Soil Nitrate Uptake Relative to Nitrate Availability in a Restored Agricultural Wetland

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Introduction

Nitrate is the most common form of nitrogen pollution in agricultural rivers. Excess nitrogen can cause harmful algal blooms and low oxygen levels in aquatic environments. Riparian wetlands in agricultural watersheds can be very efficient at removing nutrients before they reach streams and restoring agricultural wetlands for improving water quality has become a major focus of the USDA Natural Resources Conservation Service.

Many wetland properties can affect nutrient removal rates and understanding how each parameter alters nutrient retention can help optimize restoration strategies. Water nutrient concentration is directly related to removal rates in aquatic systems[1], but this relationship is not well known in restored wetlands. The goal of this study was to determine the relationship between nitrate concentration and soil uptake across the different habitats within a wetland.

Methods: Soil Collection, Incubation, and Analysis

- 60 soil cores were collected from a west Tennessee restored wetland along the Obion River (Figure 1).
- 15 cores from each of the four major habitat types: shallow water, natural regeneration, tree planting, and remnant forest.
- Cores were incubated in a flow-through system in an environmental chamber at 24°C (Figure 2) simulating a flood. Three cores from each habitat were placed in each of five nitrate concentrations ranging from 0.1 -10 mg/L. (Figure 3).
- Cores were sampled at 12, 24, and 36 hours for ammonium, nitrite, nitrate, phosphate, and nitrogen gas to determine nitrogen and phosphorus uptake rates, and denitrification rates. Nutrient samples were analyzed using an AQ400 Discrete Autoanalyzer, and nitrogen gas was measured on a membrane inlet mass spectrometer. Nutrient flux rates were calculated as the difference between inflowing and outflowing water concentrations[2].

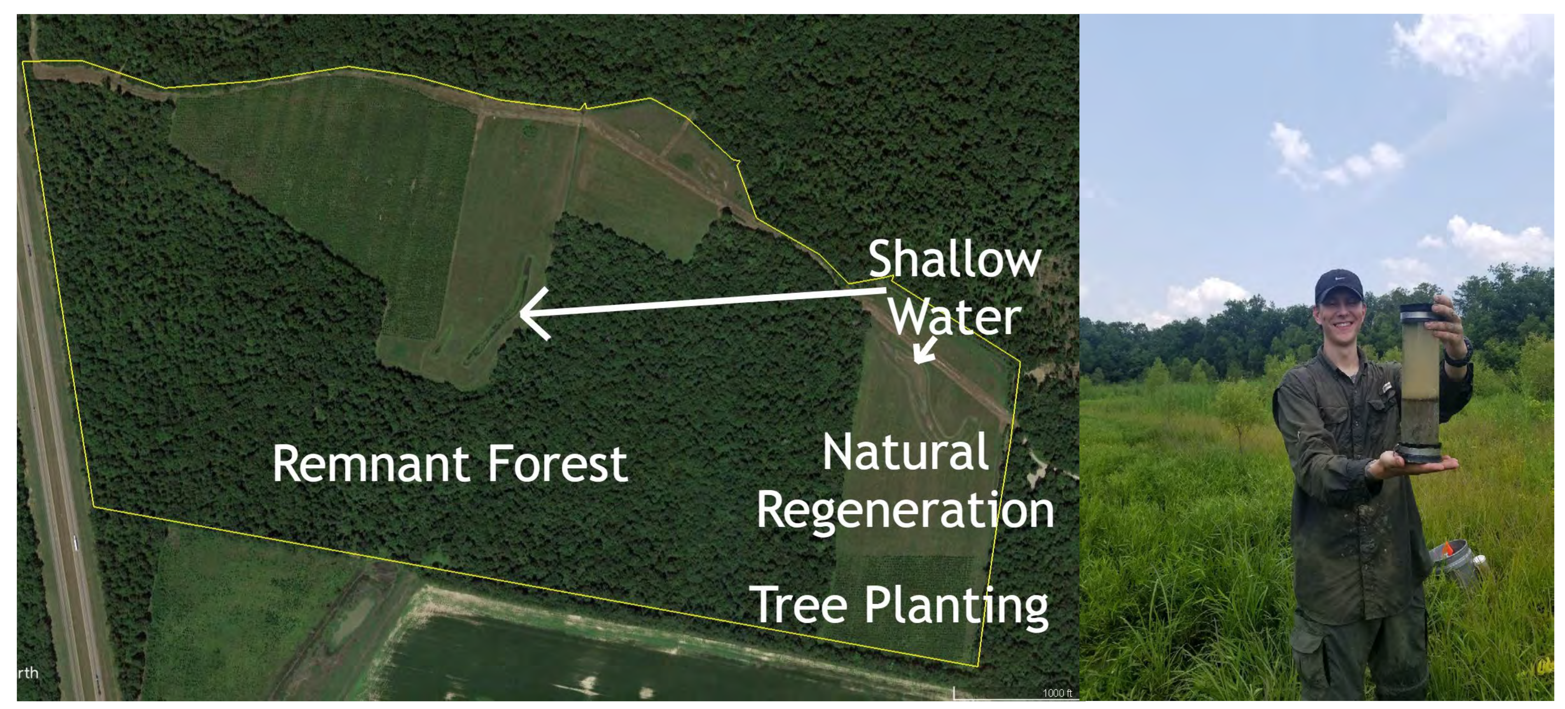


Figure 1. Satellite imagery of the restored wetland in Obion County, Tennessee (Left) and a soil core collected from the shallow water area (Right).

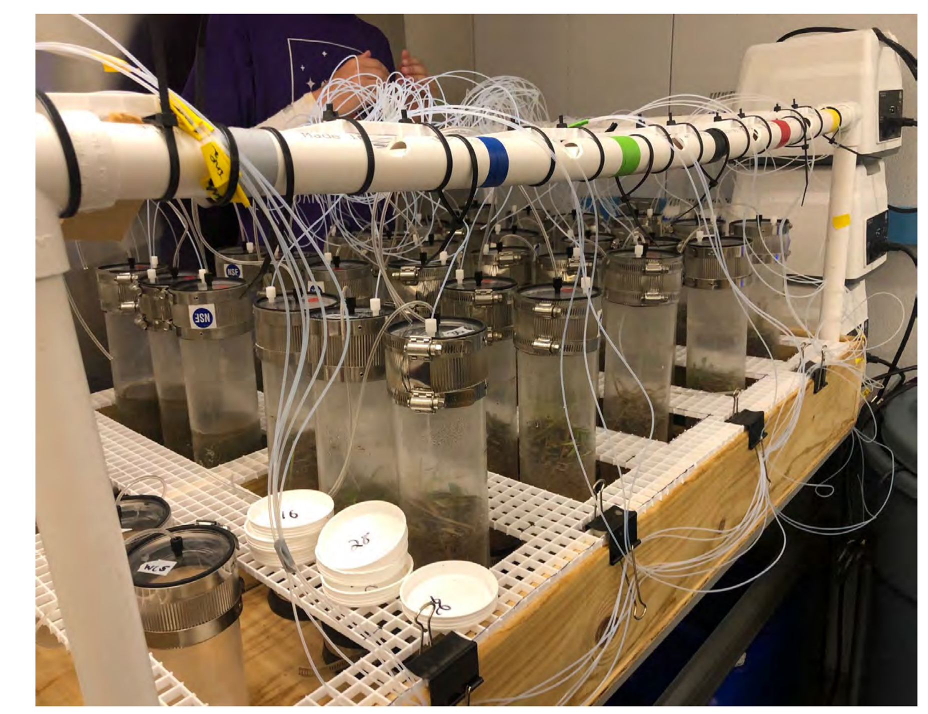
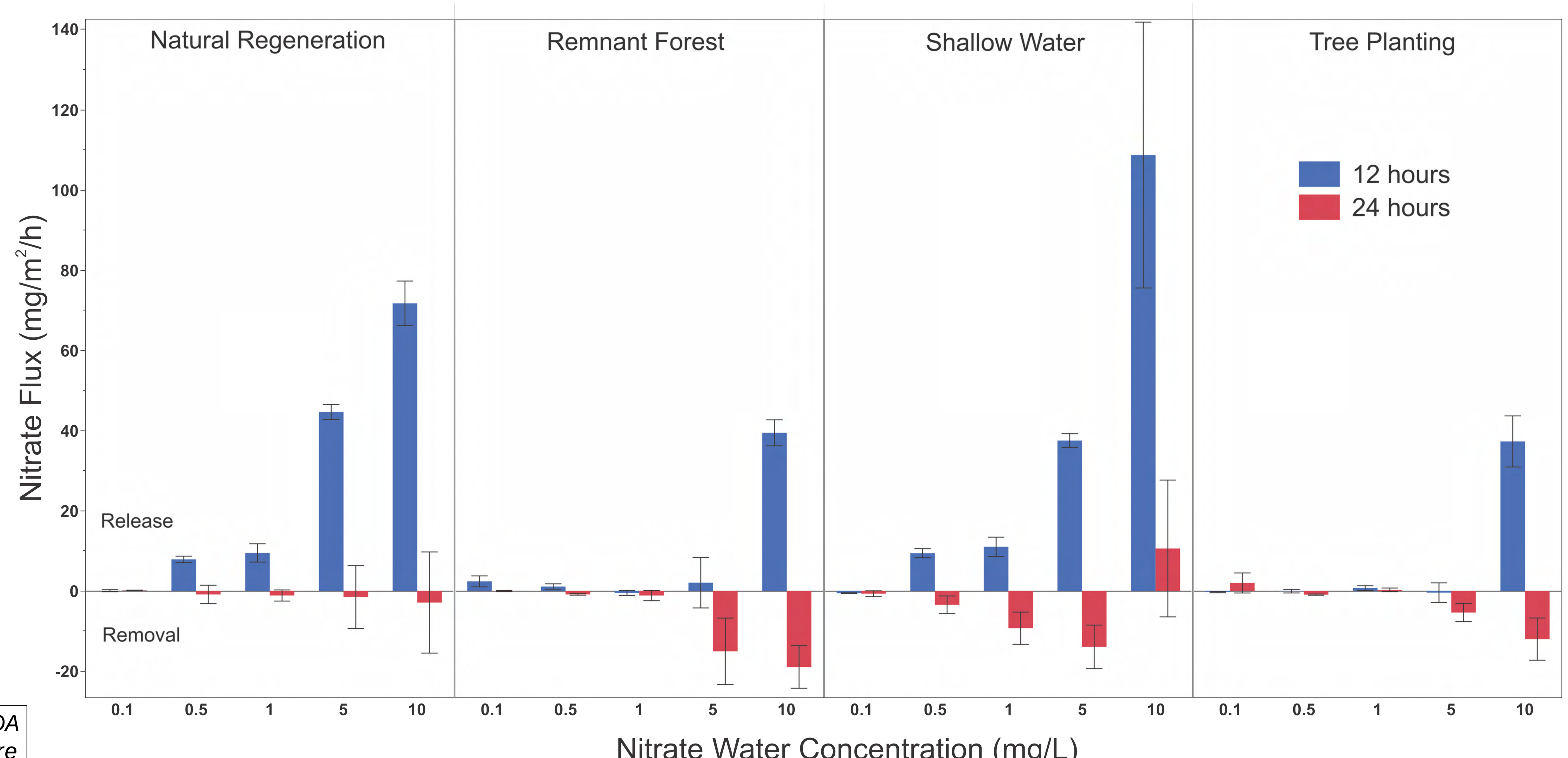


Figure 2. Soil core incubation in the flow through system

Figure 3. The five different water sources corresponding to different nitrate concentrations.

Main Results (Nitrate Uptake)

- Nitrate uptake varied over time with soil generally releasing nitrate initially and retaining nitrate after 24 hours.
- Nitrate uptake rates increased with more nitrate availability in all habitats.
- Higher nitrate concentrations had a much larger shift from release to uptake of 24 hours of inundation.
- Other forms of dissolved nitrogen uptake and denitrification were analyzed and show a similar trend.



Bars are flux means and error bars are one standard deviation.

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Conclusions

- Wetlands can potentially be a source of nitrate when they are initially flooded, but become nitrate sinks with a longer water residence time.
- Areas with trees may be removing more nitrate when water concentrations are high, but shallow water areas remove the most at lower water concentrations.
- Restoring native bottomland hardwood forests and reestablishing the natural hydrological regime are both important for restoring a wetland's ability to retain nitrogen pollution in agricultural watersheds.

References

(1) Dodds, W. K., López, A. J., Bowden, W. B., Gregory, S., Grimm, N. B., Hamilton, S. K.,& Wollheim, W. (2002). N uptake as a function of concentration in streams. *Journal of the North American Benthological Society*, *21*(2), 206-220.

(2) Speir, S. L., Taylor, J. M., & Scott, J. T. (2017). Seasonal differences in relationships between nitrate concentration and denitrification rates in ditch sediments vegetated with rice cutgrass. *Journal of environmental quality*, *46*(6), 1500-1509.