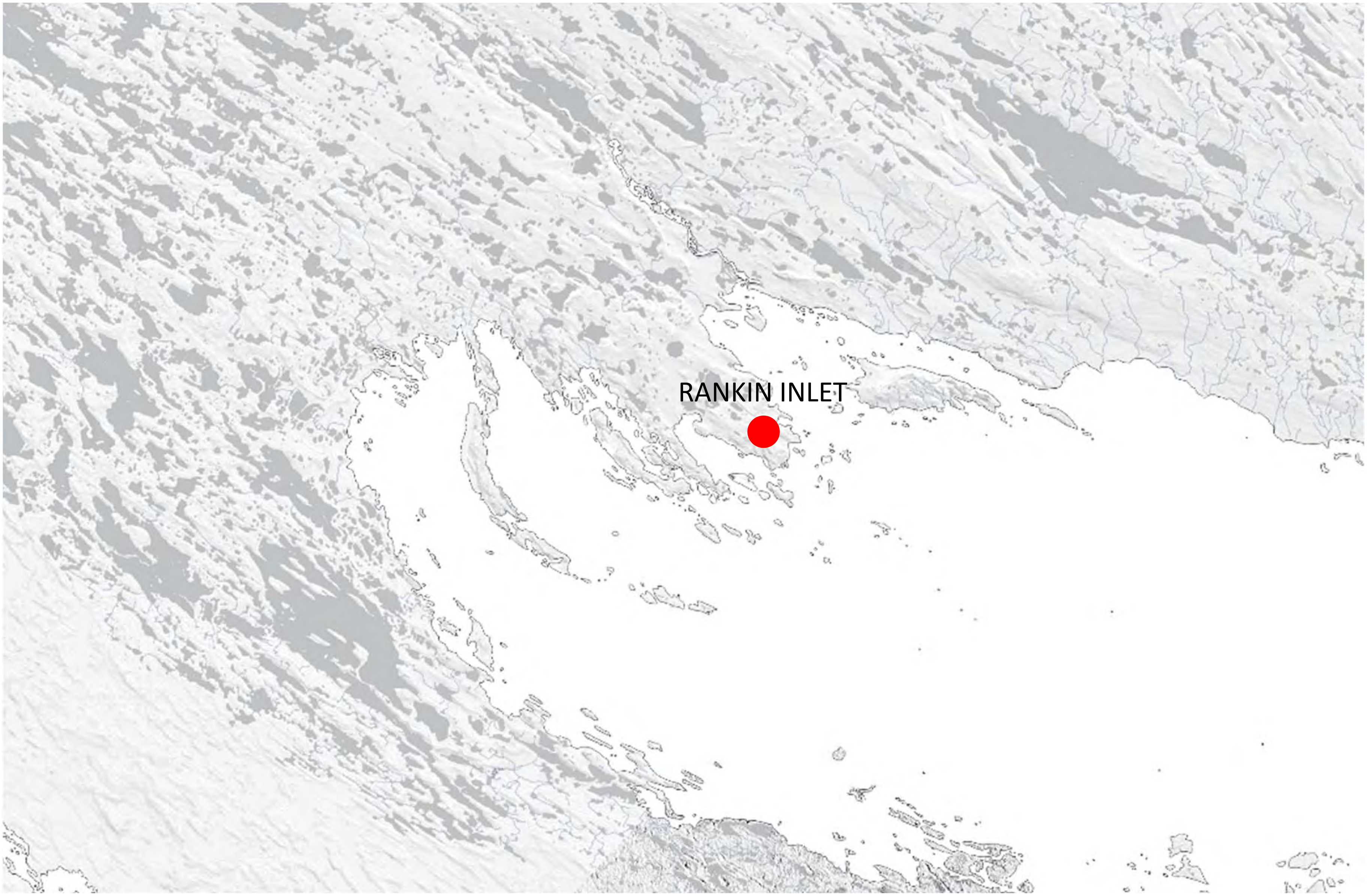
Caribou Use
Sampling Location
Vegetation Plot
Graminoid
Heath
Shrub
ARU
weather
reconyx
random
0.5 m
15 m
percent cover
species presence / richness


R1Z1
R1Z2
R1Z4
R1Z5
R1Z6
R1Z7
R2Z7
R4Z7
Rankin Inlet
R3Z7
R3Z6
R3Z5
Whale Cove
R3Z4
R3Z3
R3Z2
R3Z1

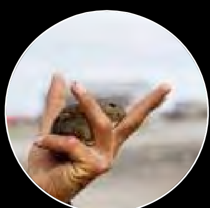
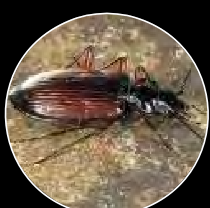

Banks Lake JB
Rankin Inlet
Snug Lake JB
Whale Cove

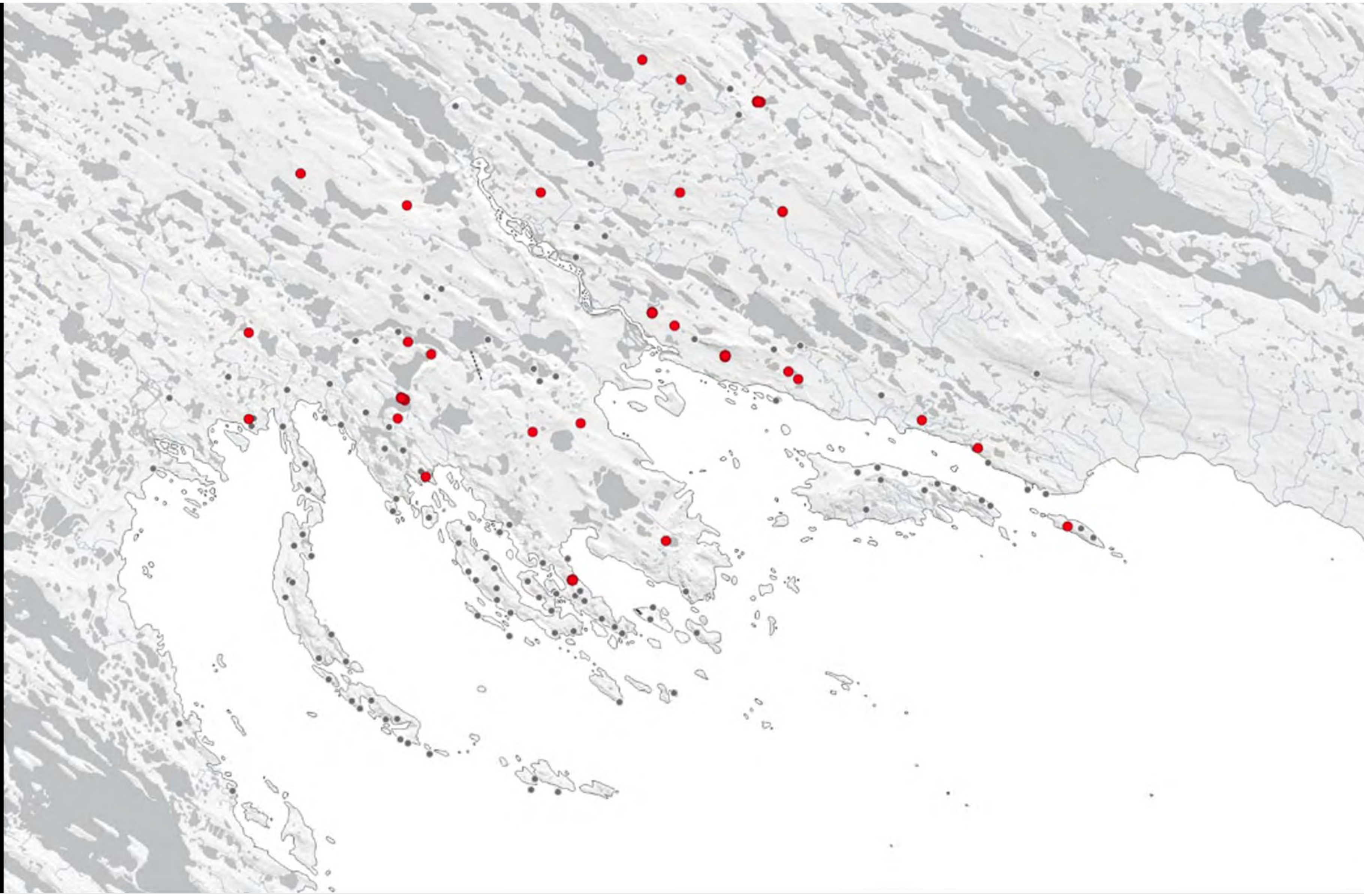
Qamanirjuaq Calving Grounds

	2012	2013	2014	2015	2016	2017	2018	2019
Lead	N. Lecomte	N. Lecomte	/	M. Wilson	M. Wilson	/	NuWCRU	NuWCRU
Veg	Yes	Yes	/	Yes	No	/	Yes	Yes
Scat	Removal	Removal/Count	/	Removal	No	/	Removal	Removal/count
Camera	No	No	/	Yes	Yes	/	No	No
ARU	No	No	/	Yes	Yes	/	No	No


RANKIN INLET

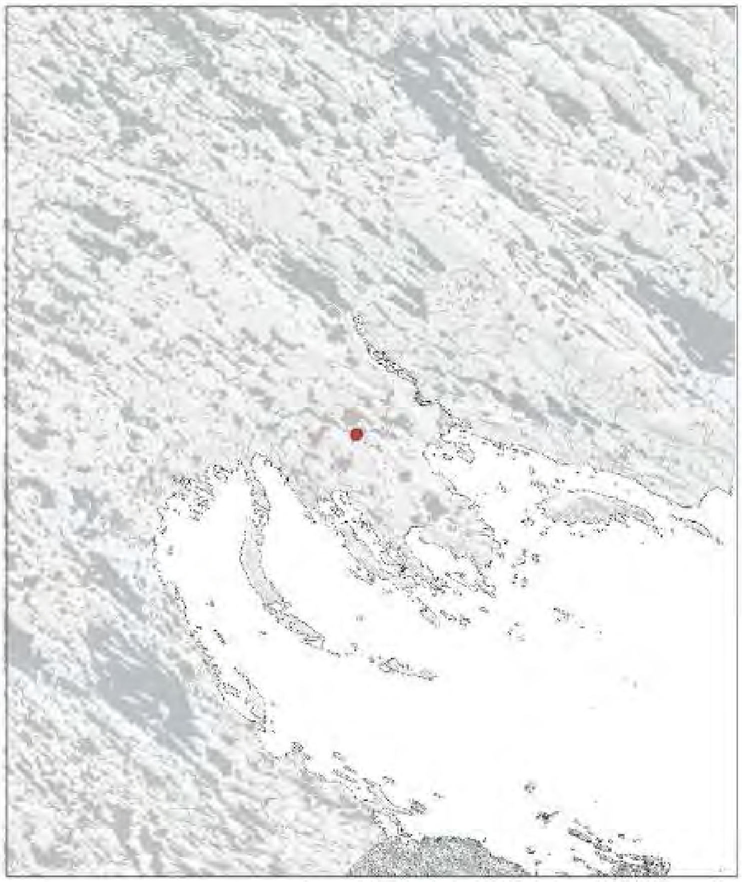


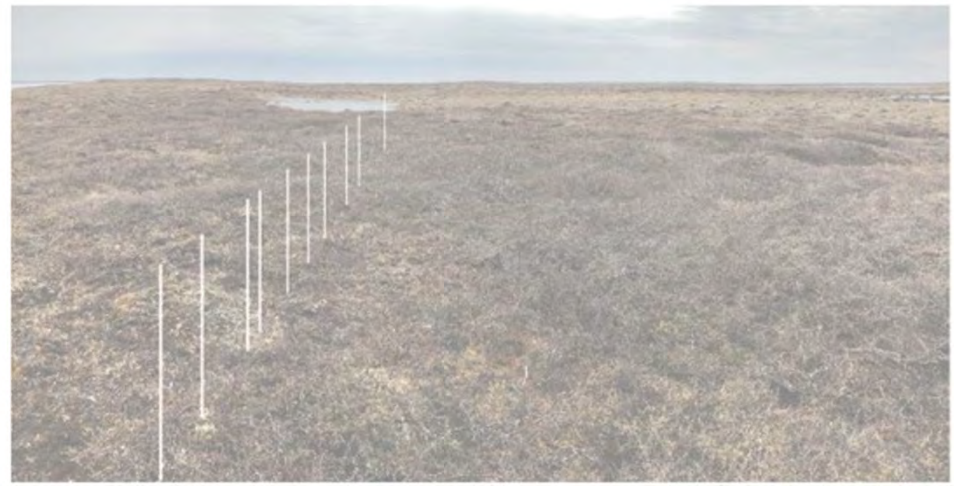





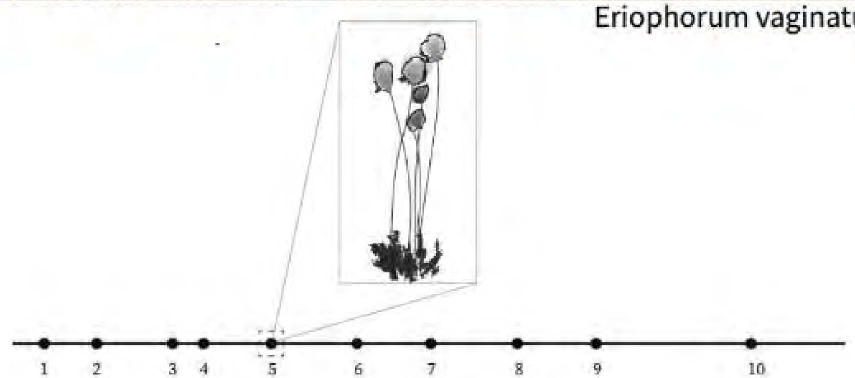

May
June
July
August
Raptor
Occupancy and Productivity
Small Mammal
Snap Trapping
Songbird
Point Transects
ARU
Invertebrate
Pollinator Trap
Pitfall Trap
Vegetation
Dendro Ecology
Phenology
Community Composition

Vegetation Phenology



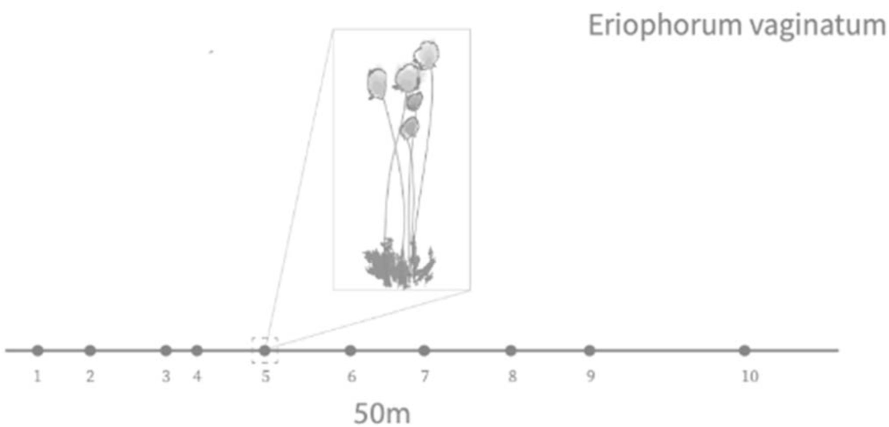


Eriophorum vaginatum

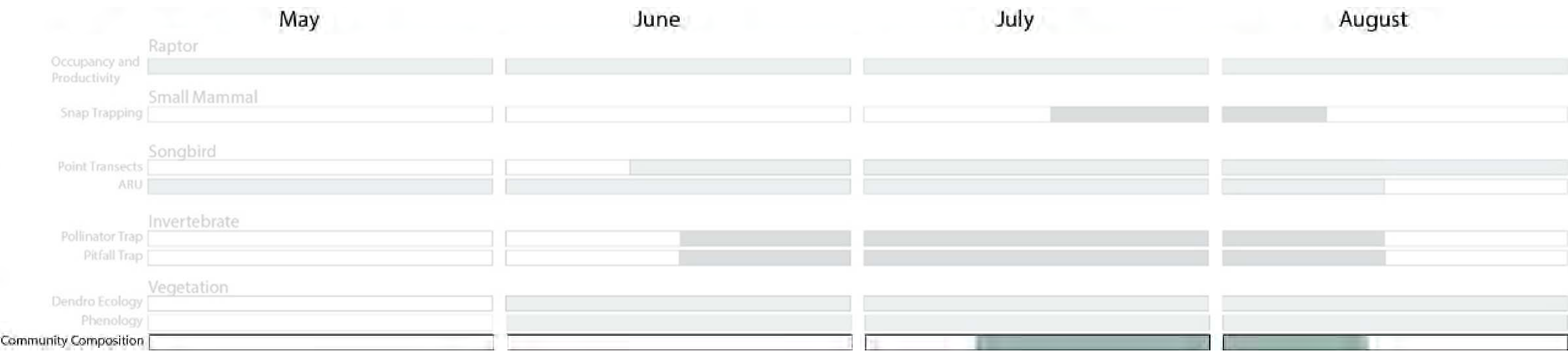


50m

Vegetation Phenology



1. date snow free
2. date first appearance of flower buds
3. date first pollen visible (yellow anthers)


May
June
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Occupancy and Productivity
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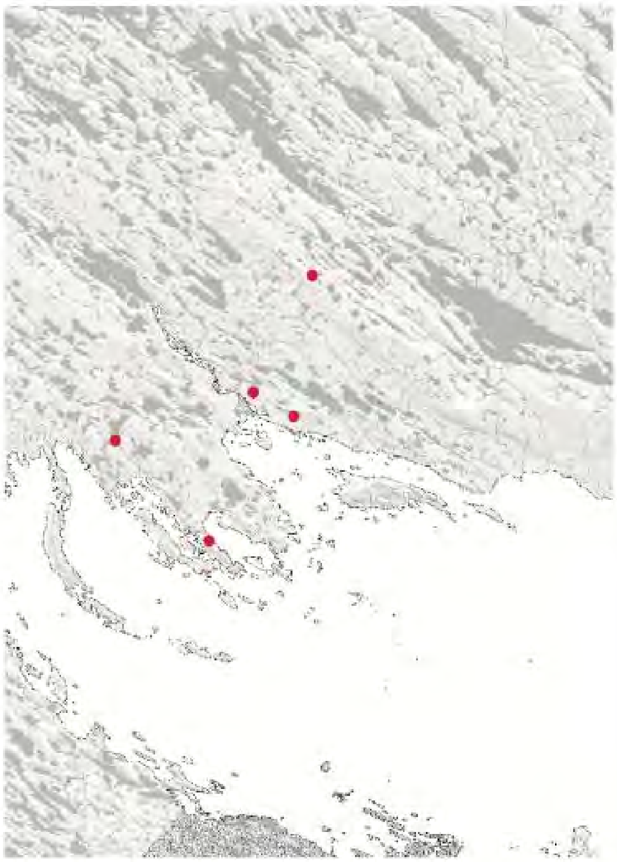
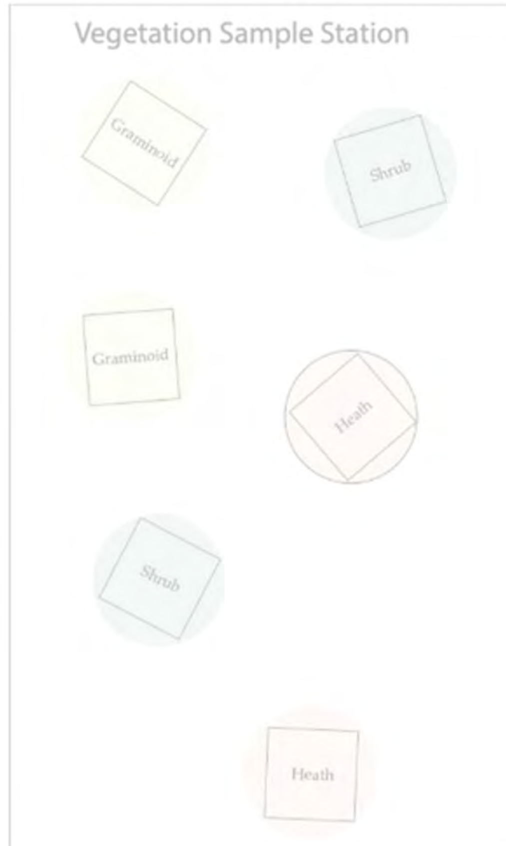
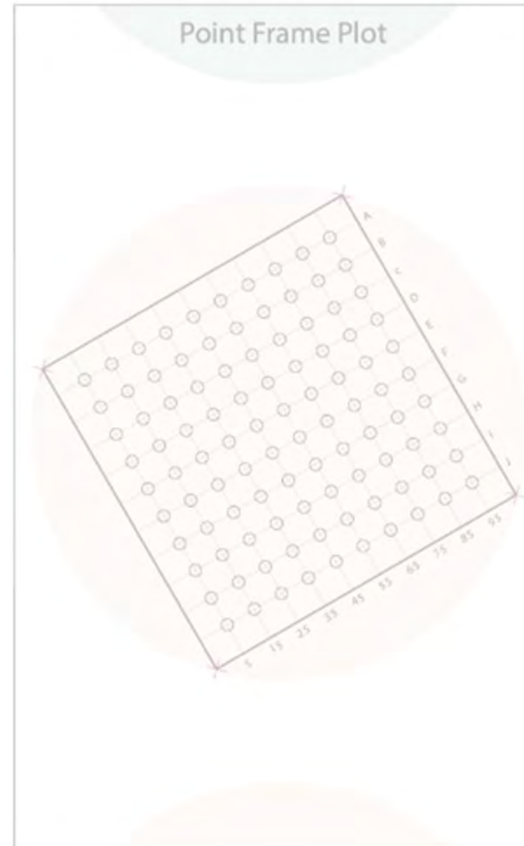
Community Composition

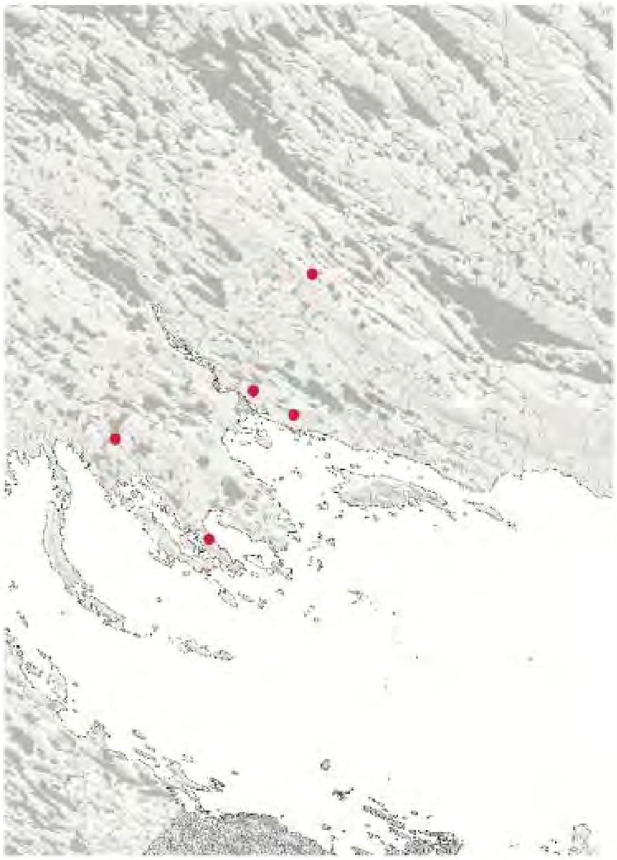
Community Composition

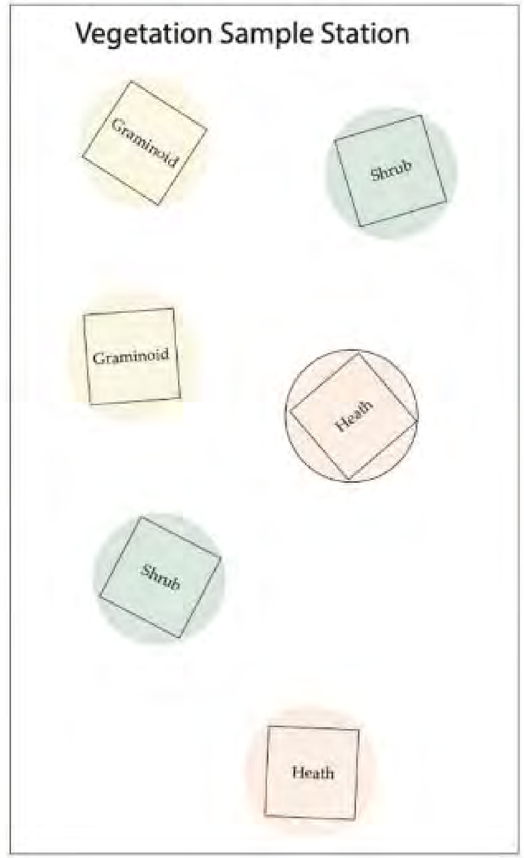


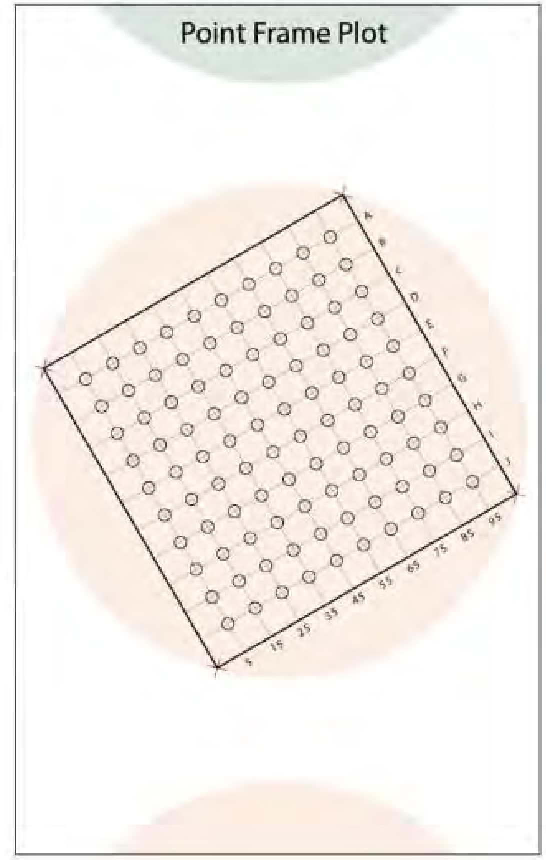




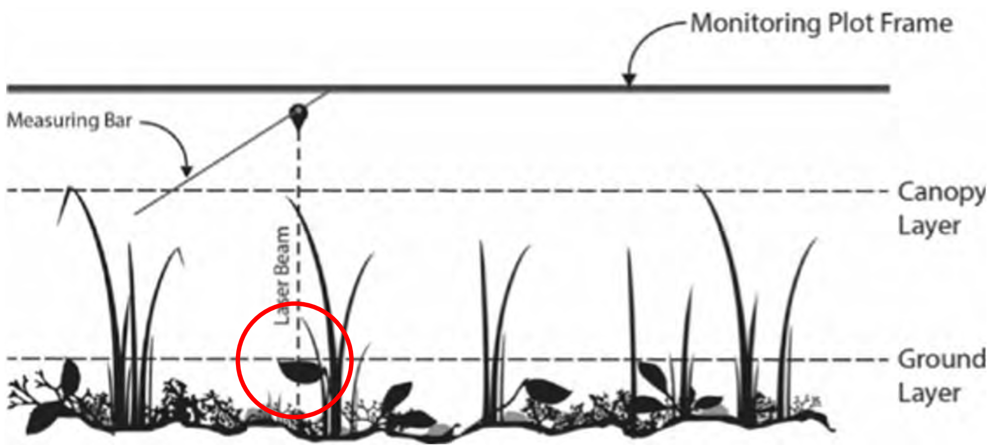
Community Composition

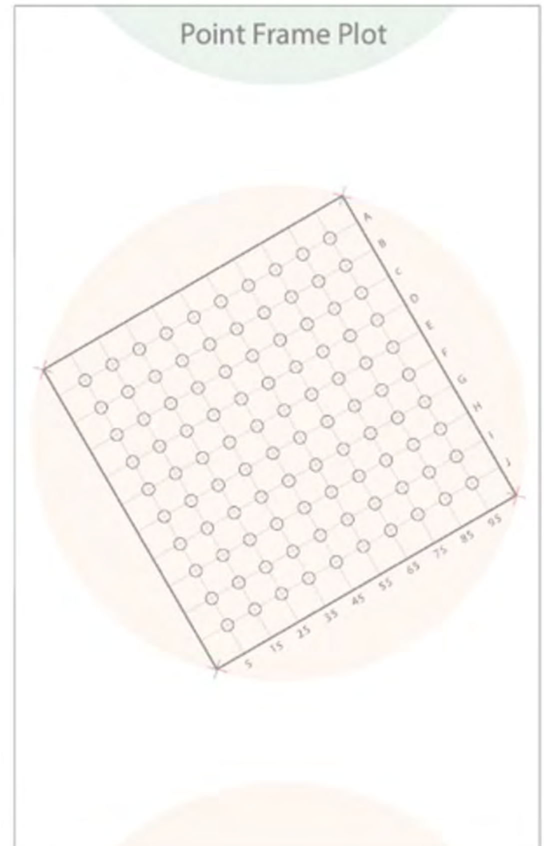






Community Composition





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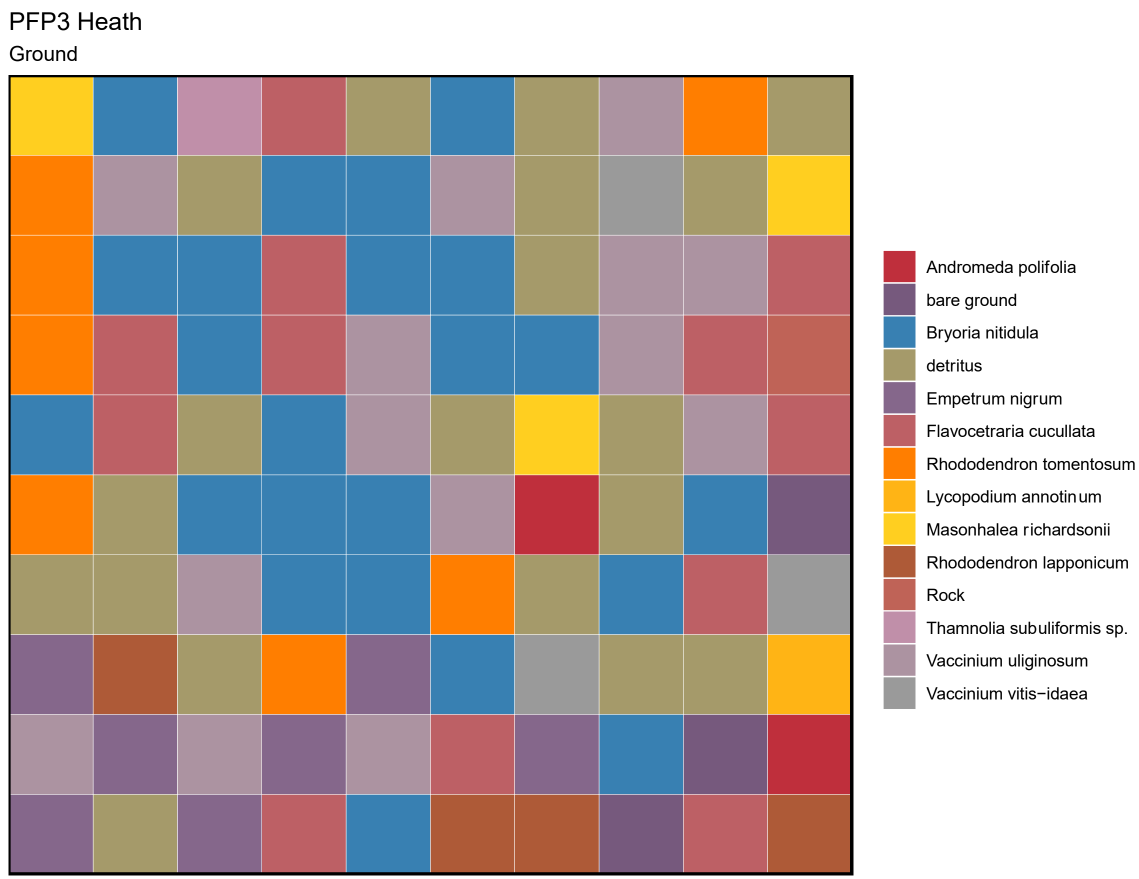

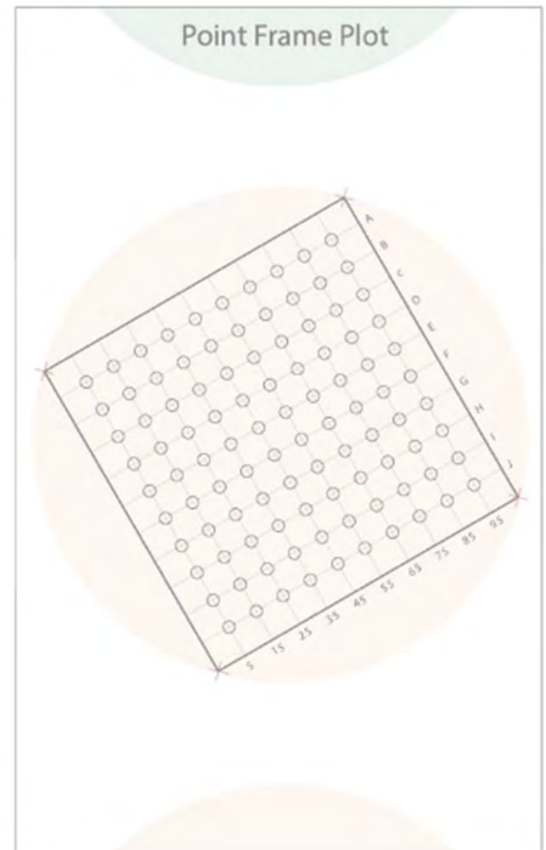

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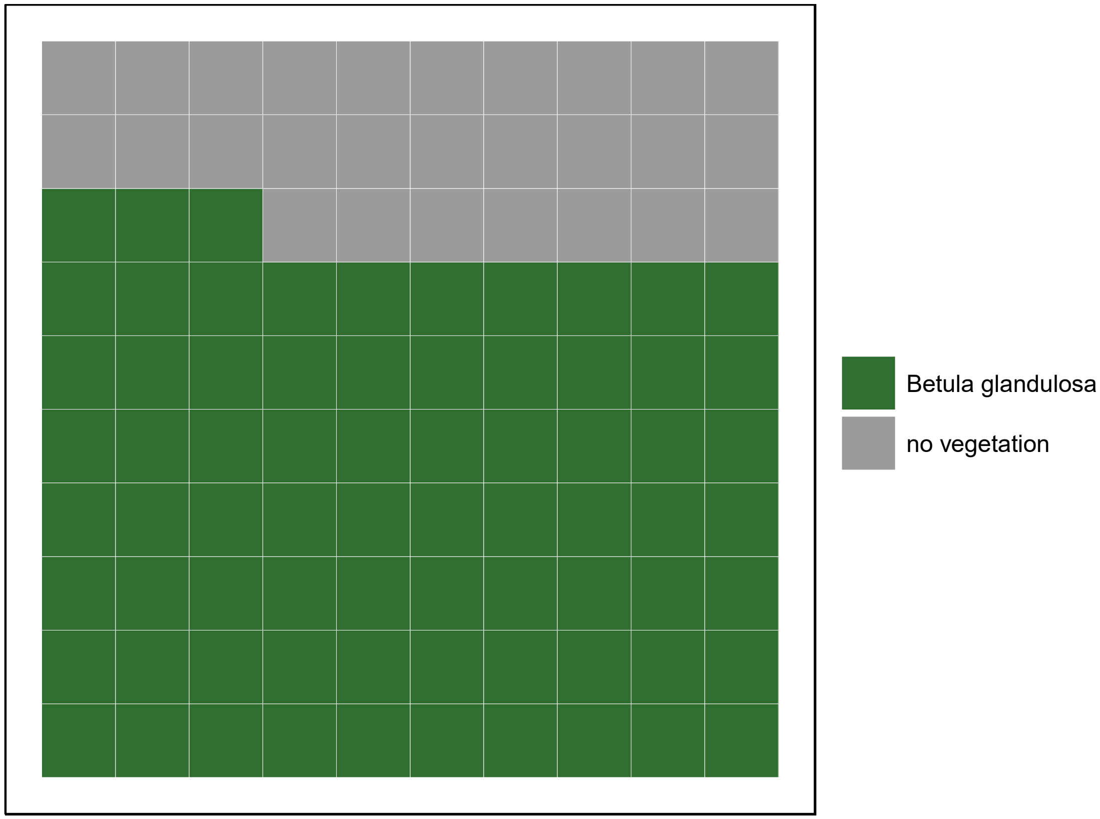

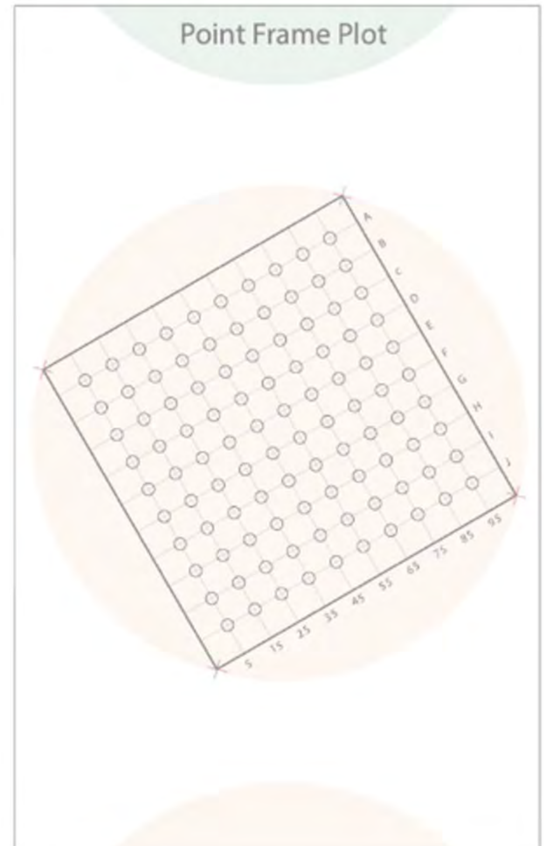

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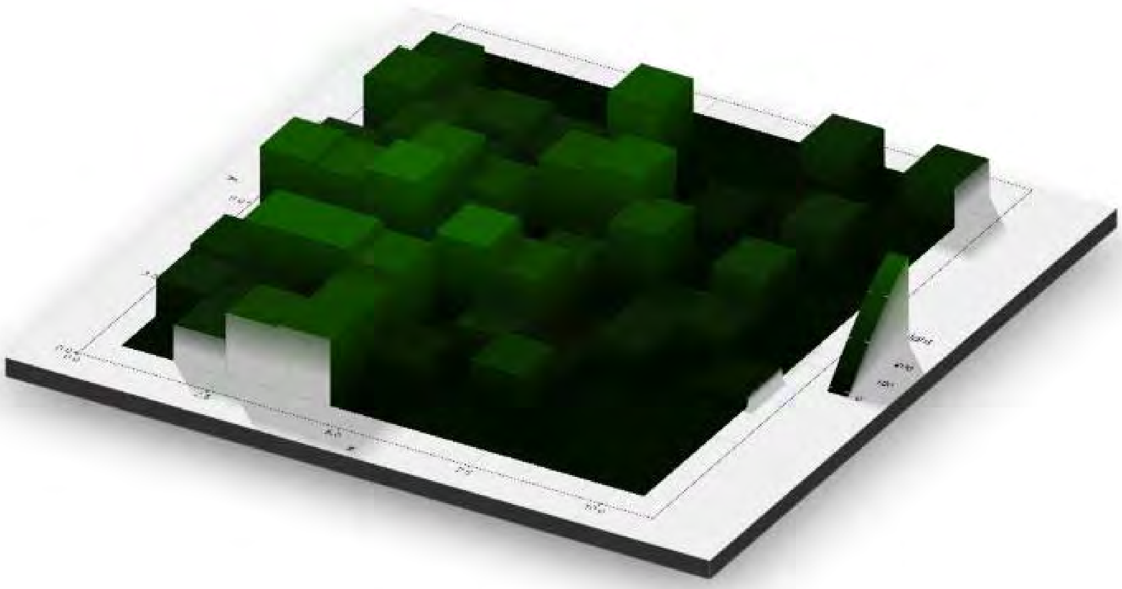
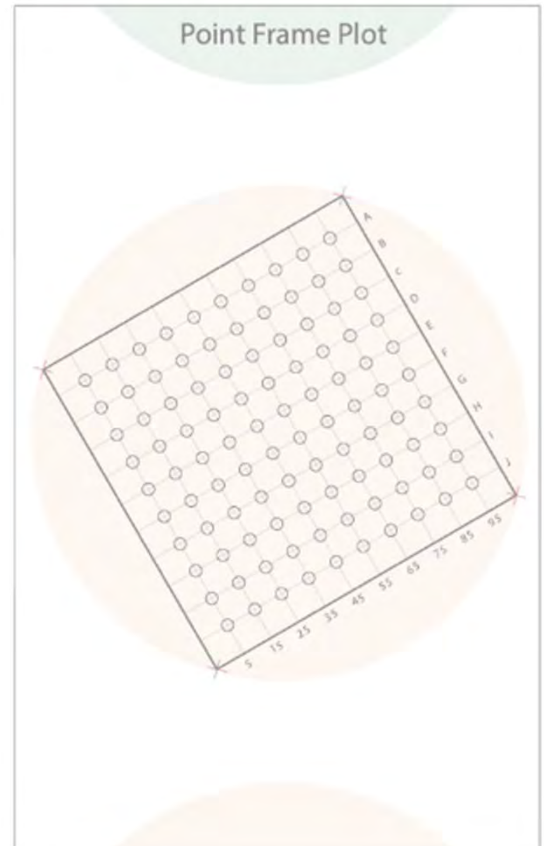
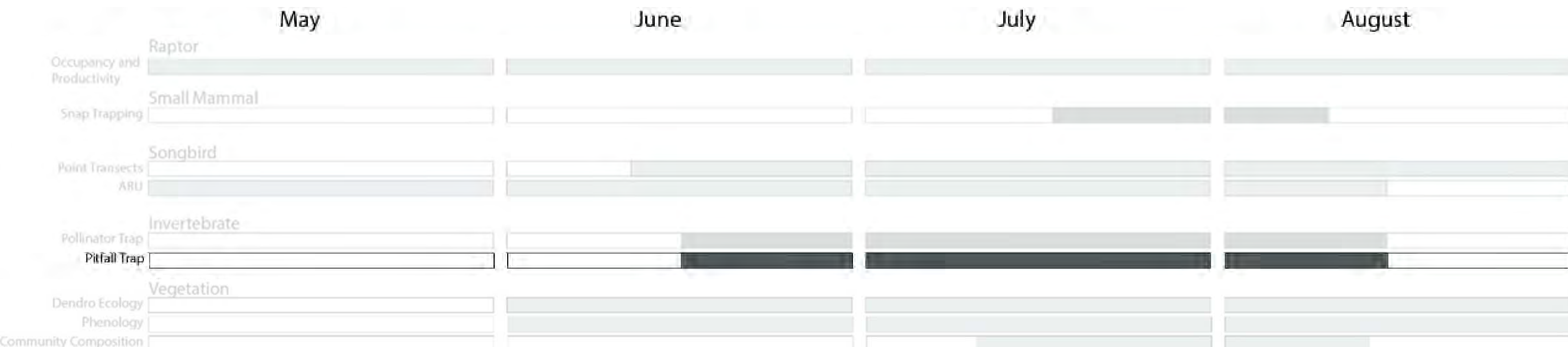
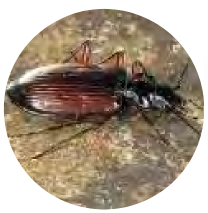
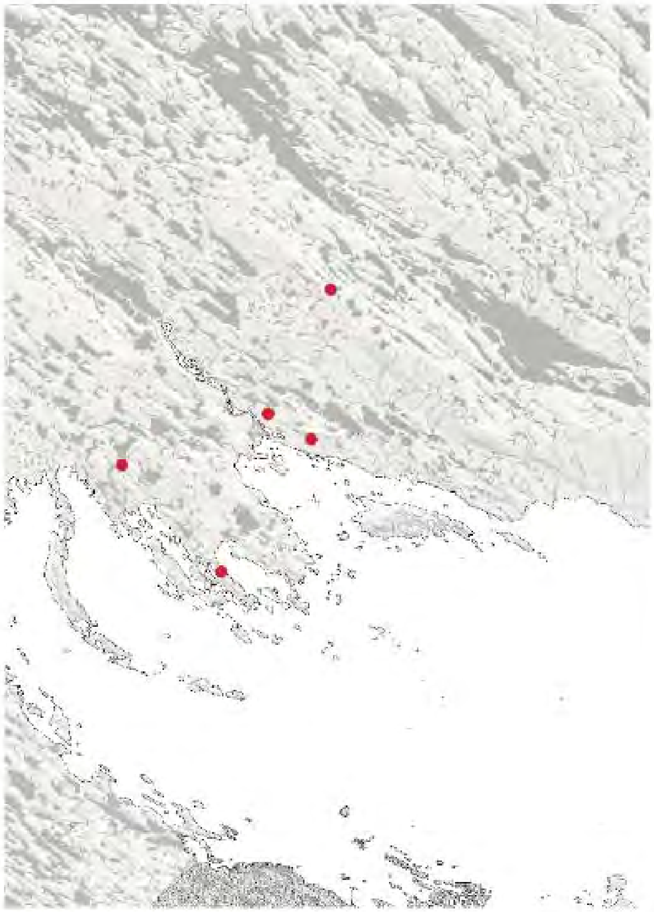


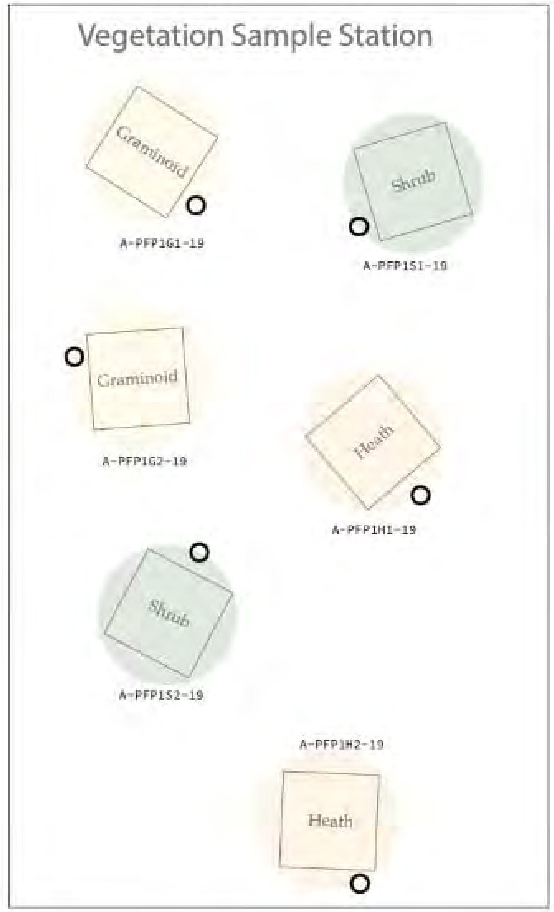


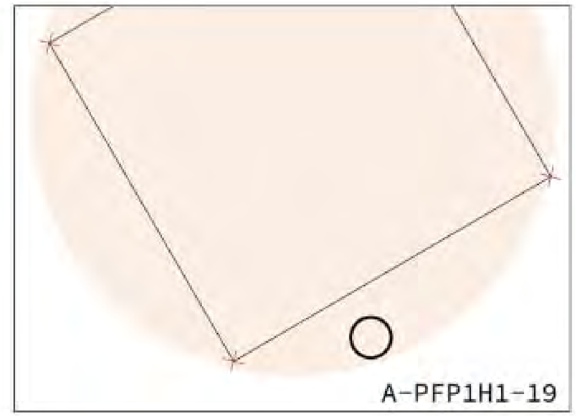

May
June
July
August
Raptor
Occupancy and Productivity
Small Mammal
Snap Trapping
Songbird
Point Transects
ARU
Invertebrate
Pollinator Trap
Pitfall Trap
Vegetation
Dendro Ecology
Phenology
Community Composition

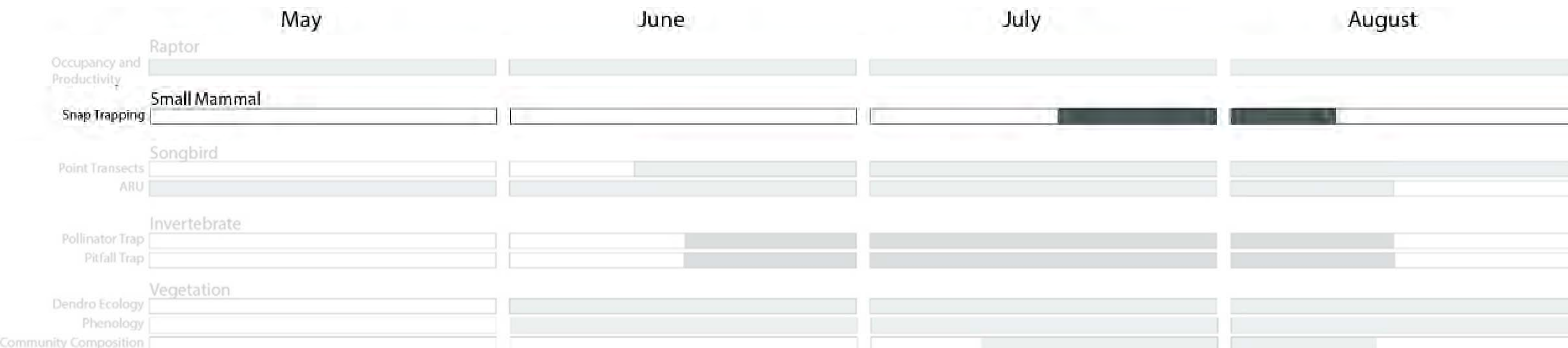
Community Composition










May
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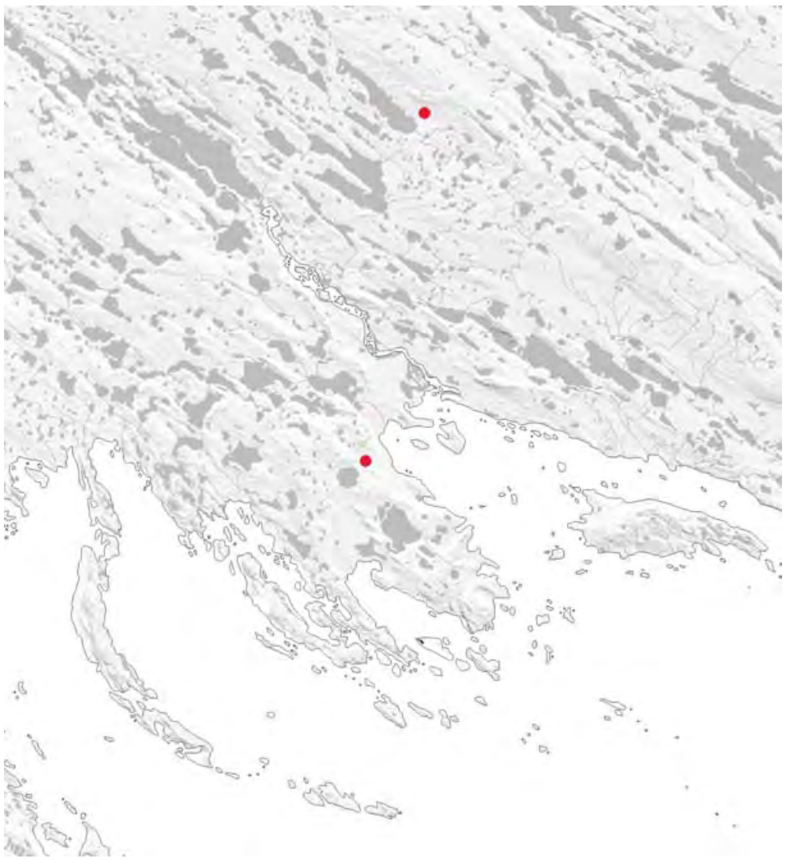
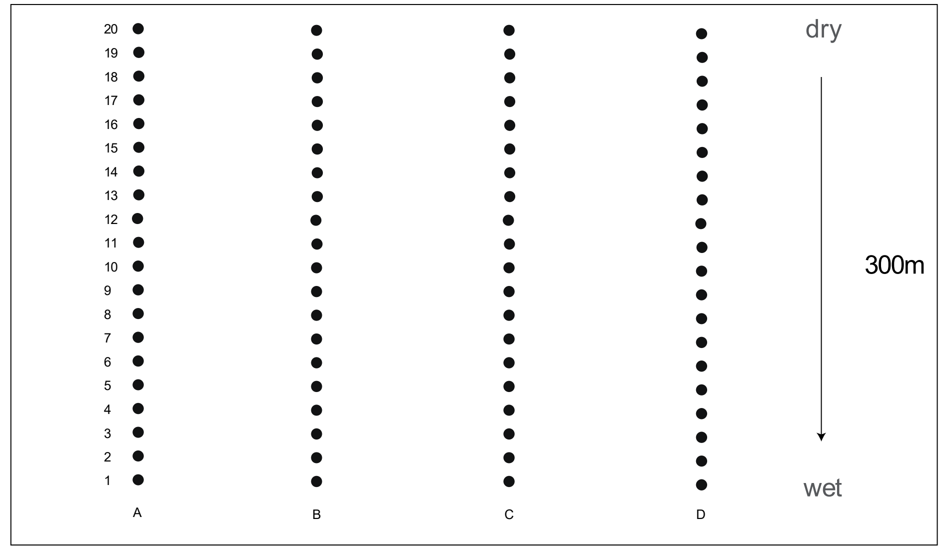
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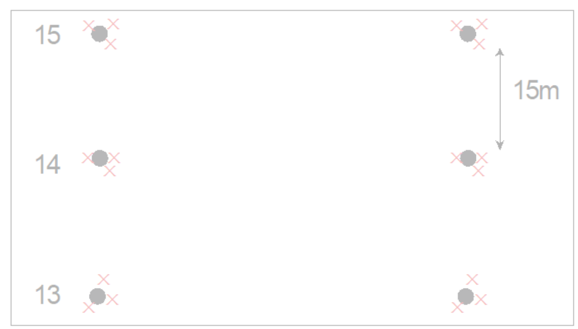
300m
wet

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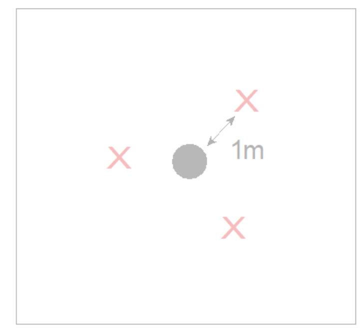
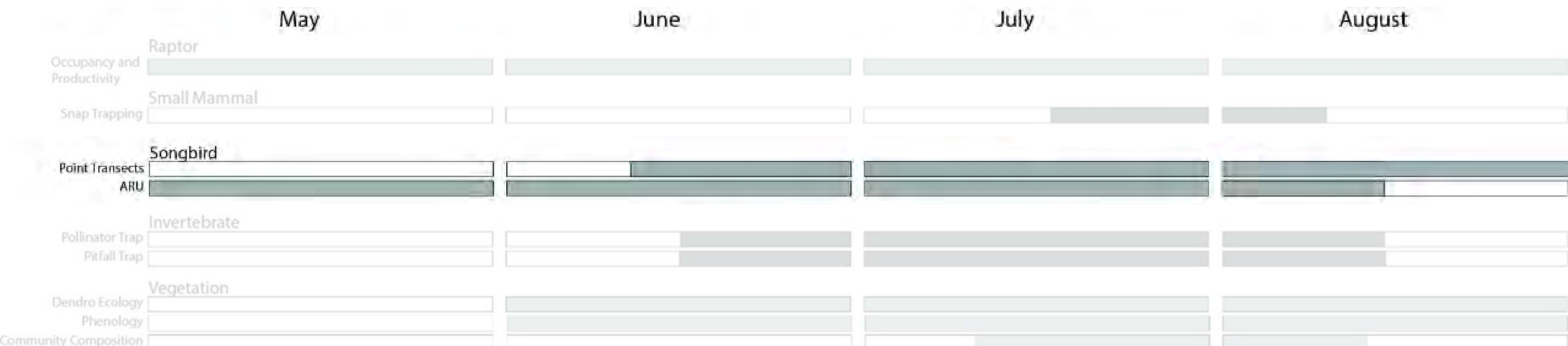
13
15m

1m


May
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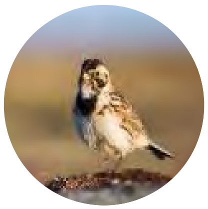

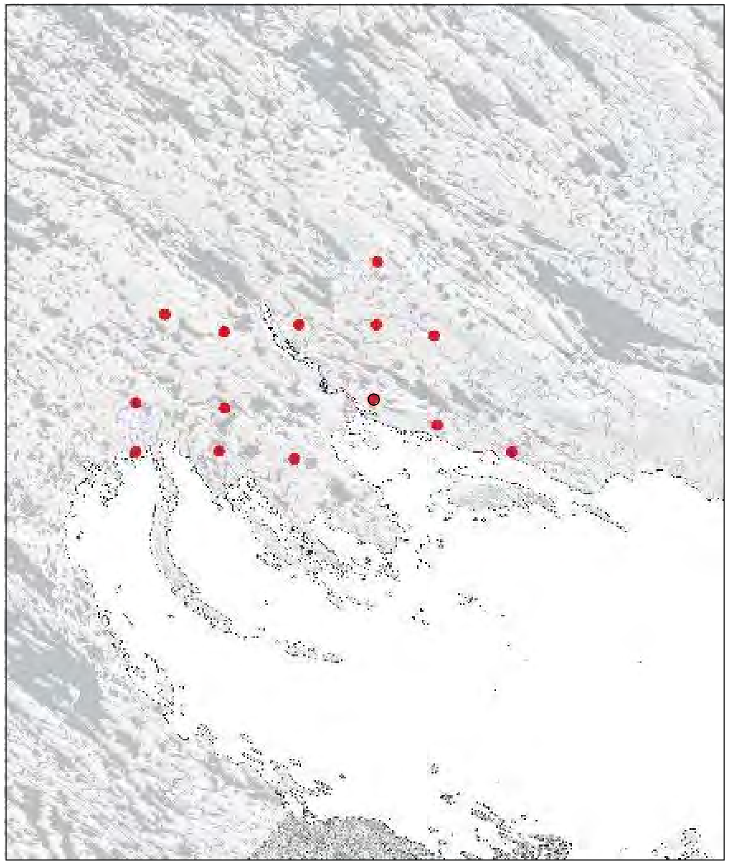

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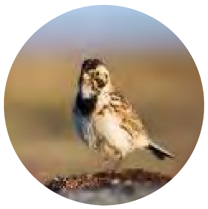


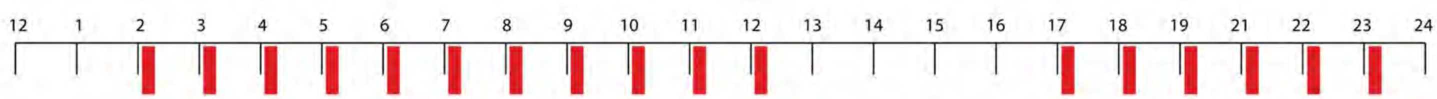
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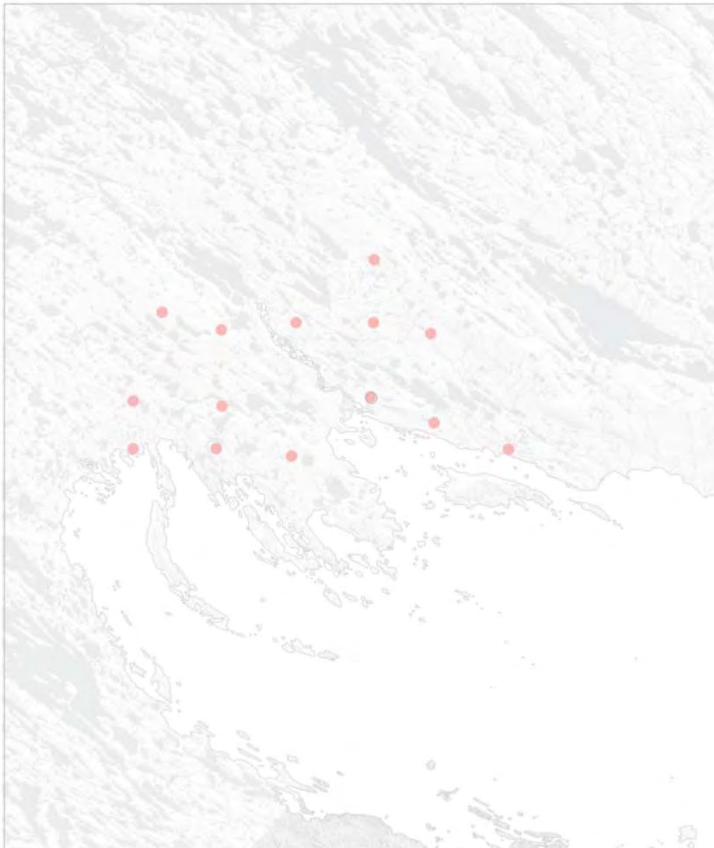
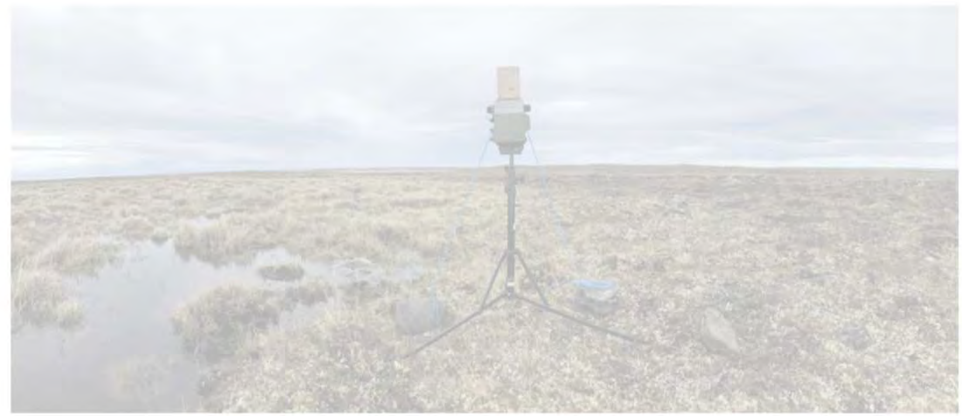
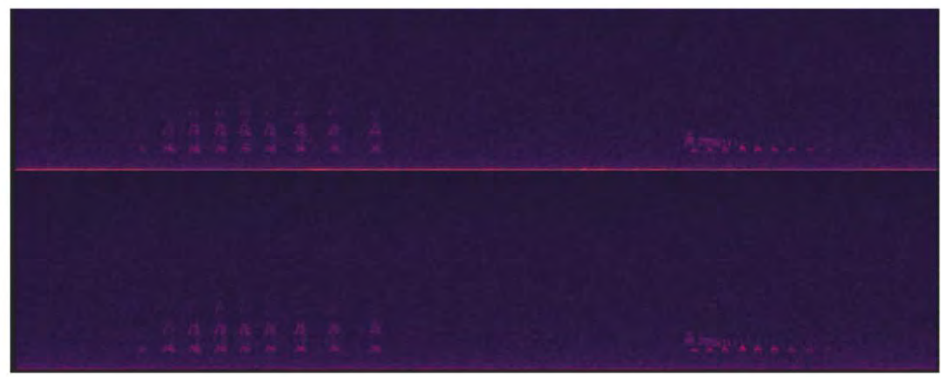

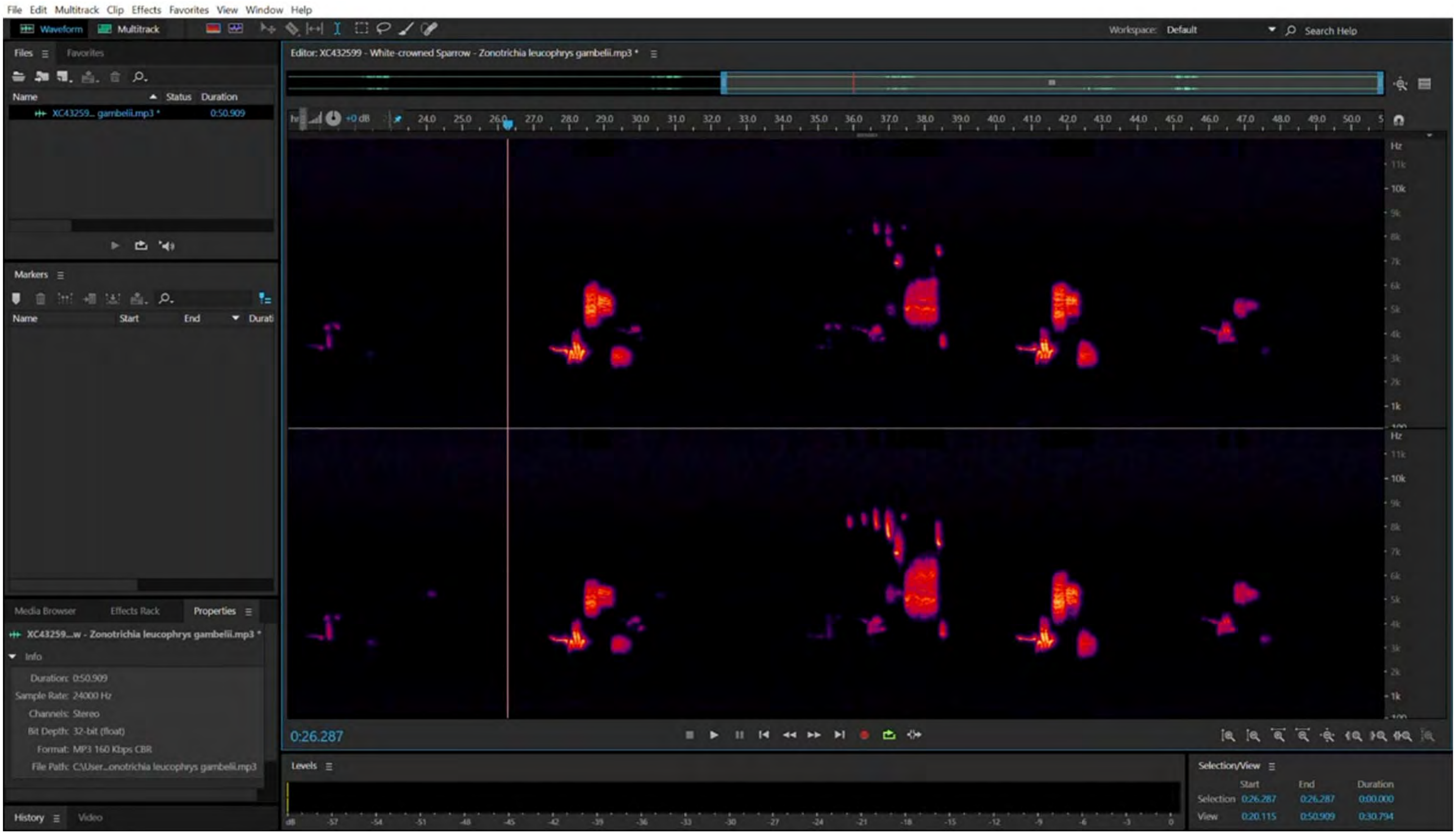
File Edit Multitrack Clip Effects Favorites View Window Help
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Multitrack
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Files
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Name
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Video
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Levels
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Selection
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View
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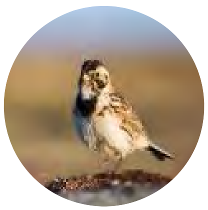

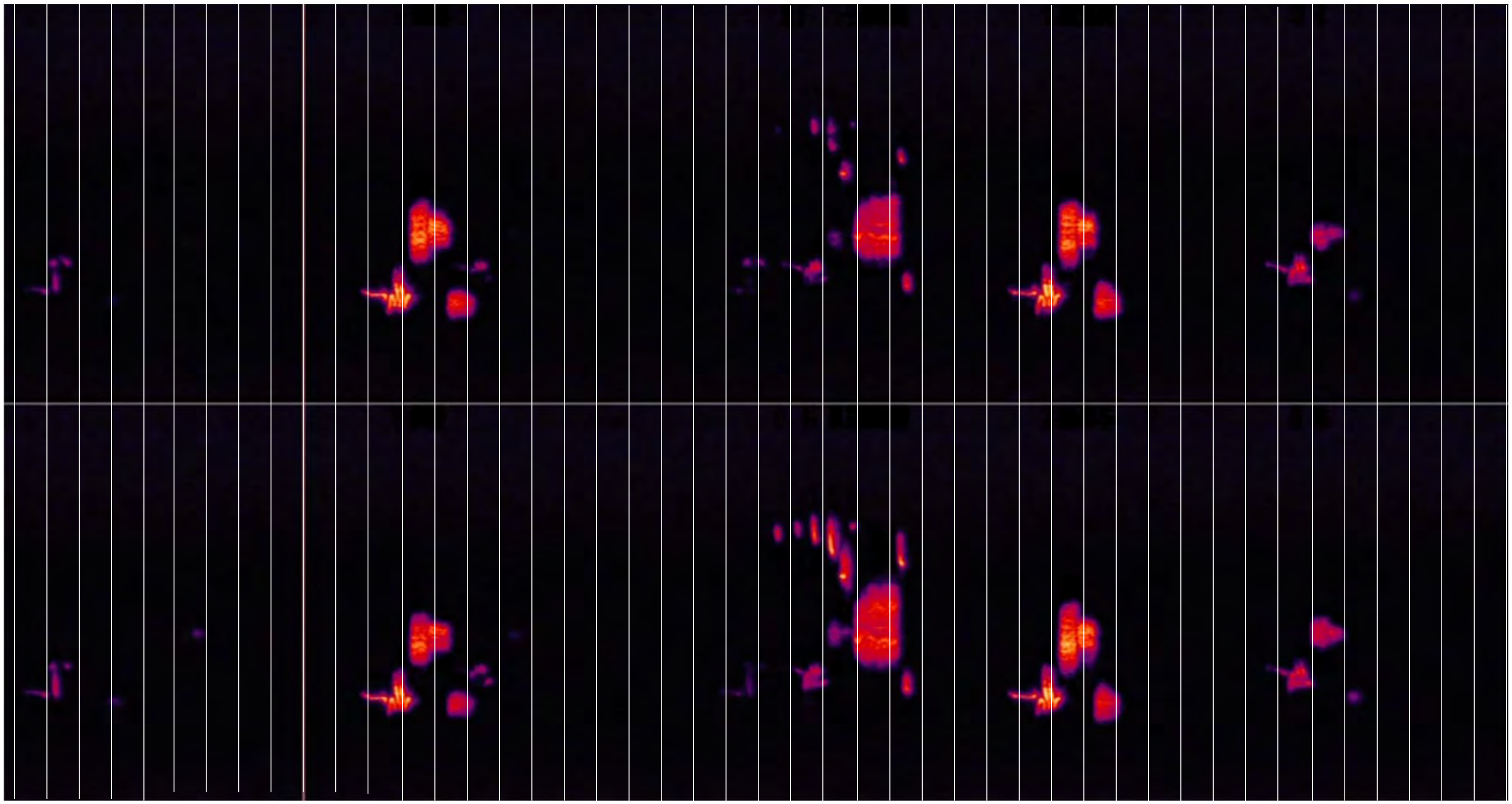

Ecology and Evolution

Open Access

Using bioacoustics to examine shifts in songbird phenology

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Keywords
Acoustic Complexity Index, Alaska, climate change, Glacier Bay, monitoring, songbirds, soundscape.

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Funding Information
No funding information provided.

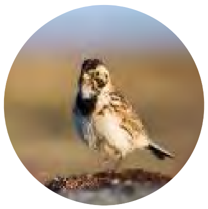
Received: 29 November 2015; Revised: 13 May 2016; Accepted: 16 May 2016

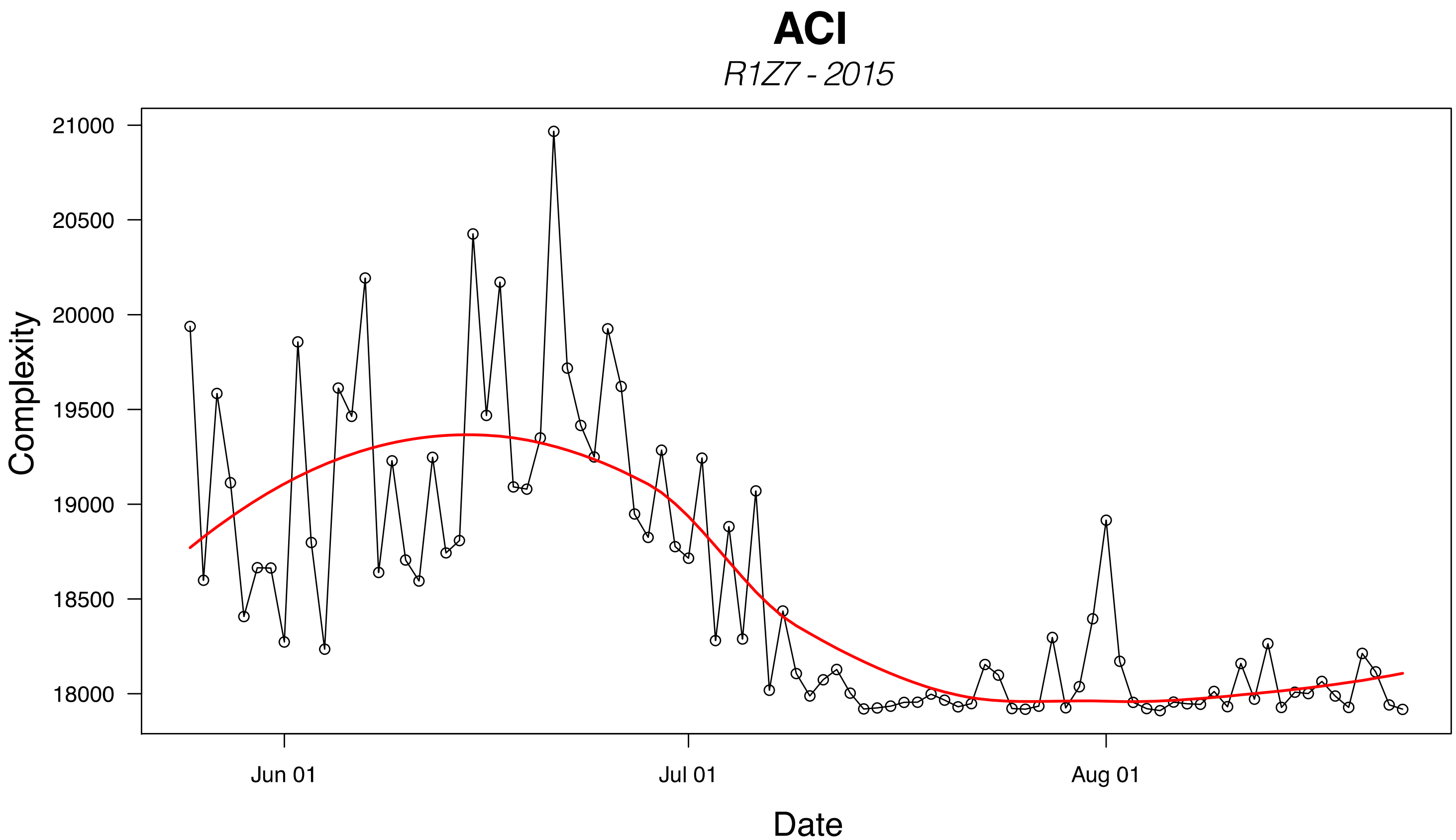
Ecology and Evolution 2016; 6(14): 4697–4710

doi: 10.1002/ece3.2242

Abstract

Monitoring patterns in biodiversity and phenology have become increasingly important given accelerating levels of anthropogenic change. Long-term monitoring programs have reported earlier occurrence of spring activity, reflecting species response to climate change. Although tracking shifts in spring migration represents a valuable approach to monitoring community-level consequences of climate change, robust long-term observations are challenging and costly. Audio recordings and metrics of bioacoustic activity could provide an effective method for monitoring changes in songbird activity and broader biotic interactions. We used 3 years of spring and fall recordings at six sites in Glacier Bay National Park, Alaska, an area experiencing rapid warming and glacial retreat, to examine the utility of bioacoustics to detect changes in songbird phenology. We calculated the Acoustic Complexity Index (ACI), an algorithm representing an index of bird community complexity. **Abrupt changes in ACI values from winter to spring corresponded to spring transition, suggesting that ACI may be an effective, albeit coarse metric to detect the arrival of migrating songbirds.** The first peak in ACI shifted from April 16 to April 11 from 2012 to 2014. Changes in ACI were less abrupt in the fall due to weather events, suggesting spring recordings are better suited to indicate phenology. To ensure changes in ACI values were detecting real changes in songbird activity, we explored the relationship between ACI and song of three species: varied thrush (*Ixoreus naevius*), Pacific wren (*Troglodytes pacificus*), and ruby-crowned kinglet (*Regulus calendula*). ACI was positively related to counts of all species, but most markedly with song of the varied thrush, the most common species in our recordings and a known indicator of forest ecosystem health. We conclude that acoustic recordings paired with bioacoustic indices may be a useful method of monitoring shifts in songbird communities due to climate change and other sources of anthropogenic disturbance.

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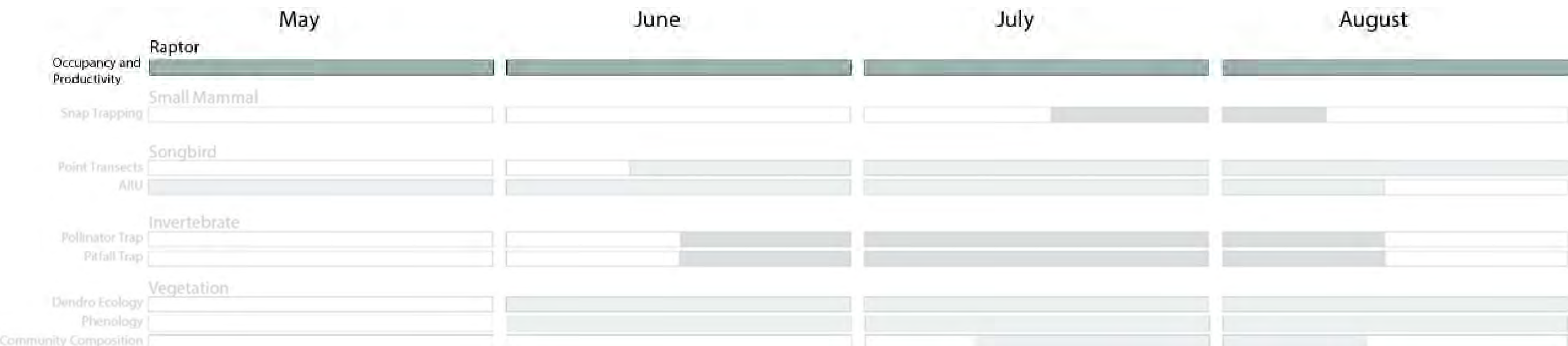
R1Z7 - 2015
Complexity
Date
21000
20500
20000
19500
19000
18500
18000
Jun 01
Jul 01
Aug 01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Songbird
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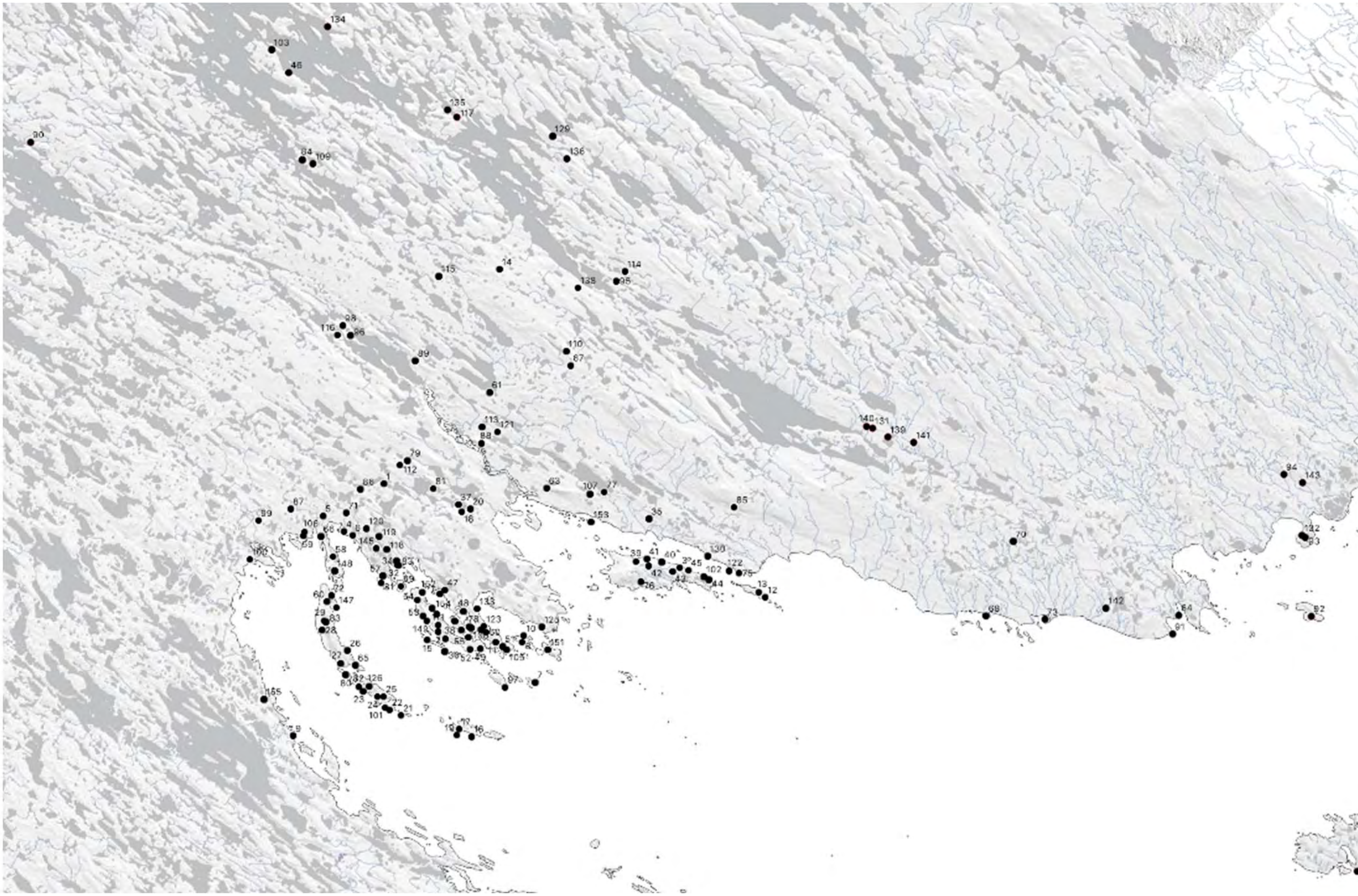
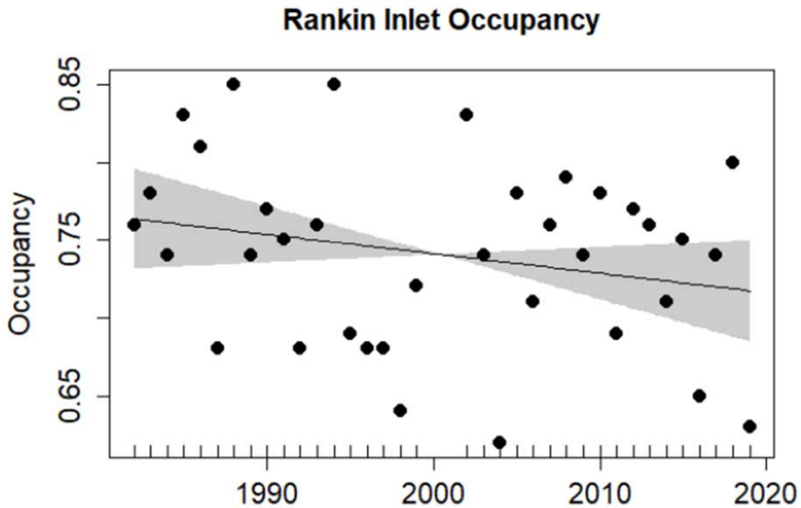
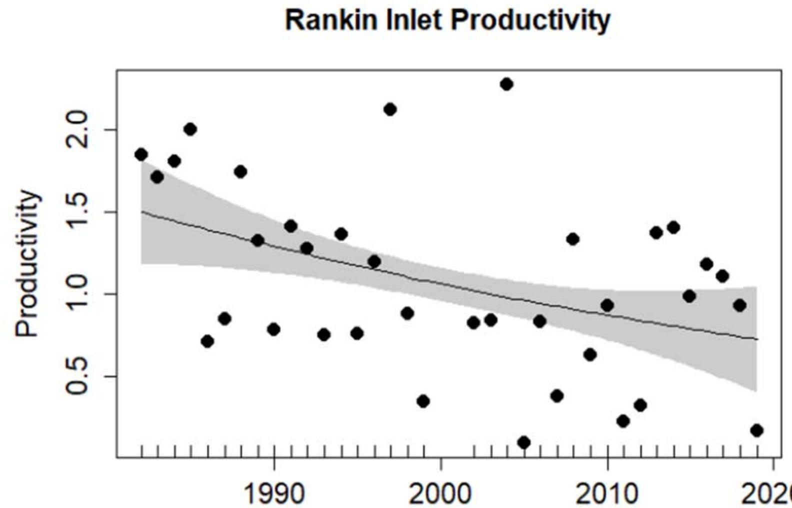
ARU
Invertebrate
Pollinator Trap
Pitfall Trap
Vegetation
Dendro Ecology
Phenology
Community Composition




Rankin Inlet Occupancy
Occupancy
0.65
0.75
0.85
1990
2000
2010
2020

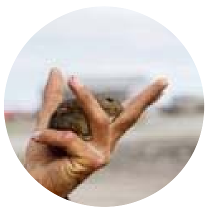

Rankin Inlet Productivity
Productivity
0.5
1.0
1.5
2.0
1990
2000
2010
2020


2011-07-16 01:48:29 M 1/1 5°C
SITE18
RECONYX


2012-07-29 2:26:22 AM M 1/1 7°C
SITE67

CALVING GROUNDS –EXTENSIVE SAMPLING		RANKIN INLET – INTENSIVE SAMPLING
2015 – 2016 < 50 images passive sampling		1980 – 2019 ≥ 1200 nest*years
2015 – 2016 ≥ 181, 960 minutes passive sampling 2015 – 2016 > 48, 000 images passive sampling		2015 – 2019 ≥ 550 1-km transects active sampling 2019 ≥ 73, 130 minutes passive sampling
2012 - 2015 ≥ 192 plot*yrs., 695 caribou pellets 2012 - 2015 ≥ 192 plot*yrs., 294 sm. mammal pellets 2012 - 2015 ≥ 192 plot*yrs., 294 ptarmigan pellets		2008 – 2019 ≥ 720 trap*nights/yr
		2019 ≥ 17, 377 trap*hours, 376 specimens ID'd
2012 - 2019 ≥ 192 plot*yrs., 3,840 specimens ID'd 2012 - 2019 ≥ 192 plot*yrs., 1920 quadrat photos		2019 ≥ 10 PFPs, 1500 specimens ID'd





Questions?