Spatial Variation of Nitrogen Fixation and Denitrification Across a Wetland – Stream – Lake Interface

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Objective
Evaluate how N₂ fixation and denitrification co-vary spatially in wetland – stream – lake interfaces

Background
• N₂ fixation and denitrification control net N₂ gas fluxes in ecosystems
• Spatial heterogeneity of wetland – stream – lake interfaces regulates complex biogeochemical cycling
• Processes may be driven by spatial variation in environmental constraints such as nutrient limitation
• Evaluating spatial patterns could change our understanding of the N cycle in a region where P limitation of primary producers has been emphasized

Study Design & Methods
• 3 wetland – stream – lake interfaces in northern Lakes Huron and Superior were sampled Jul – Aug 2018
• Sampling transects of 10-15 points crossed the wetland – stream – lake interface (Fig. 1)
• Chamber measurements of N₂ fixation and denitrification using acetylene reduction or block.

Hypothesis 1
The spatial heterogeneity of the wetland – stream – lake interface facilitates the co-occurrence of N₂ fixation and denitrification

Hypothesis 2
Spatial heterogeneity of nutrient, oxygen, and organic matter concentrations, and temperature will predict occurrence of processes

Background
• Dissolved oxygen was the best predictor of N₂ fixation and organic matter was the best predictor of Denitrification, but all models had poor fit

Results
• N₂ fixation and denitrification control net N₂ gas fluxes in ecosystems
• Spatial heterogeneity of wetland – stream – lake interfaces regulates complex biogeochemical cycling
• Processes may be driven by spatial variation in environmental constraints such as nutrient limitation
• Evaluating spatial patterns could change our understanding of the N cycle in a region where P limitation of primary producers has been emphasized

Discussion
• N₂ fixation and denitrification rates co-occurred on sediment and macrophyte substrate in 18% of points across all transects
• Denitrification alone was more common than N fixation alone (62% vs 16%, respectively)
• Denitrification rates were higher and were detected more frequently than N₂ fixation across all interfaces

Conclusions & Future Directions
Spatial patterns of environmental variables may drive the occurrence of N₂ fixation and denitrification across wetland – stream – lake interfaces

Next steps: Re-sample in Summer 2019
• Spatial analysis using a suite of broader environmental variables and microbial gene abundances to explain the variation of rates across the interfaces
• Measure nutrient limitation using nutrient diffusing substrata to assess the role of nutrient limitation in the spatial variation of processes
• Perform nutrient enrichments and trace the fate of N using isotopic analysis

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Literature Cited

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Table 1. Logistic regressions for rates of N₂ fixation and denitrification using generalized linear models. Temp is temperature, CC is canopy cover, OM is organic matter, and ODO is dissolved oxygen concentration. Pseudo - R² is calculated as McFadden’s R².

<table>
<thead>
<tr>
<th>Process Rate</th>
<th>Models</th>
<th>AIC</th>
<th>Pseudo - R²</th>
<th>Number of parameters with significant p-value</th>
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<tbody>
<tr>
<td>N₂ Fixation</td>
<td>+CC+ODO</td>
<td>64.39</td>
<td>0.07</td>
<td>1 at p = 0.10</td>
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<tr>
<td>+CC+Depth+ODO</td>
<td>66.61</td>
<td>0.09</td>
<td>1 at p = 0.10</td>
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<tr>
<td>+Temp+CC+Depth+OM+ODO</td>
<td>68.01</td>
<td>0.10</td>
<td>0</td>
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<tr>
<td>Potential</td>
<td>+OM</td>
<td>55.67</td>
<td>0.13</td>
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<tr>
<td>Denitrification</td>
<td>+OM+ODO</td>
<td>57.38</td>
<td>0.13</td>
<td>1 at p = 0.05</td>
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<td>+Depth+OM+ODO</td>
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<tr>
<td>+CC+Depth+OM+ODO</td>
<td>61.01</td>
<td>0.14</td>
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</tr>
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<td>62.87</td>
<td>0.14</td>
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</table>

Figure 1. a) GIS imagery of the Nara Interface. From left to right the points are 1-11. b) GIS imagery of the Sioux Interface. From top to bottom the points are 1 – Mouth. c) GIS imagery of the Mackinac Bay Interface with an inset of interface locations from Google Earth. From top to bottom the points are 1 – 12. d) N₂ fixation and denitrification rates for each interface at all transect points separated by substrate type (sed = sediment, macro = macrophyte).

Field work in progress at the Nara, Sioux, and Mackinac Bay Interfaces

Photo Credit: Brockit