From soil degradation to restoration via soil microorganisms

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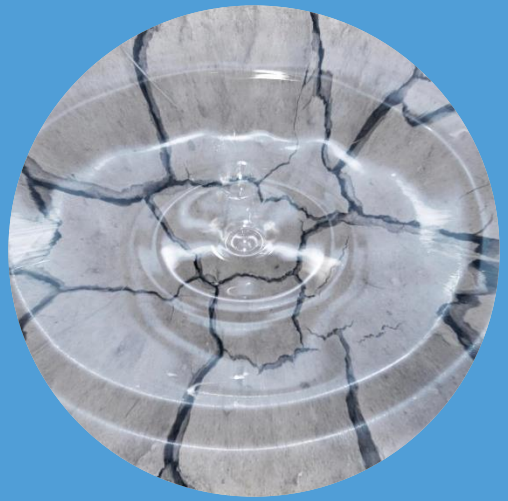

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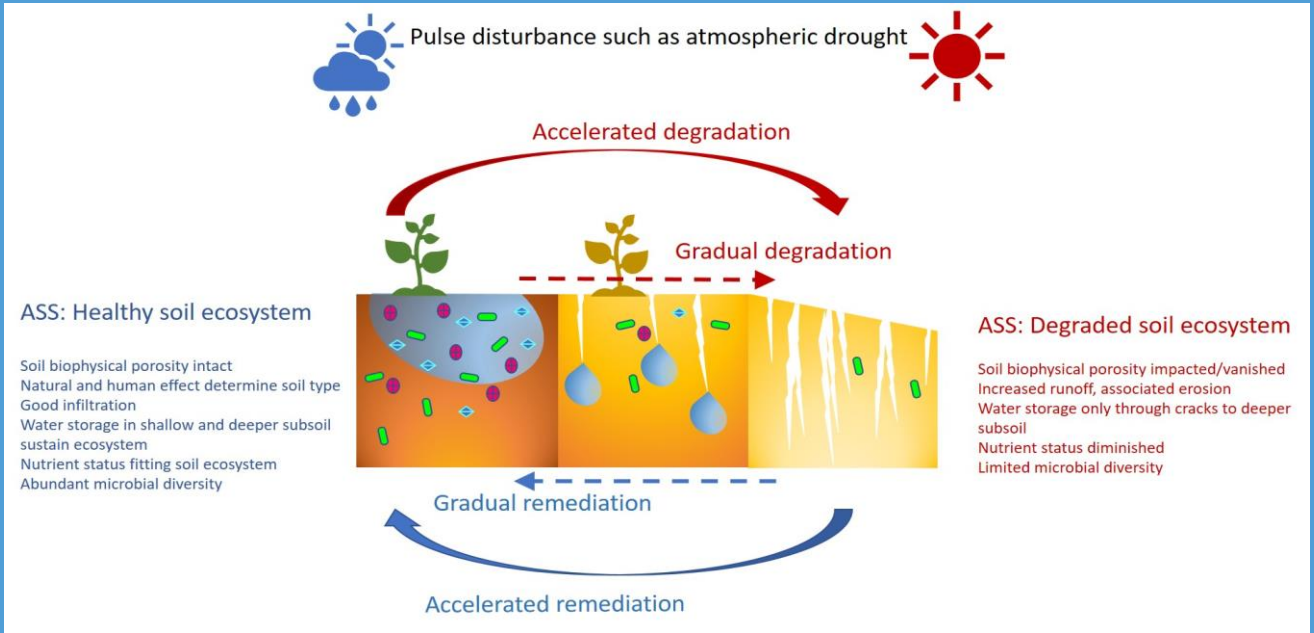
Soil degradation and remediation



What are the effective strategies for remediation of degraded soil?

Existing approaches for soil restoration

Replanting (wetlands)

Photo credit: Wikipedia

Replanting (trees)

Photo credit: Wikipedia

Cover crops, weed management and no-till practices

Photo credit: Paul Jasa, University of Nebraska-Lincoln

This works for moderately degraded lands…

Possible approaches for soil restoration

...but what about severely degraded lands?

Photo credit: Andrea Borkenhagen, Colorado State University

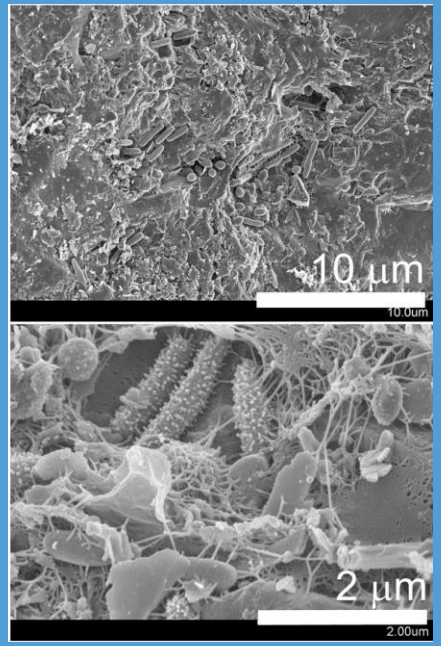


Photo credit: Lewis Lab at Northeastern University

Solution: restoration via microorganisms!

State-of-knowledge

Microbial community structure and diversity are used as indicators of soil degradation. However, they perform an array of vital soil functions. Thus, they should be seen as facilitators of ecosystem changes, and not just as the followers.

Previous work (*e.g.*, Zheng *et al.*, 2018, Volk *et al.*, 2016) showed that bacteria improved soil water holding capacity and increased soil water availability.

Still, little is known about the mechanisms how microorganisms improve soil hydraulic properties. The cross-over between soil biology and soil physics disciplines has not been sufficiently explored.

Research objectives

1) Find promising soil microbes

2) Understand mechanisms how microorganisms affects soil physical properties

3) Investigate how indigenous microbiology and organic materials can be used to restore degraded topsoil

Standardization of methodology

- Setting appropriate controls
- Soil sterilization
- Soil compaction
- Temperature and humidity
- Monitoring of microbial growth

Challenges

- Combination of soil physics and soil microbiology
- Preventing contamination control
- Variability depending on soil type
- Incubation in ‘living’ soil

Methodology

Soil preparation

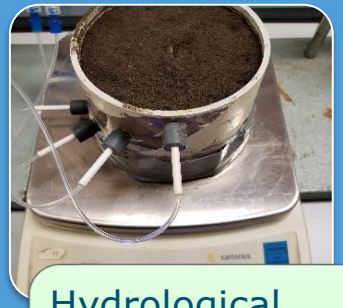
- Sieving
- Sterilization (double autoclaving)

Bacteria preparation

- Growing on TSB plates
- Suspending in water

Soil inoculation

- Mixing soil with bacterial suspension
- Incubating for 10-24 days

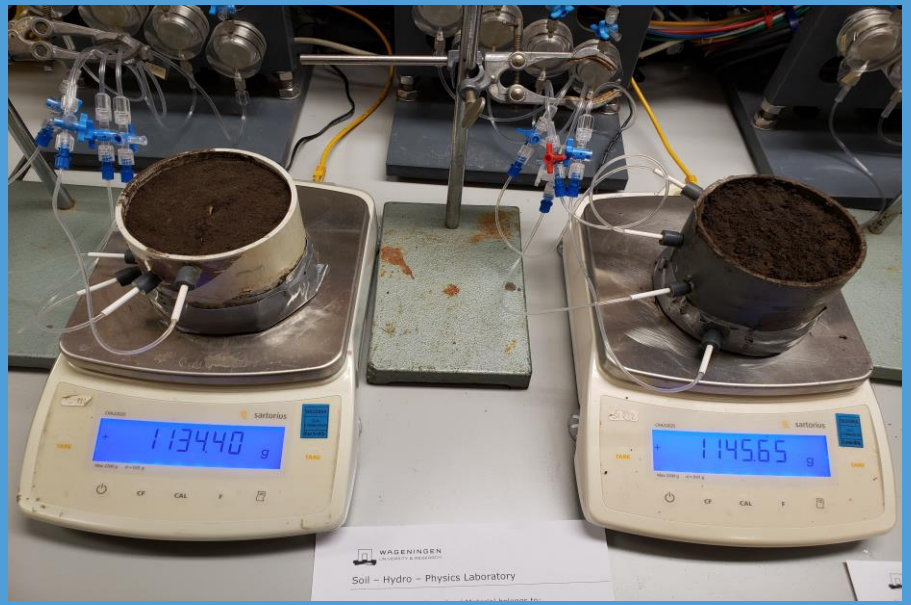


Hydrological measurements

- Evaporation method
- Pressure plate method

Results: evaporation method

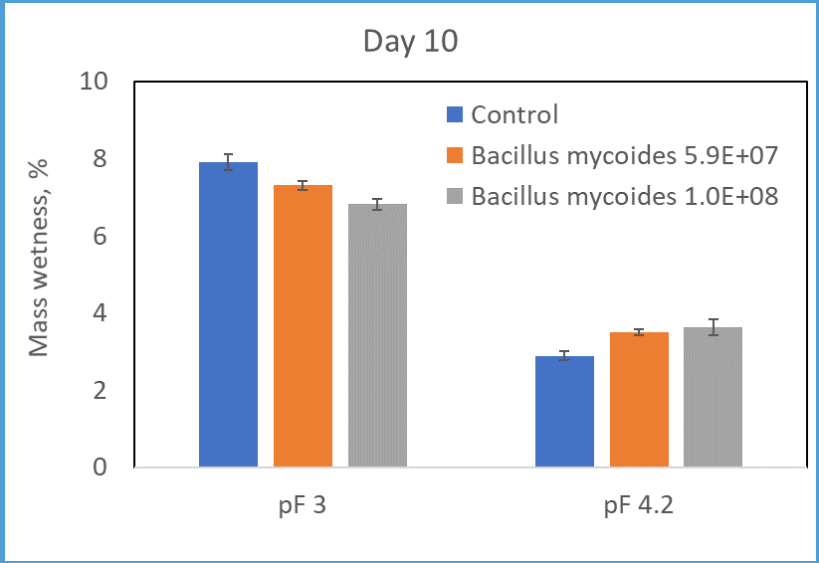
Control

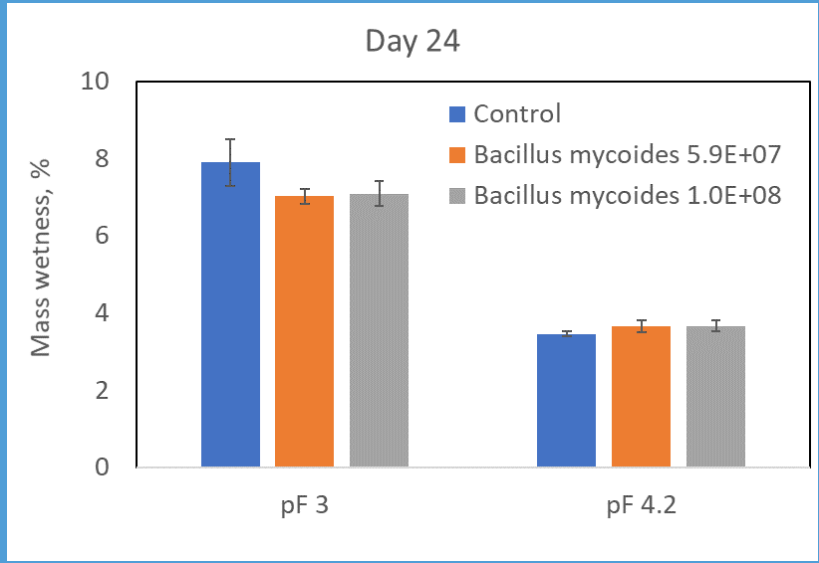


With *Bacillus mycoides*

After three weeks soil with *B. mycoides* retains more water

Results: pressure plate method





- At higher water availability (pF 3) control soil holds more water
- However, in dry soil (pF 4.2) inoculated soil has better water holding capacity
- Better moisture availability for plants under water limiting conditions

Next steps

- Testing more species of microorganisms
- Effect of soil type
- Incubation in ‘living’ soil
- Investigating microbial community dynamics
- Field experiments

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Comments?