Moss-associated bacterial communities in a warming Arctic

with the focus on nitrogen fixing bacteria

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University of Akureyri

UNIVERSITY OF ICELAND

Micro Arctic
Microorganisms in Warming Arctic Environments, Marie Skłodowska-Curie ITN

European Commission

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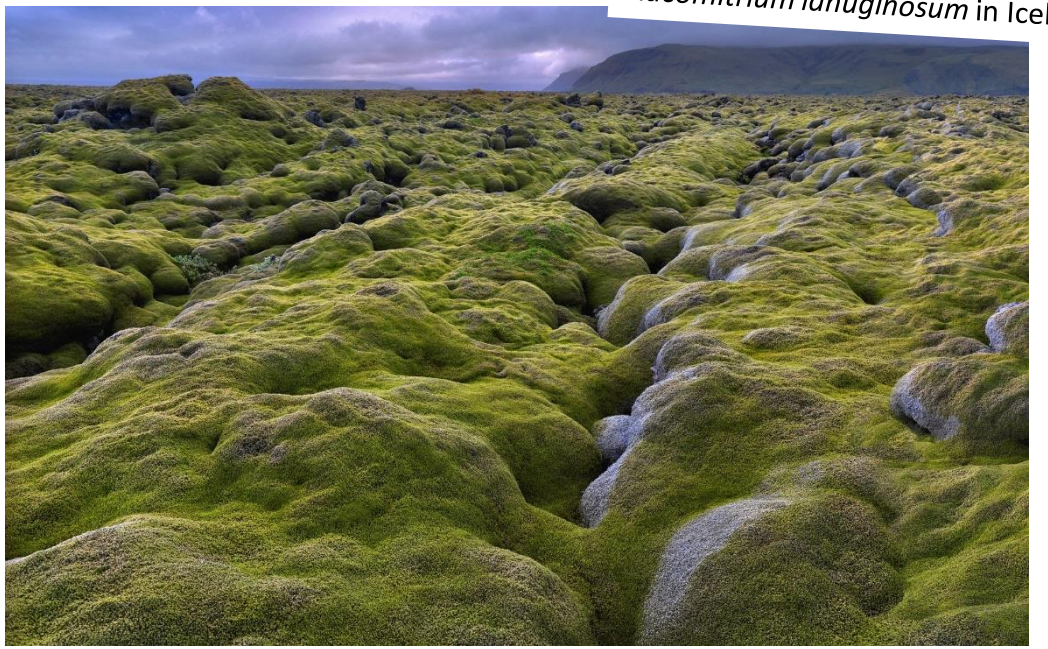
Mosses matter

- Carbon sink
- Major source of N – N_2-fixing bacteria
- Higher temperatures → increase in N_2 fixation
- Shading by higher plants → decrease in N_2 fixation
- Moisture
  - Drier conditions → decrease in N_2 fixation
- Recent meta-analysis: experimental warming has no effect (Salazar et al 2019 Ecology in press)
  - Is it due to a shift in the bacterial community?

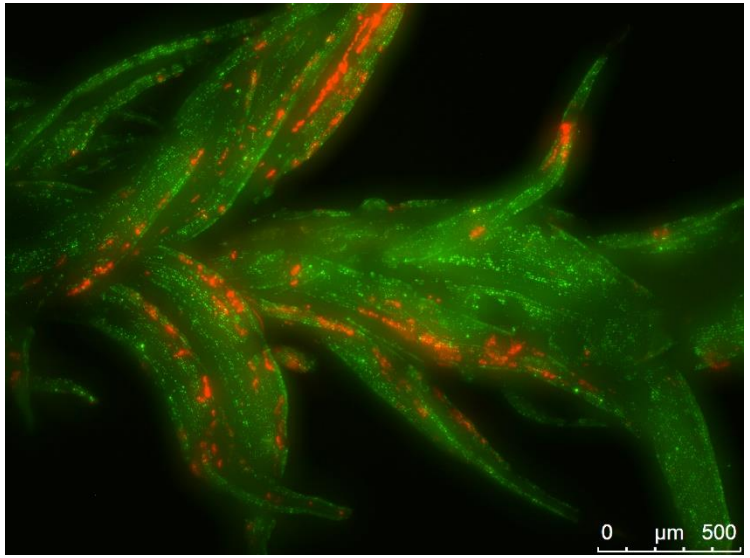


Racomitrium lanuginosum in Iceland

The bryosphere – the bacterial component

“the combined complex of living and dead moss tissue and associated organisms”

Lindo and Gonzalez 2010 Ecosystems



- **Cyanobacteria**
- **Alphaproteobacteria**
- Betaproteobacteria
- Gammaproteobacteria
- **Verrucomicrobia**
- Plancomycetes
- Bacteroidetes
- Acidobacteria
- **Actinobacteria**

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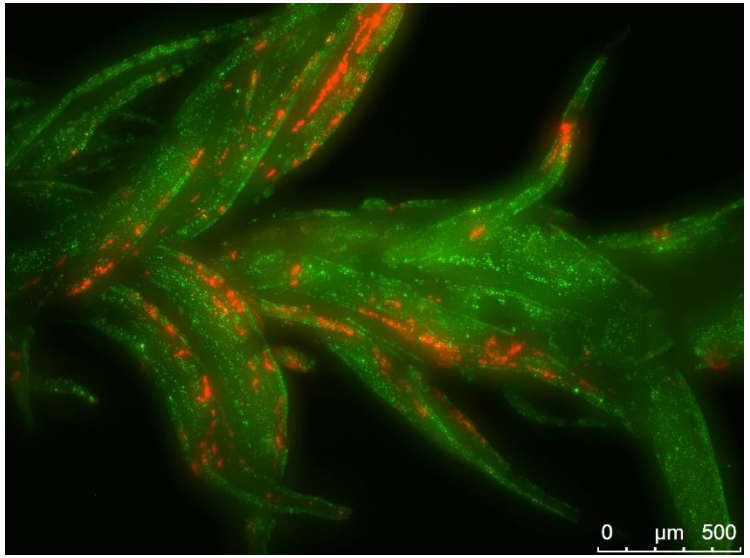

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ORIGINAL ARTICLE

Sphagnum mosses harbour highly specific bacterial diversity during their whole lifecycle

Anastasia Bragina[1], Christian Berg[2], Massimiliano Cardinale[1], Andrey Shcherbakov[3], Vladimir Chebotar[3] and Gabriele Berg[1]
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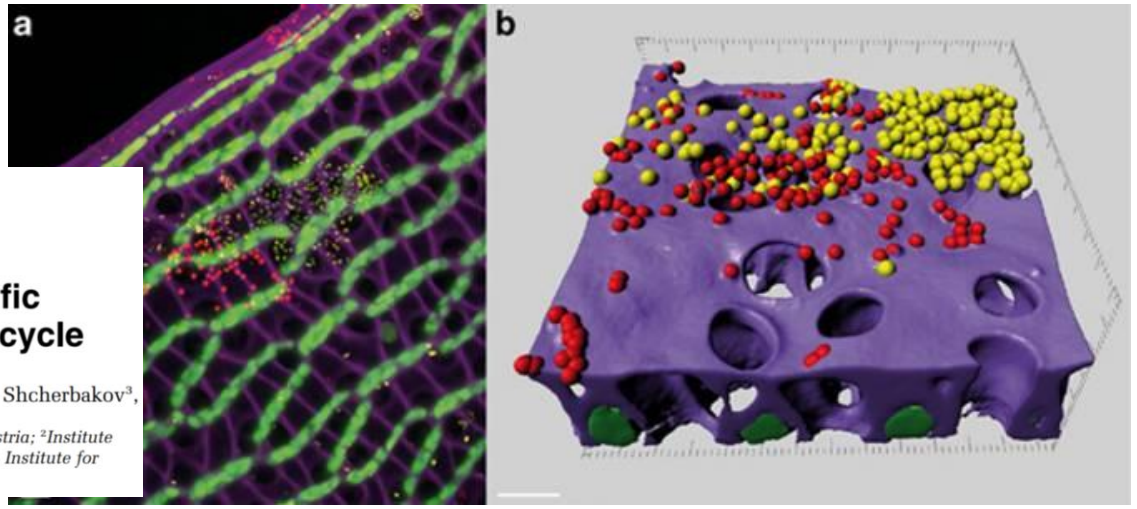


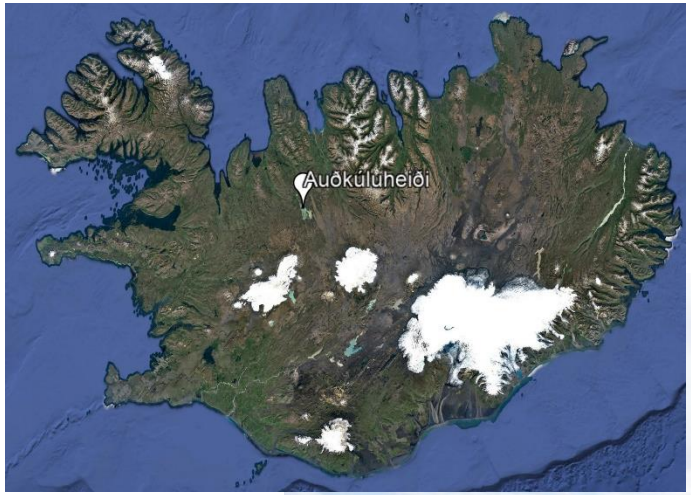
What is the effect of long-term warming on the bacterial community associated with *Racomitrium lanuginosum*?

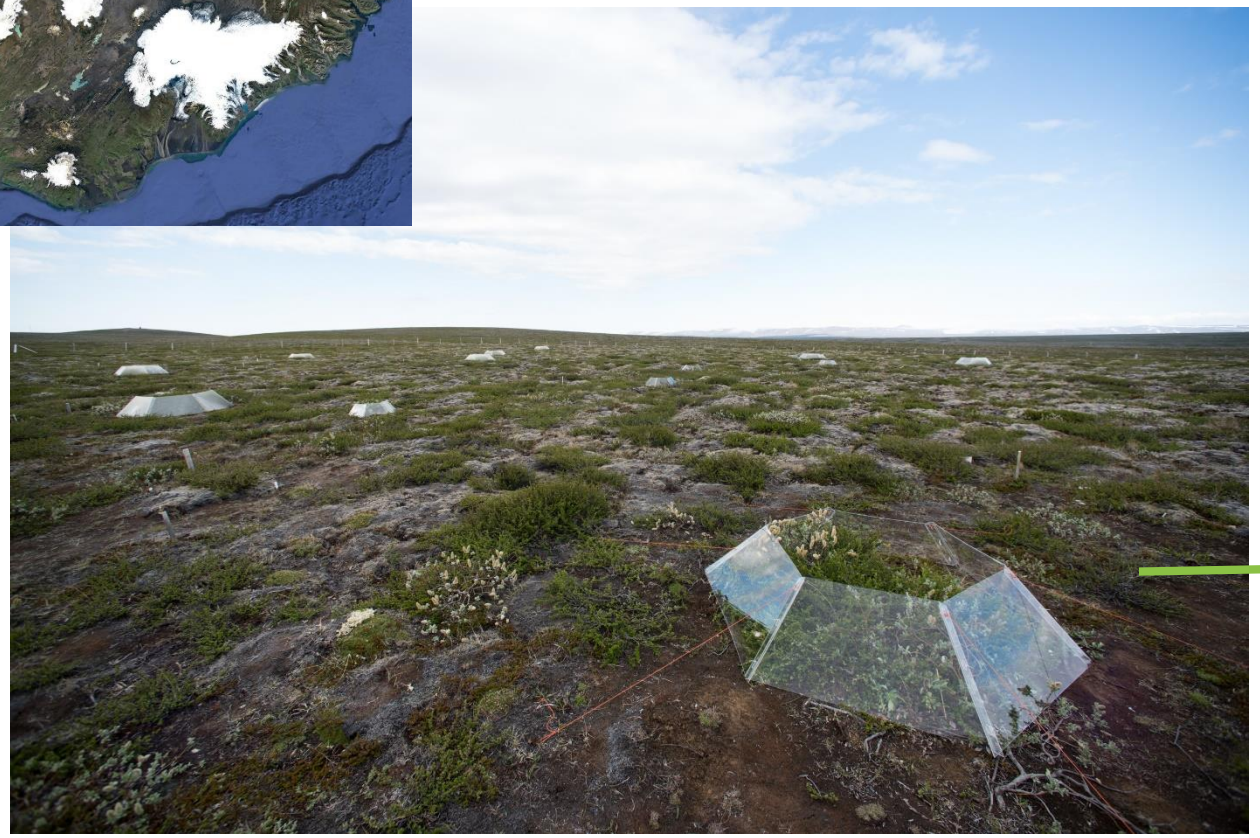
"Warming leads to a shift in N_2-fixing bacterial taxa with consequences for N_2-fixation rates"

- N_2 fixation rates and *nifH* gene copy numbers
- Community structure
- Changes in relative abundance
- Taxonomic composition

} of potential N_2-fixing taxa

Experimental design





Auðkúluheiði, Iceland

- Species-rich dwarf shrub heath
- 10 OTCs
- 10 control plots
- since 1997/1998 (20 years)

Racomitrium lanuginosum

Sample processing

N_2-fixation rates

Acetylene reduction assays

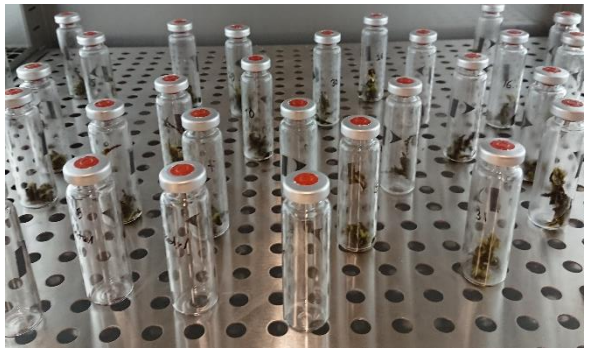
N_2-fixation potential

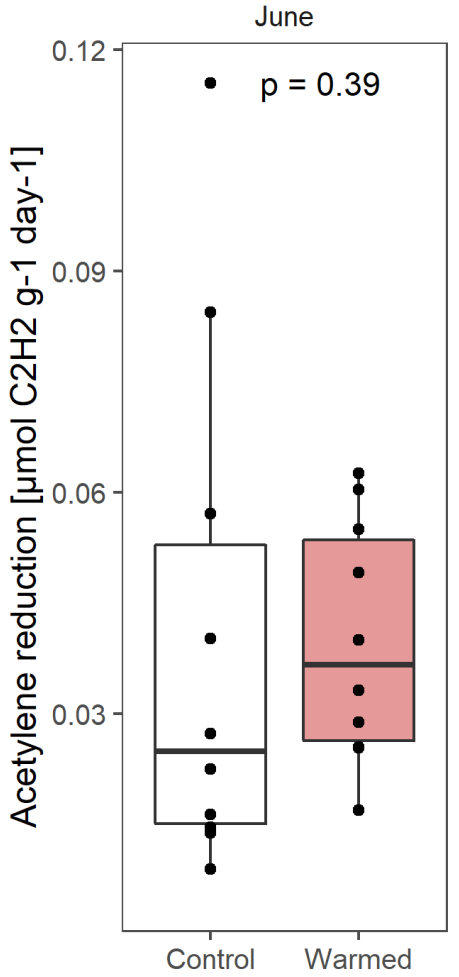
qPCR of *nifH* genes

Taxonomy and relative abundance of potentially N_2-fixing bacteria

16S rRNA amplicon sequencing

No difference in N_2-fixation rates

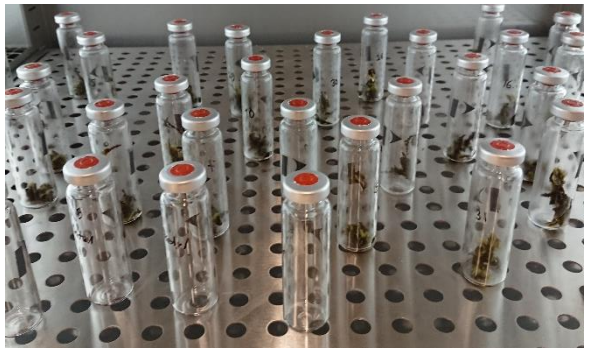


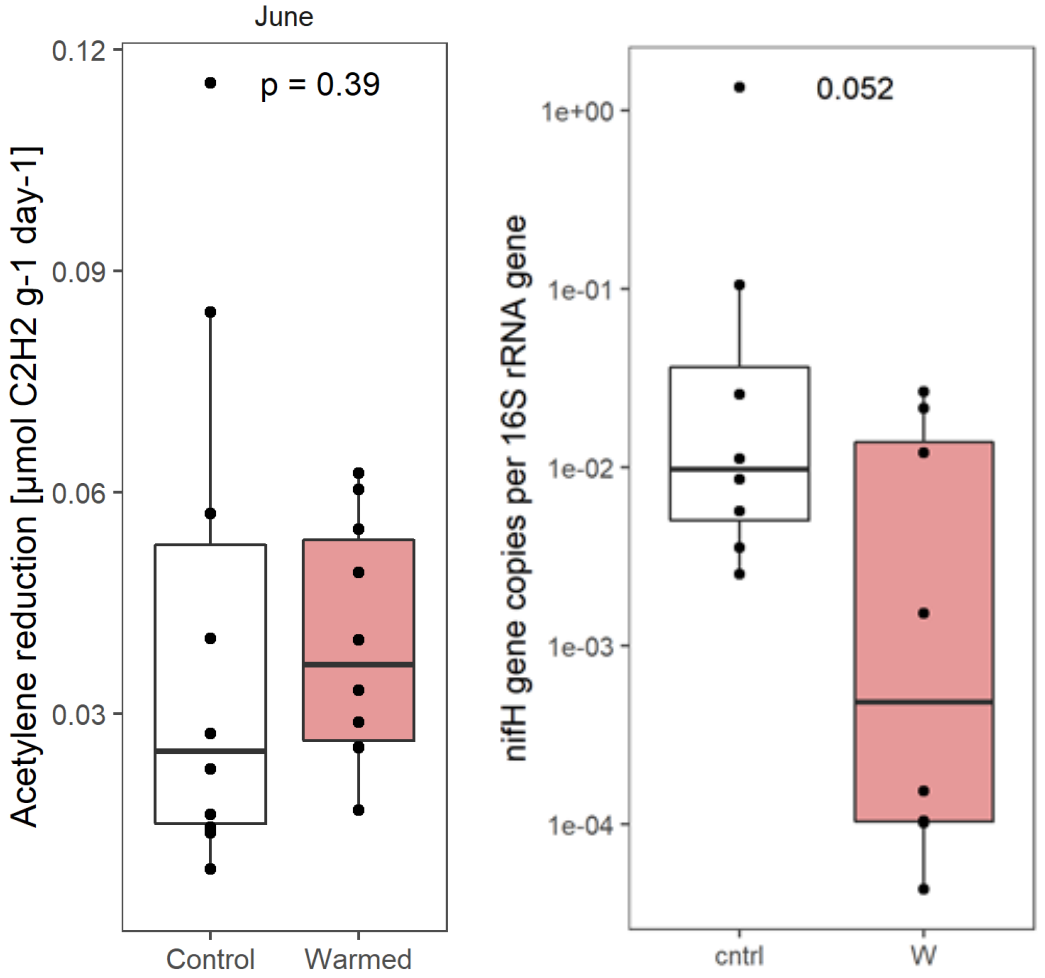


Data from Ana J. Russi

No difference in N_2-fixation rates, but N_2-fixation potential tends to be lower under warming

- Proportion of N_2-fixing taxa (*nifH* copy per 16S rRNA gene copy) tends to be lower under warming
- Potential for N_2-fixation as part of the total bacterial community is lower under warming





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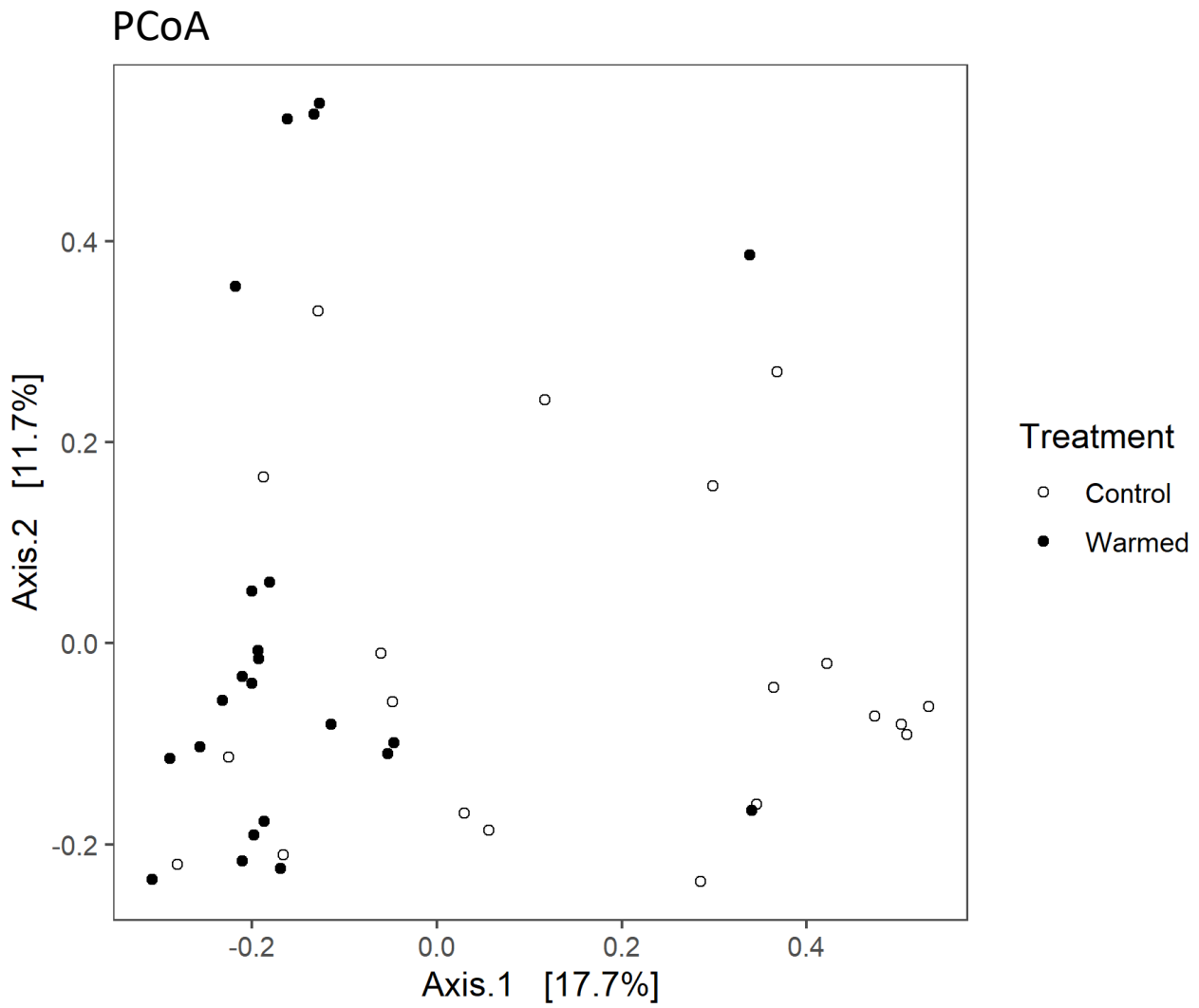
Warming slightly affects N_2-fixing community composition

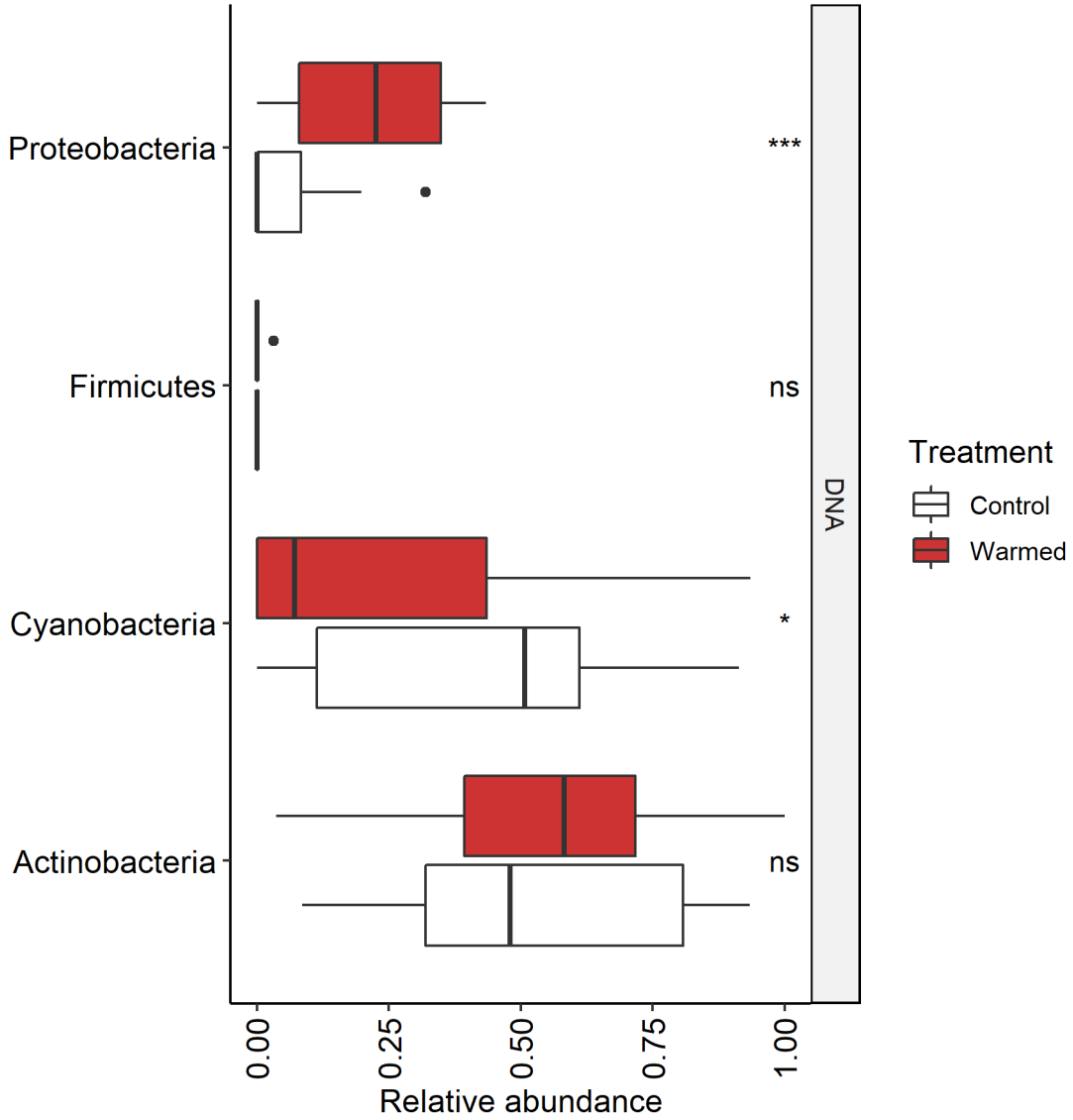
Potential N_2-fixers
Permanova ~ Treatment
$P = 0.001$ and $R^2 = 0.08$



Changes in relative abundance of taxa on phylum level

Potential N_2-fixers

- Cyanobacteria ↓
- Proteobacteria ↑
  - Probably not adding significant amounts

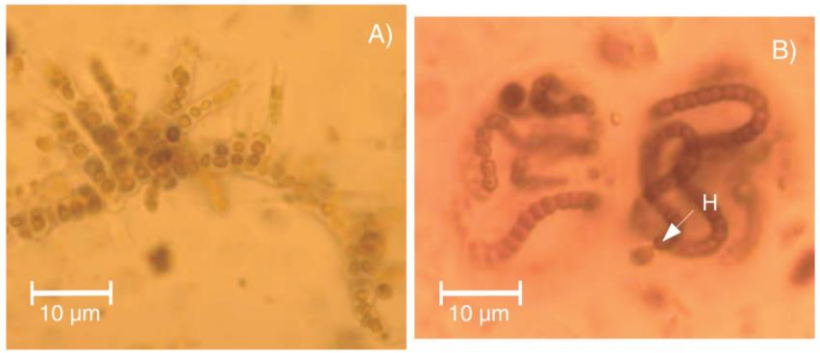


Cyanobacterial indicator taxa

- Cyanobacterial genera:
  Stigonema warming
  Nostoc control

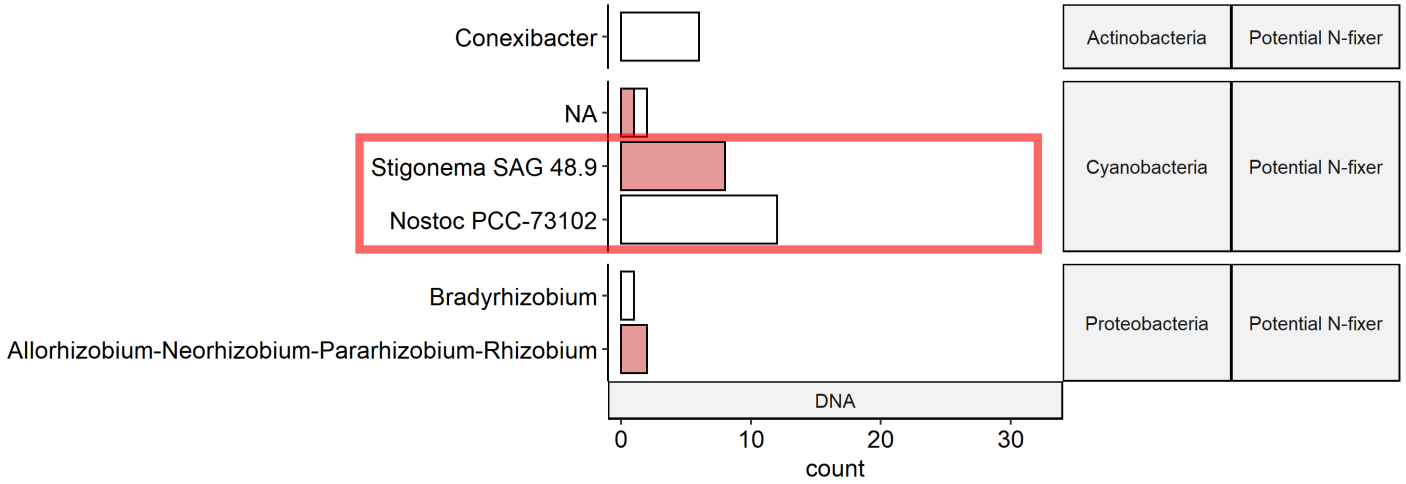
- *Stigonema* most transcriptionally efficient N_2-fixer in boreal forest feathermosses (Warshan et al. 2016)

- Might explain why *nifH* gene abundances decrease while N_2-fixation rates stay similar



Houle et al (2006) Identification of two genera of N2-fixing cyanobacteria growing on three feater moss species in boreal forests of Quebec, Canada

Potential N_2-fixing indicator taxa



Conclusion

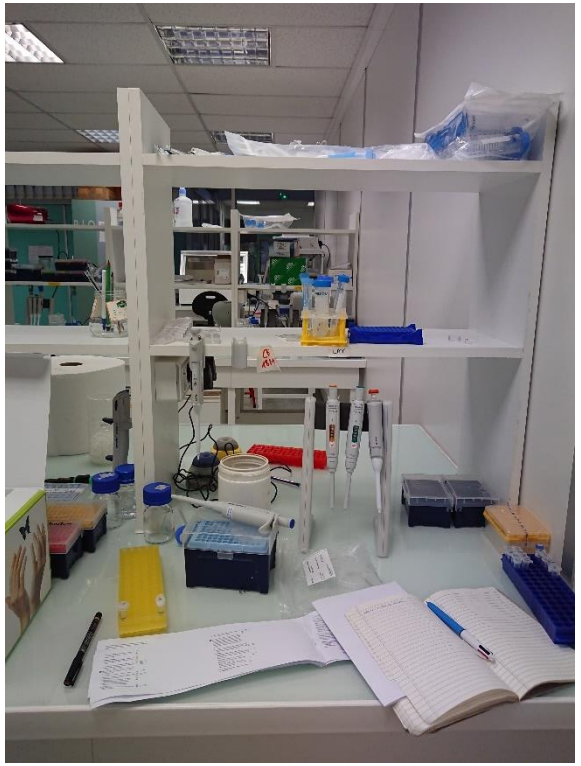
N_2 fixation rates did not change,

due to shifts in the bacterial community

Other work: lichen bacterial community under warming,

moss bacterial community during primary succession

Thanks for your attention!



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