LTEMP

Long-term Ecological Monitoring Program

Nunavut Wildlife Cooperative Research Unit
Government of Nunavut
University of Alberta

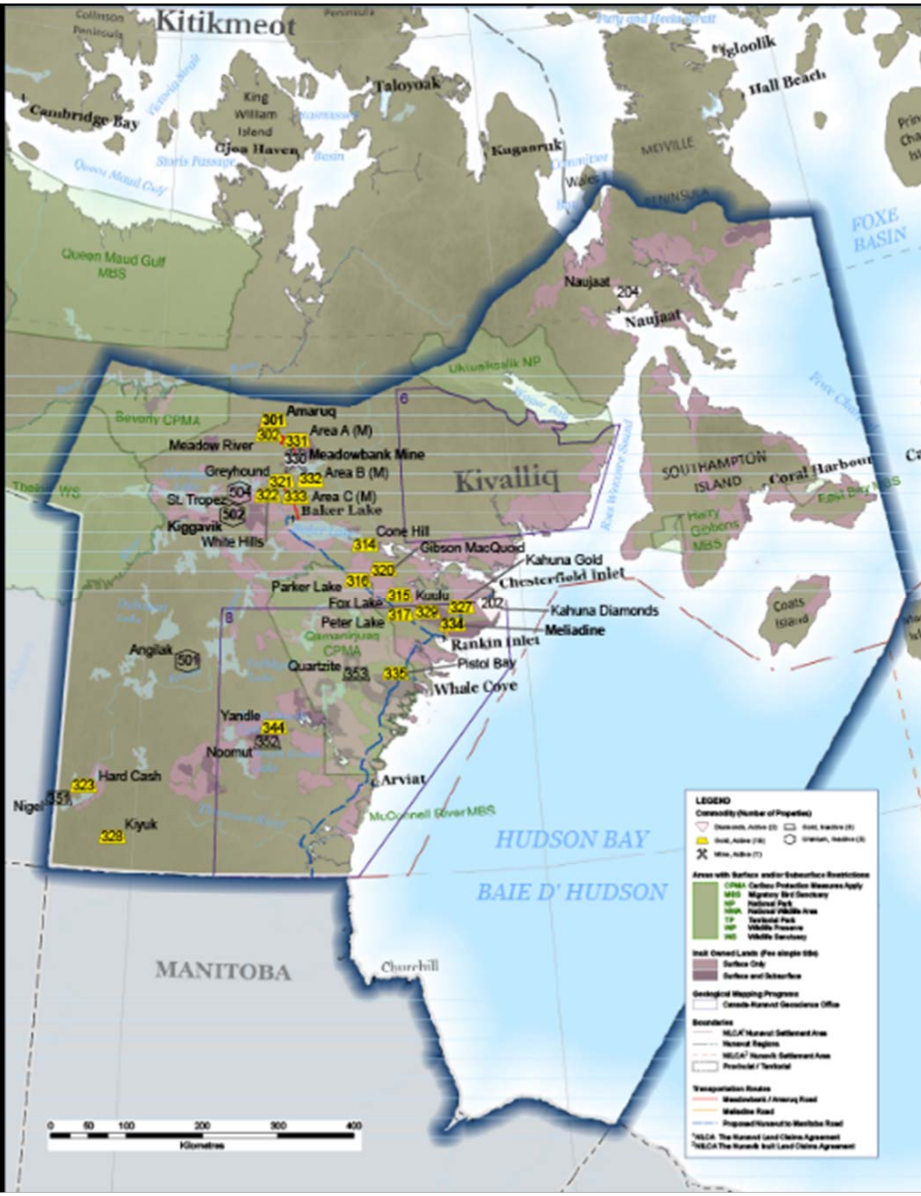
2019 - Nov
Annual Report

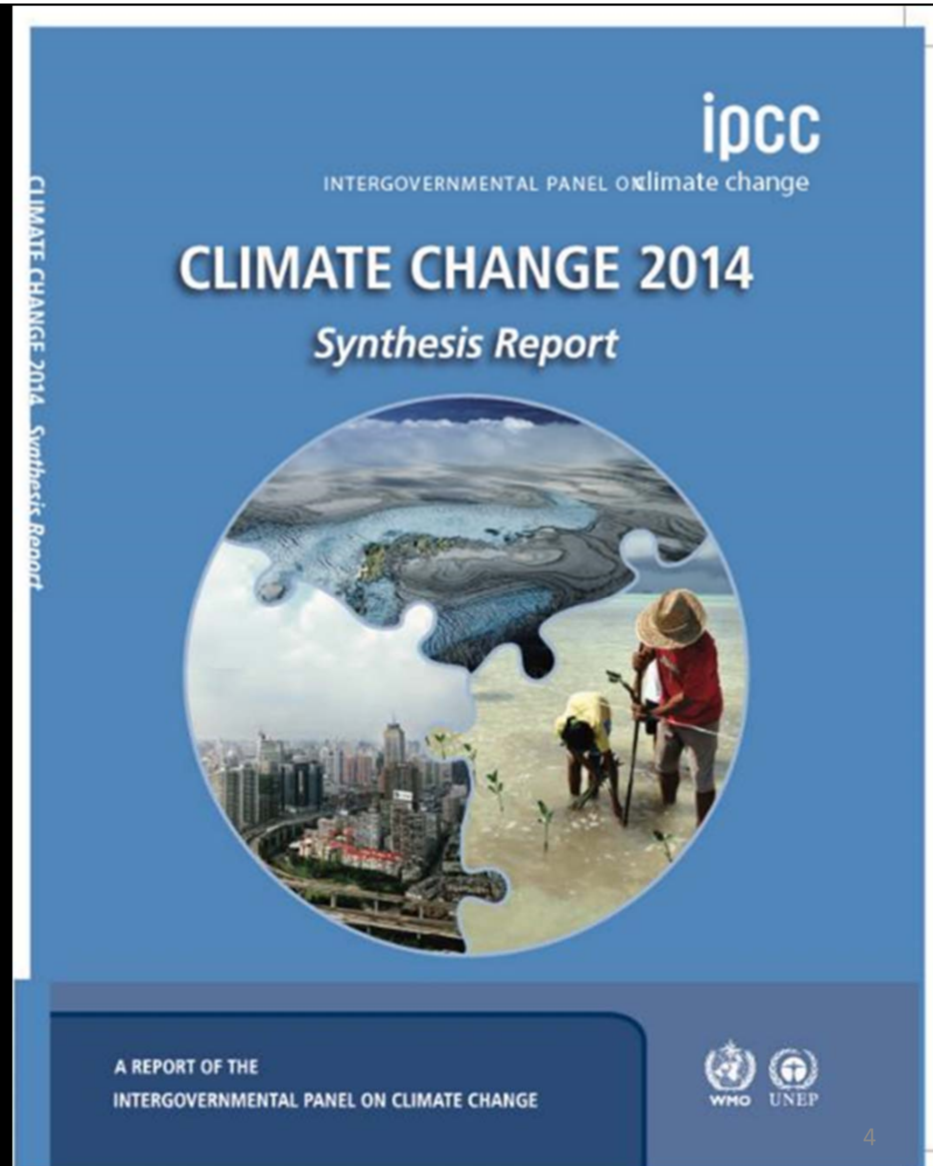
Erik Hedlin
Alastair Franke
Kevin Hawkshaw
Rebekah McKinnon
Nick Gulotta

ᐅᖃᐅᓯᖃᒃᓯᒪᓂᖏᑦ

- ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᑦ ᓴᖅᑭᑎᑦᑎᓚᐅᖅᑐᑦ ᐊᑯᓂᐅᔪᒧᑦ ᐊᕙᑎᖓᓂ ᖃᐅᔨᓴᓂᕐᒧᑦ ᐸᓖᓇᐊᖅ (LTEMP) 2012−ᒥ ᖃᐅᔨᓴᕐᓗᑎ ᐊᕙᑎᖓᓂ ᖁᕝᕙᓯᓐᓂᖓ ᐊᓯᔾᔩᖅᑐᑦ ᐊᑦᑐᐊᓃᓐᑦ ᓯᓚᖓᓄ ᐊᒻᒪ ᐱᕙᓪᓕᐊᑎᑦᑎᓂᕐᒧᑦ.
- ᖃᐅᔨᓴᕐᕕᐅᔪᒥᑦ ᖃᐅᔨᓴᕐᓂᖃᓚᐅᖅᑐᑦ 2012-2013 ᐊᒻᒪ 2015-2016. ᖁᕝᕙᓯᓐᓂᖏᓐᓄᑦ ᓄᖅᑲᖅᑕᖅᑐᑦ ᐃᖅᑲᓇᐃᔭᖅᑎᓂᑦ, ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᐃᓱᒪᓕᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᖃᑎᖃᕐᓗᑎ ᐃᓕᓐᓂᐊᕐᓂᓕᓂᕐᒨᖓᔪᓂᑦ ᐱᓕᕆᖃᑎᖏᓐᓂ ᓴᓇᔪᑎ ᐊᑯᓂᐅᔪᒧᑦ ᐱᔪᓐᓇᓂᖏᓐᓄᑦ ᐱᓕᕆᔭᐅᒍᓐᓇᖅᑐᓂᑦ ᐱᓕᕆᐊᒥᑦ.
- ᑐᑭᓯᐅᒪᖃᑎᒌᓐᓂᖏᑦ ᐊᖏᕈᑦ ᓯᓚᑦᑐᓴᕐᕕᒃᔪᐊᒧᑦ ᐃᐅᐚᑕ, ᐱᓕᕆᕝᕕᖓ ᖃᐅᔨᓴᕐᓂᐅᔪᓂᑦ, ᐊᒻᒪ ᐋ. ᕗᕌᖕᑭ ᓴᖅᑭᖅᑎᑕᐅᓚᐅᖅᑐᖅ ᐱᓕᕆᐊᖃᕐᓗᓂ ᐱᓕᕆᖃᑎᖏᓐᓂ ᐃᓕᓐᓂᐊᓂᕐᒧᑦ ᖃᐅᔨᓴᖅᑎᓂᑦ ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᖏᓐᓄᑦ ᑐᑭᒧᐊᖅᑎᑕᐅᔪᖅ ᖃᐅᔨᓴᓂᕐᒧᑦ ᐱᓕᕆᐊᑦ, ᓵᕐᓗ ᐊᑯᓂᐅᔪᒧᑦ ᐊᕙᑎᖓᓂ ᖃᐅᔨᓴᓂᕐᒧᑦ ᐸᓖᓇᐊᖅ.

- ᑐᕌᒐᖅ: ᖃᐅᔨᓴᕐᓗᒍ ᐊᕙᑎᖅ ᐊᐅᔭᒃᑰᕐᕕᕆᕙᑦᑕᖅᑎᑦ ᖃᒪᓂᕐᔪᐊᖅ ᑐᑦᑐᖅᑎᓐᓄᑦ.
- ᐃᓱᒫᓗᕆᔭᓪᓗᐊᑕᐅᔪᑦ: 1) ᑎᑎᕋᖅᑕᐅᓂᖅᑎᑦ ᐊᑯᓂᐅᔪᒧᑦ ᐊᓯᔾᔨᖅᑐᑦ ᐱᔾᔪᑎᒋᓪᓗᒍ ᓯᓚᖓ ᐊᓯᔾᔨᕐᓂᖓᓄᑦ, ᐊᒻᒪ 2) ᓴᖅᑭᑎᑦᑎᓂᖅ ᑐᓐᖓᓂᕕᖅᑎᓐᓂ ᖃᓄᐃᓐᓂᖅᑎᓐᓂ (ᐅᔭᕋᓐᓂᐊᕋᓵᖃᐅᖅᑐᑦ ᐊᕕᑦᑐᖅᓯᒪᔪᖅ).
  - <u>ᖃᐅᔨᓴᑦᑎᐊᖃᑦᑕᕐᓂᖅ</u> ᐱᓕᕆᐊᖑᔪᖅ ᐊᕐᕌᒍᑕᒫᑦ ᖃᓂᕆᔭᖓᐊᓂ ᓄᓇᓕᖓᓂ ᑲᖅᑭᕐᓵᓂᖅ
  - <u>ᖃᐅᔨᓴᑦᑎᐊᖃᑦᑕᕐᓂᖅ</u> ᓄᕋᓕᐅᕐᕕᖅᑎᓐᓂ ᓄᓇᖅᑎᓐᓂ ᖃᒪᓂᕐᔪᐊᖅ ᑐᑦᑐᖅᑎᓐᓄᑦ
- ᓄᓇᕗᒻᒥ ᑕᒪᐃᓐᓂᒃ ᖃᐅᔨᓴᕈᑎᓄᑦ ᐸᕐᓇᐅᑏᑦ (NGMP) ᐊᖏᔪᑳᓚᐅᔪᖅ, ᐊᖏᔪᑳᓚᐅᔪᖅ, ᐊᑯᓂᐅᔪᒧᑦ ᑮᓇᐅᔭᖃᖅᑎᑦᑎᓂᕐᒧᑦ ᐱᓕᕆᖃᑎᐅᔪᖅ (2019/20-2021/22).
- ᓄᓇᕗᒻᒥ ᓯᓚᑦᑐᓴᕐᕕᒃ ᐊᒻᒪ ᑭᕙᓪᓕᕐᒥ ᐃᓄᐃᑦ ᑐᔾᔨᖃᑎᒌᑦ ᐃᑲᔪᖅᑐᑦ ᐊᕙᑎᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᐊᒥ ᐃᓕᓐᓂᐊᖅᑎᓂᑦ ᐃᖅᑲᓇᐃᔭᖅᑎᑕᐅᓂᖅᑎᓐᓄᑦ ᐃᓕᓐᓂᐊᓯᓐᓈᑦ ᐃᖅᑲᓇᐃᔭᓂᕐᒧᑦ ᐱᓕᕆᐊᒥᑦ.
- ᒪᕐᕉᒃ ᓄᓇᕗᒻᒥ ᐃᓅᒃ ᐃᖅᑲᓇᐃᔭᖅᑎᑕᐅᔪᑦ ᐊᑐᓂ ᐊᕐᕌᒍᓂ
  - ᐱᖃᑕᐅᔪᖅ ᖃᐅᔨᓴᕐᑯᐅᔪᒥᑦ ᐱᓕᕆᐊᓕᒫᖑᔪᓂᑦ
  - ᐊᐅᓪᓛᖅᑕᐅᓂᖅᑎᑦ ᓄᓇᓖᒻᒥ ᖃᐅᔨᒪᔭᐅᔪᑦ ᐊᒻᒪ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖅᑎᑦ
- ᐊᑯᓂᐅᔪᒧᑦ ᐊᕙᑎᖓᓂ ᖃᐅᔨᓴᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᐱᔪᒥᓇᖅᑐᖅ ᓄᓇᓖᒻᒧᑦ ᐊᐅᓚᑕᐅᔪᒧᑦ ᖃᐅᔨᓴᓂᕐᒥᑦ ᐊᑕᖏᕐᓗᓂ ᐃᓚᓕᐅᔾᔭᐅᒍᓐᓇᖅᑐᖅ.


Kitikmeot
Cambridge Bay
King William Island
Gjoa Haven
Taloyoak
Kugaaruk
Igloolik
Hall Beach
MELVILLE PENINSULA
FOXE BASIN
Queen Maud Gulf MBS
Naujaat
204
Ukkusiksalik NP
Amaruq
301
302
331
Area A (M)
Meadow River
Meadowbank Mine
330
Greyhound
321
332
Area B (M)
Kivalliq
SOUTHAMPTON ISLAND
Coral Harbour
St. Tropez
504
322
333
Area C (M)
Baker Lake
Kiggavik
502
Cone Hill
White Hills
314
Gibson MacQuoid
Kahuna Gold
320
Chesterfield Inlet
Parker Lake
316
Fox Lake
315
Kuulu
327
202
Kahuna Diamonds
Peter Lake
317
326
334
Meliadine
Rankin Inlet
Coats Island
Angilak
501
Pistol Bay
Quartzite
353
335
Whale Cove
Yandle
344
352
Noomut
Arviat
Hard Cash
323
Nigel
351
Kiyuk
328
HUDSON BAY
BAIE D' HUDSON
MANITOBA
Churchill
LEGEND
0
50
100
200
300
400
Kilometres


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

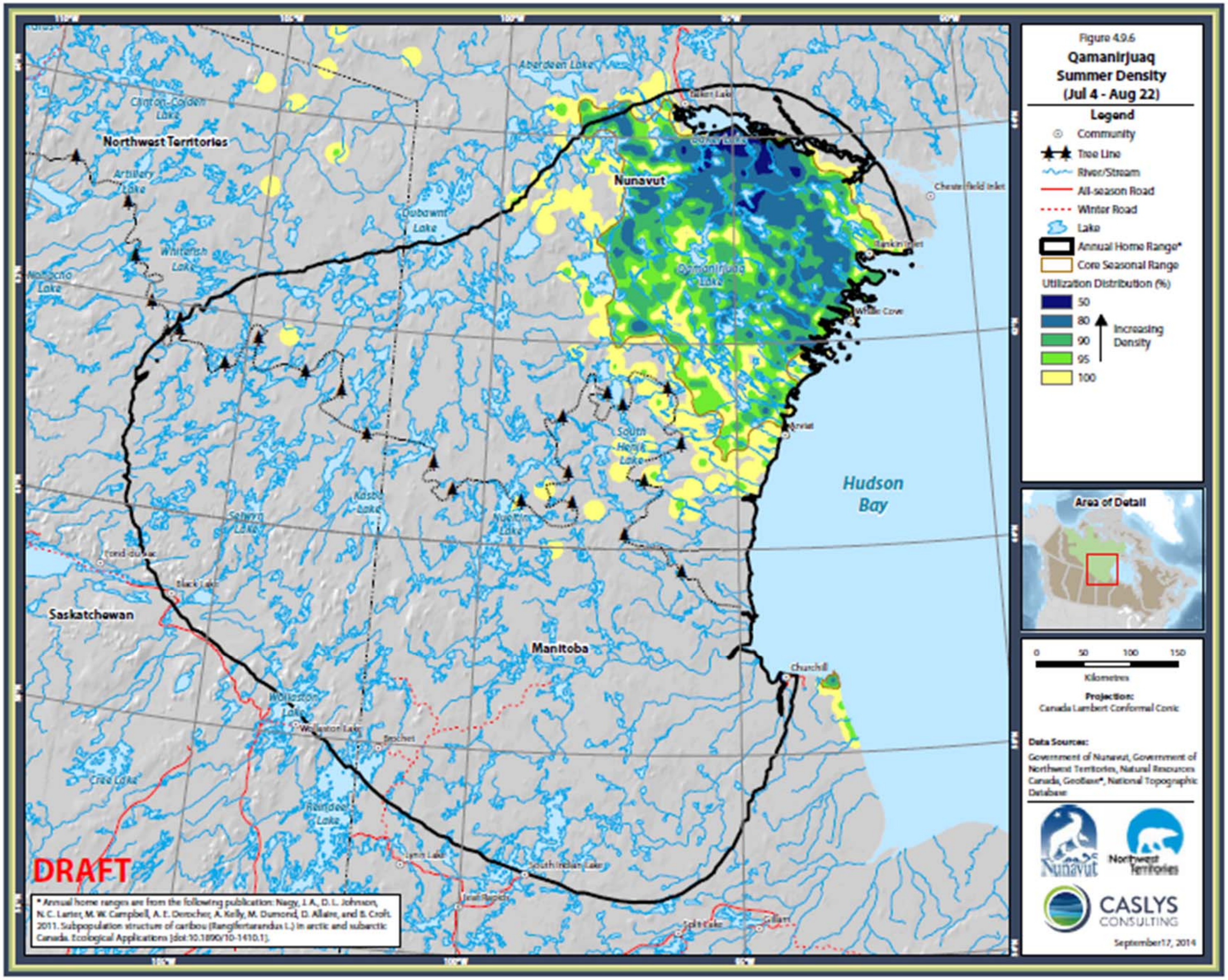


Figure 4.9.6
Qamanirjuaq
Summer Density
(Jul 4 - Aug 22)
Legend
Community
Tree Line
River/Stream
All-season Road
Winter Road
Lake
Annual Home Range*
Core Seasonal Range
Utilization Distribution (%)
50
80
90
95
100
Increasing Density
Area of Detail
0 50 100 150
Kilometres
Projection:
Canada Lambert Conformal Conic
Data Sources:
Government of Nunavut, Government of Northwest Territories, Natural Resources Canada, GeoBase*, National Topographic Database
CASLYS CONSULTING
September17, 2014
Aberdeen Lake
Clinton-Colden Lake
Northwest Territories
Artillery Lake
Dubawnt Lake
Whitefish Lake
Nunavut
Baker Lake
Chesterfield Inlet
Rankin Inlet
Qamanirjuaq Lake
Whale Cove
Arviat
South Henik Lake
Hudson Bay
Kasba Lake
Nueltin Lake
Selwyn Lake
Fond-du-Lac
Black Lake
Saskatchewan
Manitoba
Churchill
Wollaston Lake
Brochet
Cree Lake
Reindeer Lake
Lynn Lake
South Indian Lake
Split Lake
Gillam
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 (Rangifertarandus L.) in arctic and subarctic Canada. Ecological Applications [doi:10.1890/10-1410.1].

MENU 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

ᑭᓯᐊᓂ ᖃᓄᐃᓘᖃᑦᑕᐅᑎᒧᓂᑦ ᐱᔾᔪᑕᐅᔪᑦ, ᖃᐅᔨᓴᕐᓂᖅ ᐊᕙᑎᖕᒐᓂ ᐊᓯᔾᔨᖅᑐᑦ ᐱᒻᒪᖅᑐᖅ.

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]

[1]*Department of Geography and Biodiversity Research Centre, University of British Columbia, Vancouver, BC V6T 1Z4, Canada,* [2]*German Centre for Integrative Biodiversity Research and University of Leipzig, Leipzig 04103, Germany,* [3]*National Ecological Observatory Network, Boulder, CO 80301, USA,* [4]*Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO 80309, USA,* [5]*Periglacial Research Unit, Alfred Wegener Institute, Potsdam 14473, Germany,* [6]*Département de biologie, Université de Sherbrooke, Sherbrooke, QC J1K2R1, Canada*

ᖃᐅᔨᓴᕐᓂᖅ ᐅᑎᖃᑕᖅᑐᓂᑦ ᓯᕗᓗᕆᐊᖏᑦᑐᑦ

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, Evgeniy 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

ᖃᐅᔨᓴᕐᓂᖅ ᐅᑎᖃᑕᖅᑐᓂᑦ ᓯᕗᓗᕆᐊᖅᑐᑦ

Abstract

Climate change may disrupt interspecies 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

Isla H. Myers-Smith[1*], Sarah C. Elmendorf[2,3], Pieter S. A. Beck[4,5], Martin Wilmking[6], Martin Hallinger[6,7], Daan Blok[8], Ken D. Tape[9], Shelly A. Rayback[10], Marc Macias-Fauria[11], Bruce C. Forbes[12], James D. M. Speed[13], Noémie Boulanger-Lapointe[14,15], Christian Rixen[16], Esther Lévesque[14], Niels Martin Schmidt[17], Claudia Baittinger[18], Andrew J. Trant[19,20], Luise Hermanutz[20], Laura Siegwart Collier[20], Melissa A. Dawes[16], Trevor C. Lantz[19], Stef Weijers[21], Rasmus Halfdan Jørgensen[22], Agata Buchwal[23], Allan Buras[6], Adam T. Naito[24], Virve Ravolainen[25], Gabriela Schaepman-Strub[26], Julia A. Wheeler[16,27], Sonja Wipf[16], Kevin C. Guay[5], David S. Hik[28] and Mark Vellend[29]

ᐃᕕᔅᓱᒐᐃᑦ ᓇᓗᓇᐃᔾᖅᓯᒪᓂᖏᑦ

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[1,10] have not occurred at all sites. Models predict that warming of 2–10 °C (ref. 11) could convert as much as half of current

[1]School of GeoSciences, University of Edinburgh, Edinburgh EH9 3FF, UK. [2]National Ecological Observatory Network, 1685 38th Street, Suite 100, Boulder, Colorado 80301, USA. [3]Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, Colorado 80309, USA. [4]European Commission, Joint Research Centre (JRC), Institute for Environment and Sustainability (IES), Forest Resources and Climate Unit, Via Enrico Fermi 2749, 21027 Ispra VA, Italy. [5]Woods Hole Research Center, 149 Woods Hole Road, Falmouth, Massachusetts 02540, USA. [6]Institute of Botany and Landscape Ecology, Ernst-Moritz-Arndt University Greifswald, D-17487 Greifswald, Germany. [7]Department of Ecology, Swedish University of Agricultural Sciences,

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

JOHAN OLOFSSON*, LAURI OKSANEN†‡, TERRY CALLAGHAN§¶, PHILIP E. HULME||, TARJA OKSANEN* and OTSO SUOMINEN†
*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

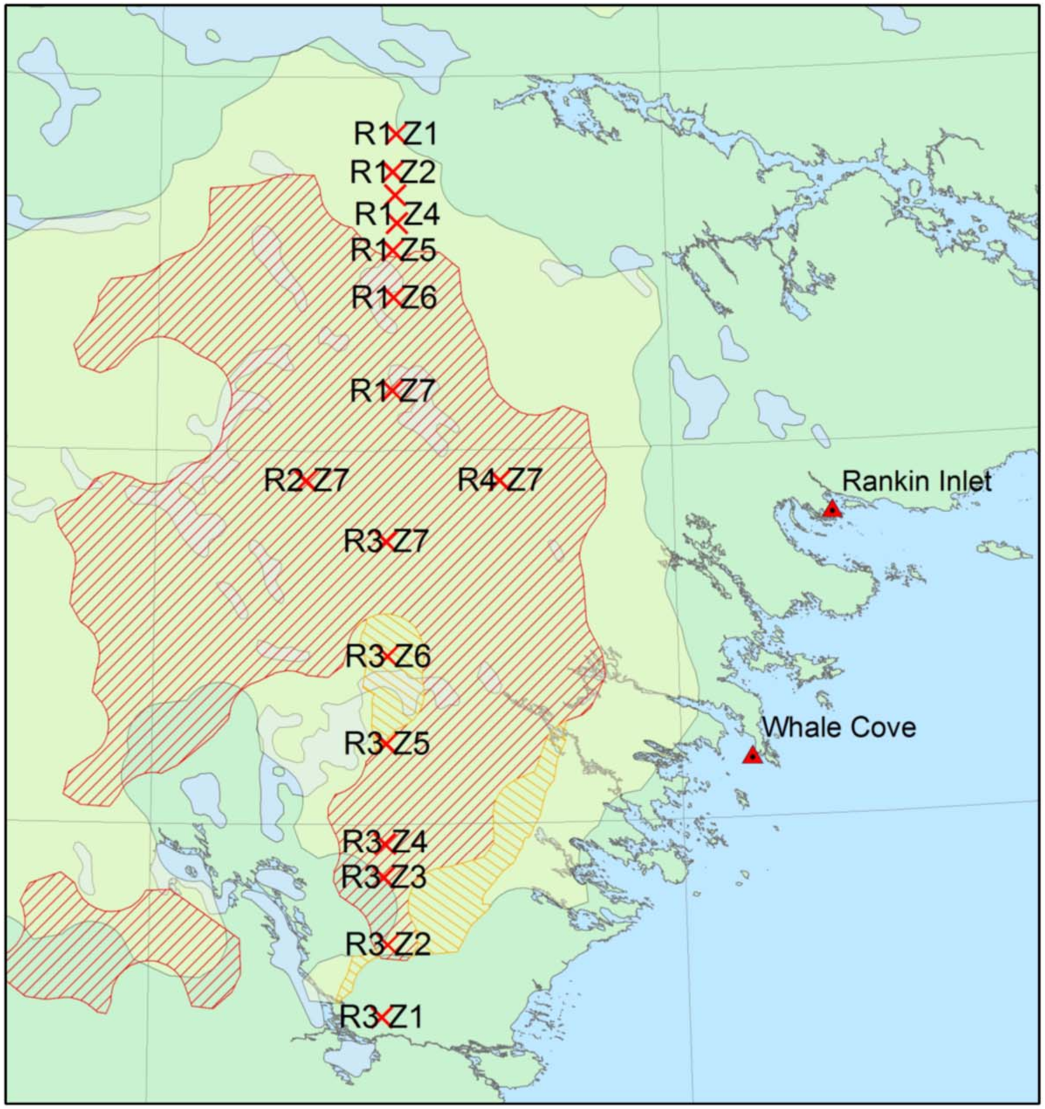
ᐃᕕᔅᓱᒐᐃᑦ ᓇᓗᓇᐃᔾᖅᓯᒪᓂᖏᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ
ᐱᑯᖅᑐᓂᑦ ᖃᐅᔨᓴᓂᕐᒧᑦ

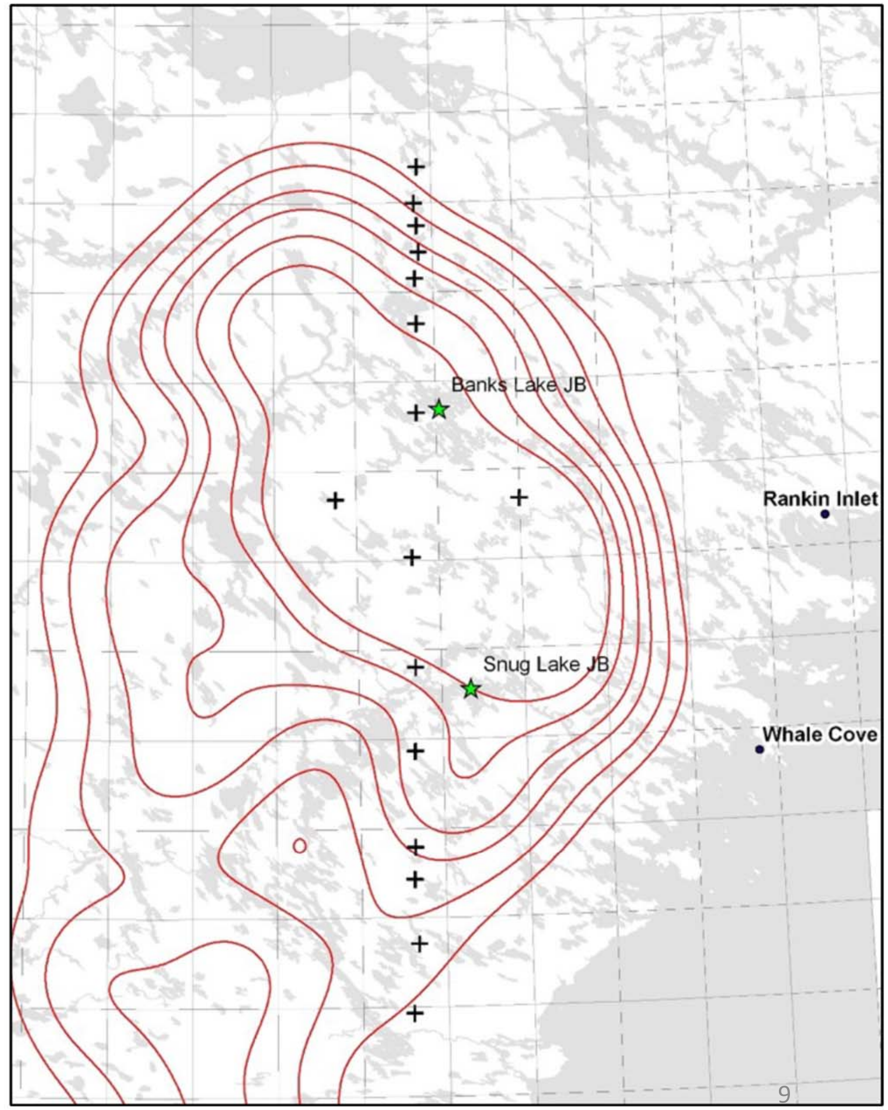
Abstract

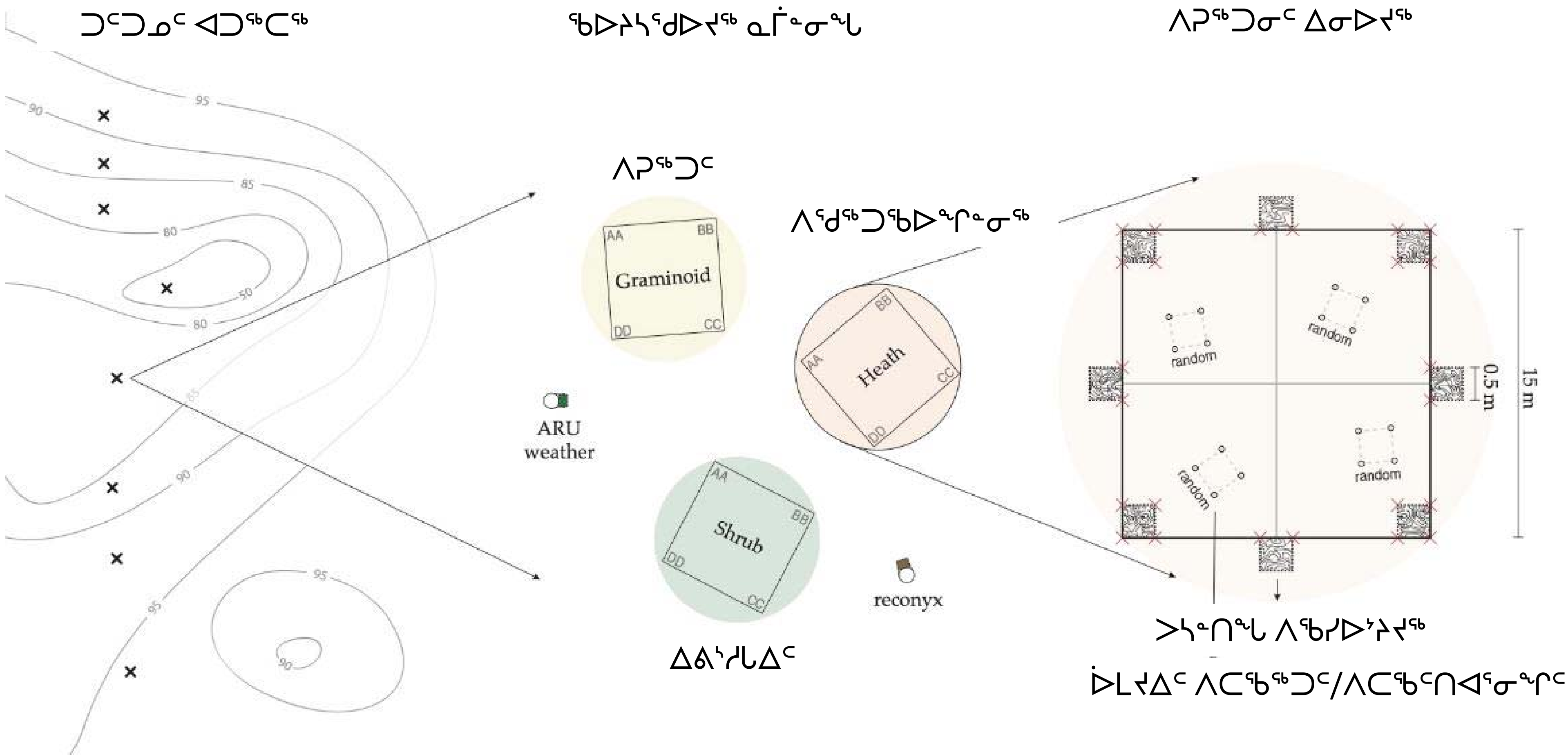
Recent Pan-Arctic shrub expansion has been interpreted as a response to a warmer climate. However, herbivores can also influence the abundance of shrubs in arctic ecosystems. We addressed these alternative explanations by following the changes in plant community composition during the last 10 years in 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

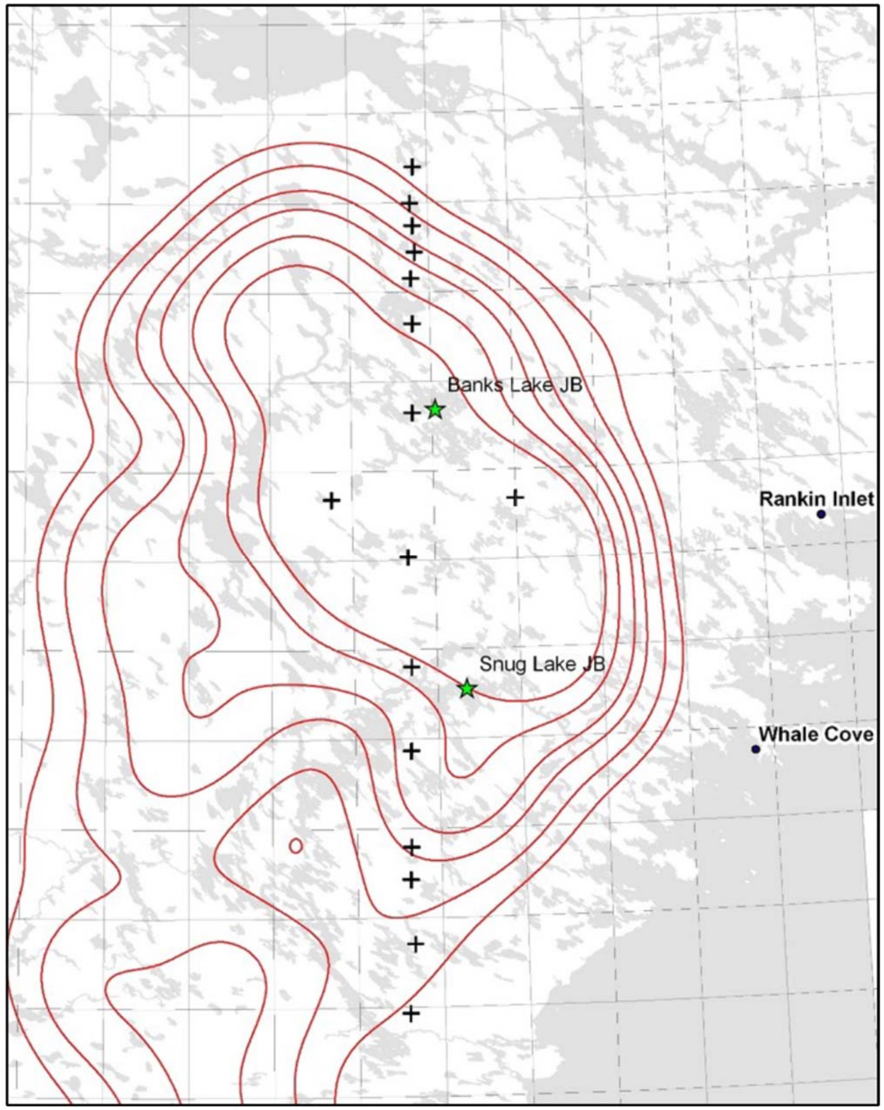
Received 15 October 2008 and accepted 16 February 2009

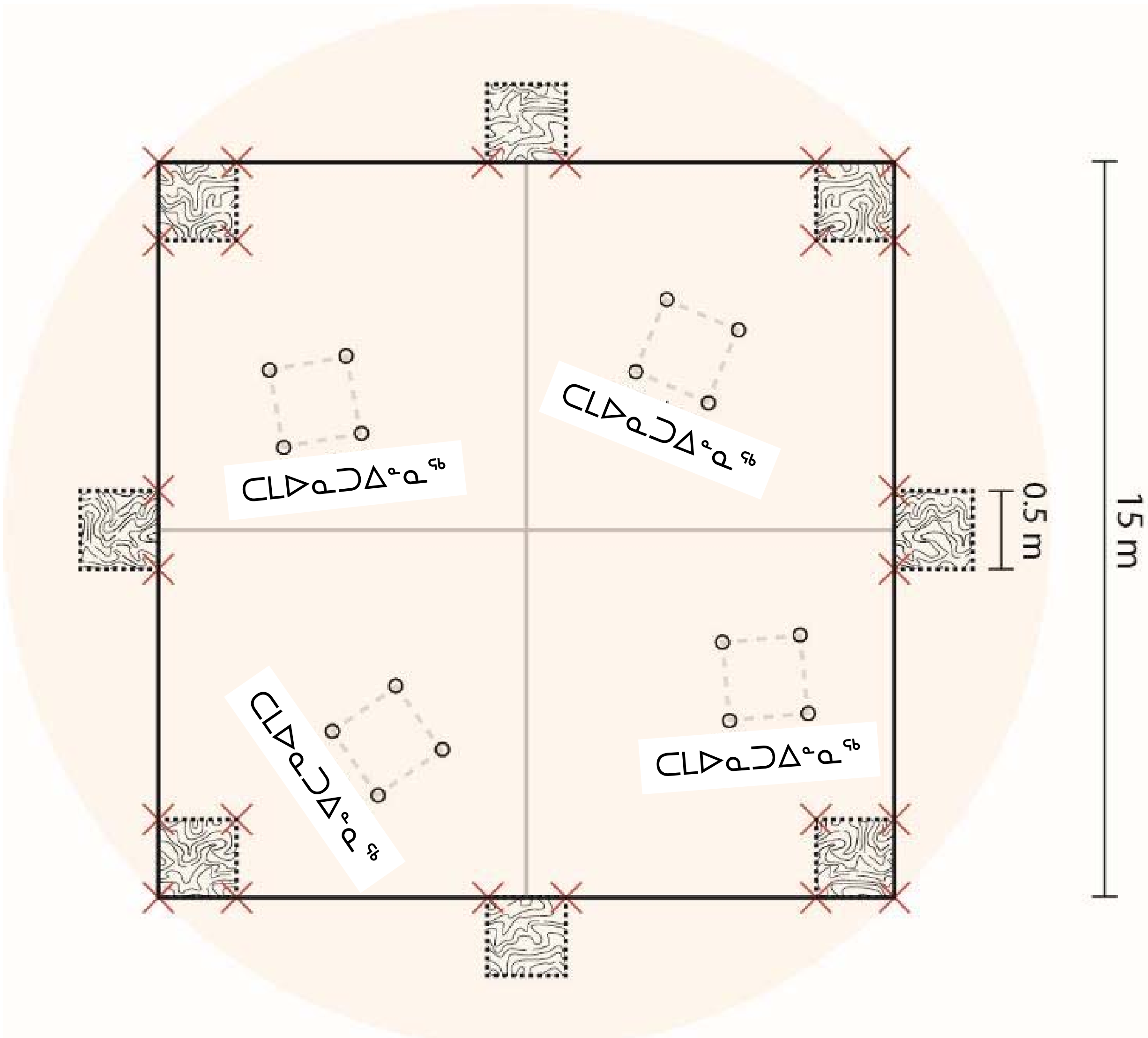

R1Z1
R1Z2
R1Z4
R1Z5
R1Z6
R1Z7
R2Z7
R4Z7
Rankin Inlet
R3Z7
R3Z6
Whale Cove
R3Z5
R3Z4
R3Z3
R3Z2
R3Z1

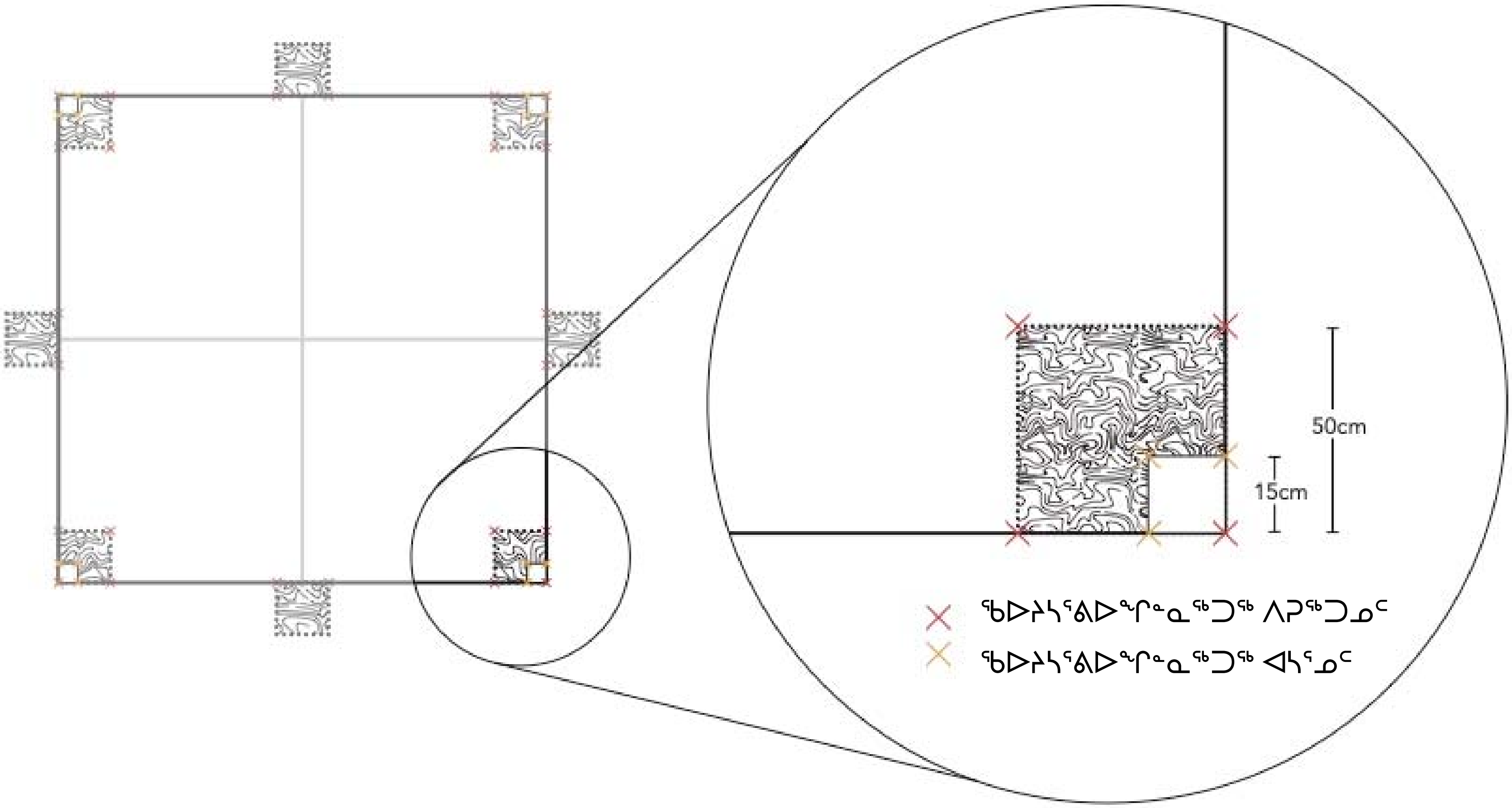

Banks Lake JB
Rankin Inlet
Snug Lake JB
Whale Cove



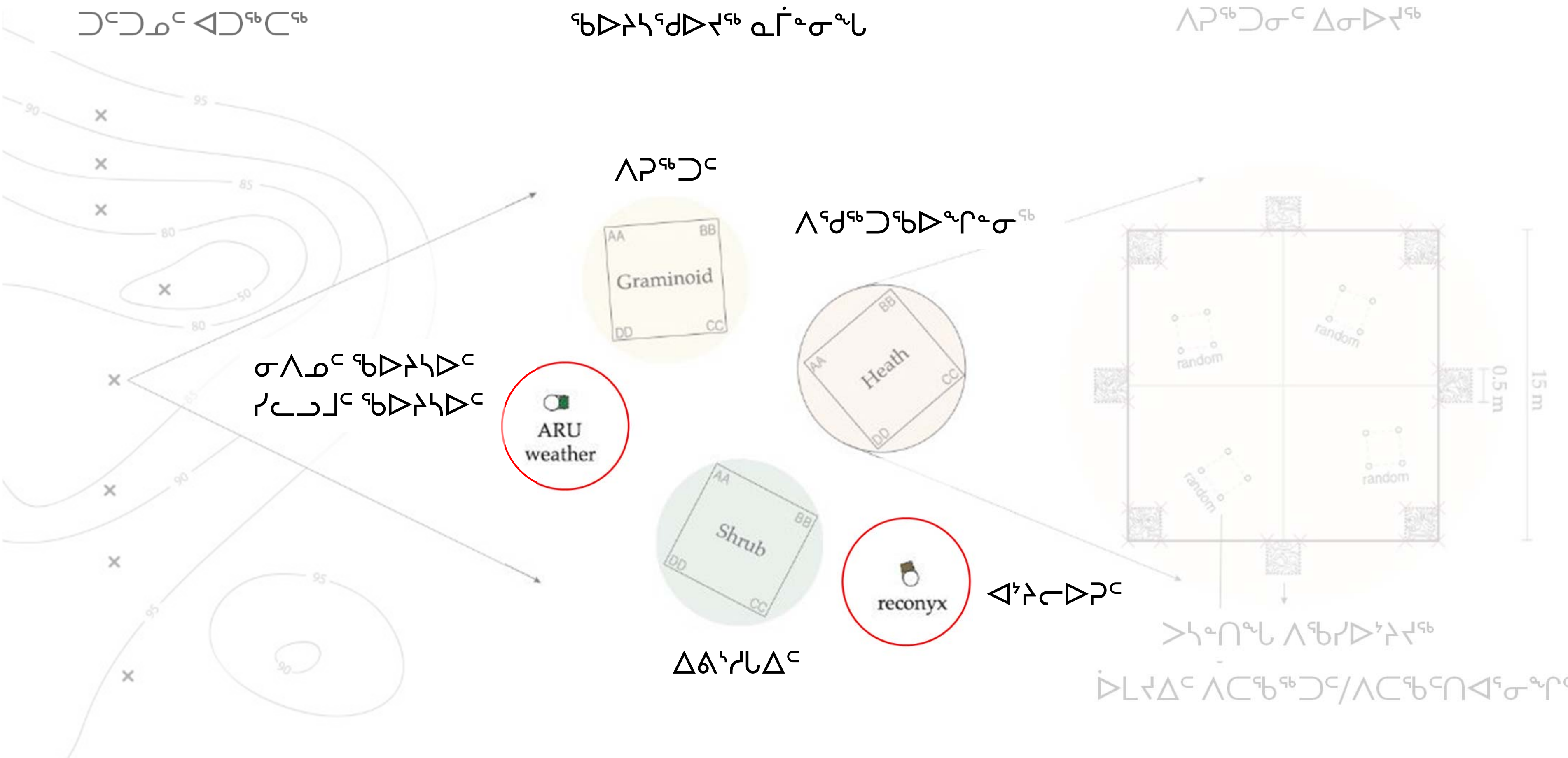
ᑐᑦᑐᓄᑦ ᐊᑐᖅᑕᖅ
ᖃᐅᔨᓴᕐᑯᐅᔪᖅ ᓇᒦᓐᓂᖓ
ᐱᕈᖅᑐᓂᑦ ᐃᓂᐅᔪᖅ
ᐱᕈᖅᑐᑦ
Graminoid
AA
BB
CC
DD
ᐱᕐᑯᖅᑐᖃᐅᖏᓐᓂᖅ
Heath
ARU
weather
Shrub
ᐃᕕᔅᓱᒐᐃᑦ
reconyx
random
0.5 m
15 m
ᐳᓴᓐᑎᖓ ᐱᖃᓯᐅᔾᔪᖅ
ᐆᒪᔪᐃᑦ ᐱᑕᖃᖅᑐᑦ/ᐱᑕᖃᑦᑎᐊᕐᓂᖏᑦ

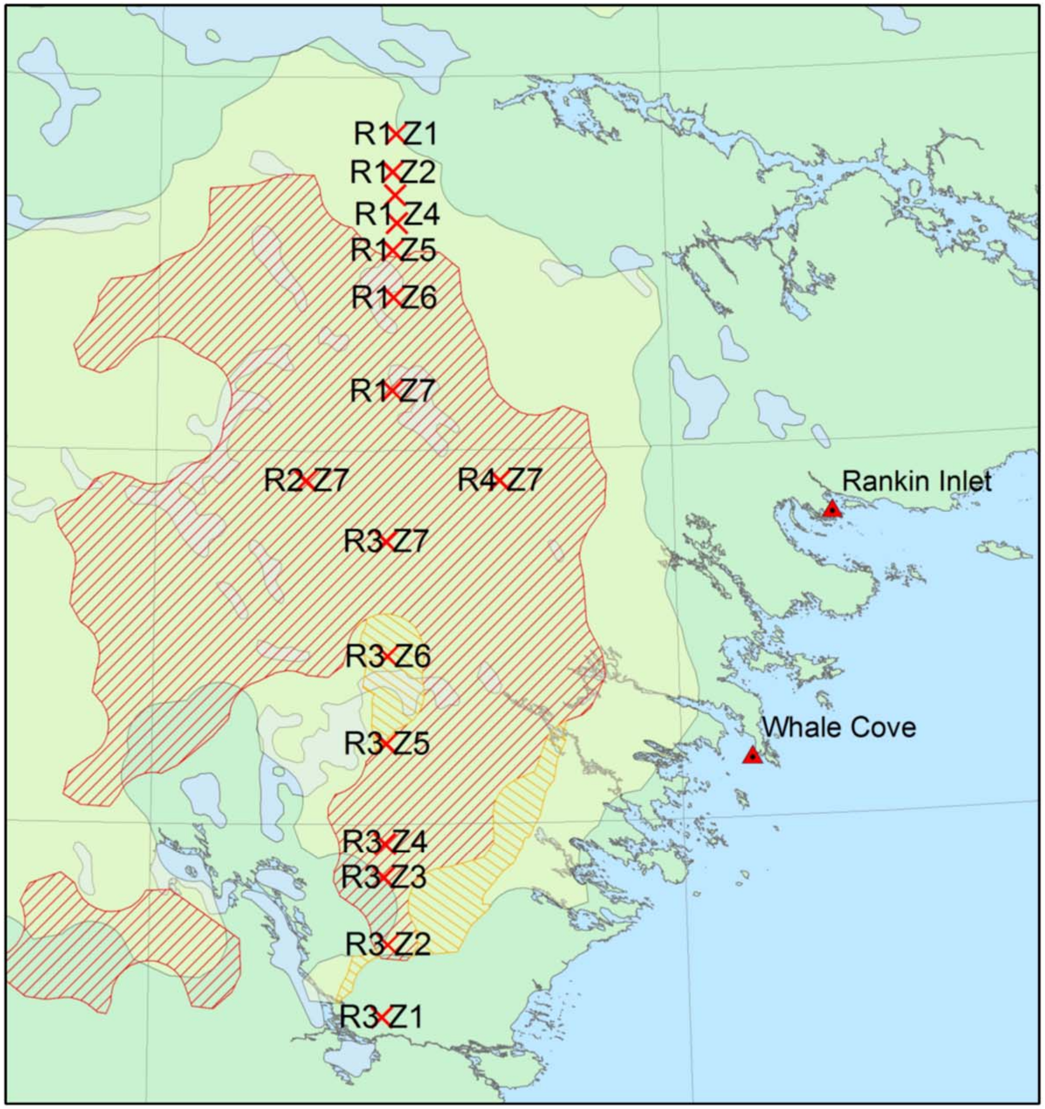

Banks Lake JB
Rankin Inlet
Snug Lake JB
Whale Cove

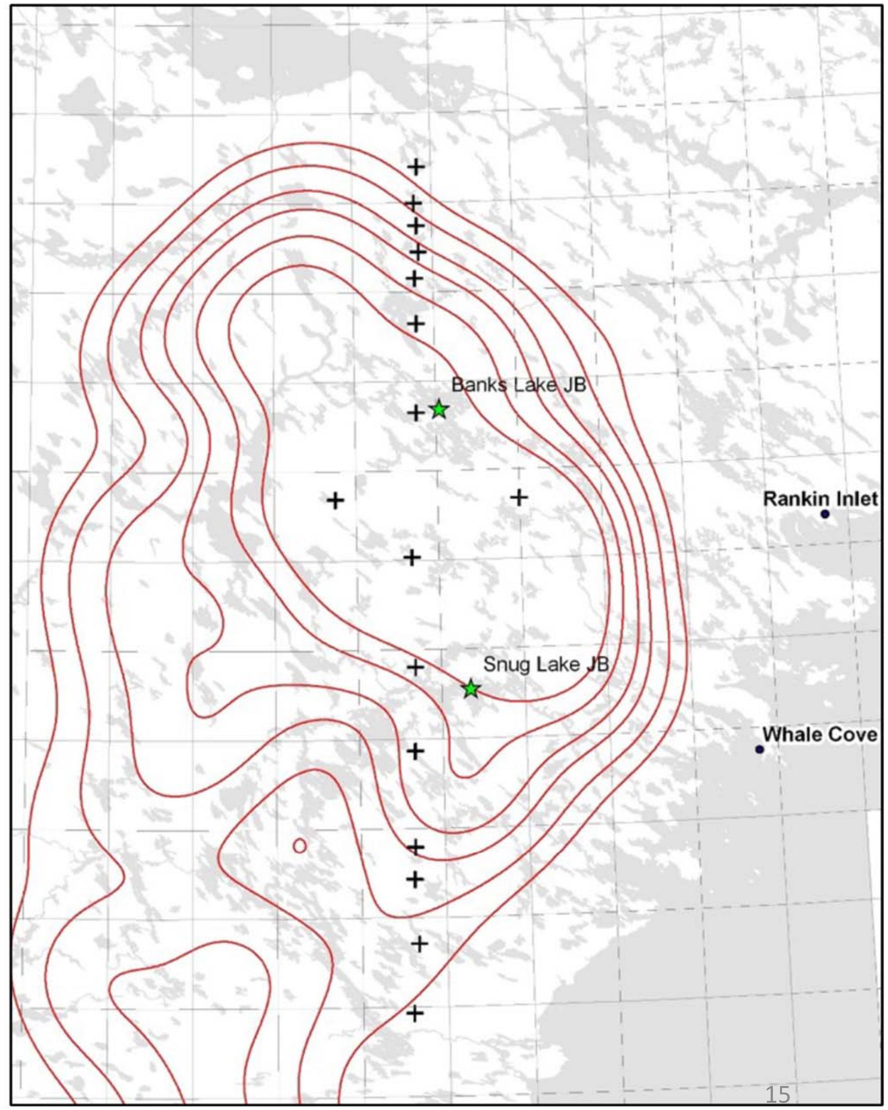

ᑕᒪᐅᓇᑐᐃᓐᓇᖅ
ᑕᒪᐅᓇᑐᐃᓐᓇᖅ
ᑕᒪᐅᓇᑐᐃᓐᓇᖅ
ᑕᒪᐅᓇᑐᐃᓐᓇᖅ
0.5 m
15 m



50cm
15cm
ᖃᐅᔨᓴᖅᕕᐅᖕᒋᓐᓇᖅᑐᖅ ᐱᕈᖅᑐᓄᑦ
ᖃᐅᔨᓴᖅᕕᐅᖕᒋᓐᓇᖅᑐᖅ ᐊᓯᖅᓄᑦ

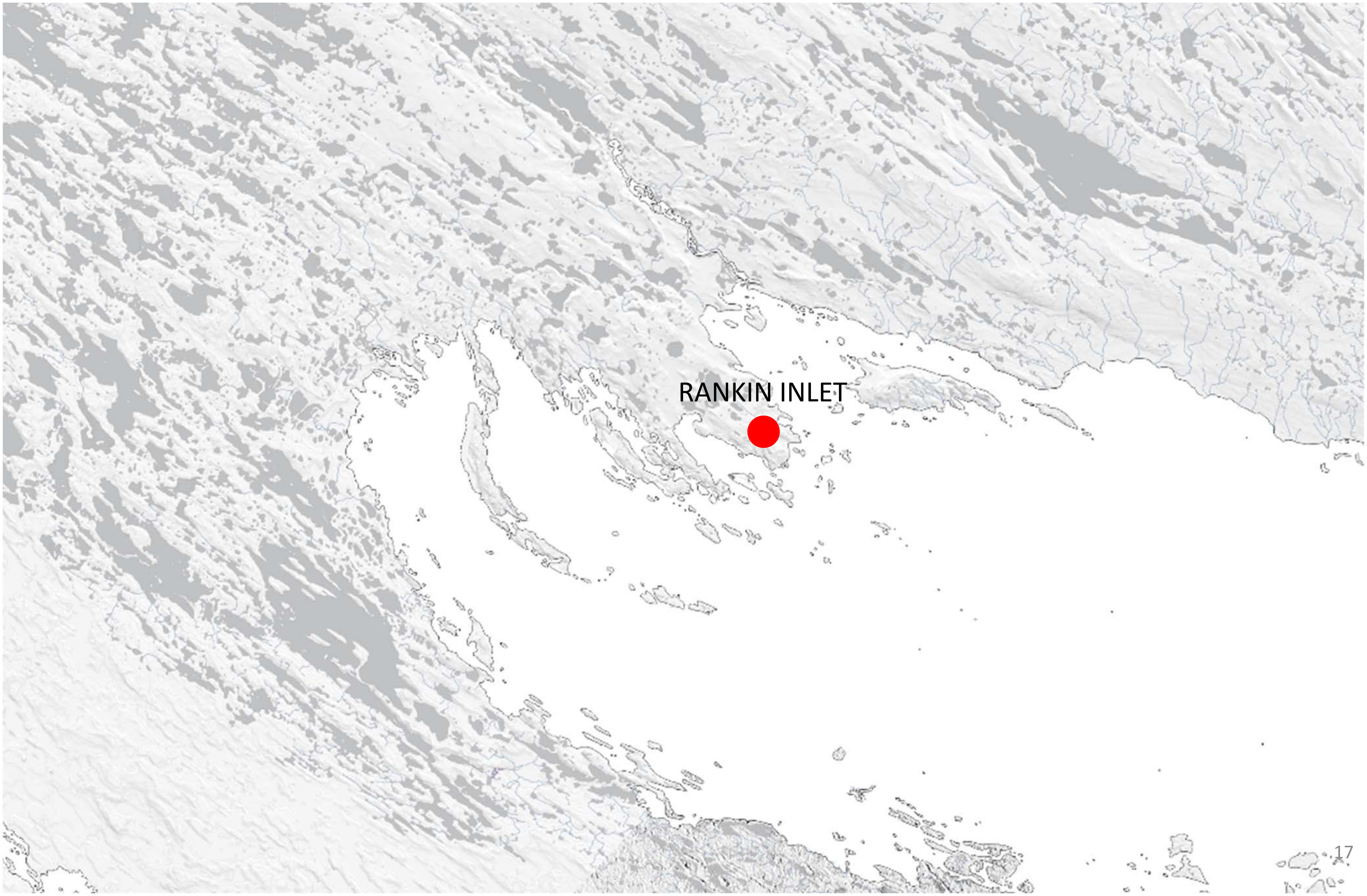

ᑐᑦᑐᓄᑦ ᐊᑐᖅᑕᖅ
ᖃᐅᔨᓴᕐᑯᐅᔪᖅ ᓇᒦᓐᓂᖓ
ᐱᕈᖅᑐᓂᑦ ᐃᓂᐅᔪᖅ
ᐱᕈᖅᑐᑦ
ᐱᖁᖅᑐᖃᐅᖏᓐᓂᖅ
ᓂᐱᓄᑦ ᖃᐅᔨᓴᐅᑦ
ᓯᓚᓗᒧᑦ ᖃᐅᔨᓴᐅᑦ
Graminoid
Heath
ARU
weather
Shrub
reconyx
ᐊᔾᔨᓕᐅᕈᑦ
ᐃᕙᔅᓯᒪᐃᑦ
random
0.5 m
15 m
ᐳᓴᓂᖓ ᐱᖃᓯᐅᔅᓴᔪᖅ
ᐆᒪᔪᐃᑦ ᐱᑕᖃᖅᑐᑦ/ᐱᑕᖃᑦᑎᐊᕐᓂᖏᑦ


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

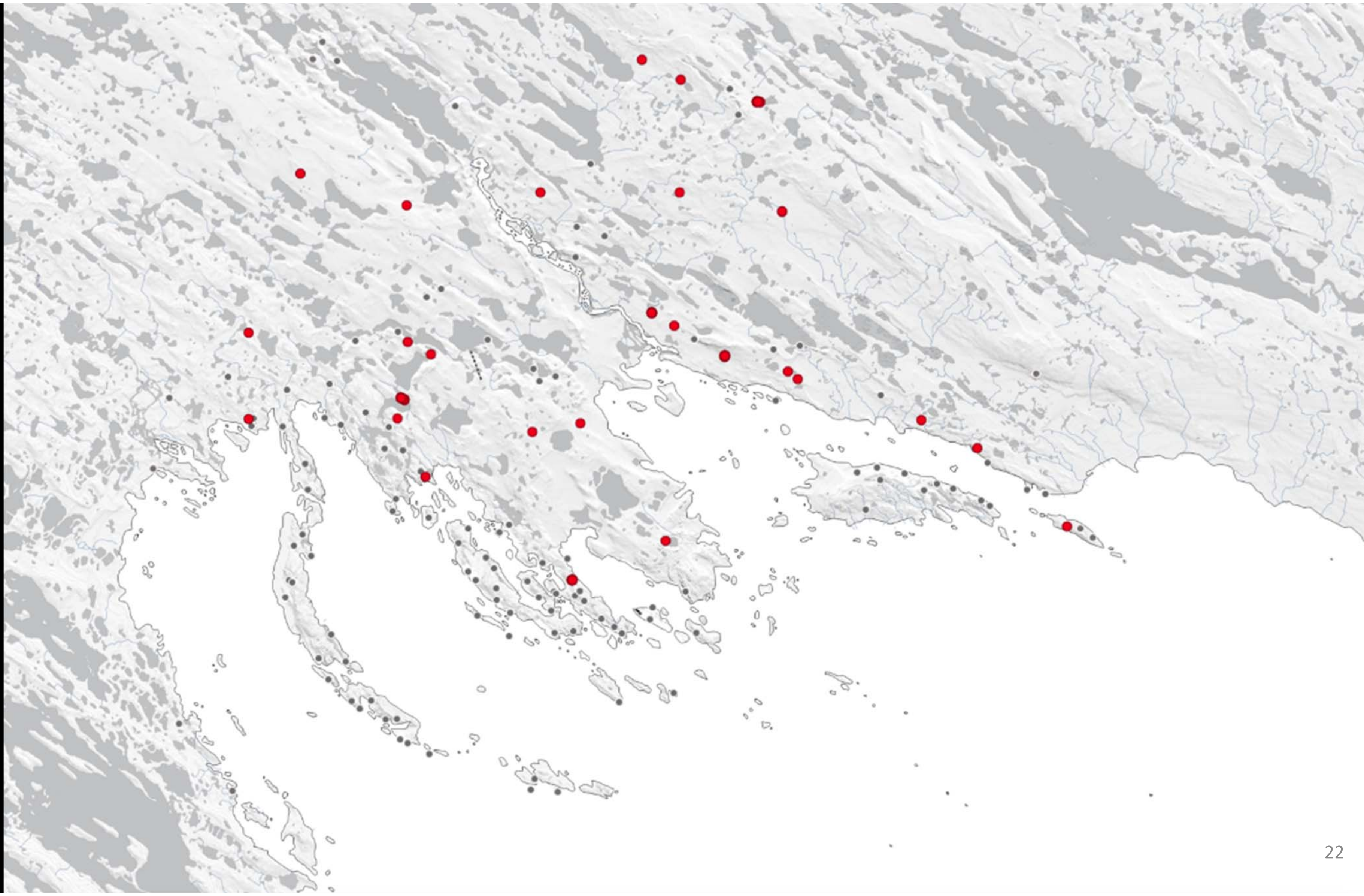

Banks Lake JB
Rankin Inlet
Snug Lake JB
Whale Cove

ᖃᒪᓂᕐᔪᐊᖅ ᓄᕐᕋᓕᐅᕐᕕᖕᒋᑦ ᓄᓇᐃᑦ

	2012	2013	2014	2015	2016	2017	2018	2019
ᑐᑭᒧᐊᖅᑎᑦᑎᔪᖅ	N. Lecomte	N. Lecomte	/	M. Wilson	M. Wilson	/	NuWCRU	NuWCRU
ᐱᕈᖅᑐᑦ ᓄᓇᒥ	ᐄ	ᐄ	/	ᐄ	ᐄ	/	ᐄ	ᐄ
ᖅᑭᒫᔪᑦ	ᐲᖅᑕᐅᓂᖓ	ᐲᖅᑕᐅᓂᖓ / ᓈᓴᖅᑕᖅ	/	ᐲᖅᑕᐅᓂᖓ	No	/	ᐲᖅᑕᐅᓂᖓ	ᐲᖅᑕᐅᓂᖓ / ᓈᓴᖅᑕᖅ
ᐊᔾᔨᓕᐅᕈᑦ	ᐋᒡᒐ	ᐋᒡᒐ	/	ᐄ	ᐄ	/	ᐋᒡᒐ	ᐋᒡᒐ
ᓂᐱᓄᑦ ᓂᐱᓕᐅᕈᖅ	ᐋᒡᒐ	ᐋᒡᒐ	/	ᐄ	ᐄ	/	ᐋᒡᒐ	No

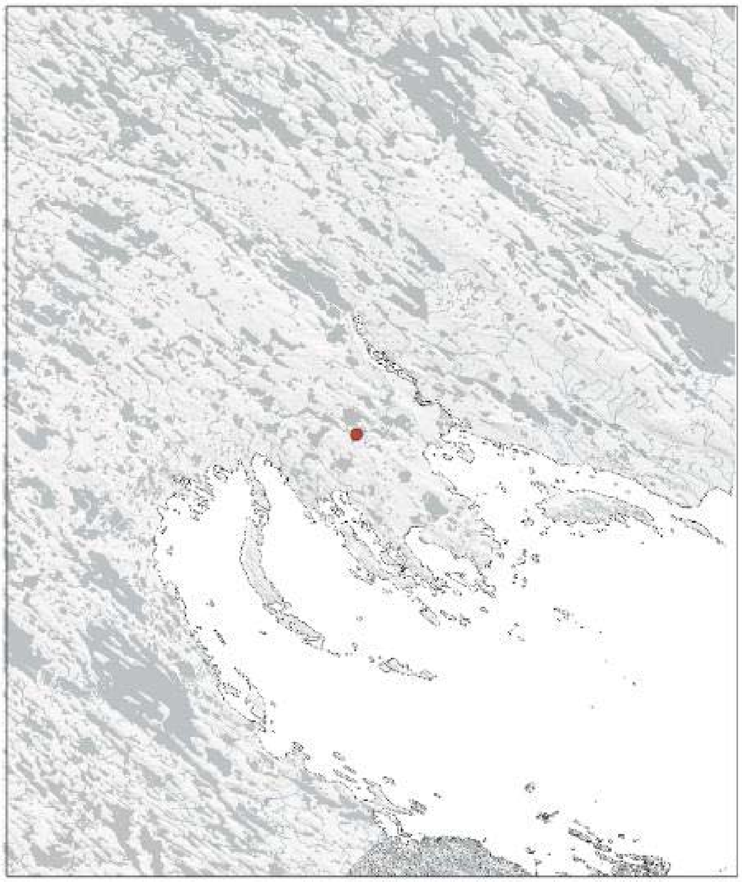

RANKIN INLET


ᖁᓕᕇᑦᑐᑦ ᓂᕆᖃᑦᑕᖅᑐᑦ
ᓂᕆᖃᑦᑕᖕᑐᐃᐸᑦᑐᑦ
ᓂᕆᖃᑦᑕᖕᑐᐃᐸᑦᑐᑦ
ᓂᕆᖃᑦᑕᖕᑐᐃᐸᑦᑐᑦ ᐊᒻᒪ ᑐᖏᓕᖏᑦ
ᑭᓯᓕᐅᖅᑎᖕᑐᐊᑕᖅ

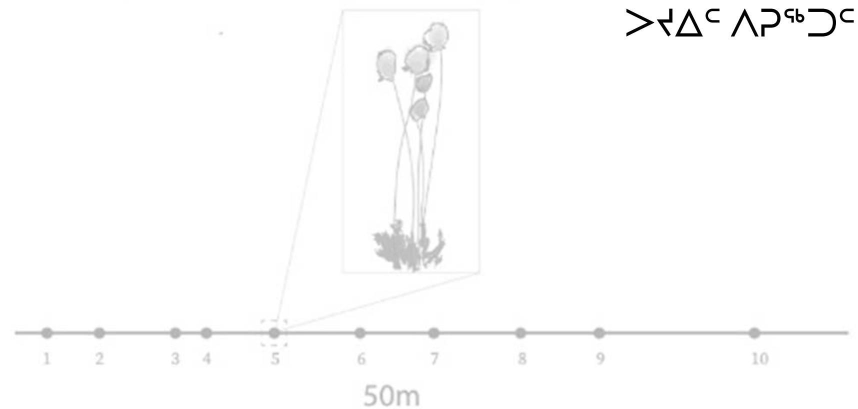


ᑎᒻᒥᐊᖅ ᓂᕿᑐᖅᑐᖅ
ᒪᐃ
ᔫᓂ
ᔪᓚᐃ
ᐋᒡᒌᓯ
ᓇᔪᖅᑕᐅᓂᖓ
ᒥᑭᔪᖅ ᐆᒪᔪᖅ
ᒪᑐᓯᔪᑦ ᐅᓂᑦᑎᑦᑎᓂᖅ
ᖁᐸᓄᐊᖅ
ᓄᕗᓕ ᖃᐅᔨᓴᕝᕕᐅᔪᑦ
ᓴᐅᓂᖃᖏᑦᑐᑦ
ᐃᔪᑦᑲᖅᑐᓄᑦ ᐅᓂᒃᕖᑦ
ᐱᕈᒃᑐᑦ ᓄᓇᒥ
ᖃᐅᔨᓴᕐᓂᖅ
ᐅᑎᖃᑕᖅᑐᓂᑦ
ᐱᑕᖃᕐᓂᖏᑦ
ᖃᓄᐃᓕᖓᓂᖏᑦ

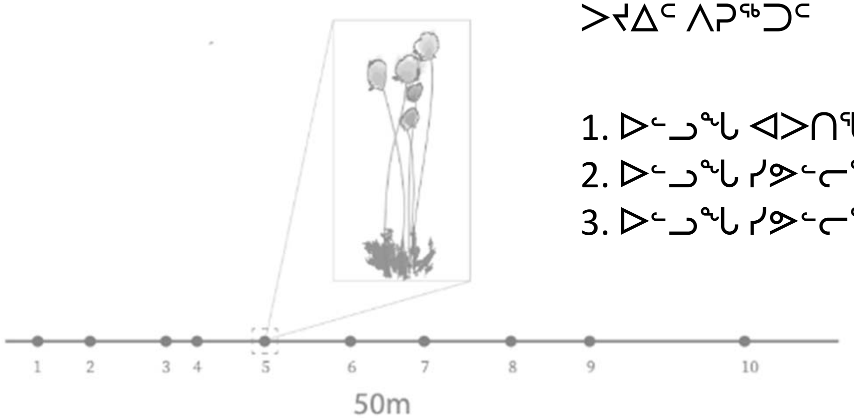
ᐱᕈᖅᑐᓂᑦ ᖃᐅᔨᓴᕐᓂᖅ ᐅᑎᖃᑕᖅᑐᓂᑦ



ᐳᔪᐃᑦ ᐱᕈᖅᑐᑦ



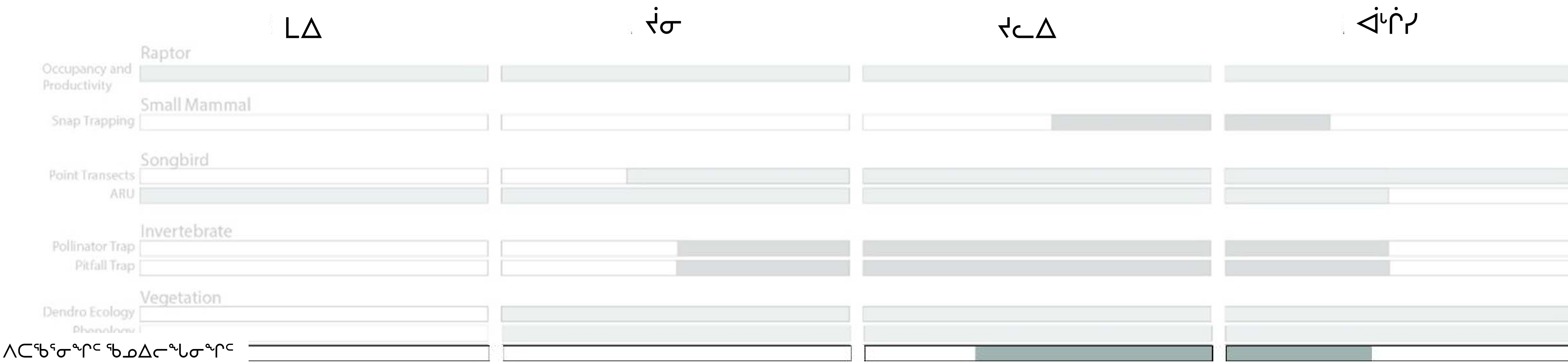
ᐱᕈᖅᑐᓂᑦ ᖃᐅᔨᓴᕐᓂᖅ ᐅᑎᖃᑕᖅᑐᓂᑦ



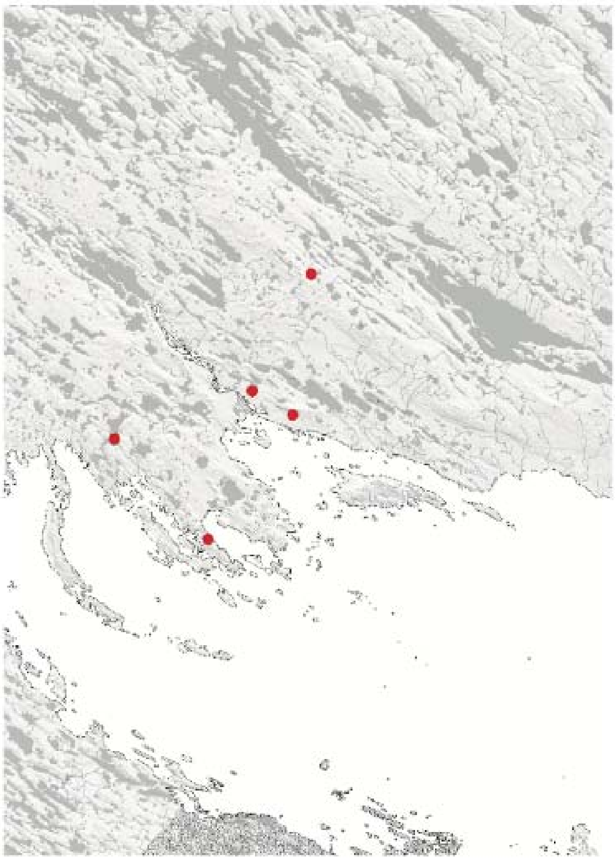
ᐳᔪᐃᑦ ᐱᕈᖅᑐᑦ

1. ᐅᓪᓗᖓ ᐊᐳᑎᖃᕈᓐᓃᕐᓂᖓ
2. ᐅᓪᓗᖓ ᓯᕗᓪᓕᖅᐹᒥᑦ ᓴᖅᑭᖅᑐᑦ ᐱᕐᑯᖅᓯᐊᑦ
3. ᐅᓪᓗᖓ ᓯᕗᓪᓕᖅᐹᒥᑦ ᐱᕈᕈᓇᐅᑏᑦ ᑕᑯᔅᓴᐅᔪᑦ (ᕐᑯᓯᖅᑐᑦ ᐱᕈᖅᑐᓕᐅᕈᑎᖓ)

ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ

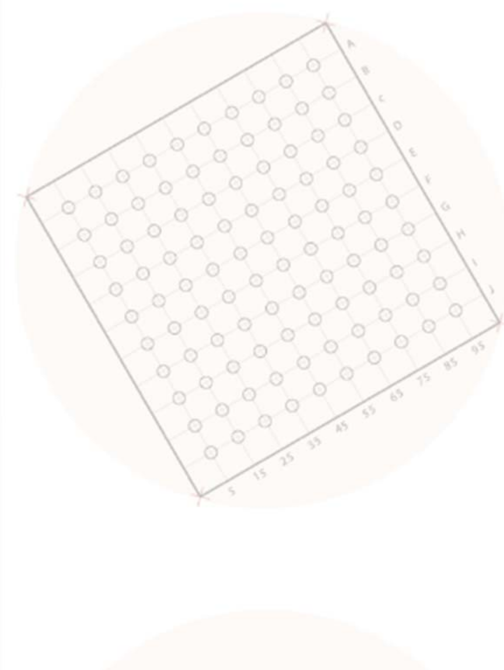


ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ

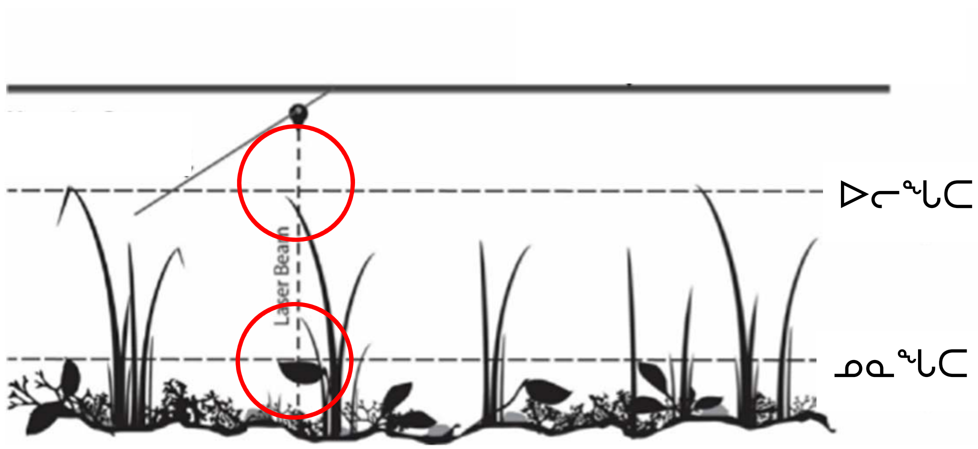


ᐯᐱᑭᖅᑐᓂᑦ ᖃᐅᔨᓴᕐᕕᒃ

ᓄᕗᓚ ᖃᐅᔨᓴᕐᕕᐅᔪᑦ



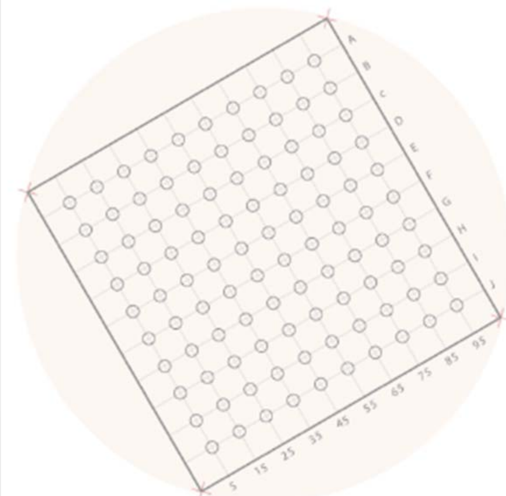
ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ



ᐅᓕᖓᑕ ᖁᓕᖓ

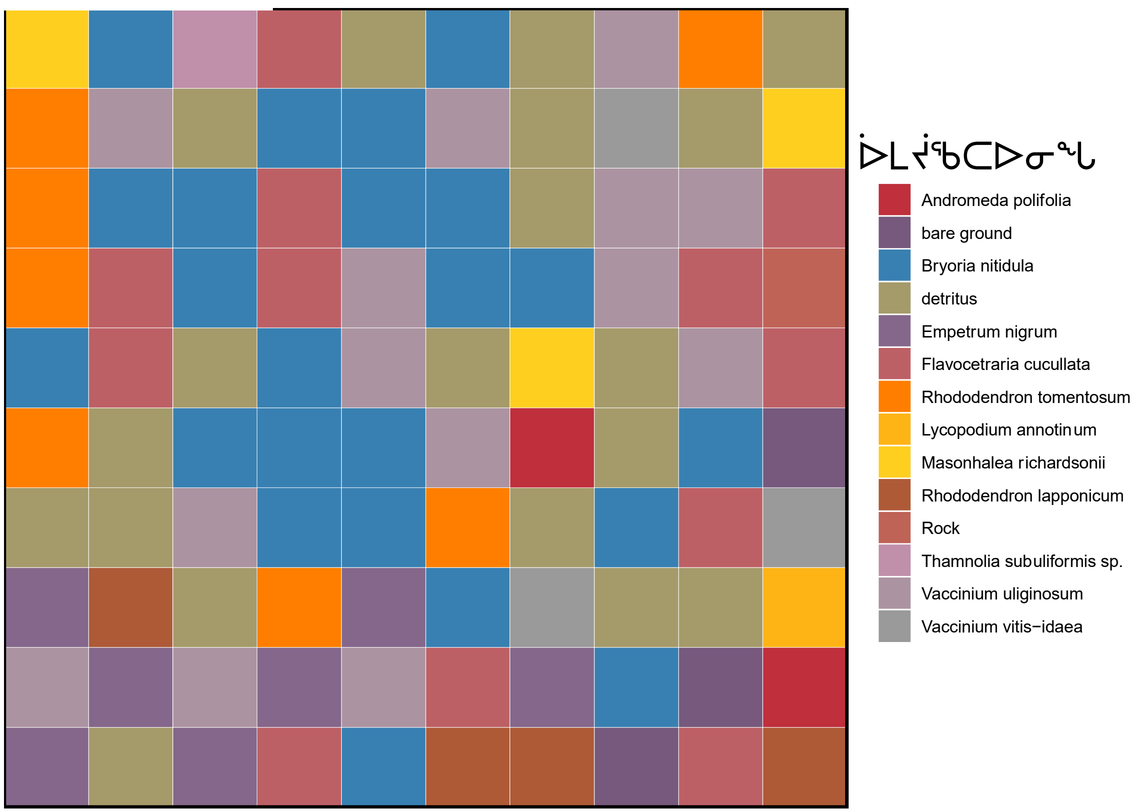
ᓄᓇᖓᑕ ᖁᓕᖓ

ᓄᕗᓕ ᖃᐅᔨᓴᖅᐱᐅᔪᑦ

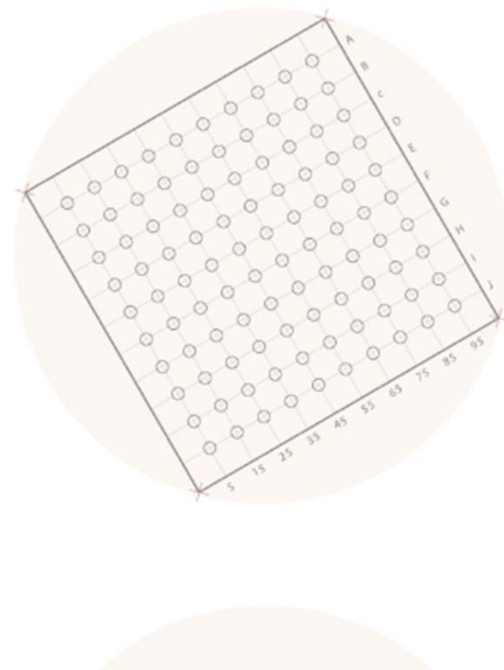


ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ

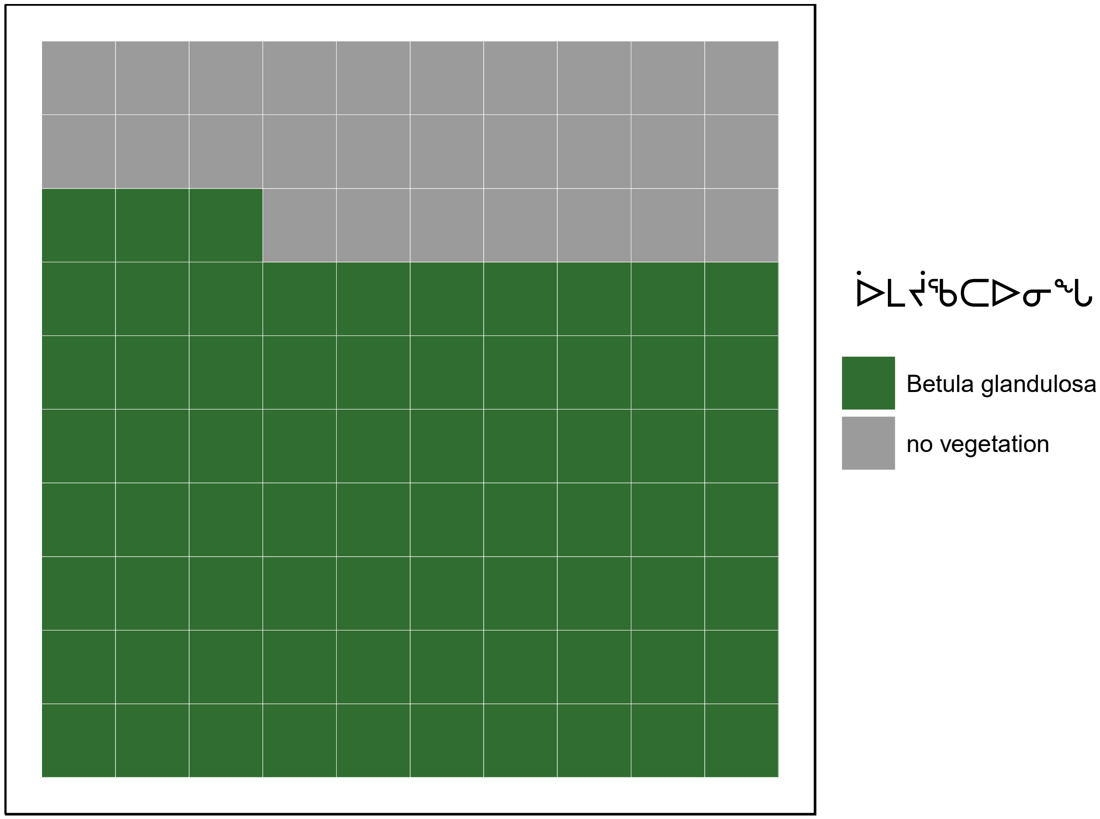
ᓄᓇᖓᑕ ᖁᓕᖓ

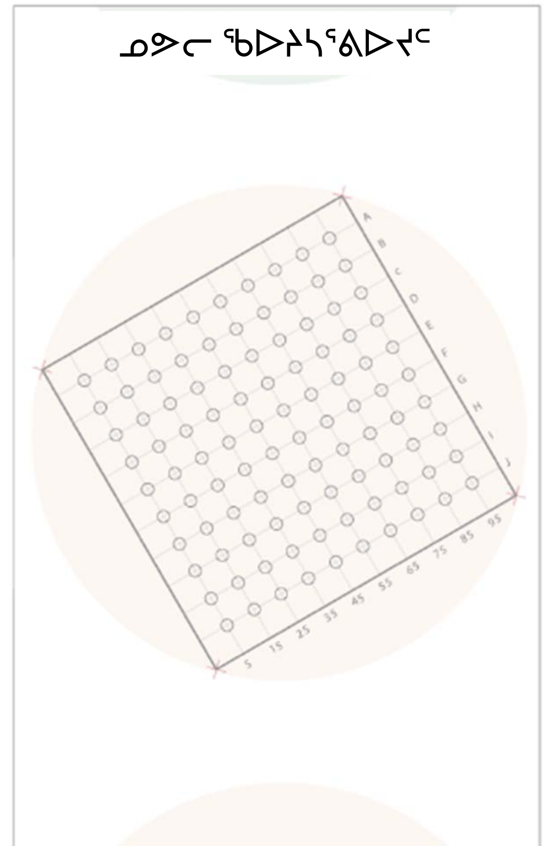


ᓄᕗᓚ ᖃᐅᔨᓴᖅᕙᐅᔪᑦ

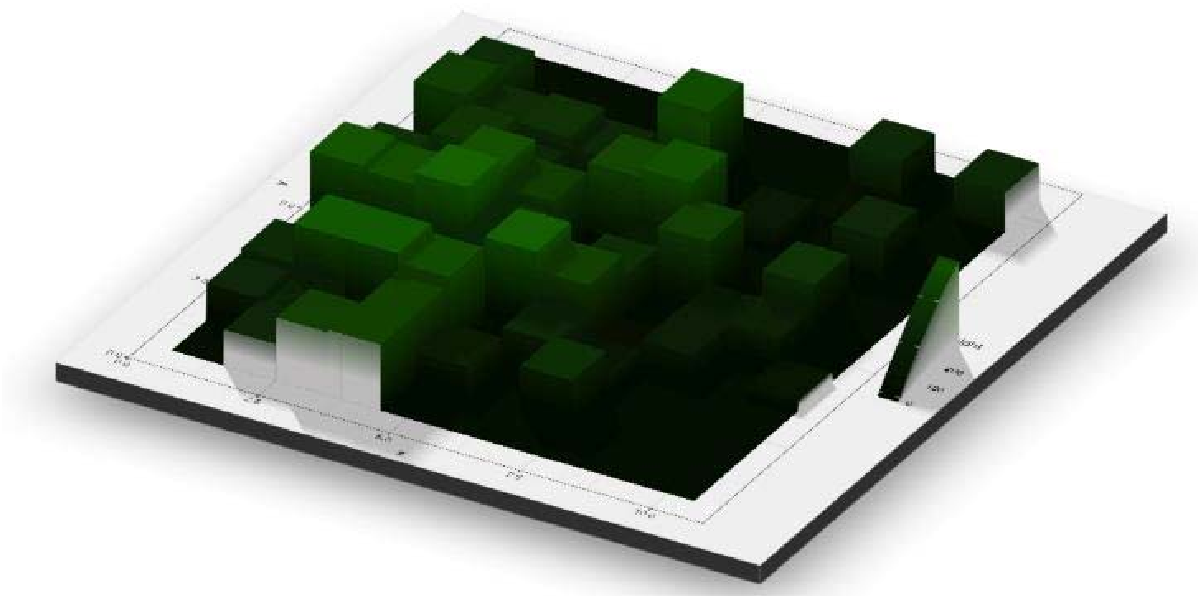


ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ

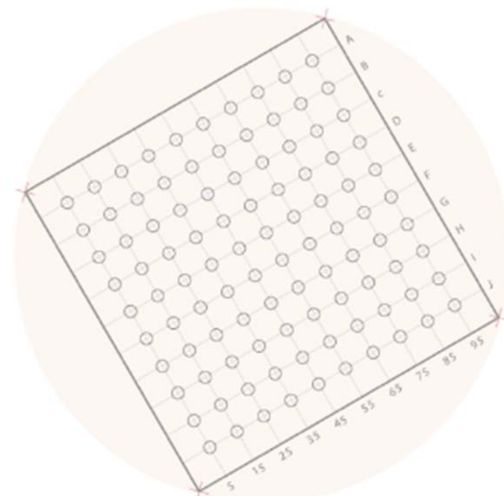




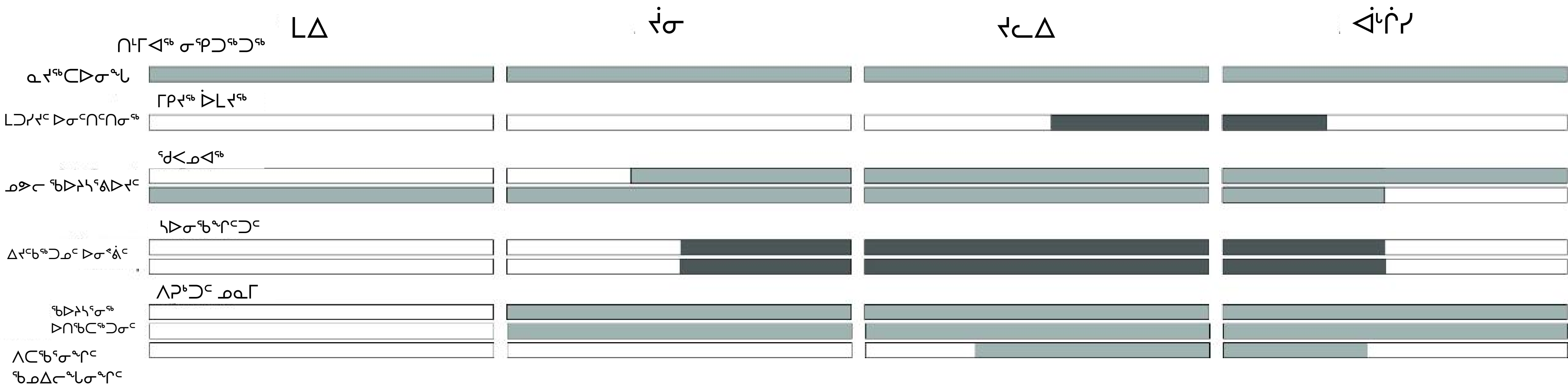
ᐱᑕᖃᕐᓂᖏᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ



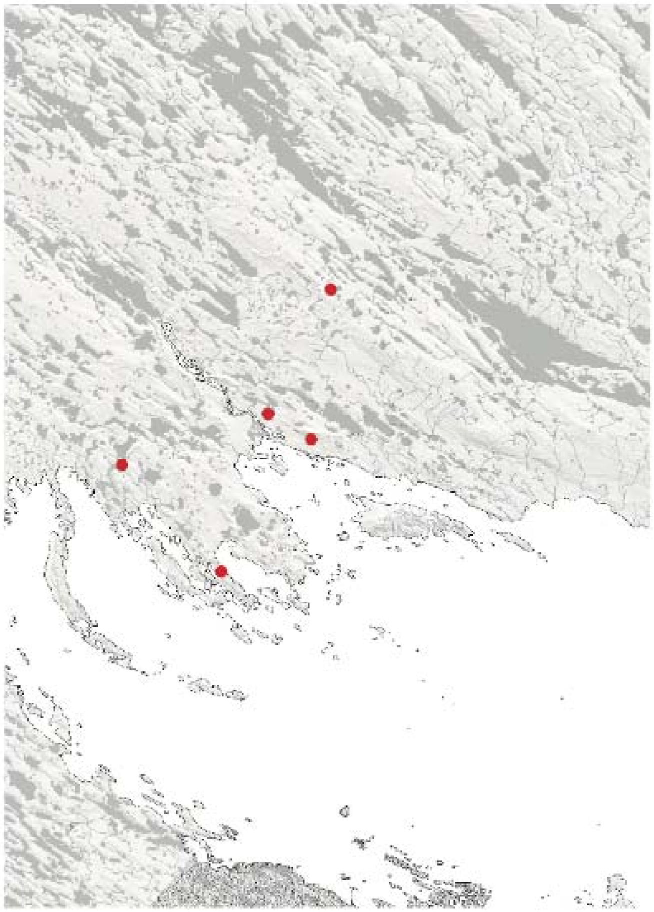
ᓄᕗᓕ ᖃᐅᔨᓴᖅᕕᐅᔪᑦ



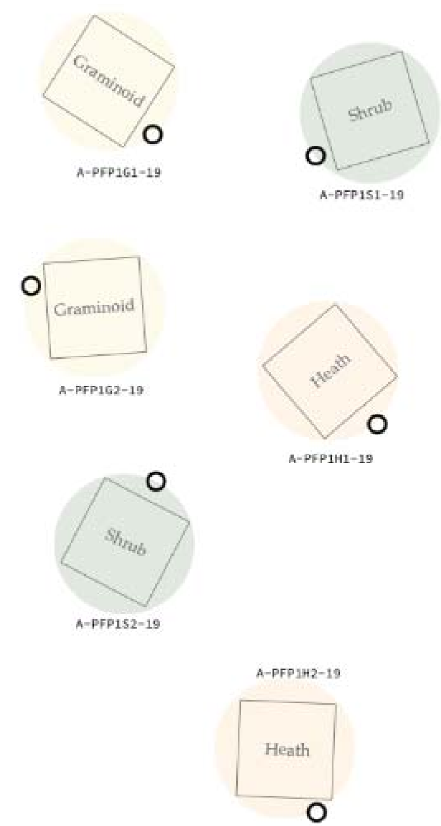
ᐃᔪᓪᑲᖅᑐᓄᑦ ᐅᓂᒃᑳᑦ

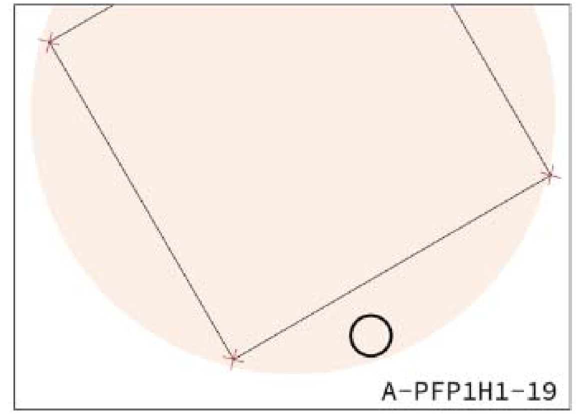


ᐃᔪᑦᑲᖅᑐᓄᑦ ᐅᓂᒡᕖᑦ

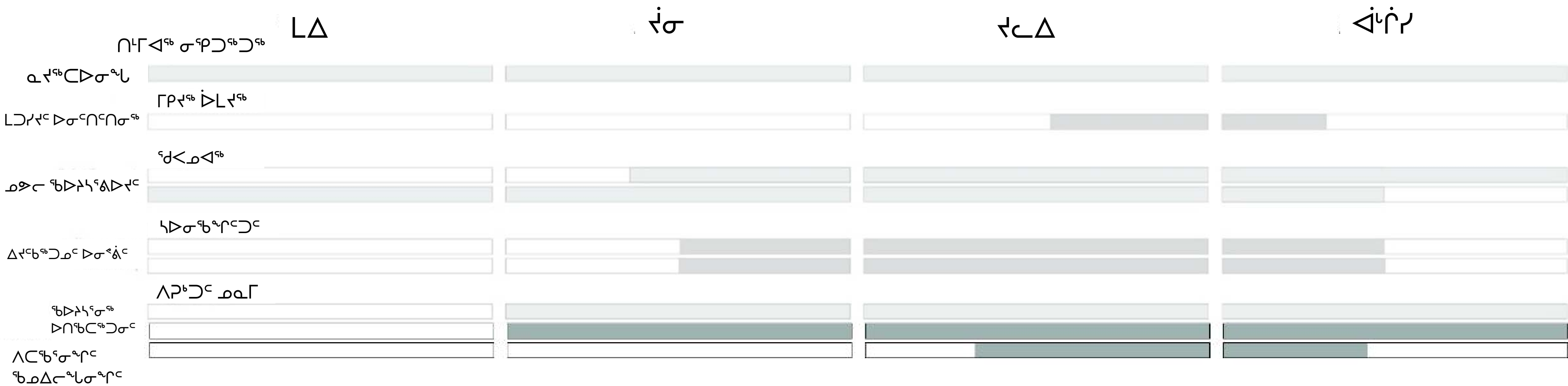


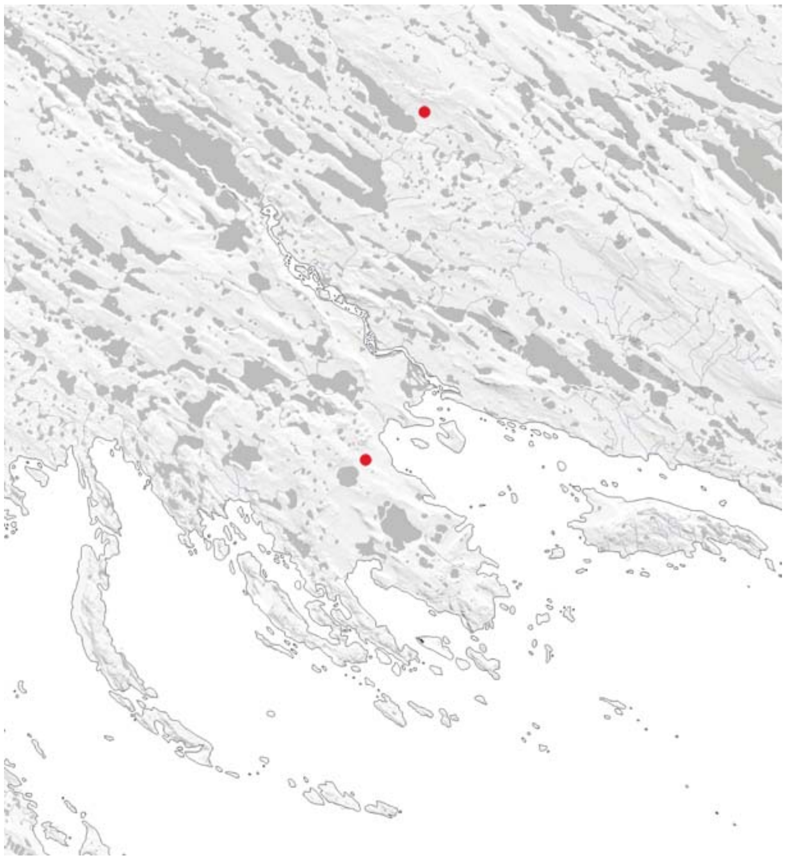
ᐯᐱᕈᖅᑐᓂᑦ ᖃᐅᔨᓴᕐᕕᒃ





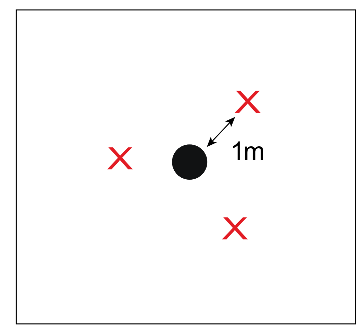
ᒥᑭᔪᖅ ᐆᒪᔪᖅ


ᑎᒻᒥᐊᖅ ᓂᕿᑐᖅᑐᖅ
ᒪᐃ
ᔫᓂ
ᔪᓚᐃ
ᐋᒡᒌᓯ
ᓇᔪᖅᑕᐅᓂᖓ
ᒥᑭᔪᖅ ᐆᒪᔪᖅ
ᒫᑐᓯᔪᑦ ᐅᓂᑦᑎᑦᑎᓂᖅ
ᖁᐸᓄᐊᖅ
ᓄᕚᓕ ᖃᐅᔨᓴᕐᕕᐅᔪᑦ
ᓴᐅᓂᖃᖏᑦᑐᑦ
ᐃᔪᒃᑲᖅᑐᓄᑦ ᐅᓂᕐᕖᑦ
ᐱᕈᕐᑐᑦ ᓄᓇᒥ
ᖃᐅᔨᓴᕐᓂᖅ
ᐅᑎᖅᑕᖅᑐᓂᑦ
ᐱᑕᖃᕐᓂᖏᑦ
ᖃᓄᐃᓕᖓᓂᖏᑦ

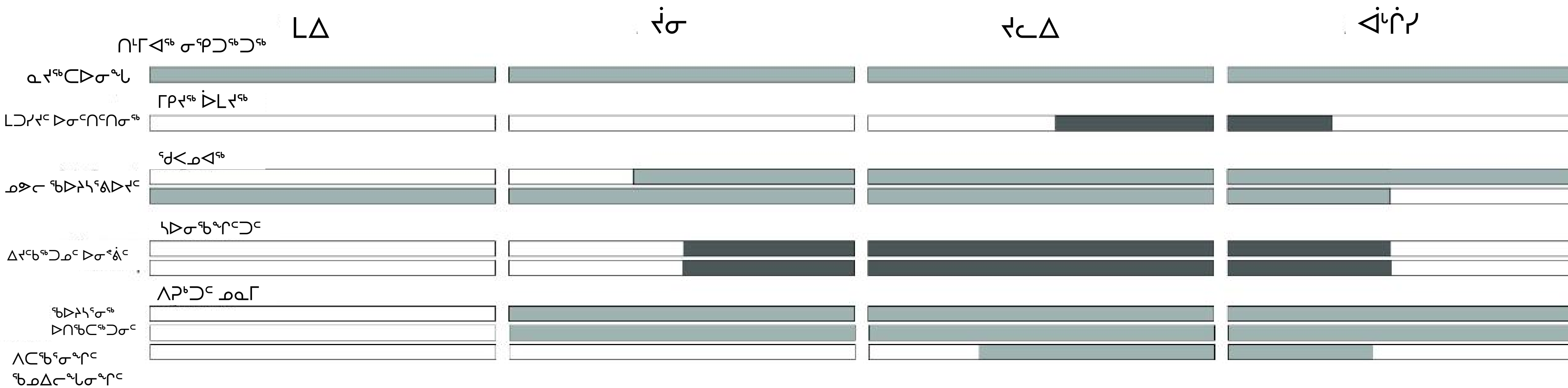



20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
A
B
C
D
ᐸᓂᖅᑐᖅ
300m
ᖃᐅᓯᖅ

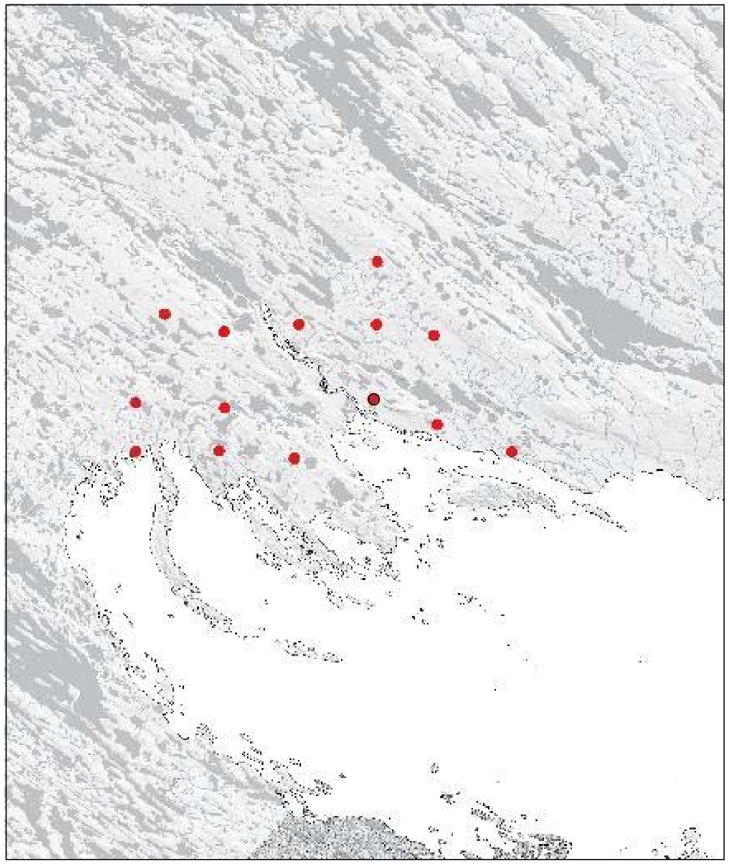

15
14
13
15m


1m

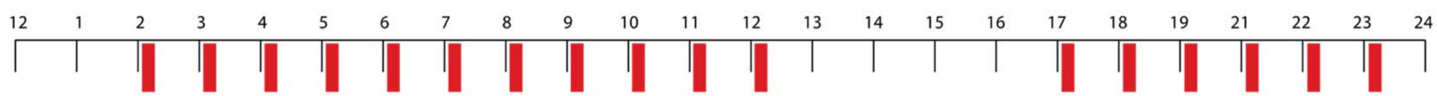
ᖁᐸᓗᐊᖅ

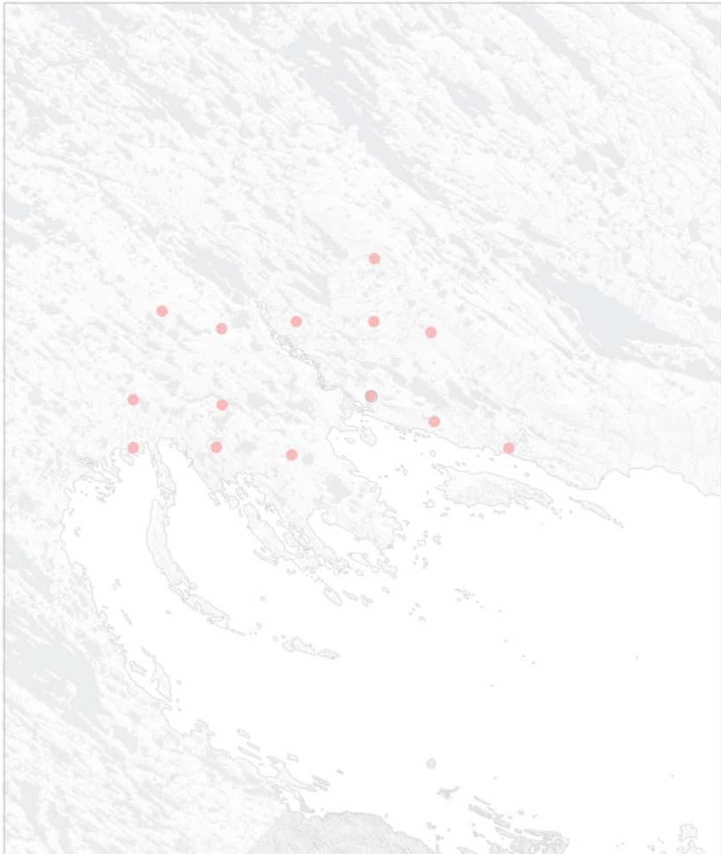
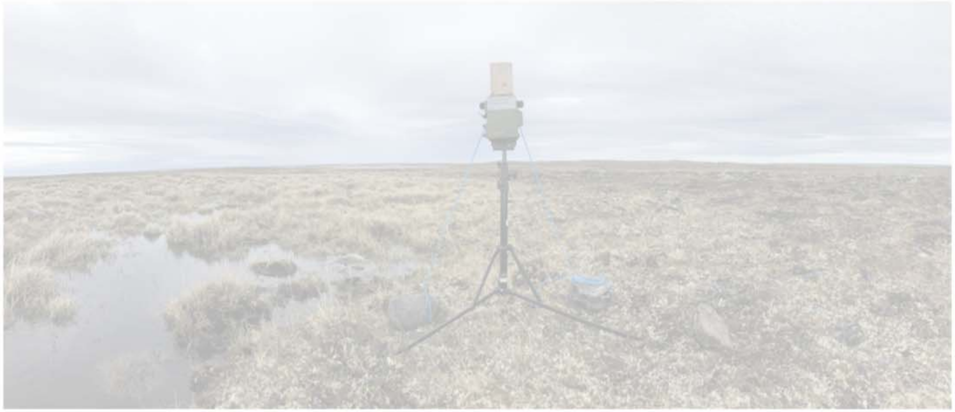
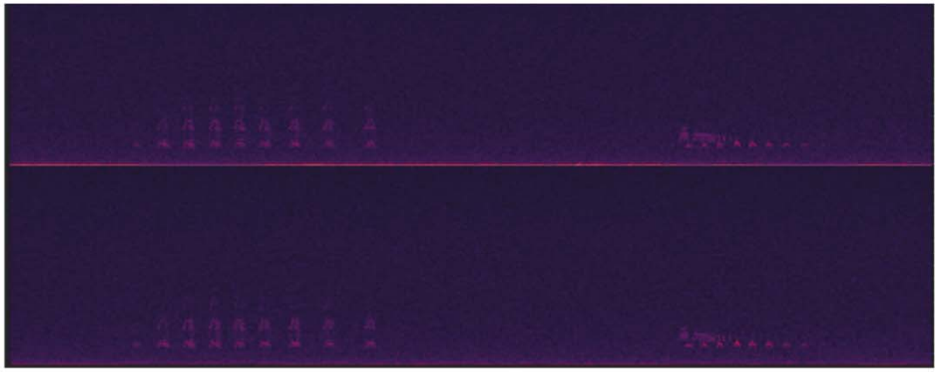


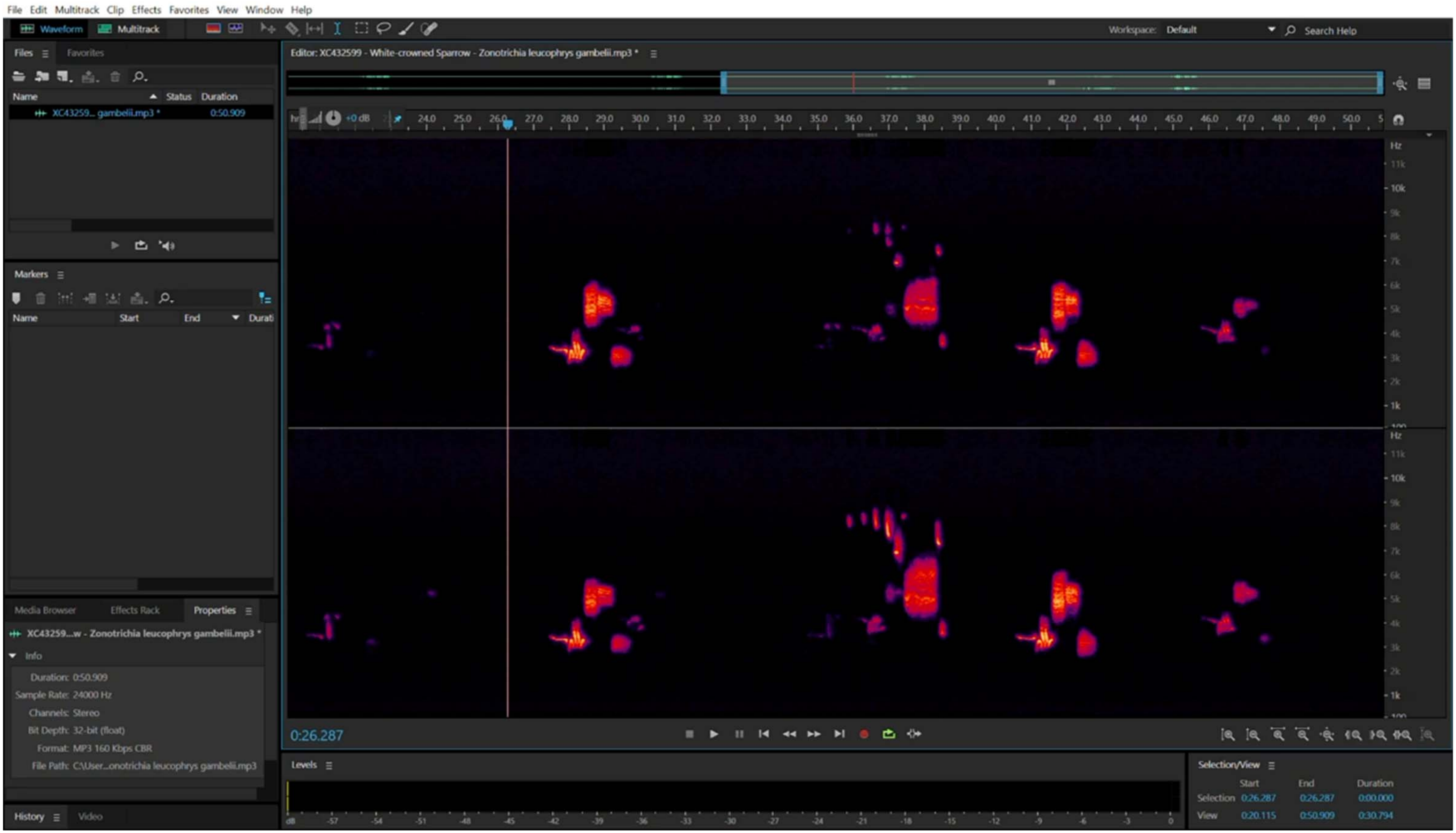
ᑎᒻᒥᐊᖅ ᓂᕿᑐᖅᑐᖅ
ᒪᐃ
ᔫᓂ
ᔪᓚᐃ
ᐋᒡᒌᓯ
ᓇᔪᖅᑕᐅᓂᖓ
ᒥᑭᔪᖅ ᐆᒪᔪᖅ
ᒪᑐᓯᔪᑦ ᐅᓂᑎᑎᓂᖅ
ᖁᐸᓗᐊᖅ
ᓄᕝᕙ ᖃᐅᔨᓴᕐᕕᐅᔪᑦ
ᓴᐅᓂᖃᖏᑦᑐᑦ
ᐃᔪᑲᖅᑐᓄᑦ ᐅᓂᕝᕚᑦ
ᐱᕈᒃᑐᑦ ᓄᓇᒥ
ᖃᐅᔨᓴᕐᓂᖅ
ᐅᑎᖃᑕᖅᑐᓂᑦ
ᐱᑕᖃᕐᓂᖏᑦ
ᖃᓄᐃᓕᖓᓂᖏᑦ

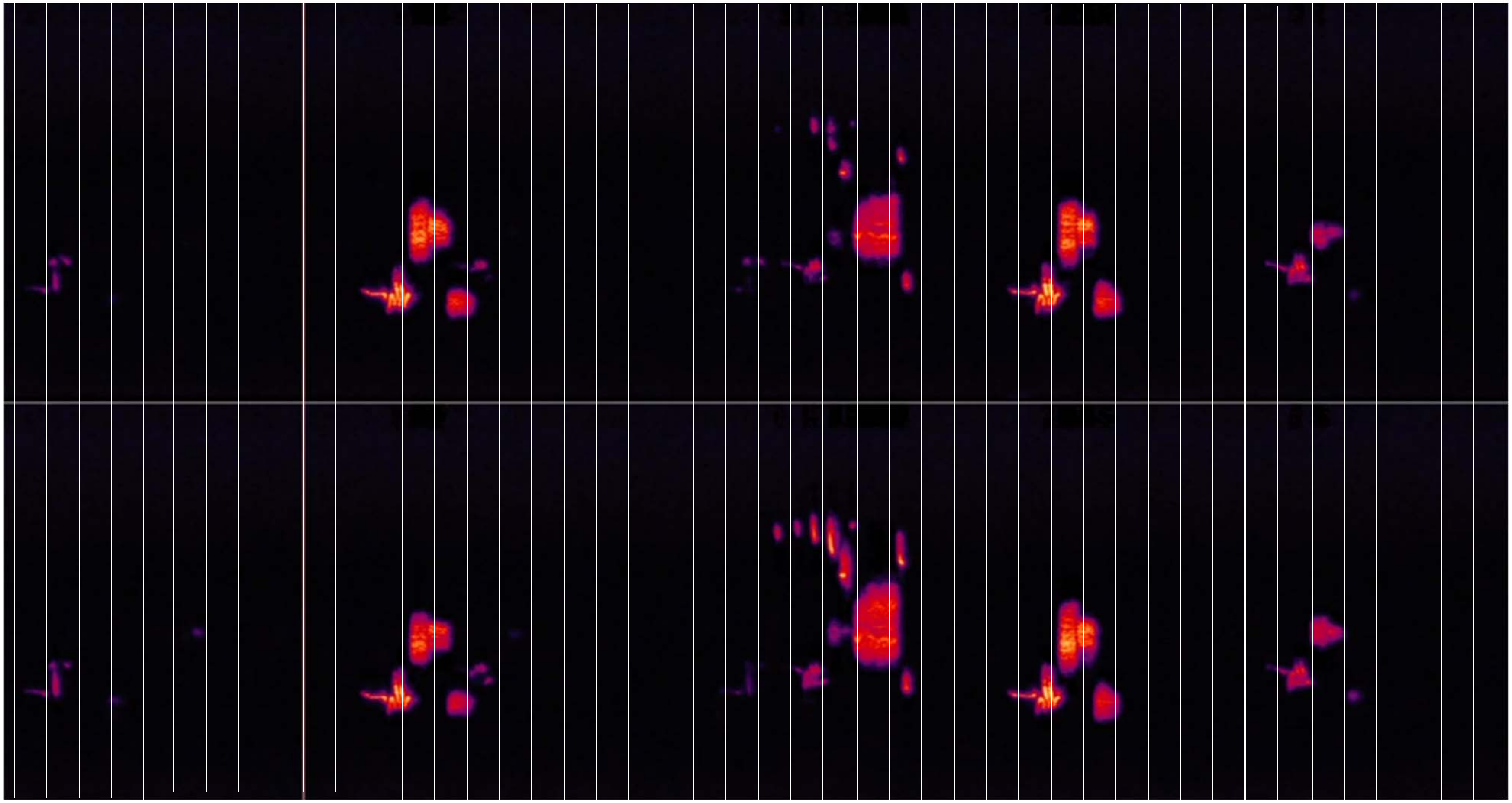


12 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24



12 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24


File Edit Multitrack Clip Effects Favorites View Window Help
Waveform
Multitrack
Workspace: Default
Search Help
Files
Favorites
Name
Status
Duration
XC43259... gambelii.mp3 *
0:50.909
Editor: XC432599 - White-crowned Sparrow - Zonotrichia leucophrys gambelii.mp3 *
Markers
Name
Start
End
Durati
Media Browser
Effects Rack
Properties
XC43259...w - Zonotrichia leucophrys gambelii.mp3 *
Info
Duration: 0:50.909
Sample Rate: 24000 Hz
Channels: Stereo
Bit Depth: 32-bit (float)
Format: MP3 160 Kbps CBR
File Path: C:\User...onotrichia leucophrys gambelii.mp3
History
Video
0:26.287
Levels
Selection/View
Start
End
Duration
Selection 0:26.287 0:26.287 0:00.000
View 0:20.115 0:50.909 0:30.794



Ecology and Evolution

Open Access

Using bioacoustics to examine shifts in songbird phenology

Rachel T. Buxton[1], Emma Brown[2], Lewis Sharman[3], Christine M. Gabriele[3] & Megan F. McKenna[2]

[1]Department of Fish, Wildlife and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, Colorado 80523
[2]Natural Sounds and Night Skies Division, National Park Service, 1201 Oakridge Drive, Fort Collins, Colorado 80525
[3]Glacier Bay National Park and Preserve, PO Box 140, Gustavus, Alaska 99826

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

Correspondence
Rachel T. Buxton, Department of Fish, Wildlife and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, CO 80523, USA.
Tel: 1 970 491 8740;
Fax: 1 970 491 5091;
E-mail: Rachel.Buxton@colostate.edu

Funding Information

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

doi: 10.1002/ece3.2242

Abstract

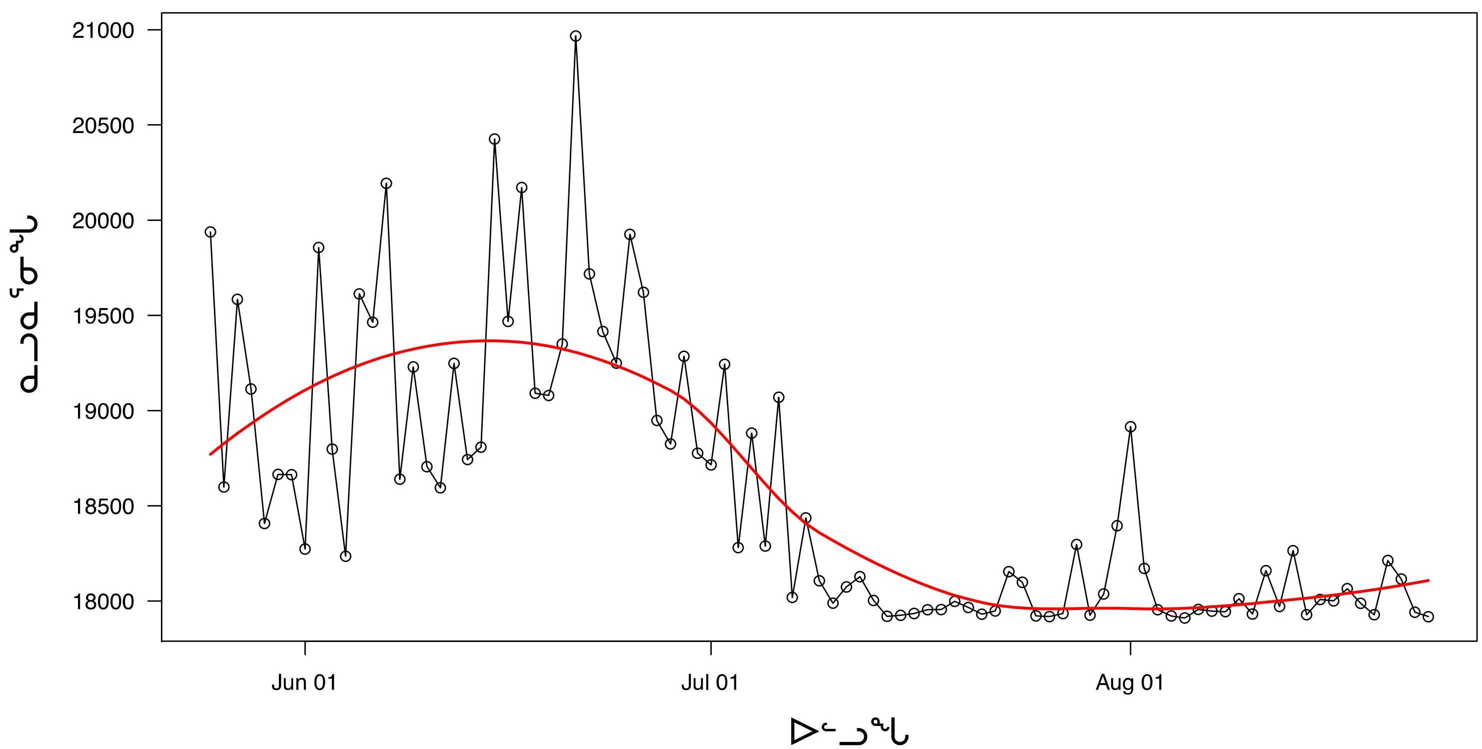
Monitoring patterns in biodiversity and phenology have become increasingly important given accelerating levels of anthropogenic change. Long-term monitoring programs have reported earlier occurrence of spring activity, reflecting species response to climate change. Although tracking shifts in spring 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

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.

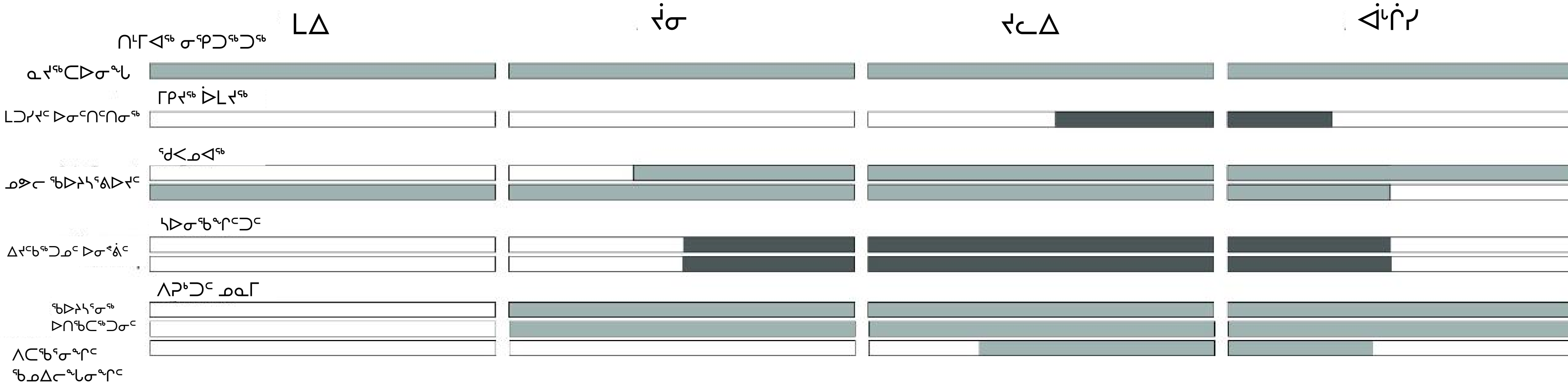
ᐊᓯᔾᔩᑳᓐᓇᑦᑐᑦ ᓇᓗᓇᕐᓂᕆᔭᖏᓐᓂ ᖁᐸᓄᐊᑦ ᖃᓄᐃᓘᕐᓂᖏᓐᓄᑦ ᐅᑭᐅᒃᑯᑦ ᐅᐱᕐᖓᔅᓵᒧᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᔾᔪᑎᐅᓪᓗᑎ ᑎᑭᓐᓂᖏᓐᓄᑦ ᐅᑎᖅᑕᖃᑦᑕᖅᑐᑦ ᖁᐸᓄᐊᑦ

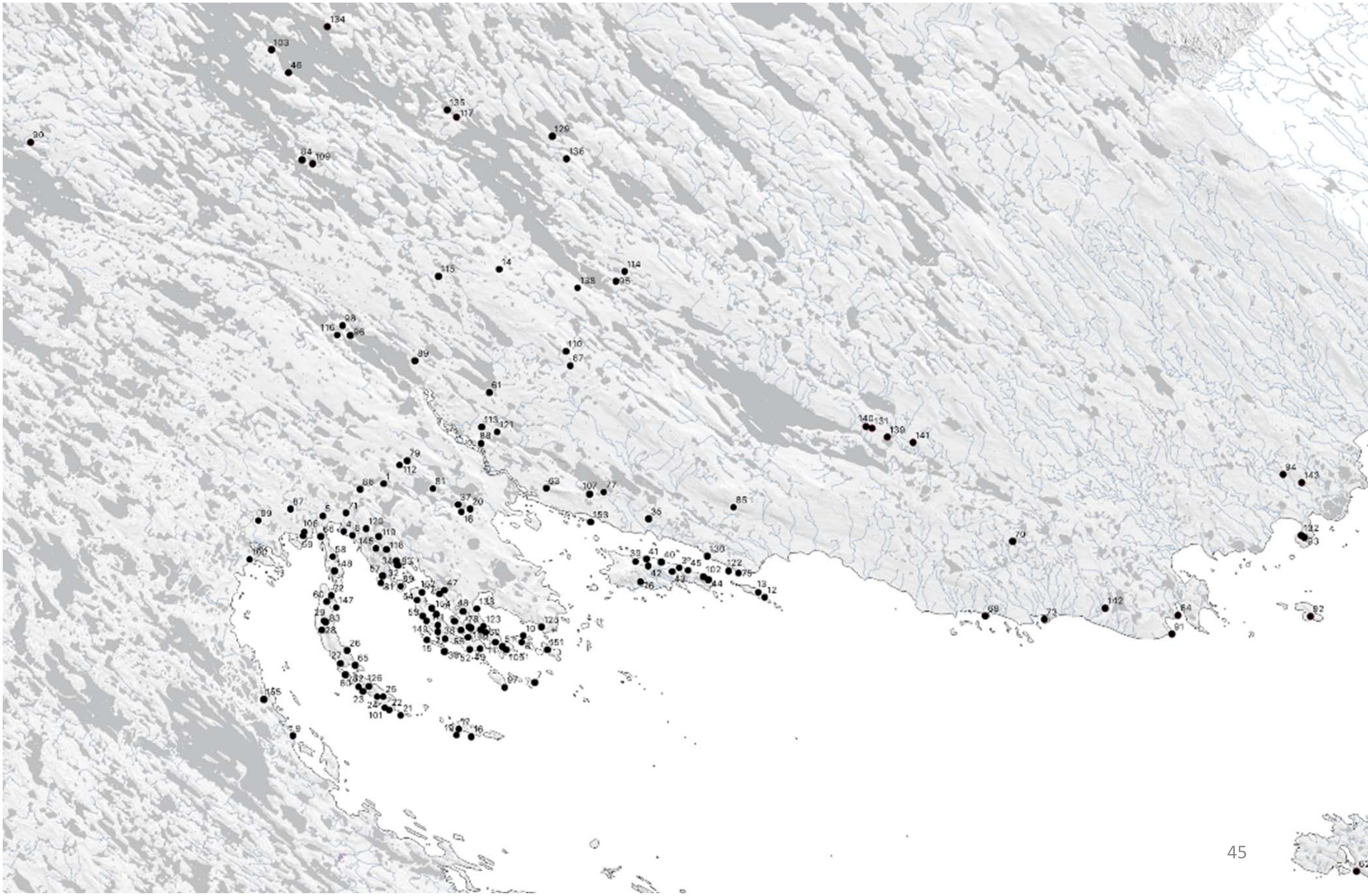
ACI

R1Z7 - 2015

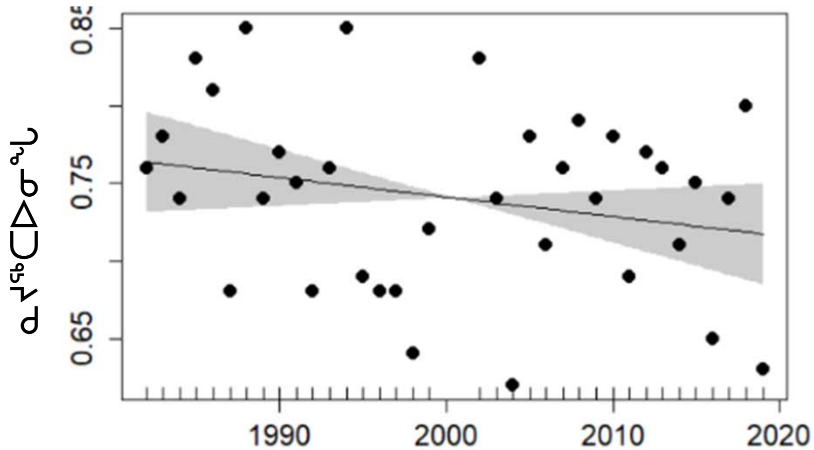


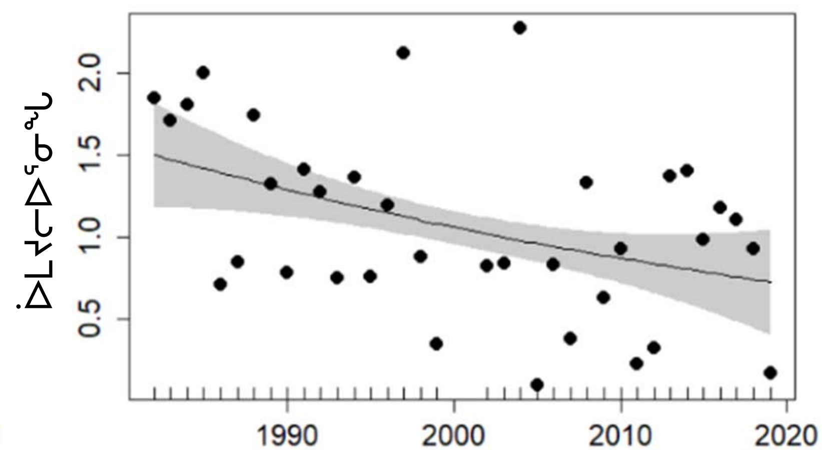
ᑎᖁᒥᐊᖅ ᓂᕿᑐᖅᑐᖅ





Avian top predators





ᓄᕐᕋᓗᐅᕐᕕᖏᑦ ᓄᓇᐃᑦ – ᖃᐅᔨᓴᕐᓂᖃᑎᐊᕐᓂᖅ

ᑲᖏᕐᓱᓂᖅ – ᖃᐅᔨᓴᕐᓂᖃᑎᐊᕐᓂᖅ

2015-2016 < 50 ᐊᔾᔨᙳᐊᑦ ᐊᖅᑯᓰᖅᑐᓂ ᖃᐅᔨᓴᓂᕐᒥᑦ

1980-2019 ≥ 1200 ᐱᑭᖅ*ᐊᕐᕌᒍᐃᑦ

2015-2016 ≥ 181, 960 ᒥᓂᑦᐢ ᐊᖅᑯᓰᖅᑐᓂ ᖃᐅᔨᓴᓂᕐᒥᑦ
2015-2016 > 48, 000 ᐊᔾᔨᙳᐊᑦ ᐊᖅᑯᓰᖅᑐᓂ ᖃᐅᔨᓴᓂᕐᒥᑦ

2015-2019 ≥ 550 1-ᑭᓚᒦᑕᐃᑦ ᖃᐅᔨᓴᕐᕕᒋᔭᐅᔪᑦ ᒫᓐᓇᐅᔪᒥᑦ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ
2019 ≥ 73, 130 ᒥᓂᑦ ᐊᖅᑯᓰᖅᑐᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ

2012-2015 ≥ 192 ᐃᓂᐅᔪᖅ*ᐊᕐᕌᒍᐃᑦ, 695 ᑐᑦᑐᓄᑦ ᐊᓇᖏᑦ
2012-2015 ≥ 192 ᐃᓂᐅᔪᖅ*ᐊᕐᕌᒍᐃᑦ, 294 ᒥᑭᔪᓄᑦ ᐆᒪᔪᓄᑦ ᐊᓇᖏᑦ
2012-2015 ≥ 192 ᐃᓂᐅᔪᖅ*ᐊᕐᕌᒍᐃᑦ, 294 ᐊᕿᒃᑎᓄᑦ ᐊᓇᖏᑦ

2008-2019 ≥ 720 ᐊᔪᓗᐅᖅᑲᔪᑦ*ᐅᓪᓄᐃᑦ/ᐊᕐᕌᒍ

2019 ≥ 17, 377 ᐊᔪᓗᐅᖅᑲᔪᑦ *ᐃᑲᕐᕋᐃᖅ, 376 ᐆᒪᔪᐃᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ

2012-2019 ≥ 192 ᐃᓂᐅᔪᖅ*ᐊᕐᕌᒍᐃᑦ, 3,840 ᐆᒪᔪᐃᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ
2012-2019 ≥ 192 ᐃᓂᐅᔪᖅ*ᐊᕐᕌᒍᐃᑦ, 1920 ᒥᑭᔪᑦ ᖃᐅᔨᓴᕐᕕᐅᔪᑦ ᐊᔾᔨᙳᐊᑦ

2019 ≥ 10 ᓄᕗᓗᒃ ᖃᐅᔨᓴᕐᕕᐅᔪᖅ ᐃᓂᖏᑦ, 1500 ᐆᒪᔪᐃᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ

ᐊᐱᖅᑯᑎᑦ