

Establishing baselines for future monitoring of invertebrate herbivory in the Arctic

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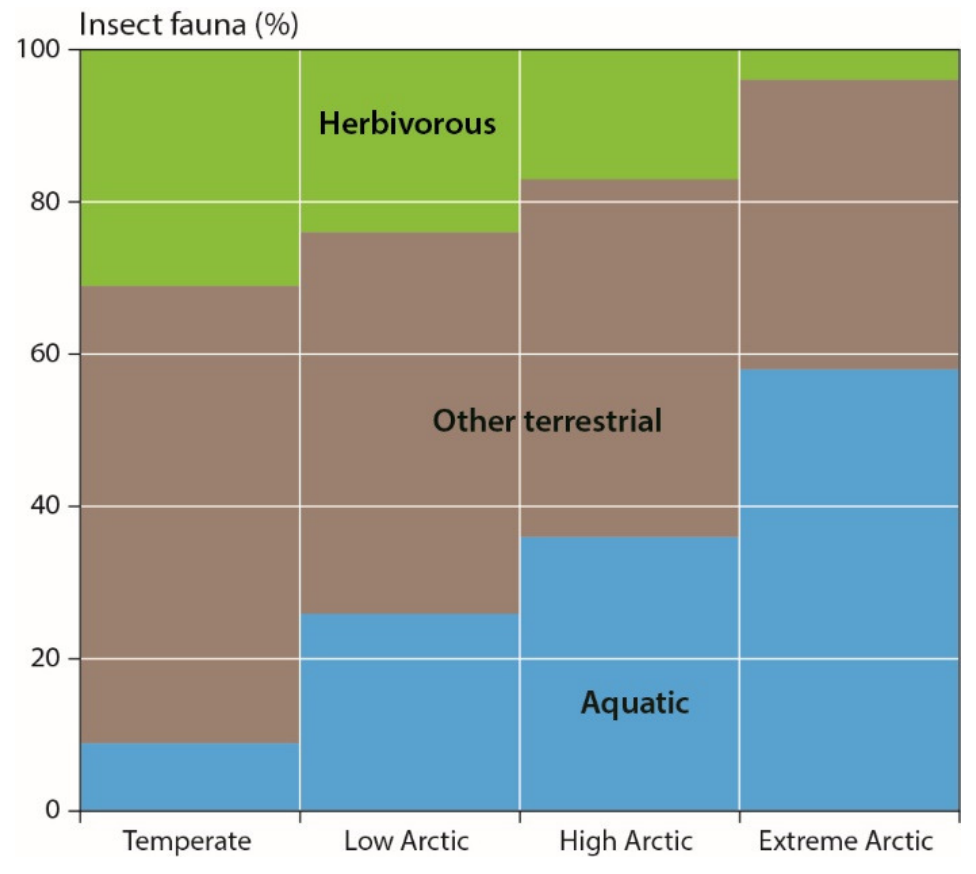
Agricultural University of Iceland

SESSION KNO9: Herbivory in the Arctic – understanding large-
scale patterns and processes of a key ecological interaction
2nd Arctic Biodiversity Congress, Rovaniemi 9-12 October 2018



We know little about invertebrate herbivores up North...

Not that many insect herbivores in the Arctic



Meltofte, H. (ed.) 2013. Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity. Conservation of Arctic Flora and Fauna, Akureyri.

We know little about invertebrate herbivores up North...

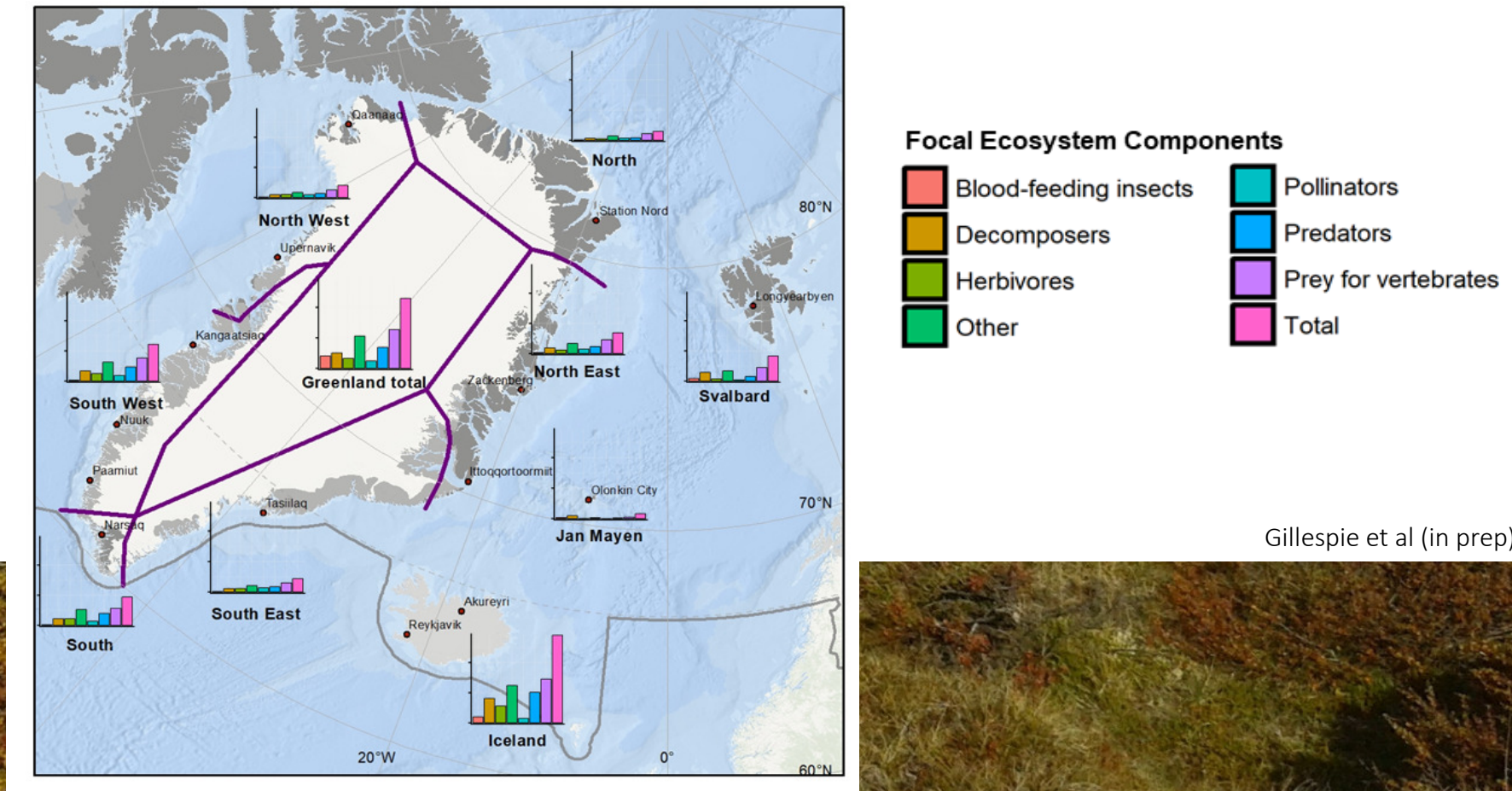
Not that many insect herbivores in the Arctic

leaf damage



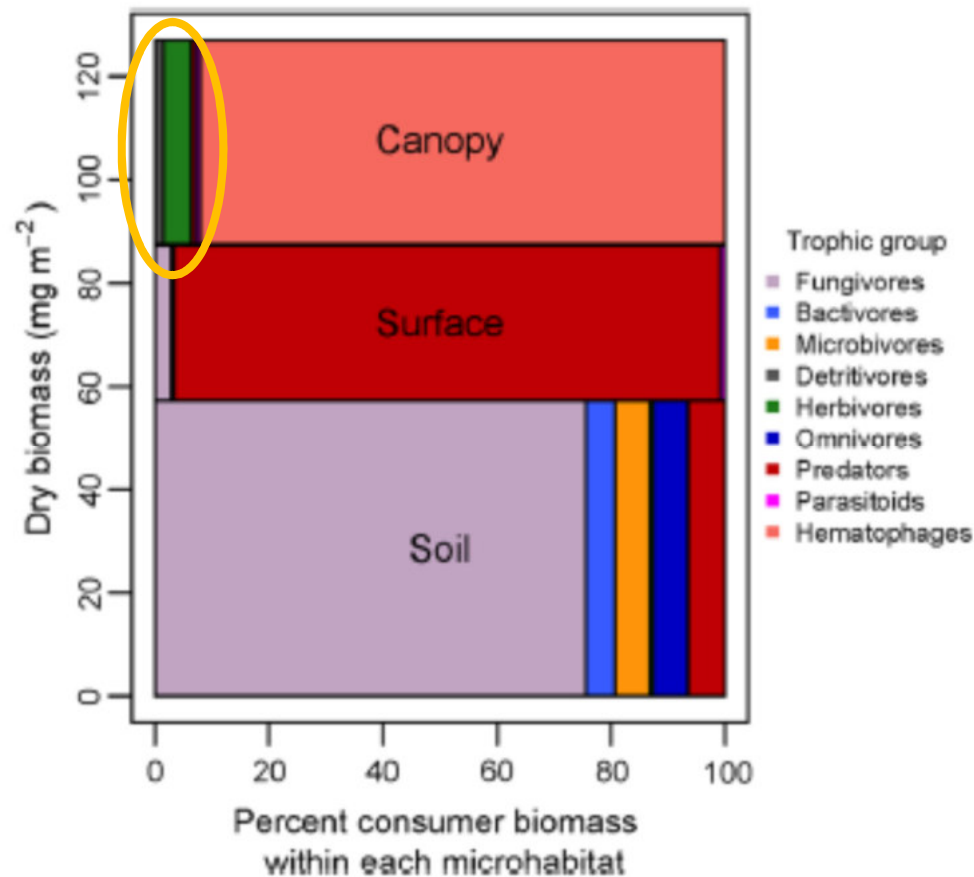
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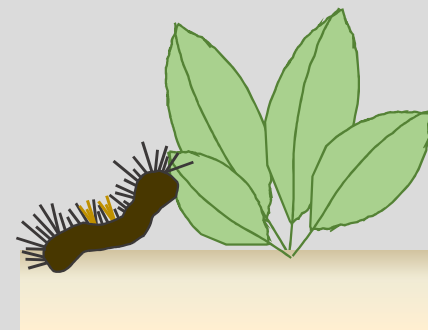
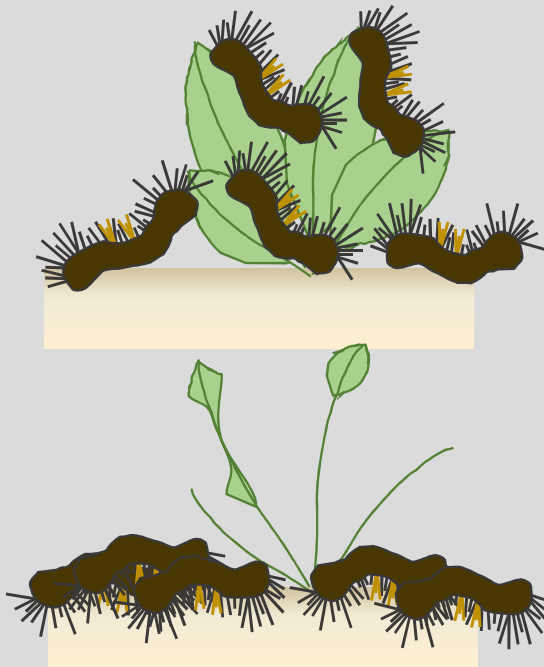


✗ invertebrate herbivores
<5% canopy biomass

Koltz et al (2018) *Polar Biology*

We know little about invertebrate herbivores up North...

Outbreaks vs background herbivory



~1% plant biomass

Kozlov et al (2015) *Polar Biol*
Barrio et al (2017) *Polar Biol*

Oikos 121: 2036–2043, 2012
doi: 10.1111/j.1600-0706.2012.20688.x
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Subject Editor: Matt Ayres. Accepted 16 March 2012

**Little strokes fell great oaks: minor but chronic herbivory
substantially reduces birch growth**

Elena L. Zvereva, Vitali Zverev and Mikhail V. Kozlov

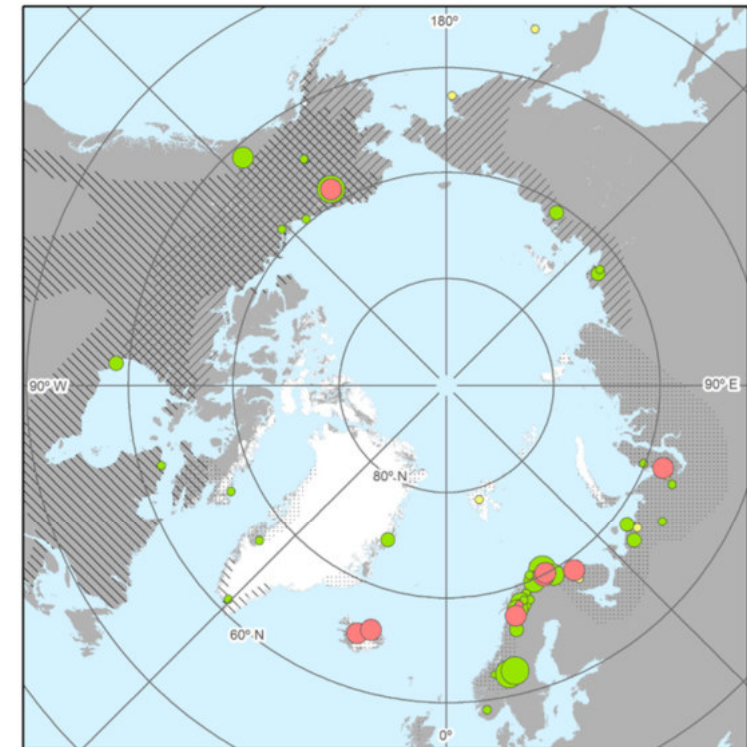
E. L. Zvereva (elzver@utu.fi), V. Zverev and M. V. Kozlov, Section of Ecology, Dept of Biology, Univ. of Turku, FI-20014 Turku, Finland.

Invertebrate herbivory in tundra



- ✖ Dwarf birch (*Betula glandulosa-nana* complex)
- ✖ 56 locations, 192 tundra sites, 3 protocols, 30817 leaves

Barrio et al (2017) *Polar Biology*



Number of samples per location

• 1-2 • 3-4 • 5-6 • 7-16

Sampling protocol

● 2008-2013 protocol ● 2014 protocol ● 2015 protocol

Dwarf birch taxa distribution

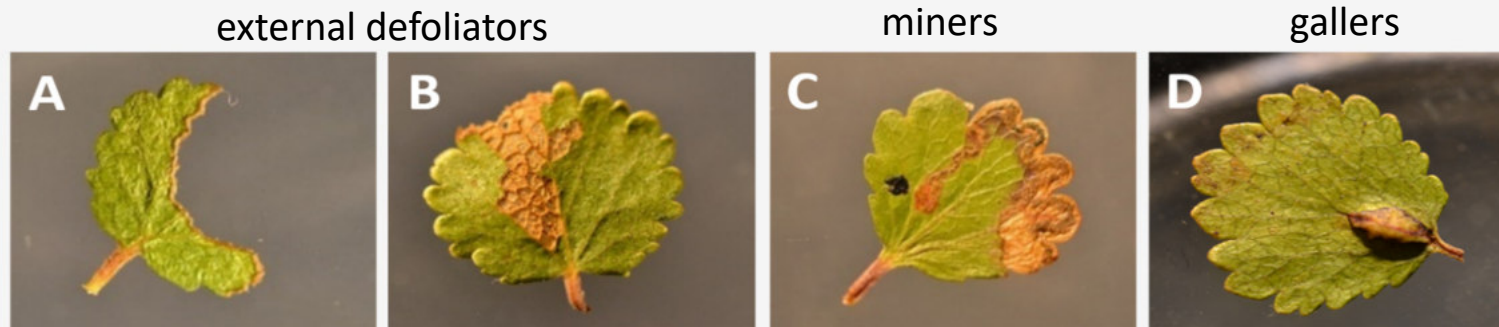
▤ *Betula nana nana* ▤ *Betula nana exilis* ▤ *Betula glandulosa*



HERBIVORY NETWORK
STUDYING HERBIVORY IN ARCTIC AND ALPINE ECOSYSTEMS

Invertebrate herbivory in tundra

signs of invertebrate herbivory on dwarf birch



✗ patterns of background herbivory by different groups of invertebrate herbivores?



Invertebrate herbivory in tundra

- ✖ Nearly ubiquitous, but at low intensity
- ✖ Most damage by external defoliators (leaf chewing and skeletonizing)
- ✖ On average 11% leaves affected, 1.4% leaf area consumed, most damaged leaves only slightly affected

To find some damage we need to collect...

33 leaves to have 95% probability of finding a damaged one

76 leaves to have 99.9% probability of finding a damaged one

Recommend 100 leaves for external defoliators (larger samples for other types of damage!)

Invertebrate herbivory in tundra

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STUDYING HERBIVORY IN ARCTIC AND ALPINE ECOSYSTEMS

Invertebrate herbivory protocol. Herbivory Network
Barrio & Koslov
Last update: 8-May-2015

Measuring background invertebrate herbivory in the tundra

Invertebrate herbivory in tundra ecosystems has received little attention¹ and effects of foliar losses to invertebrates on tundra plants have been generally neglected². Most attention has focused on extensive defoliation events during outbreaks in the forest-tundra ecotone³, but we know little about background (non-outbreak) herbivory levels in tundra⁴, despite the relevant effects it has in other systems⁵.

The goal of this document is to provide guidelines for assessment of the occurrence and intensity of invertebrate herbivory at different tundra sites. In this initial assessment (summer 2015), samples will be collected from the field from a large number of tundra sites, and leaf damage will be assessed in a common lab by the same observer. This information will allow a quantitative evaluation of invertebrate herbivory, providing information to address the following questions:

- ✓ What are the average levels of background invertebrate herbivory in tundra?
- ✓ Is invertebrate herbivory similarly prevalent across tundra sites?
- ✓ Which plant species suffer most from invertebrate herbivory?
- ✓ How variable is the occurrence of invertebrate herbivory in tundra at different scales?

Most studies investigating invertebrate herbivory have focused on leaf damage⁶. Since invertebrate herbivory are not as easily recognizable (e.g. sap feeders, root herbivores) more intensive protocols (e.g. floral herbivory and seed predation). Although the effects may be as relevant as those of folivores^{7,8}, for a preliminary assessment of invertebrate herbivory we focus on the impacts of herbivores that cause leaf damage.

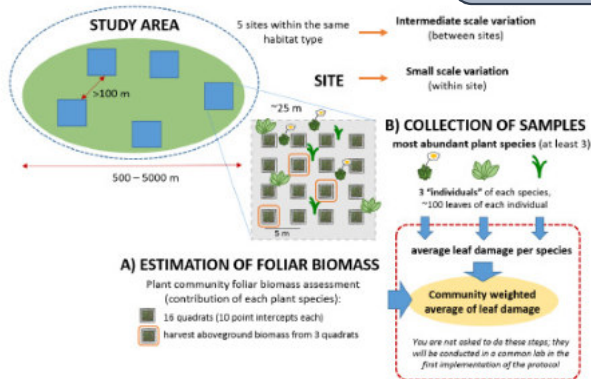


Figure 1. Study design for assessing variability in invertebrate herbivory at two spatial scales, between and within sites.

patterns of invertebrate herbivory
at the community level?

22 SITES
5 PLOTS
3 plants of 3 species
100 leaves per plant

Community Weighted
Biomass loss

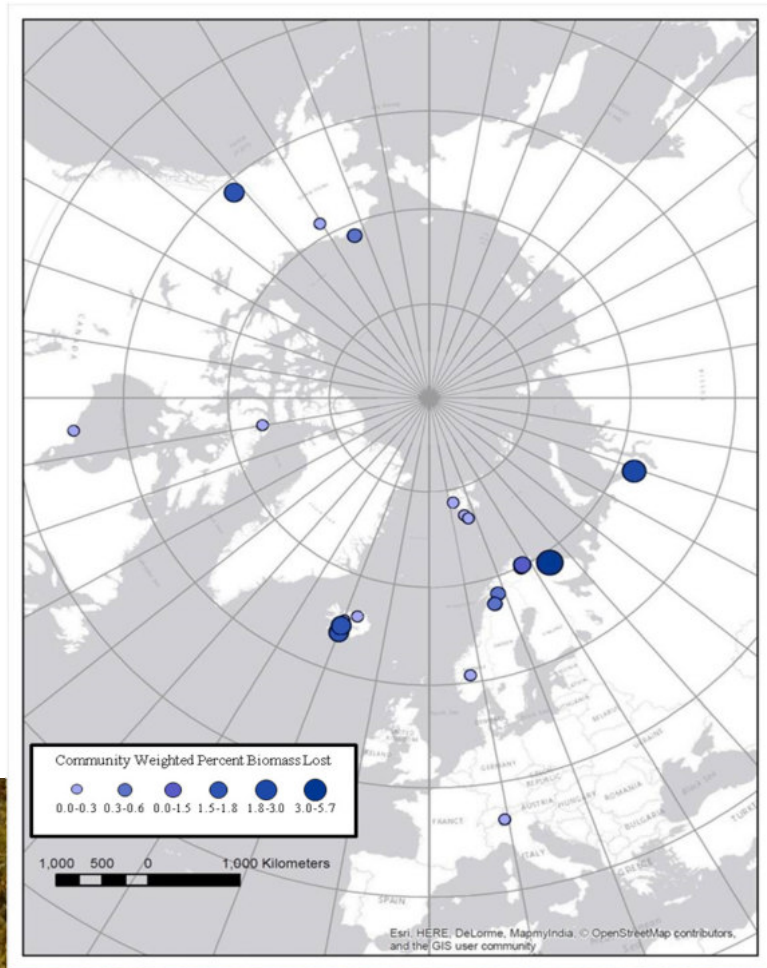
$$CWB_i = \left(\frac{\sum_{j=1}^3 \left(BM_{ij} * \frac{\overline{PLAD}_{ij}}{100} \right)}{\sum_{j=1}^3 (BM_{ij})} \right) * \overline{PFSB}$$



Sarah Rheubottom

Rheubottom et al (in prep)

Invertebrate herbivory in tundra



patterns of invertebrate herbivory
at the community level?

- ✗ Low intensity, but ubiquitous
- ✗ Most damage by external defoliators
- ✗ Most variation at local scale



Sarah Rheubottom

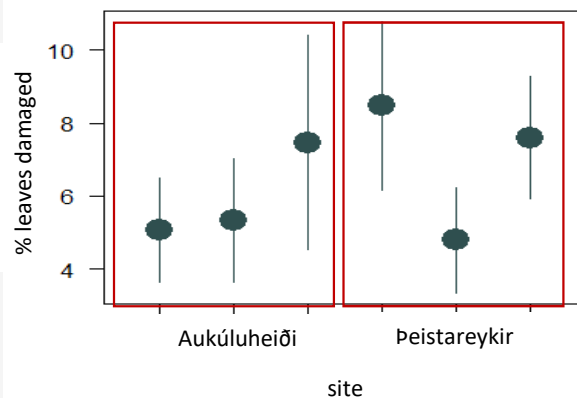
Rheubottom et al (in prep)



Invertebrate herbivory in tundra

how variable is it?

2 sites in Iceland, 6 plots, 150 plants, 4498 leaves



most variation seems to be at the **individual plant level**, not at the plot (m) or site (km) levels



- ✗ 25 plants 5 m apart, plots ~100 m apart, sites >100 km apart
- ✗ Changes over time?



Invertebrate herbivory in tundra

- Background herbivory is highly prevalent across sites but occurs at low intensity
- Most of the damage is caused by external defoliators and occurs at a local spatial scale (individual plant > plot > sites)
- Background herbivory is likely to increase as a result of warmer temperatures but standardized protocols are needed to detect and monitor changes



Thank you!

Acknowledgements

- **CBMP terrestrial arthropod group** – Mark Gillespie and Toke Høye
- **Background herbivory project** – Mikhail Kozlov and Sarah Rheubottom, and a very long list of contributors
- **NeAT and Herbivory Network**



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