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THE WOODS HOLE RESEARCH CENTER

Impact of warming and drying on microbial activity in subarctic tundra soils: inferences from patterns in extracellular enzyme activity

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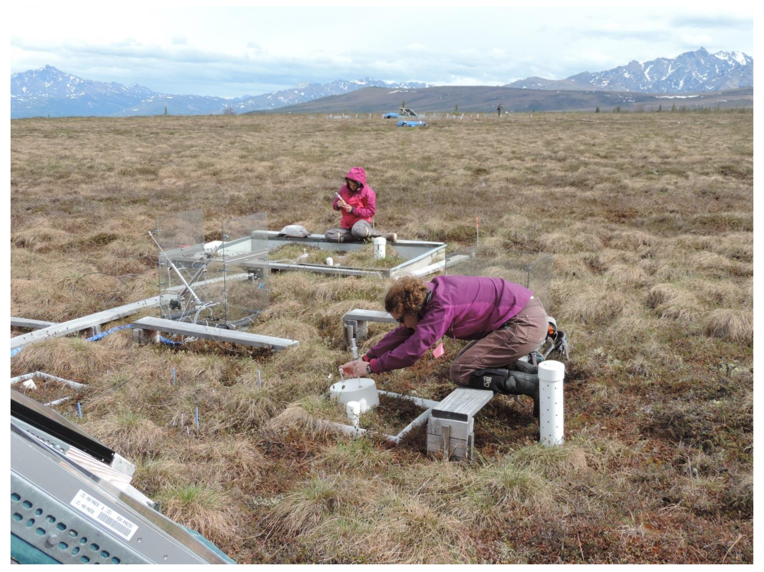
Permafrost thaw will increase rates of microbial breakdown of old soil organic matter (SOM), accelerating release of carbon to the atmosphere.

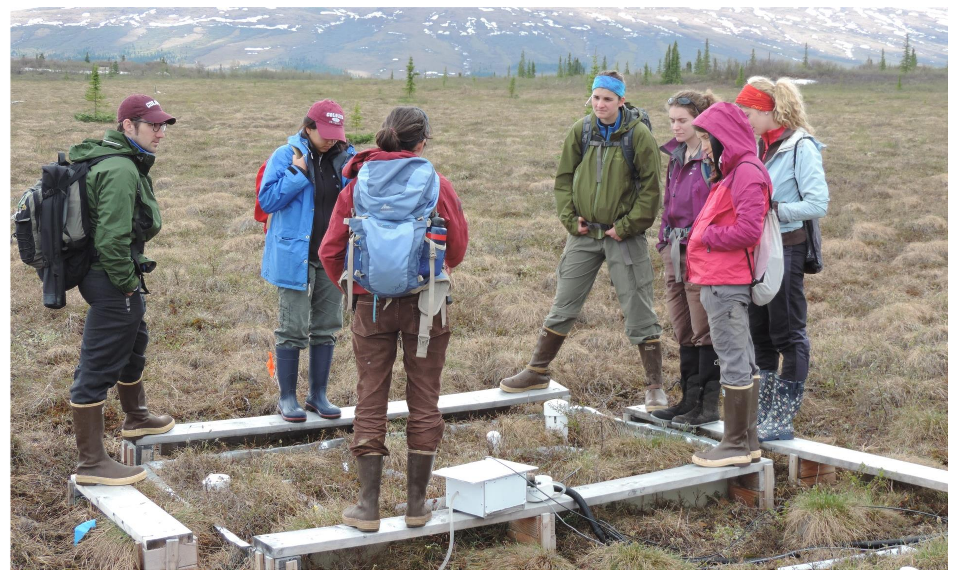
Higher rates of microbial decomposition may also release reactive nitrogen, which may increase plant production and carbon fixation.

The net effect on atmospheric carbon depends on the balance between direct and indirect effects of increased microbial activity, which depends on changes in soil conditions and microbial responses to them.

In particular, soil moisture, temperature and availability of C and N for microbes strongly influence soil respiration and primary production.

Objective: to assess the impacts of soil warming and drying on soil microbial activity and associated drivers in Alaskan upland tundra.





The Warming and Drying Experiment

- Warming (W) of soils using snow fences since 2009.
- Drying by pumping groundwater since 2011, fully crossed with warming.
- Soils collected (09/12) from Ambient (A), Warmed (W) and Warmed/Dried plots (WD).

Extracellular Enzyme Analyses (EEA)

- EEA in organic soil from 0-5 cm (shallow) and 5-15 cm (deep) depths measured using standard fluorescence-based protocols.
- Measured activity of C-acquiring hydrolytic enzymes (α-, and β-Glucosidase, and Cellobiohydrolase), N-acetylglucosaminidase (NAG), phosphatase (PHOS), and Leucine Aminopeptidase (LAP).

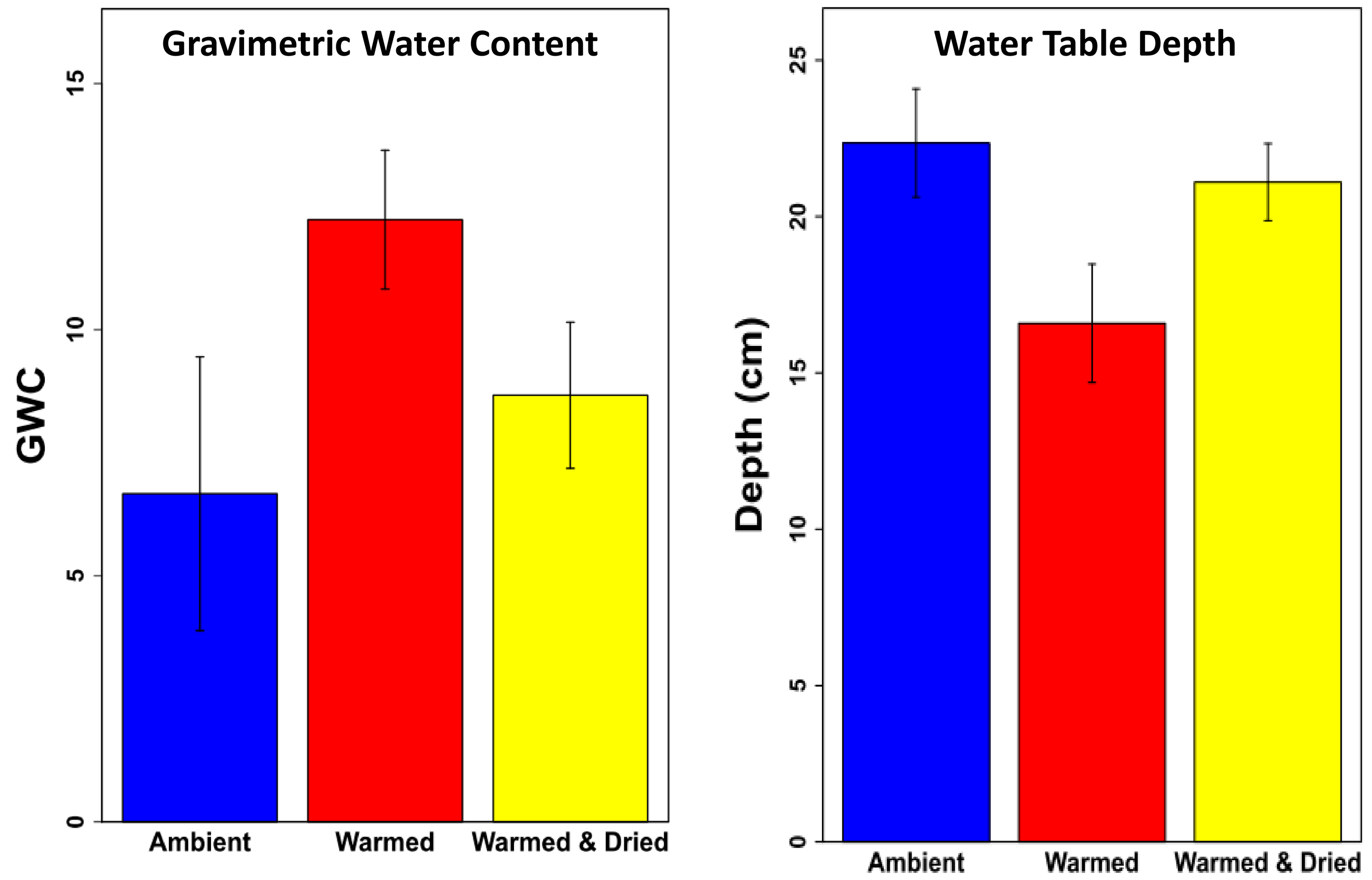


Figure 1 - Warming of soils caused ground subsidence, which led to higher soil moisture and a shallower water table.

Extracellular Enzyme Activity

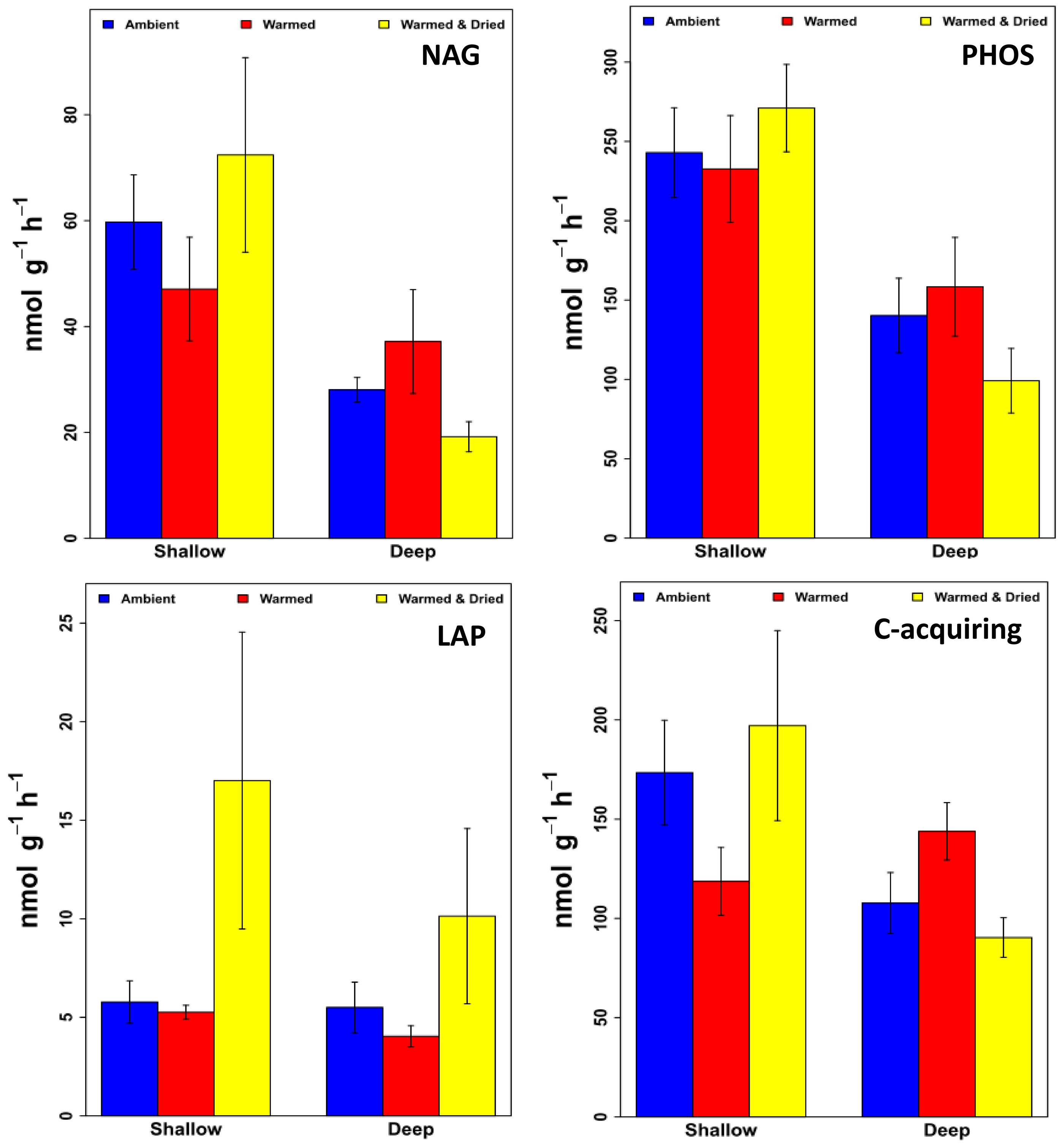
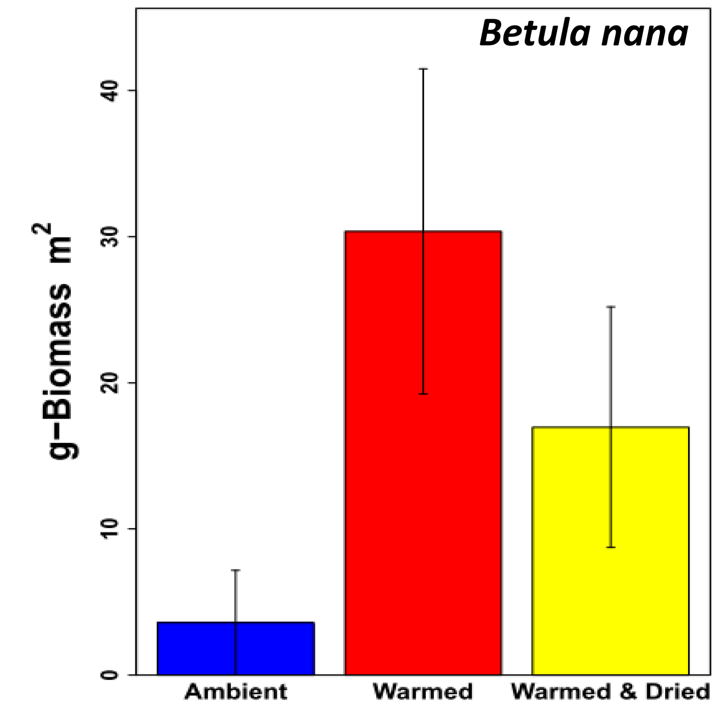
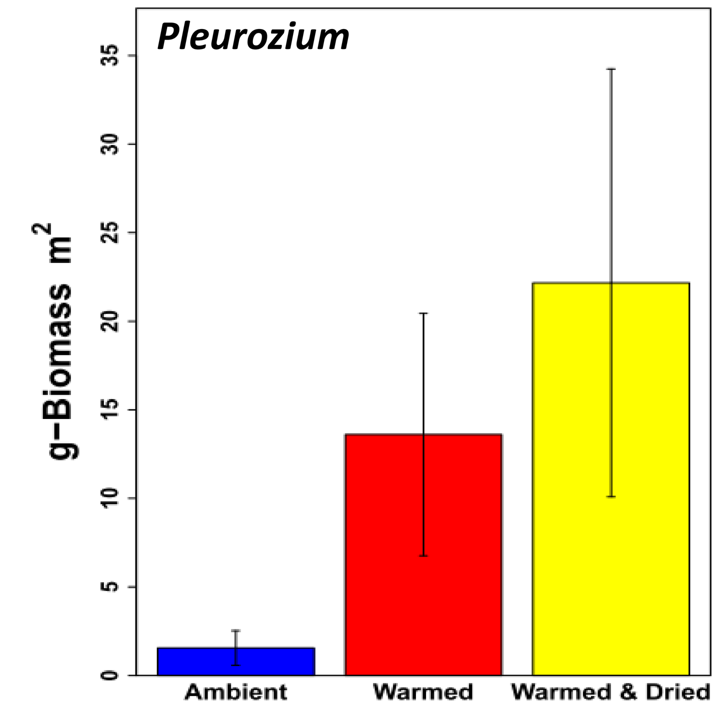


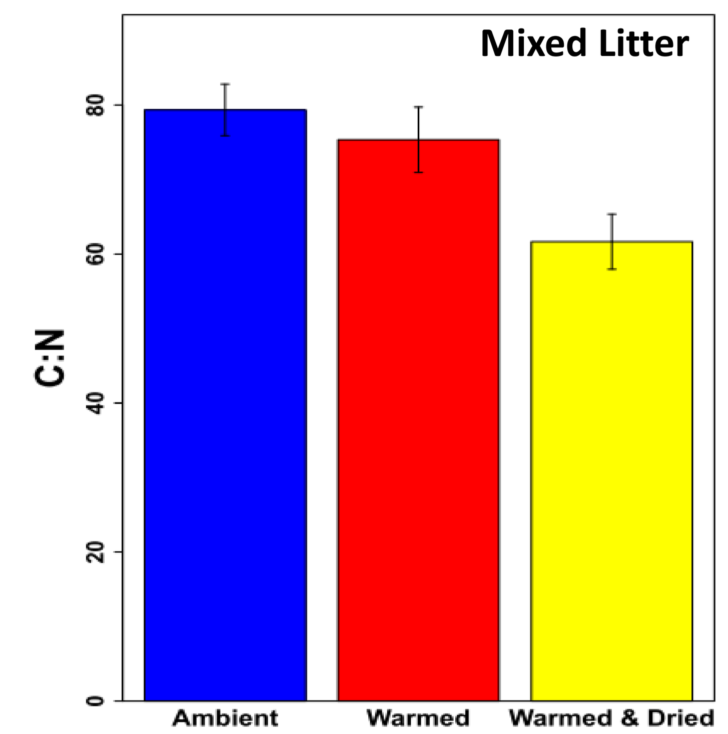
Figure 2 – Both warming and drying appear to have reduced C-limitation in shallow soils, but by different mechanisms—W by decreasing allocation to C-acquisition, WD by increasing allocation to LAP (generally considered to be N acquiring). In deep soils, W increased C limitation, while WD reduced C limitation. NAG resembles other C-acquiring enzymes suggesting it is serving as a C-acquiring enzyme in this case. No pattern in PHOS.

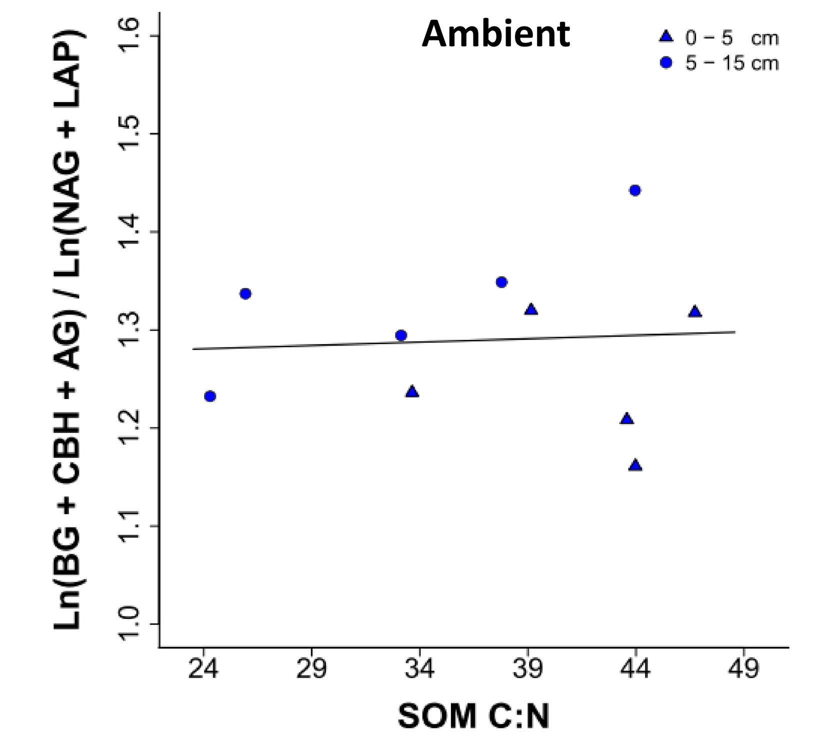
Literature Cited

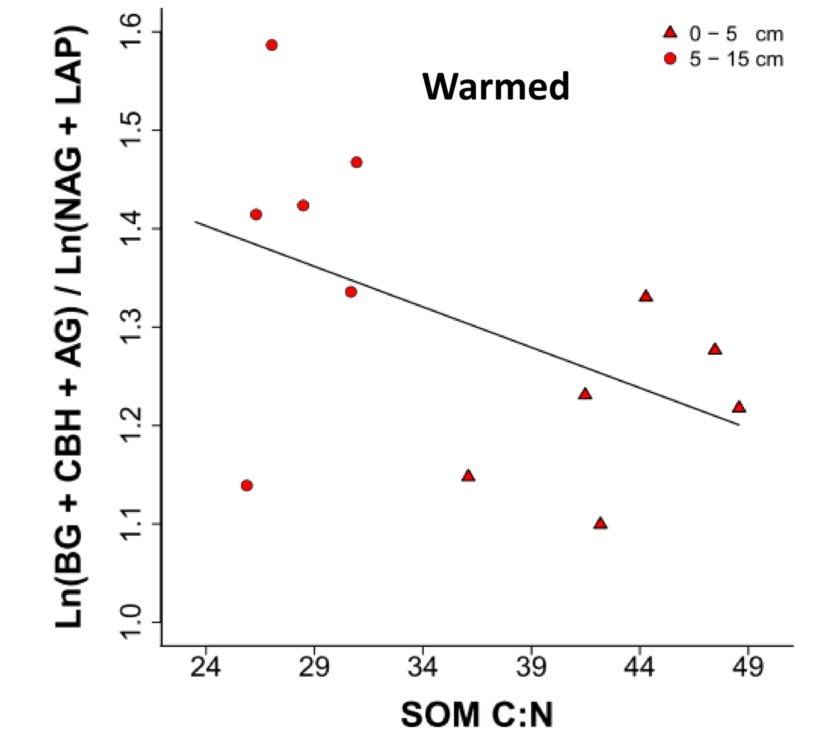
Saiya-Cork KR, Sinsabaugh RL, Zak DR (2002) Soil Biol Biochem 34: 1309–1315.

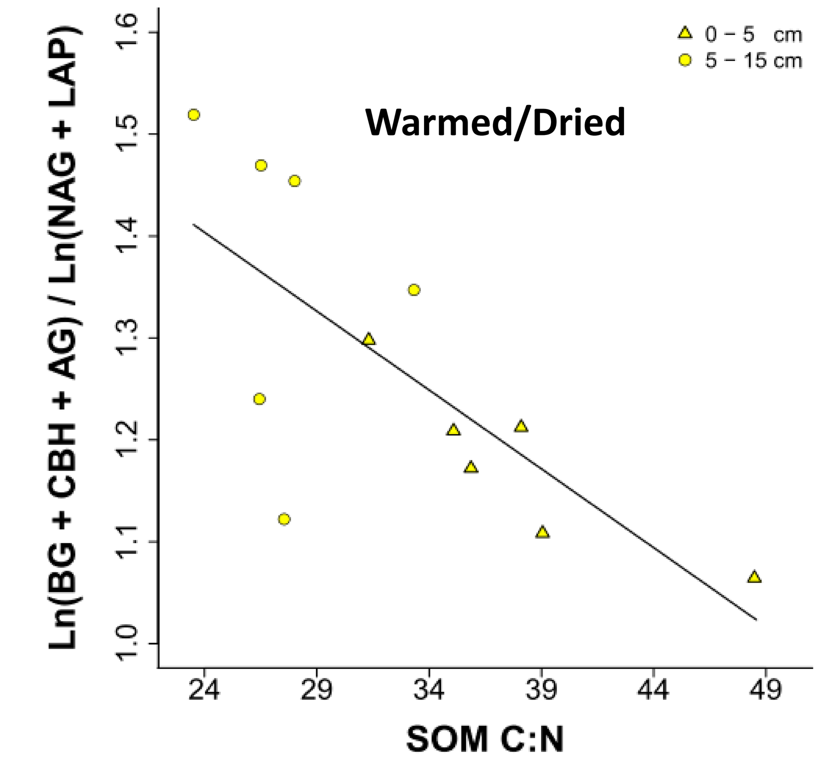












Summary

- Higher shrub biomass in W and WD, and lower litter C:N in WD are likely altering the quantity and quality of organic matter available for microbes, altering enzymatic responses.
- Enzyme activity C:N is more tightly linked to soil organic matter (SOM) C:N in WD plots, suggesting altered substrate availability or higher degree of control of EEA by substrate vs. other environmental conditions in WD.
- Differences in winter soil temp between treatments may alter the pool of labile organic matter and the impact of SOM C:N on EEA.
- Longer soil saturation in W plots may lead to hypoxic conditions in soils, reducing the degree of substrate control of EEA.