Back from the past?

Biogeochemical recovery of relict, buried organic soils following restoration

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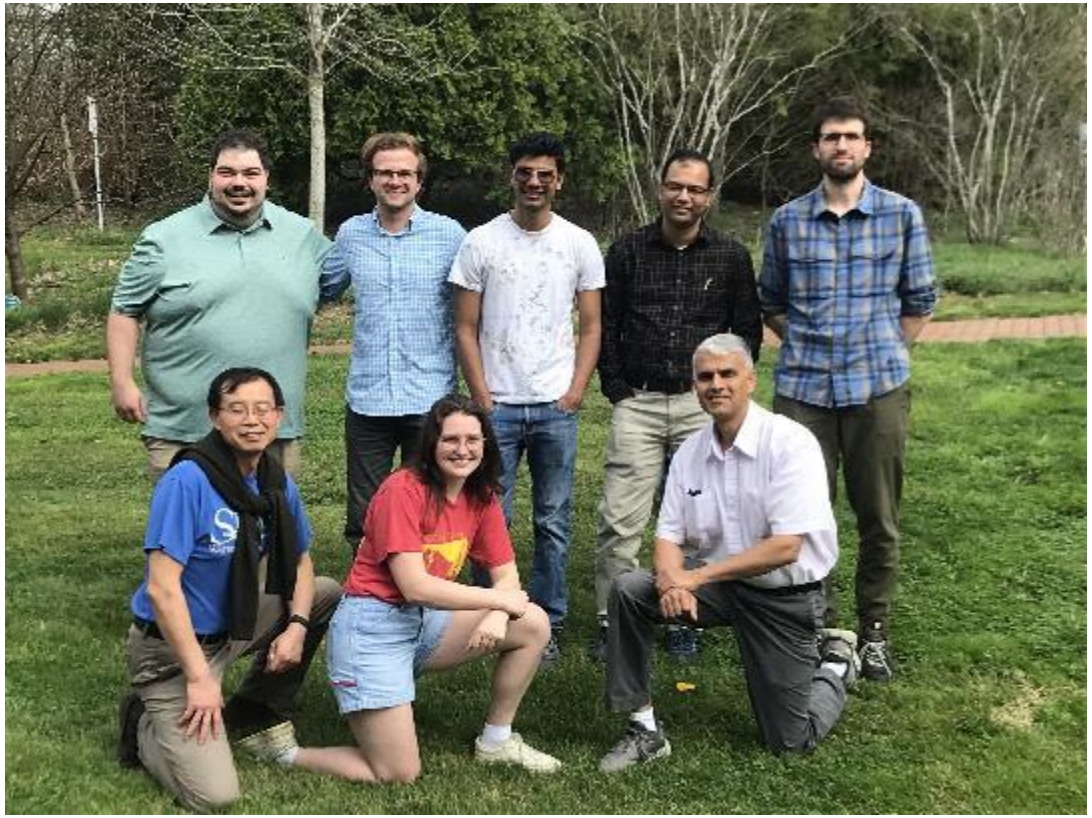
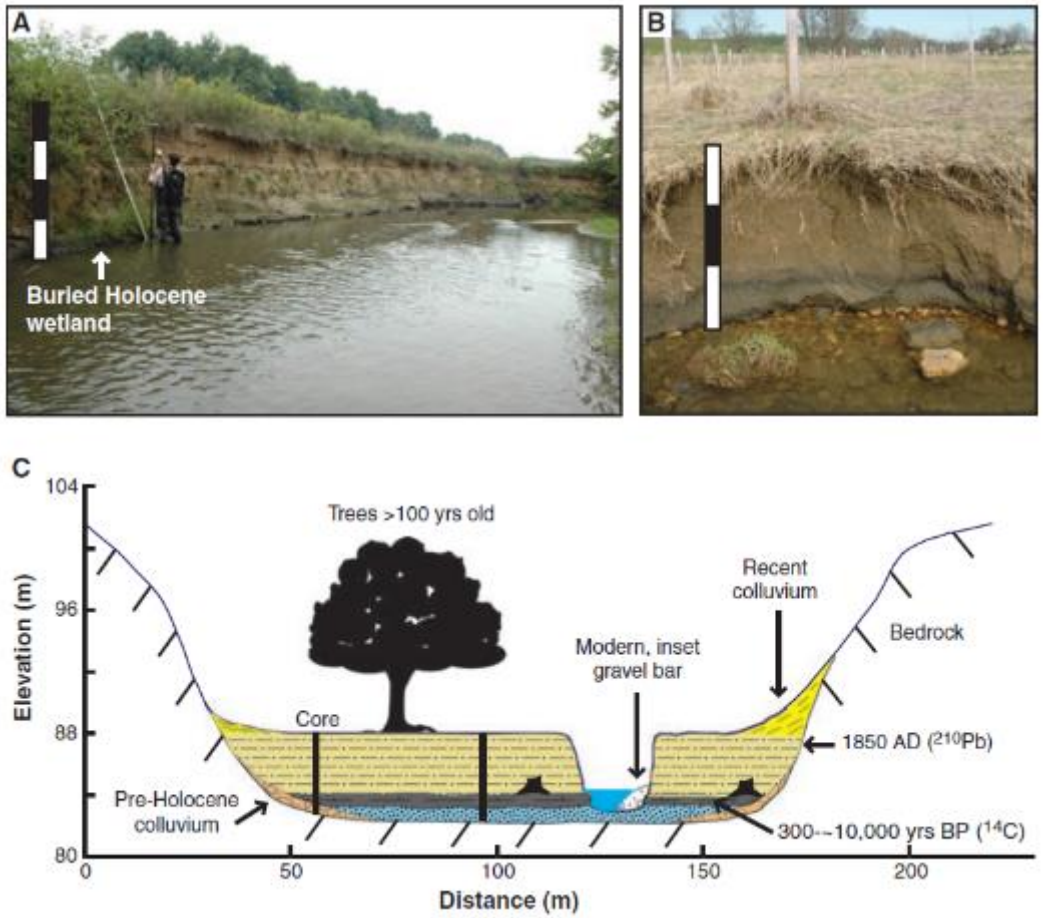


Human alteration of mid-Atlantic floodplains & streams

Natural Streams and the Legacy of Water-Powered Mills

Robert C. Walter*† and Dorothy J. Merritts*†

SCIENCE VOL 319 18 JANUARY 2008



Legacy sediments = agricultural erosion + milldams

Walter & Merritts. 2008

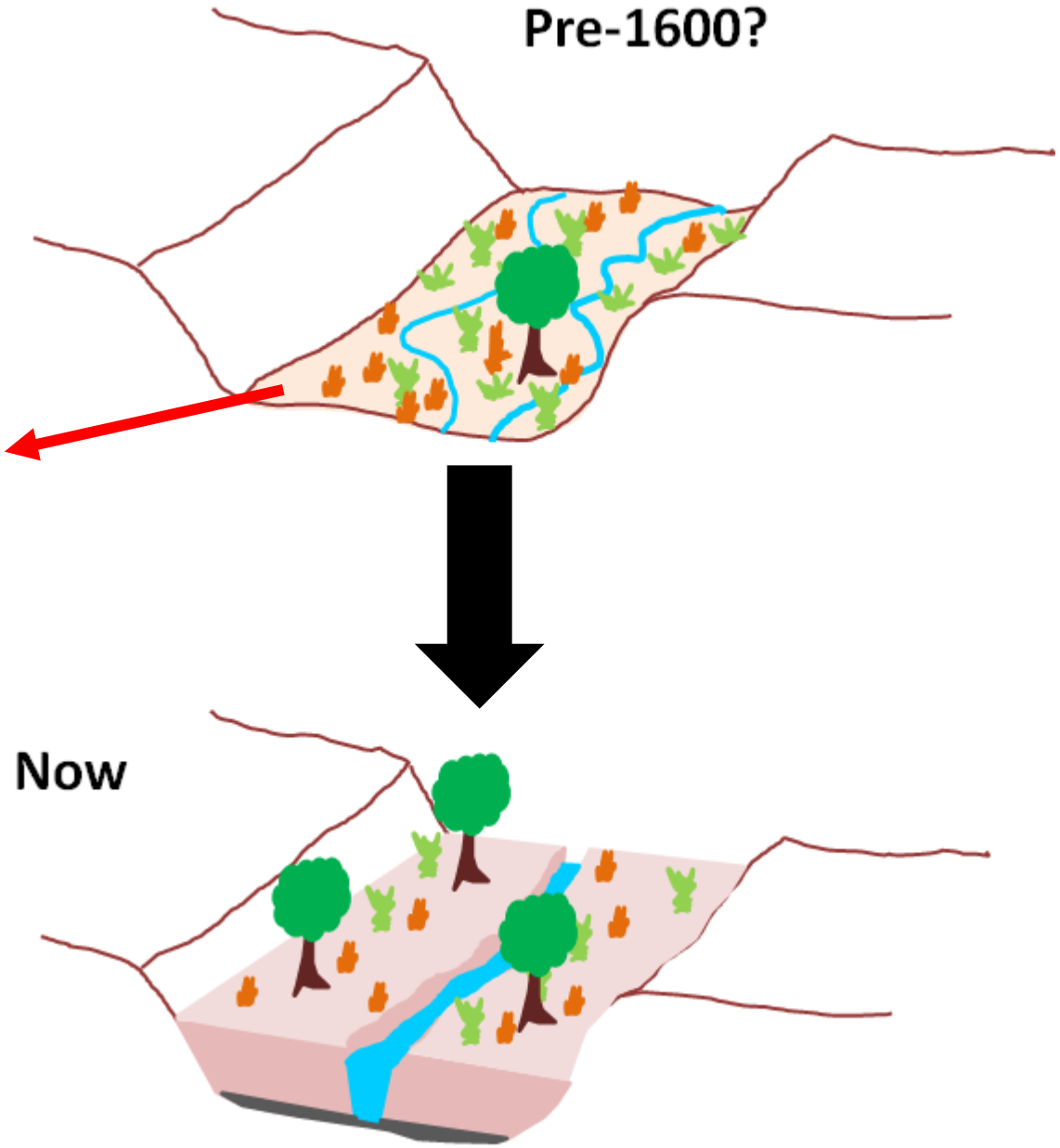
Precolonial wetlands and organic soils buried below feet of legacy sediments in valley bottoms

The ~1000 year old precolonial organic horizon at Gramies Run, MD

Stobers Dam Breach in 2011

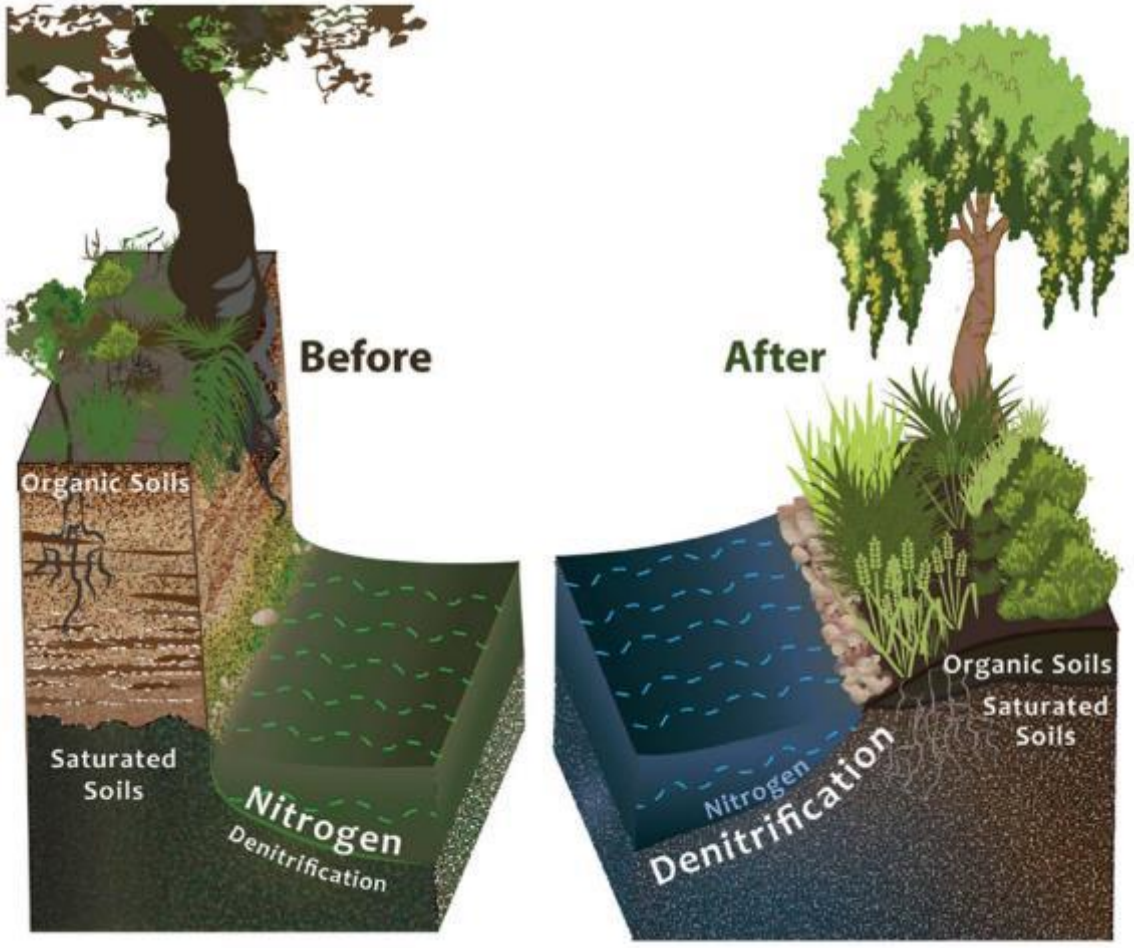
Source: Merritts & Walter

Artist’s reconstruction of pre-settlement valley-bottom wetlands and marshes – Elliott et al., 2013.



Stream & Floodplain restorations

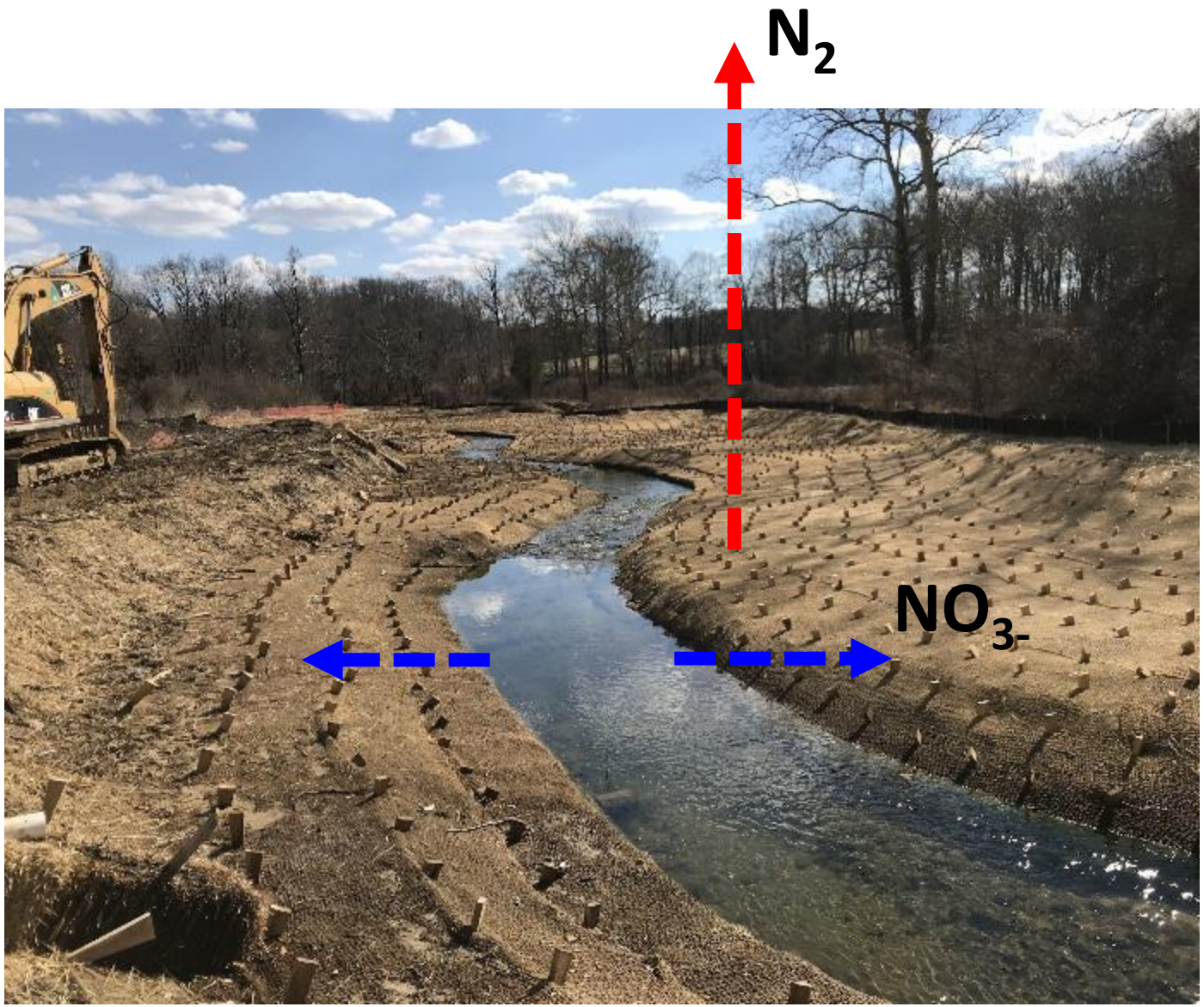
- **Legacy sediment removal**
- **Reduce erosion and mitigate sediment pollution**
- **Enhance hydrologic connectivity**
- **Promote nitrogen removal via denitrification**



Mayer et al., 2022

LSR & NCD at Gramies Run, MD

Denitrification N removal in restored floodplains



Stream & Floodplain restorations

Some restorations are retaining and leveraging the biogeochemical benefits of precolonial organic soil horizons – e.g., Big Spring Run

Others are not! (e.g., Gramies Run)

Need to leverage - Valuable historic microbiomes & seed banks!

Key Questions about Precolonial organic soils

- **Are relict soils biogeochemically and microbially active?**
- **Will they leach nutrients post restoration (C, N, P)?**
- **Will they enhance denitrification N removal immediately post restoration?**
- **If not, what could be the time of recovery?**

Objectives

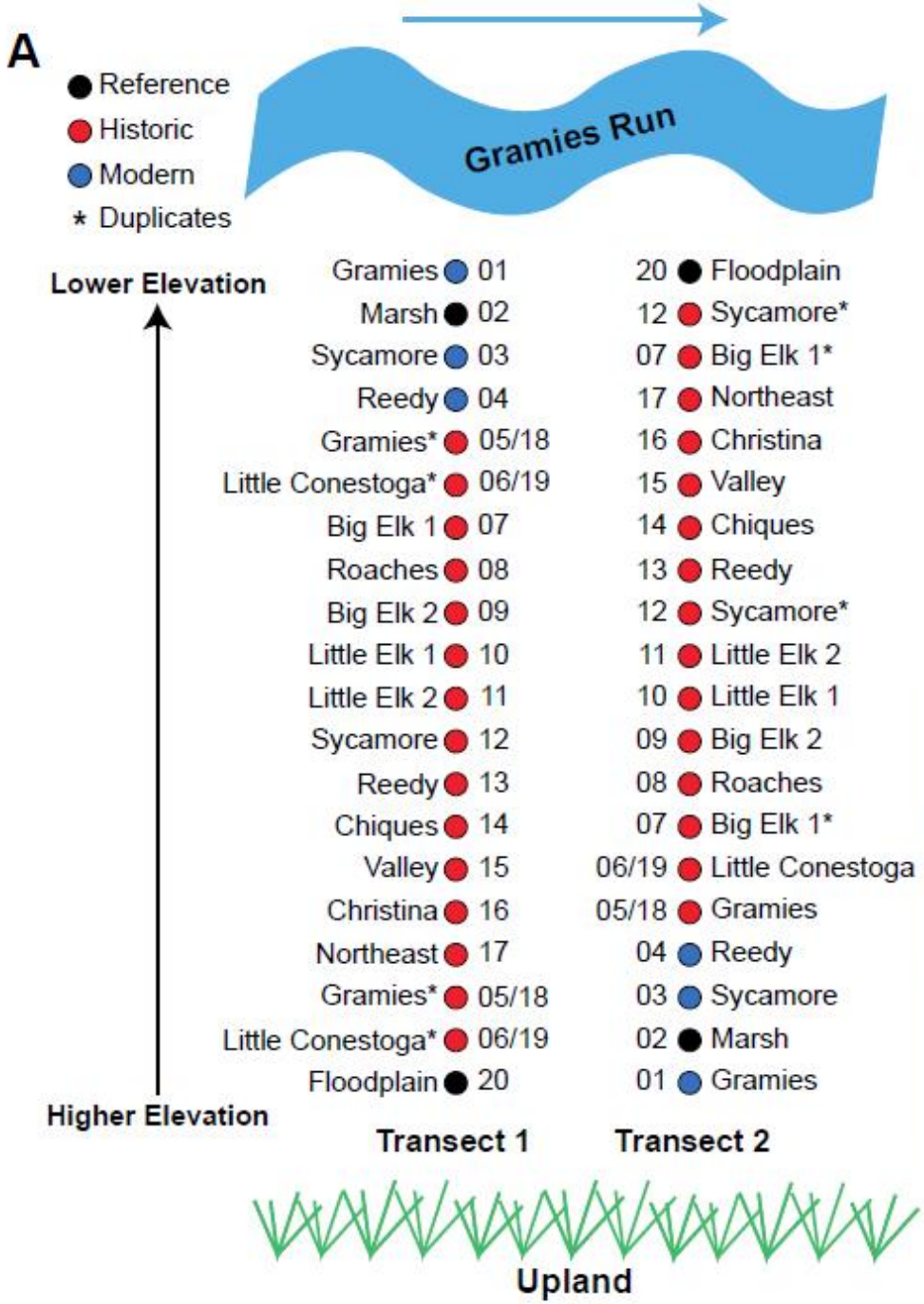
- Investigate the response of 13 relict/historic organic soils from across the mid-Atlantic – DE, MD, PA, NC.
- Determine the biogeochemical characteristics pre-burial.
- Determine biogeochemical changes post 1-year burial on a restored floodplain site.
- Compare relict/historic soil biogeochemical features to modern wetland soils.

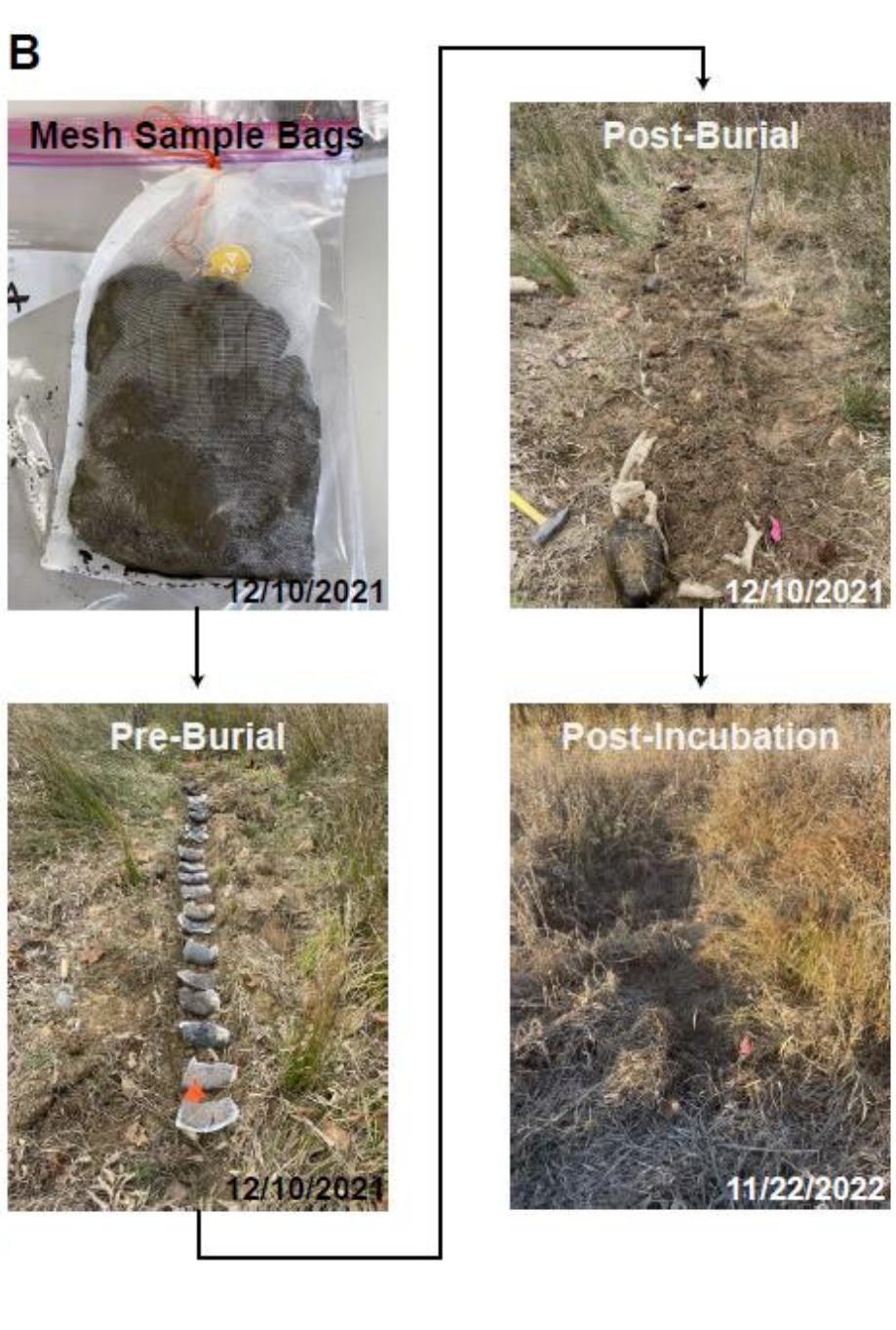
Table 1. Location information for soil samples including coordinates (WGS 84). "*" indicates replicates. Median ages of historic soils are based on ^{14}C dates (information in Table S1).

Soil Type	ID#	Creek Name	State	Latitude	Longitude	Median Age (CE)
Modern Wetland	01	Gramies Run	MD	39.6848	-75.8510	
	03	Sycamore	NC	35.8476	-78.7270	
	04	Reedy	NC	35.8301	-78.7540	
Historic Wetlands	05/18*	Gramies Run	MD	39.6886	-75.8529	1100
	06/19*	West Branch Little Conestoga	PA	39.9742	-76.3762	1804
	07	Big Elk 1	PA	39.7402	-75.8691	1109
	08	Roaches Run	MD	39.4434	-76.8021	444 BCE
	09	Big Elk 2	MD	39.6893	-75.8274	1766, 1761
	10	Little Elk 1	MD	39.7019	-75.8871	NA
	11	Little Elk 2	MD	39.7017	-75.8875	1096
	12	Sycamore	NC	35.8476	-78.7270	1448
	13	Reedy	NC	35.8301	-78.7540	1448, 722, 411
	14	Chiques	PA	40.0687	-76.4963	1249
	15	Valley	PA	40.0757	-75.4622	1248
	16	Christina	DE	39.6709	-75.7730	1185
	17	Northeast	MD	39.6408	-75.9484	966
Reference	02	Great Marsh	PA	40.1256	-75.7664	
	20	Gramies Floodplain	MD	39.6867	-75.8508	

1 year burial

At Gramies Run Floodplain restoration



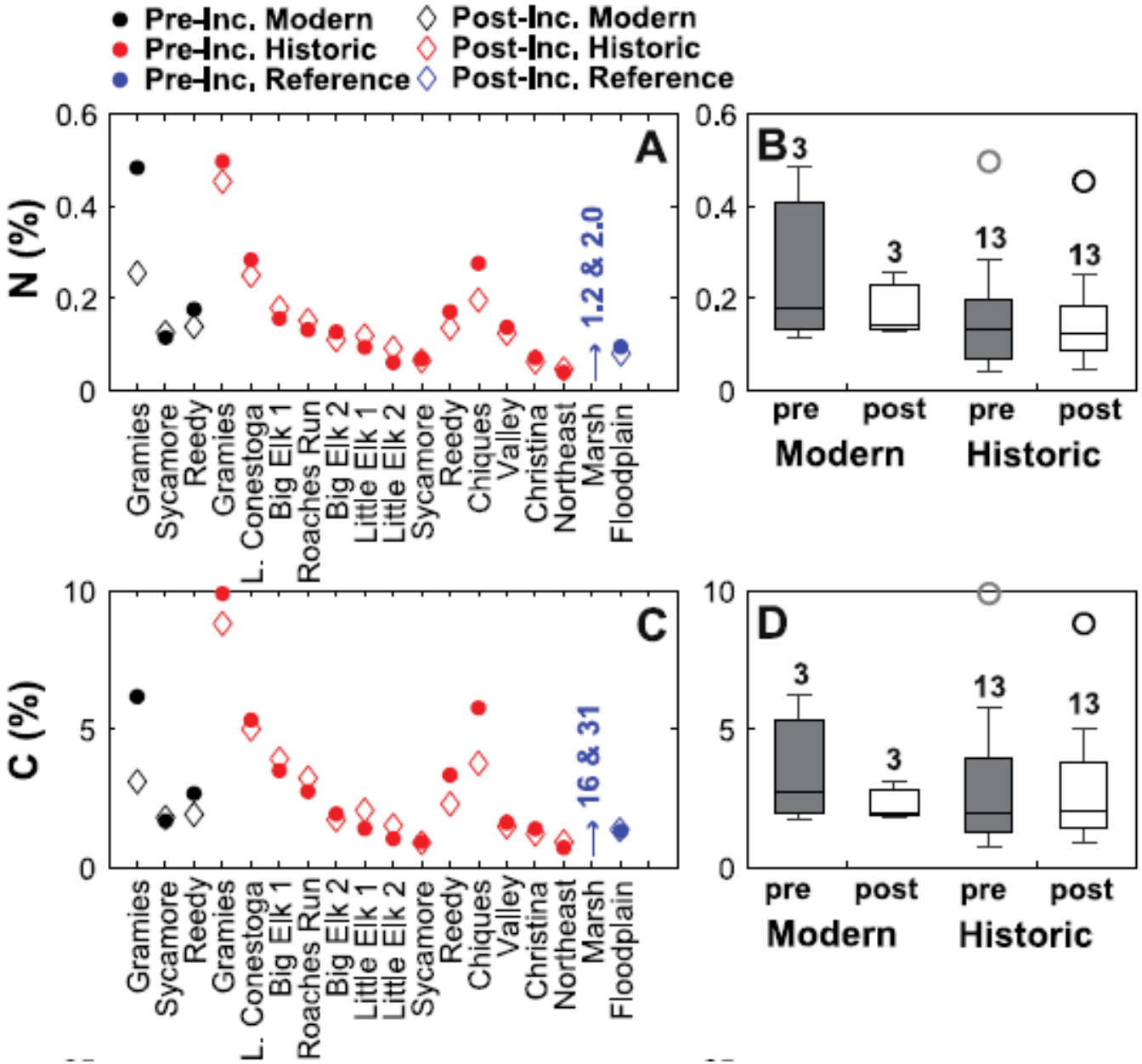


Select Comparisons –

modern versus relict/historic

& pre versus post burial

Statistical significance between pre- and post-incubation soils and between historic and modern soils are indicated with * and + respectively.



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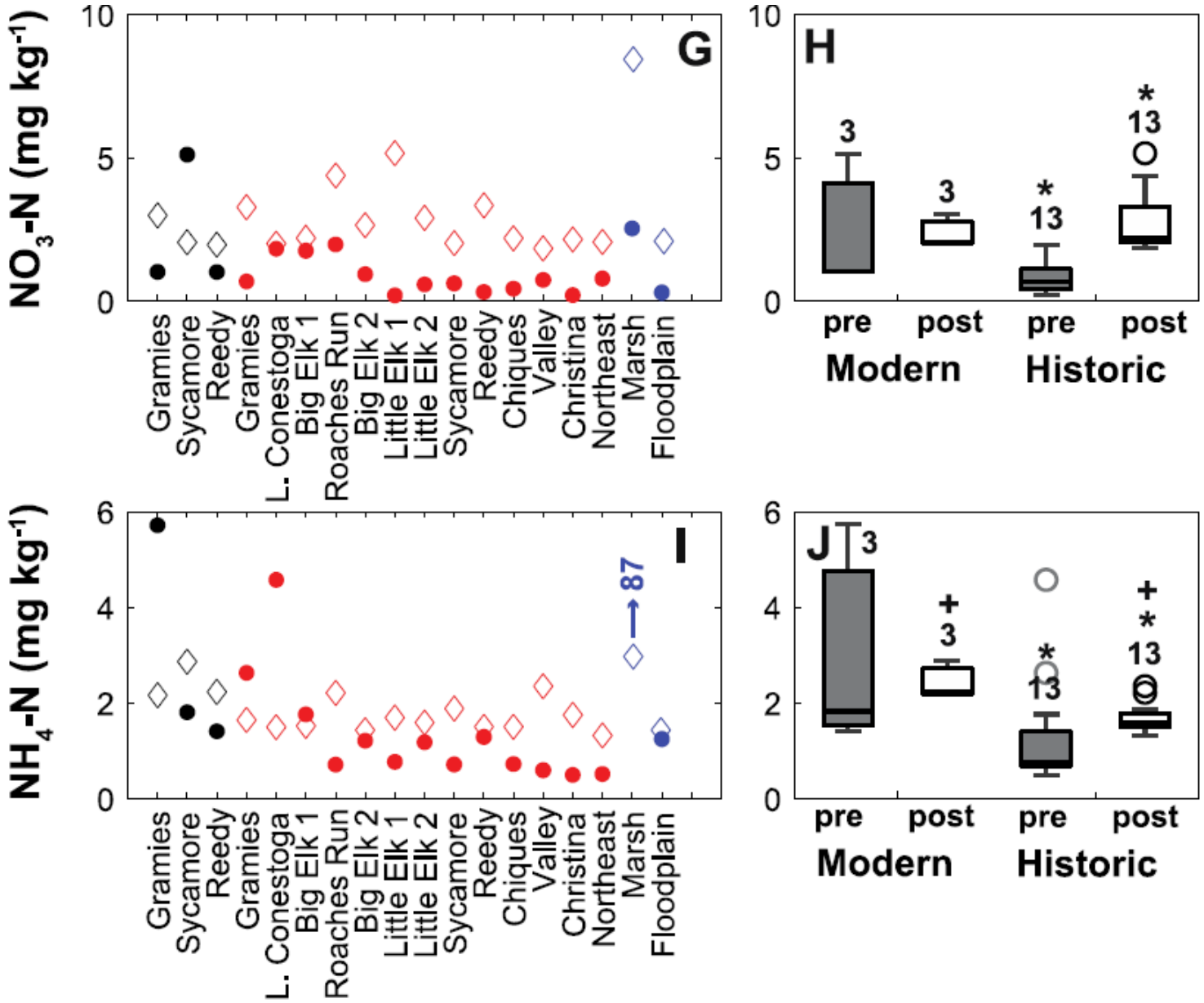
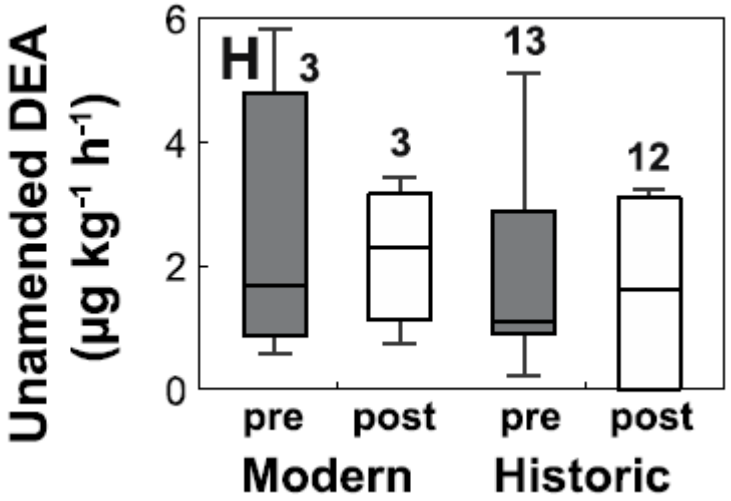
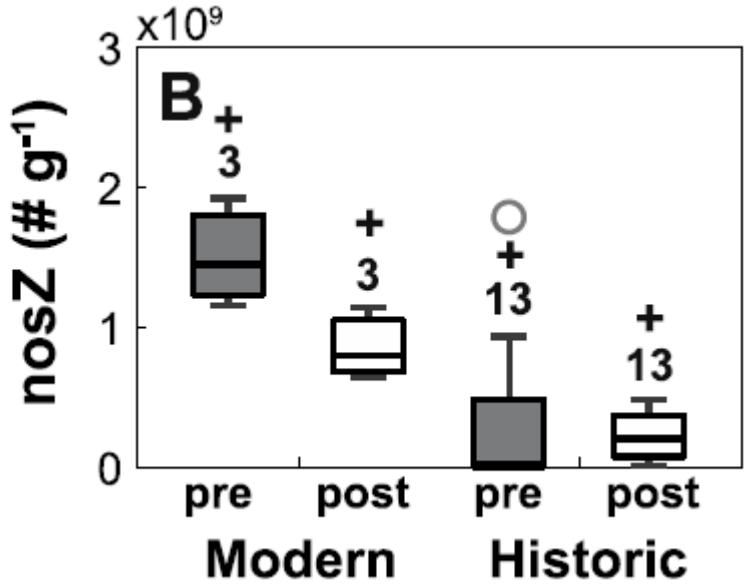


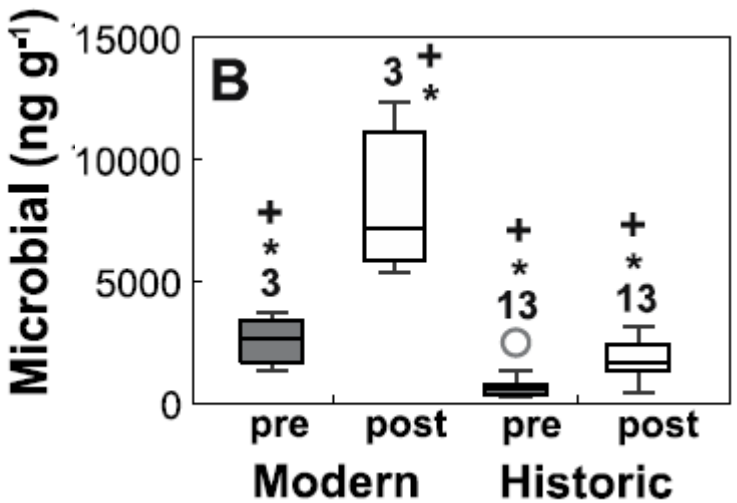
Denitrification rate



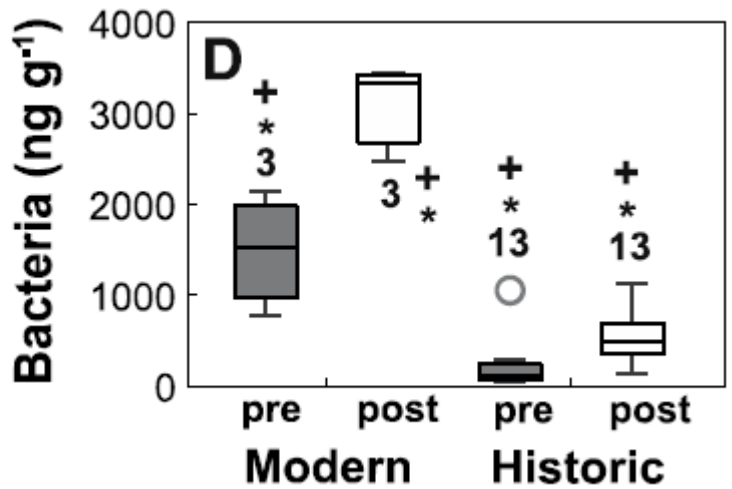
Denitrification genes



Total microbial biomass



Total bacterial biomass



Key Results

Pre-burial - modern wetland VERSUS relict soils:

- Relict/Historic soils
  - Recalcitrant organic carbon
  - were nutrient poor
  - lower microbial and bacteria counts
  - lower denitrification functional genes

Post 1-year burial:

- Different trajectories for relict and modern wetland soils

- Relict/Historic soils
  - slight increase in inorganic nutrients – some leaching potential?
  - slight increase in microbial biomass, denitrification functional genes
  - changes after 1 year burial < less than modern wetland soils

Key Deductions

- Relict/historic soil recovery is slow and may take time (> 3 years?).
- But these precolonial soils need to be leveraged in restorations. They contain valuable unique microbes that are missing in modern soils.
- In-situ retention (Big Spring type or *Stage Zero* restoration) may be preferable over disturbance and moving of soils.
- Water quality restoration targets need to be tempered based on these findings.

Increasing relict soil inoculum (Bais et al., In Prep)

Questions