Climate Clarity: Nitrogen Cycling in Soil Under Freeze-Thaw Cycles

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Introduction

Global temperatures will rise by 5°C over the next century

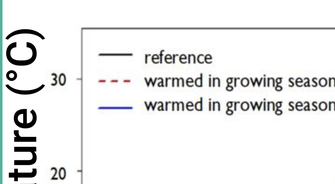
Freeze-Thaw Cycles:
Warmer winter temperatures
→less snow coverage, less insulation from the air
→soil is exposed to more temperature changes
→it cycles between freezing and thawing

Past *Climate Change Across Seasons Experiment* (CCASE) studies found
- FTCs cause reductions in soil microbial biomass
- FTCs create anaerobic conditions
  - evidenced by rust in soil →

CCASE Plots:

reference

warmed 5°C (growing season)



warmed 5°C + snow removal

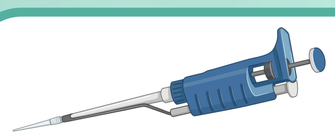
Nitrogen Cycling
- biogeochemical processes
- microbial activity
- one of the most limiting nutrients for plants
- greenhouse gas

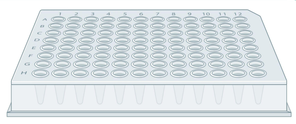
Hypothesis

A. Warmer soil→ increased N cycling
- **increased microbial activity**

B. FTCs→ decreased N cycling + accelerated DNRA
- **microbe biomass decreased**
- **anaerobic conditions**

Methods

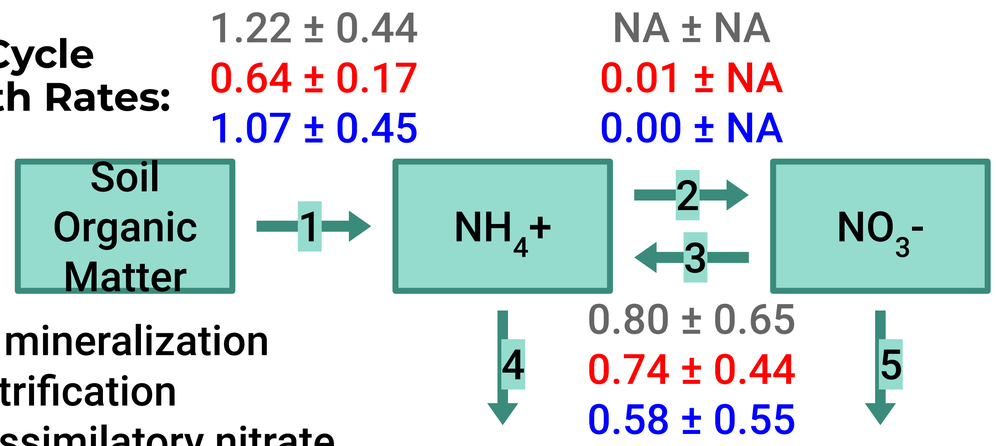




- Organic horizon (OH) soil was collected in post-snow-melt season (PSM)
- 15N labeled Ammonium and 15N labeled Nitrate were added to the samples
- Ammonium and nitrate were extracted with Potassium Chloride (KCl)
  - The concentrations were determined using the colorimetric method
  - The 15N levels were measured by the IRMS Lab at BU

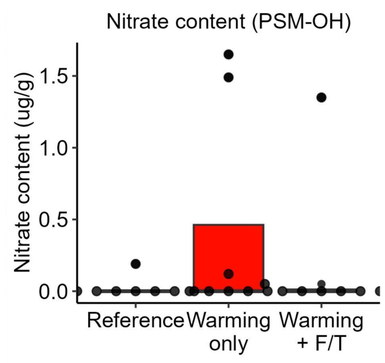
Results

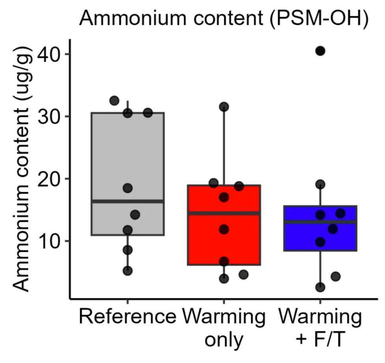
N Cycle with Rates:



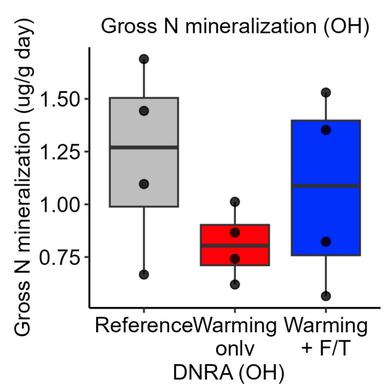
1. **N mineralization**
2. **nitrification**
3. **dissimilatory nitrate reduction to ammonium (DNRA)**
4. **NH_4+ consumption**
5. **NO_3- consumption**

Soil Contents:

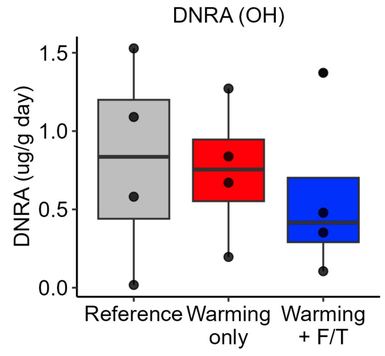


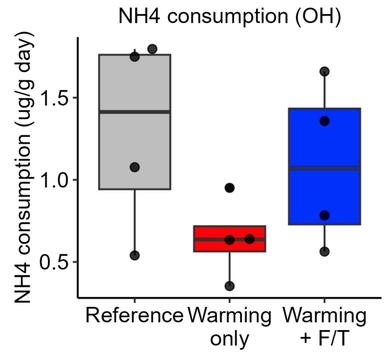


Rates of N Cycle Processes:



gross nitrification= difficult to calculate because the denominator is a log
- divide by zero error
- a graph would just be NA or ~zero





Summary:
- compared to the reference plot, rates of N Cycle processes generally decreased in both the Warmed Plot and the Warmed+FTCs Plot
- **rates of N Cycle processes generally decreased more in the Warmed Plot than in the Warmed+FTCs Plot**
- the rate of DNRA decreased more in the Warmed+FTCs Plot than in the Warmed Plot

Conclusion/ Discussion

A. Not supported
- warmed soil lowered the N cycling rate

→microbial activity does not simply increase with temperature

B. Not supported
- FTCs did not reduce N cycling; rates were relatively similar to Reference Plots
- FTCs did not accelerate the DNRA rate

→soil microbial communities adapt and maintain their N cycling processes under FTCs

→the high NH4 consumption rate + the low DNRA rate implies that ammonium was utilized in other pathways (denitrification or aerobic processes)
- supported by a previous study investigating microbial metagenomics at CCASE; observed increased genes for denitrification but decreased genes for DNRA

These results show that soil microbial N cycling is affected differently by summer and winter climate changes.

→if plants can absorb the increased N and utilize it in boosting their growth, it may help mitigate climate change
→if plants do not absorb it, the excess N could be lost to the atmosphere, accelerating greenhouse effects

References

1. Hart et al. 1994
2. Sorensen et al. 2018
3. Tatsumi et al. unpublished
4. Templer et al. 2017

Acknowledgements

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all the amazing members of the Bhatnagar Lab <3