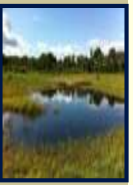
# The Mid-Atlantic Wetland Conservation Effects Assessment Project: Assessing Effects and Enhancing Effectiveness

**M. Lang, G. McCarty, M. Yepsen, D. Whigham, M. Walbridge, A. Sharifi, M. Rabenhorst, C. Palardy; J. Mitchell, J. Miller, L. McFarland, O. McDonough, P. Hunt, D. Fenstermacher, T. Ducey, J. Denver, C. Church, A. Baldwin, S. Ator**



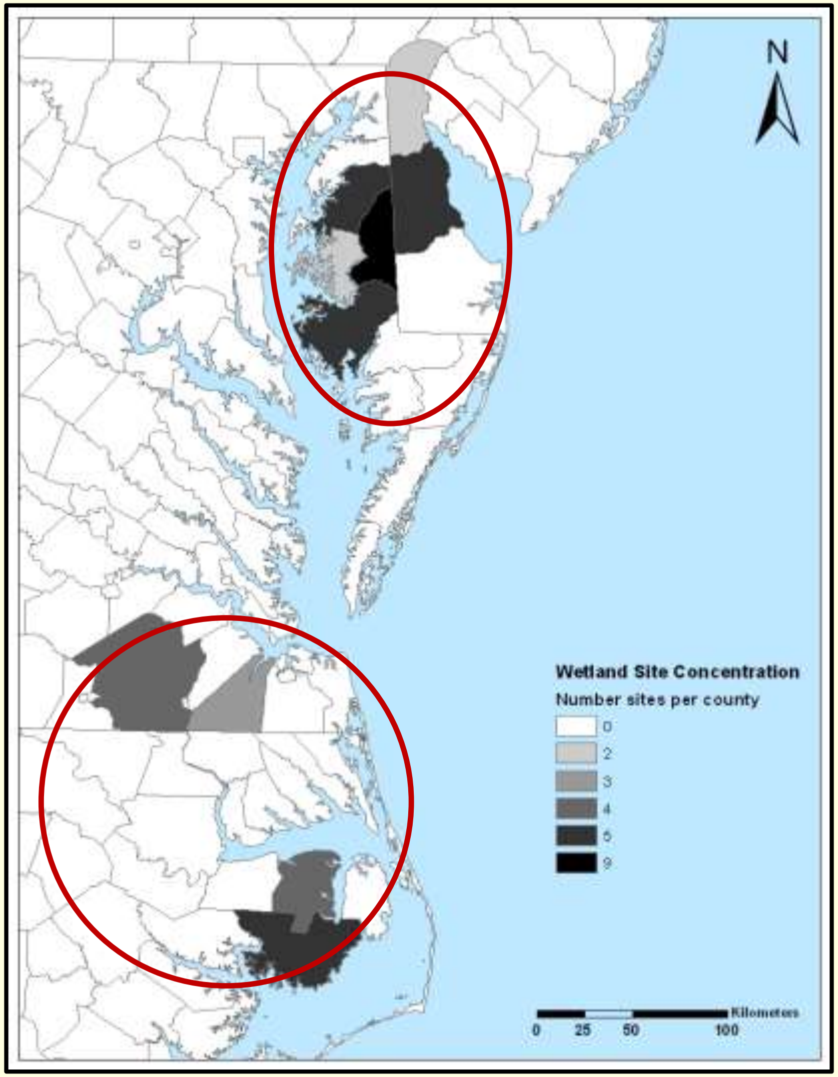
# Background

- Conversion of natural lands to agriculture has led to broad scale wetland loss.
- USDA conservation programs seek to replace or ameliorate ecosystem services lost to agricultural conversion.
- Best use of funds to improve environmental outcomes requires improved understanding of the effects and effectiveness of wetland restoration practices is needed.

# MIAR CEAP-Wetland Study

**Study Goal**: to quantify the effects and effectiveness of depressional, non-tidal wetland restorations

**Study Location**: representative sites (48) were randomly selected within the outer Coastal Plain of DE, MD, VA, and NC.

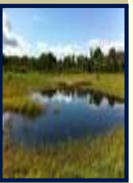


# Wetland Alteration Gradient

**Natural**

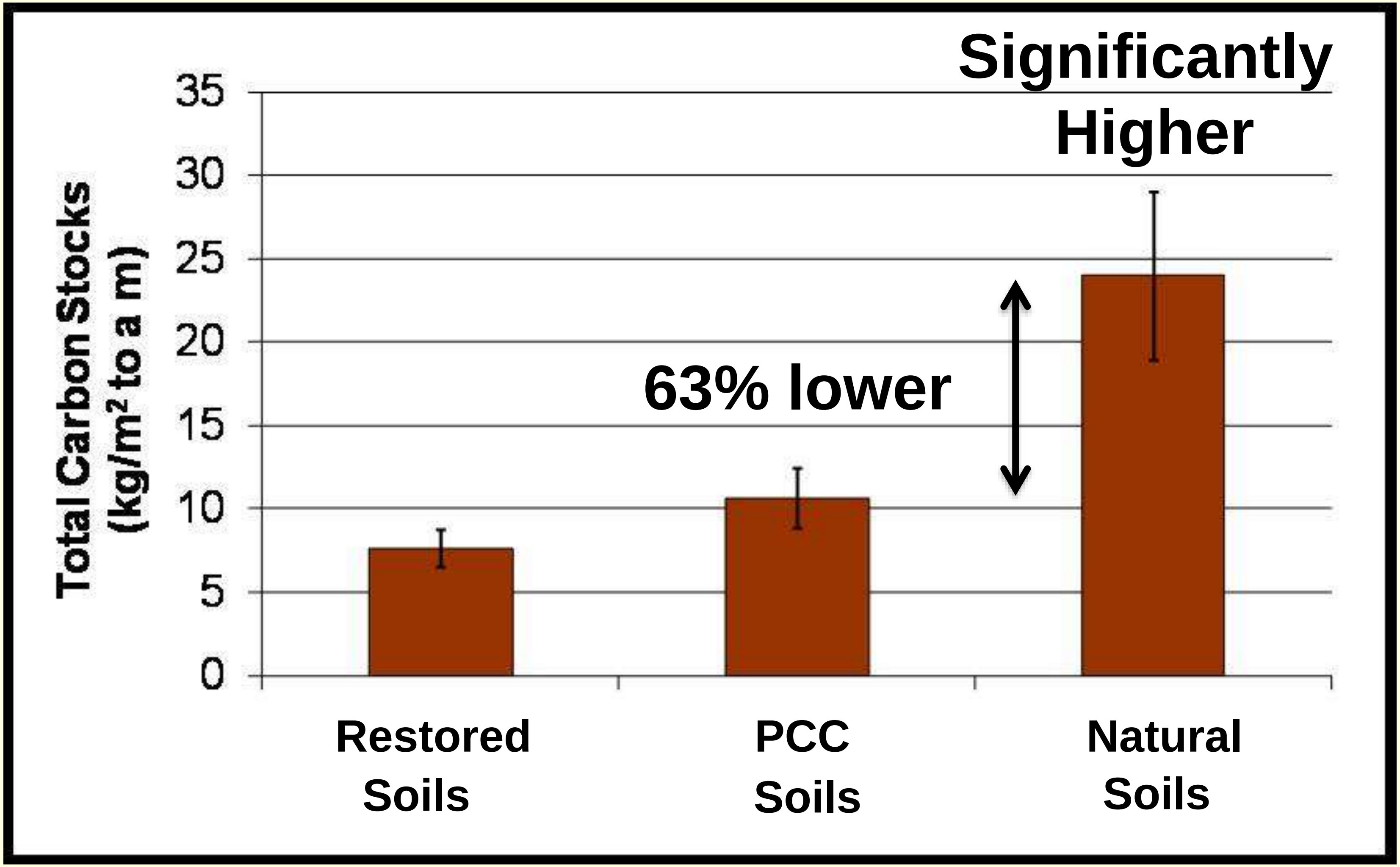
**Restored**

**Prior Converted Cropland**

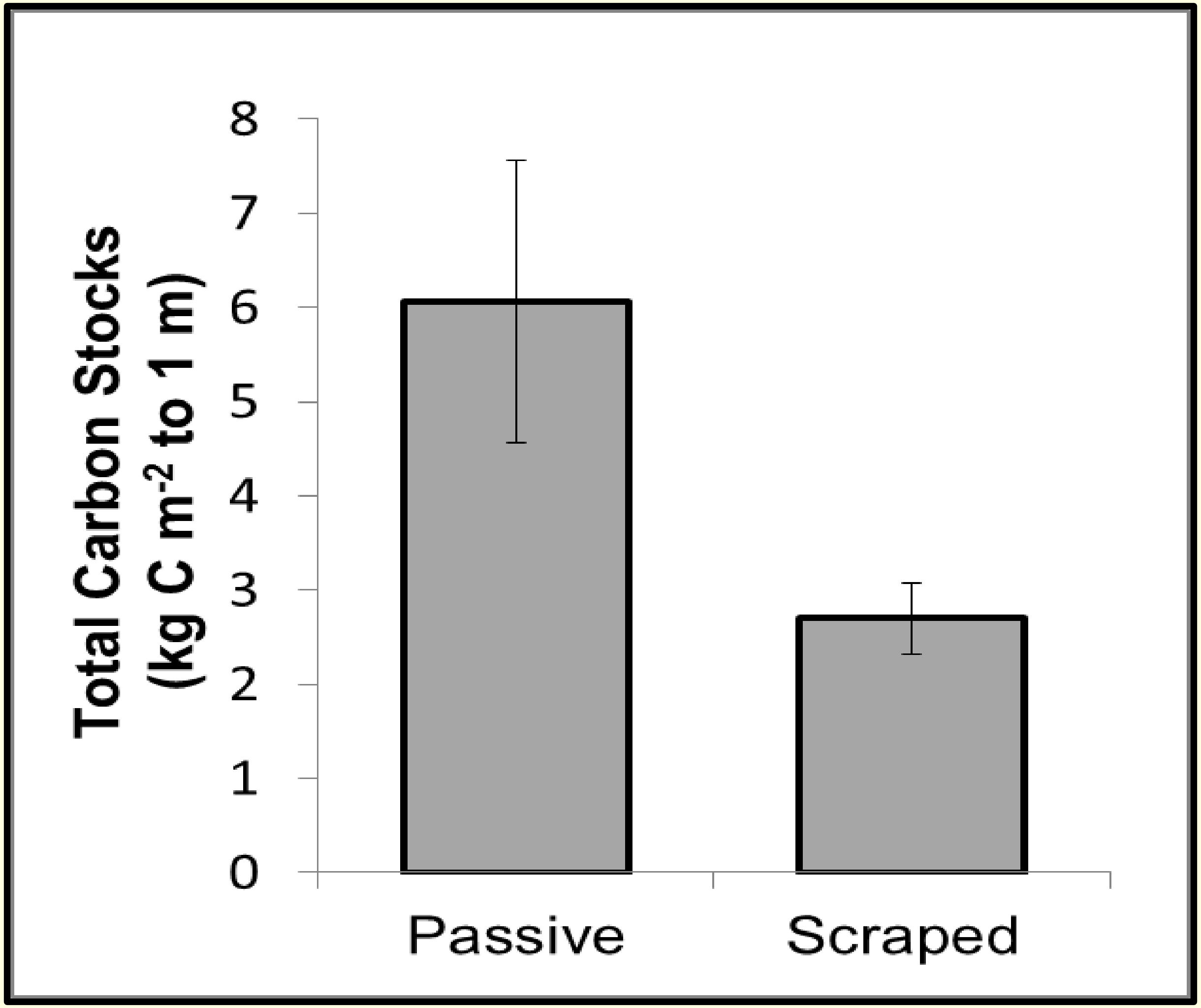


# Primary Ecosystem Services

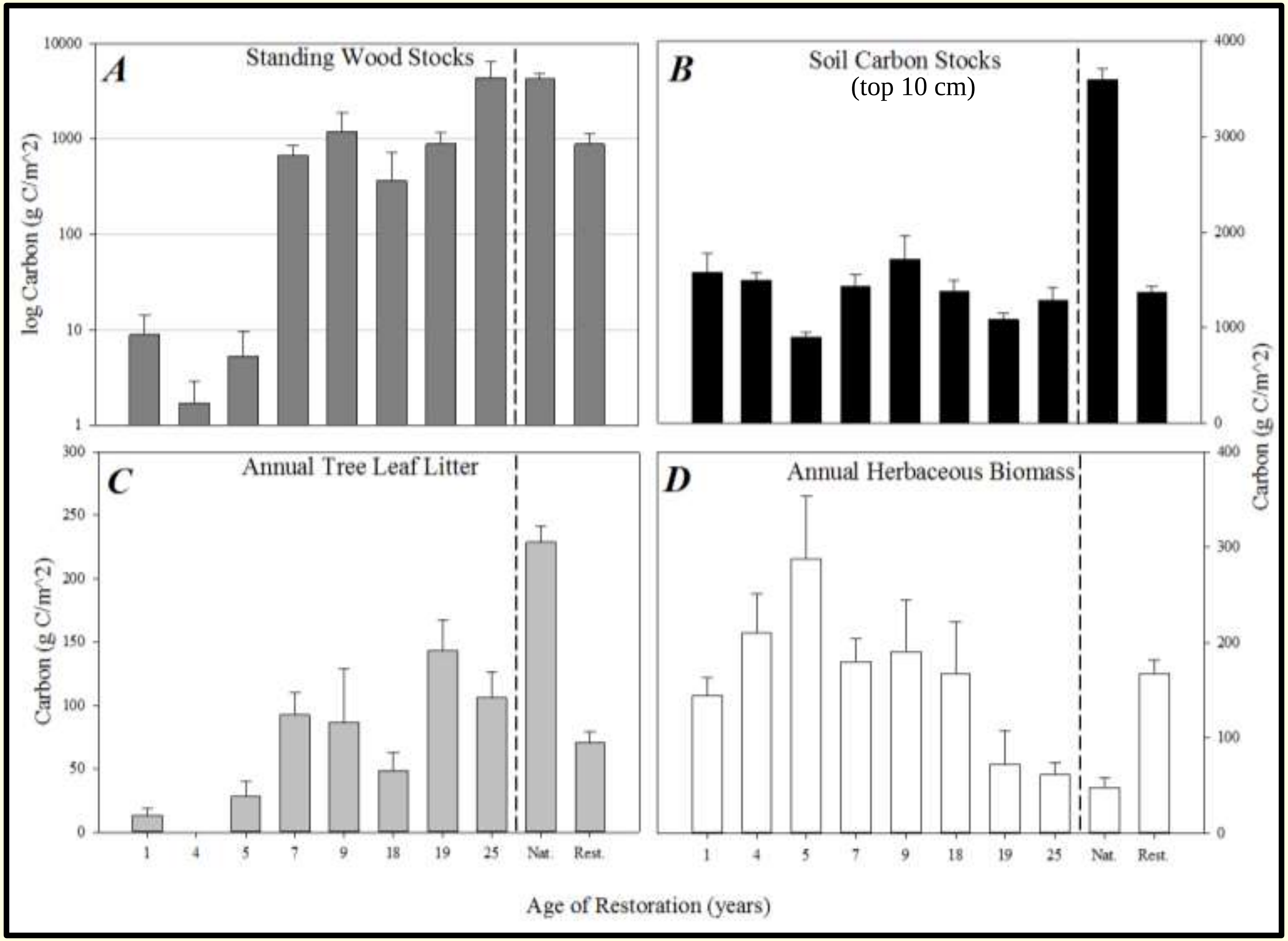
- **Climate Regulation**
  - Carbon capture and sequestration
  - Greenhouse gas emissions
- **Pollutant Mitigation**
  - Nutrients (N and P)
- **Management of Natural Hazards and Hydrologic Flows**
  - Volume storage
- **Biodiversity Support**
  - Plants
  - Amphibians




Wetlands should be wet enough to limit C loss but water shallow enough to support plants.

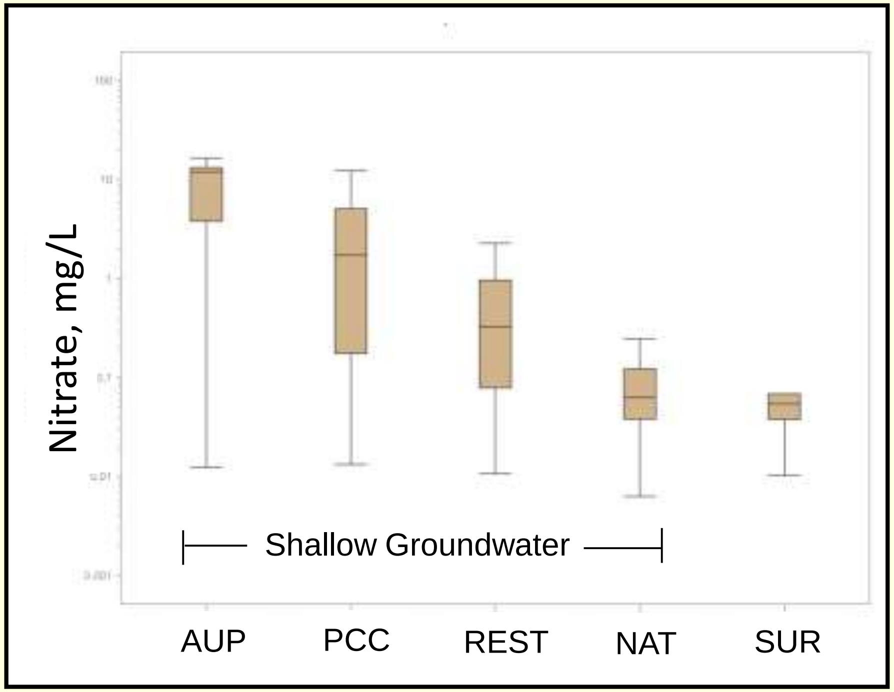


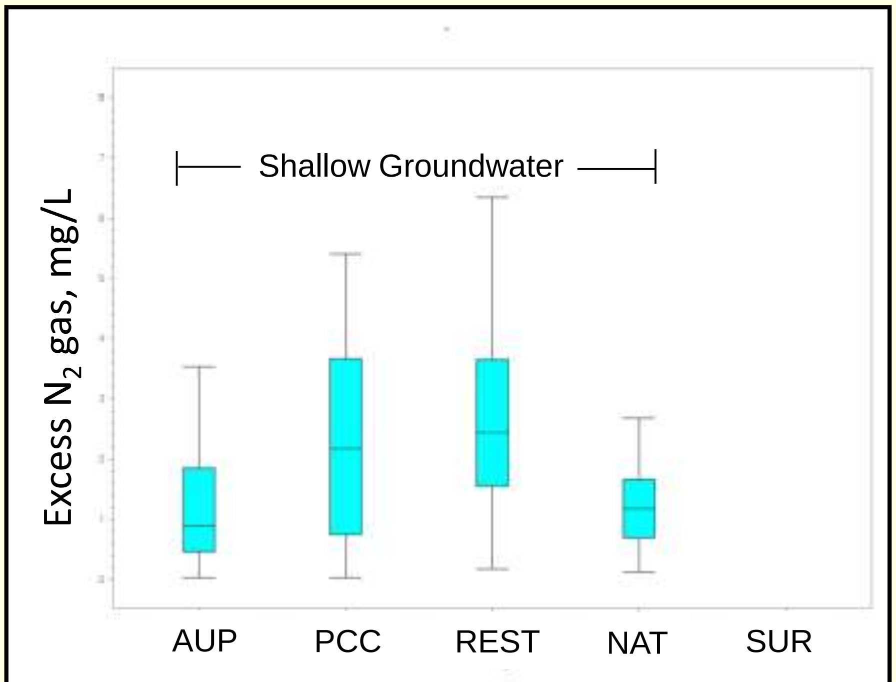

Excavation should be avoided or topsoil excavated should be replaced. Restoration did not increase emission of greenhouse gases ($CO_2$ and $N_2O$).




Restored wetlands are on a trajectory toward natural wetland condition and capture similar amounts of carbon, but it may take a long time for soil carbon stocks to recover.

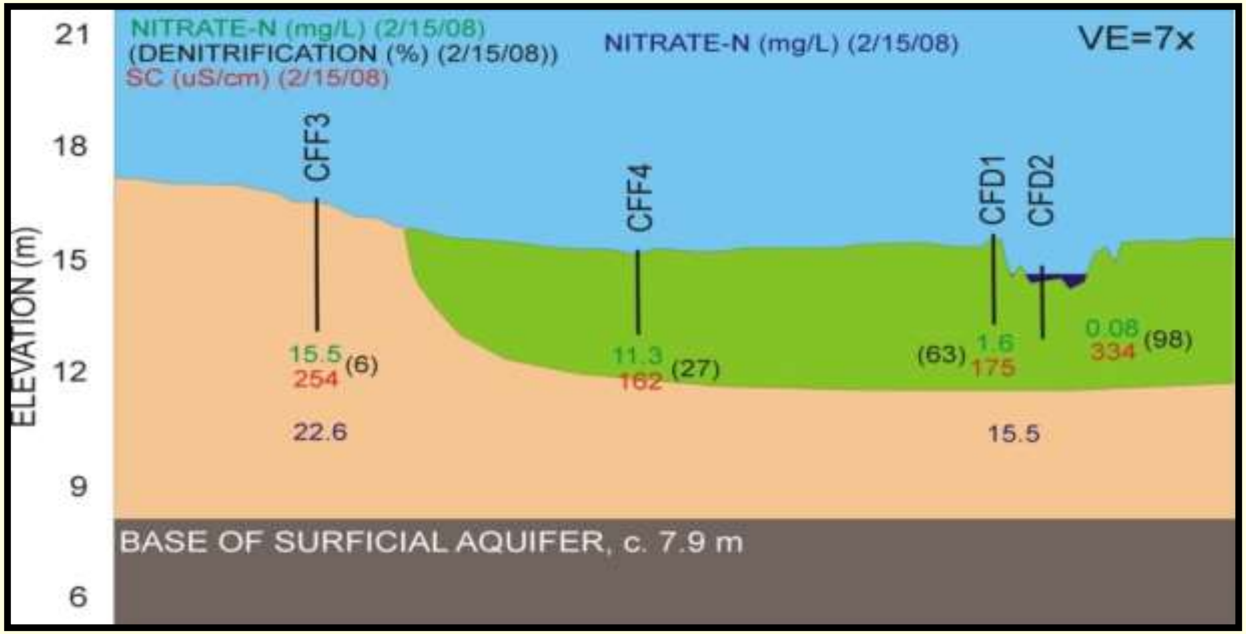
•Potential denitrification (DEA) in mineral soils exhibited recovery subsequent to restoration.
•Restorations with heavy reliance on recalcitrant soil organic carbon demonstrated low denitrification potential
•New carbon inputs are important for driving biogeochemistry (the importance of good vegetation cover)



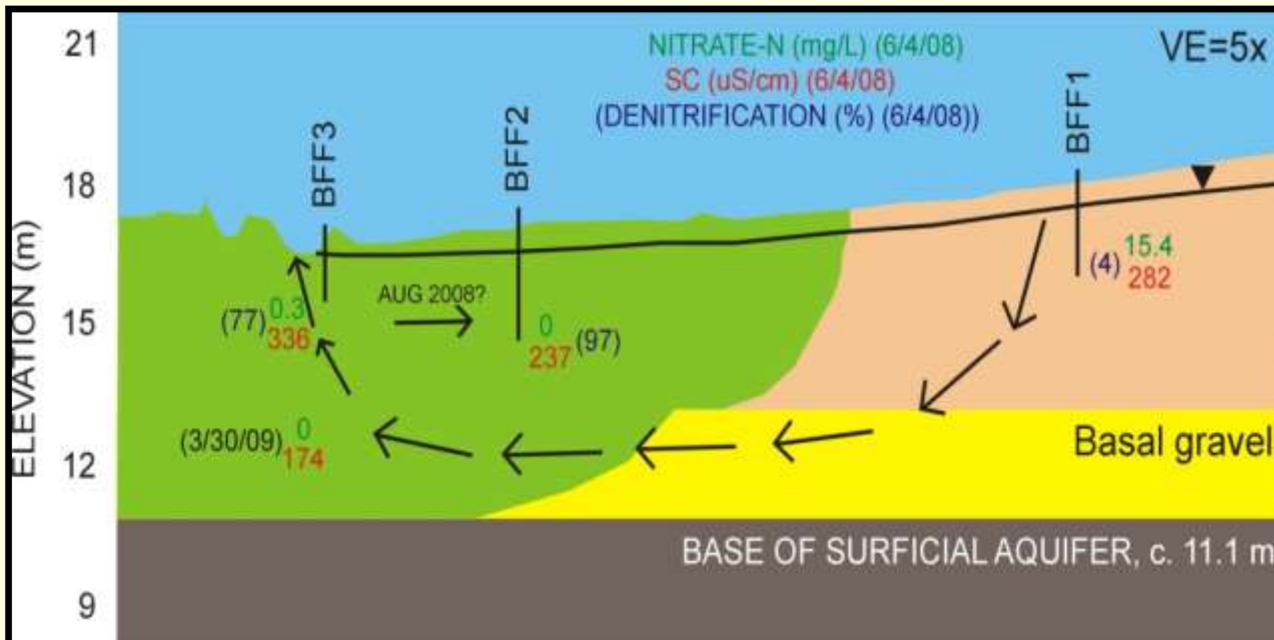

- Nitrate highest and effects of denitrification lowest in agricultural uplands.
- Many PCCs are not completely drained and provide WQ services
- Restoration of wetland hydrology increases percent nitrate denitrified
- Many natural wetlands do not intercept ag nitrate but improve WQ via dilution

AUP, agricultural uplands; HST, historical wetlands; REST, Shallow water management and restored wetlands; NAT, wetlands with native vegetation; SUR, surface water

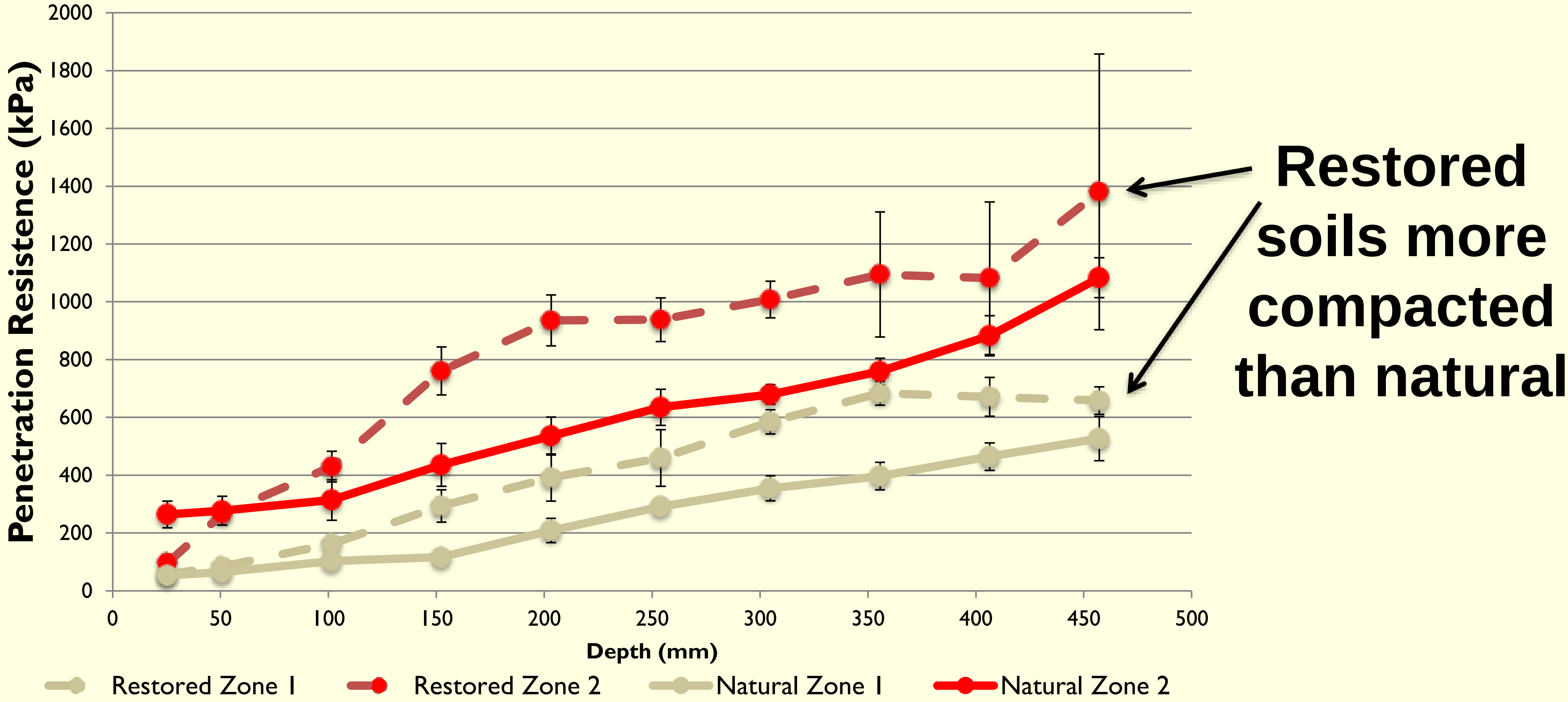



Effectiveness of nutrient mitigation service is highly dependent on the volume of agricultural water entering zone of denitrification.

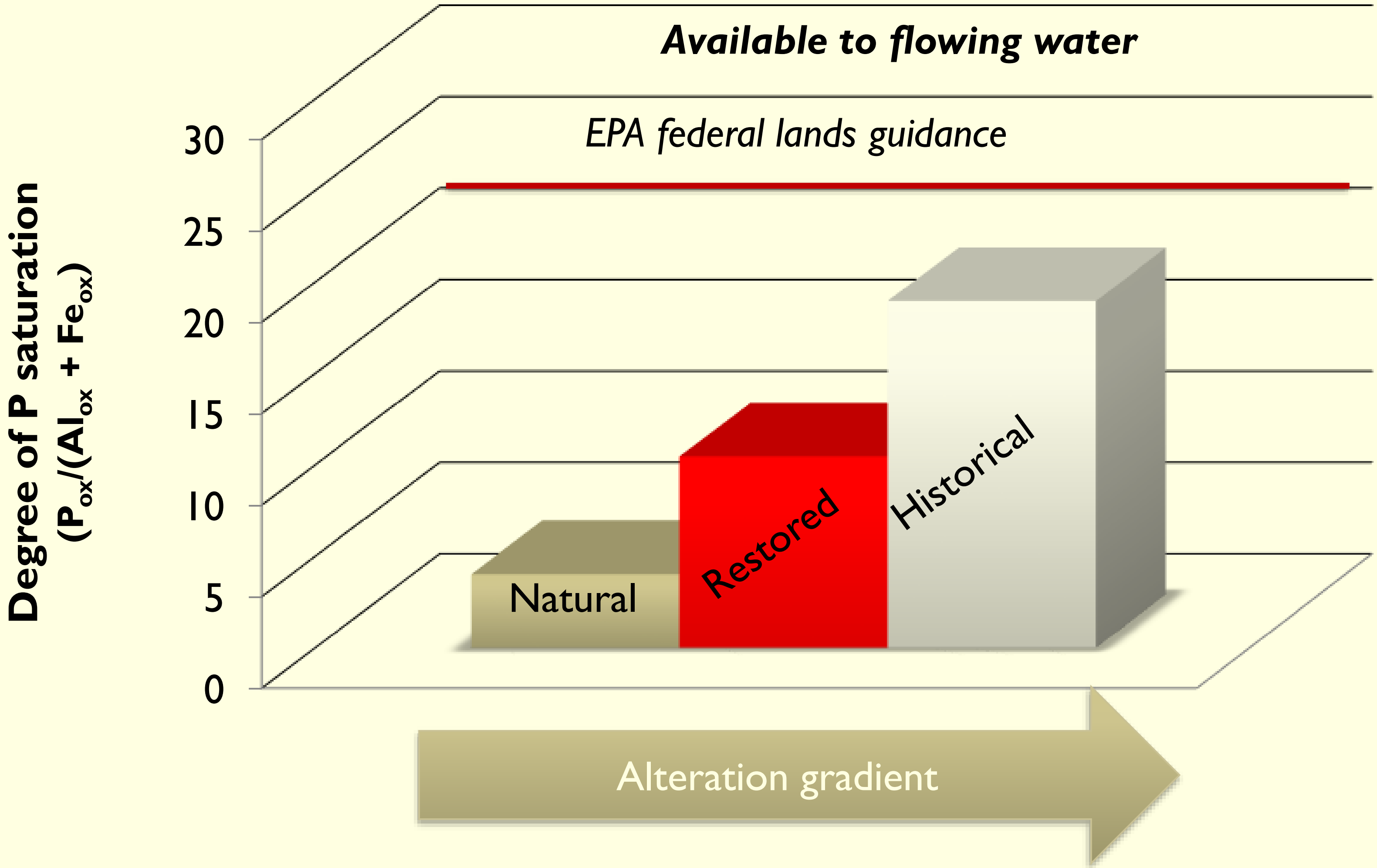
Addition of confining layer limits exposure of groundwater to wetland soils <u>where denitrification occurs.</u>



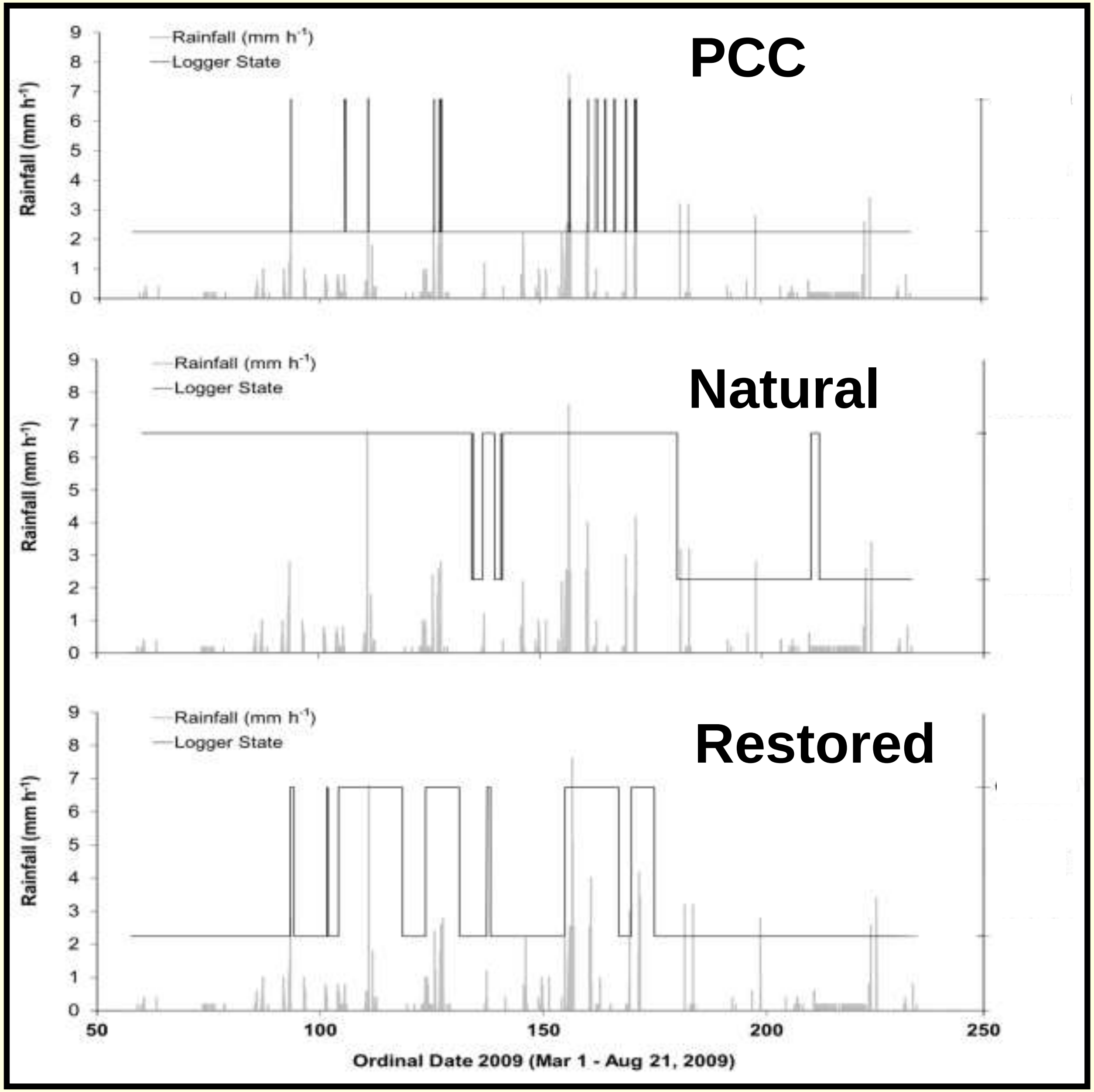
# Penetration Resistance with Depth



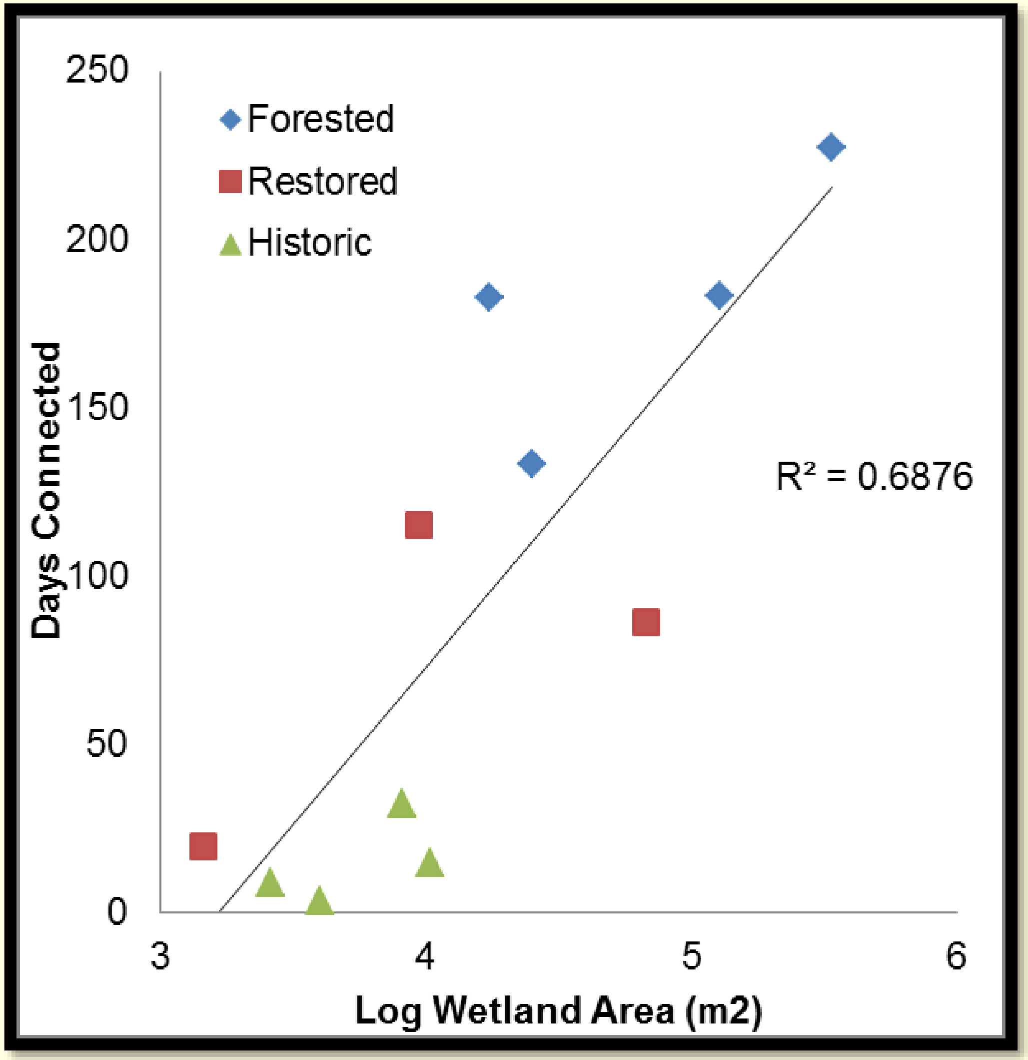

A confining layer often serves to increase hydroperiod, but it also isolates the wetland from groundwater, potentially reducing pollutant (nitrate) mitigation.



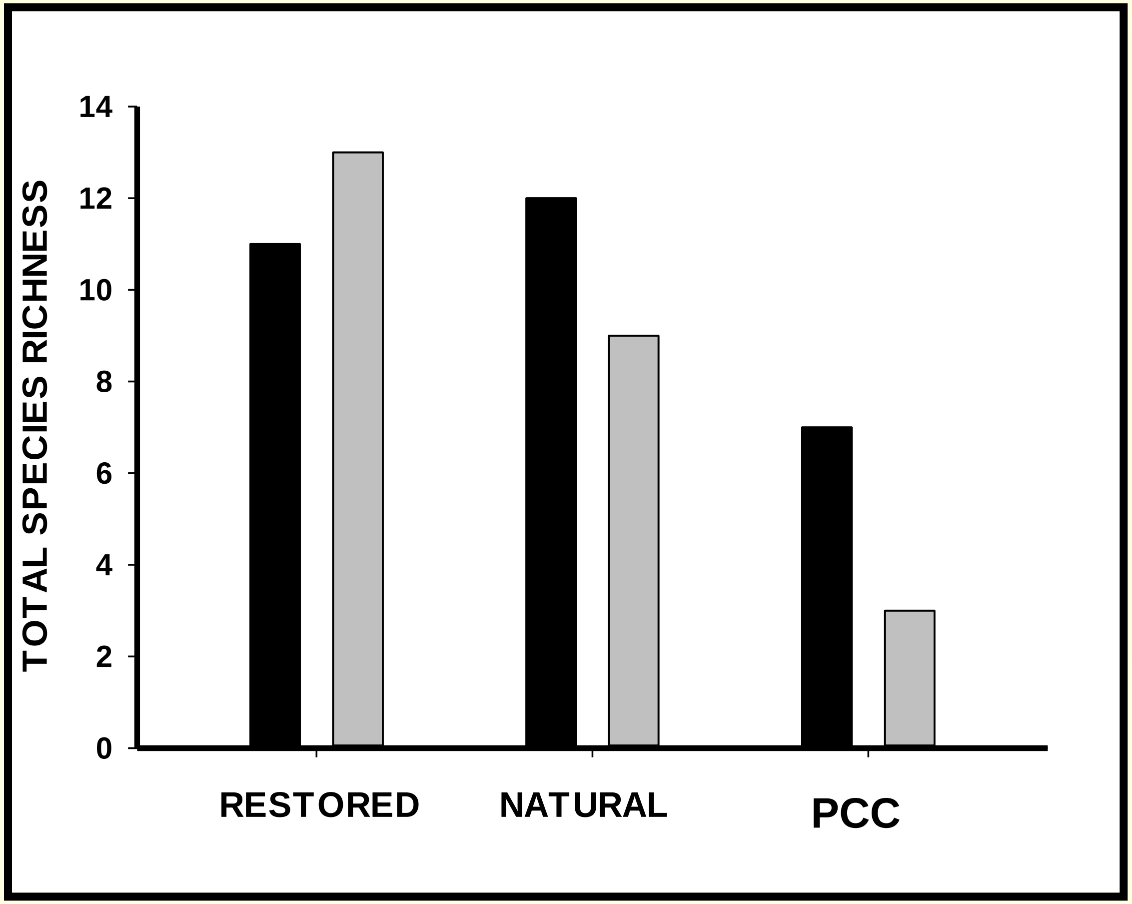

P saturation of restored wetland soils was half of PCC soils, likely due to the removal of topsoil during restoration. Removing P rich topsoil (excavation) renders it less likely to be transported to adjacent streams


PCC
Natural
Restored
Rainfall (mm h-1)
Logger State
Rainfall (mm h-1)
Ordinal Date 2009 (Mar 1 - Aug 21, 2009)

Duration of flow was found to be related to wetland size, with larger wetlands with greater volume providing longer duration flows.




On average, restored wetlands contained ~30% of surface water volume as natural wetlands. Restoration of larger cells or groups of cells may better regulate hydrologic flows.

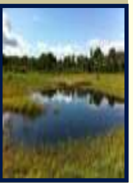



**Total amphibian species richness in northern (black bars) and southern region (gray bars; left).**

- Restored and natural wetlands supported a similar number of species and equal percents of generalists and specialists, but community similarity was low.
- Landscape scale biodiversity is supported through conservation of natural and restored wetlands.

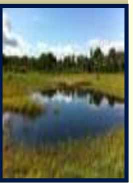
- While restored wetlands were dominated by herbaceous species (left), natural wetlands were dominated by woody species (right).

- Although these wetland types appeared quite different, the diversity and quality of their plant communities were comparable.



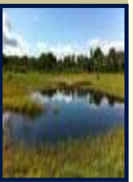
# Take-Home Message

- Results highlight multiple ecosystem service gains relative to the pre-restoration condition, but also the importance of implementation and management practices.
- Before implementation, practitioners should consider restoration goals, the effects of different implementation and management strategies, and trade-off relationships between various ecosystem services.



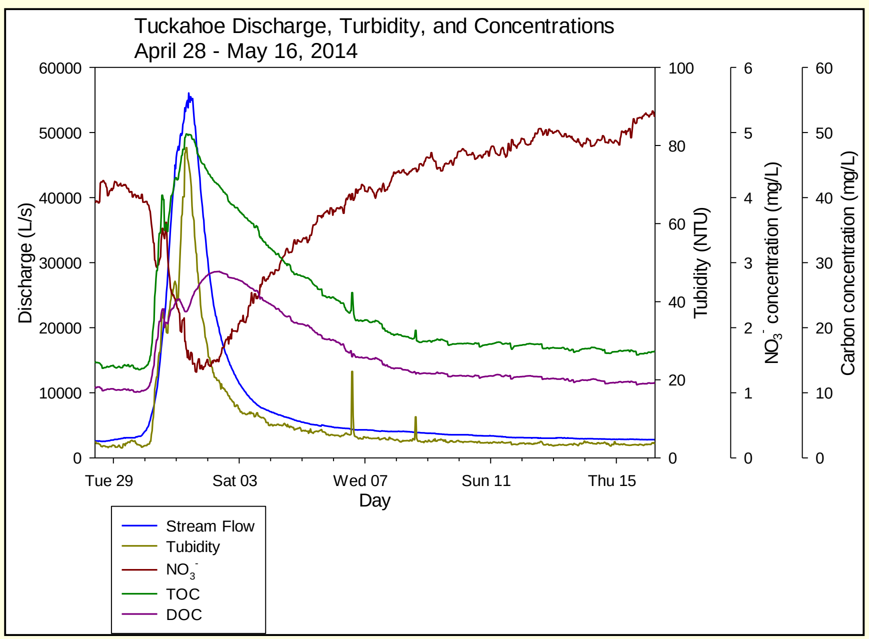
# Next Steps

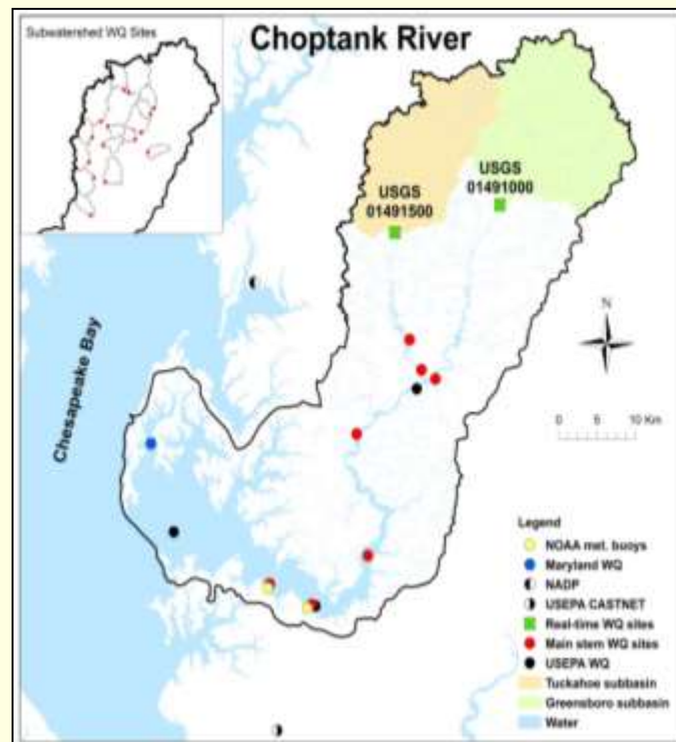
- Findings are currently being used to support the development of wetland functional assessment protocols for the National Resource Inventory.
- Remotely sensed data are being used to directly enhance process based modeling and develop widely applicable empirical relationships, which can be used to predict wetland characteristics and functions at the landscape scale.



# Modeling

- Objectives: 1) support of SWAT/APEX model adaptations to enhance wetland modeling capabilities, 2) build capacity for future model improvements through deployment of sensor networks.



# Subbasin Comparison

**Land use**

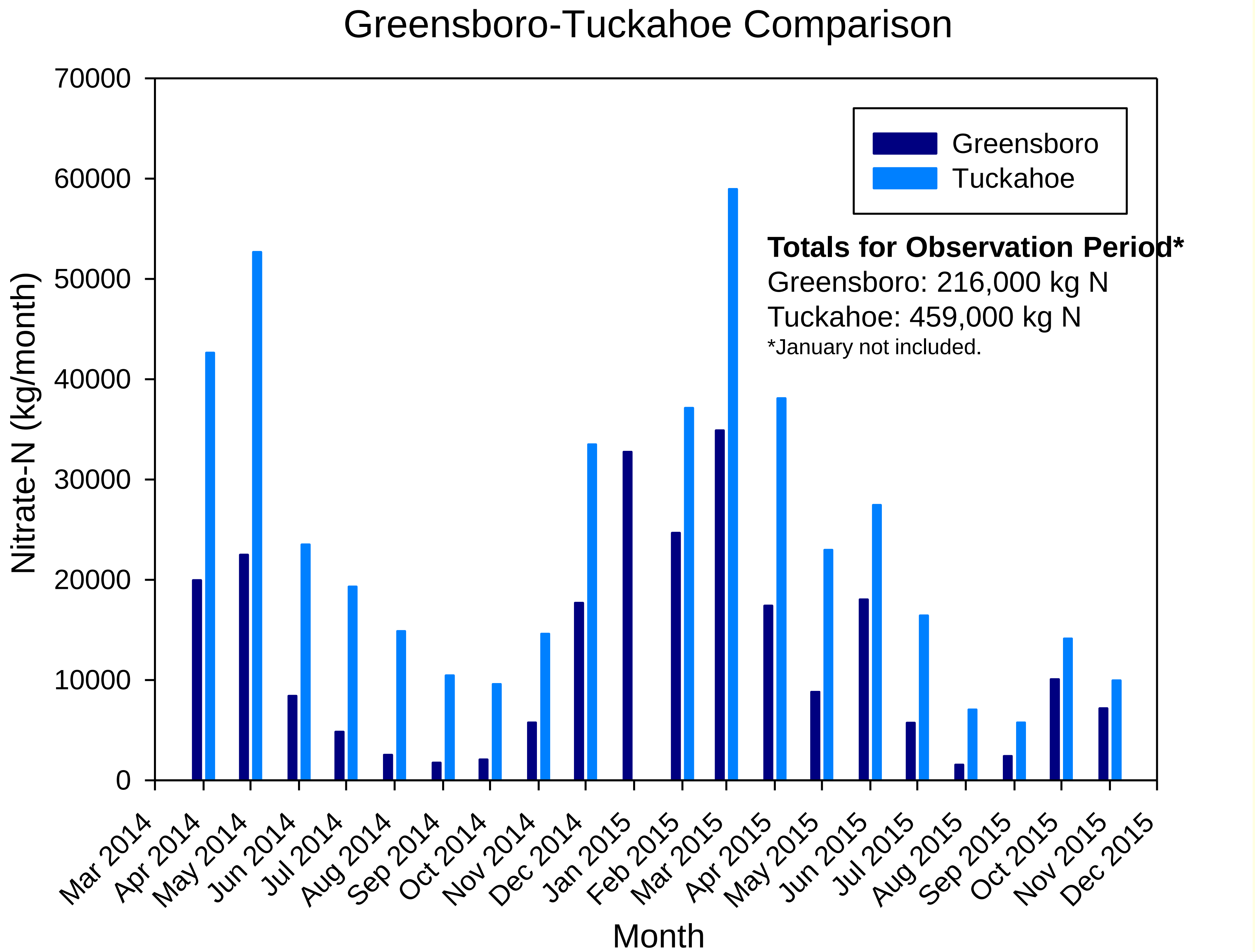
| | Total area | Cropland |
|---|---|---|
| Subbasin | $km^2$ | $km^2$ |
| Greensboro | 293 | 129.9 |
| Tuckahoe | 226 | 129.3 |
| Ratio G/T | 1.3 | 1.0 |

**Land use *vs.* Drainage Class**

| **Tuckahoe** | A (%) | B (%) | C (%) | D (%) |
|---|---|---|---|---|
| Cropland | 0.39 | 57.10 | 6.58 | 35.92 |
| Non-cropland | 1.70 | 37.54 | 4.41 | 56.35 |

| **Greensboro** | A (%) | B (%) | C (%) | D (%) |
|---|---|---|---|---|
| Cropland | 3.07 | 33.85 | 19.26 | 43.82 |
| Non cropland | 5.33 | 19.29 | 9.35 | 66.04 |

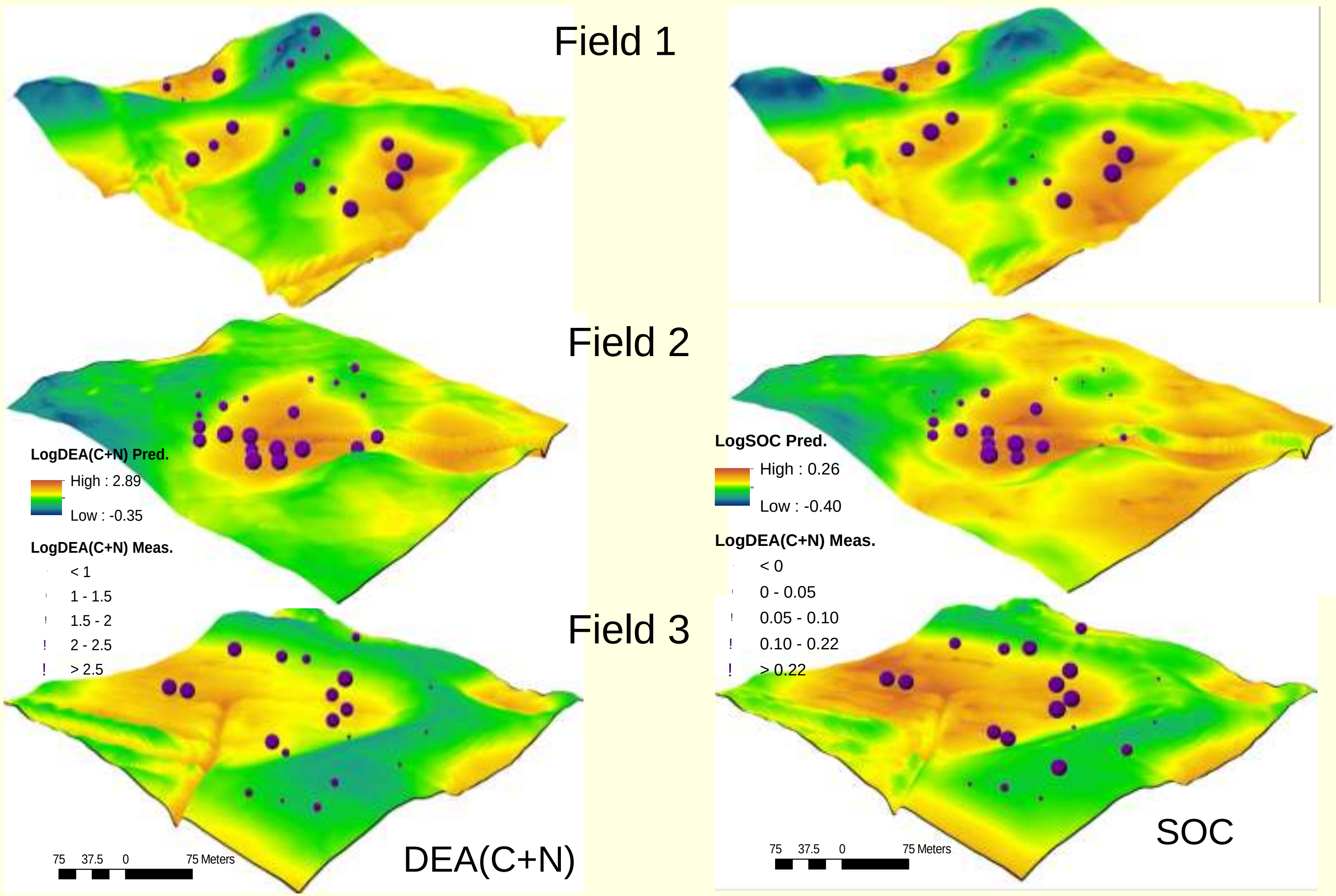
**Cropland on poorly drained soils (C + D)**
**Tuckahoe subbasin 42 %**
**Greensboro subbasin 63 %**



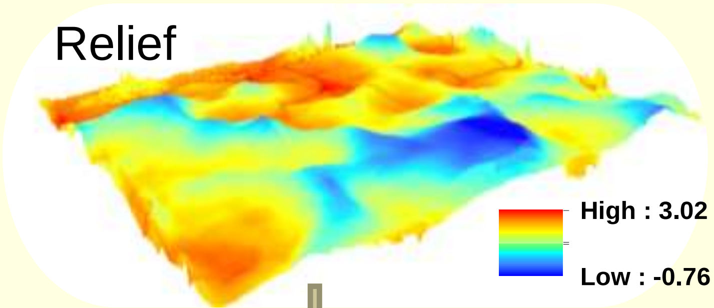
Greensboro-Tuckahoe Comparison
Nitrate-N (kg/month)
70000
60000
50000
40000
30000
20000
10000
0
Greensboro
Tuckahoe
Totals for Observation Period*
Greensboro: 216,000 kg N
Tuckahoe: 459,000 kg N
*January not included.
Mar 2014
Apr 2014
May 2014
Jun 2014
Jul 2014
Aug 2014
Sep 2014
Oct 2014
Nov 2014
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015
Nov 2015
Dec 2015
Month

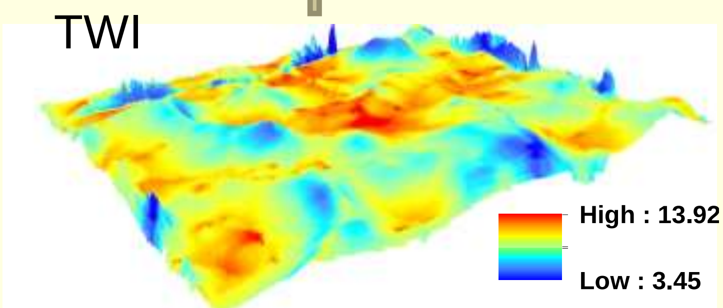
# Mapping Denitrification Potential & SOC

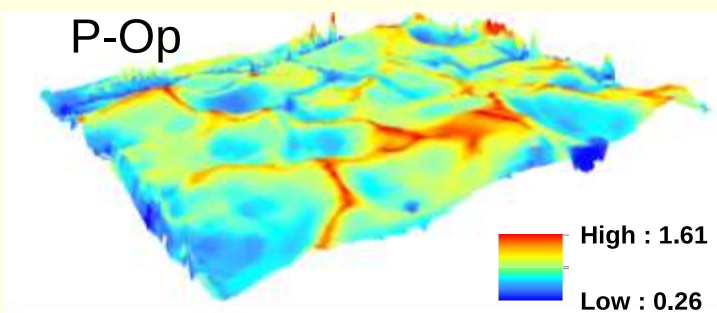
## Predicted *vs.* Observed



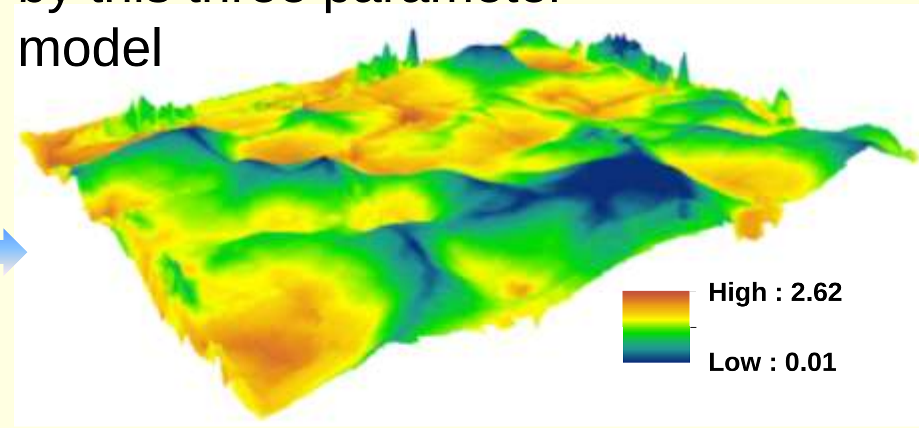
# Denitrification potential map based on a topographic model



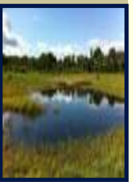




Over 50% of the variance accounted for by this three parameter model



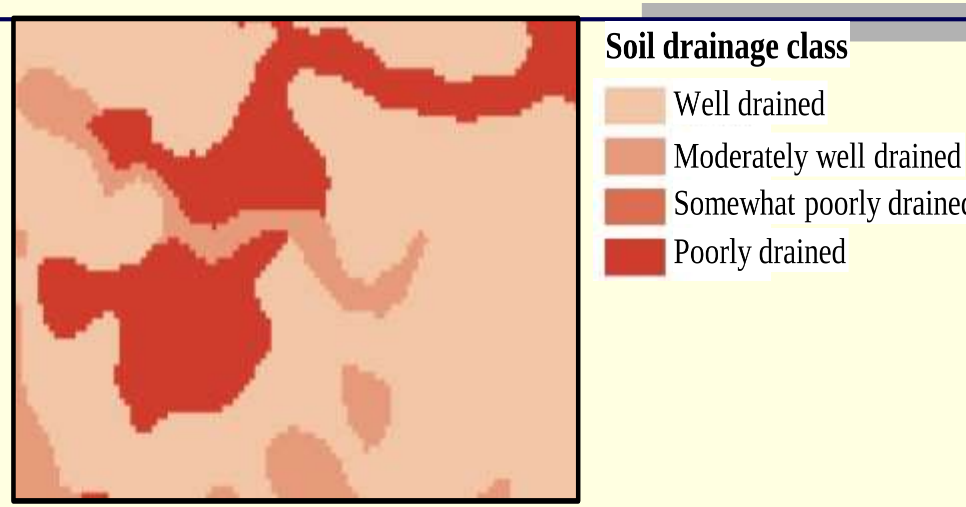

PCCs have elevated denitrification potential

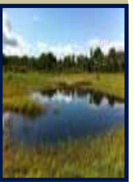


# Better Representation of Landscapes in the SWAT Model

- Can process-based models accurately represent complex landscape interactions?
- We implemented the SWAT model
  - Novel parallel calibration approach for paired basins to constrain model parameters.
  - Use of real time WQ data for Cal/Val
  - Modified the model to better reflect local vadose zone associations (varied denitrification likelihood based on local drainage condition)

# Improved Landscape Representation



# Take-Home Message

- Although prior converted croplands represent the loss of wetlands within agricultural landscapes, their biogeochemistry maintains significant wetland characteristics.
- PCCs are an important determinant of agricultural nitrate fate in agricultural ecosystems.
- PCCs represent an important resource that needs to be conserved.

# *Thank you!*

**Acknowledgements**: This research was funded by the Wetland Component of the USDA Conservation Effects Assessment Project (CEAP). Much thanks goes to the land owners who allowed us to access their properties.