Patch Dynamics of Nitrogen Fixation and Denitrification in Streams

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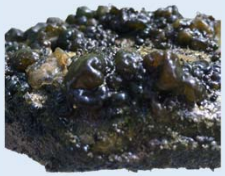
Objective

- Evaluate where patches (hotspots) of nitrogen (N) fixation and denitrification occur in streams and the patch characteristics that may drive these processes

Background

- N_2 fixation and denitrification are key processes controlling net N gas (N_2) fluxes in streams
- N_2 fixation and denitrification have been found to co-occur in streams despite their difference in N requirements[1]
- The spatial heterogeneity of streams create patches or hotspots that show disproportionally high reaction rates relative to the surrounding spatial area[2]

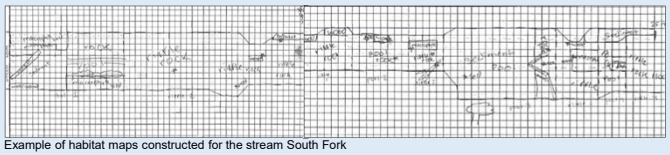


Common fixer *Nostoc*

- Evaluating how the spatial heterogeneity of patch characteristics facilitates the co-occurrence of N_2 fixation and denitrification will further understanding of the complexity of N cycling

Study Design & Methods

- Selected 3 streams in Michigan and 4 in Idaho with high substrate variability that were studied in Jun - Aug 2016 and 2017
- An 80 m reach of each stream was mapped and broken down into microhabitats of rock, sediment, macrophyte, and wood
- Substrate from each microhabitat was collected in chambers to measure rates of N_2 fixation and denitrification using acetylene reduction or block methods



Example of habitat maps constructed for the stream South Fork

Microhabitat scale measurements at South Fork in ID

Hypothesis 1

Rates of N_2 fixation and denitrification will vary within stream reaches via patches

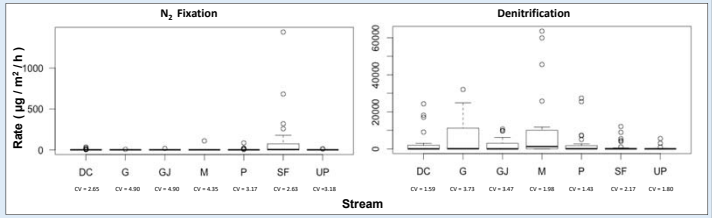


Figure 1. N_2 fixation and denitrification box and whisker plots of Diggie Creek (n = 26) , Gratiot River (n = 24), Gibson Jack (n = 24), McGunn (n = 19), Pilgrim River (n = 24), South Fork (n = 33), and the Upper Portneuf River (n = 21). Boxes denote first, second, and third quartile ranges; whiskers highlight the maximum values. Coefficient of variation (CV) is a measure of variability relative to the mean.

- Streams with the greatest variation in rates of N_2 fixation and denitrification were those that had the smallest number of patches with non-zero rates of either process

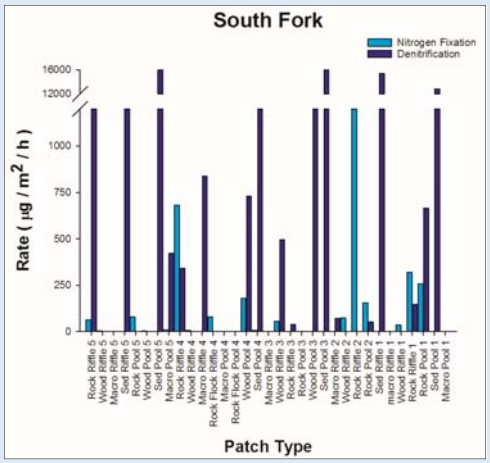


Figure 2. Rates of N_2 fixation and denitrification versus patch type for South Fork in Idaho.

- South Fork was the stream with the highest occurrence of N_2 fixation in patches
- N_2 fixation rates were detectable on rock, sediment, and wood substrates
- Some N_2 fixation rates were comparable to denitrification rates, which suggests that this could be an important source of N in some patches

Hypothesis 2

Patches that have a higher abundance of the microbial genes needed for a process will exhibit higher rates than patches in the same stream with lower abundances of those genes

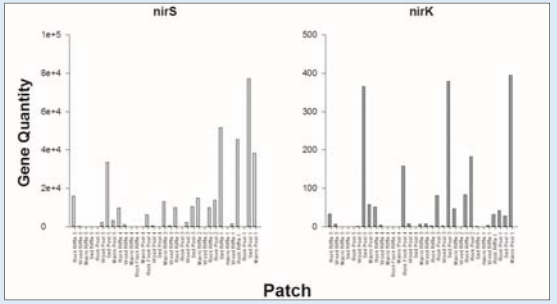


Figure 3. Gene quantities for nirS and nirK in the patches of the stream South Fork. The Y axis for nirK is 200x less than that of nirS

- nirS and nirK, associated with denitrification, are abundant in patches even where there were not high rates measured which suggests the potential to perform this process is more widespread

Conclusions & Future Directions

- **Rates of N_2 fixation and denitrification do vary among patches within streams**
- Plan to do spatial analysis using a suite of environmental variables and microbial gene abundances to explain the variation of rates within streams
  - Including the abundance of gene nifH related to N_2 fixation
  - Assemblage analysis of microbes present in each patch

Sampling in progress at the Upper Portneuf

Literature Cited

1. Eberhard et al. 2017 in review. *Biogeochemistry*
2. McClain et al. 2003. *Ecosystems* 6:301-312

Acknowledgements

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