Small- and large-scale drivers of denitrification patterns in "accidental" urban wetlands in Phoenix, Arizona

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Introduction

Background

Understanding spatial and temporal patterns of microbial conversion of nitrate (NO_3^-) to nitrogen (N) gas (denitrification) is important for predicting permanent losses of reactive N from systems. In many landscapes, wetlands serve as hotspots of denitrification by providing optimal conditions for denitrifiers (sub-oxic, carbon-rich sediments). Much research on denitrification has occurred in non-urban or highly managed urban wetlands. However, in urban landscapes N-rich storm- and wastewater is often discharged into areas not designed or managed to reduce N loads. "Accidental" wetlands forming at these outfalls may have the capacity to remove NO_3^-; however, these "accidental" urban wetlands can contain novel soils and vegetation, and are subject to unique hydrologic conditions that could create spatial and temporal patterns of denitrification that differ from those predicted in non-urban counterparts.

Objectives

In "accidental" urban wetlands, I examine:

1) Temporal variation in denitrification potentials across seasons.
2) Variation in denitrification potentials among wetlands with different flood regimes.
3) Spatial variation in denitrification potentials among plant patches.
4) Interactions between plant patches, flood regime, and season.

Methods

Study Area

This study was conducted in the Salt River in Phoenix, Arizona. The Salt River, a historically perennial river, is now a mostly dry riverbed as it bisects downtown Phoenix. However, sections of the river receive storm water discharges and wetlands have formed at many of these outfalls. These storm drains discharge water at different rates and frequencies resulting in wetlands that are flooded at different times of year and/or for different durations of the year.

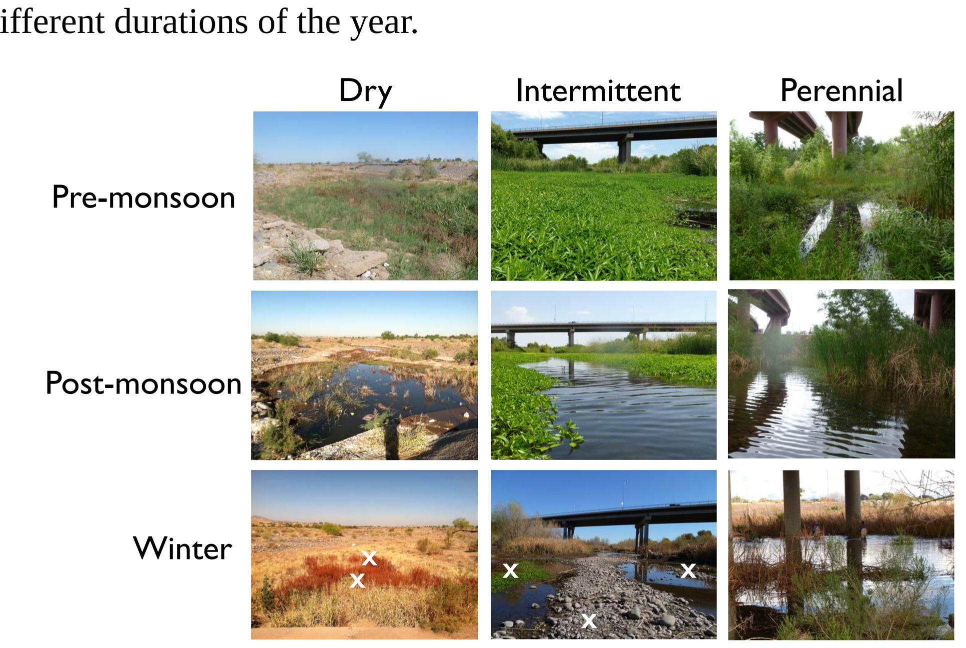

Figure 1: Photo representation of one wetland in each flood regime across seasons. X's represent examples of patch types.

Data Collection

Soil cores were collected from nine wetlands that ranged from perennially flooded, to intermittently flooded (~9 months/year), to ephemerally flooded (2-3 weeks/year). Soil cores were collected from 3 dominant patch types at each site (Figure 1). Collection occurred during three seasons that differed in precipitation regimes (pre-monsoon, post-monsoon, and winter). Denitrification potentials were measured using denitrification enzyme assays. Soil cores were homogenized and amended with 100 mg NO_3-N kg^{-1} soil (KNO_3), and 40 mg glucose-C kg^{-1}soil.

Results

Objective 1: How do denitrification potentials vary across seasons?

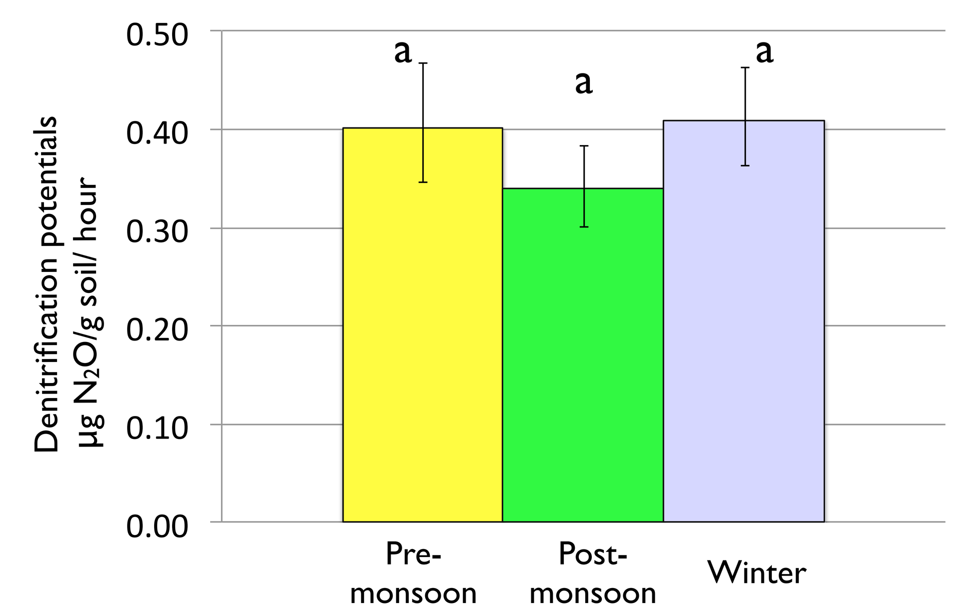

Figure 2: Denitrification potentials show no significant difference among seasons when averaged across all sites. Error bars denote +/- 1 SE.

Objective 2: How do denitrification potentials vary across flood regimes?

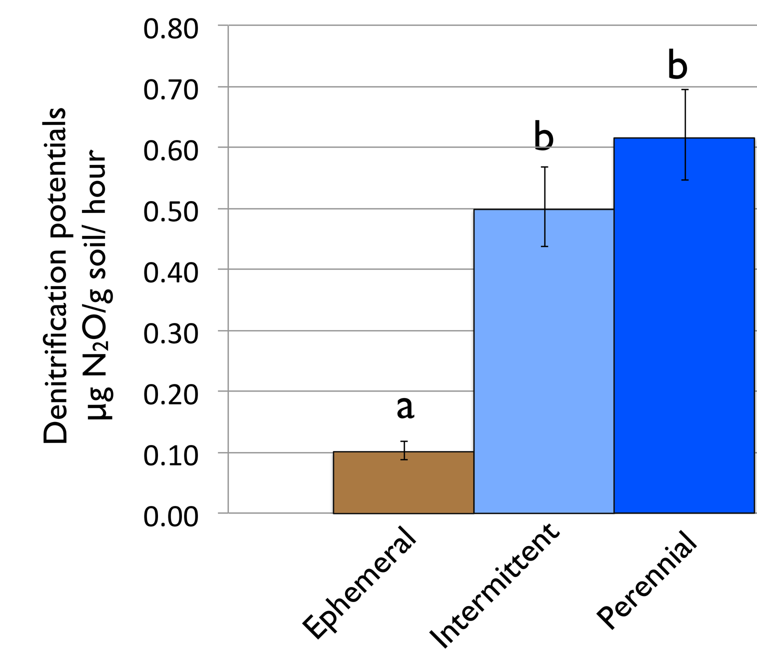

Figure 3: Denitrification potentials from ephemeral sites are significantly lower than denitrification potentials from the wetter sites (intermittent and perennially flooded sites). Error bars denote +/- 1 SE.

Below analyses are divided between "dry" sites and "wet" sites.

Objective 3 and 4: What affects patterns of denitrification potential in "dry" sites?

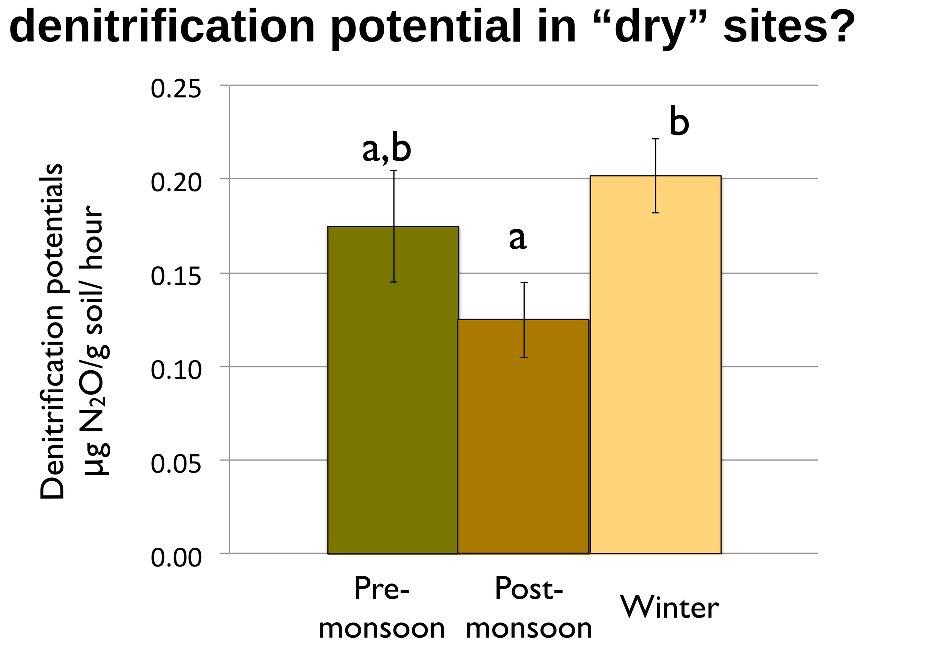

Figure 6: Denitrification potentials are significantly lower post-monsoon than during the winter season. Error bars denote +/- 1 SE.

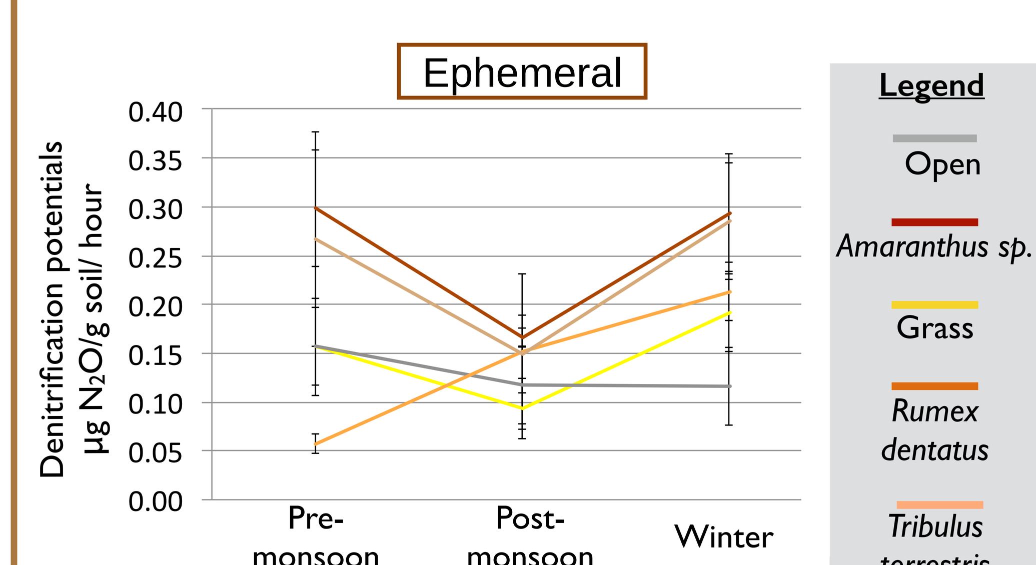

Figure 7: Interaction plot between season and patch type, indicating no significant interaction between season and patch type. Error bars denote +/- 1 SE.

Objective 3 and 4: What affects patterns of denitrification potential in "wet" sites?

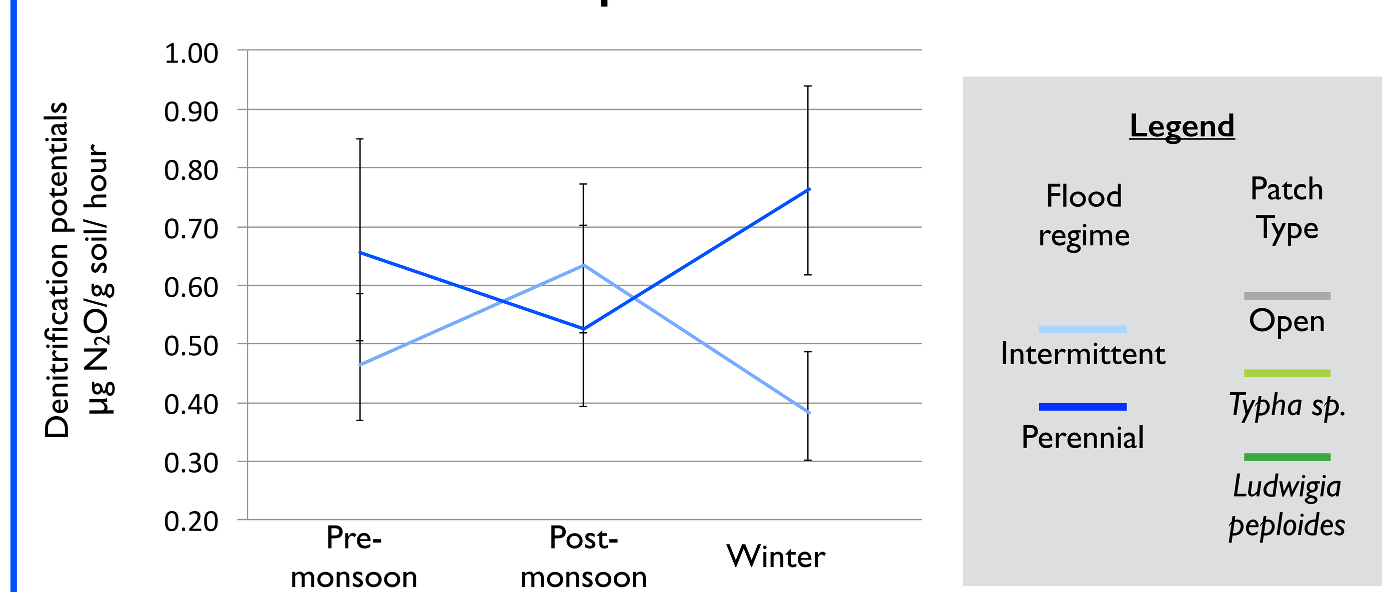

Figure 4: Plots showing a significant interaction between flood regime and season. Error bars denote +/- 1 SE.

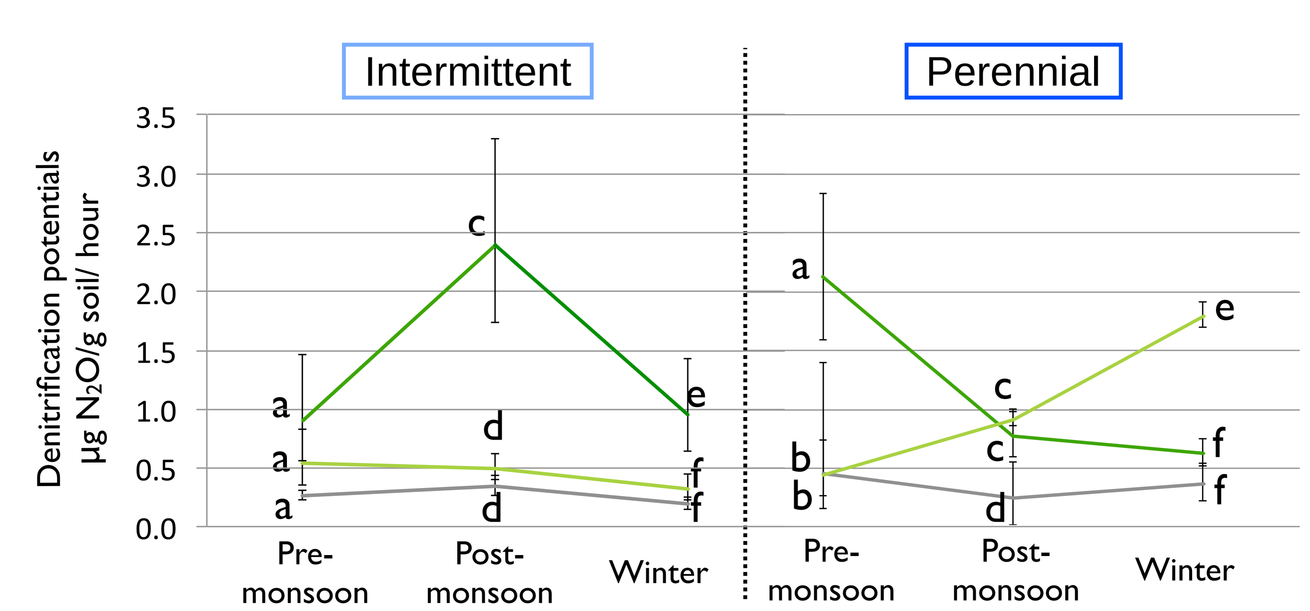

Figure 5: Plots showing a significant interaction between flood regime, season, and patch type. Letters indicate significance between patch types within a season.Error bars denote +/- 1 SE.

Conclusions

Objective 1

- Averaged across all sites, denitrification potentials **(DP)** do not vary across seasons. However, season interacts significantly with flood regime and patch type.

Objective 2

- DP is significantly lower in ephemeral wetlands. This is expected as these sites have lower soil moisture and lower soil organic matter, resulting in conditions that are less suitable for denitrifies.

Objectives 3 and 4

Ephemeral ("Dry") Sites

- DP is lower after monsoon flooding, an unexpected finding as increased DP has been observed after monsoon floods in other ephemeral desert streams.
- Overall, plant patches had no significant effect on DP, with the exception that *Amaranthus sp.* was significantly different than open patches.

Intermittent and Perennial ("Wet") Sites

- Plant patches significantly affect DP; however, there is a significant interaction between flood regime, season, and patch types.
- *Ludwigia peploides* (floating primrose) patches had significantly higher DP at the intermittent sites after monsoon floods; whereas at the perennial sites, it has highest DP before monsoon floods.
- *Typha sp.* (cattail) patches are not significantly different than the unvegetated (open) patches at the intermittent sites. However, at the perennial sites, *Typha sp.* becomes increasingly important for denitrification at the year progresses.
- These findings suggests having a diversity of plant patches in a wetland can help maximize nitrogen removal across seasons.

Where are the "hotspots"?

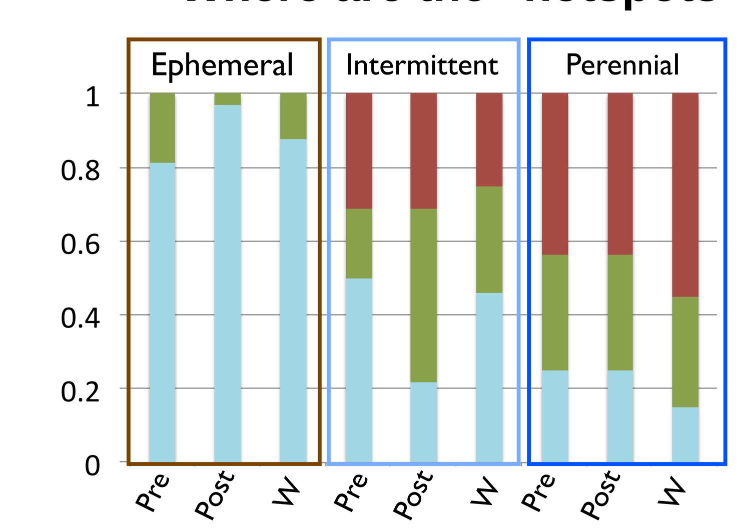

Figure 8

Figure 8 denotes where and when "hotspots" of denitrification potentials occur for all wetlands.

Hotspots are defined as denitrification potentials in the 4th quartile of the distribution.

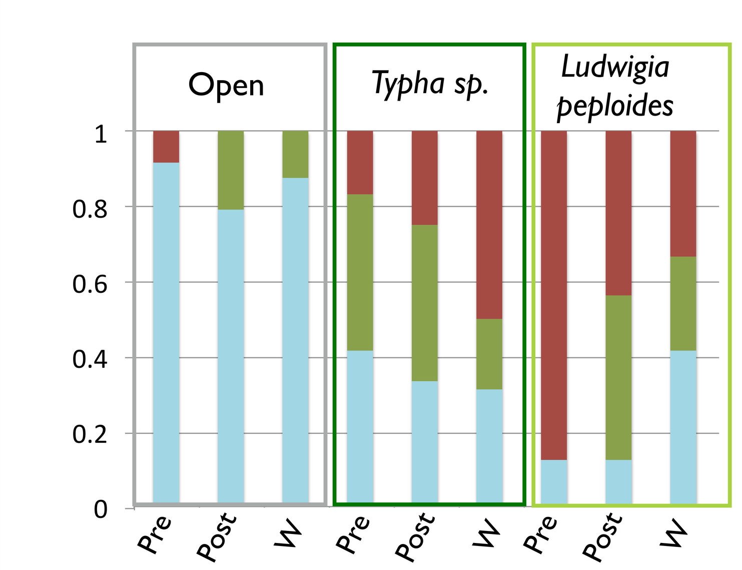

Figure 9

Figure 9 denotes where and when "hotspots" of denitrification potentials occur for only the "wet" sites (intermittent and perennial sites combined).

Pre = Pre-monsoon; Post = Post-monsoon; W=Winter