Defining the Balance Between N_2 Fixation and Denitrification in Falls Lake

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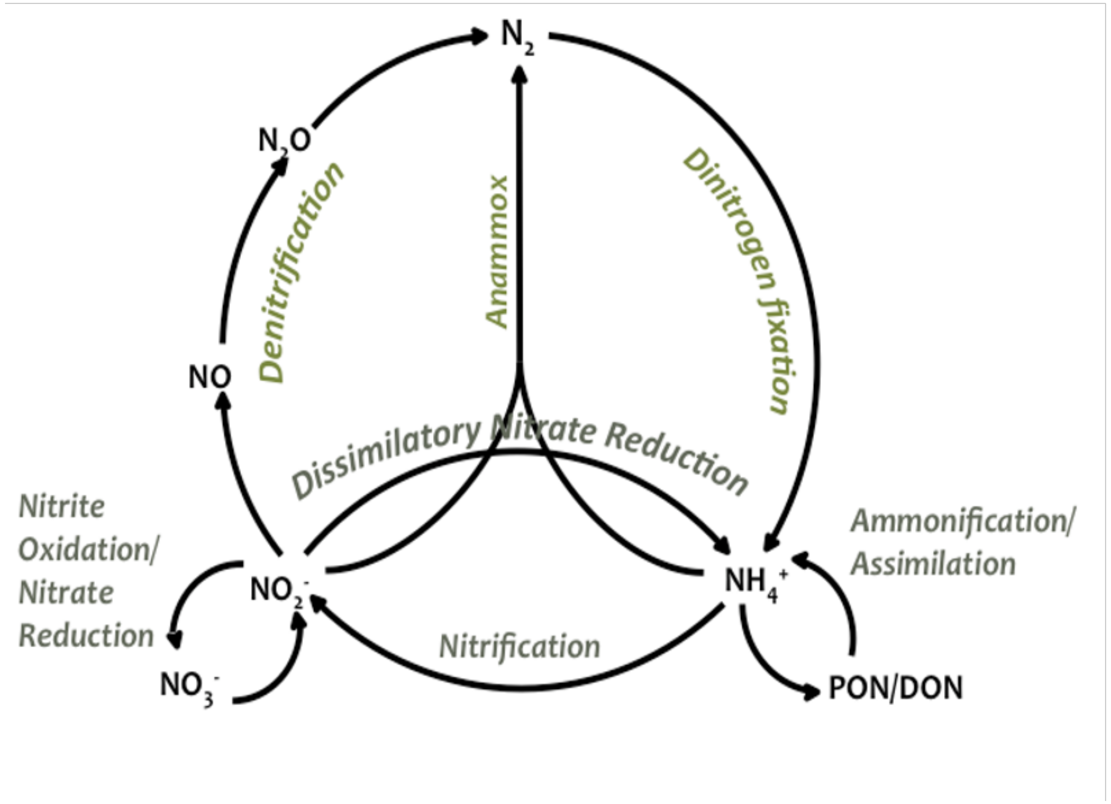
Falls Lake Nutrient Study Research Symposium
19 April 2022

Understanding N_2 fixation & denitrification in Falls Lake is important



Balance of N_2 fixation and denitrification can determine nutrient limitation-can inform more effective nutrient control strategies

N_2 fixing cyanobacteria are surface bloom and/ or toxin producers

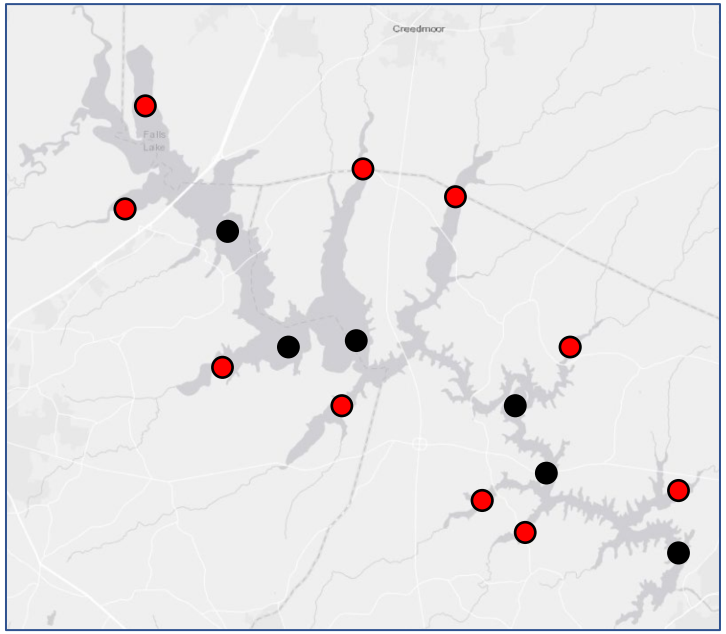
Measuring either helps constrains other parts of the N budget that are difficult to measure

Research Questions

1) Do microbial processes cause a net production (N_2 fixation) or removal (Denitrification) of N from Falls Lake?

2) Is N_2 fixation quantitatively important relative to stream loads and atmospheric deposition? Worth including in models?

3) What factors stimulate or constrain N_2 fixation?



Nitrogen Fixation Measurement Methods

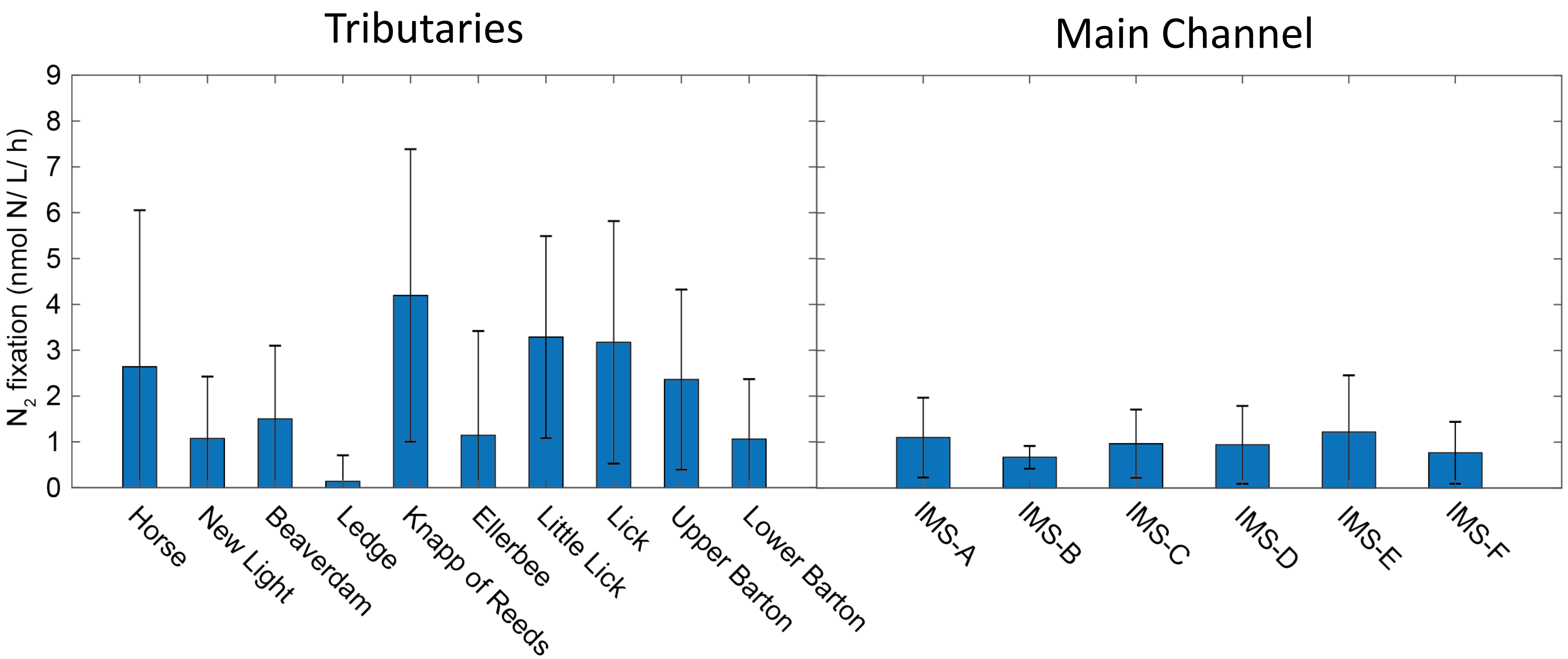
1) Collected surface samples
   - 5 samplings at 6 main channel (2019-2020)
   - 5 samplings at 10 creeks (2021)
   - 2 summer samplings at 6 channel and 10 creeks (2022)

2) N_2 fixation measured by acetylene reduction under simulated in situ conditions

3) Ancillary measurements of nutrients, phytoplankton biomass/ composition, hydrographic profiles, and light

4) Nutrient (N & P) addition experiments to determine limiting nutrient(s) and to assess P limitation of N_2 fixation

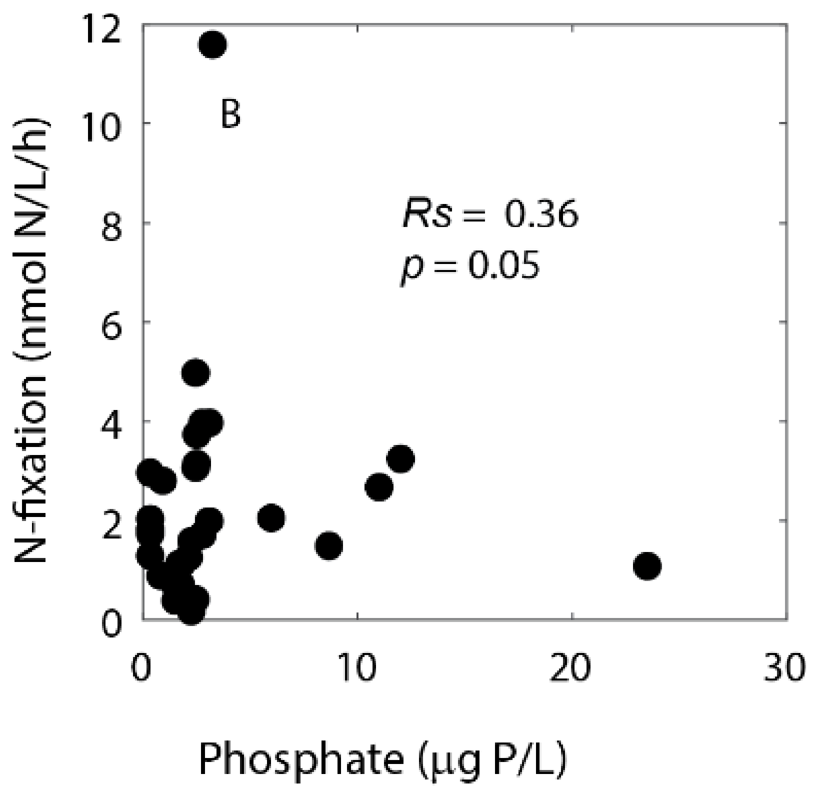
N_2 fixation measurements and scaled-up annual estimates

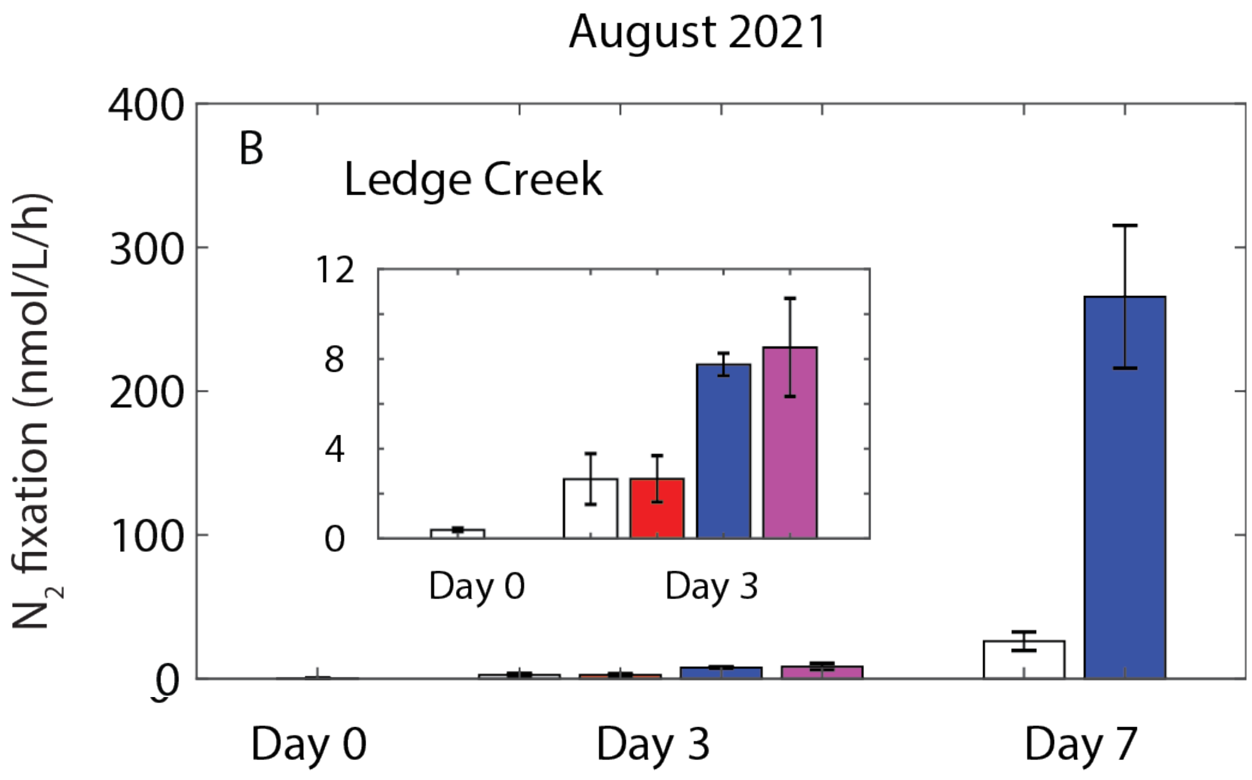


Assumptions: Measured photic depth, 12 h photic period, 180 d season

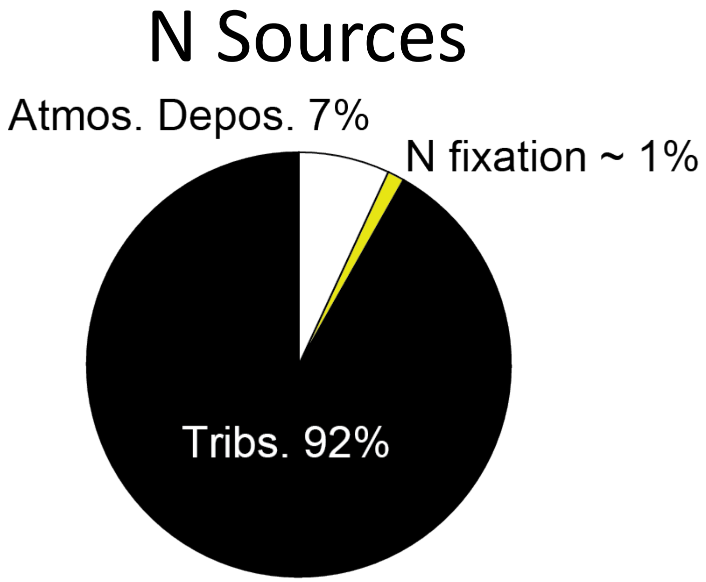
N_2 fixation = 3300 kg N/y, ~ 1% of stream N load

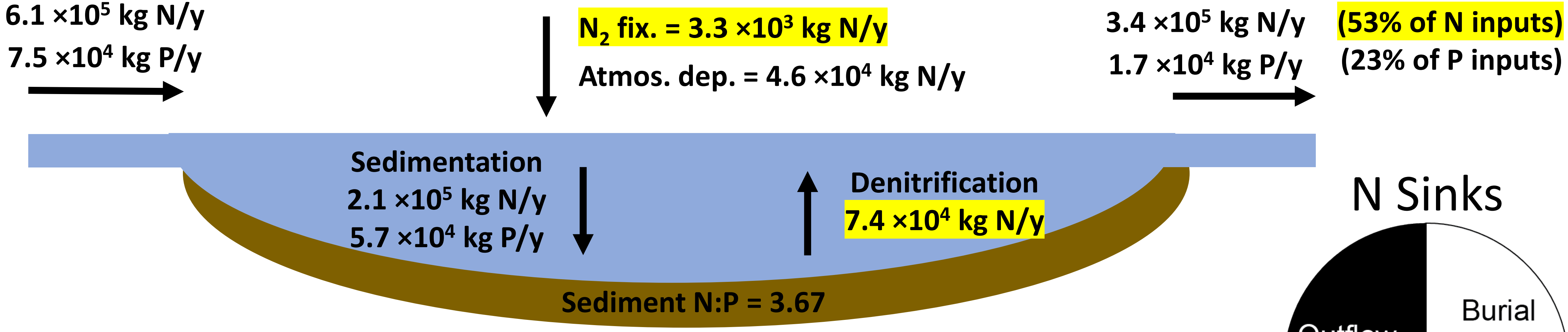
Two pieces of evidence for P availability as a constraint on N_2 fixation

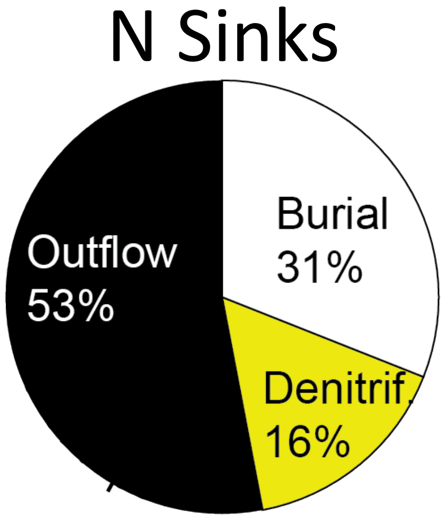


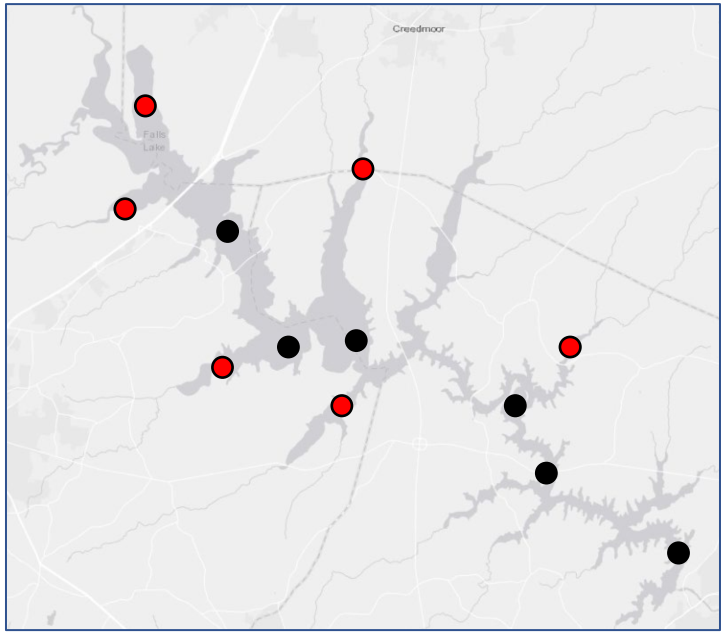


Nutrient Budget for 2006-2019









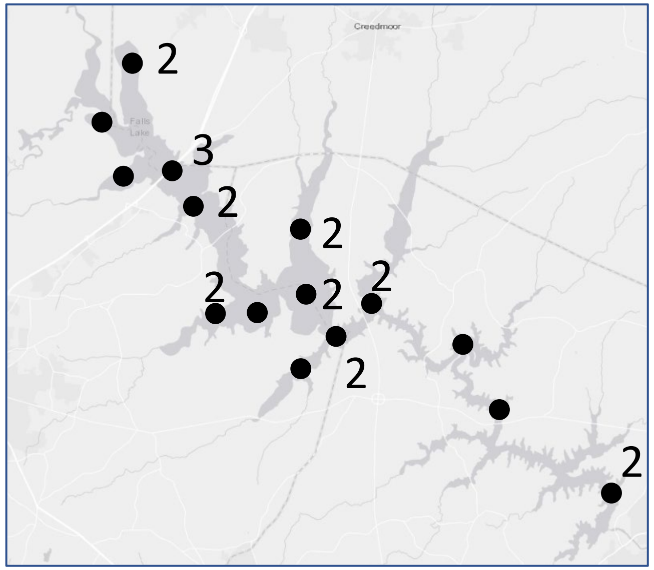
Direct Denitrification Measurements

(Piehler lab)

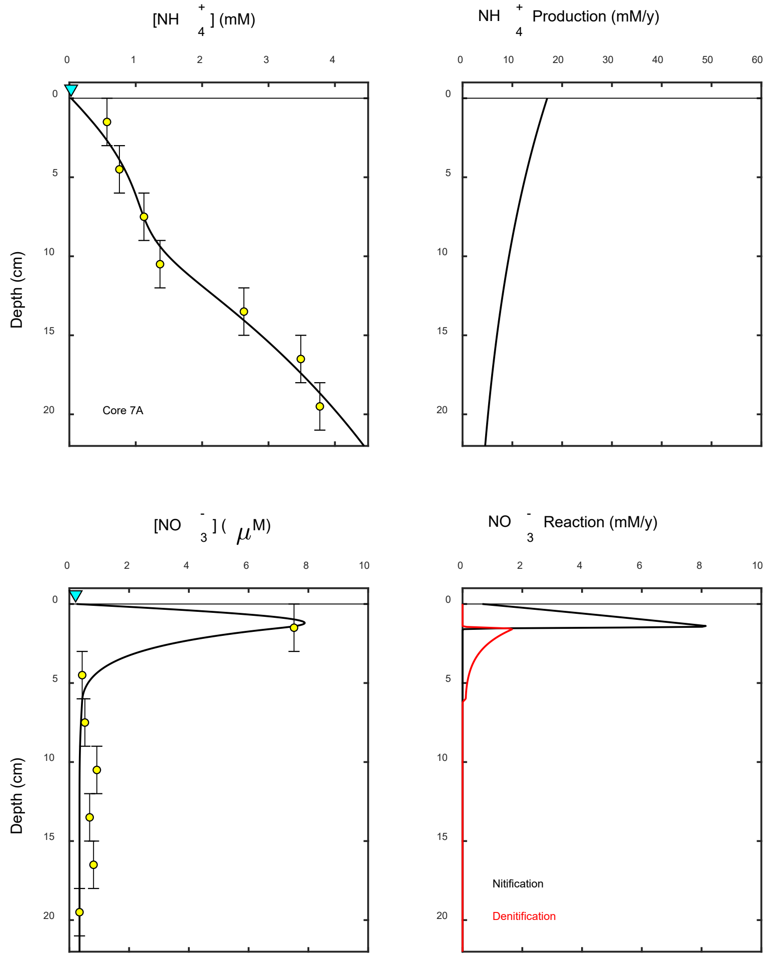
1) Collected sediment cores
   - 3 samplings at 6 main channel (Oct 2019, May, Aug 2020)
   - 1 sampling at 6 creeks (Jul 2021)
2) Steady-state, continuous flow incubation- N_2 production measured by membrane inlet mass spectrometry
3) Scaled to total surface area and annual period

Estimated N loss = 42% of stream N load

Denitrification from a sediment diagenesis model
(Dr. Marc Alperin, UNC Chapel Hill)



Used model results from 25 cores



1) Steady state flux = Depth integrated net reactions

2) Integrated denitrification over model domain (mmol/m^2/y)

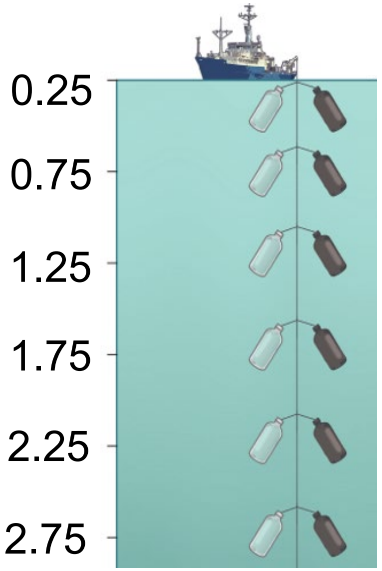
3) Scaled mean of cores to total surface area

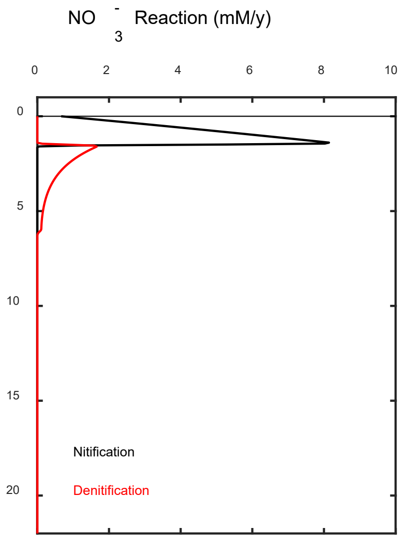
Estimated N loss ~ 1 % of stream N load

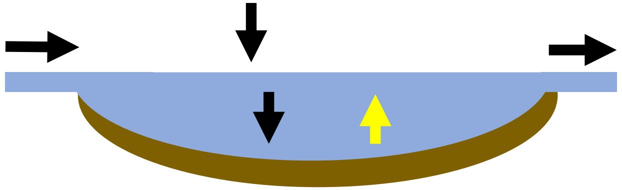
Balance of microbial N processes tilts toward N loss by denitrification

(Rates expressed as % of stream load)

N_2 fixation Direct measurements		**Denitrification** Diagenesis model	**Denitrification** Nutrient budget	**Denitrification** Direct measurements
0.5 %	*VS*	**1 %**	**16 %**	**42 %**







Policy Implications

1) Net loss of N by microbial processes may produce N limited conditions for algal growth- supports management of N loads

2) N_2 fixation likely constrained by P availability- supports P management

3) Water quality models appear justified in omitting N_2 fixation