

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.

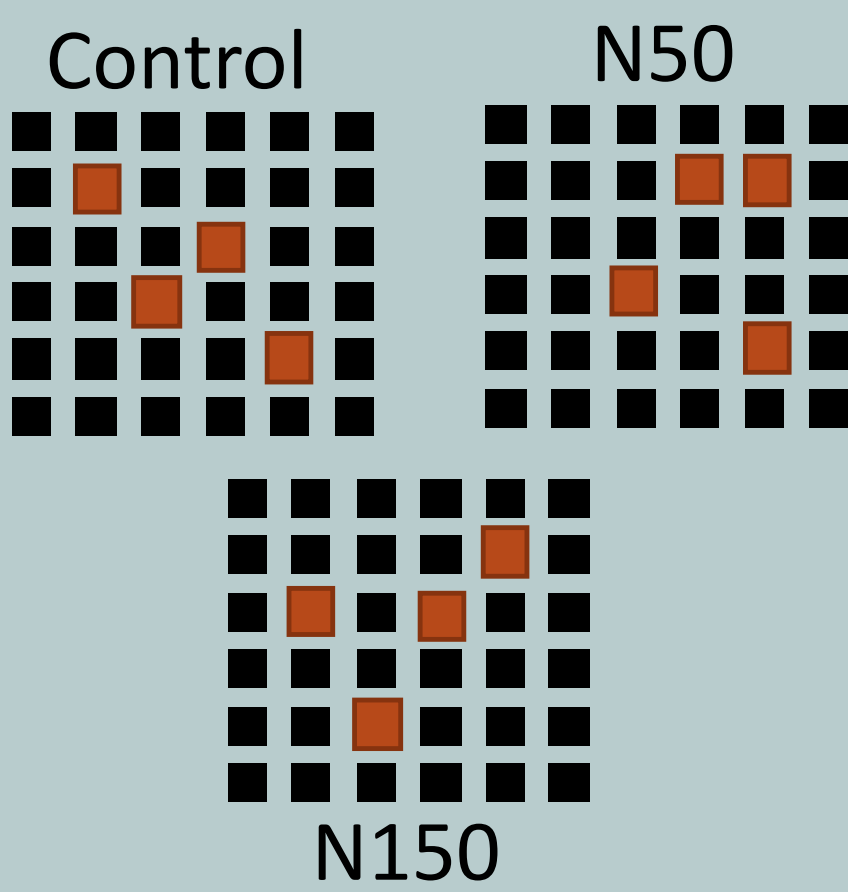
Previous research at Harvard Forest has examined both biogeochemical and microbial responses to simulated N deposition. In 2019, the highest N treatment at the long-term Chronic N Amendment Study was discontinued, creating a unique opportunity to study potential recovery of soil biogeochemistry and microbial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

OBJECTIVE

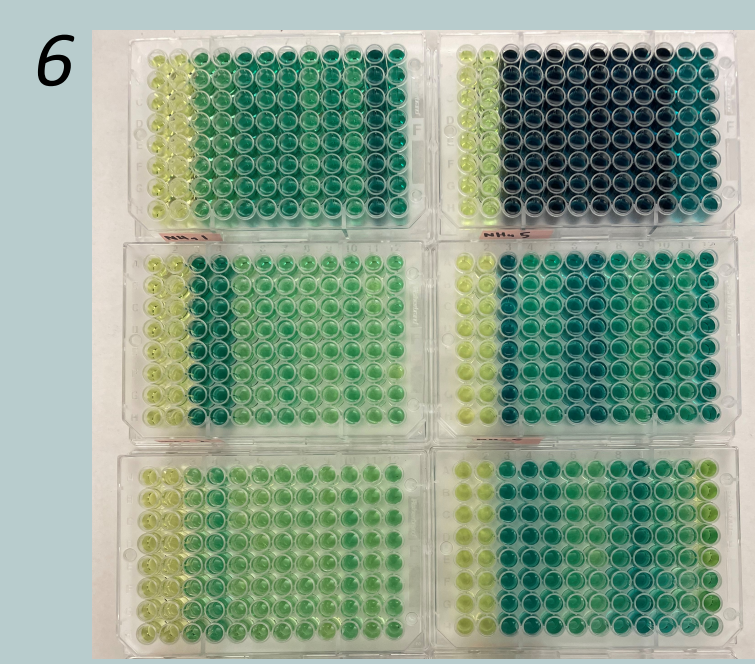
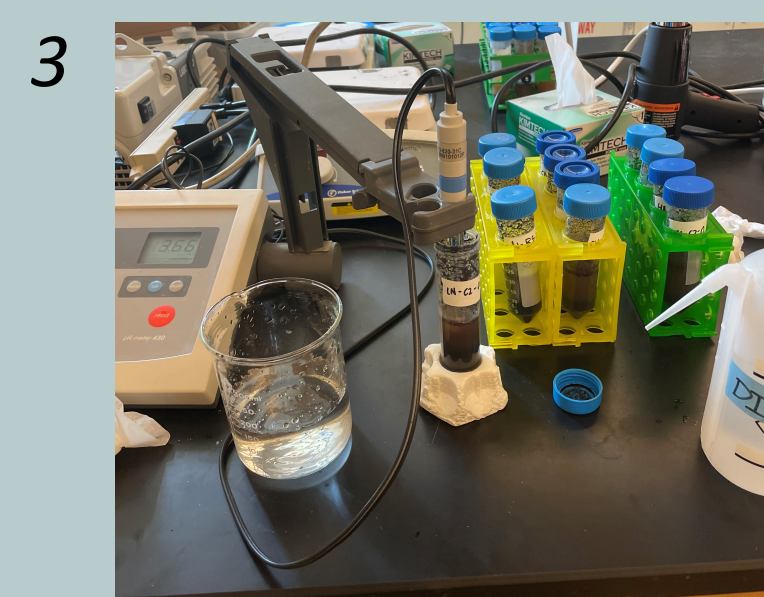
To characterize biogeochemical responses of soil in a temperate hardwood forest to the cessation of long-term N enrichment.

METHODS

Chronic N Amendment Study
est. 1988



Control: no added N
N50: +50 kg N ha⁻¹ yr⁻¹
N150: +150 kg N ha⁻¹ yr⁻¹ until 2019



Pictured:
1 sampling May 2023
2 enzyme assays
3 pH measurements
4 LICOR used for respiration
5 inorganic N extractions
6 NH₄ assay

ACKNOWLEDGEMENTS

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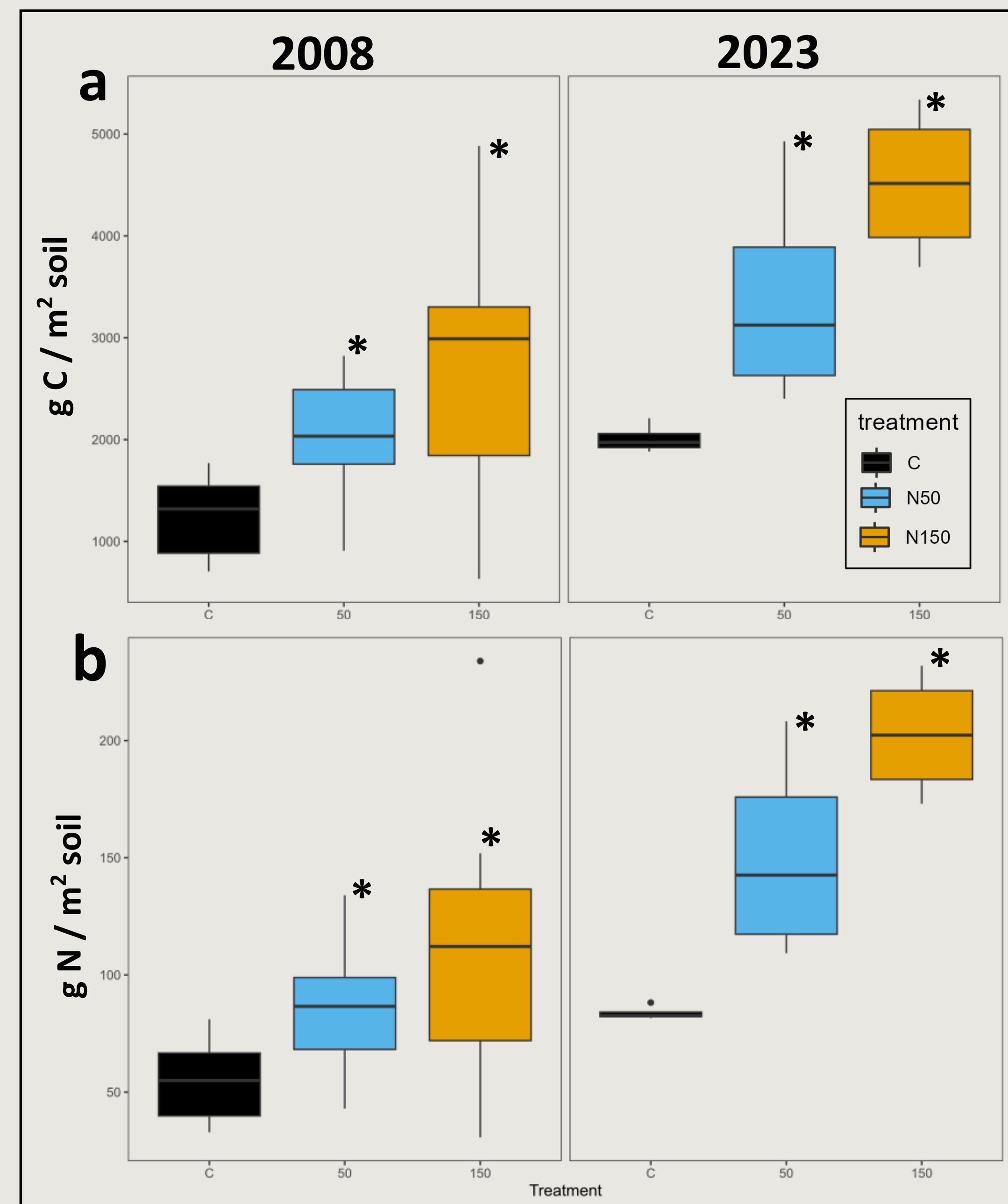
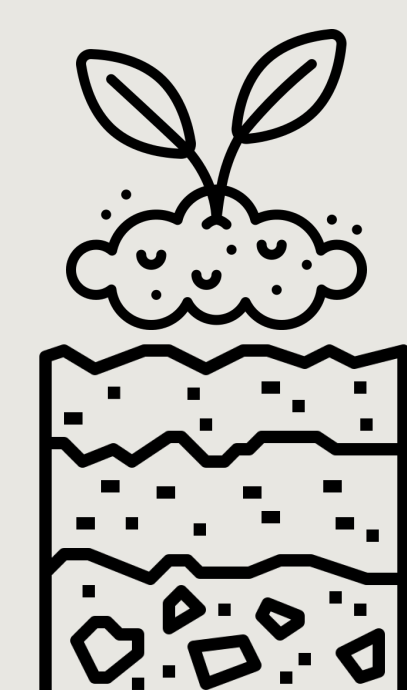


Figure 1: (above) Total organic carbon (a) and nitrogen (b) stocks in the organic horizon for each treatment as measured in 2008 and 2023. Boxes with an asterisk indicate a significant difference from control levels ($P < 0.05$). 2008 data from Frey et al. (2014).

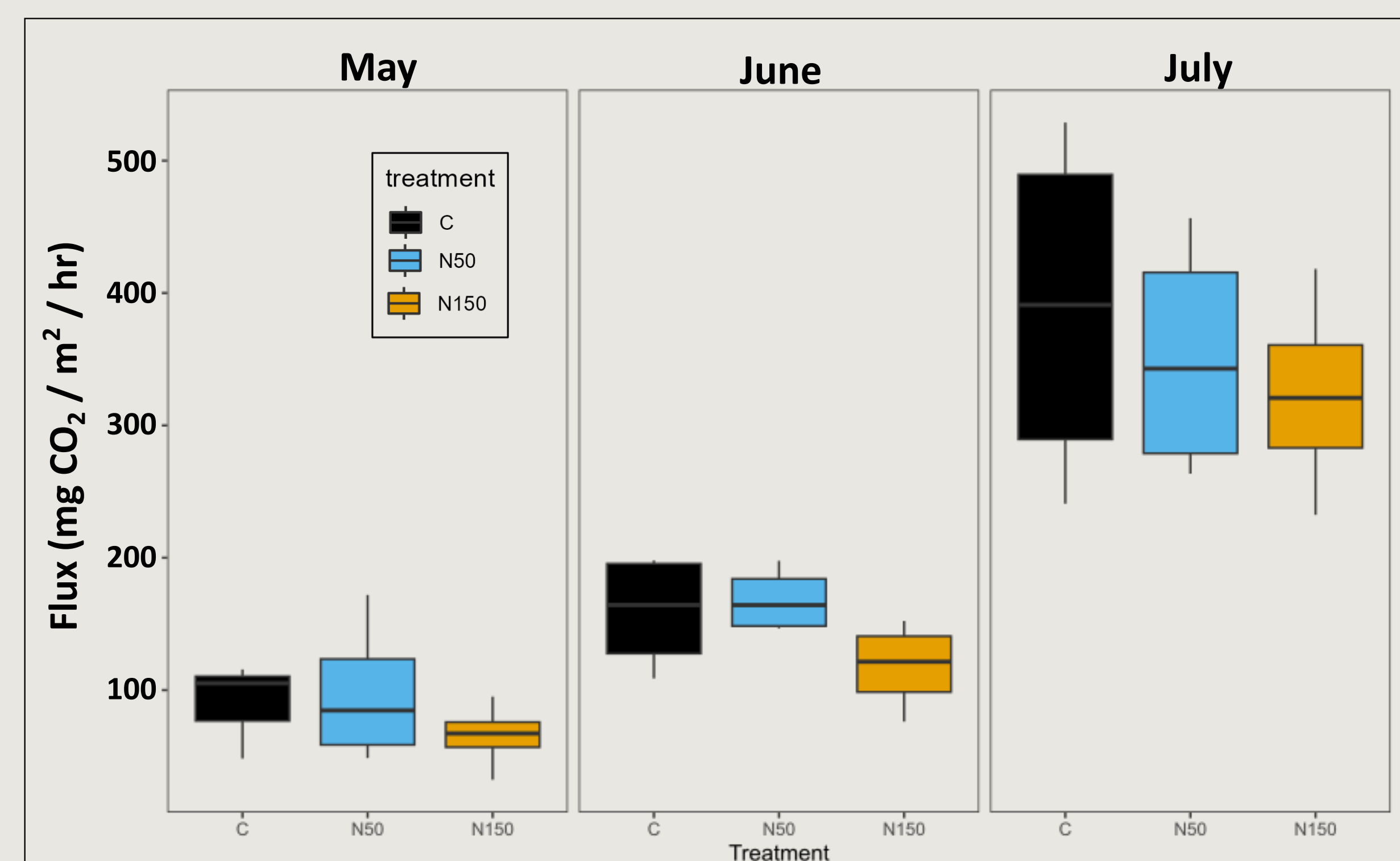


Figure 2: (above) Comparison of soil respiration (CO₂ flux) across treatments measured in the months of May, June, and July of 2023.

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 ⁻¹ soil) ¹				
	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 ⁻¹ soil	9.19 (1.85)	12.9 (3.20)	25.1 (5.45)*
N mineralization rate				
	µg N g ⁻¹ soil d ⁻¹	2.08 (0.58)	3.34 (0.88)	4.17 (0.72)

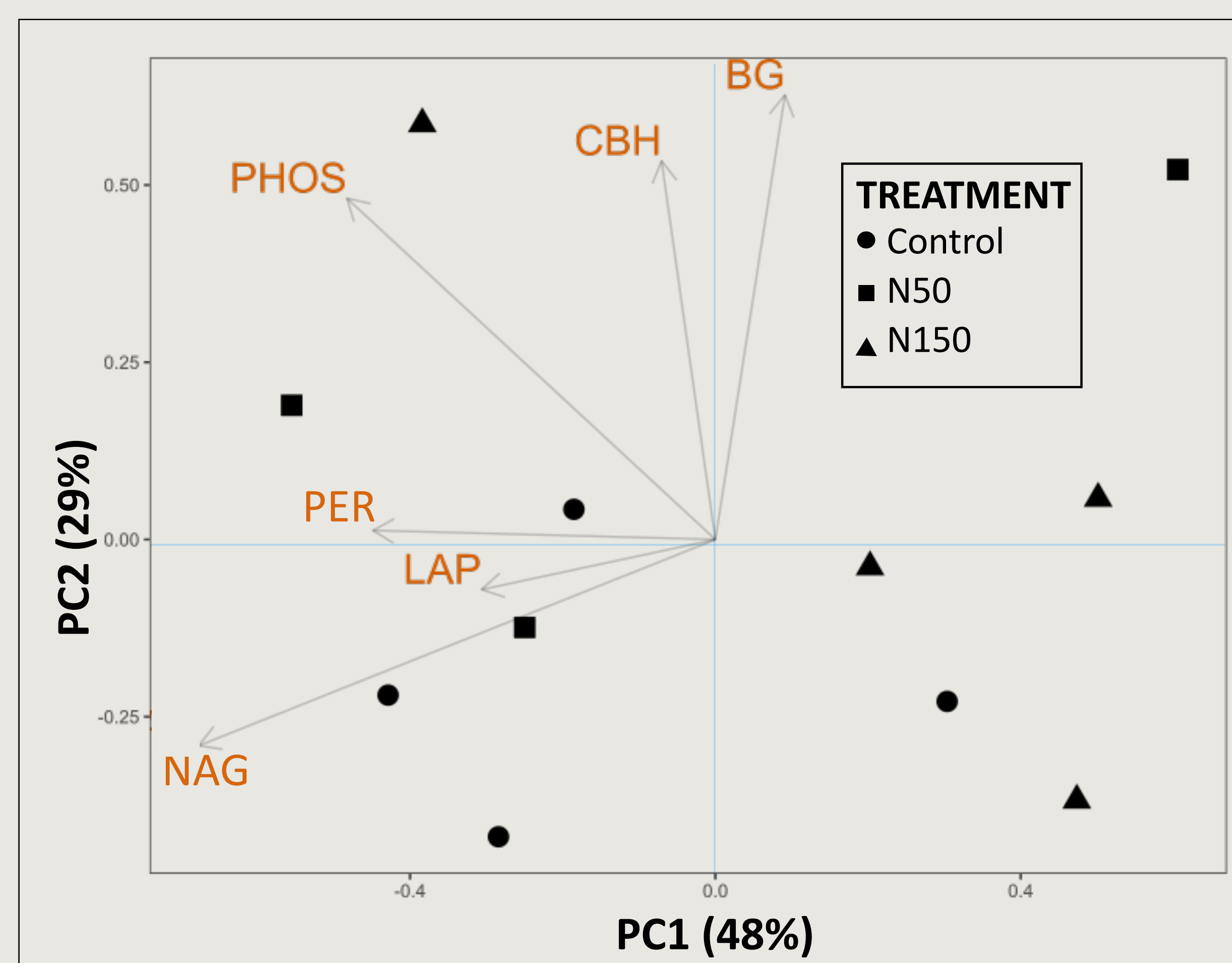


Figure 3: (above) Comparison of microbial extracellular enzyme activities across treatments using PCA on log + 1 transformed data (nmol h⁻¹ g⁻¹ soil).

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