Back From the Past?

Recovery of Buried Relict Soils on Restored Floodplains

Alexis Yaculak[1], Shreeram Inamdar[1], Jinjun Kan[2], and Marc Peipoch[2], Sujay Kaushal[3]

[1]Department of Plant and Soil Sciences, University of Delaware; [2]Stroud Water Research Center; [3]Department of Geology, University of Maryland

National Stream Restoration Conference

8/22/2023

USDA

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Floodplain Restoration in the Mid-Atlantic

Stream and Floodplain restorations represents a multibillion-dollar industry in the U.S

Approaches:

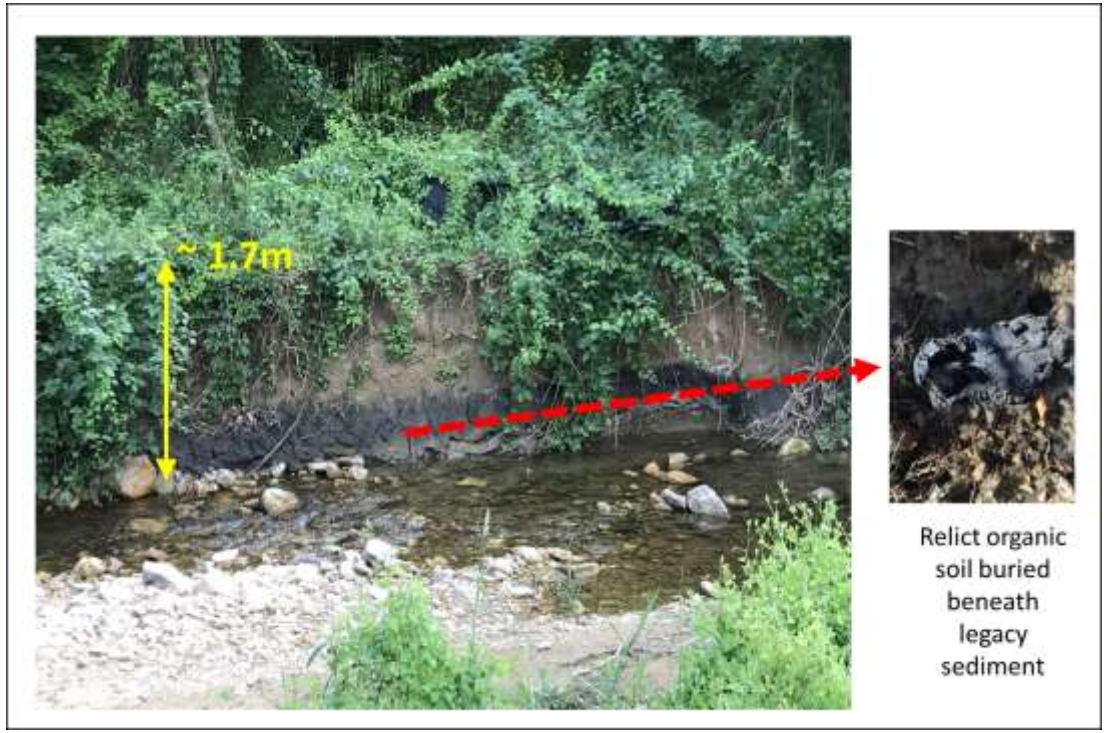
- Natural Channel Design (NCD)
- Regenerative Stormwater Conveyance (RSC)
- Legacy Sediment Removal (LSR)
- Stage Zero Restoration

Goals:

- Reduce streambank erosion
- Reduce watershed sediment and nutrient loads
- Increase stream water exchange with the floodplain

Buried Relict Soils

- Organic-rich (C and N) soil horizon from pre-colonial wetlands overlain by legacy sediment deposits
- Buried by legacy sediment deposits resulting from colonial era agricultural and deforestation practices.
- Buried organic horizon exists in many stream environments across the Mid-Atlantic U.S



Buried Relict Soils – Removal During Restoration

- Buried Relict Soils are typically removed with overlying legacy sediment during restoration

Relict soil horizons contain historical soil microbiomes and nutrients that could be leveraged to improve water quality at restored sites

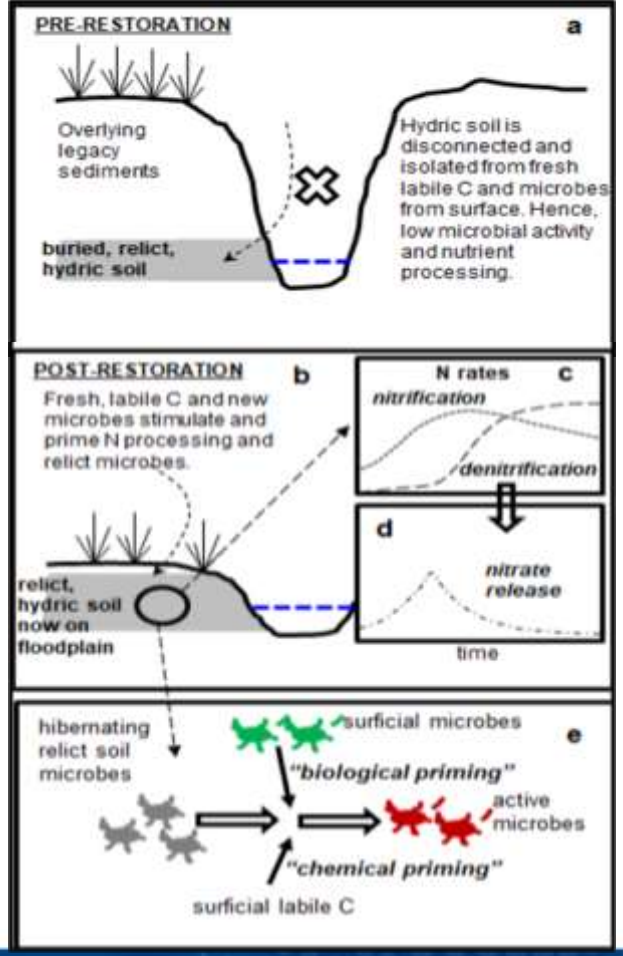
Pre-restoration

Post-restoration

Buried Relict Soils – Benefit to Restoration

“Daylighting” of relict soils

- Exposure of relict soil horizons to floodplain surface
- Enhance denitrification within the floodplain
- Improve nitrogen removal in the floodplain

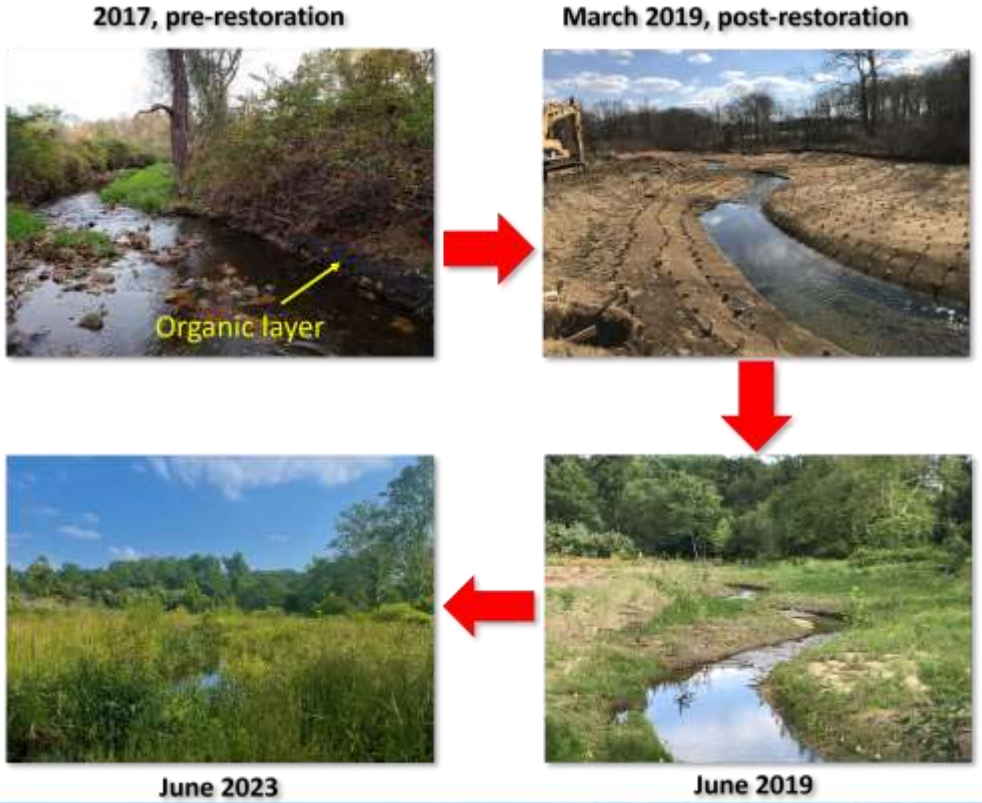


Overall Research Goal

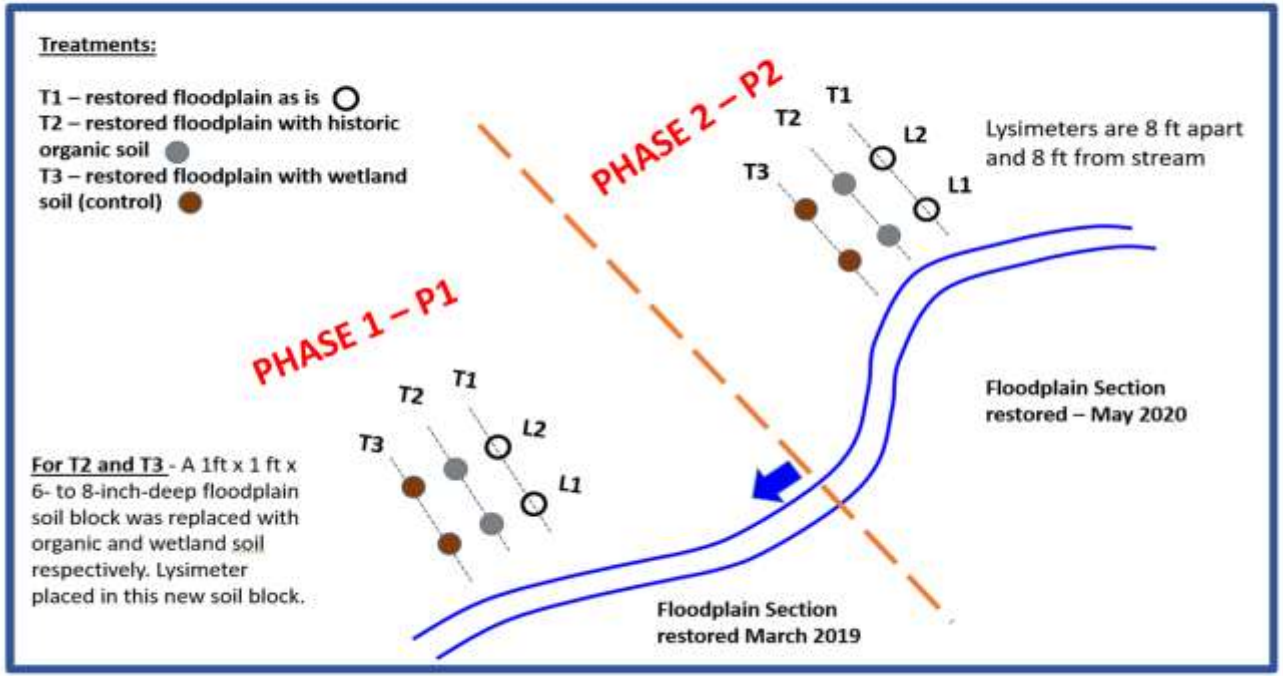
Investigate changes in relict soil following daylighting and provide guidance to stream restoration practitioners for its use for nitrogen removal

Study Site – Gramies Run Elkton, Maryland

- Floodplain restoration project completed between March 2019 and March 2020
- Removal and regrading of overlying legacy sediments
  - **Relict soil horizon was removed**
- Raising of streambed
- Construction of instream structures



Site Design


Treatments:
T1 – restored floodplain as is
T2 – restored floodplain with historic organic soil
T3 – restored floodplain with wetland soil (control)
PHASE 2 – P2
T1
T2
T3
L2
L1
Lysimeters are 8 ft apart and 8 ft from stream
PHASE 1 – P1
T1
T2
T3
L2
L1
Floodplain Section restored – May 2020
For T2 and T3 - A 1ft x 1 ft x 6- to 8-inch-deep floodplain soil block was replaced with organic and wetland soil respectively. Lysimeter placed in this new soil block.
Floodplain Section restored March 2019

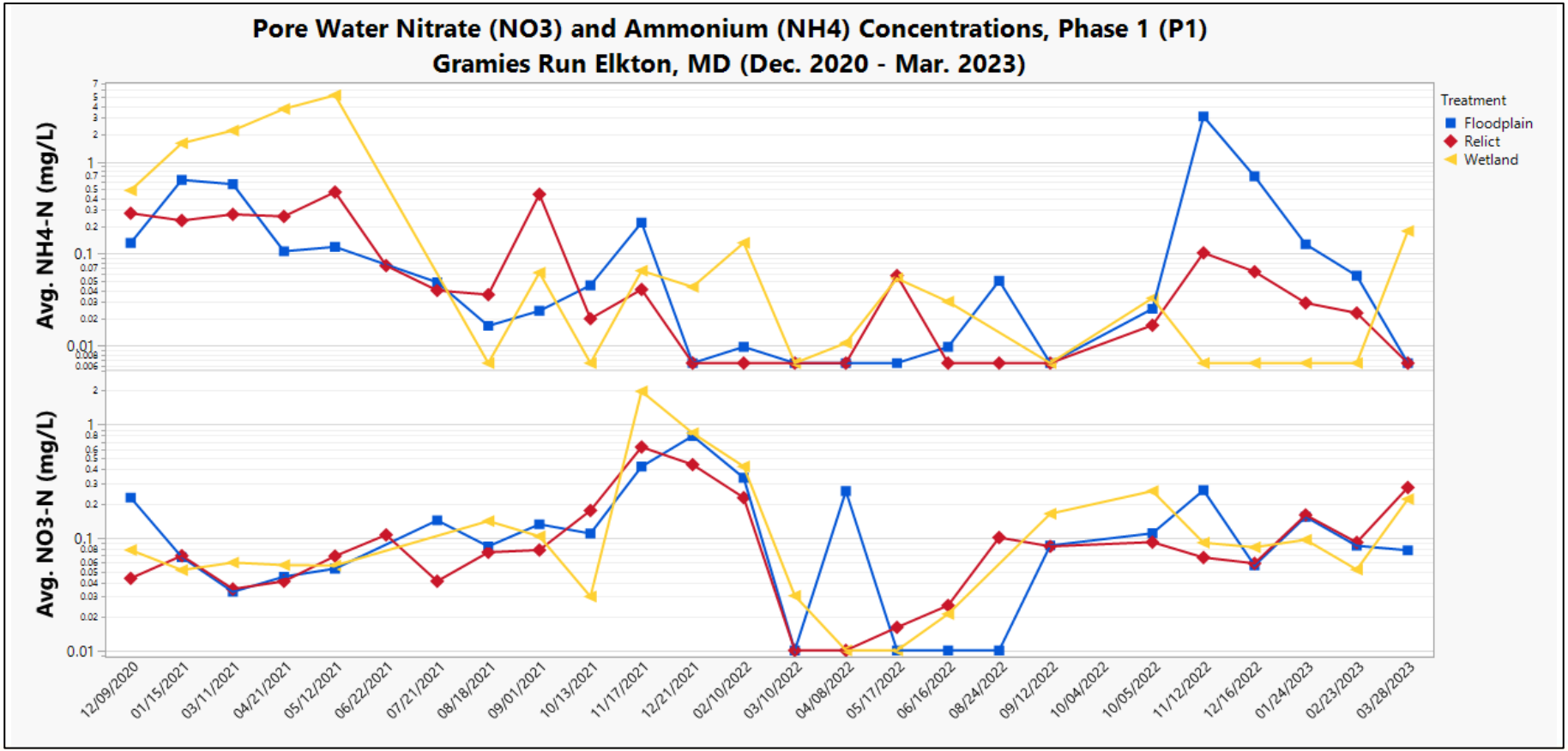
Sampling and Analyses

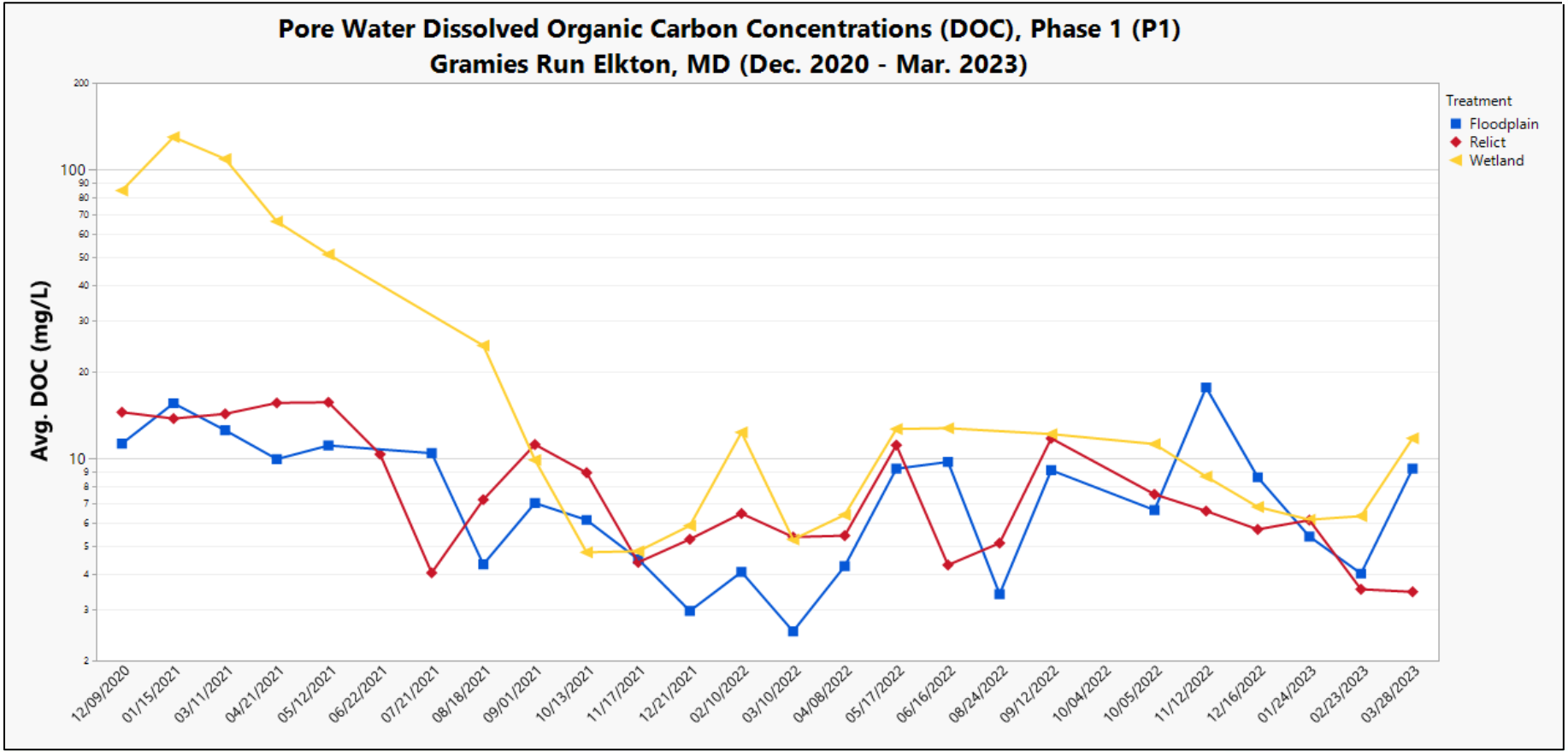
Soil Pore Water Chemistry:

- Monthly sampling of pore water from all soil treatments (Dec. 2020 – Dec. 2023)
- Nitrate (NO3), Ammonium (NH4), Total Nitrogen (TN), Dissolved Organic Carbon (DOC)

Soil Chemistry:

- Twice yearly (spring and fall) sampling of soil from all soil treatments (Nov. 2020 – Nov. 2023)
- Nitrate (NO3), Ammonium (NH4), Total Nitrogen (TN), Total Carbon (TC)


Pore Water Nitrate (NO3) and Ammonium (NH4) Concentrations, Phase 1 (P1)
Gramies Run Elkton, MD (Dec. 2020 - Mar. 2023)
Avg. NH4-N (mg/L)
Avg. NO3-N (mg/L)
Treatment
Floodplain
Relict
Wetland
12/09/2020
01/15/2021
03/11/2021
04/21/2021
05/12/2021
06/22/2021
07/21/2021
08/18/2021
09/01/2021
10/13/2021
11/17/2021
12/21/2021
02/10/2022
03/10/2022
04/08/2022
05/17/2022
06/16/2022
08/24/2022
09/12/2022
10/04/2022
10/05/2022
11/12/2022
12/16/2022
01/24/2023
02/23/2023
03/28/2023


Pore Water Dissolved Organic Carbon Concentrations (DOC), Phase 1 (P1)
Gramies Run Elkton, MD (Dec. 2020 - Mar. 2023)
Avg. DOC (mg/L)
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
Treatment
Floodplain
Relict
Wetland
12/09/2020
01/15/2021
03/11/2021
04/21/2021
05/12/2021
06/22/2021
07/21/2021
08/18/2021
09/01/2021
10/13/2021
11/17/2021
12/21/2021
02/10/2022
03/10/2022
04/08/2022
05/17/2022
06/16/2022
08/24/2022
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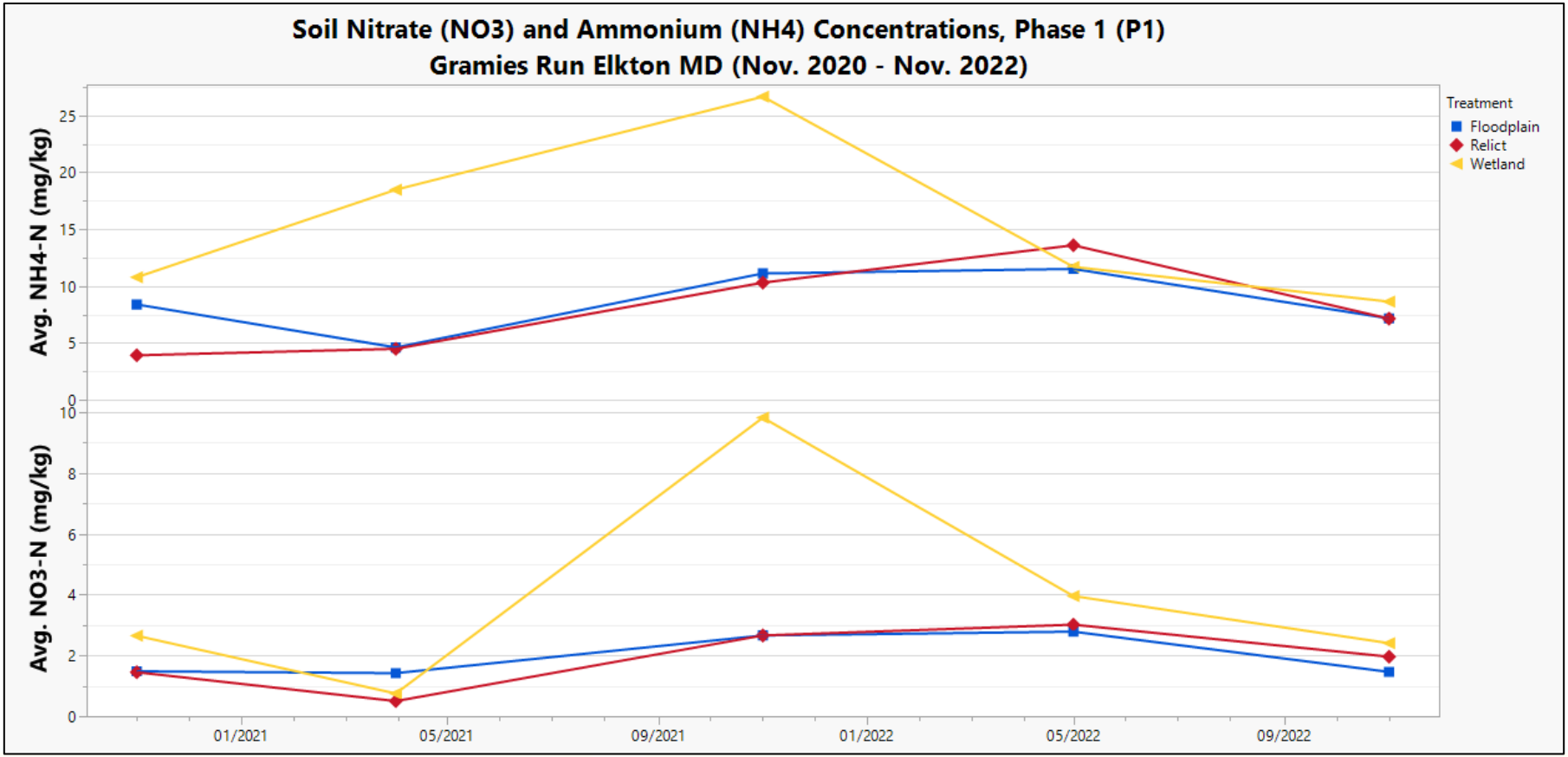
03/28/2023


Soil Nitrate (NO3) and Ammonium (NH4) Concentrations, Phase 1 (P1)
Gramies Run Elkton MD (Nov. 2020 - Nov. 2022)
Avg. NH4-N (mg/kg)
Avg. NO3-N (mg/kg)
Treatment
Floodplain
Relict
Wetland
01/2021
05/2021
09/2021
01/2022
05/2022
09/2022

Key Findings

- Results show an increase in pore water NH4 concentrations followed by an increase in NO3 concentrations across all three treatments in the first year of the study (Dec. 2020 – Dec. 2021). This may be the result of mineralization, nitrification, and low denitrification rates
- There is an observed increase in soil NH4 and NO3 concentrations across treatments in first year of study (Nov. 2020 – Nov. 2021). Soil NH4 and NO3 concentrations are similar across treatments by end of second year of study (Nov. 2021 – Nov. 2022).
- Current findings may indicate that the recovery of relict soils is slow and nutrient reductions may not be expected in the first few years (1-2)

Future Work

- Continued pore water and soil sampling through Dec. 2023 (3-year data set)
- Denitrification enzyme assays (DEA) are being performed to assess denitrification rates of soil treatments
- Microbial communities (dormant and active) and functional genes are also being analyzed for all treatments and will provide additional insights into recovery of buried, relict soils.

Thank You!