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How do we manage microbiomes to promote urban wetland functions?

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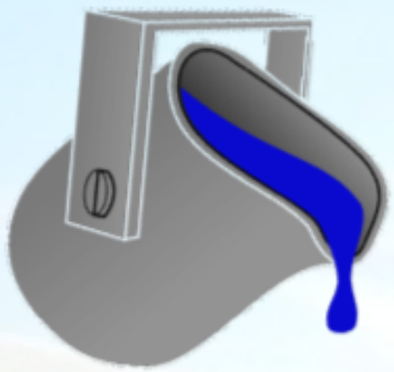
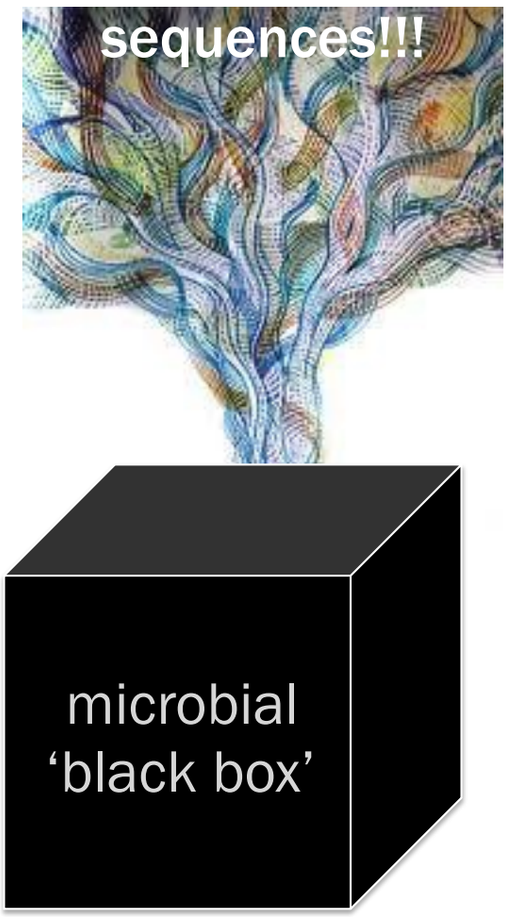
12th International Symposium on
Biogeochemistry of Wetlands
24 April 2018

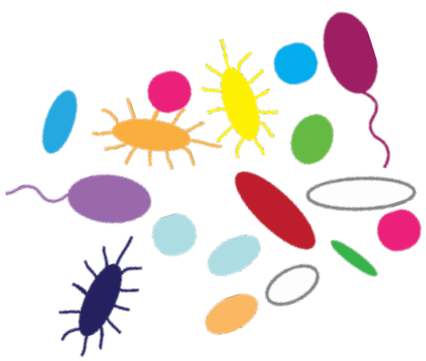
Manipulating microbiomes

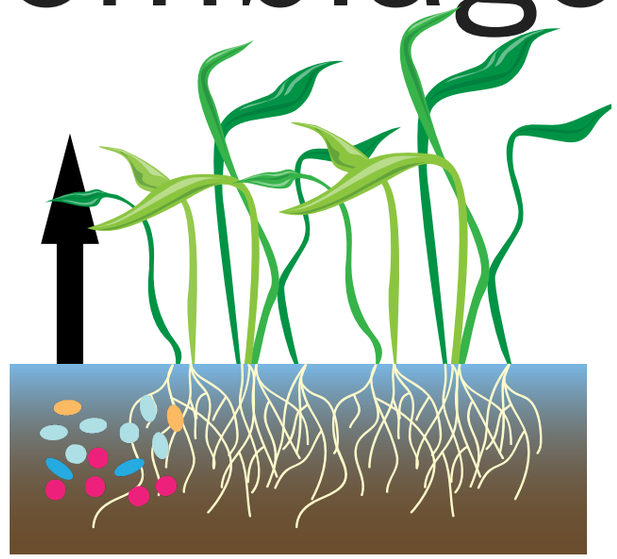


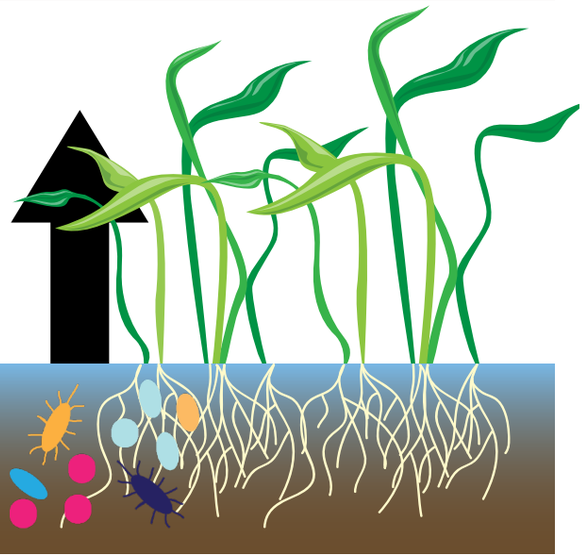
	Electron Acceptor	Microbial Functional Groups
	Oxygen	Decomposers
Moist Soils Low Oxygen	Nitrate	Denitrifiers
	Iron	Fe/Mn
	Manganese	Reducers
	Sulfate	Sulfate Reducers
Saturated Soils No Oxygen	Carbon Dioxide	Methanogens

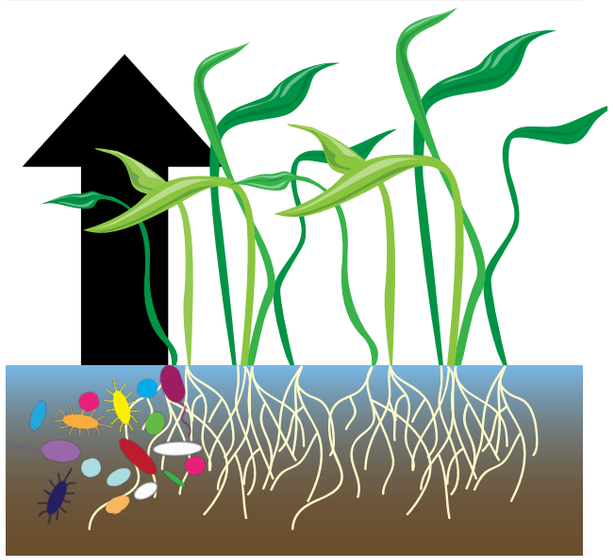
Not all microbial assemblages are created equal











*microbes not to scale

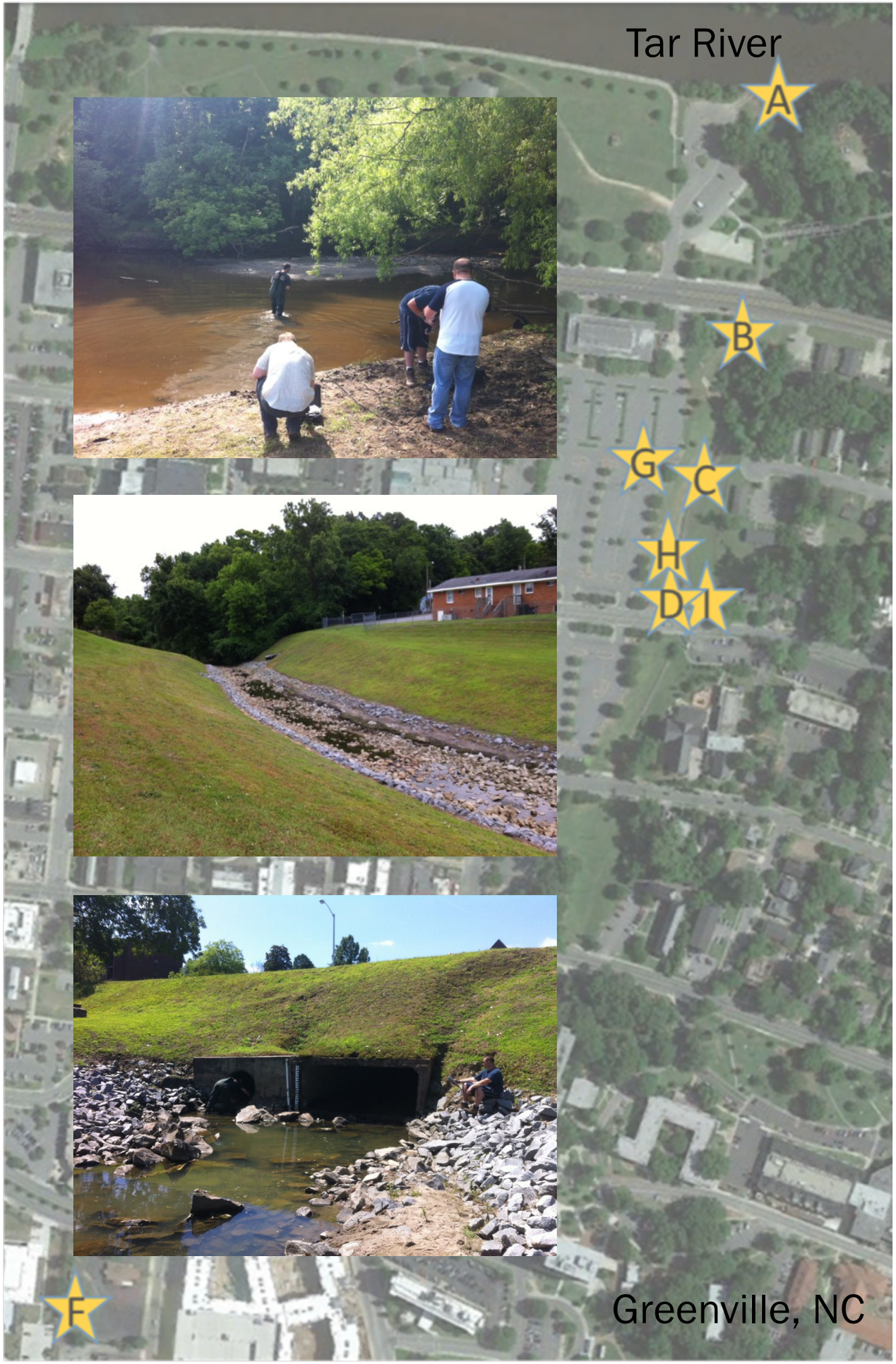
How do environmental features of urban wetlands influence microbial community structure and denitrification potential?

Urban stream restoration

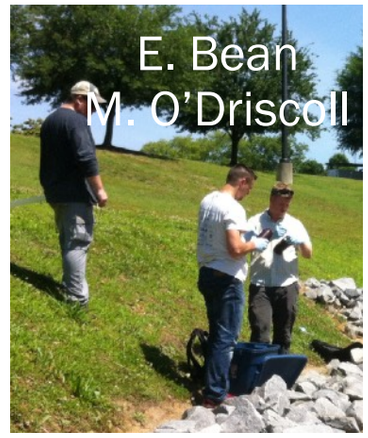
Town Creek, Greenville, NC

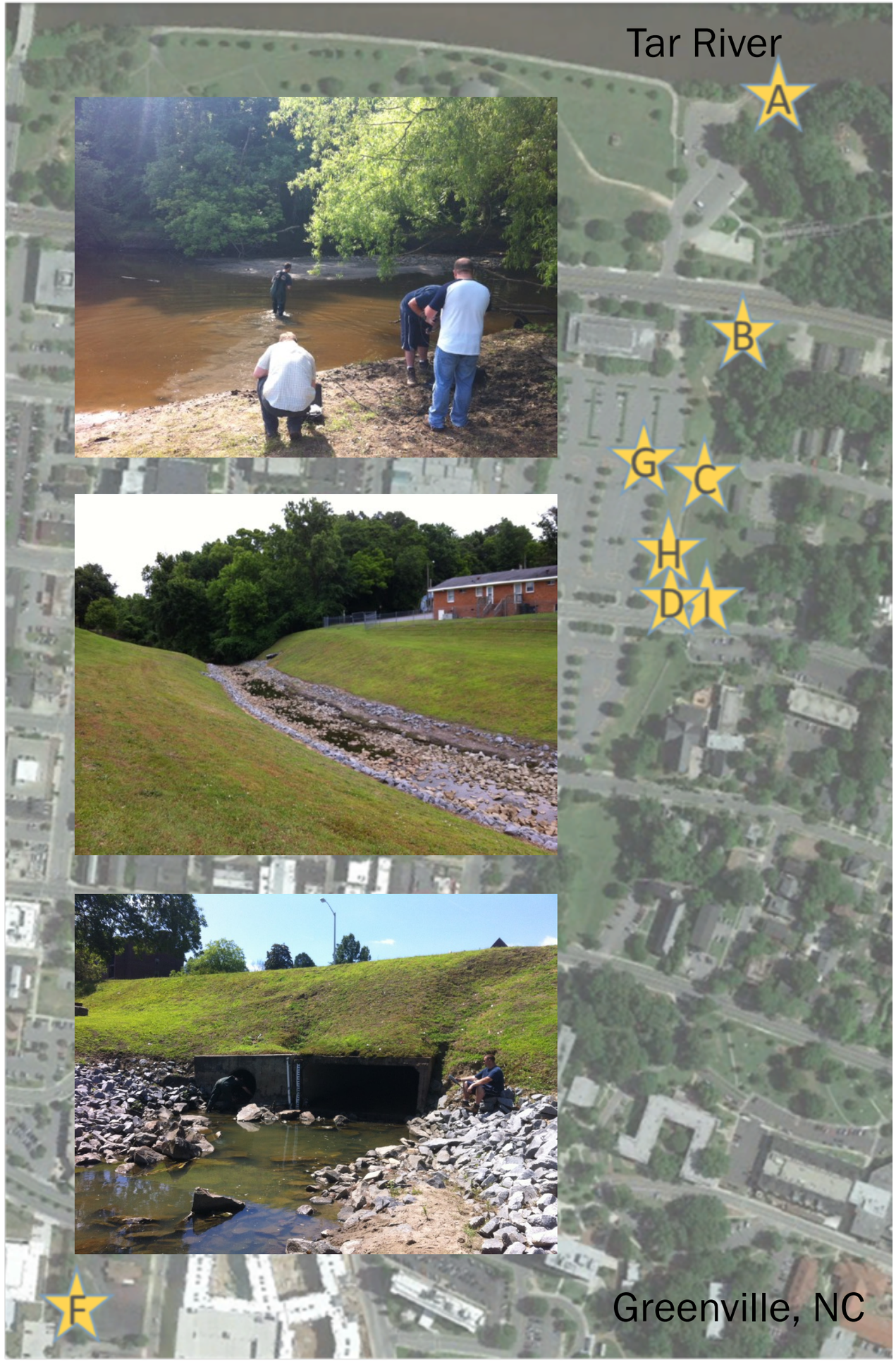
- Replacement and Enhancement
- Construction planned to begin in March 2018 (!)
- Stormwater control measures:
  - Bioretention
  - Permeable Pavement
  - Stormwater Wetlands
  - Regenerative Stormwater Conveyance

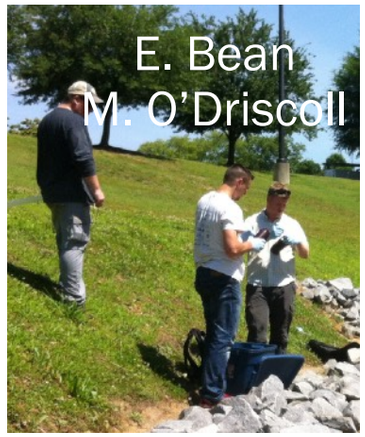
NC Environmental Enhancement Grant (Collaborators: M. O'Driscoll, C. Humphrey, E. Bean)

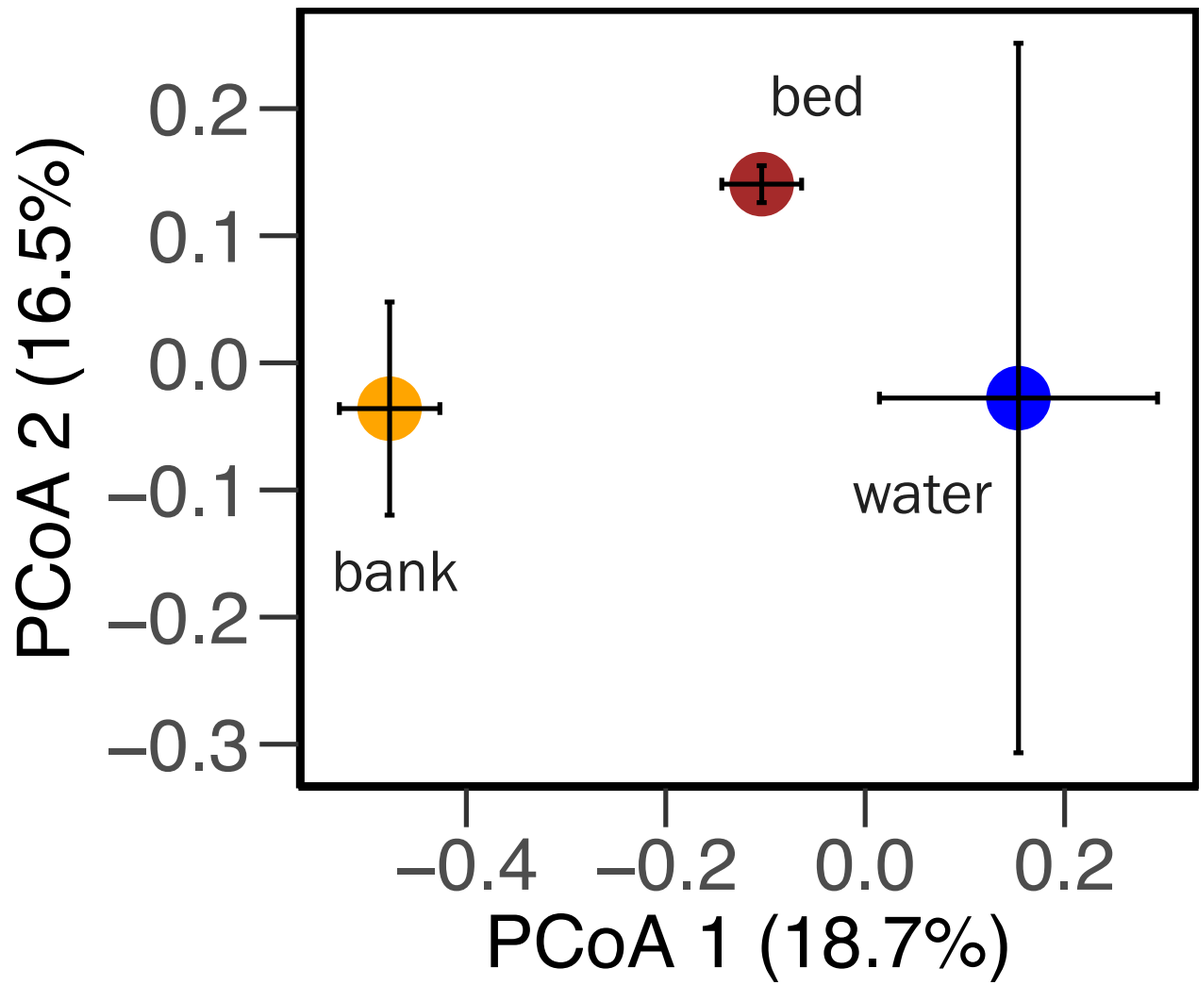

Tar River
A
B
G
C
H
D
I
F
Greenville, NC


J. LeCrone


E. Bean
M. O'Driscoll







16S rRNA amplicon sequencing

Indicator Bacterial Taxa

WATER

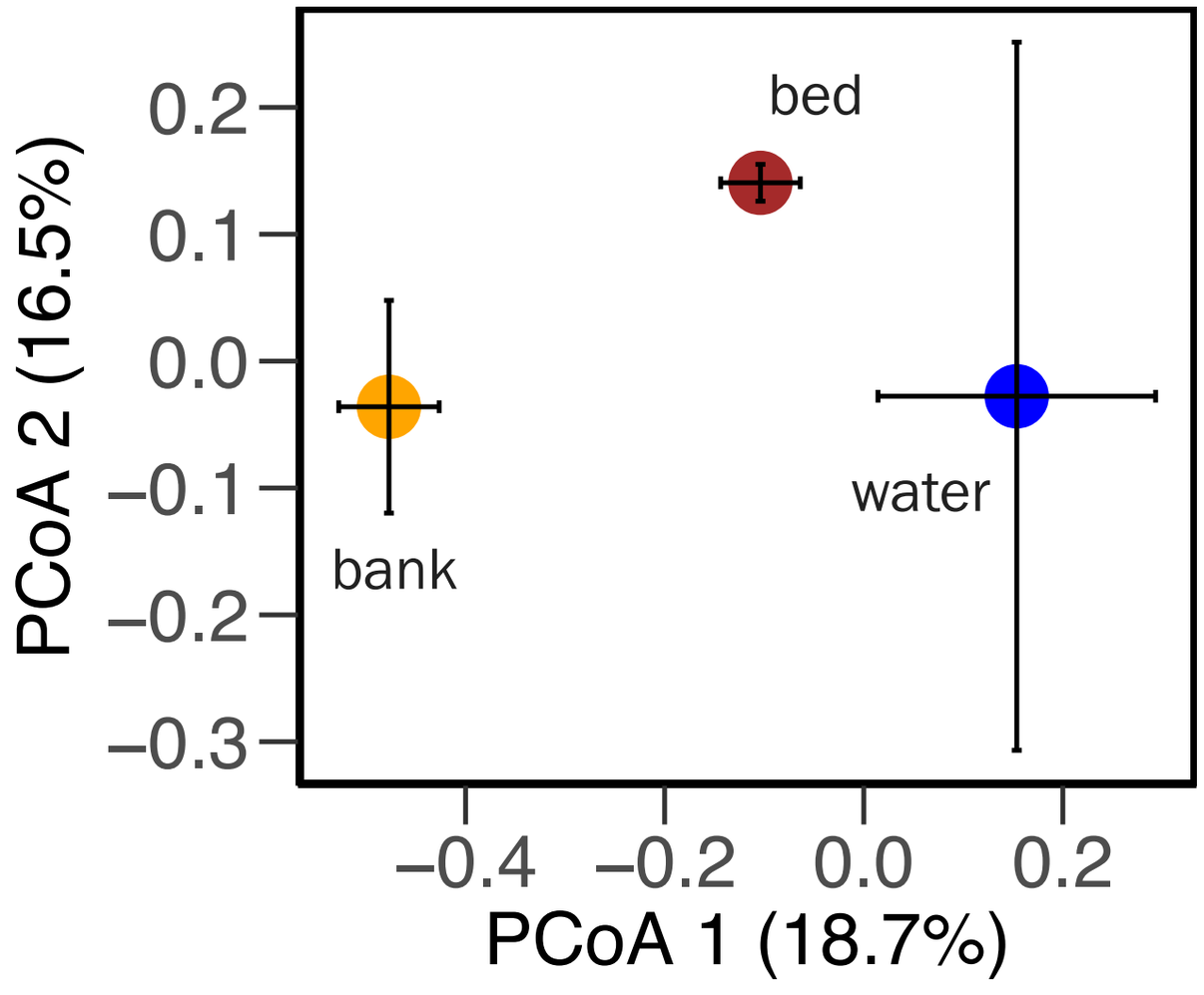
- *Massilia* spp.
- *Rheinheimera* spp.

SEDIMENT BED

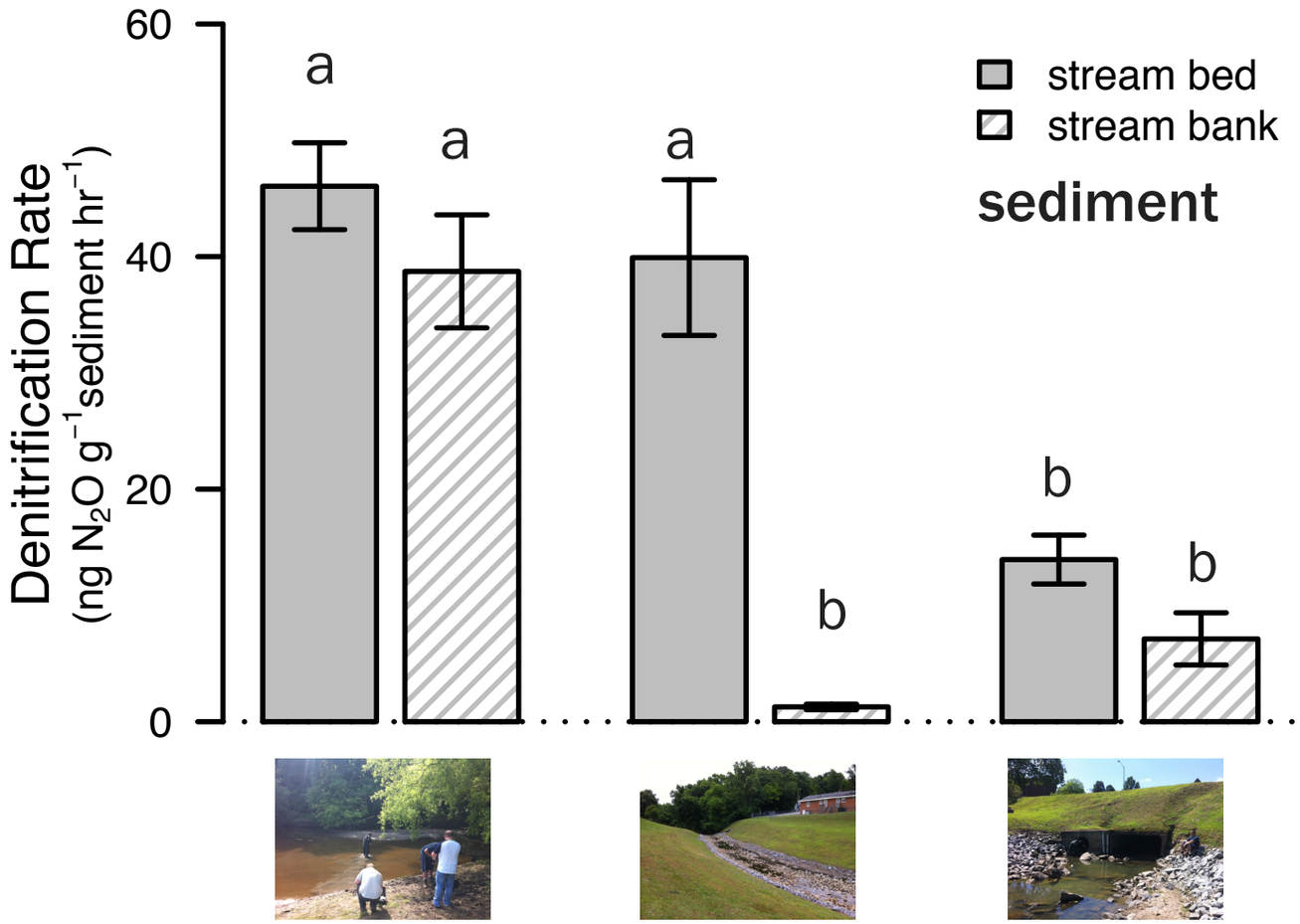
- *Dermatophilaceae* spp.
- *Quadrisphaera* spp.

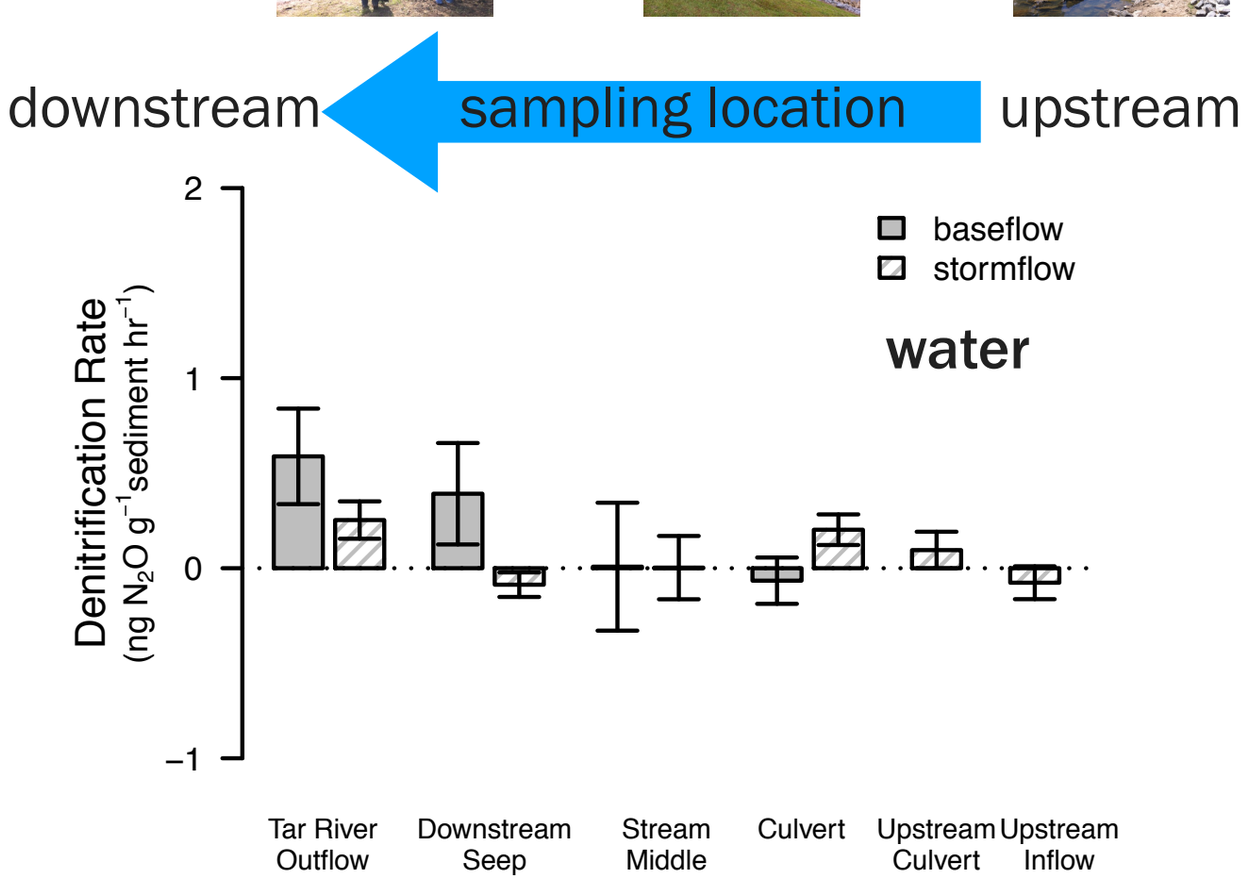
SEDIMENT BANK

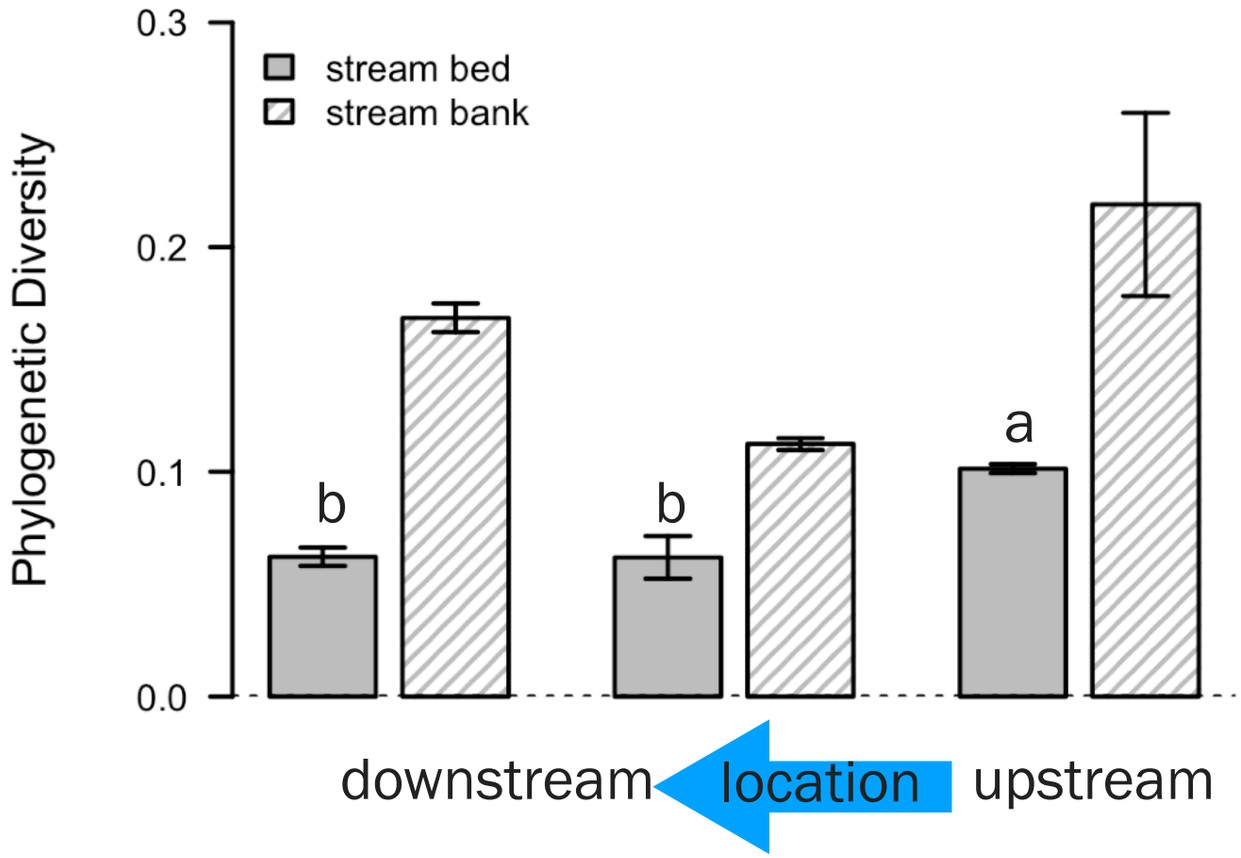
- Desulfurellales
- Nitrospirales
- Rhizobiales



16S rRNA amplicon sequencing


Denitrification Rate
(ng N_2O g^{-1}sediment hr^{-1})
60
40
20
0
a
a
a
b
b
b
stream bed
stream bank
sediment


downstream
sampling location
upstream
Denitrification Rate
(ng N_2O g^{-1}sediment hr^{-1})
2
1
0
−1
baseflow
stormflow
water
Tar River Outflow
Downstream Seep
Stream Middle
Culvert
Upstream Culvert
Upstream Inflow


Phylogenetic Diversity
0.3
0.2
0.1
0.0
stream bed
stream bank
b
b
a
downstream
location
upstream

Denitrification Rate
(ng N2O g−1 sediment hr−1)
60
40
20
0
a
a
a
b
b
downstream
sampling location
upstream
2
1
0
−1
baseflow
stormflow
Tar River Outflow
Downstream Seep
Stream Middle
Culvert
Upstream Culvert
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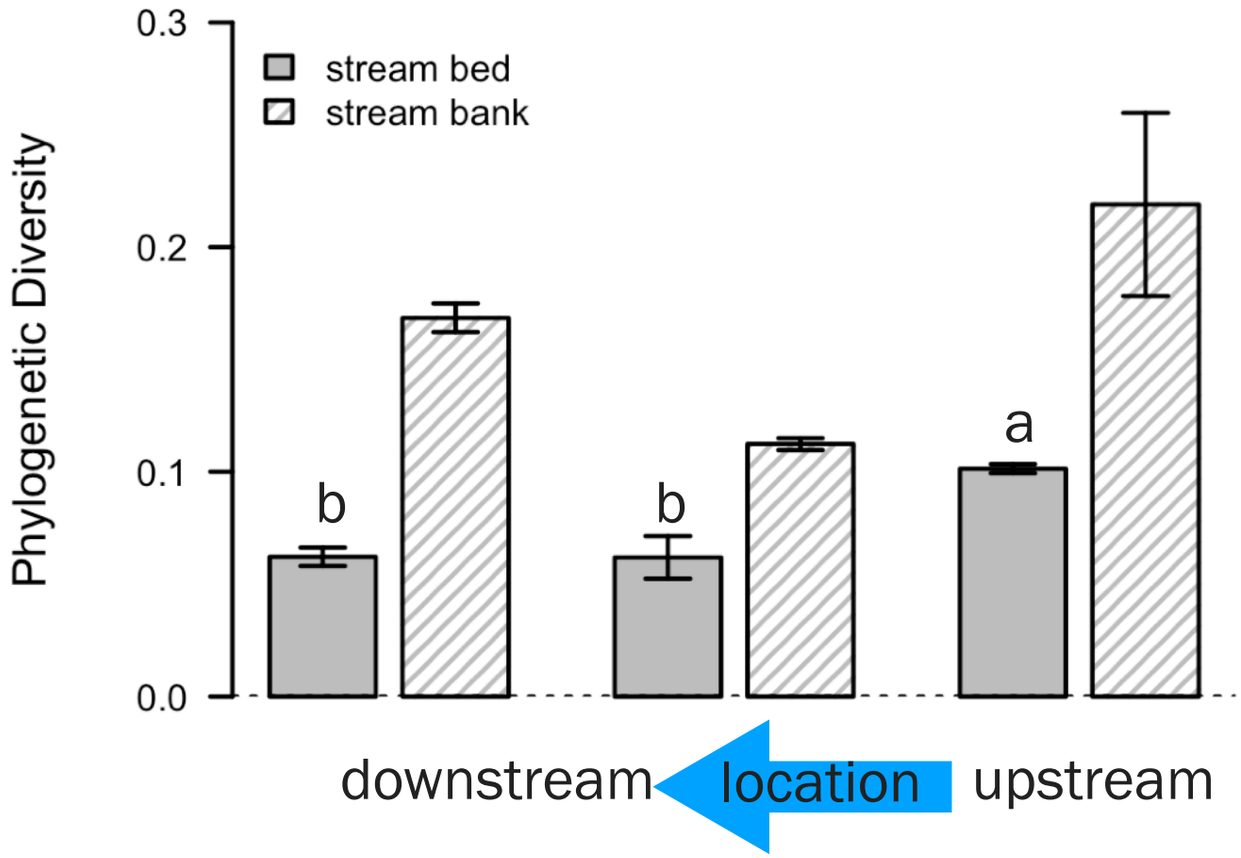


Structure-Function Patterns

- Microbes with higher denitrification capacity are more related to each other (stream bed)
- Nitrogen removal function occurs in stream bed > stream bank > water column

How do environmental features of urban wetlands influence microbial community structure and denitrification potential?

Microbial communities in saturated conditions (with higher capacity for nitrate removal) are more related to each other

How can an undersized stormwater wetland be managed for increased N processing function?

Integrating biology into green stormwater infrastructure design

- Hydrologic gradient
- Vegetation (varies along hydrologic gradient)
- Flow control (riser installation)

How can an undersized stormwater wetland be managed for increased N processing function?

1. Quantify nitrogen removal (via denitrification, incomplete denitrification) capacity across hydrologically distinct zones
2. Measure how seasonality affects nitrogen removal capacity associated with complete denitrification

East Carolina University

Stormwater Wetland Dedicated to Mark Brinson

SOUND RIVERS
NEUSE & PAMLICO-TAR RIVER FOUNDATIONS

Landscaping for Water Quality

Green infrastructure is the use of manmade structures designed to reduce stormwater runoff generated from impervious surfaces, such as roofs and parking lots. These technologies utilize plants, soils, and natural processes to manage and create healthier urban environments. Examples of these on East Carolina University's campuses are rain gardens, stormwater wetlands, cisterns, and permeable pavement.

Stormwater Management on Campus

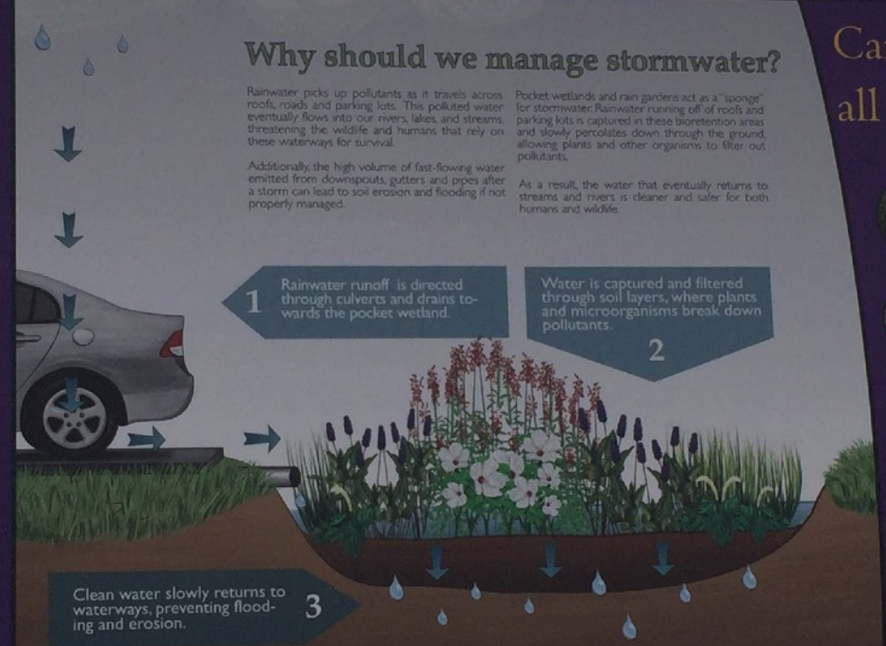
Why should we manage stormwater?

Rainwater picks up pollutants as it travels across roofs, roads and parking lots. This polluted water eventually flows into our rivers, lakes, and streams, threatening the wildlife and humans that rely on these waterways for survival.

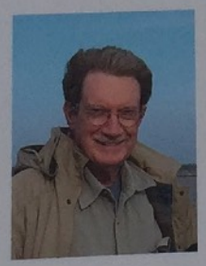
Additionally, the high volume of fast-flowing water emitted from downspouts, gutters and pipes after a storm can lead to soil erosion and flooding if not properly managed.

Pocket wetlands and rain gardens act as a "sponge" for stormwater. Rainwater running off of roofs and parking lots is captured in these bioretention areas and slowly percolates down through the ground, allowing plants and other organisms to filter out pollutants.

As a result, the water that eventually returns to streams and rivers is cleaner and safer for both humans and wildlife.



Who is Mark Brinson?

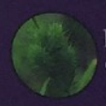


Dr. Mark Brinson was an accomplished professor and researcher at East Carolina University. He researched and taught numerous courses and workshops on wetlands and ecosystem ecology in these settings. In addition to his role at ECU, he was a technical consultant for the US Environmental Protection Agency, US Fish and Wildlife Service, and numerous agencies and organizations within North Carolina. He was elected President of the Society of Wetland Scientists and served on its Board of Directors for several years.

Dr. Brinson passed away unexpectedly in January 2011. This stormwater wetland is dedicated to Dr. Brinson's contributions to advance scientific understanding of wetlands and their ecosystem ecology.

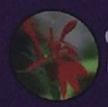
Can you identify all of the plants?


American Lotus
Nelumbo lute


Hop Sedge
Carex lupulina


Spotted Joe Pye Weed
Eutrochium maculatum

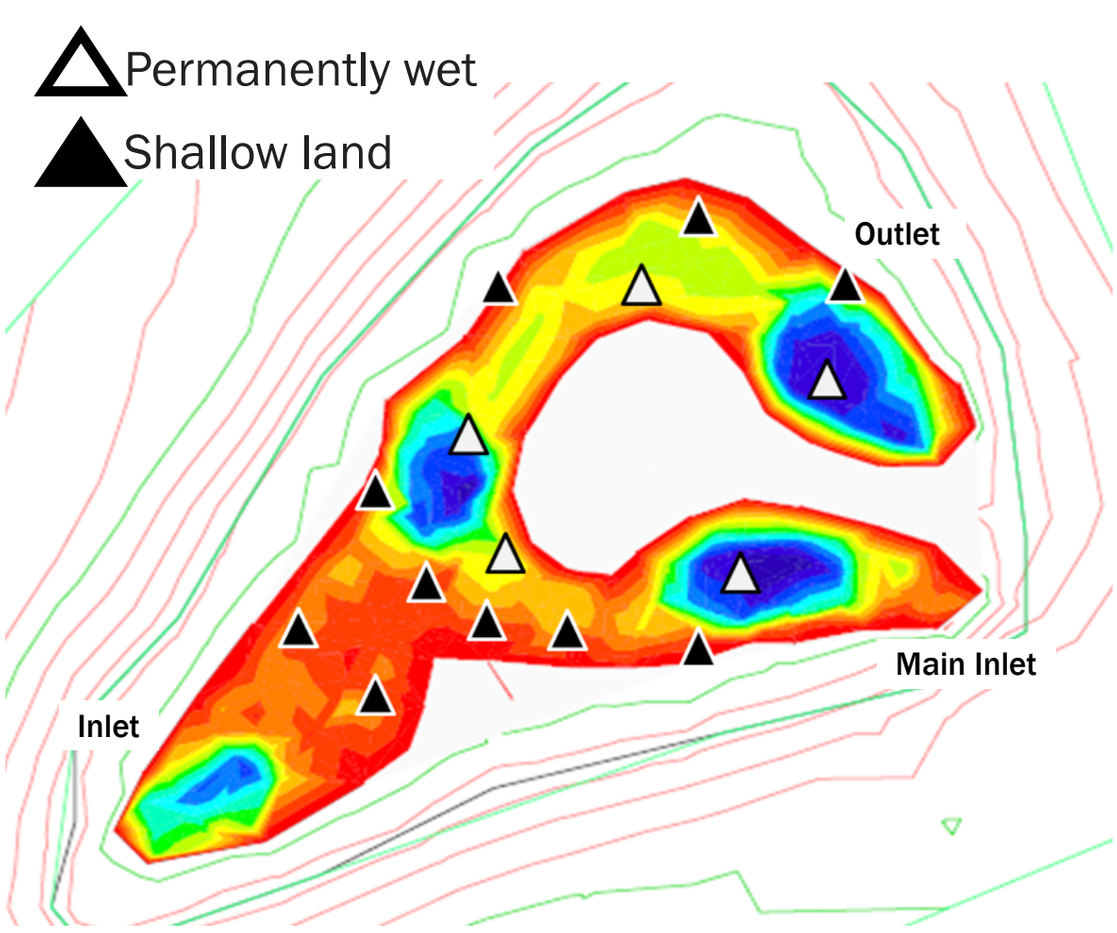

Blue Flag Iris
Iris versicolor


Cardinal Flower
Lobelia cardinalis


Big Blue Lobelia
Lobelia siphilitica


Pickerel Weed
Pontederia cordata

Retrofitting Constructed Stormwater Wetlands



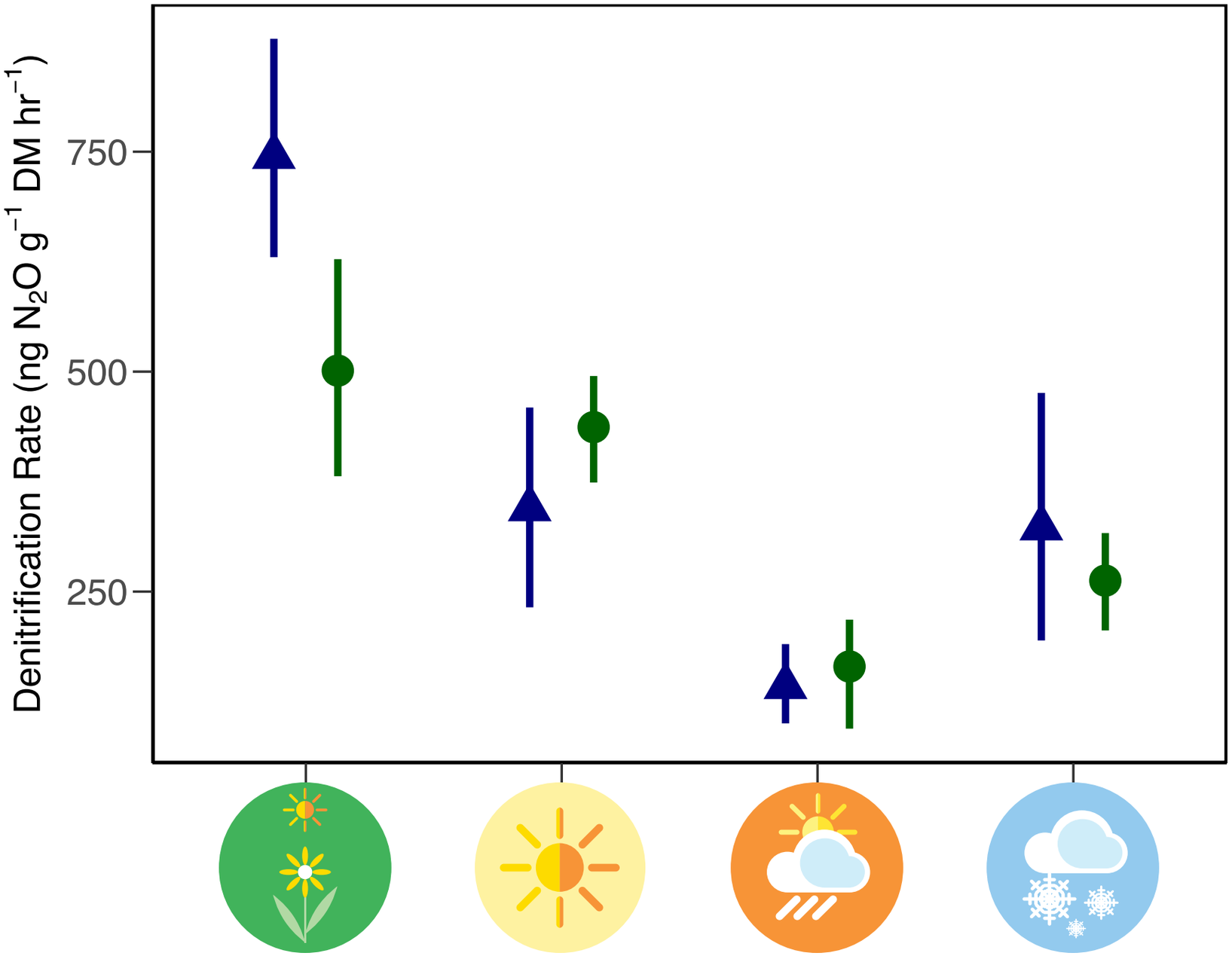
- Hydrologic gradient
- Vegetation
- Flow control

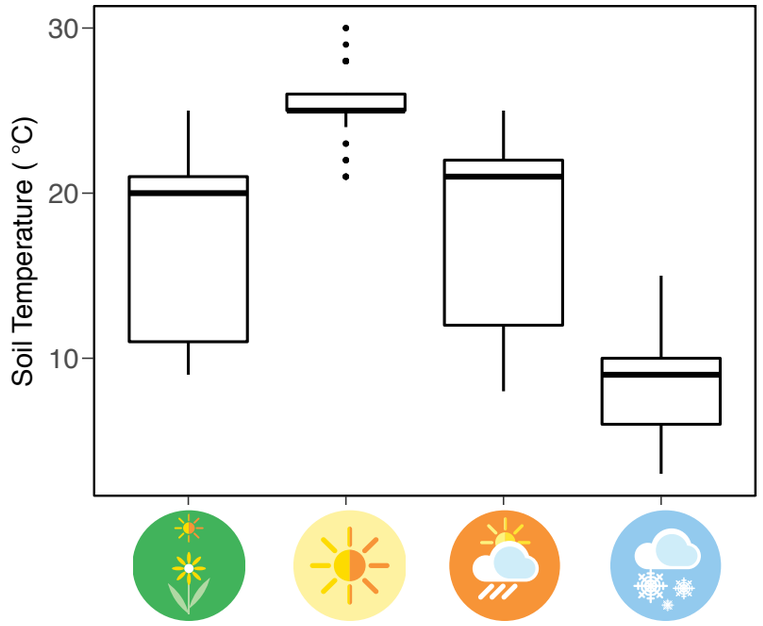
heat map showing elevation
warm colors = high elevation
cool colors = low elevation

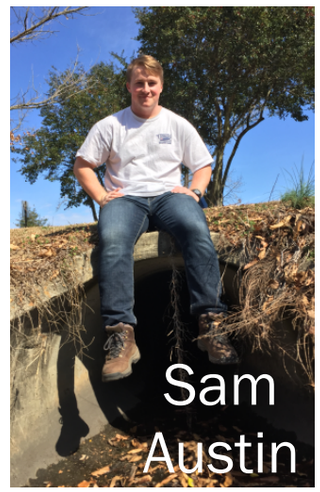
Seasonal denitrification potential is similar between habitats (except during spring)

Permanently wet

Shallow land







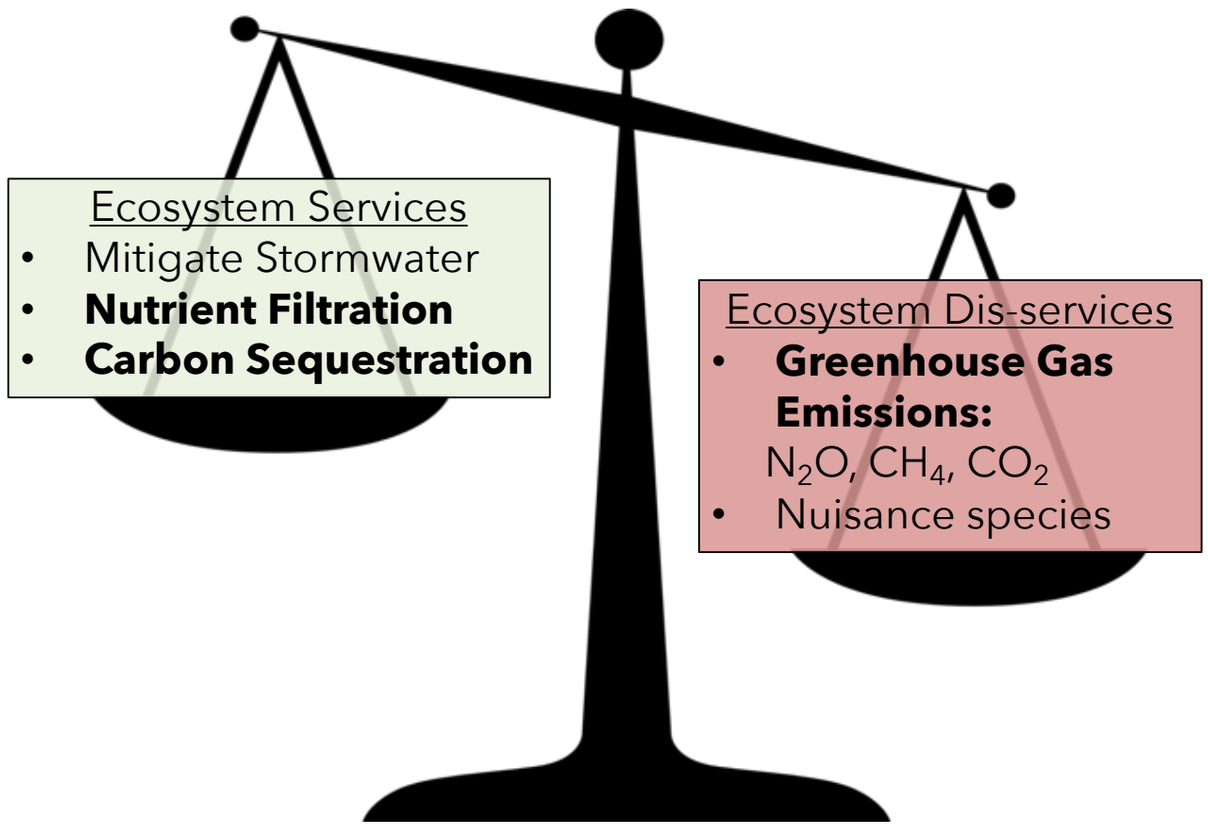
season: $F_{3,172}$=27.76, P<0.001; season*hydrology: $F_{3,172}$=3.95, P=0.009

Learn more about …

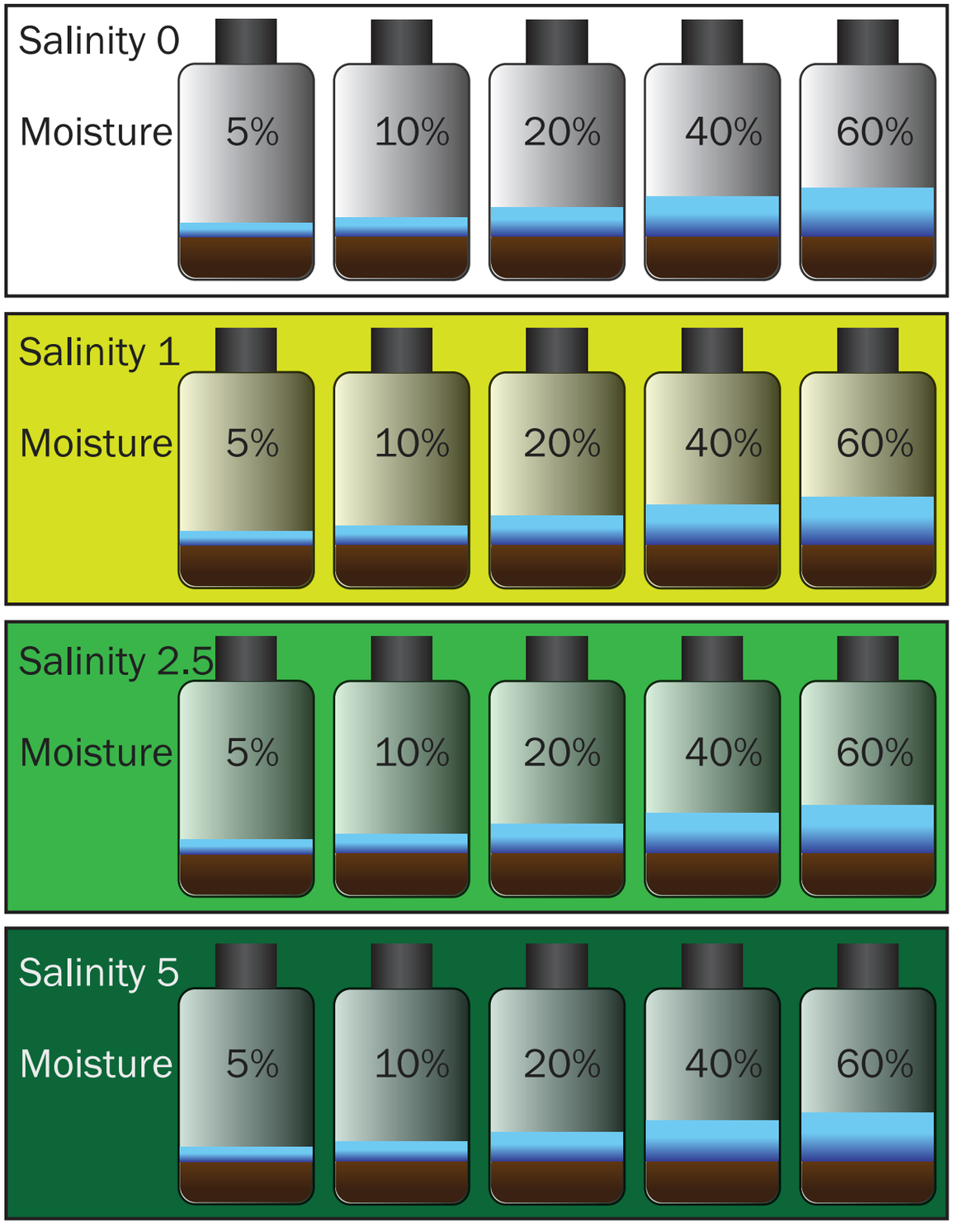
Tradeoffs in Biogeochemical Functions at a CSW

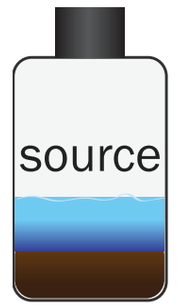
Visit Gina Bledsoe's Poster # 6

"Greenhouse Gas Potential of a Constructed Stormwater Wetland"



What happens to N processing function under multiple stressors?

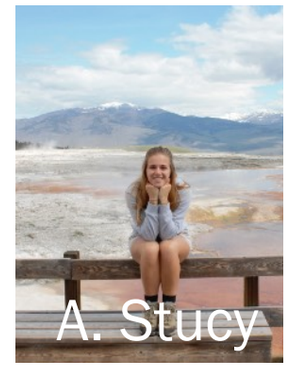


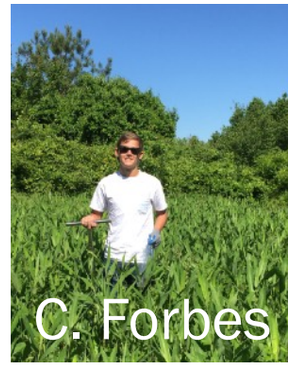


1 week incubation

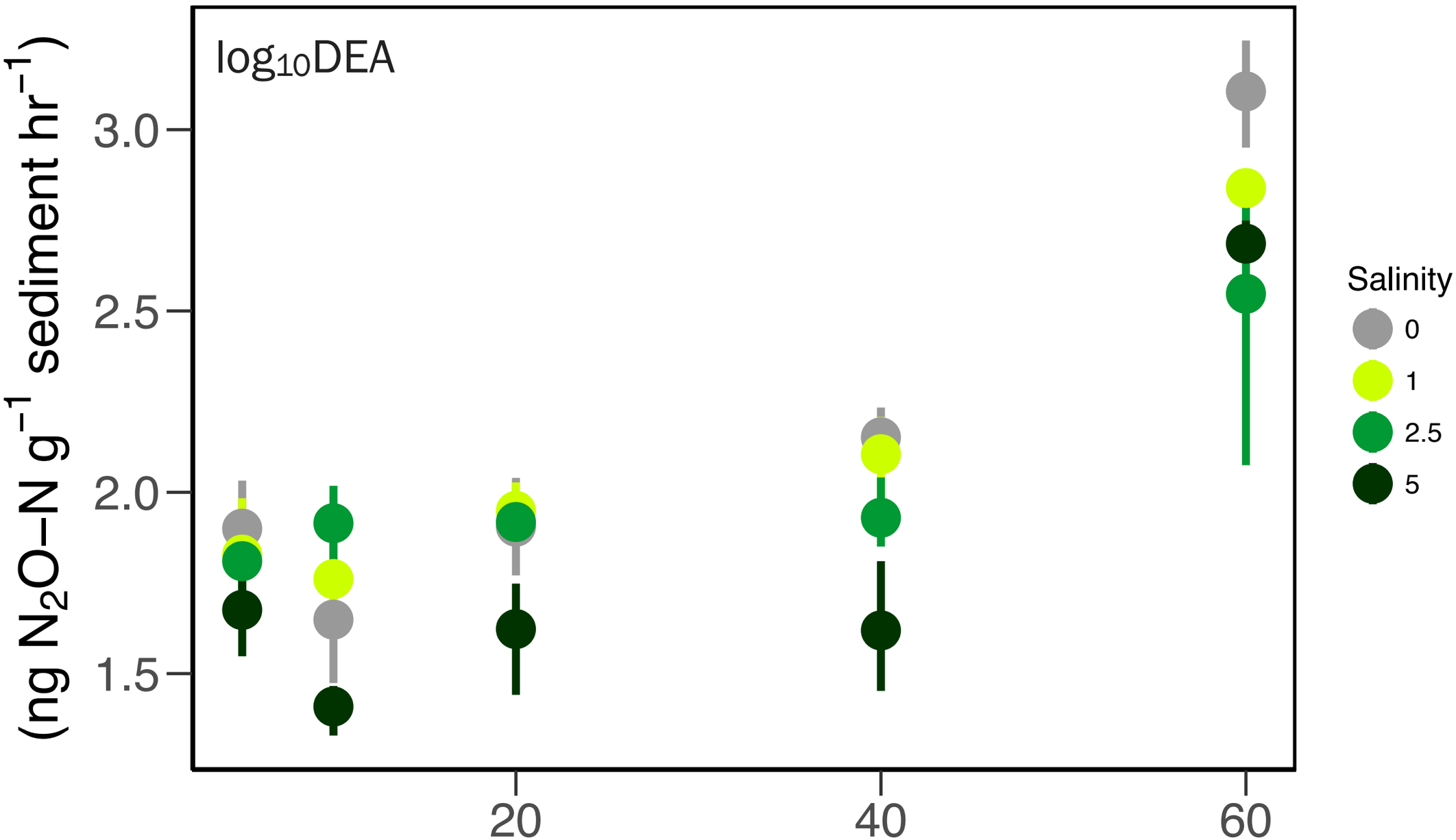
nitrate removal analysis

denitrification enzyme assay
(acetylene block method)



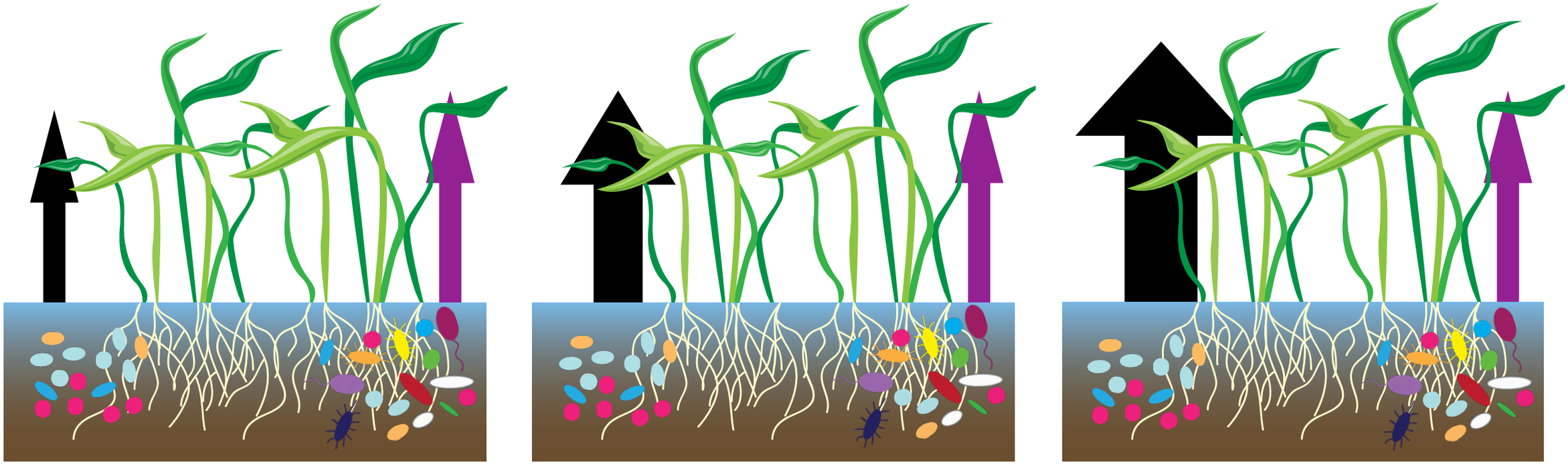


Salinity significantly reduced denitrification rates under the most saturated conditions



salinity × moisture ($F_{1,54}$=1.2;P=0.274)
salinity ($F_{1,54}$=15.7;P=0.0002)
moisture ($F_{1,54}$=115.0;P<0.0001)
[ANOVA model; $\log_{10}$DEA ~ moisture | salinity]

Take-home



Managing microbial functions can improve water quality in urban wetlands

THANKS!!!

@ArianePeralta
@Gina_Bledsoe
@EbanBean

www.peraltalab.com

How do we manage microbiomes to promote urban wetland functions?

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