A Cross-Ecoregion Evaluation of Nitrogen Fixation and Denitrification in Streams and Rivers of the United States of America

Amy Marcarelli, Erin Eberhard, Michelle Kelly and Kevin Nevorski
Michigan Technological University, Department of Biological Sciences

Objective: Conduct a cross-ecoregion study to test the hypothesis that N_2 fixation and denitrification would co-occur in streams and rivers across a range of reactive N concentrations.

Background:

Typically assumed that nitrogen (N_2) fixation and denitrification do not co-occur in streams and rivers because N_2 fixation is favored in high light, low N environments but denitrification is favored under anoxic, high N conditions.

Recent work in marine and lake ecosystems has demonstrated that N_2 fixation can happen under high N conditions and in sediments, challenging this assumption.

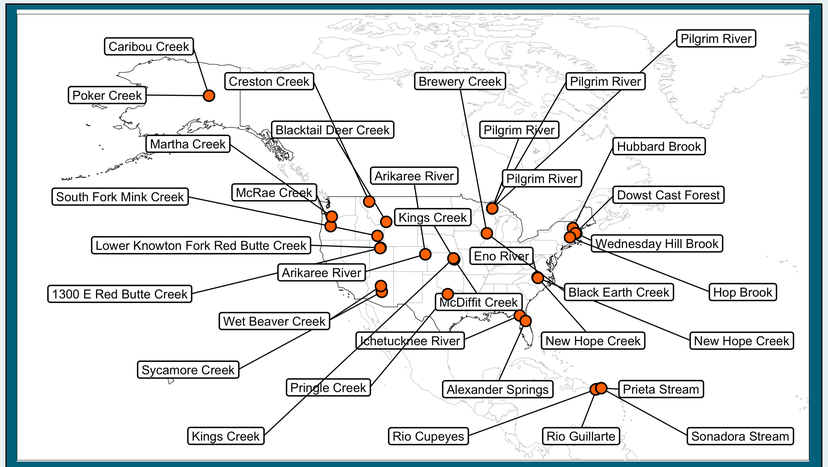

Figure 1. Stream locations sampled for this study. All sites were either part of the StreamPULSE network (https://streampulse.org/) or part of NEON (https://www.neonscience.org/), except the two Red Butte Creek sites, which were part of the iUTAH network (https://iutahepscor.org/) and South Fork Mink Creek in Idaho.

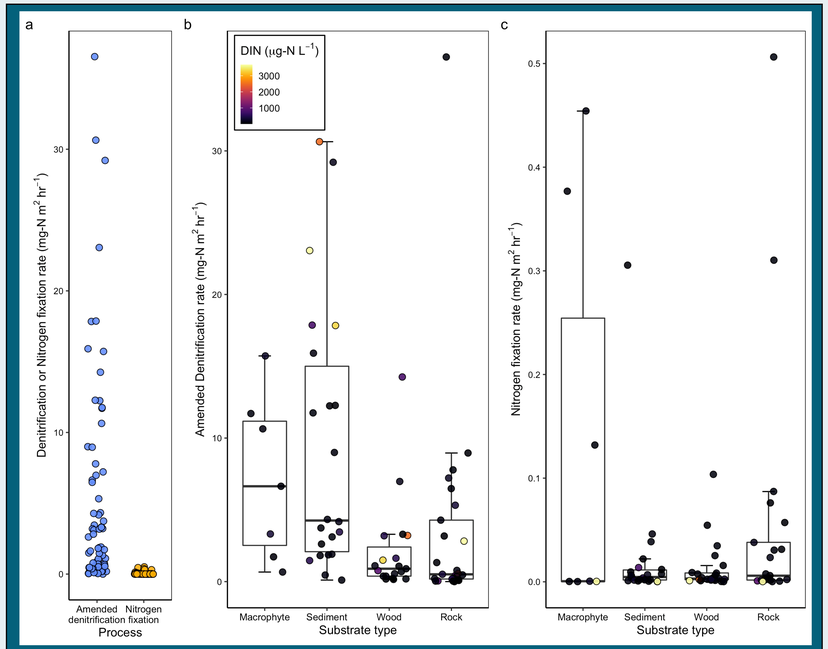

Figure 2. (a) Comparison of rates measured on all substrates, across all streams. (b) Denitrification and (c N_2 fixation rates measured on dominant substrates, with points colored to indicate dissolved inorganic nitrogen (DIN) concentration measured in the stream on that sampling date.

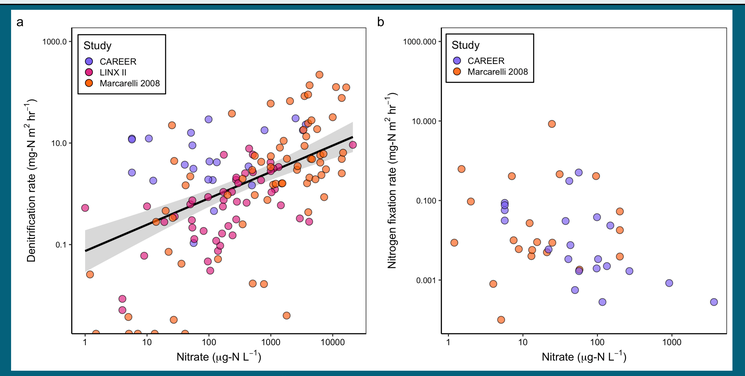

Figure 3. (a) Denitrification [regression R^2 = 0.254, p < 0.001, log(y + 1) = -0.2844 + 0.2833 log(x + 1)] and (b) N_2 fixation rates measured during this study (CAREER) vs. literature review (Marcarelli et al. 2008 https://doi.org/10.1899/07-027.1) and LINX II (Mulholland et al. 2008 https://doi.org/10.1038/nature06686)

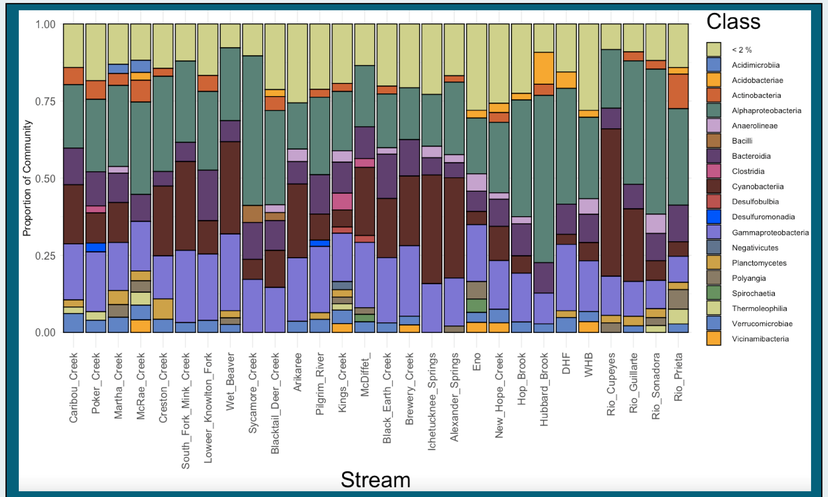

Figure 4. A taxa plot of the % proportion of the microbial community determined using 16S sequencing, represented by specific Class for each study stream. Streams are organized from West to East along the x-axis. Classes that represented < 2% of the overall proportion were grouped together.

Next steps:

Scale substrate-specific rates using benthic cover estimates to compare process co-occurrence and relative contributions at the reach scale.

Evaluate microbial diversity and composition relative to process rates across streams and biomes.

Explore interrelationships between N process rates, stream energy budgets and environmental controls across streams and biomes.

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