More than Dirt: Soil Health needs to be emphasized in floodplain restorations

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Talk based on recently published work -

soil systems

MDPI

Perspective

More Than Dirt: Soil Health Needs to Be Emphasized in Stream and Floodplain Restorations

Shreeram P. Inamdar [1,*], Sujay S. Kaushal [2], Robert Brian Tetrick [3], Larry Trout [4], Richard Rowland [5], Dennis Genito [5] and Harsh Bais [1]

Manuscript available for free from link below –
Soil Syst. 2023, 7, 36. https://doi.org/10.3390/soilsystems7020036

- Provides an **initial blueprint for how Soil Health can be incorporated in floodplain restorations**.
- Academia-industry-government partnership!
- Blueprint being tested with data.

Introduction & Benefits

- Stream & floodplain restorations – growing billion-dollar industry
- Very popular in the mid-Atlantic & Chesapeake Bay – number of permits & length of restoration has increased
- Cost = $1600-4000 per meter of restored length
- Key tool to mitigate nutrient pollution and meet regulatory TMDL goals
- Multiple approaches – Natural Channel Design (NCD), Legacy Sediment Removal (LSR), Regenerative Stormwater Conveyance (RSC), Stage 0, and various combinations
- Has provided important gains in erosion control & water quality improvement

Challenges & Questions

- **However, there are some challenges & questions –**
  - Long-term effectiveness for sediment & nutrient reduction
  - Attainment of “functional” or ecological uplift; ecosystem services
  - Tree removal versus legacy sediments
  - Invasive vegetation
  - Public acceptance

Soil Health is Missing!

- However, there have been some challenges & questions too –
  - Long-term effectiveness for nutrient reduction
  - "Functional" or ecological uplift; ecosystem services
  - Invasive vegetation

Lack of Soil health in restored floodplains may be contributing to some of the challenges above

What is Soil health? – *soil physical, chemical & biological properties that enhance ecosystem services – infiltration, erosion control, nutrient removal & cycling (e.g., denitrification), insect habitat, etc.*

Why Soil Health Not Addressed?

Lack of Soil health in restorations because:

- *Lack of knowledge about soil health and its important consequences*
- ***Absence of design & implementation "best practices"***
- ***Unavailability of specific soil metrics & tests***
- *Unknown "Desired" or "reference" soil conditions*
- ***Lack of regulatory credits or benefits for restoration agencies***

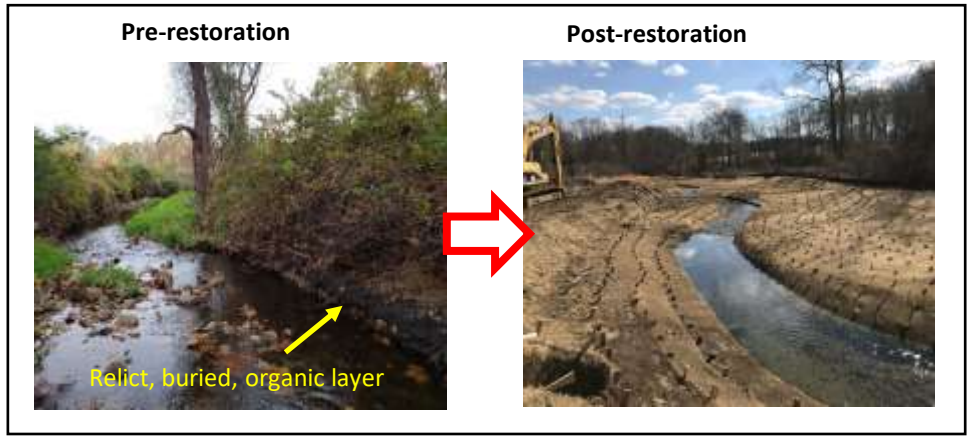
Our blueprint provides initial guidance to address these knowledge gaps.

Stream restoration impacts on floodplain soil health

Reduced floodplain soil thickness

Compacted floodplain soils with low porosity

Decreased water infiltration and retention



Decreased plant rooting depth resulting in displacement of tree saplings and "root-ball potholes"

Reduction and homogenization of organic matter in restored floodplains

Altered nutrient removal capacity (e.g., denitrification) due to loss of organic matter & microbiome

LSR+NCD

Destruction and loss of mycorrhizal fungi and soil arthropods

Loss of buried organic horizons and their historic soil microbomes

Nutrient, contaminant leaching from soil conditioners and introduced foreign soils/amendments

Inamdar et al. 2023

Loss of precolonial soils with current practice

~1000 year old precolonial hydric soil not retained on restored floodplain because of non-consideration and constraints of initial NCD design

The ~1000 year old precolonial hydric soil likely contains original, native microbiome and seeds and should be preserved, as is, in place

How soon will the dormant microbiome recover? Will the carbon provide for denitrification in the restored floodplain? Will the historic microbiome "rewild" the degraded floodplain?

- Alexis Yaculak talk – Session H, 2.30 pm

Inamdar et al. 2023

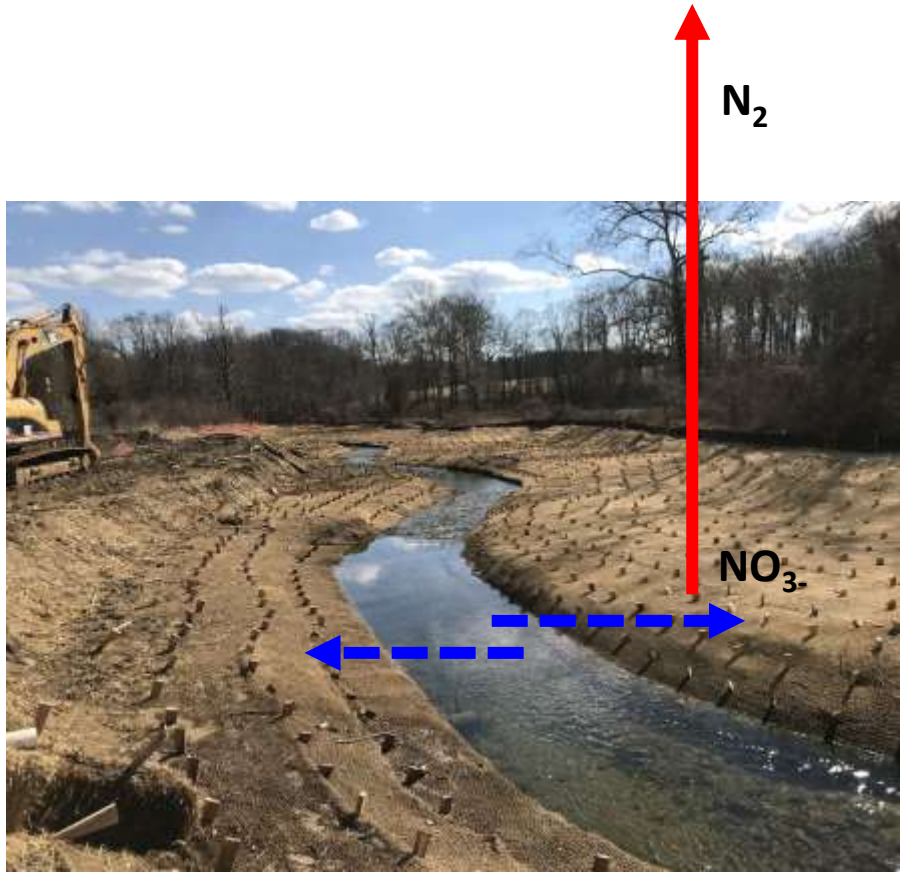
Initial tests suggest that historic hydric soils contain novel microbes that may enhance plant growth!

- Bais et al. In prep.

Cannot afford to lose this valuable biodiversity.

Microbial inoculum

Denitrification N removal in restored floodplains



Current approach - primarily based on hydrologic connectivity
Default denitrification rates are used in the design process

But if soil organic matter and microbiome is enhanced – <u>denitrification rates could be much higher</u>!

Improved soil health can provide additional/greater water quality credits.

Recommended Best Practices for Soil Health

- *Provide sufficient floodplain soil thickness*
- *Reduce floodplain compaction & disturbance – work from the stream bed*
- *Retain original soils/hydric horizons in place (where practical) and use native seeds*
- *Avoid external commercial soil conditioners; increase spatial OM heterogeneity*
- *Use specific soil tests pre and post restoration*
- *Target "desired" soil health end points*
- ***Include these practices in restoration design so that restoration agencies receive credit for protecting soil health - incentivize!***

Key Soil properties that can be measured to assess floodplain soil health

Soil Metric	Motivation/use for	Method/citation
Physical soil properties		
Bulk density	Compaction	Blake and Hartge, 1986
Porosity	Compaction, water retention, nutrient conditions, microbial habitat	Derived from bulk density measurements; Weil & Brady, 2017
Texture	Basic soil metric used for numerous other properties like soil hydraulic conductivity (via pedotransfer function)	Gee and Bauder, 1986
Aggregate stability	Potential for erosion resistance	Kemper and Roseanu, 1986
In-situ infiltration rate	Water retention; potential for surface runoff and erosion	Reynold and Elrick, 1990
Chemical soil properties		
pH & organic matter	Basic chemical condition	Thomas, 1996
Electric conductivity	Presence of ions and metals, salinization	Rhoades, 1996; a hand-held electric conductivity sensor – e.g., Hanna Soil Test meter.
Total C and N	C and N sequestration	Nelson & Sommers, 1996
Nitrate-N and ammonium-N by KCl extraction	Inorganic N removal and retention in soils	Saha et al. (2018)
Biological soil properties		
Phospholipid fatty acids (PLFAs)	Broader test for active microbial biomass; fungi to bacteria ratio	Buyer and Sasser, 2012
Fine root biomass	Potential for plant growth & recovery	Root sampling with narrow soil auger - e.g., Frasier et al., 2016

Should be – easy to measure and interpret & inexpensive
Available to practitioners (via commercial labs)

Inamdar et al. 2023

Benefits & ecosystem services from improved floodplain soil health and integrity

Increased water infiltration, soil moisture storage and reduced surface runoff

Increased long-term sustainability and resilience to climate change

Enhanced soil aggregation and reduced soil erosion

Improved habitat for aquatic & terrestrial biota

Improved nutrient cycling, sequestration, and reduced nutrient exports

Greater microbial diversity and improved microbial soil functions

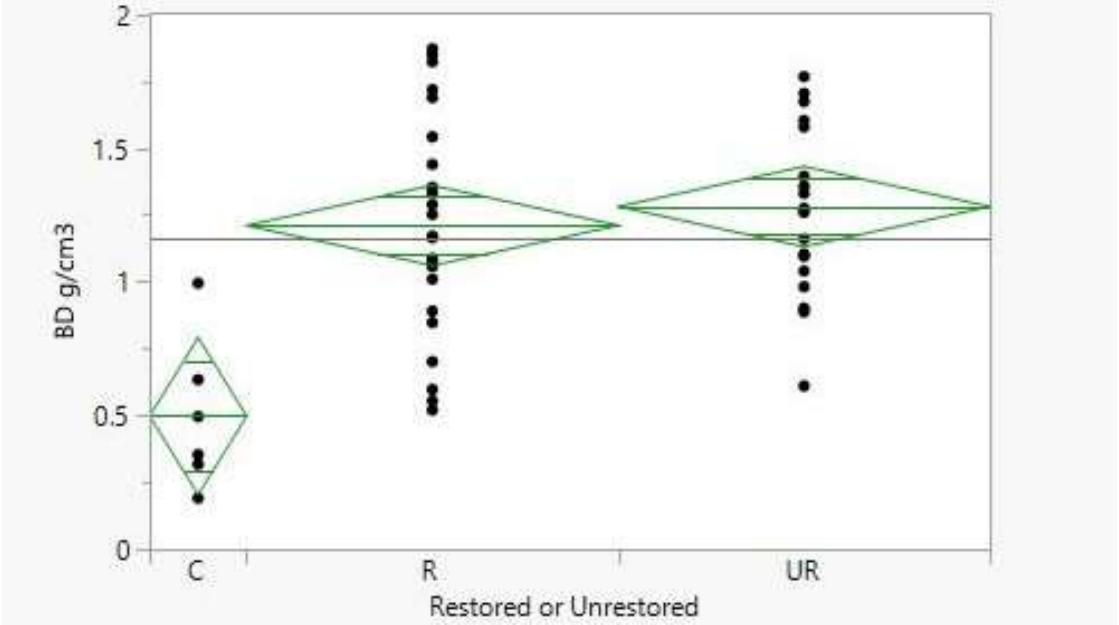
Reduced opportunity for invasive plants and increased native species

Increased plant survival & health, and reduced plant “potholes” with large storms

Next Steps

- *We are currently **assessing the value/sensitivity of soil health metrics** for pre and post floodplain restoration conditions – **0 to 25 years post restoration**!*
- *2 Chesapeake Bay Trust (CBT) funded projects*
- *> 12 restored sites across the mid-Atlantic*
- *Comparisons with "reference" or "desired" or "control" soil conditions*

Bulk density comparisons
(lower is better)



Next Steps

- *Temporal **recovery of buried relict hydric soil being evaluated** – USDA & EPA project*

- *When do the dormant microbes in relict soils "wake up" and do they contribute to denitrification?*

- *Also assessing **if soil metrics (isotope 15N) provide estimate on long-term effectiveness** – water quality and functional uplift – CBT project*

Next Steps

- *We need your participation – scientists, practitioners, & regulators*
- *Developing acceptable soil health recommendations*
- *Revising floodplain restoration design protocols to include soil health*
- *Revised protocols should benefit the environment and all stakeholders*

- ***Please contact us if you are interested in shaping floodplain science, practices, & policy*** *– lnamdar@udel.edu (or have sites we can sample for soil health)*

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