

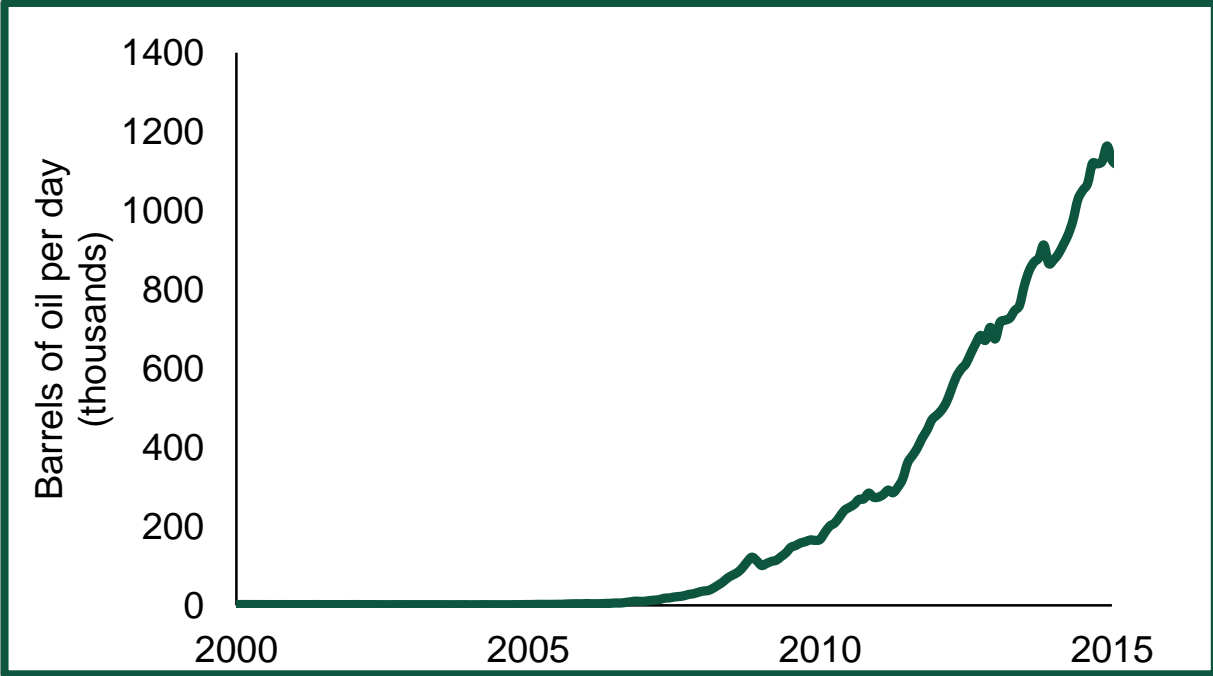
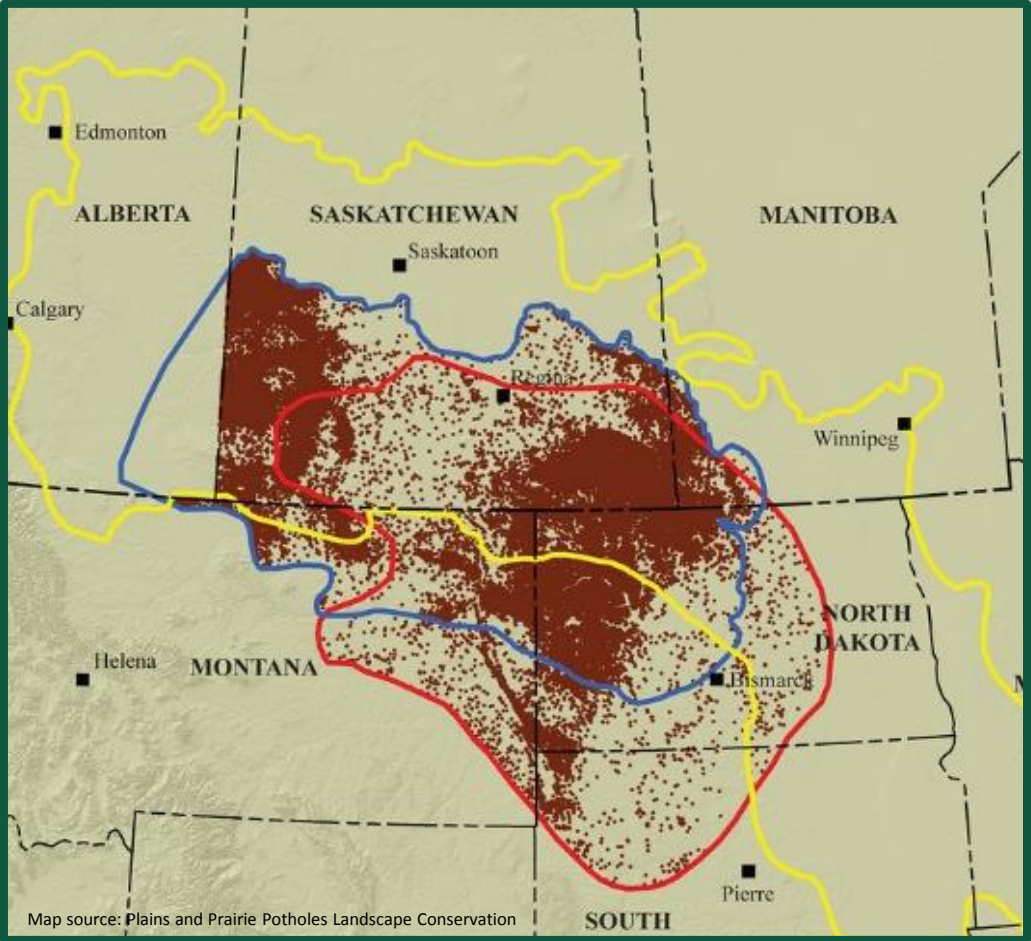
# Thermal desorption impacts on soil chemical, physical, and biological properties: Evaluation for agricultural production

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# Bakken oil production



Data: North Dakota Department of Mineral Resources

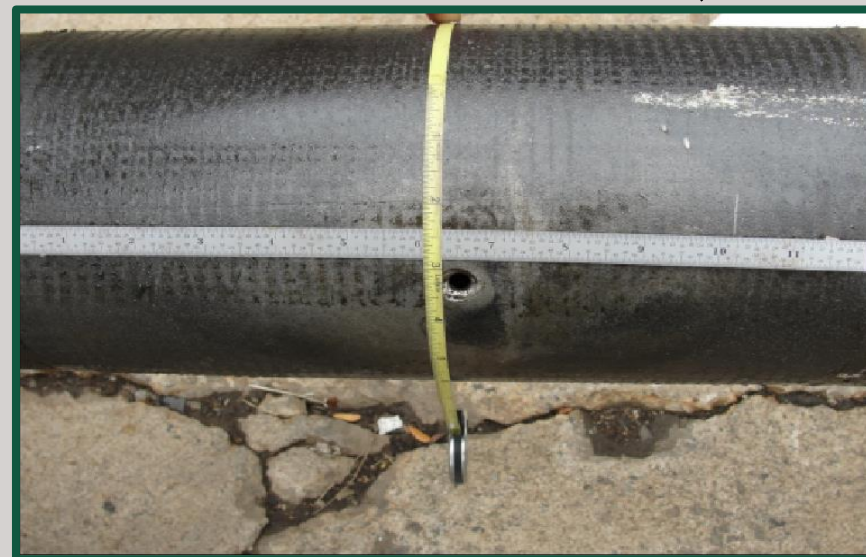
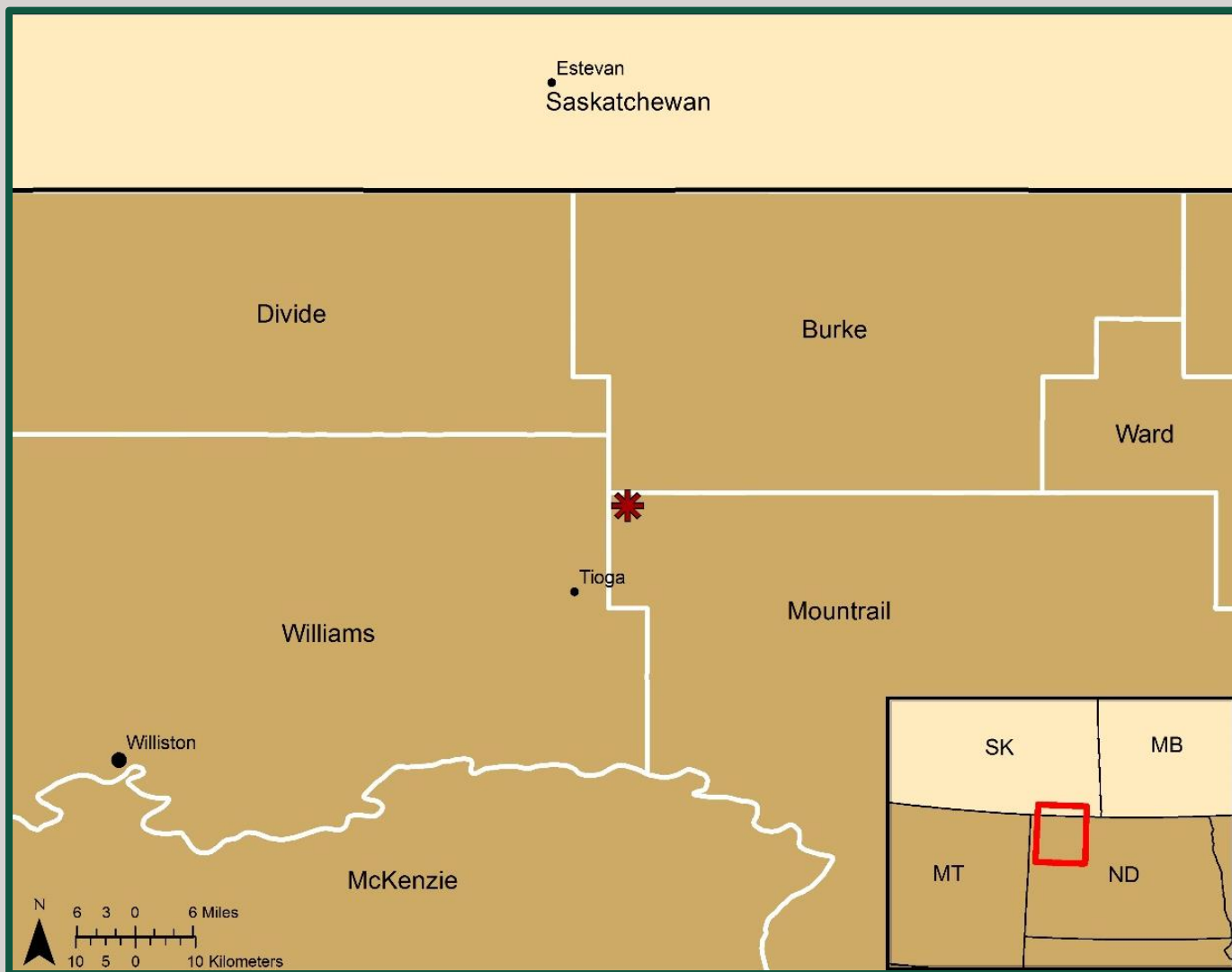
- Petroleum related wells
- Williston basin
- Bakken formation



# 2013 Oil spill



8.5 mm diameter hole released 21,000 barrels



# Remediation objectives



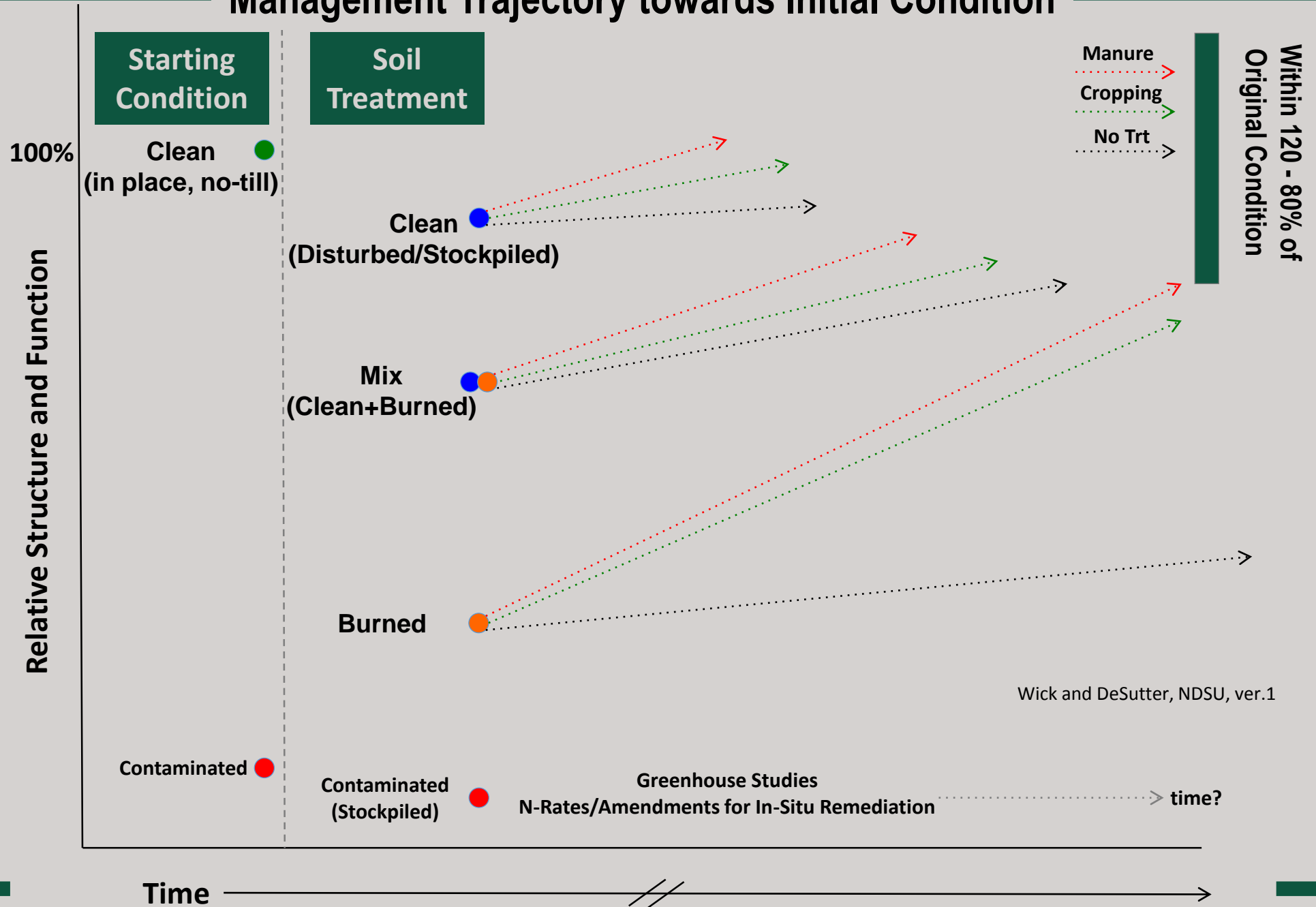
- 1) Reduce contaminant concentration
- 2) Return the land to pre-spill levels of agricultural productivity



- Landowner
- Oil company
- Remediation professionals
- NDSU
- Regulatory agency



# Management Trajectory towards Initial Condition



# Holistic Approach to the Remediation/ Reclamation/Restoration of Soils



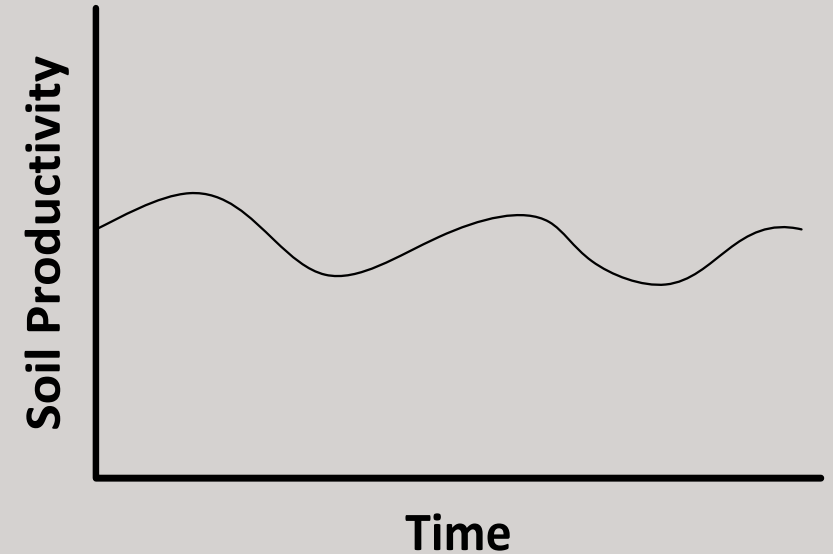
**Soil Physical Properties**  
-Available water  
-Cone Penetrometer Resistance or Bulk Density

**Soil Biological Properties**  
-Nutrient Cycling  
-Carbon turnover  
-Enzyme Production  
-Microbial and Fungal Pools

**Soil Chemical Properties**  
-Electrical Conductivity  
-Sodium Content  
-Nutrients  
-pH

**Soil Health/Quality**

**Yield or  
Productivity**





# Can we use TD soils for cropland production?



## Laboratory analyses

- Physical characteristics
- Chemical characteristics

## Greenhouse experiments

- Plant growth and yield
- Contaminant uptake
- Soil respiration

## Field research plots

- Large scale plant growth and yield
- Biological indicators
- Contaminant uptake
- Contaminant degradation
- Surface energy balance

# Lab findings: soil characteristics following TD



• Particle size, clay mineralogy, available water =

• Soil organic C, surface area, total aggregation —

• Saturated hydraulic conductivity +

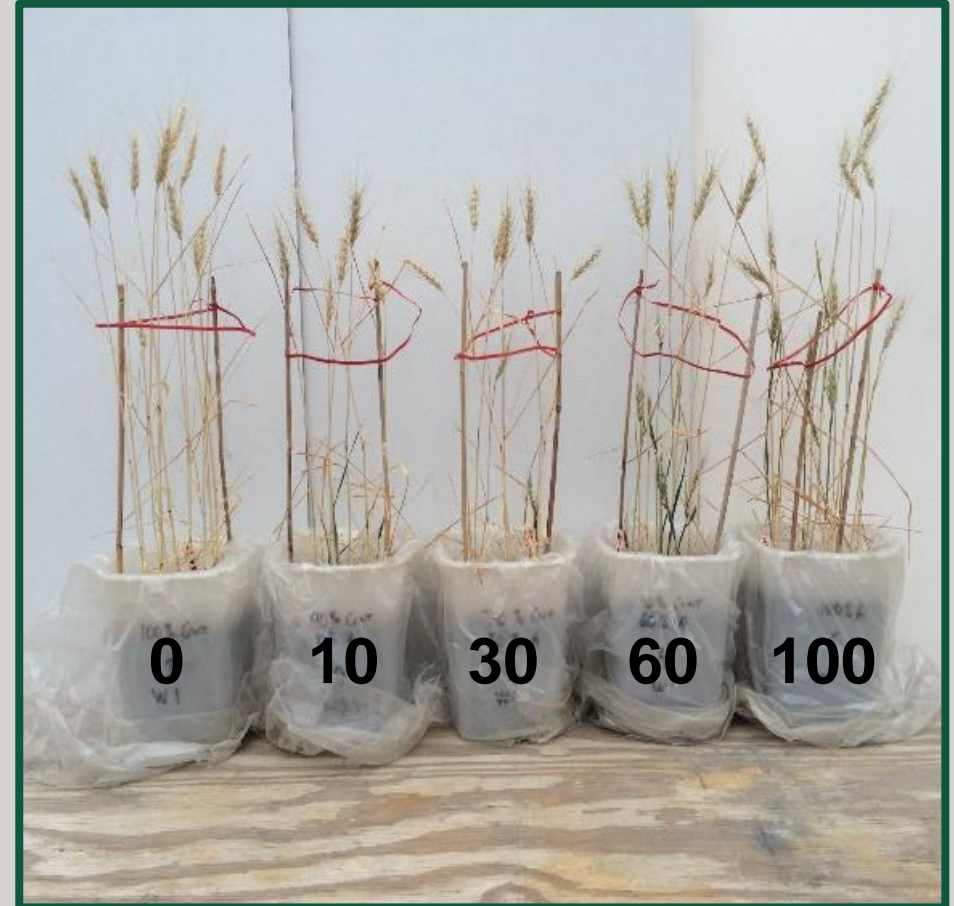
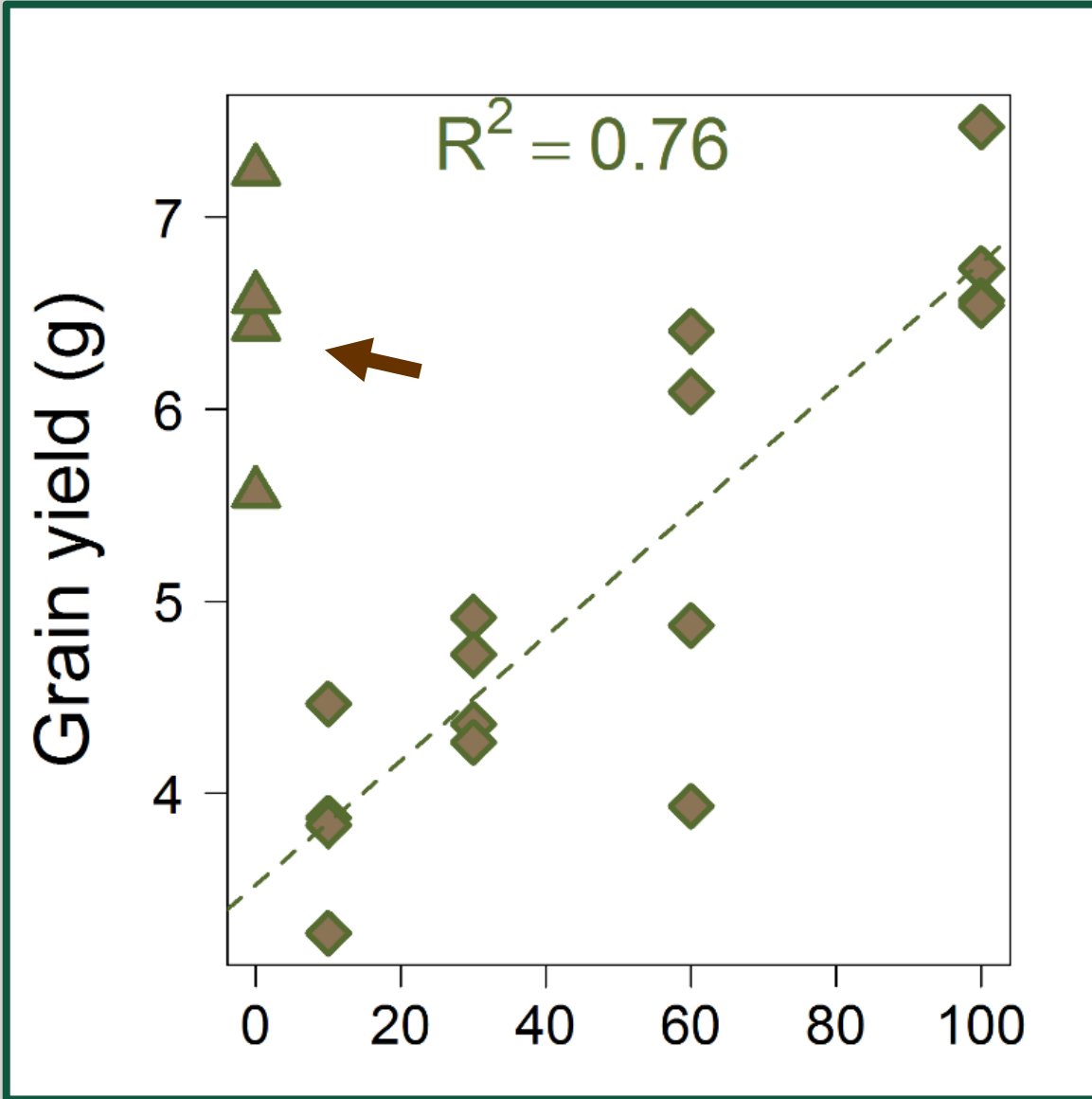
• Cation exchange capacity —

• Cation selectivity =

• pH +



# Greenhouse experiments

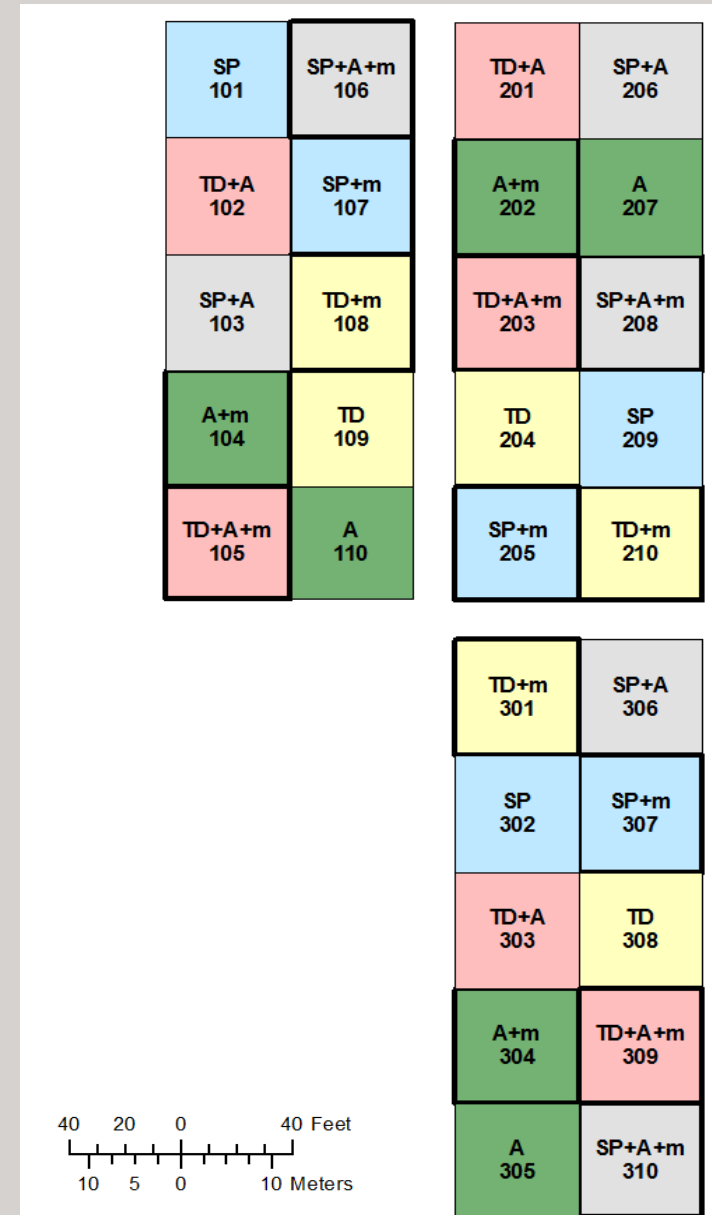


# Field research plots



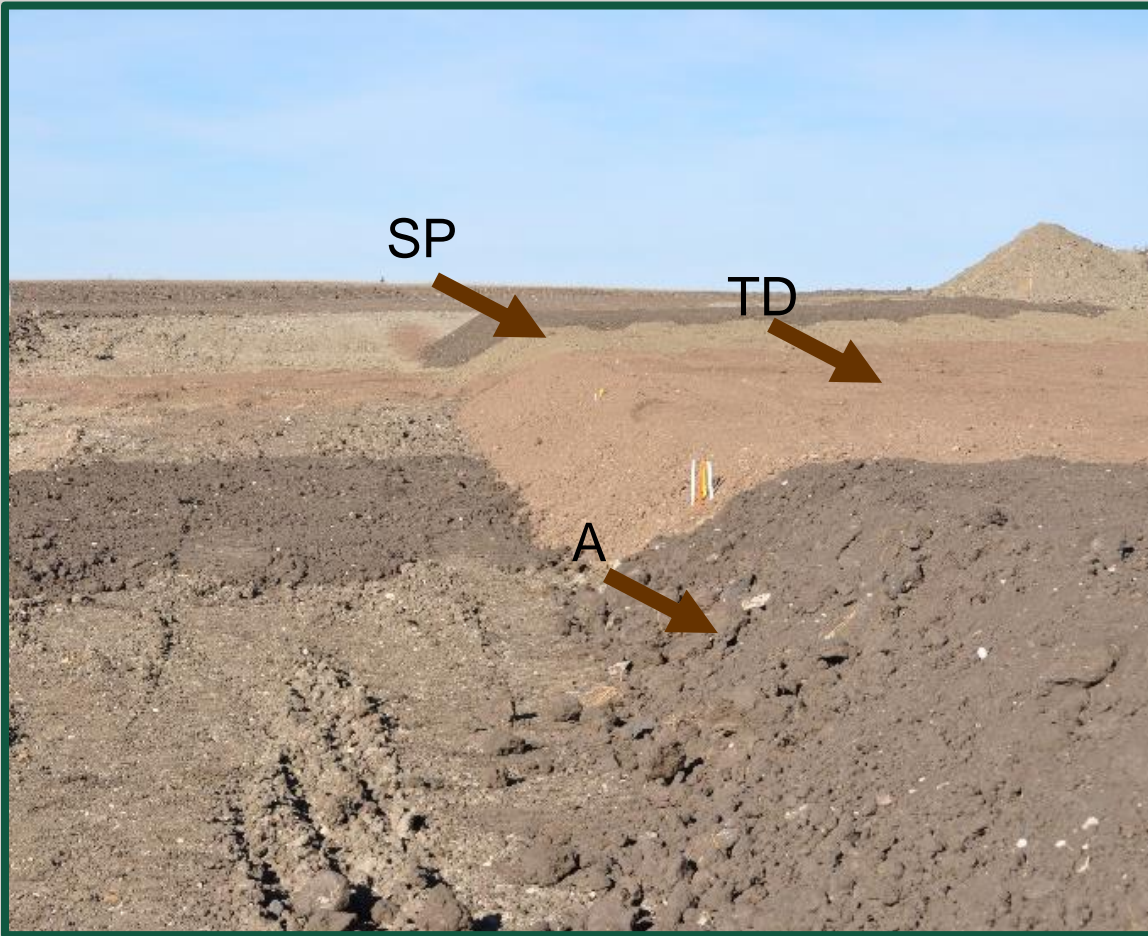
Treatment	Soil mix
A	100% Native topsoil
TD	100% TD treated soil
SP	100% contaminated stockpile soil
TD+A	50% Topsoil and 50% TDU soil (by volume)
SP+A	50% Topsoil and 50% SP soil (by volume)

**+ m denotes 'manure' amendments at 45 Mg ha<sup>-1</sup> (20 ton ac<sup>-1</sup>)**





# Field research plots

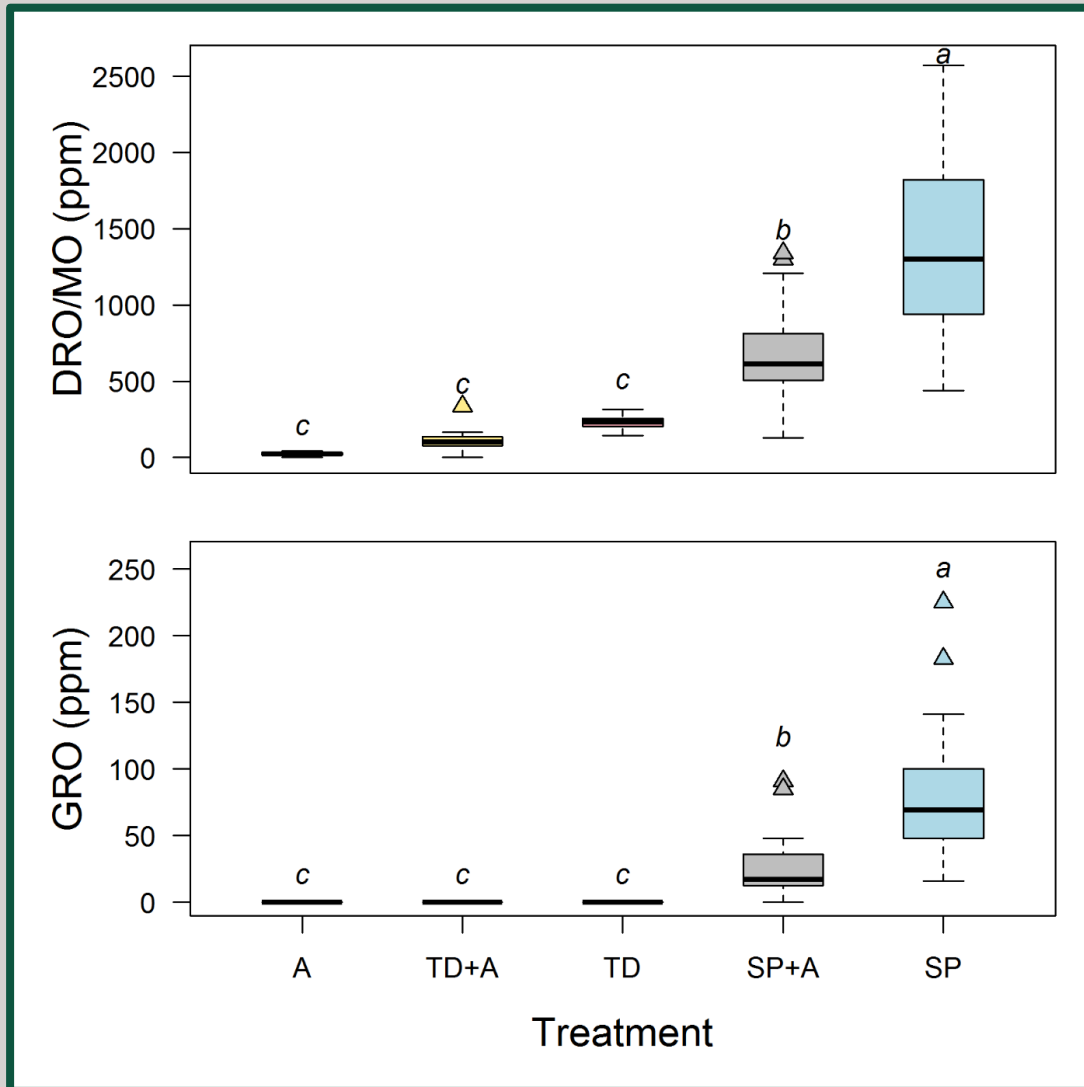




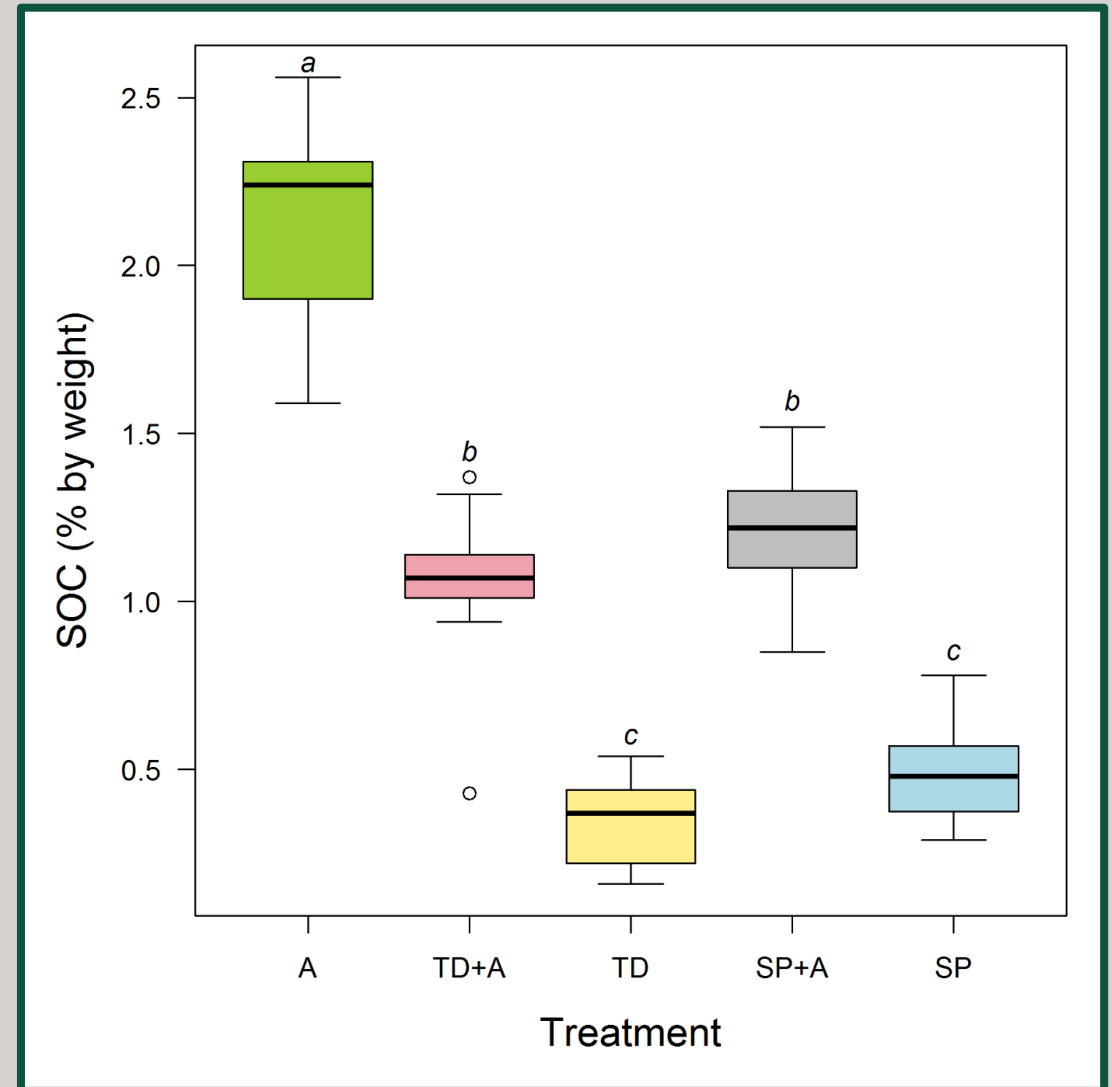
# Homogenous mixing



## Petroleum hydrocarbons



## Soil organic carbon



# Field research plots



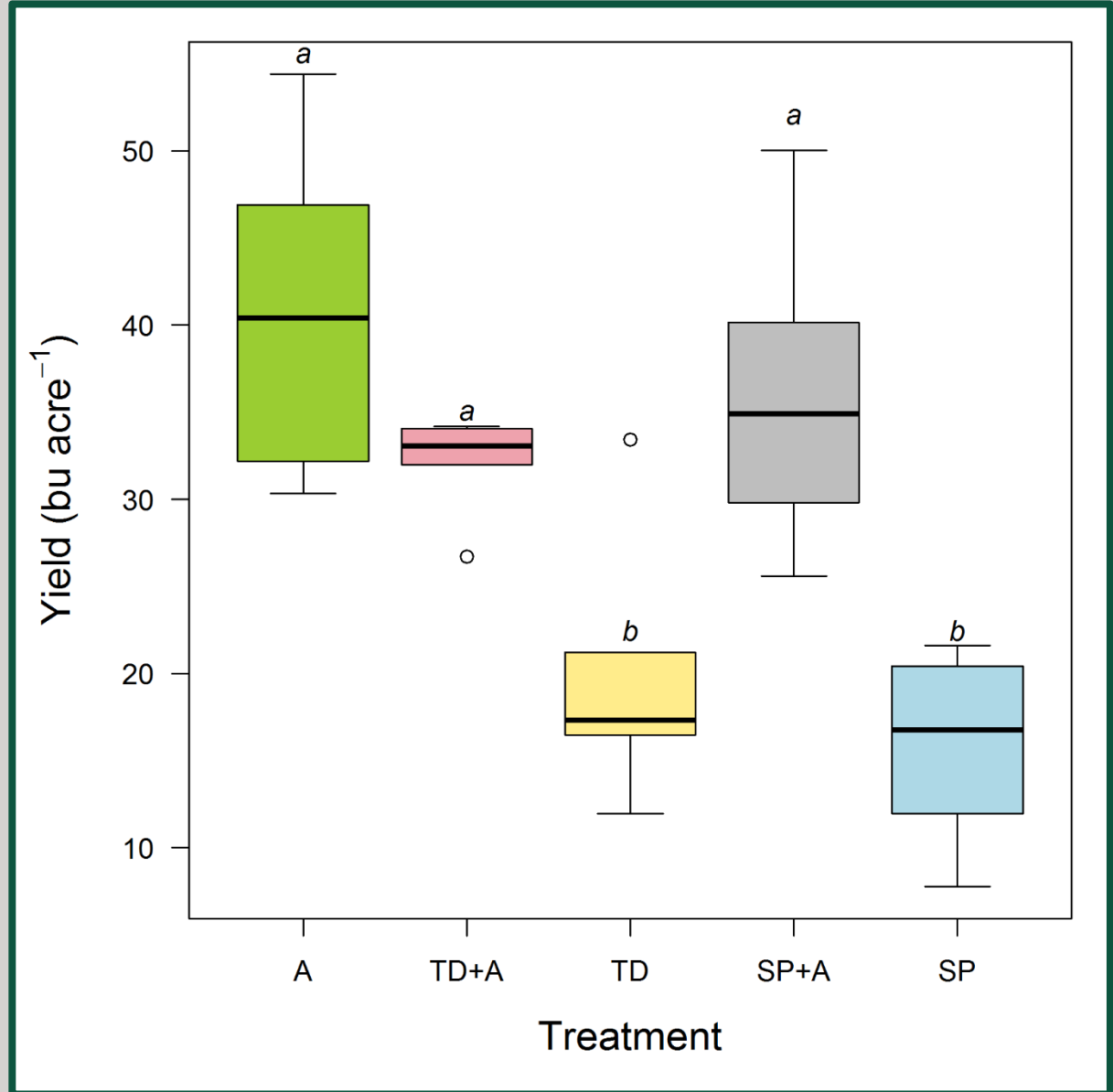


# Research plot progress

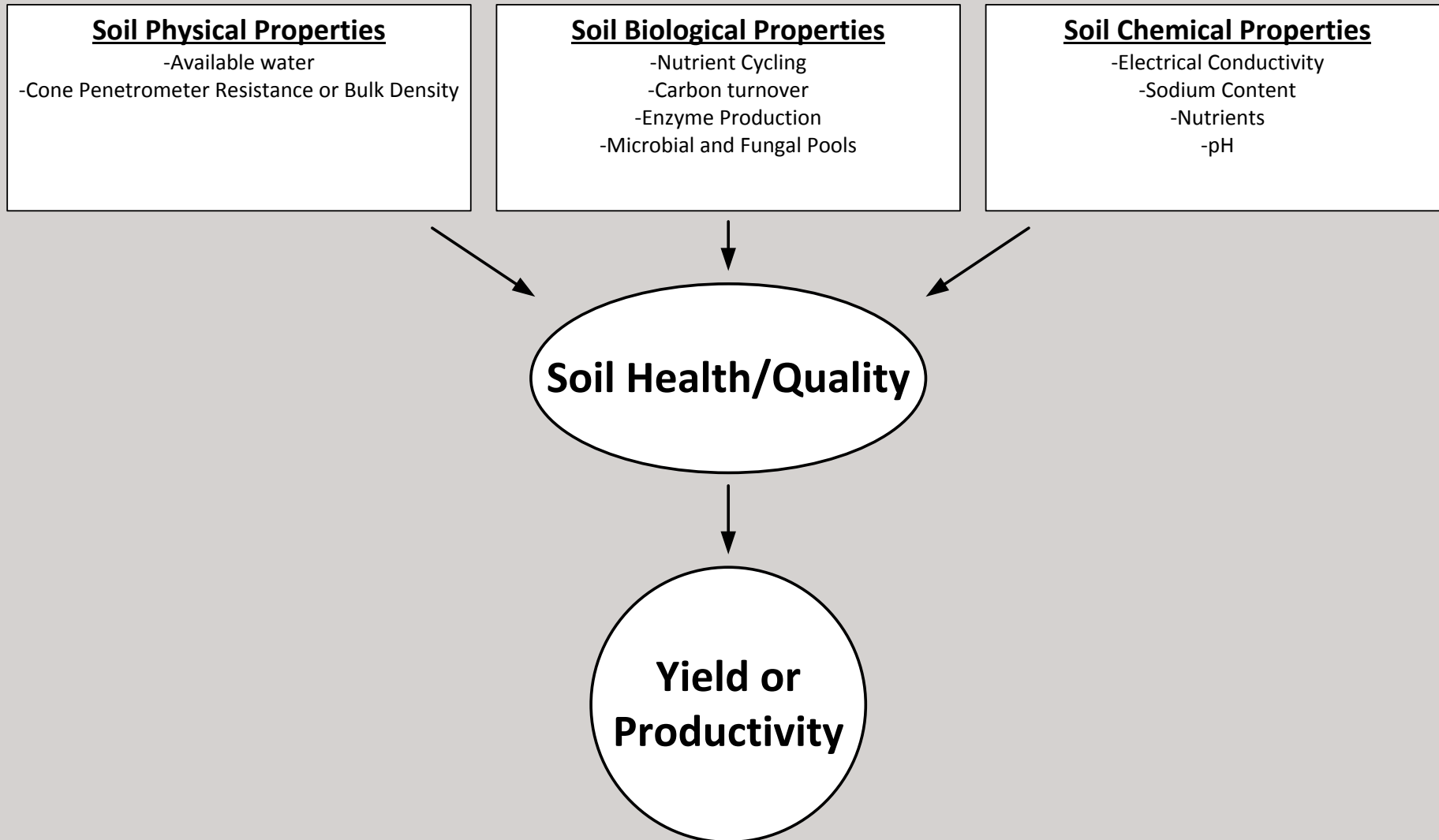




# Wheat yield



# Holistic Approach to the Remediation/ Reclamation/Restoration of Soils



# Biological indicators



## Soil health

**“capacity of soil to function and sustain biological productivity, maintain environmental quality, and promote plant, animal and human health”**

**Physical and chemical properties have been the focus**



# Nitrogen



**High annual nitrogen inputs to agricultural systems**

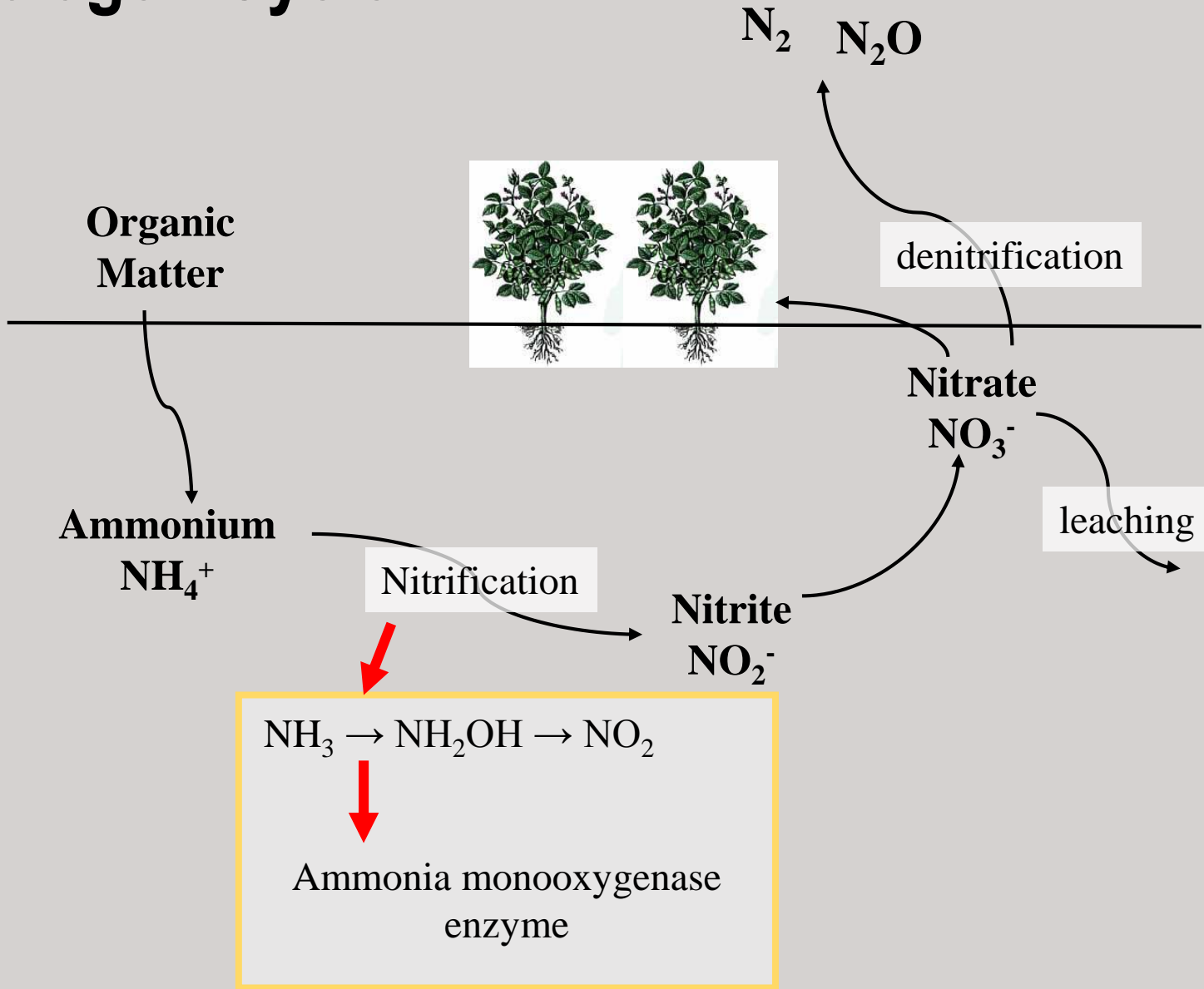
**Essential for plant growth**

**High proportion of unavailable (organic) nitrogen**

**Ammonium ( $\text{NH}_4^+$ ) and nitrate ( $\text{NO}_3^-$ ) accessible to plants**

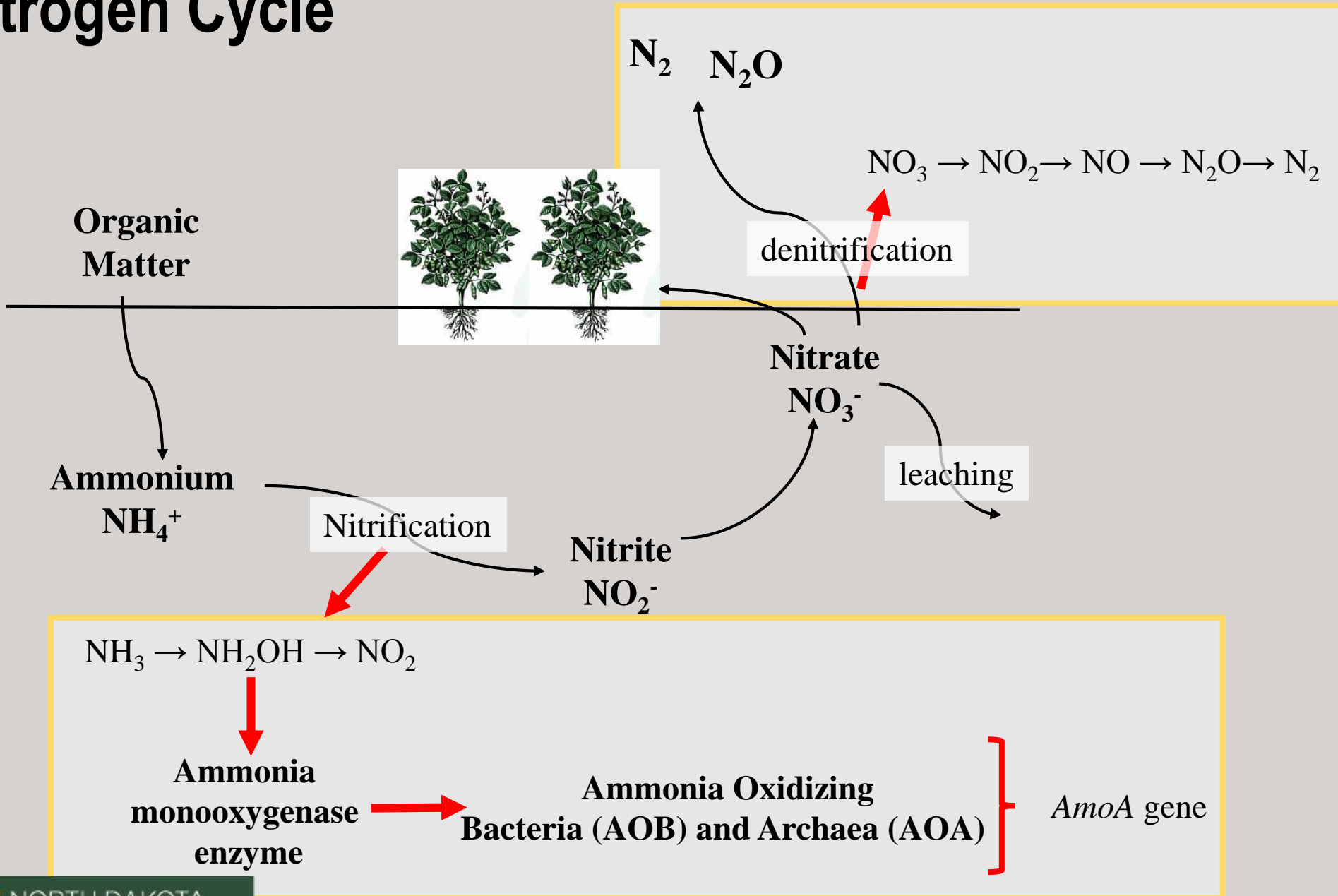


# Nitrogen Cycle



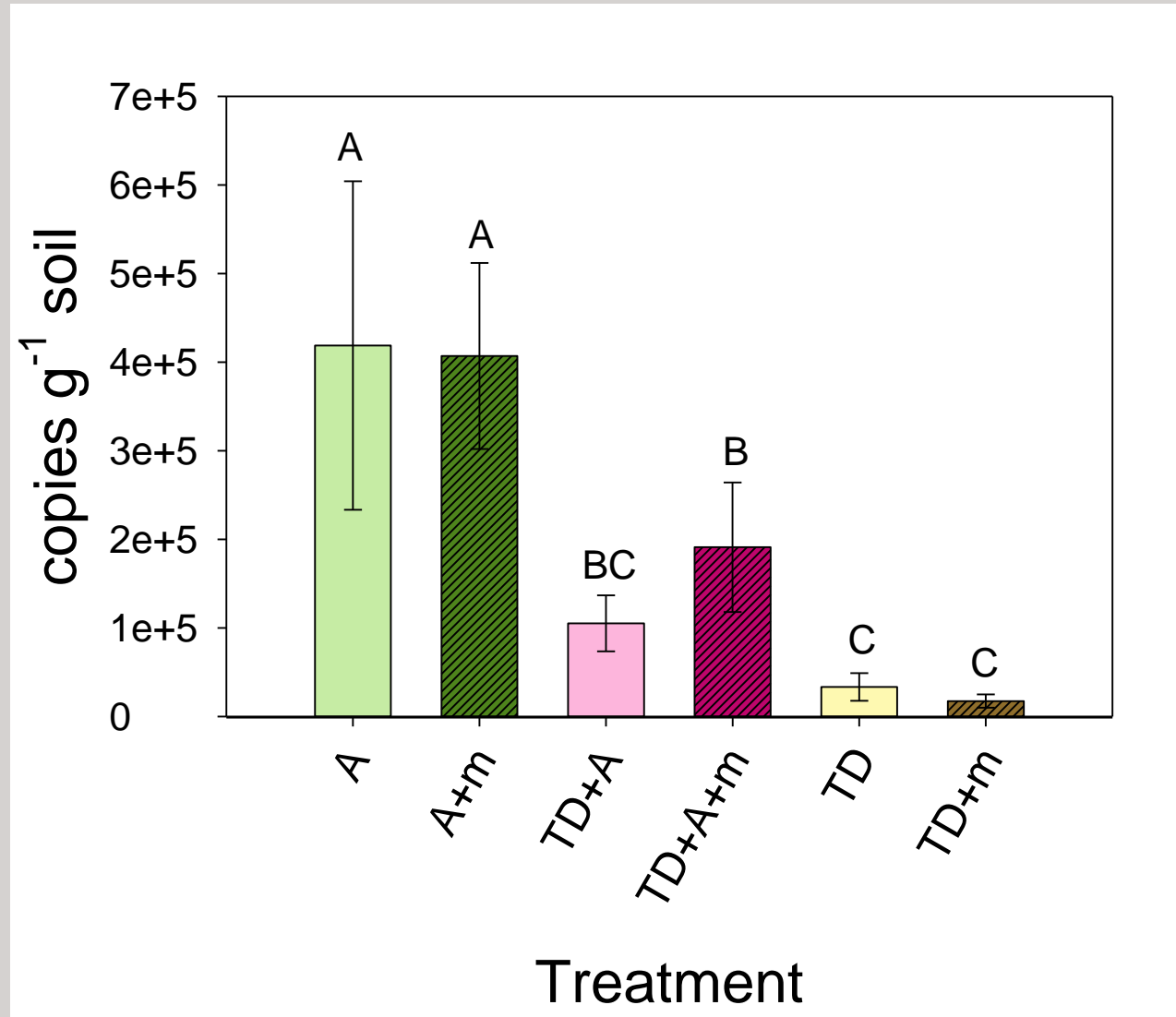


# Nitrogen Cycle

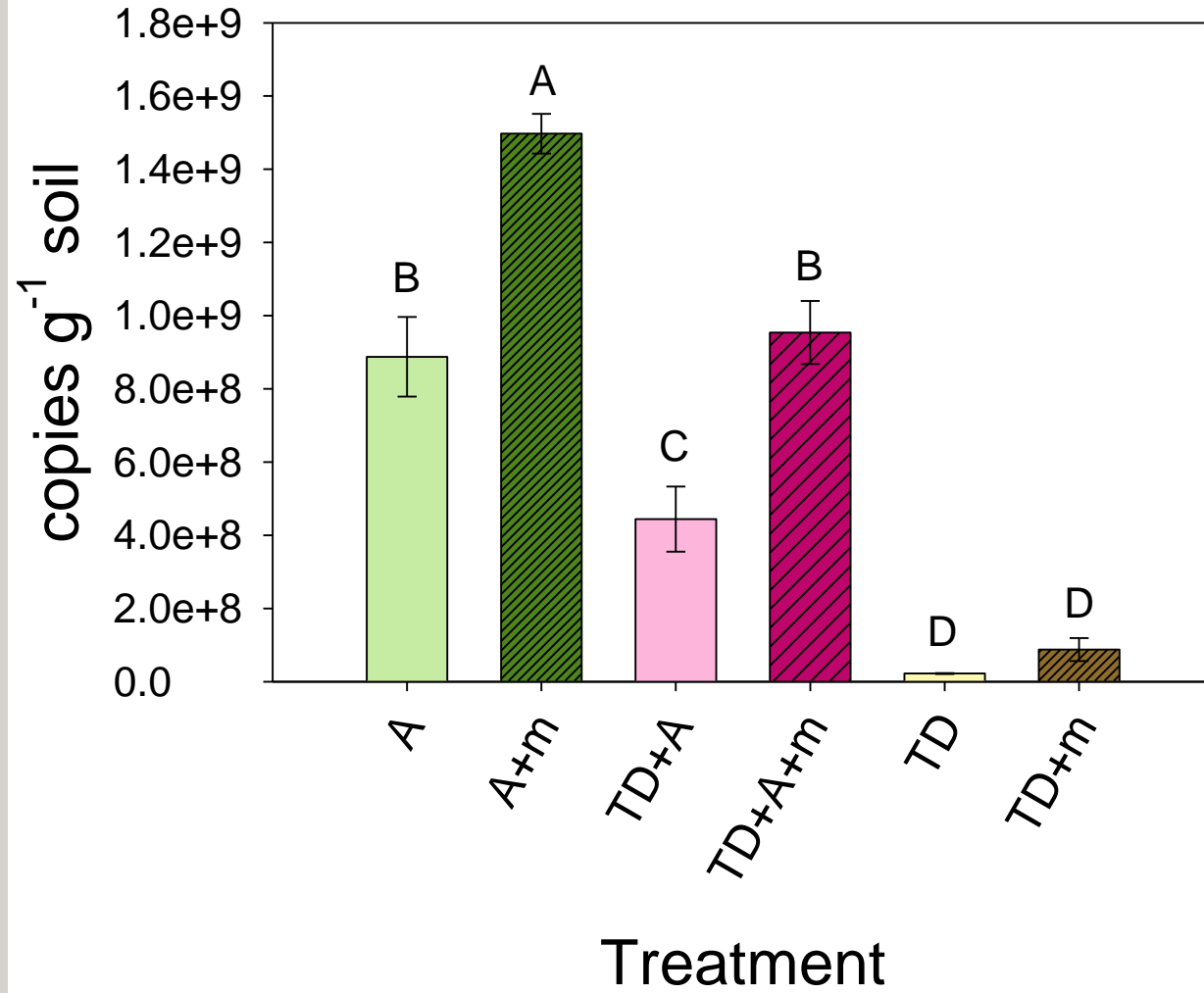




# AOA

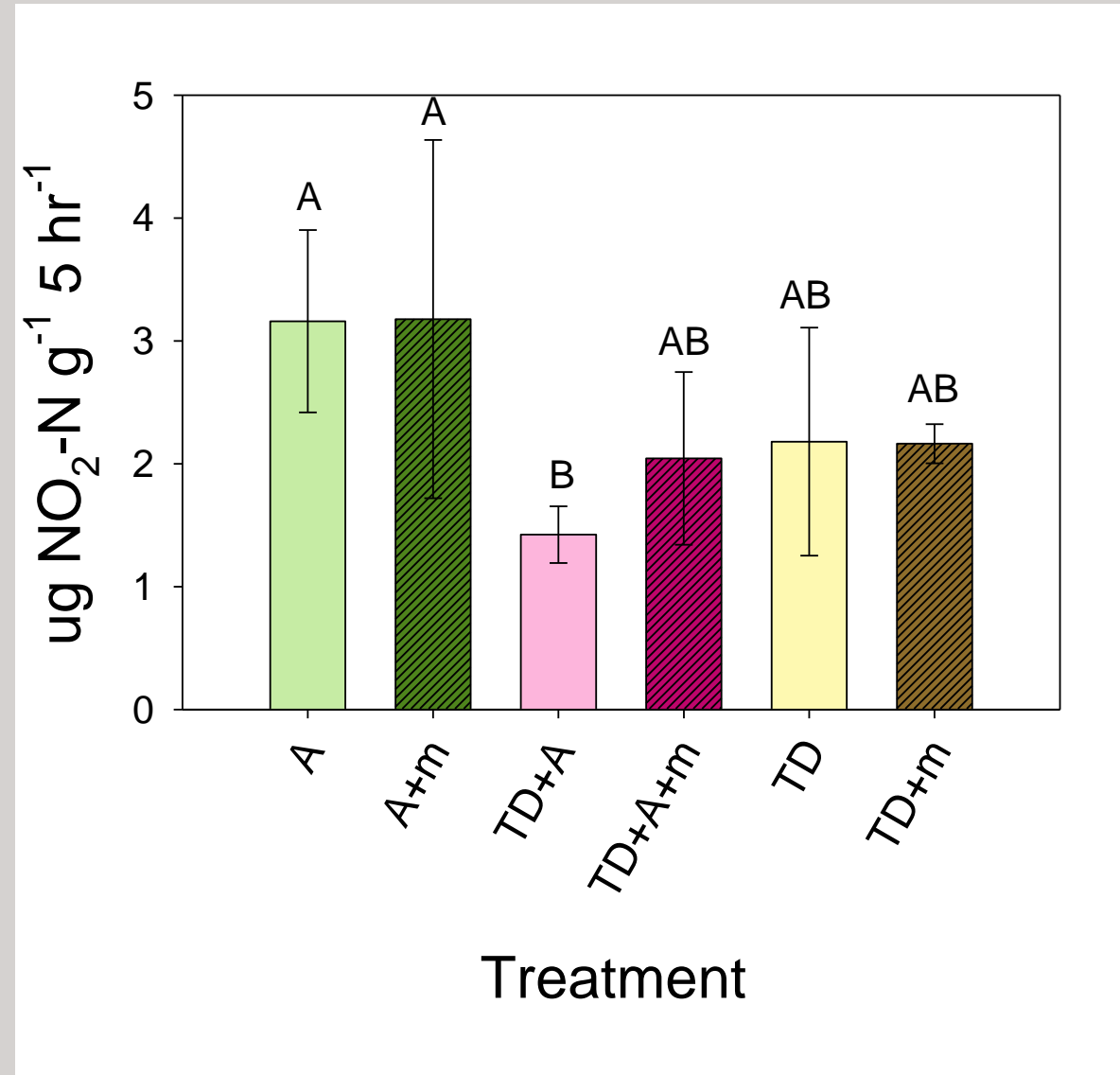


# AOB





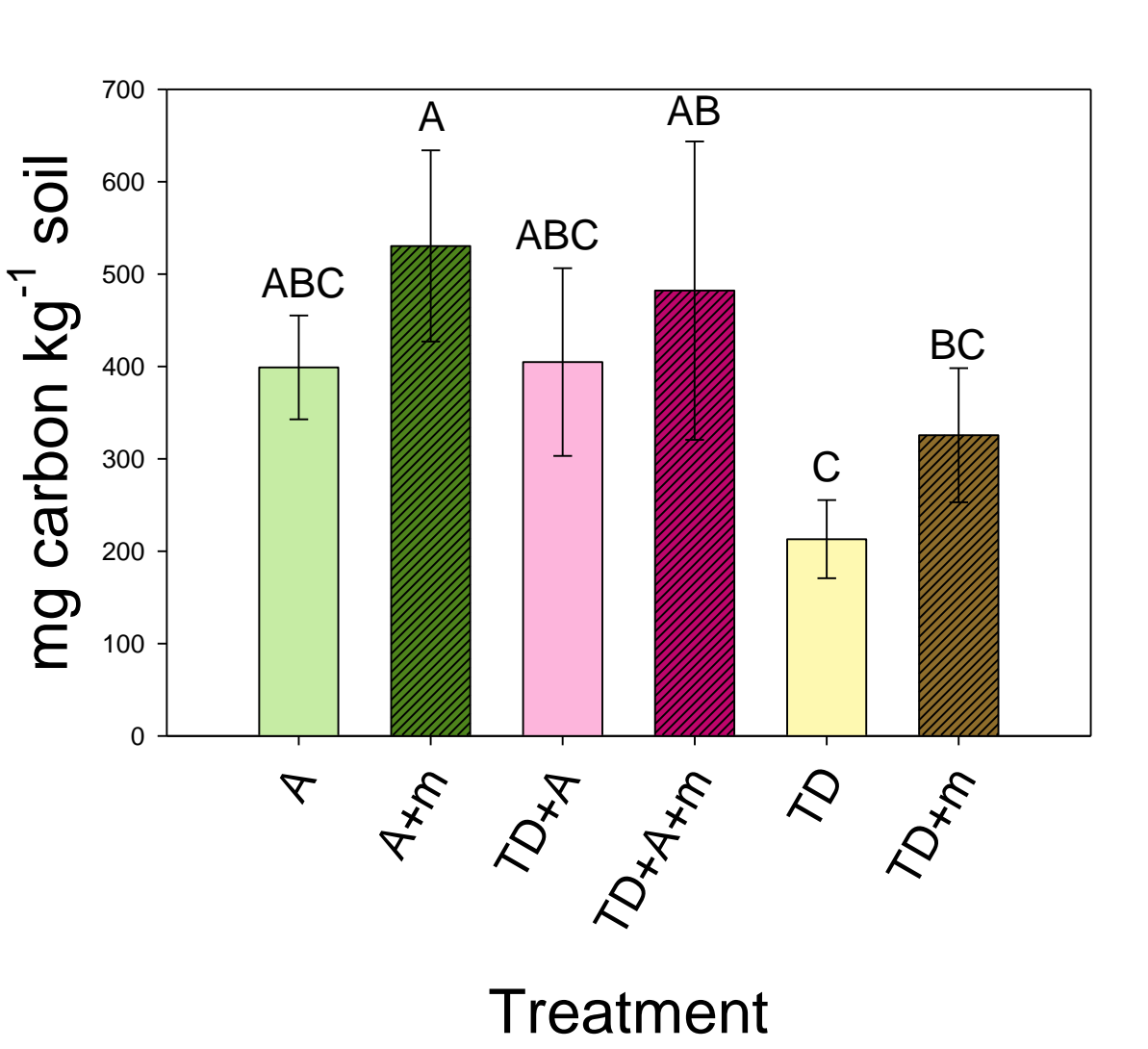
# Ammonia monooxygenase enzyme







# Active Carbon



# Conclusions

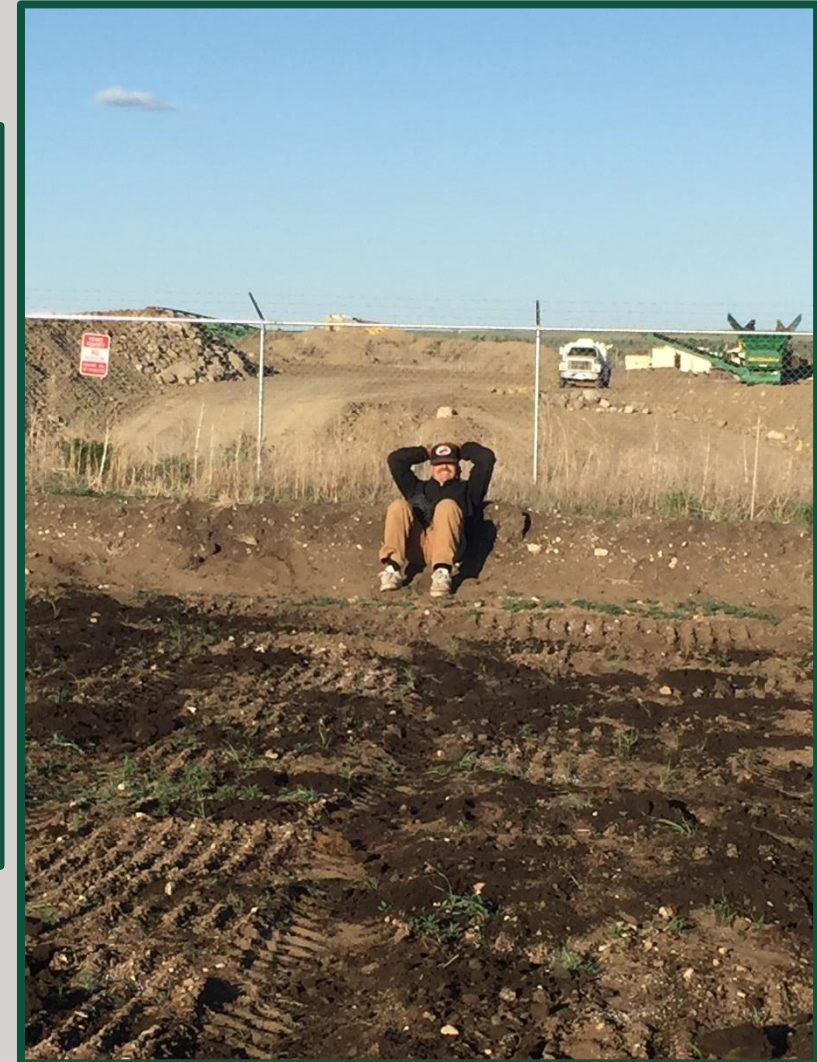


- **TD treatment at 350 C (8-15 min) does not greatly alter soil physical and chemical properties**
- **Blending TD soil with native topsoil may be a viable option to match local soil productivity**
- **Biological indicators in blended treatments responded favorably, but more investigation is required for conclusive results**
- **A holistic approach to soil remediation improves soil resilience to changing conditions through time**

# Acknowledgements



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Thank you

