Factors Affecting Denitrification Estimates in Restored Floodplain Wetlands

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Background

Accurate ecosystem-scale denitrification estimates are essential for quantifying and evaluating contributions of wetland management practices to regional nutrient removal. It is difficult to design laboratory studies that precisely capture variation in denitrification capacity across heterogeneous landscapes. Thus, monitoring efforts benefit from evaluating sources of error between measured and scaled rates. We are monitoring denitrification rates in 40 Wetland Reserve Program (WRP) easements managed by the USDA Natural Resources Conservation Service (NRCS) to access nutrient removal processes across converted croplands in west Tennessee and Kentucky. Here we present preliminary analysis for areal and scaled denitrification rates for one easement, and an assessment of denitrification variation across a subset of 10 easements by management area type.

A newly constructed WRP shallow water area

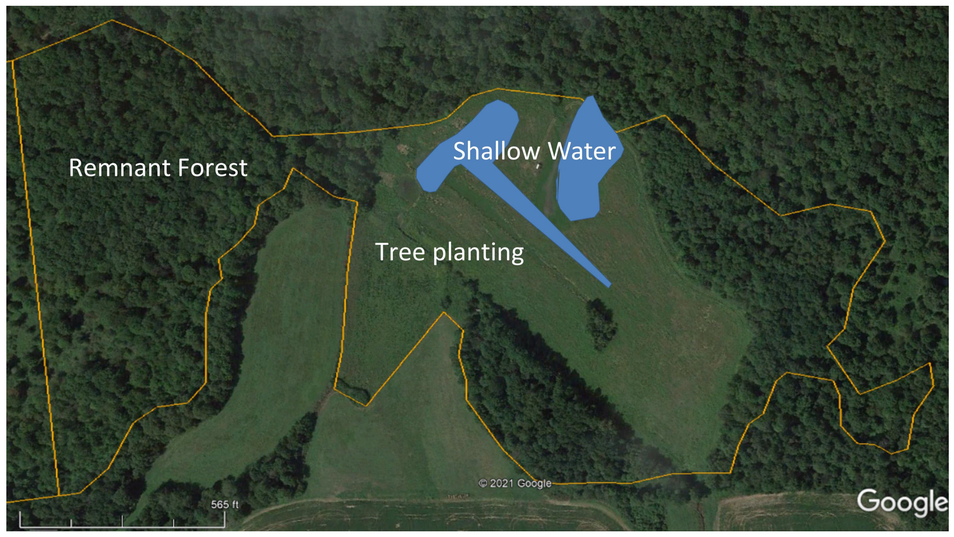
Objectives

- Scale denitrification potentials across representative management areas for one easement to assess contributions of land cover and inundation time to whole easement denitrification
- Identify relationships between location of core collection (distance between cores in a management area; distance to nearest river) that potentially influence measurement variation for denitrification estimates and inform future core collection across WRP easements

Soil Incubation and Analysis

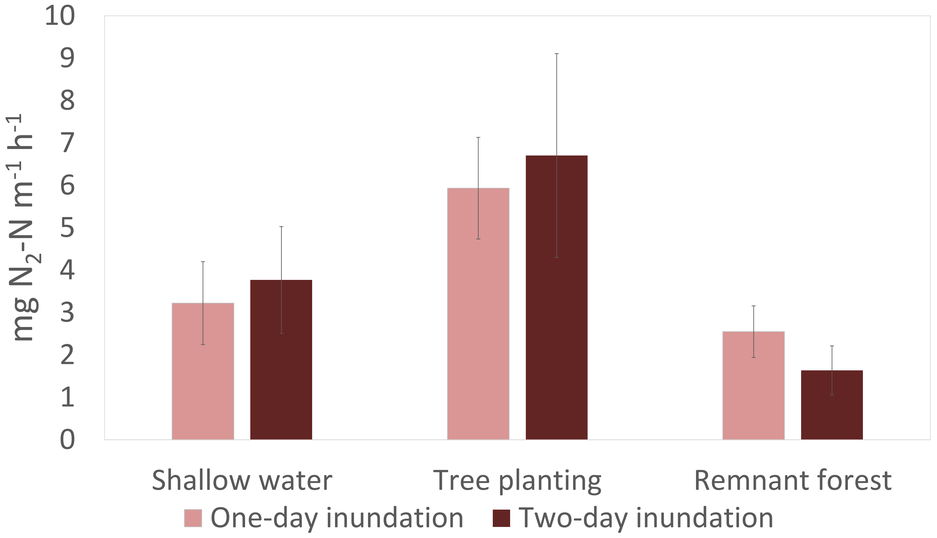
- Approximately 30 soil cores were collected from representative management areas on each of 10 WRP easements in June-August 2020 (307 total cores, 6 to13 cores per management area)
- Cores were incubated at 24˚C in a flow-through system
- Water samples were collected from inflows and outflows after approximately one- and two-day inundations and analyzed for N_2, O_2, and Ar via membrane inlet mass spectrometry (MIMS)
- Denitrification rates were calculated for each core using N_2:Ar ratios and reported in mg N_2-N m^{-2} h^{-1}
- Mean denitrification rates, 95% confidence intervals, and coefficients of variation (CV) were calculated for representative management areas in each easement
- Mixed-effect models were used to identify factors affecting CVs across easements
- A CV >1 indicates standard deviation is higher than mean estimates for a given management area

Focal Easement



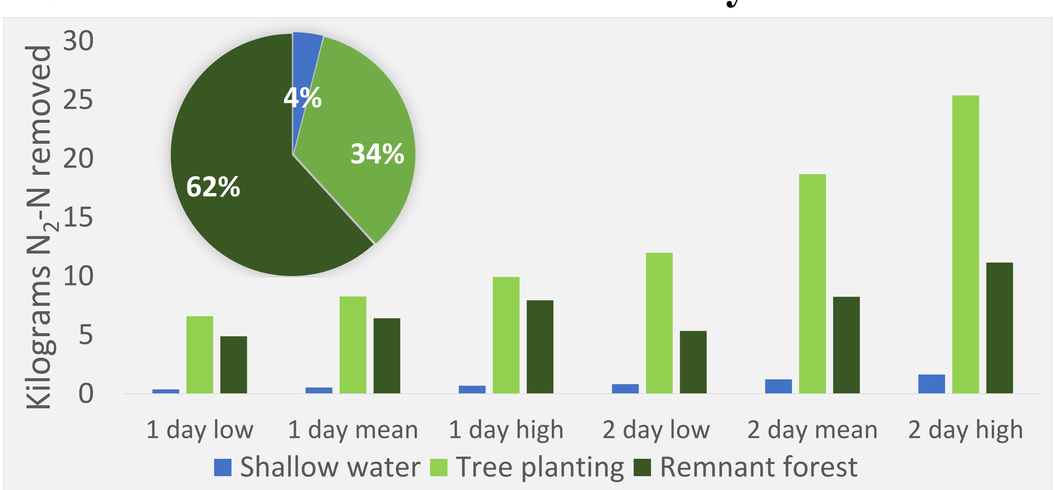
- 68-acre WRP easement in west Kentucky
- Tree planting and shallow water construction in 2015
- 10 soil cores collected from each of three management areas

Areal Denitrification Rates



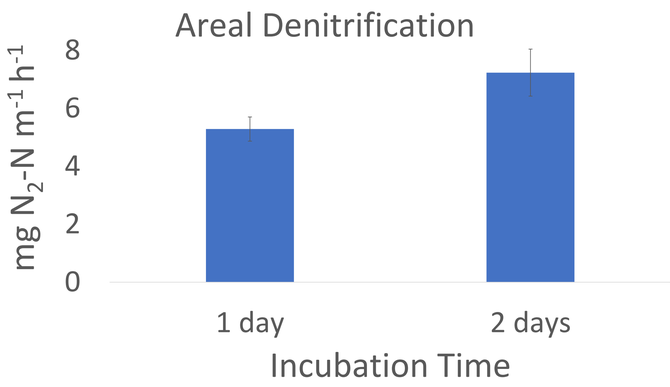
- Two-way ANOVA ($F_{(2,54)} = 8.898$, $p < 0.001$) and Tukey's post-hoc tests showed areal rates were highest for tree plantings but not significantly different between inundation times for any habitat
- Tree planting rates were, on average, 81% ($p = 0.002$) and 200% ($p < 0.001$) higher than shallow water and remnant forest areas, respectively
- Shallow water areal rates were marginally higher (66%, $p = 0.095$) than remnant forest on average

Scaled Denitrification Estimates by Land Area

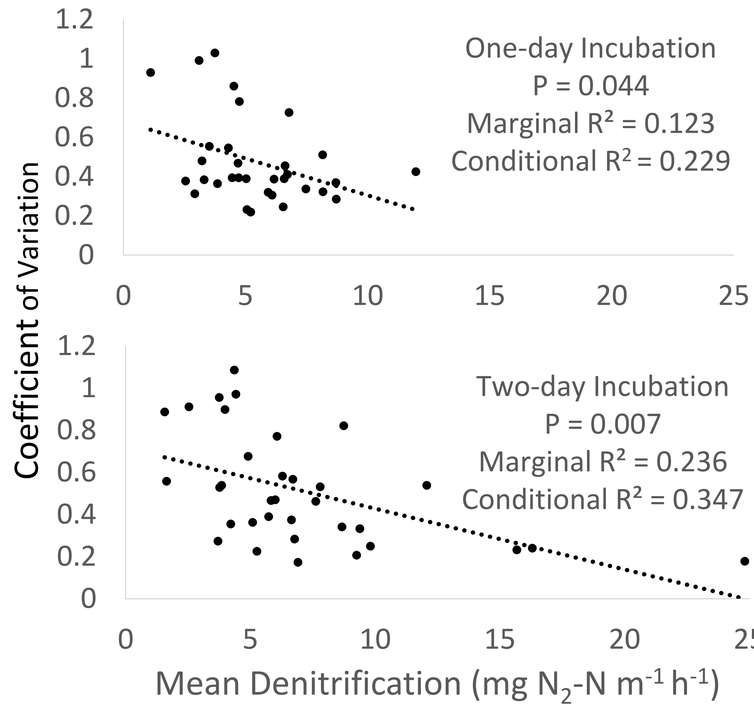


- Scaled estimates show extrapolated means and low and high bounds of 95% CIs for each landcover area over the course of a two-day simulated flood

Estimates Across 10 Easements



- A paired t-test showed mean areal rates increased by 1.89 ± 0.527 mg N_2-N m^{-1} h^{-1} between incubation day one → two when pooled across easements ($t_{(306)} = 7.035$, $p < 0.001$)
- Contrasting results with focal easement



- Mixed-effects models with a random intercept for easement showed no influence of distance between soil cores within management areas and distance to nearest river on CVs
- CVs for individual management areas (n = 33) decrease with mean rates, but conditional R^2 indicate that differences between easements influence this relationship

Discussion

- Measuring areal denitrification rates for more easements is more likely to improve accuracy of scaled estimates of management types than sampling individual easements more intensively
- Non-linear mixed-effect models, along with soil structure data should improve understanding of biogeochemical drivers of denitrification across easements

Acknowledgments

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