Ambient and experimental warming caused stronger changes in tundra plant communities in Iceland than grazing exclusion

Ingibjörg S. Jónsdóttir[1], Jón Guðmundsson[2], Borgþór Magnússon[3], Járngerður Grétarsdóttir[3], Noémie Boulanger-Lapointe[1,4]

[1]University of Iceland, [2]Agricultural University of Iceland, [3]Icelandic Institute of Natural History, [4]University of Victoria

Background

- Climate in Iceland has been warming on average by 1ºC per century since 1900.
- There is evidence of substantial 'greening' occurring from 1982 to 2010, but trends are uneven across the country.
- Changes in greenness can only partly be attributed to climate as substantial reduction in livestock grazing and restoration measures also occurred over the last decades.

Aims

- ITEX sites were installed in two different tundra habitats in1996 to disentangle the drivers of vegetation changes and to provide insights on the cause of the heterogeneity in response.

Study sites

Audkuluheidi - BH

- Relatively diverse *Betula nana* dwarf-shrub heath (BH) in the highlands.
- Degraded by centuries of heavy grazing.
- Includes a grazing exclusion treatment.

2019 – Inside-outside the exclosure. Slow recovery from sheep grazing (to the right of the fence).

Thingvellir - MH

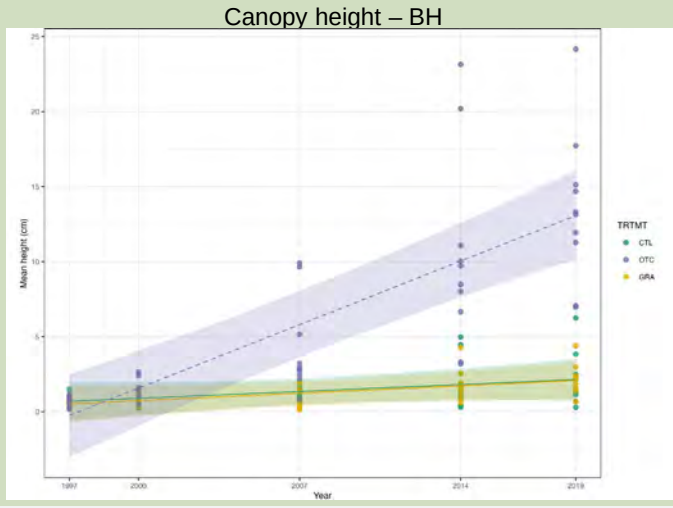
- Moss heath (MH), dominated by *Racomitrium lanuginosum* below the mountain birch treeline.
- Low diversity and abundance of palatable plant species.
- Not a favourable grazing habitat for livestock.

2019 – No or little sheep grazing for the last 90 years

Main results

Species composition

Canopy height – BH



Plant community responses

BH at Audkuluheidi:

Quick and strong responses to the warming treatment

- Significant increase in the cover of *Betula* shrubs
- Decrease of the dominating moss *R. lanuginosum*.

MH at Thingvellir:

Changes were slow both in control plots and OTCs.

Small changes in vegetation cover and height occurred only in the last few years.

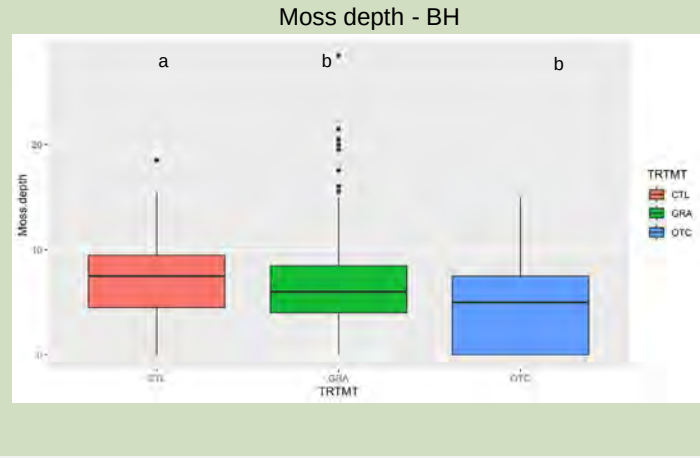
Community structure

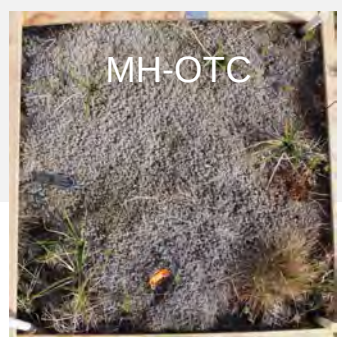
Greatest change in the BH:

- Canopy height increased overall.
- The increase in the OTCs was tenfold the increase in the ungrazed and grazed control plots.
- Moss layer depth and density decreased in the OTCs but increased when protected from grazing.

Relative cover of different growht forms

Moss depth - BH





Conclusion

- Warming contributes to greening in Icelandic tundra, most strongly where responsive shrubs are present.
- Grazing exclusion alone had minor effect on vegetation under ambient warming in the degraded highland tundra (BH) and mainly through increased moss layer depth.

Increased biocrust cover and activity in the highlands of Iceland after five growing seasons of experimental warming

Alejandro Salazar[1], Eyrún G. Gunnlaugsdóttir[2], Ingibjörg S. Jónsdóttir[3], Ian Klupar[3], Ruth-Phoebe T. Wandji[1], Ólafur Arnalds[1], Ólafur Andrésson[3]

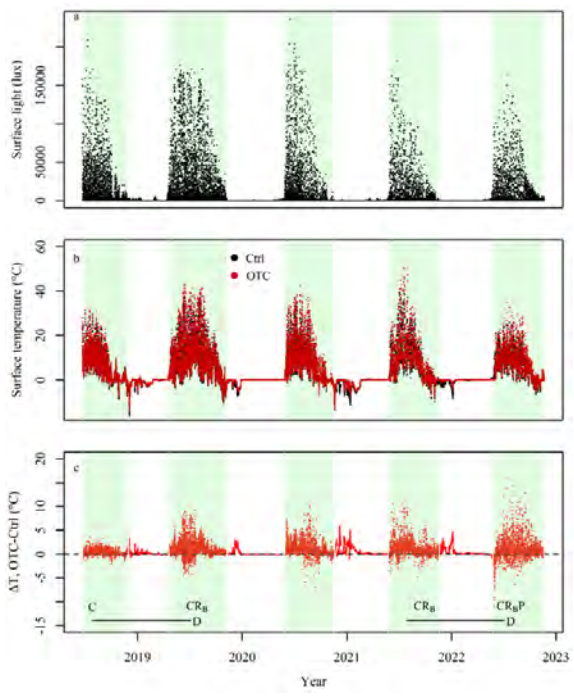
1 Faculty of Environmental and Forest Sciences, Agricultural University of Iceland, Keldnaholt, Árleynir 22, 112 Reykjavík
2 Institute for Atmospheric and Earth System Research / Physics, Faculty of Science, University of Helsinki, Finland
3 Faculty of Life and Environmental Sciences, University of Iceland, Sturlugata 7,102, Reykjavık, Iceland.

Abstract

One of the most important questions of our time is how ecosystems will be transformed by climate change. Here, we used a multi-year field experiment to investigate the effects of climate warming on the cover and function of a sub-Arctic alpine ecosystem dominated by biocrust (biological soil crust) —a system that plays major ecological roles in a substantial part of the terrestrial surface. We used Open Top Chambers (OTCs) to simulate warming; standard surface and NDVI analyses to measure plant composition, cover and function; gas analyzers to monitor biocrust respiration; and the Tea Bag Index (TBI) approach to estimate decomposition and soil carbon stabilization rates. Contrary to our initial hypothesis of warming accelerating an ecological succession of plants growing on biocrust, we observed a warming-induced decreased abundance of vascular plants and mosses and an increase in the cover of visible biocrust—possibly caused by high temperature summer peaks that resemble heat waves. The functional responses of biocrust to warming, including increased respiration rates and a lower capacity to store labile carbon into recalcitrant forms, may suggest climate-driven depletion of soil nutrients. It remains to be studied how the effects of warming on biocrusts from high northern regions could interact with other drivers of ecosystem change, such as grazing; and if in the long-term global change could favor the growth of vascular plants on biocrust habits in the highlands of Iceland and similar ecosystems. For the moment, our experiment points to a warming-induced increase in the cover and activity of biocrust.

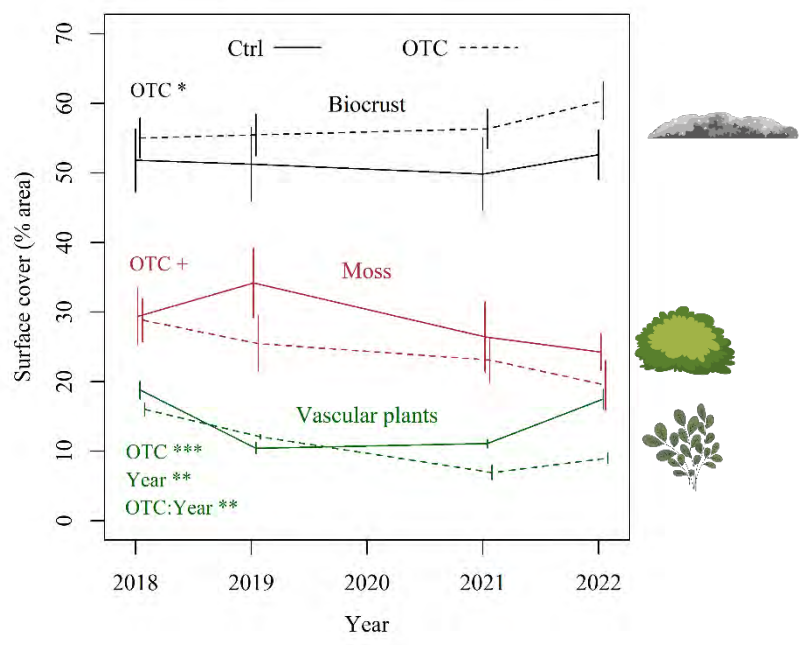
Experimental warming

In addition to the average warming of 0.83 ± 0.01 °C, OTCs created heat wave-like warming events of up to +16 °C that lasted for several hours.



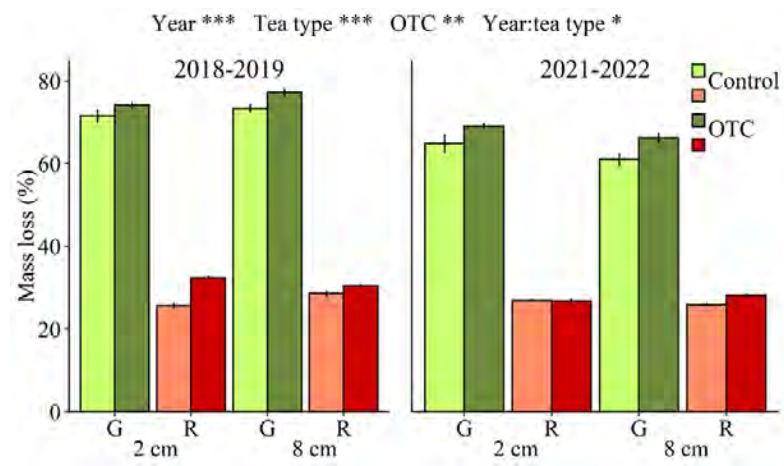
Surface cover

In the summer of 2022, after five growing seasons of OTC-warming, the biocrust, moss, and vascular plant covers were 15% higher, 20% lower and 49% lower in the OTC than in the control plots, respectively.



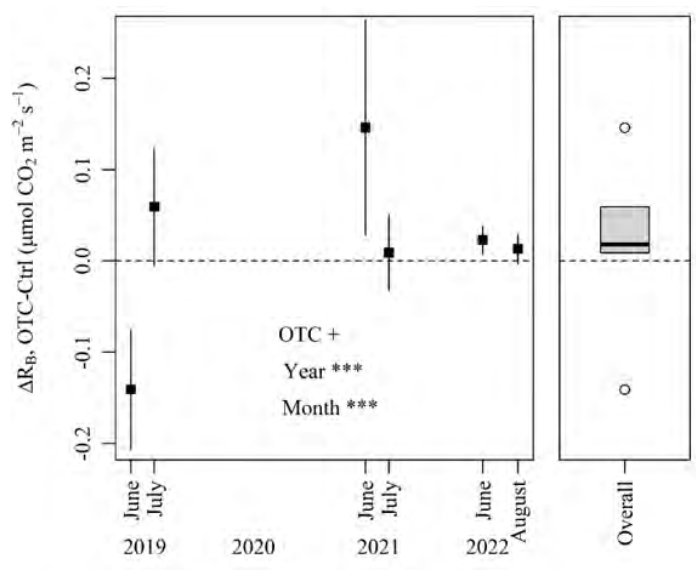
Mass loss (TBI)

OTC increase mass loss both at 2cm (right below the biocrust) and 8cm (underlying soil). We used this mass loss data to calculate stabilization factors (S) and decomposition (k) as in Keuskamp et al. (2013). S, an indicator of the capacity of the system to stabilize labile compounds into recalcitrant forms during decomposition, decreased by 25% with the OTC treatment.



Biocrust respiration (R_B)

The marginal but positive effect of warming on R_B in our experiment is consistent with a recent synthesis of 56 open-top-chamber *in-situ* experiments located at arctic and alpine tundra sites that reports an average 30% increase in ecosystem respiration with warming (Maes et al., 2024. Accepted).



I tried to attend the meeting. Need a visa. Applied in Octiober. Case still „in progress“. Hence, a poster with lots of text. I hope it is clear! If you read it and want to talk, send me an email ☺

alejandro@lbhi.is

Alejandro Salazar
Assistant Professor
Faculty of Environmental and Forest Sciences
Agricultural University of Iceland