Examining the Effects of Rising Air Temperature on Nitrogen Cycling in Alpine Ecosystems

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Overview

- Mountain environments are one of the most critical ecosystems for people and wildlife, providing about one half of the world's drinking water supply and supporting about one third of terrestrial biodiversity.[1]
- Characterized by short growing seasons and extreme weather, they are also one of the most sensitive environments to climate change and are disproportionately impacted relative to lower elevation ecosystems.[2]
- Nitrogen (N) availability, a first order control on primary productivity, may also be affected by air temperature.[3]
- At NWT, Williams et al. (2015) and Bowman et al. (2018) found that current alpine plants and microbial processes are N-limited, Understanding how temperature can affect nitrogen transformation is critical to predicting if alpine ecosystems will continue to experience nitrogen limitations. A potential release from N limitations may change alpine plant species compositions, especially if nitrogen is in excess.[4]
- To study the effects of higher air temperatures on N transformation, I will be collaborating on the recently planned NSF NWT-VIII turf transplant experiment.
- The turf transplant experiment will be moving intact plants and soil from the alpine to the subalpine zones (~2°C warmer from alpine to subalpine)
- **I will add the biogeochemical component that:**

  (1) Investigates the relationships among warming, N cycle processes, and plant communities, and

  (2) Quantifies GHG fluxes from plant communities corresponding to different moisture regimes and subjected to warming for the turf transplant experiment.


PC: Hannah Miller

Questions & Hypothesizes

Q1: How do rising air temperatures change nitrogen (N) availability and transformations across plant communities in alpine soil sites?

H1: Warmer conditions will increase net soil N mineralization and nitrification rates and thus increase the concentrations of available N. However, the rates of N mineralization and nitrification will differ spatially and temporally depending on the plant community type (corresponds to moisture gradient). For example, moist meadows will have the largest increase in rates of net N transformations over most of the growing season.

Q2: What are the effects of rising air temperatures on soil respiration and trace gases in alpine soils across microclimates?

H2: With increased air temperature, soil respiration and trace gas fluxes will increase across all sites, but moist and wet meadows will have disproportionately higher rates of microbial processes, and, thus, larger increases in trace gas fluxes.

Experimental Design & Methods

Experimental Design:

- 20 plots per block (Control and Warm)
- Each block consists of dry and moist meadow plots
- Subplots will be dived into transplanted and control groups and observation and destructive (S) subplots
- Each subplot will contain turf transplants that are 25cm x 25cm x 10cm depth.

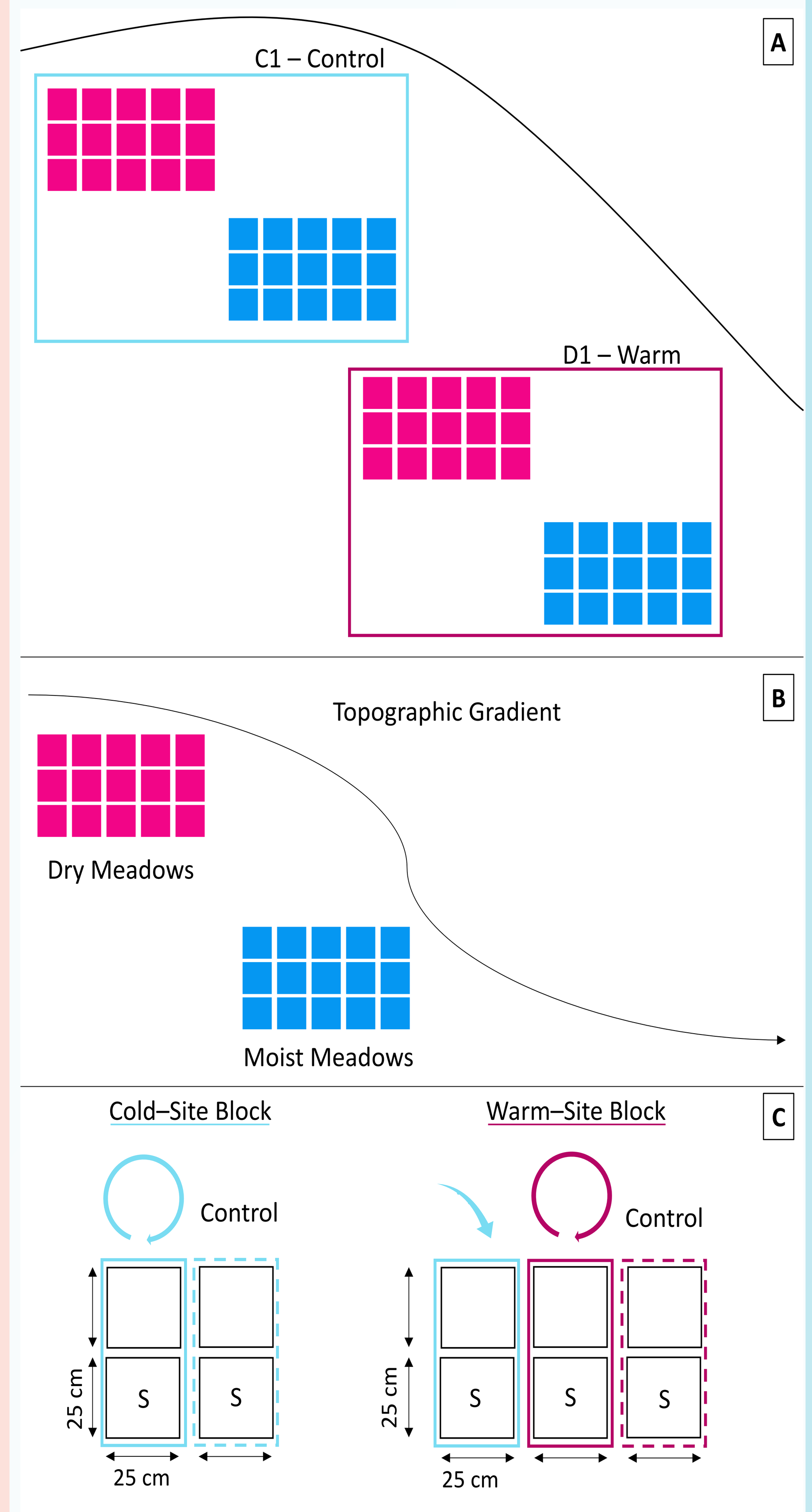
Methods:

Soils:

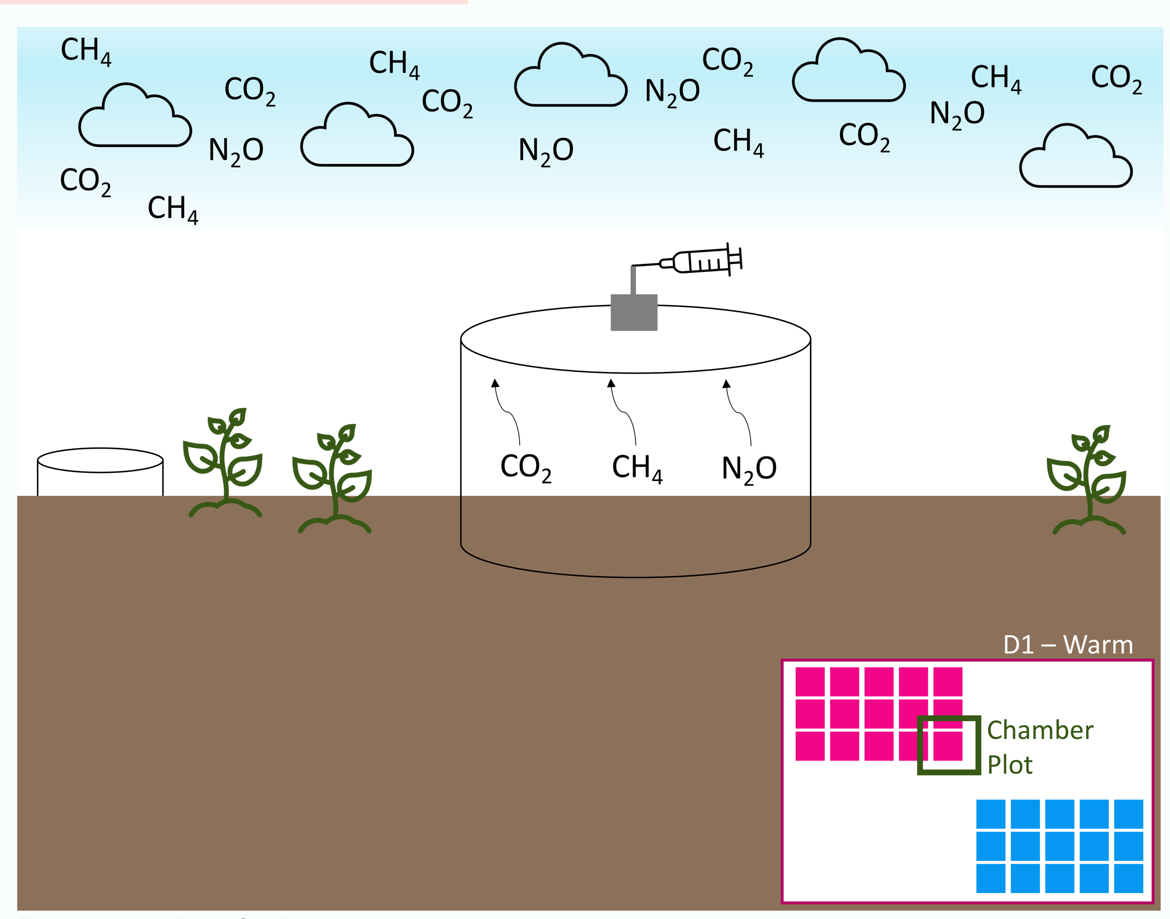
- Collecting soil cores (0-10 cm) throughout the growing season
- Quantifying net N cycling rates
- Measuring soil pH, total C, total N, soil moisture, bulk density
- Analyzing inorganic N concentrations

Gases:

- I will be quantify CO_2, CH_4, and N_2O fluxes using *in situ* gas chamber collection methods
- 6 chambers will be placed in the alpine and subalpine and sampled monthly coincident with the soil collections for net N rates.



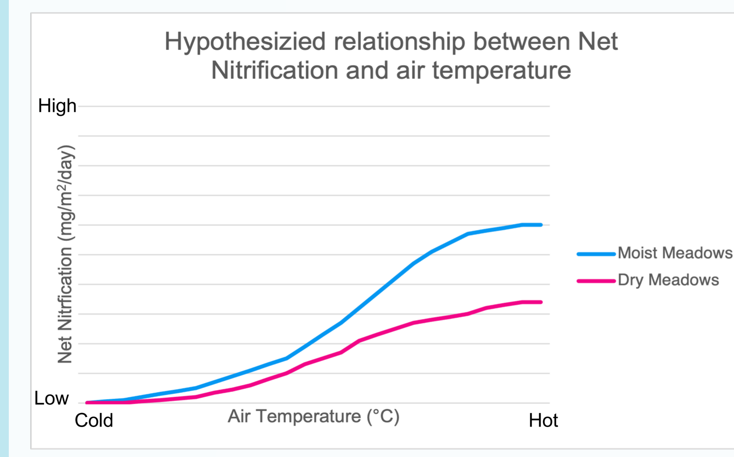
Experimental design. (A) Alpine and subalpine sites and the turf transplant sites with plant community types designated by color. (B) Distinguish the dry and moist meadow plots along the topographic gradient. (C) Shows an example of individual plots and subplots within cold and warm sites. Solid lines are paired-experimental subplots and dashed lines are paired-control plots.

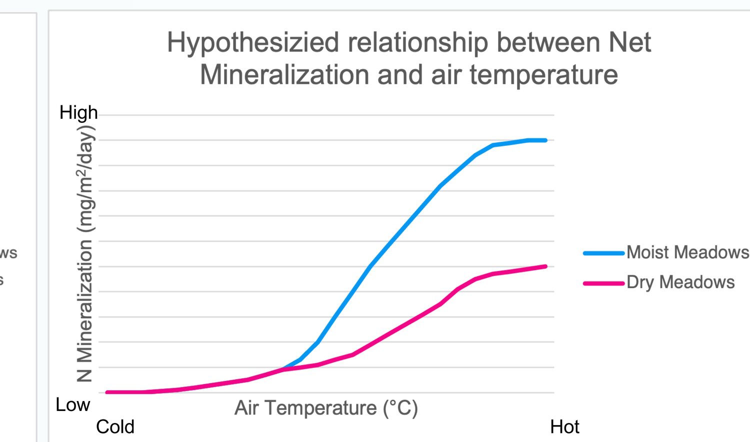


Representation of a *in situ* gas chamber

Expected Results

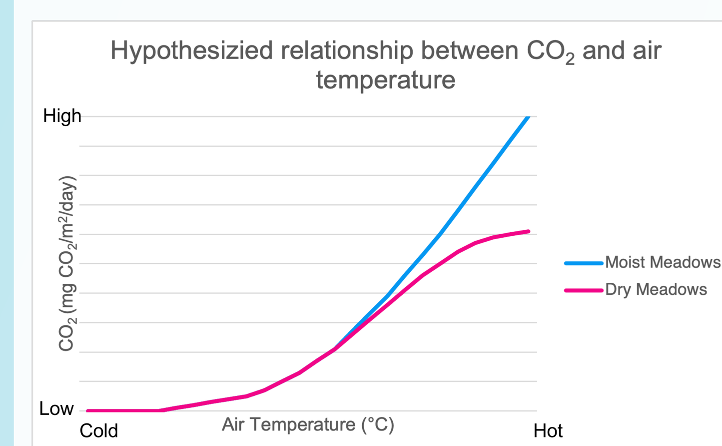
Soils

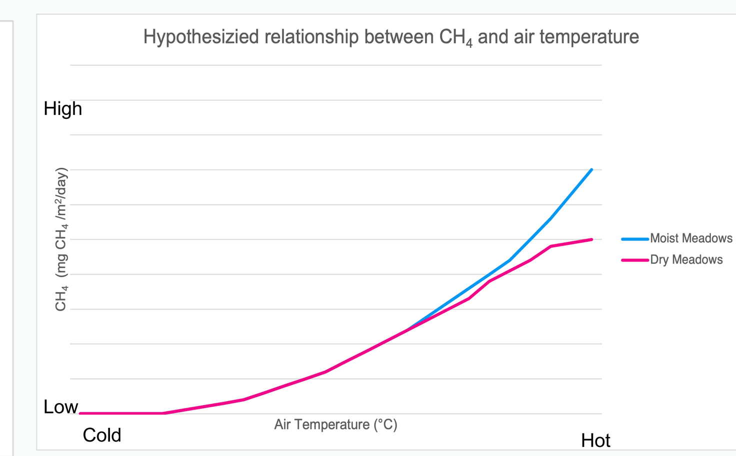


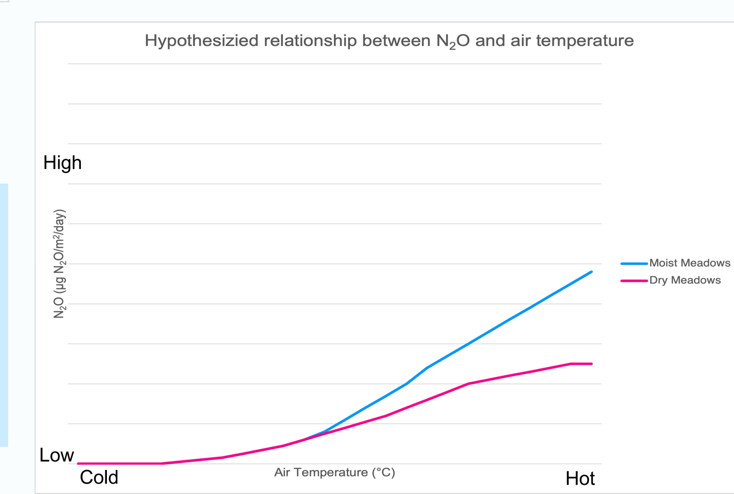


- Early in the growing season, rates of net N mineralization and nitrification will be similar
- As the growing season progresses, other factors (e.g., moisture) will being to limit rates of mineralization and nitrification

Gases







- Trace gas emissions will increase with temperature, but eventually reach will trail off based on other limiting factors (e.g., nitrogen and carbon availability, moisture, etc.)


Caption – Photos from the pilot experiment, curtesy if Dr. Nancy Emery

References:

1. Immerzeel et al., 2020
2. Williams et al., 2015
3. Chen et al., 2020
4. Bowmen et al., 2018

Acknowledgments:
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