# Evaluating Nitrate Reduction in a Hydrologically Restored Bottomland Hardwood Forest: Is Reconnection Improving Water Quality Function?

<sup>1</sup>Nia R. Hurst, <sup>1</sup>John R. White and <sup>2</sup>Joseph Baustian

<sup>1</sup>Department of Oceanography and Coastal Sciences, Louisiana State University

<sup>2</sup>The Nature Conservancy

# Nitrogen Fertilization

- Application of fertilizer has allowed for increased global population growth through increased crop production
- Half of the world's population today could not exist without nitrogen fertilization



Bureau of Labor Statistics

#### Population Compared to Synthetic Nitrogen Fertilizer Use



#### Mississippi River Watershed



# Nitrogen Loading in the Mississippi River

• 1972 average N export: 300,000 metric tons



# Hypoxia in the Gulf of Mexico

#### Bottom Water Dissolved Oxygen – 2015



# Nitrogen Cycling in Wetlands



Reddy & DeLaune, 2008

# Loss of River/Floodplain Connectivity



Since the 1700s, 2,700 km of levees have reduced floodplain interaction with river water by 90%

Credit: National Geographic

# **Reconnect Bottomland Hardwood Forests**

The dominant wetland type along the Lower Mississippi Alluvial Valley 80% of bottomland hardwoods have been converted, primarily for agriculture



# **Mollicy Farms**



- Located in northern Louisiana on the east bank of the Ouachita River
- Restored between 1998 and 2013 after being farmed for ~ 25 years
- Reconnected to the Ouachita River in 2009

Credit: The Nature Conservancy

# Bottomland Hardwood Restoration: Mollicy Farms



The largest floodplain reconnection and bottomland hardwood reforestation project in the Lower Mississippi River Basin (6,475 hectares)

Credit: The Nature Conservancy



Credit: The Nature Conservancy

# **Research Questions**

- How has the microbial community responded to restoration?
- What are the rates of nitrate reduction in Mollicy Farms (restored) compared to a natural site?
- How does Mollicy Farms impact nitrate reduction in the Ouachita River?



The Nature Conservancy

# Sample Collection



- Twenty-Four, 20 cm long intact soil cores were collected at each site: total of 48 cores
  - 12 to evaluate nitrate reduction
  - 12 to analyze soil & microbial properties





# Nitrate reduction analysis



- Cores were flooded with a 1 mg L<sup>-1</sup> NO<sub>3</sub><sup>-</sup> solution and incubated for 15 days in a 20°C water bath in the dark
- Water samples were taken every other day to measure rate of NO<sub>3</sub><sup>-</sup> loss



# Soil Analyses

#### Soil physiochemical characteristics

- Moisture Content
- Bulk Density
- Total carbon
- Total nitrogen
- Total phosphorus

#### Microbial property characteristics

- Microbial Biomass N
- Potentially mineralizable N
- β-glucosidase activity



#### **Results: Soil Characteristics**

Soil Parameter	Mollicy Farms	Natural Site	P-Value	Percent Restoration (%)
Moisture Content (%)	38.8 ± 2.7	48.7 ± 10.3	0.004*	79.7
Bulk Density (g cm <sup>-3</sup> )	$0.94 \pm 0.03$	$0.65 \pm 0.17$	0.01*	144.6
Total Carbon (g kg <sup>-1</sup> )	14.2 ± 3.95	38.6 ± 16.6	<0.001*	46.3
Total Nitrogen (g kg <sup>-1</sup> )	1.22 ± 0.42	2.69 ± 1.16	<0.001*	44.4
Total Phosphorus (g kg <sup>-1</sup> )	395 ± 41.2	524 ± 130.1	0.01*	75.5

#### **Results: Microbial Analyses**

Soil Parameter	Mollicy Farms	Natural Site	P-Value	Percent Restoration (%)
Potentially Mineralizable N (mg kg <sup>-1</sup> day <sup>-1</sup> )	3.90 ± 0.68	8.90 ± 3.0	<0.001*	43.8
Microbial Biomass N (mg g <sup>-1</sup> )	5.90 ± 5.70	33.4 ± 21.6	<0.001*	17.7
β-glucosidase Activity (nmol g <sup>-1</sup> h <sup>-1</sup> )	116 ± 32.6	328 ± 152	<0.001*	35.1

# **Results: Nitrate Reduction**



On average, nitrate reduction was significantly lower in the Restored Site than the Natural Site (11.8 vs. 16.4 mg N m<sup>-2</sup> d<sup>-1</sup>).



# Conclusions

After 6 years of hydrologic restoration:

- Soil properties in the restored site have yet to meet those of the control site
- Microbial characteristics
  - 18% Microbial biomass of control
  - 35% enzyme activity of control



#### Impact of Mollicy Farms Restoration on Nit

Nitrate reduction rates Average annual flooding days

Portion of site flooded when river rises

Mollicy Farms can remove 48.1metric tons NO<sub>3</sub>-N from the Ouachita River annually



# Implications

- Not all biogeochemical properties/functions will follow the same restoration trajectory
- Lack of primary production and lower total soil carbon have strong influence on biogeochemical functioning in Mollicy Farms
- Hydraulic reconnection of BLHs can improve water quality and nitrate reduction in river floodwaters more quickly than other functions.
- Nitrate is measures in part per million while Soil Carbon has units of parts per hundred.

# Questions?



Nia Hurst