Soil Nitrogen Dynamics Impact Carbon Exchange Processes in a High Arctic Wetland

Jacqueline K.Y. Hung (jacqueline.hung@queensu.ca)
Queen's University https://orcid.org/0000-0001-5245-0896
Neal A. Scott
Queen's University
Paul M. Treitz
Queen's University

Research Article

Keywords: nitrogen availability, net carbon dioxide exchange, High Arctic wetland, climate change

Posted Date: June 17th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-607560/v1

Abstract

Increased soil nutrient availability, and associated increases in vegetation productivity, could create a negative feedback between Arctic ecosystems and the climate system, thereby reducing the contribution of Arctic ecosystems to future climate change. To predict whether this feedback will develop, it is important to understand the environmental controls over nutrient cycling in High Arctic ecosystems and their impact on carbon cycling processes. This study, conducted at the Cape Bounty Arctic Watershed Observatory, Melville Island, Nunavut, examined the environmental controls over soil nitrogen availability in a High Arctic wet sedge meadow and how they influenced carbon dioxide exchange processes from 2016-2018. Moisture variability across a seemingly homogenous wet sedge meadow allowed us to investigate nutrient availability and carbon dioxide exchange across naturally occurring moisture gradients over three growing seasons. The nature of the relationships (i.e., trends) between variables was consistent over the three years, but their magnitudes varied depending on climate conditions. Soil nitrogen availability, particularly ammonium, was higher in warmer years and wetter conditions and correlated positively with gross primary production (R 2 = 0.97) and net carbon dioxide uptake (R 2 = 0.88). Drier areas within the wetland had more nitrate availability, and this correlated negatively with net carbon dioxide exchange. Projections of a warmer, wetter Arctic and increased nutrient availability due to higher soil organic matter turnover suggest that northern wetlands will remain strong carbon dioxide sinks, or become stronger sinks, contributing to a negative feedback on the climate system.

Full Text

This preprint is available for download as a PDF.

Figures

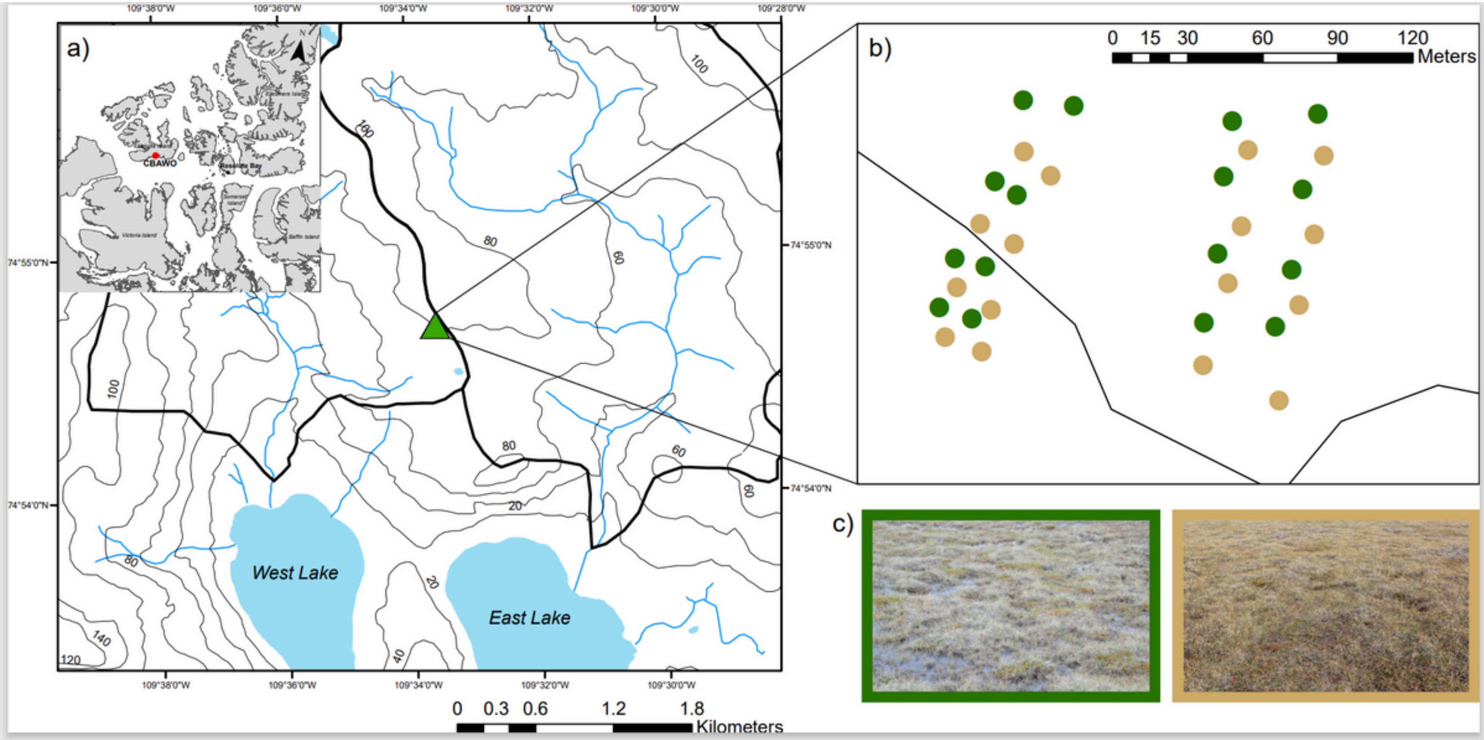

Figure 1

a) Location of the study area (green triangle) within the Cape Bounty Arctic Watershed Observatory (CBAWO). b) Cryogenically formed longitudinal hummocks naturally partition the wet sedge meadow into wet (green) and dry (brown) moisture regimes, which formed the basis for sampling site selection. c) Wet tracks (left) are characterized by standing water in some areas and higher soil moisture, while dry tracks (right) are drier and lack standing water. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

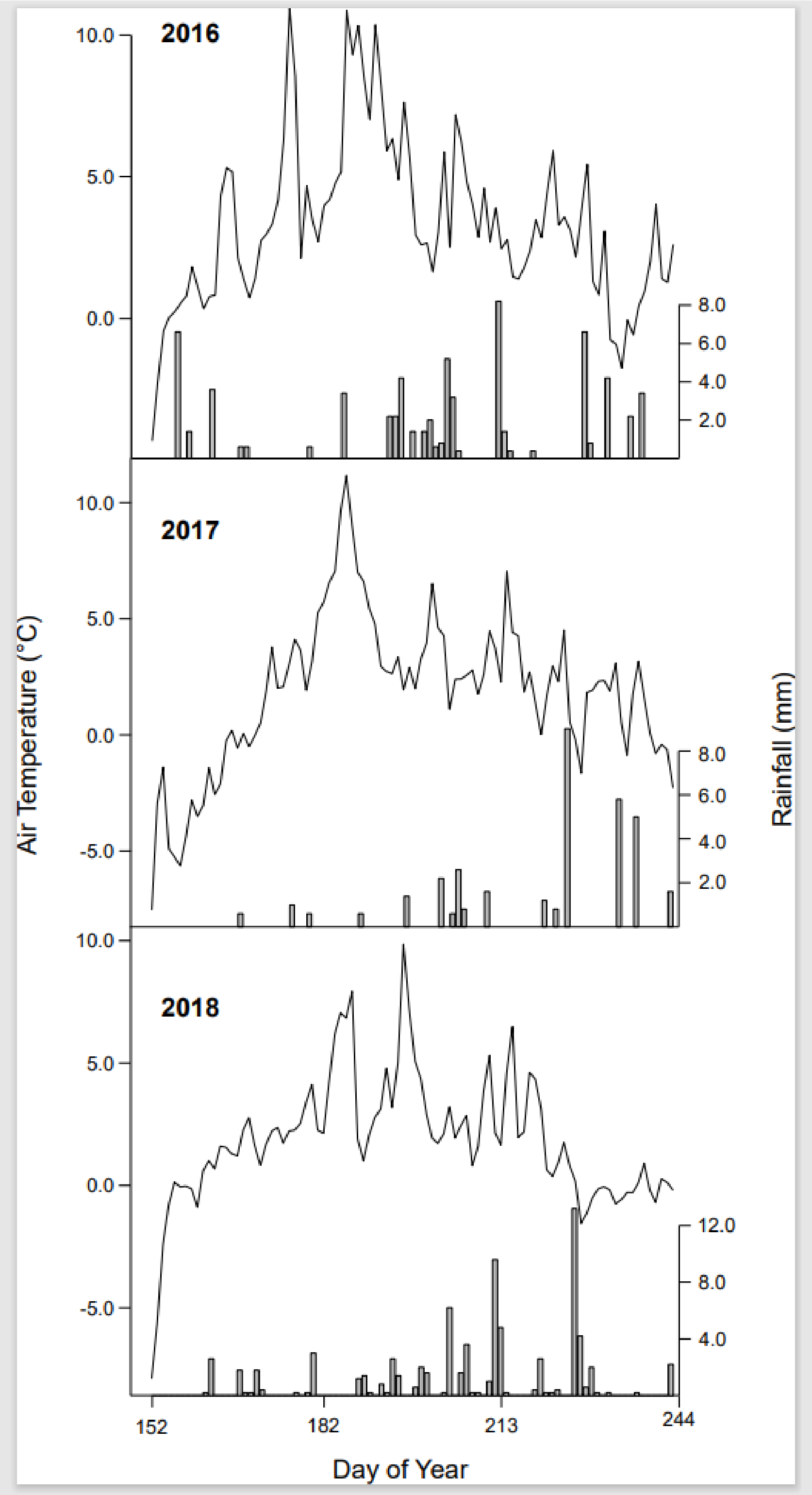

Figure 2

Daily mean air temperatures and precipitation at CBAWO during the growing season (June – August) in 2016 (top), 2017 (middle), and 2018 (bottom).

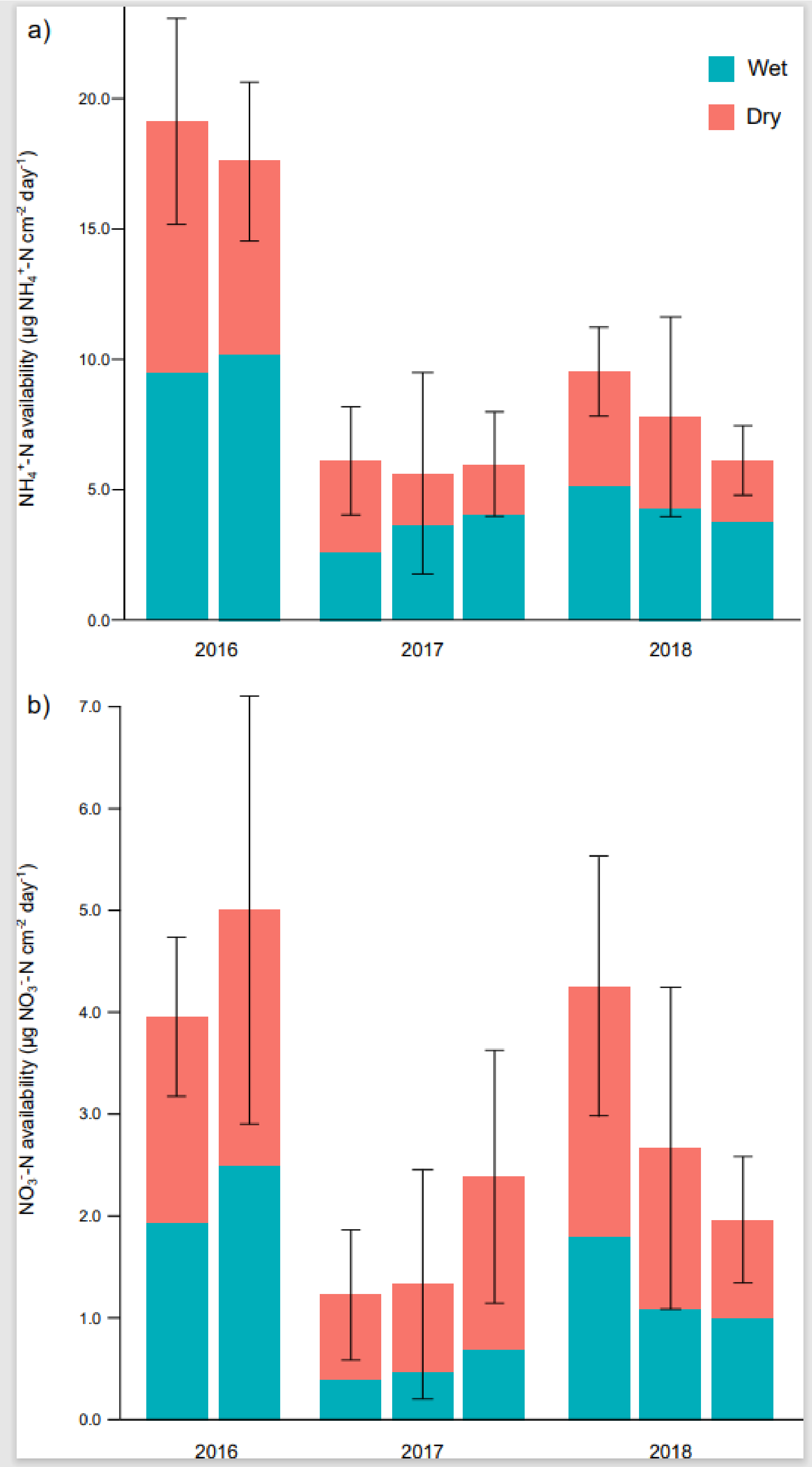

Figure 3

Patterns of a) NH4 + -N availability and b) NO3 - -N availability displayed across the season (early, middle, and late; only early and late for 2016) and by moisture track for all years. Error bars represent the standard deviation of all plots.

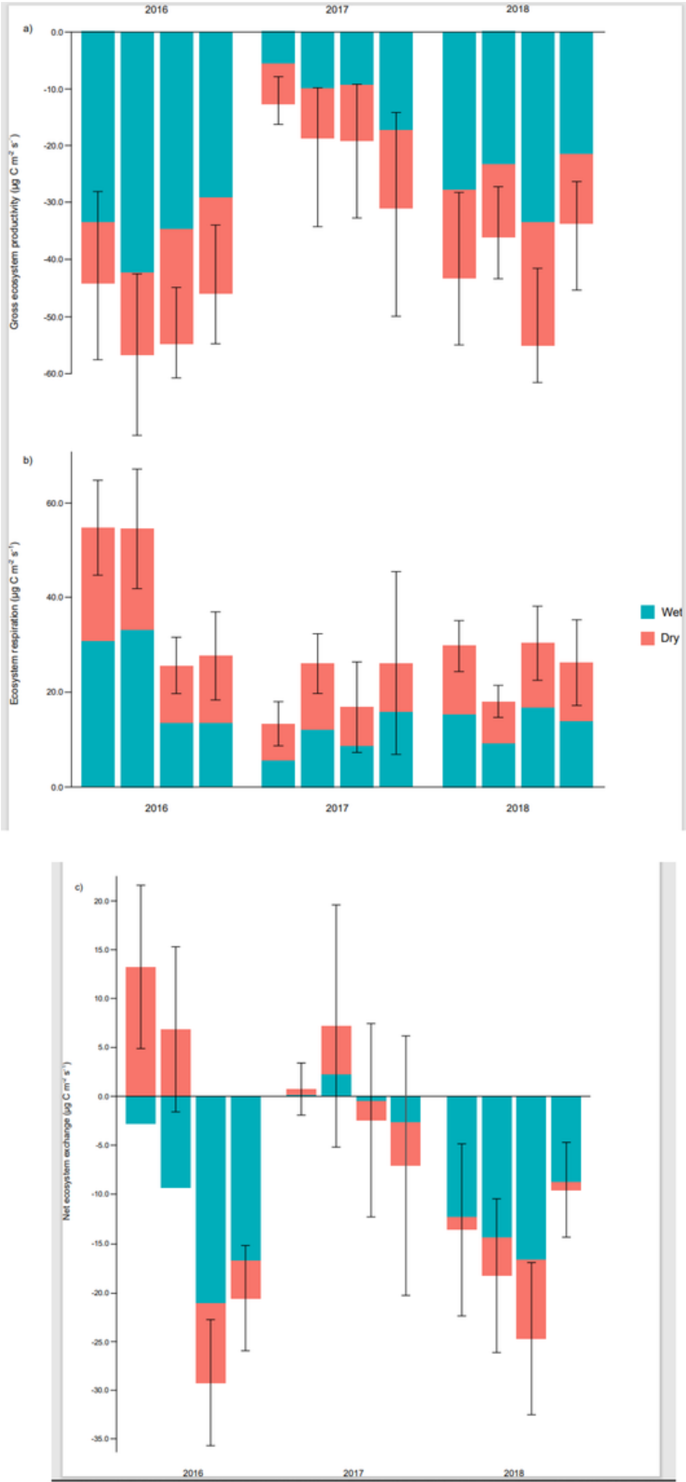

Figure 4

Patterns of a) gross ecosystem productivity, b) ecosystem respiration, and c) net ecosystem exchange displayed across the season (day of year 186, 191, 198, and 205) and by moisture track for all years. Error bars represent the standard deviation of all plots.

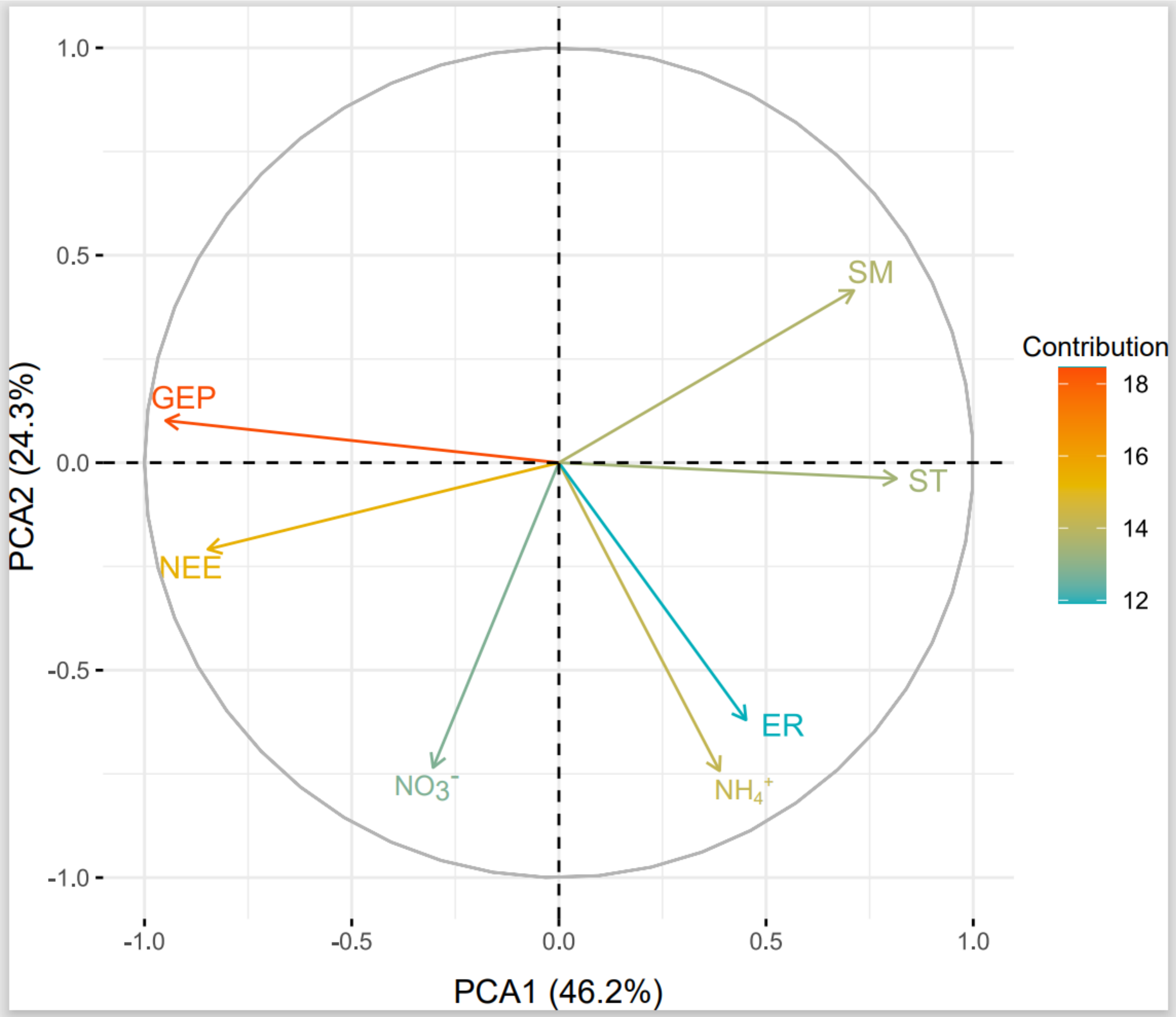

Figure 5

Principal component analysis biplot of environmental measurements (soil temperature and soil moisture), N availability, CO2 exchange for all years.

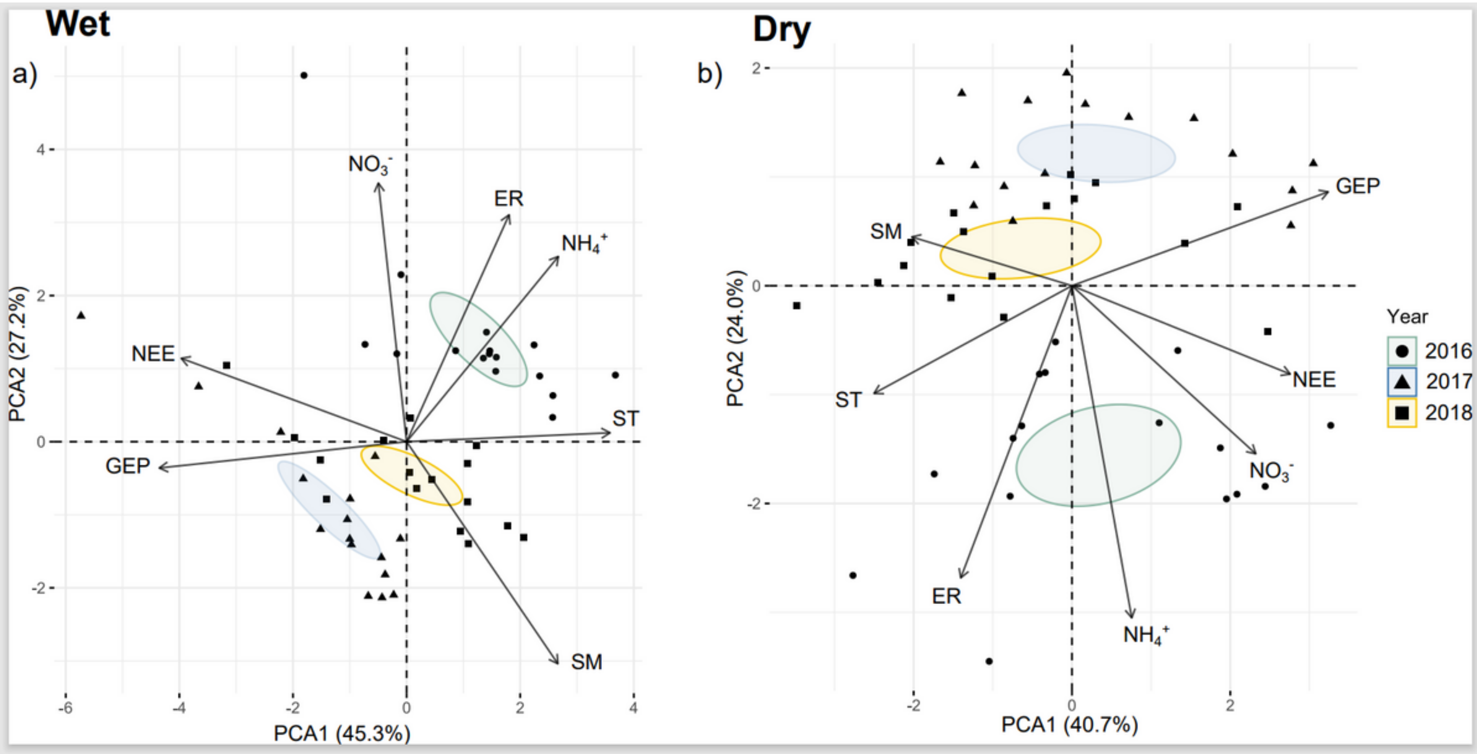

Figure 6

Principal component analysis biplots of: a) wet and b) dry plot variables (soil temperature, soil moisture, N availability, and CO2 exchange) by year.

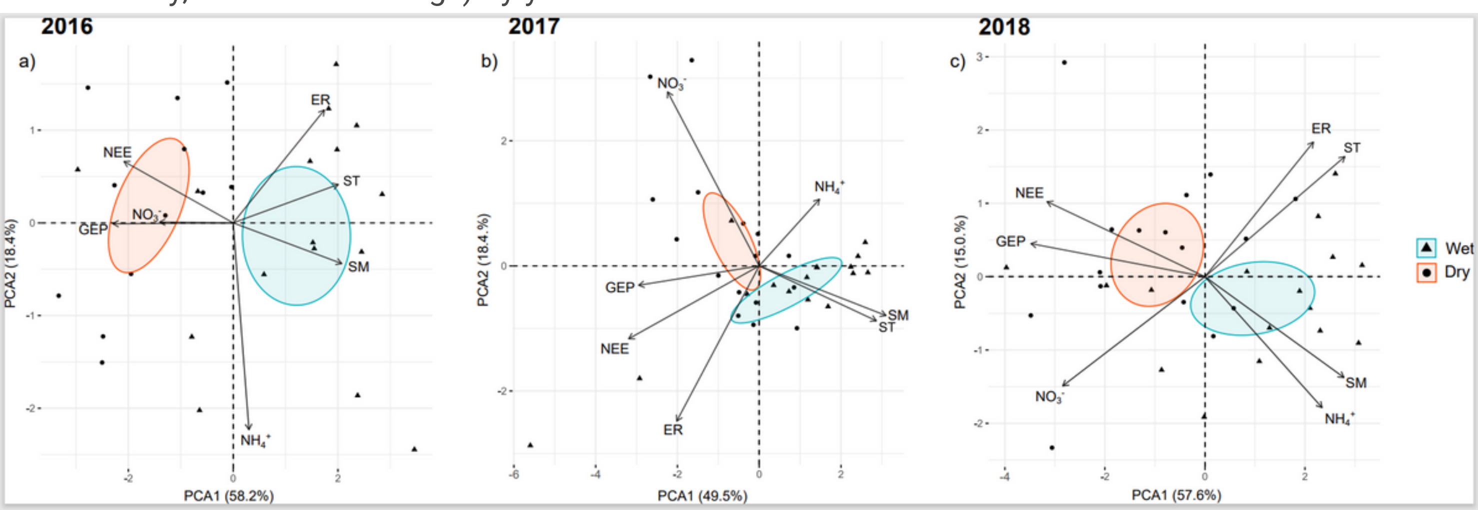

Figure 7

Principal component analysis biplots of: a) 2016, b) 2017, and c) 2018 (by moisture regime).