The Rates and Controls of Nitrogen Biogeochemistry in Prairie Potholes, Canada

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Background

- The Prairie Pothole Region spans 780,000 km^2 and contains a high density of wetlands, or *potholes*, ranging from 5-60 per km^2 which provide valuable ecosystem services across the Prairies
- This region is under stress associated with climate change, land modification, and pollutants
- Potholes are being converted to agriculturally useable land at a considerable rate[1] and agricultural fertilizers are heavily relied on to supplement plant growth
- Nitrogen (N) is the nutrient most applied across agricultural land[2] and in excess can have negative impacts on biodiversity, human health, and water quality
- Potholes can help offset the impacts of nutrient inputs to downstream water bodies through the many processes naturally occur within
- Increasing N availability and decreasing pothole density is jeopardizing the sustainability and health of our wetland ecosystems
- While we know that potholes can help retain nutrients, we know relatively little about the controls on these processes in this region— limiting our ability to understand which potholes are most effective in retaining nutrients

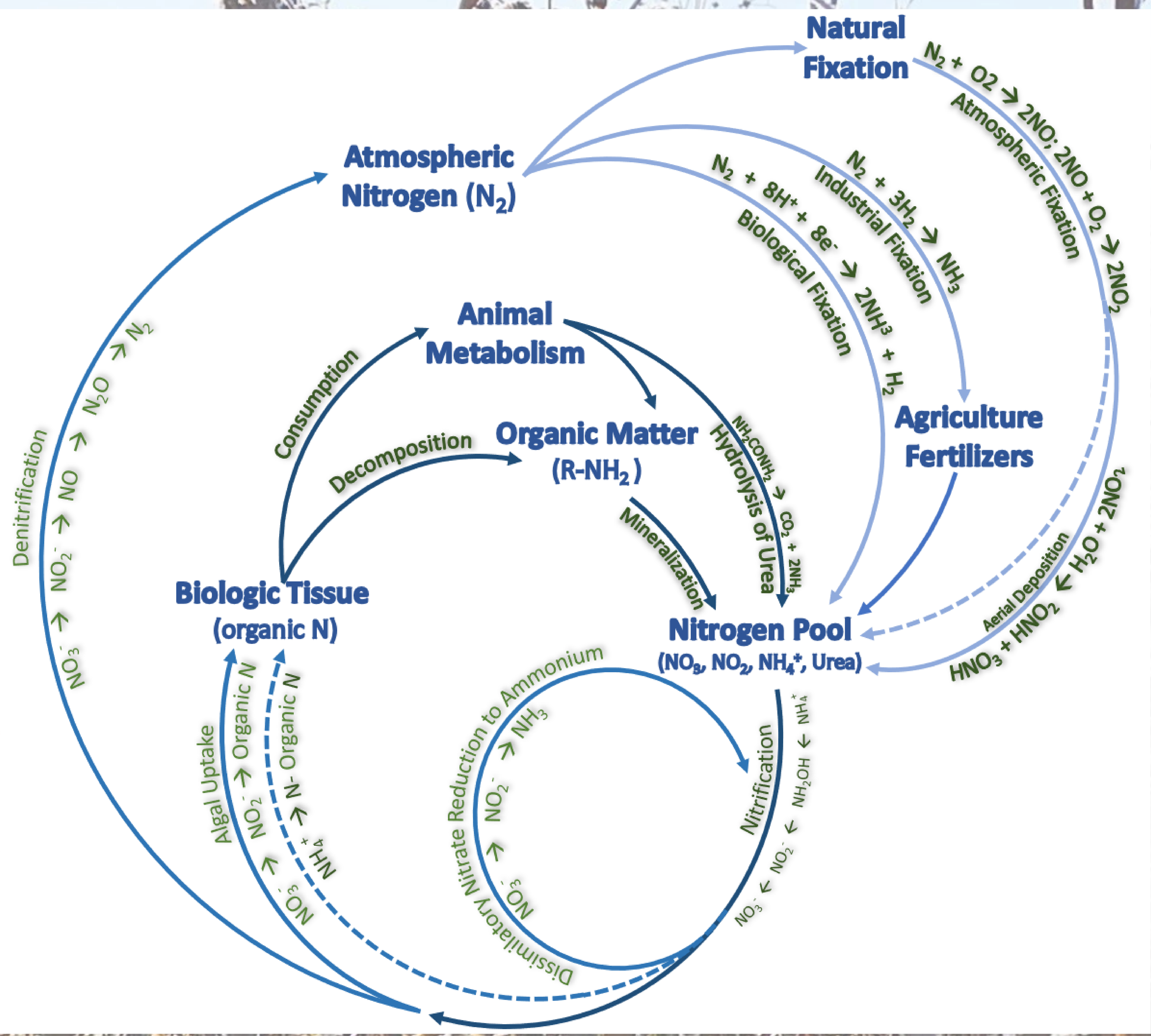


Fig. 1: Schematic diagram simplifying nitrogen transformations throughout the environment. Of interest are those illustrated in medium blue: dissimilatory nitrate reduction to ammonium, algal uptake, and denitrification. These processes are expected to be important controls on nitrogen availability in these ponds.

Research Objectives

Research Questions: Do potholes vary in their rates of N transformations? What are the key processes controlling pond chemistry?

Objective 1: Quantify the rate of DNRA and denitrification across gradients (such as pH, salinity, and permanence) to understand whether unique region conditions favour N recycling over removal

Objective 2: Measure algal uptake to understand the rapidity with which inorganic N is transformed to organic N.

Objective 3: Characterize variability in nutrient chemistry across wetland classes of the three prairie provinces.

Methods

Water Quality Survey: We collected water samples and field parameters from potholes across the Prairies (n = 347). The data collected will support objective 3, and help constrain conditions used in experiments.

Experimental measurements: Stable isotopes of nitrogen will be used to measure uptake, denitrification, and DNRA. Experiments will be performed at the St. Denis National Wildlife Area (SDNWA). This 383 ha area contains over 200 wetlands, varying in permeance, salinity, and size.

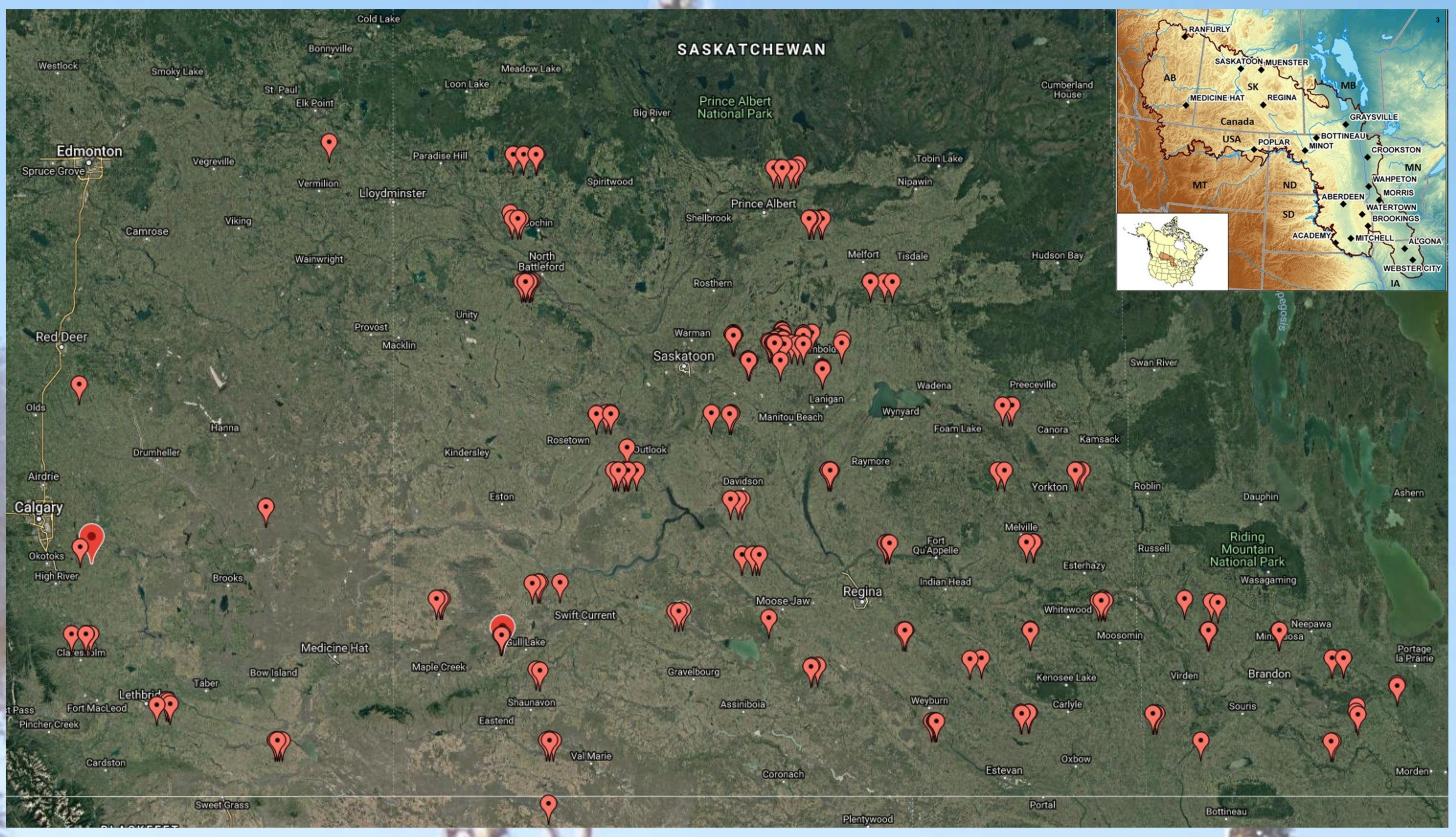


Fig. 2: Mapped locations of the prairie—wide water quality survey sites. The survey sample collection occurred May through September 2018 and collected 347 samples.

Results

- Algal community uptake of inorganic N is significant — with available nitrate and ammonium typically consumed within an hour
- Across the range of nitrate and ammonium concentrations studied, algae show high capacity for continued removal
- Full saturation was accomplished in site 38 and 41, and leveling out in site 39a, identifying the maximum amount of N that can be utilized by the community
- Higher in situ concentrations of nitrate uptake are associated with higher uptake rates
- Together, these results suggest algal uptake is rapid, helping to attenuate dissolved inorganic nitrogen transported to wetlands

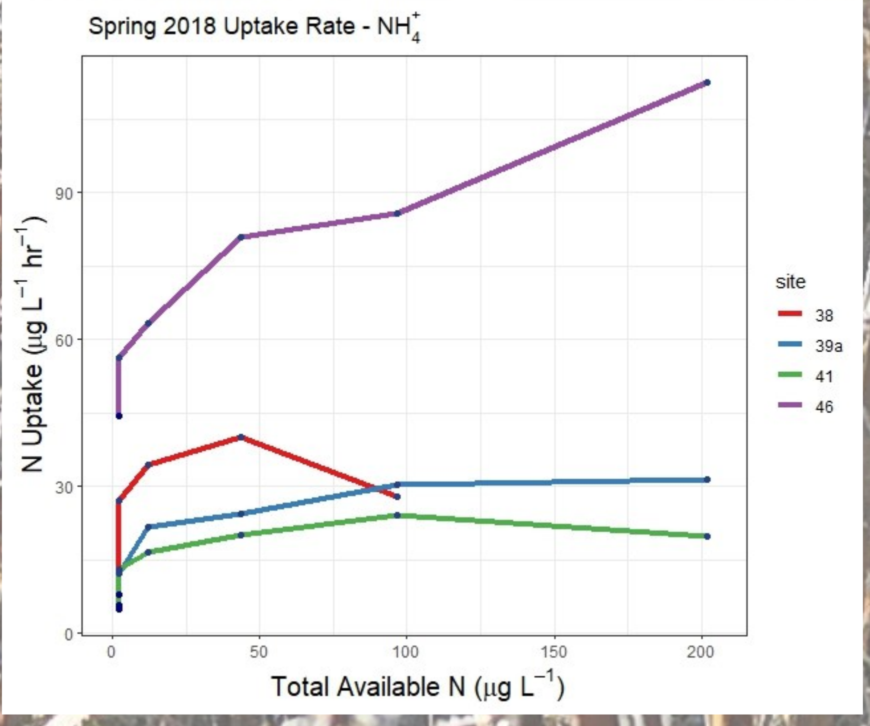


Fig. 3: A line graph displaying the rate of uptake against total available ammonium-N. Full saturation was accomplished in site 38, 41, and leveling out in 39a.

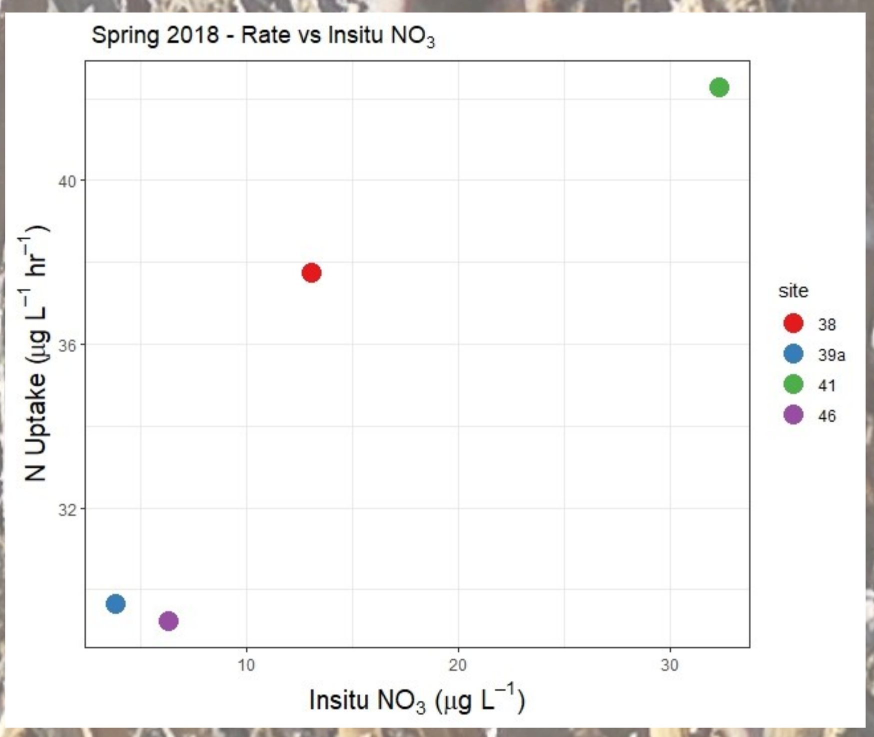
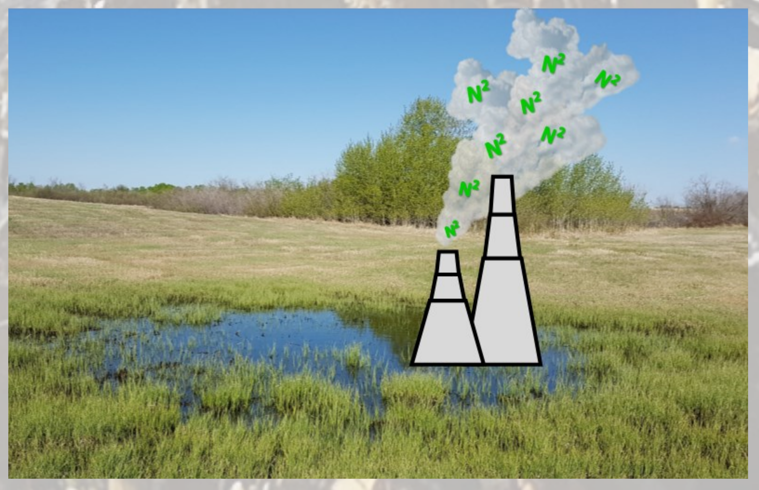


Fig. 4: A point graph displaying the positive relationship between the rate of nitrate uptake and in situ nitrate concentrations.

Applications

Through incorporating this information, varying field parameters, and pothole characteristics, we can determine which potholes are the best nitrogen *transformers*.



This information can facilitate:

- Wetland governance and policy through more informed decisions by producers, managers, agencies, and government personnel
- Better informed management decisions for wetlands and fertilizer applications
- Provide better nutrient budgets across the Prairie Pothole Region
- Support and guide the prediction of nitrogen behaviour in potholes
- Contribute to a better understanding of pothole biogeochemistry

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References: [1]Thompson et al. 2013; [2]Crumpton and Goldsborough 1998; [3]Johnson et al. 2010

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