

# Examining soil biogeochemical recovery from long-term simulated N deposition in a northeastern temperate forest



## SOIL COMMUNITIES & ANTHROPOGENIC CHANGE

Atmospheric nitrogen (N) deposition rates have historically increased with anthropogenic activity, but some regions, including the Northeastern US, have experienced a decrease since the enforcement of regulatory policy.

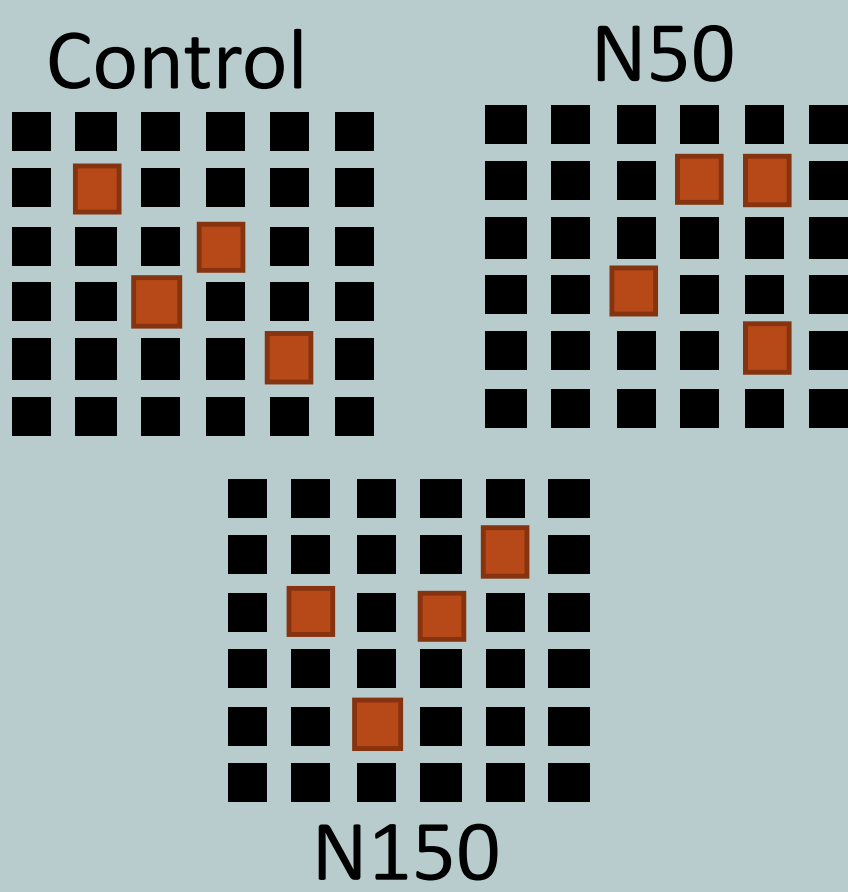
Previous research at Harvard Forest has examined both biogeochemical and microbial responses to simulated N deposition. In 2019, the highest N treatment at the long-term Chronic N Amendment Study was discontinued, creating a unique opportunity to study potential recovery of soil biogeochemistry and microbial community structure and function.

### OBJECTIVE

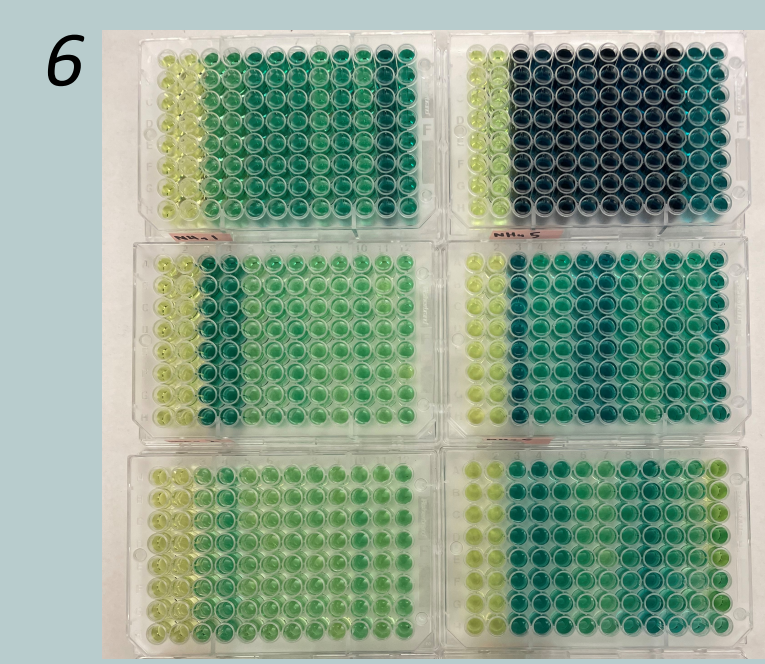
To characterize biogeochemical responses of soil in a temperate hardwood forest to the cessation of long-term N enrichment.

### METHODS

Chronic N Amendment Study  
est. 1988



Control: no added N  
N50: +50 kg N ha<sup>-1</sup> yr<sup>-1</sup>  
N150: +150 kg N ha<sup>-1</sup> yr<sup>-1</sup> until 2019



Pictured:  
1 sampling May 2023  
2 enzyme assays  
3 pH measurements  
4 LICOR used for respiration  
5 inorganic N extractions  
6 NH<sub>4</sub> assay

### AWKNOWLEDGEMENTS

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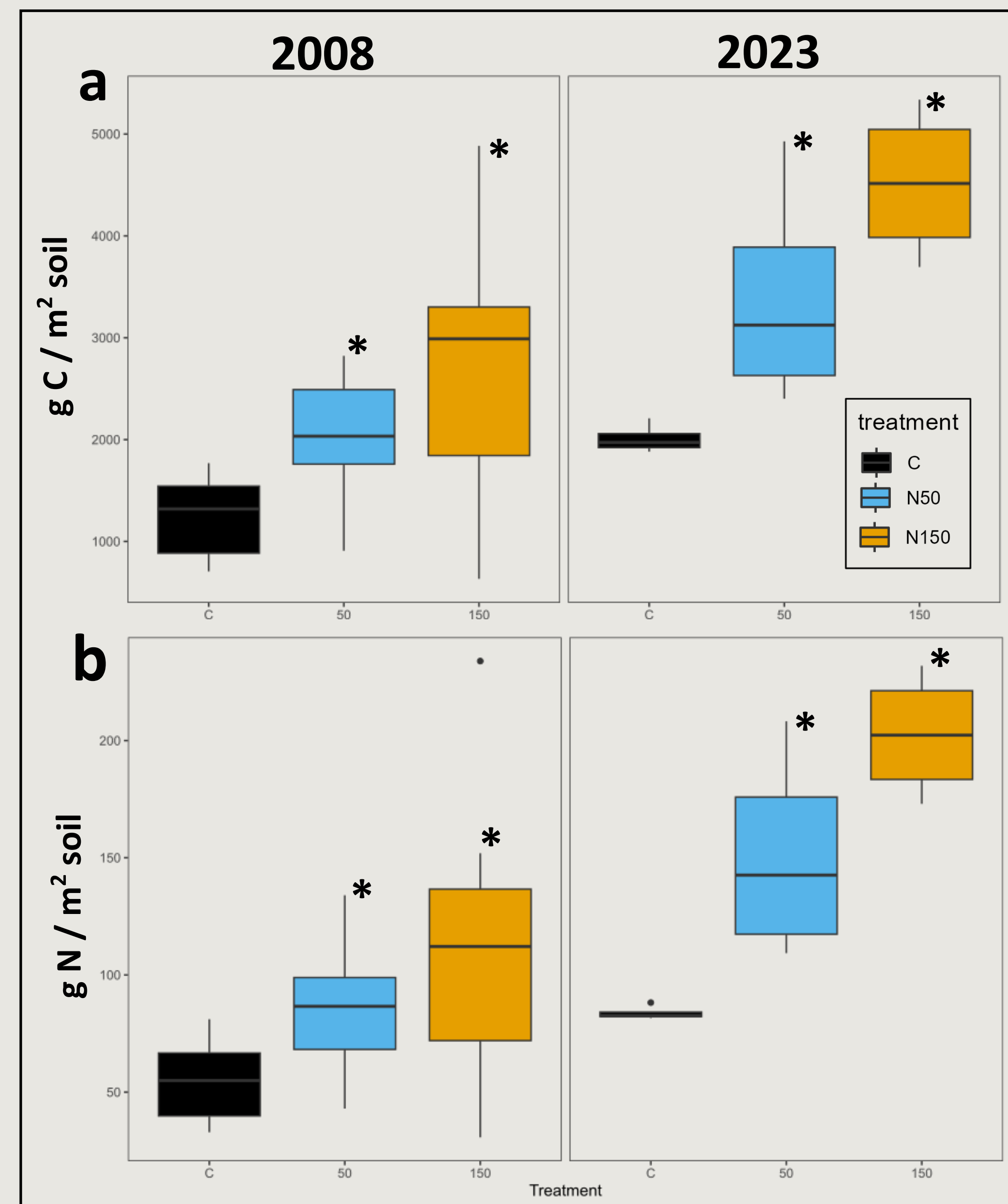
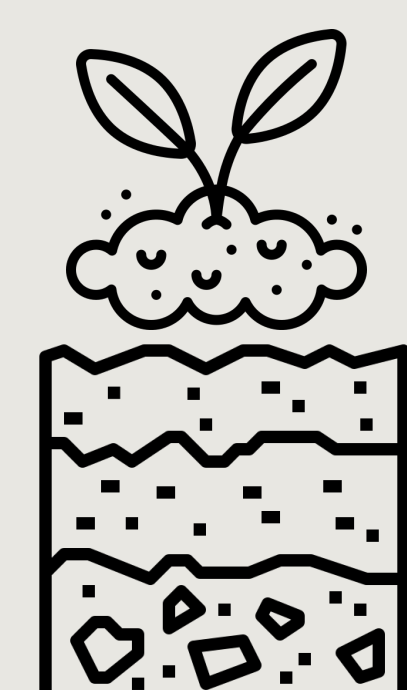


Figure 1: (above) Total organic carbon (a) and nitrogen (b) stocks in the organic horizon for each treatment as measured in 2008 and 2023. Boxes with an asterisk indicate a significant difference from control levels ( $P < 0.05$ ). 2008 data from Frey et al. (2014).

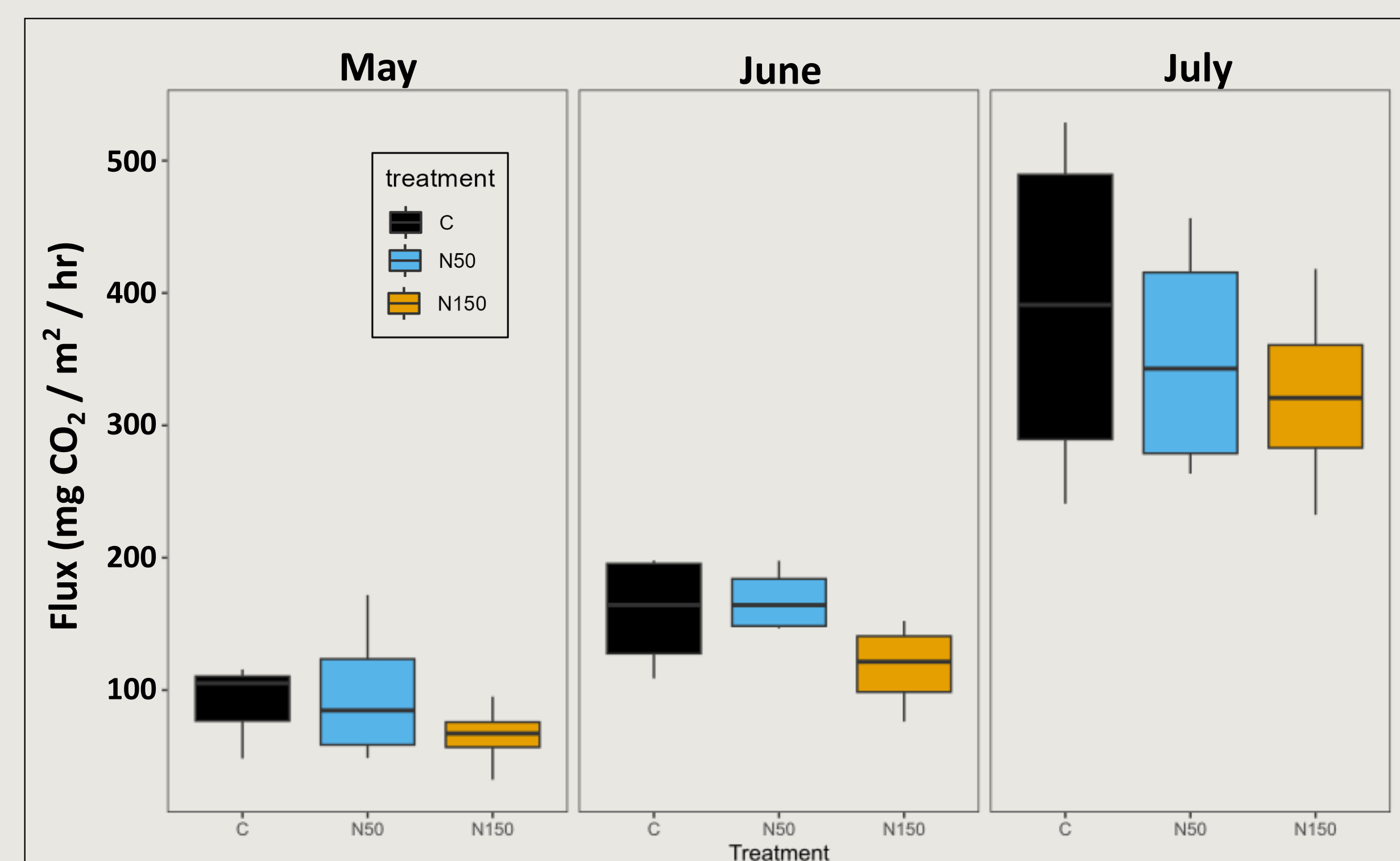


Figure 2: (above) Comparison of soil respiration (CO<sub>2</sub> flux) across treatments measured in the months of May, June, and July of 2023.

Table 1: (below) Soil characteristics for the organic (O) horizon. Average values for each group (n=4) are given with standard error in parentheses. Values found to be significantly different from the control levels are indicated by asterisks (\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ ; one-way ANOVA). 2016 pH data from Whalen et al. (2019).

		N Addition Level (kg N / hectare / year)		
		Control	50	150 until 2019
pH	2023	4.24 (0.08)	3.84 (0.07)**	3.66 (0.07)***
	2016	4.03 (0.10)	3.82 (0.18)	3.38 (0.07)**
Nutrient Content (mg kg <sup>-1</sup> soil) <sup>1</sup>				
	Cu	3.45 (1.62)	4.69 (3.26)	6.16 (3.62)
	Fe	353 (30.8)	333 (69.0)	363 (103)
	Mn	40.2 (5.05)	9.88 (2.07)***	10.7 (1.96)***
	Zn	7.06 (2.18)	5.41 (1.35)	3.34 (1.14)
Total inorganic N				
	µg N mg <sup>-1</sup> soil	9.19 (1.85)	12.9 (3.20)	25.1 (5.45)*
N mineralization rate				
	µg N g <sup>-1</sup> soil d <sup>-1</sup>	2.08 (0.58)	3.34 (0.88)	4.17 (0.72)

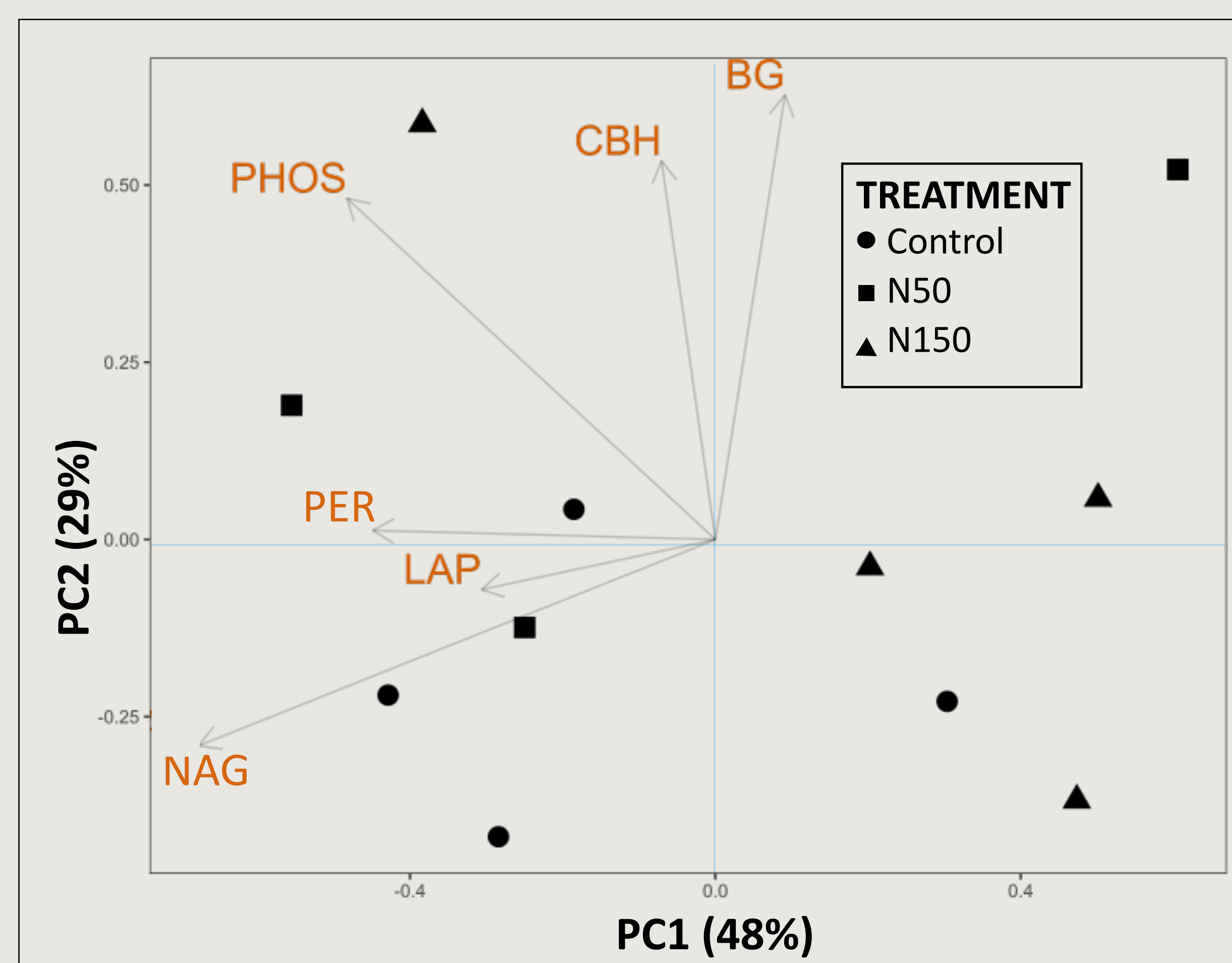


Figure 3: (above) Comparison of microbial extracellular enzyme activities across treatments using PCA on log + 1 transformed data (nmol h<sup>-1</sup> g<sup>-1</sup> soil).

### TAKEAWAY

Inorganic N levels are still elevated in the high N treatment four years after fertilization cessation, with no recovery of key biogeochemical parameters.

### FUTURE WORK

For the second phase of this project, we will be measuring microbial biomass and sequencing the fungal & bacterial communities across treatments.

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## RESULTS

- Total organic C and N content in the N50 and N150 discontinued plots were significantly different from control, a pattern which has remained consistent before and after the cessation of fertilization.
- Activity levels did not vary significantly across treatments for any enzyme measured; however, enzymes responsible for the breakdown of cellulases (BG, CBH) showed closer correlation with N150 treatment.
- Lower levels of soil respiration in the N150 plots were measured in comparison to the control, following previously reported patterns.
- pH in N-amended plots remained consistently more acidic in the O horizon