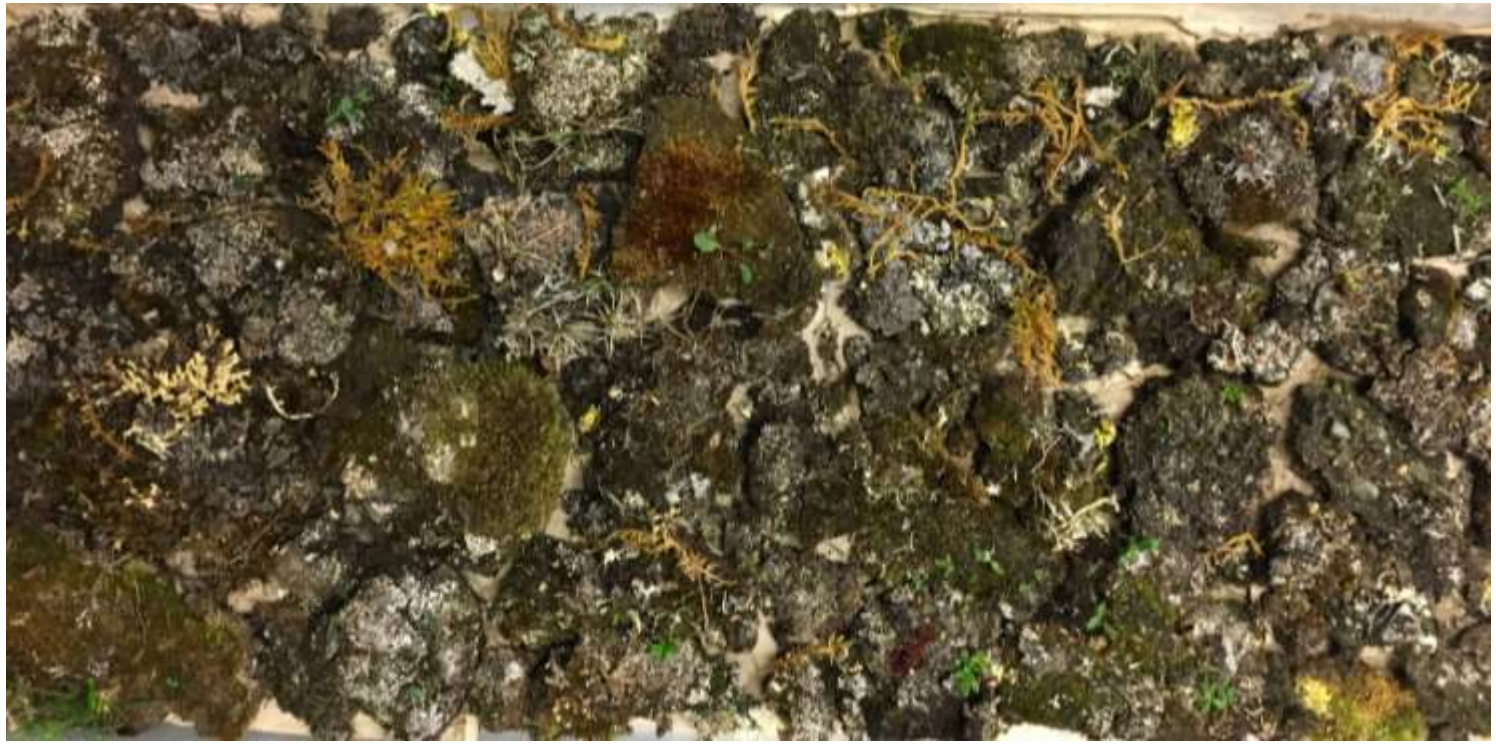
Opportunities and challenges for restoring northern ecosystems with locally sourced biological soil crust



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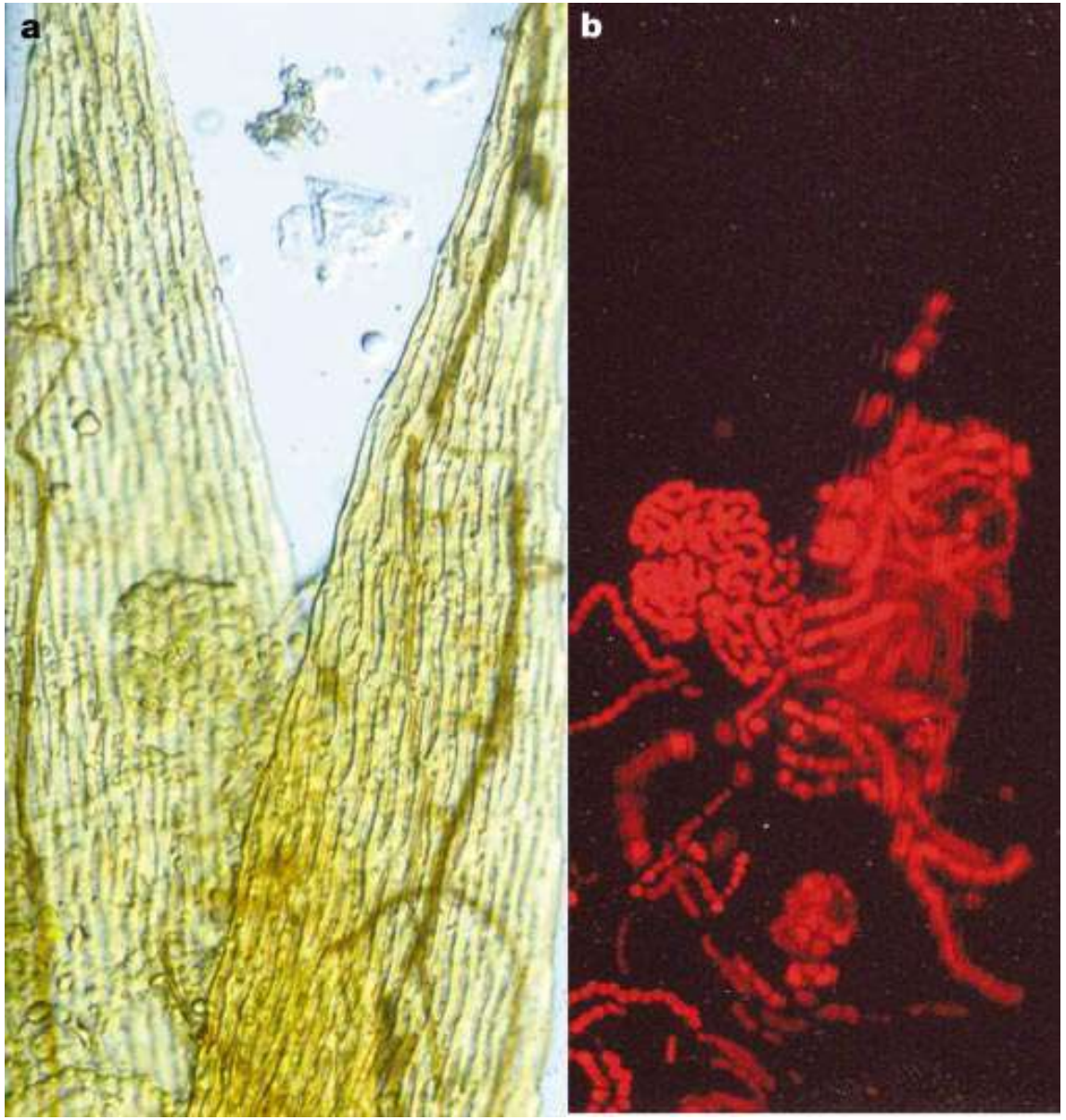
Department Soil Science
University of Saskatchewan

UNIVERSITY OF SASKATCHEWAN


D. Coxson

Moss leaf X 200 magnification

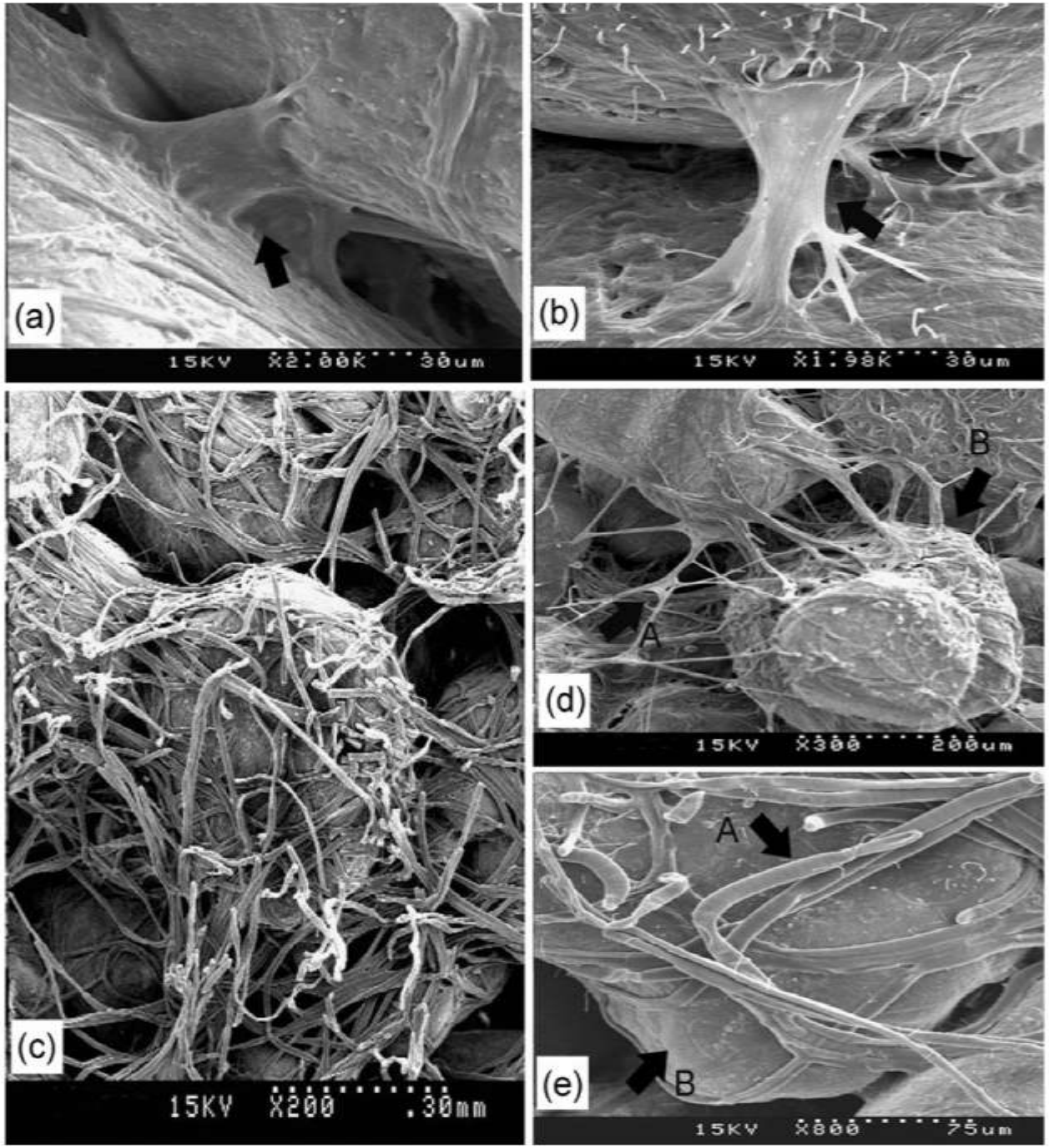


Under light microscope

Under ultraviolet-fluorescence micrograph with a green filter

- Nitrogen fixation

Nature **419**, 917-920 (31 October 2002) | doi:10.1038/nature01051



- Extracellular polysaccharide matrix helps to bind soil preventing erosion and retaining moisture

Zhen et al., 2011. Effects of inoculated Microcoleus vaginatus on the structure and function of biological soil crusts of desert. Biol Fertil Soils, 47:473-480. pp. 477.

Biological Soil Crust Function

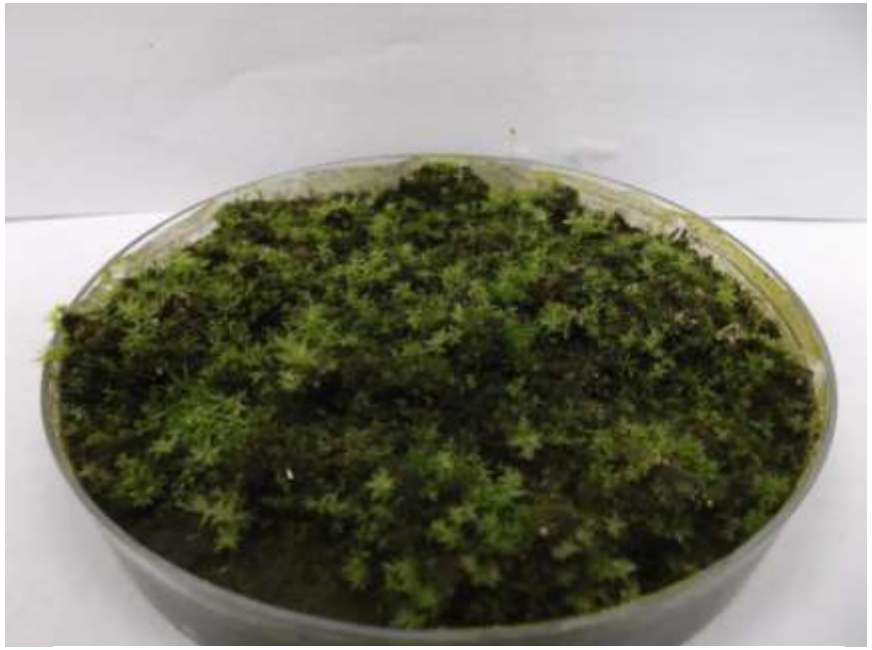
- Soil stabilization
- Nitrogen fixation
- Carbon fixation
- Water and nutrient retention

Growth and nitrogen fixation of biological soil crusts on mine tailings

- ~ 4,050,000 tonnes of tailings in 19 ha impoundment
- Exceed CCME: Sb, As, Cd, Cu, Pb, Ag, Ti, Zn
- pH 5.72 – 8.35
- Texture silt loam to sand

Growth Chamber Trial – BSC Inoculum on mine tailings

Application of BSC slurry at beginning of experiment



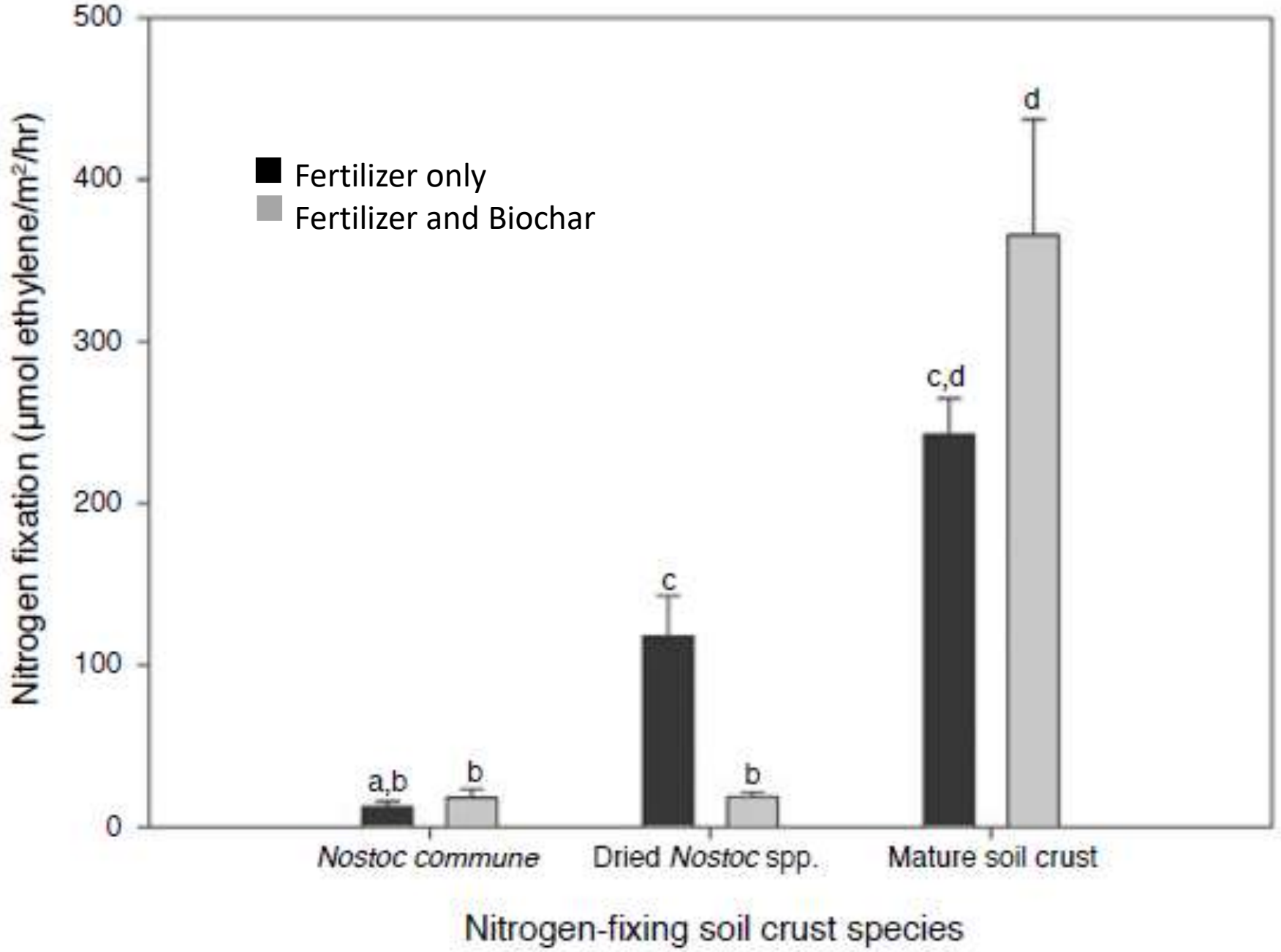
BSC development at week 4

Growth Chamber Trial – BSC Inoculum on mine tailings

Application of
beginning of

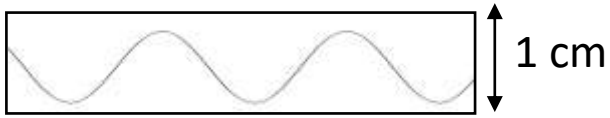
BSC development at week 10

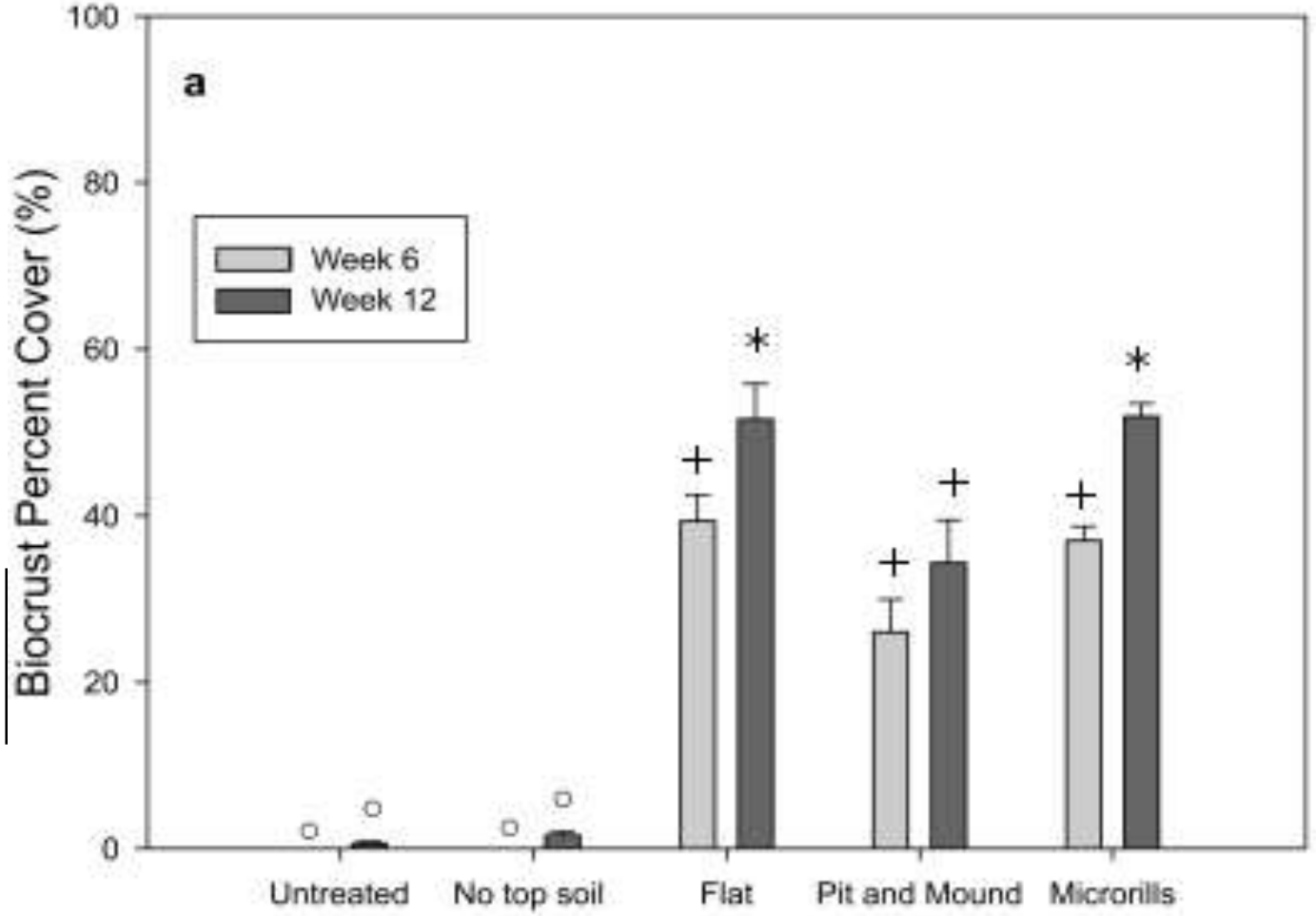
nt at week 4



Stewart, K.J. and Siciliano, S.D. 2015. Ecological Restoration 33: 30-42, p. 37.

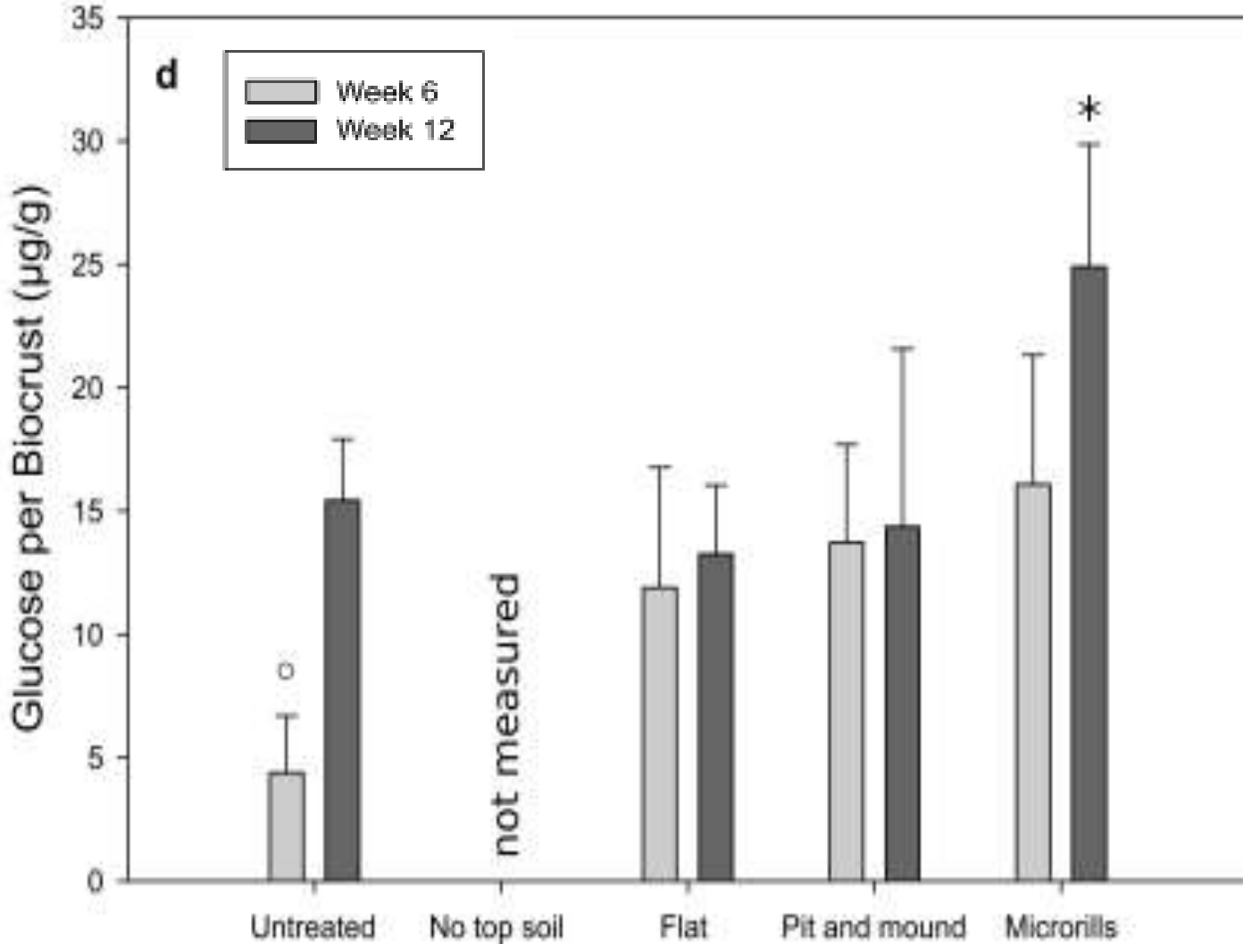
Greenhouse Trial – BSC Inoculum for pipeline restoration



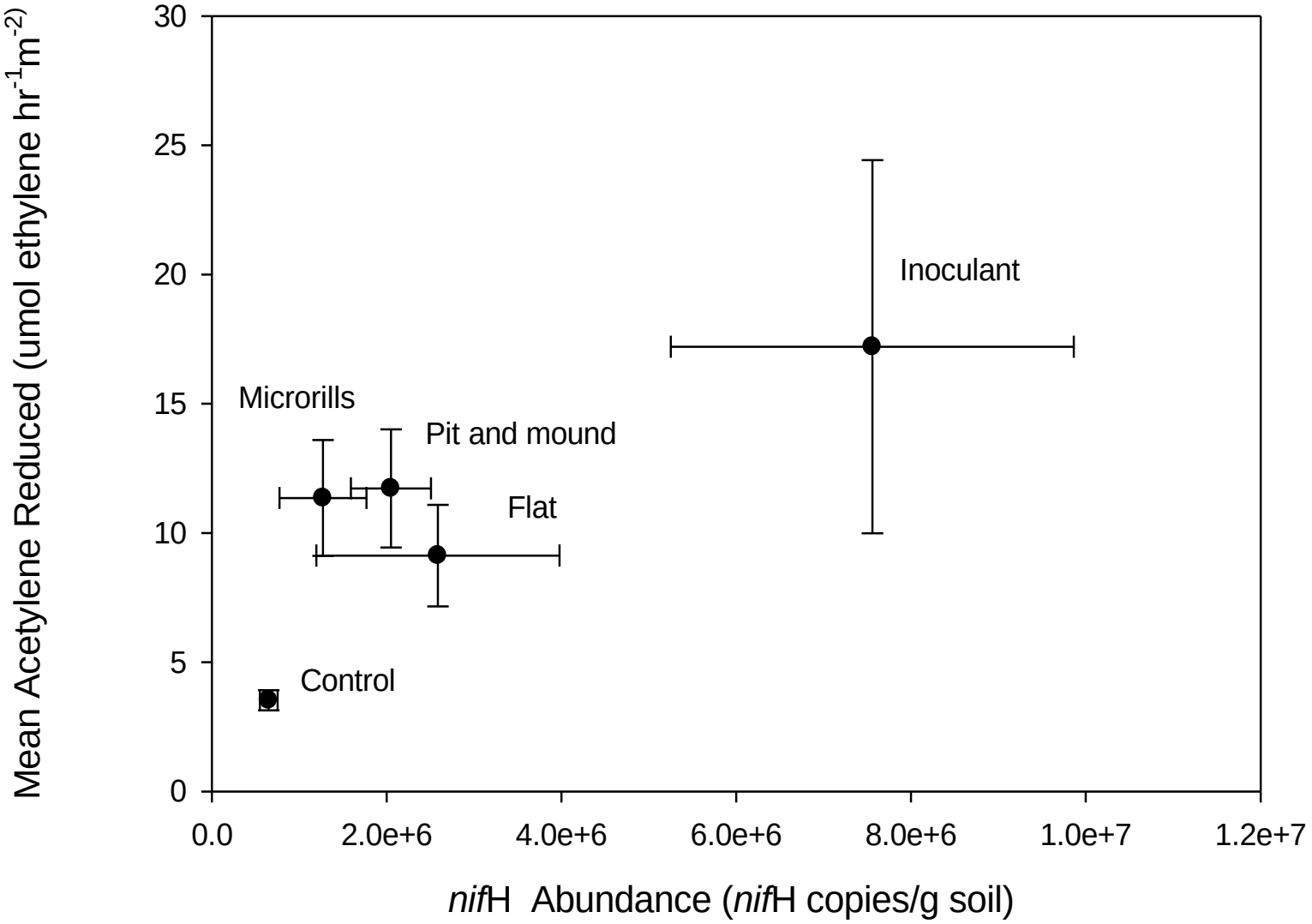


Greenhouse Trial – BSC Inoculum for pipeline restoration

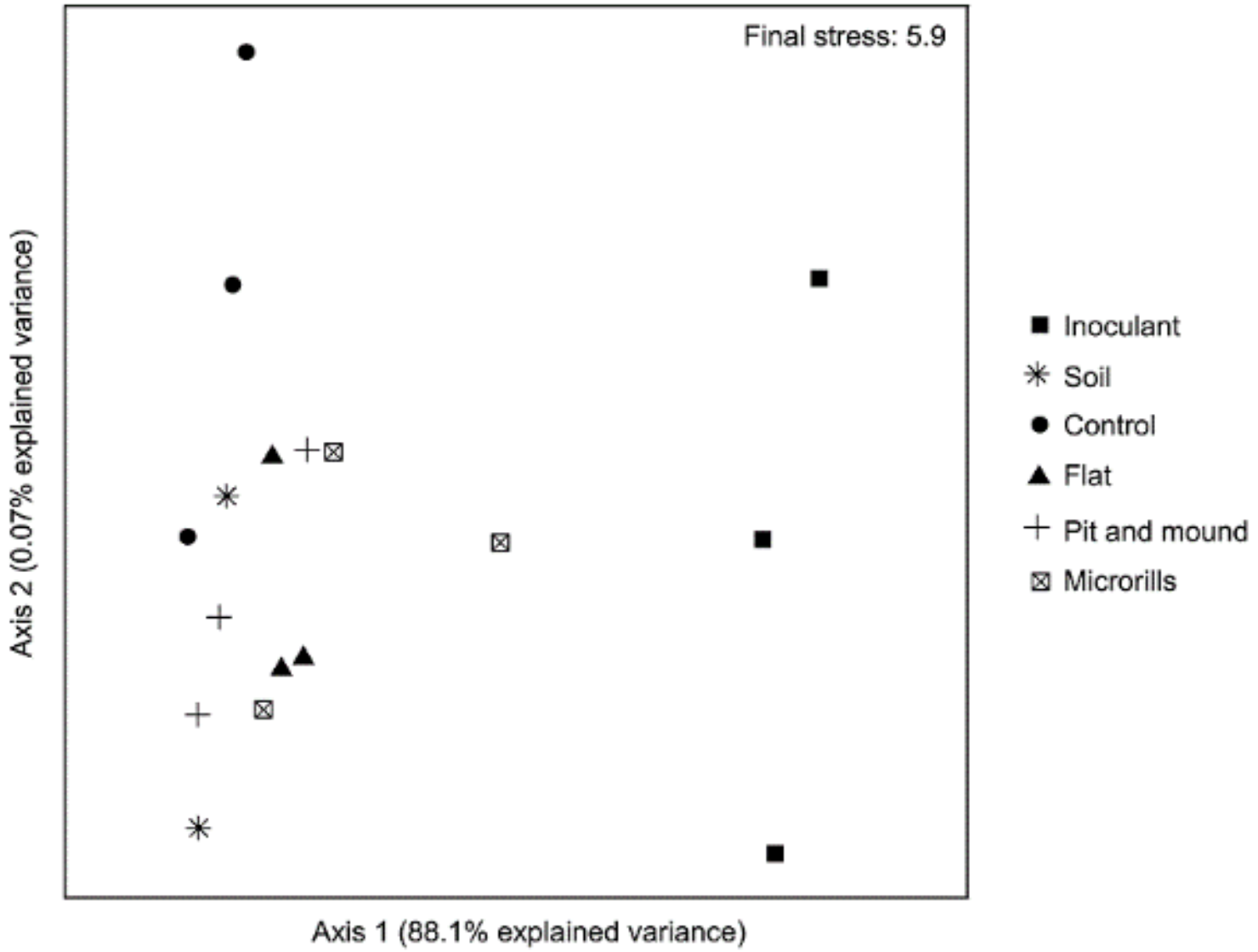
- Extracellular polysaccharides promoted with microrills



Greenhouse Trial – BSC Inoculum for pipeline restoration

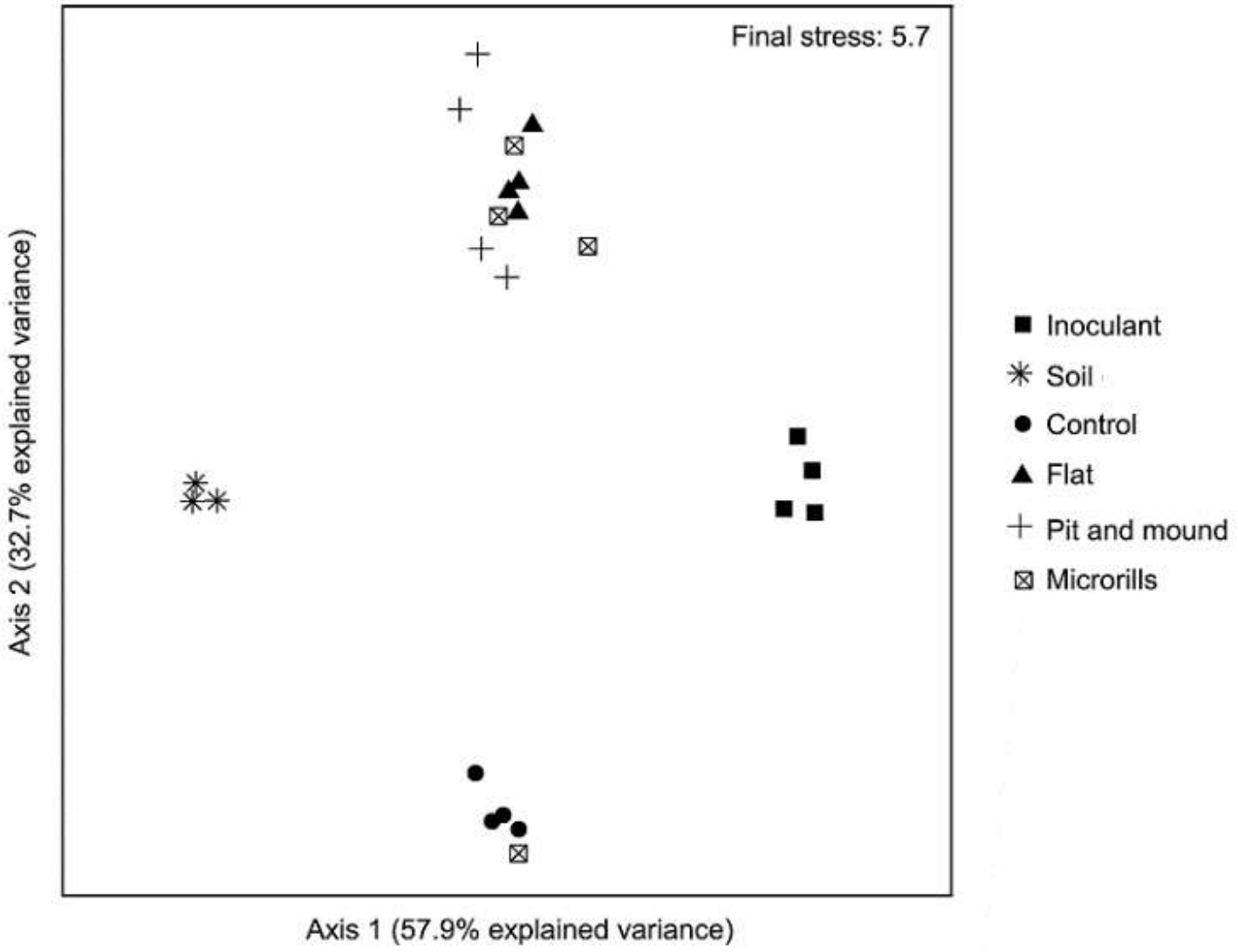


NMDS ordination of bacterial OTUs



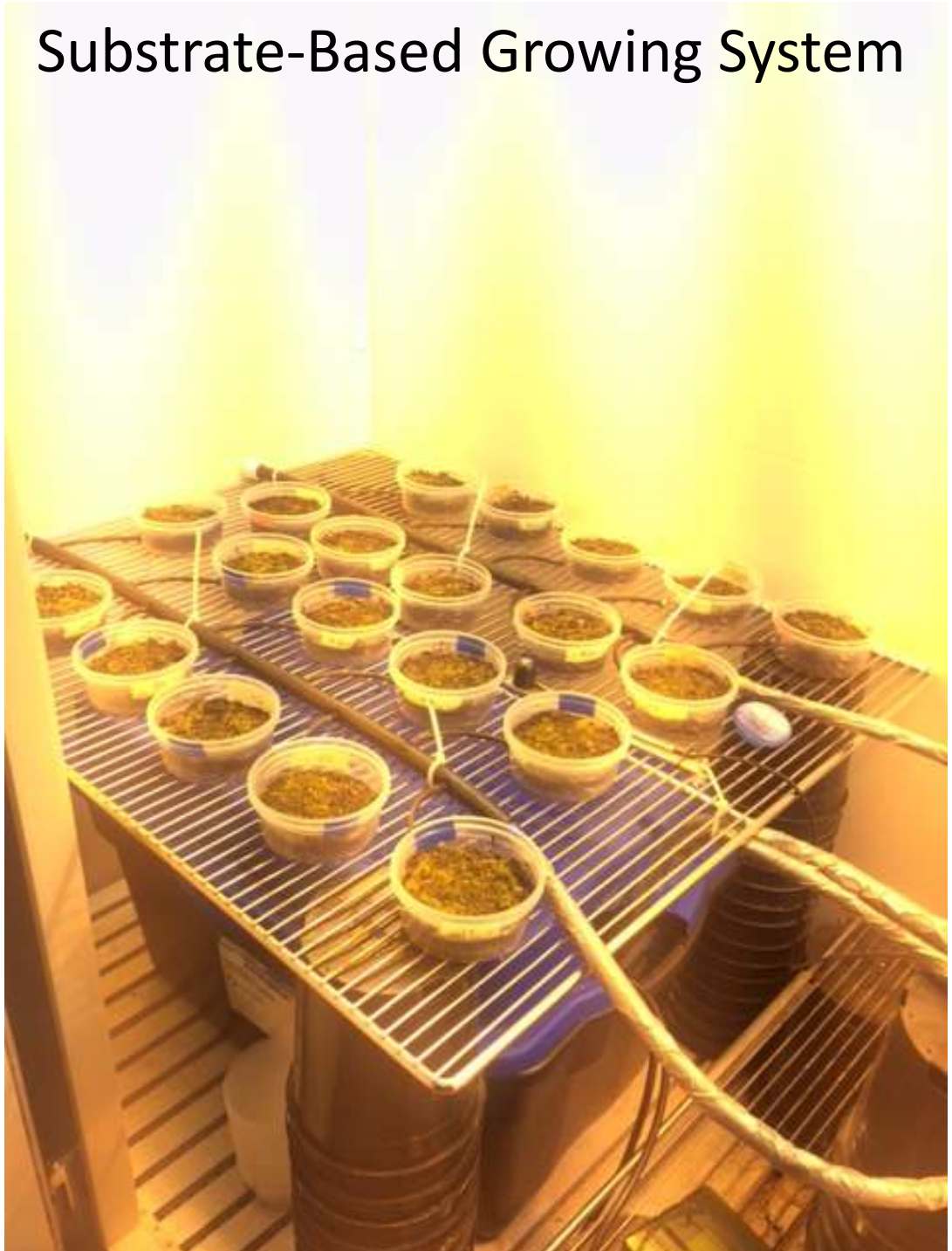
- Bacterial community level differences only observed between the inoculant and all other treatments

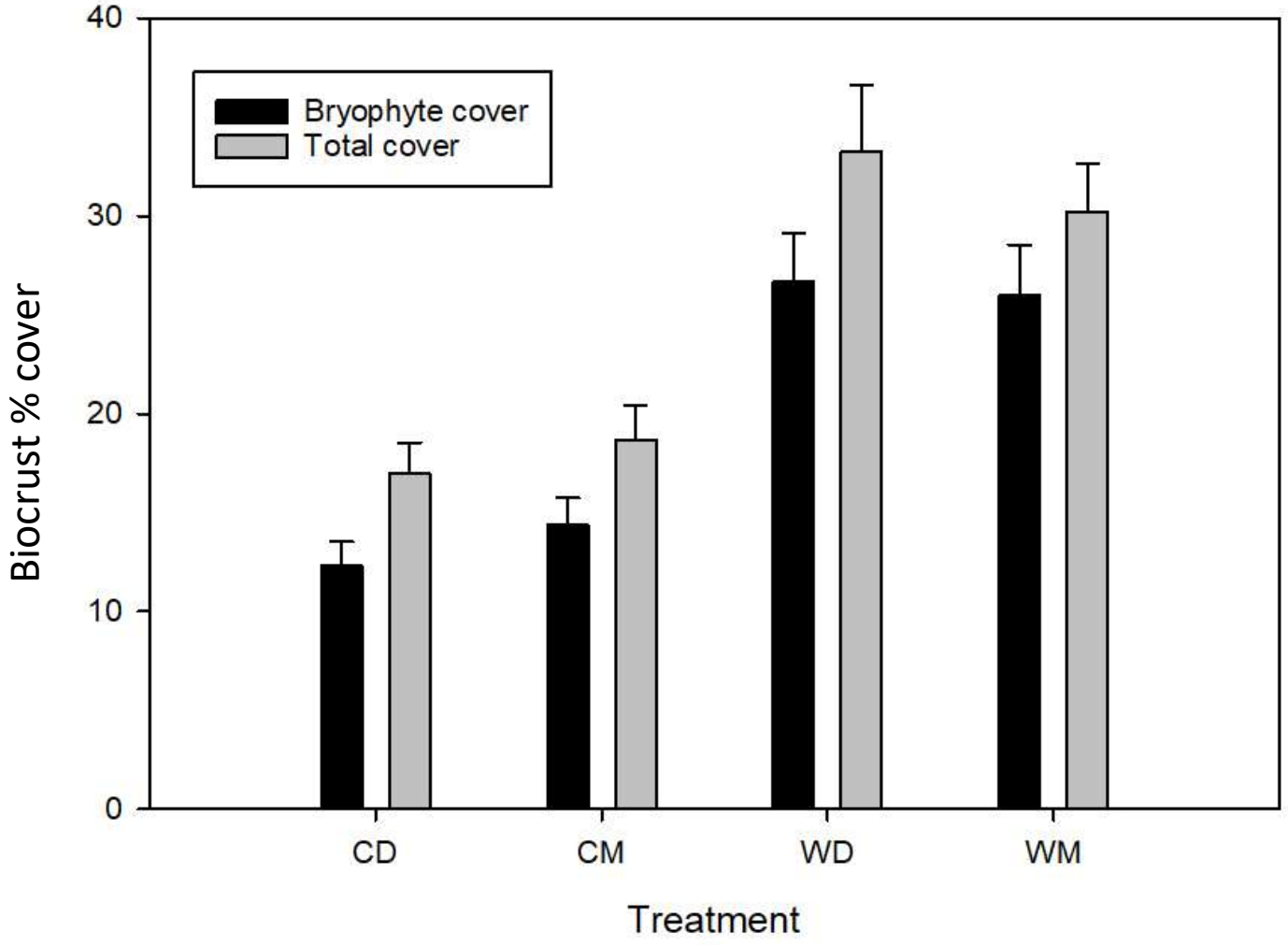
NMDS ordination of fungal OTUs



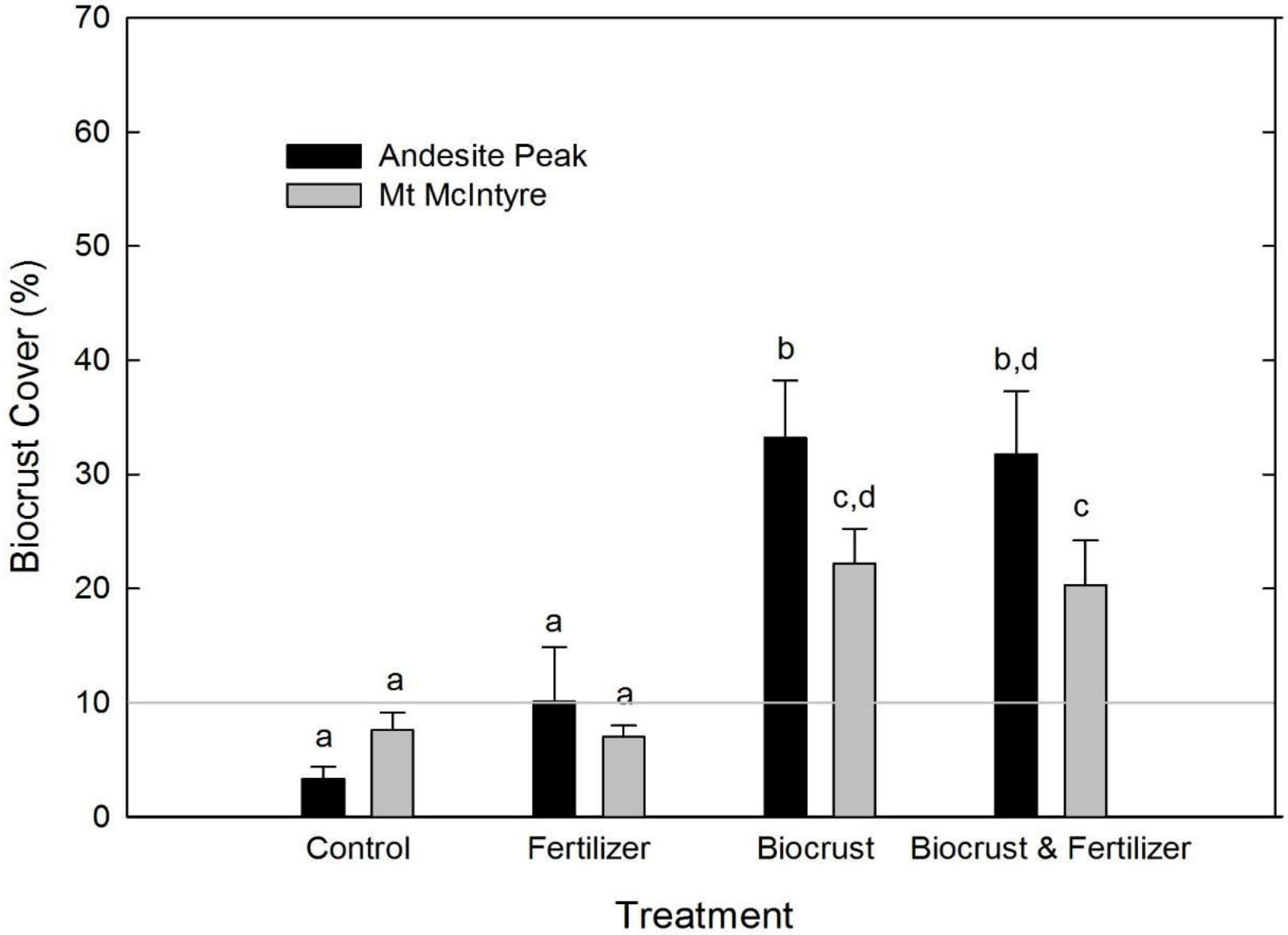
- Fungal community structure similar between the soil surface treatments
- Differences between the soil surface treatments, inoculant, untreated soils and unincubated soils

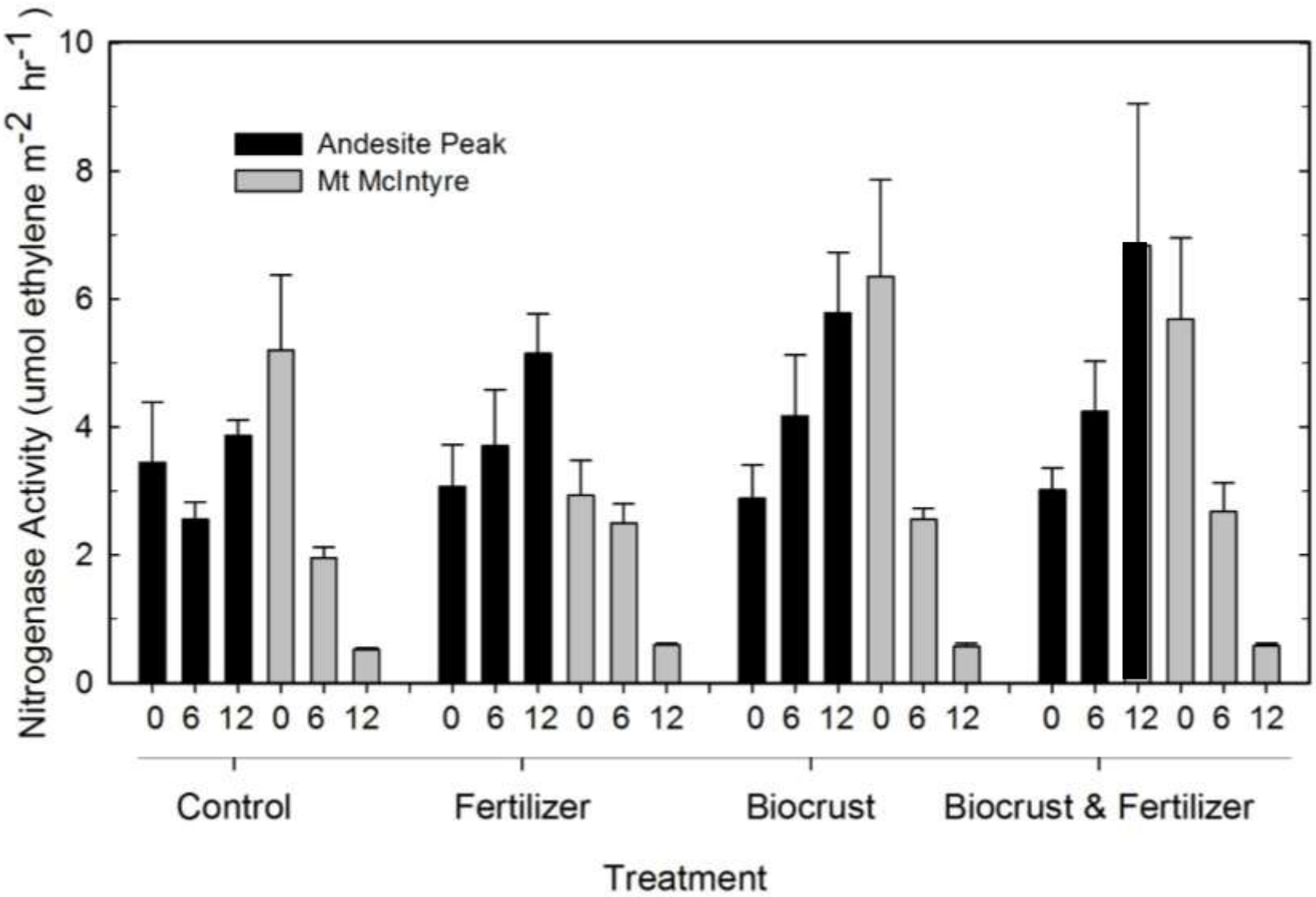
Substrate-Based Growing System



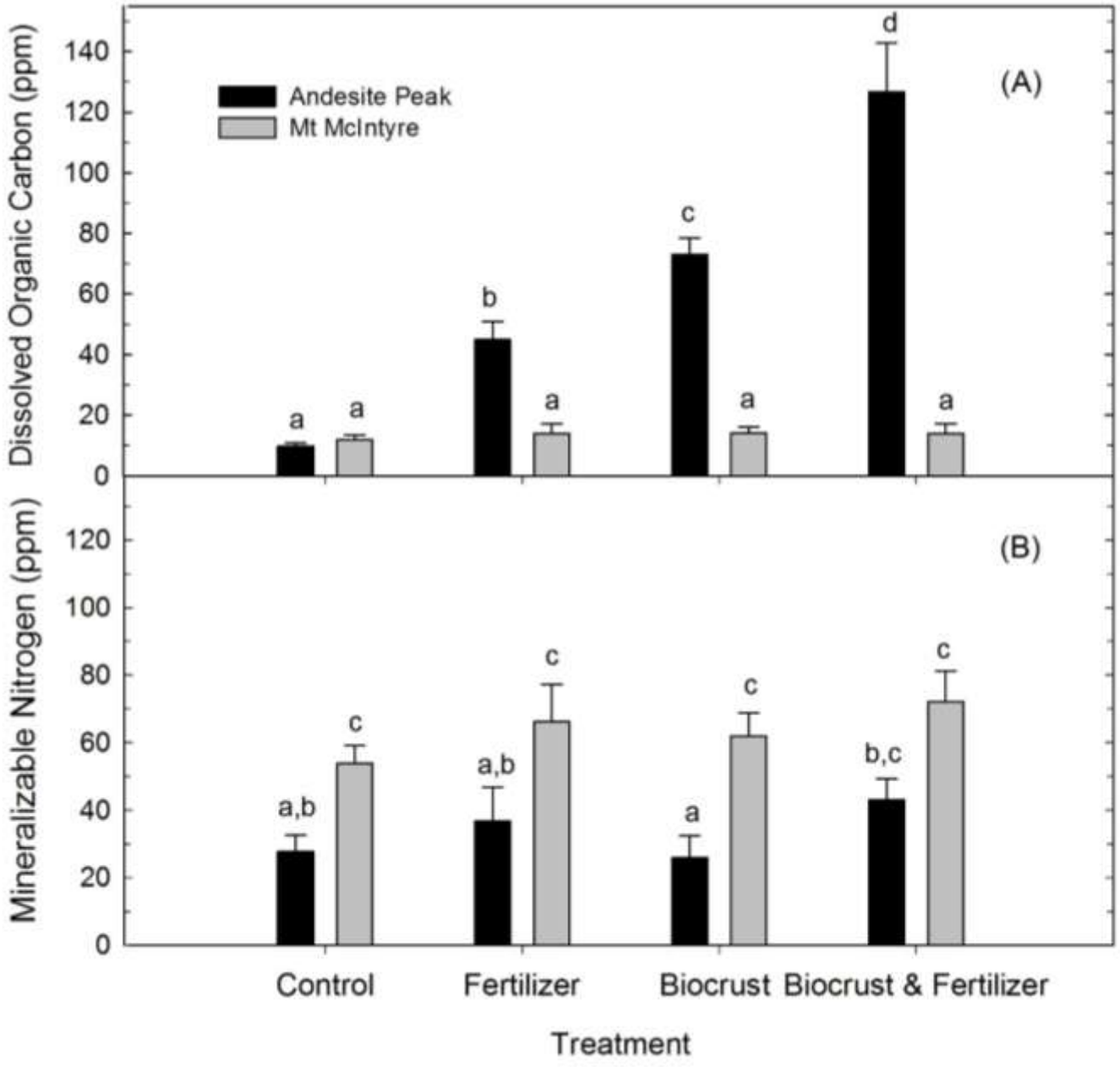


Pipeline Restoration

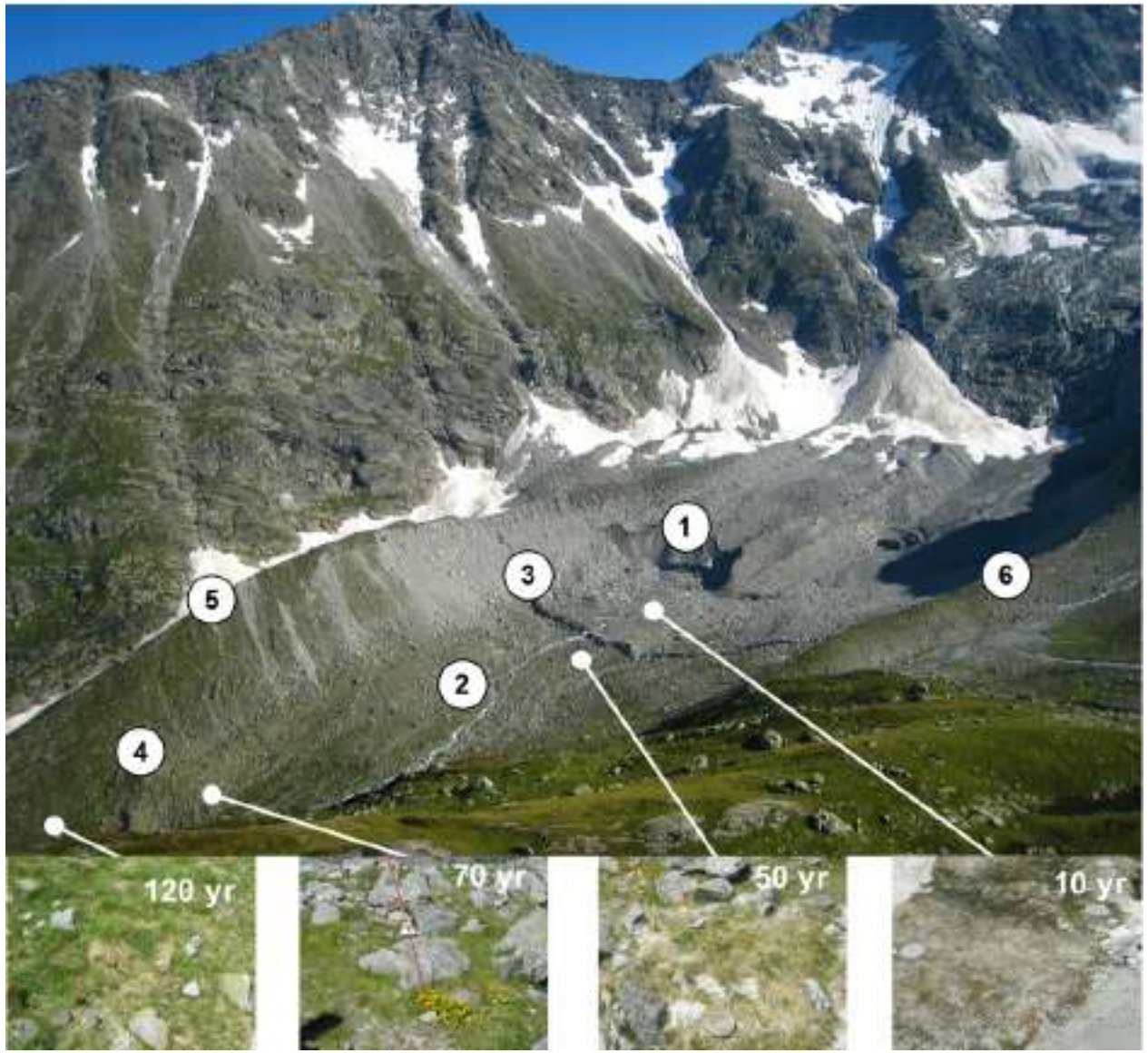

70
60
50
40
30
20
10
0
Biocrust Cover (%)
Andesite Peak
Mt McIntyre
a
a
a
a
b
c,d
b,d
c
Control
Fertilizer
Biocrust
Biocrust & Fertilizer
Treatment


Nitrogenase Activity (umol ethylene m-2 hr-1)
10
8
6
4
2
0
Andesite Peak
Mt McIntyre
0 6 12 0 6 12 0 6 12 0 6 12 0 6 12 0 6 12 0 6 12 0 6 12
Control
Fertilizer
Biocrust
Biocrust & Fertilizer
Treatment

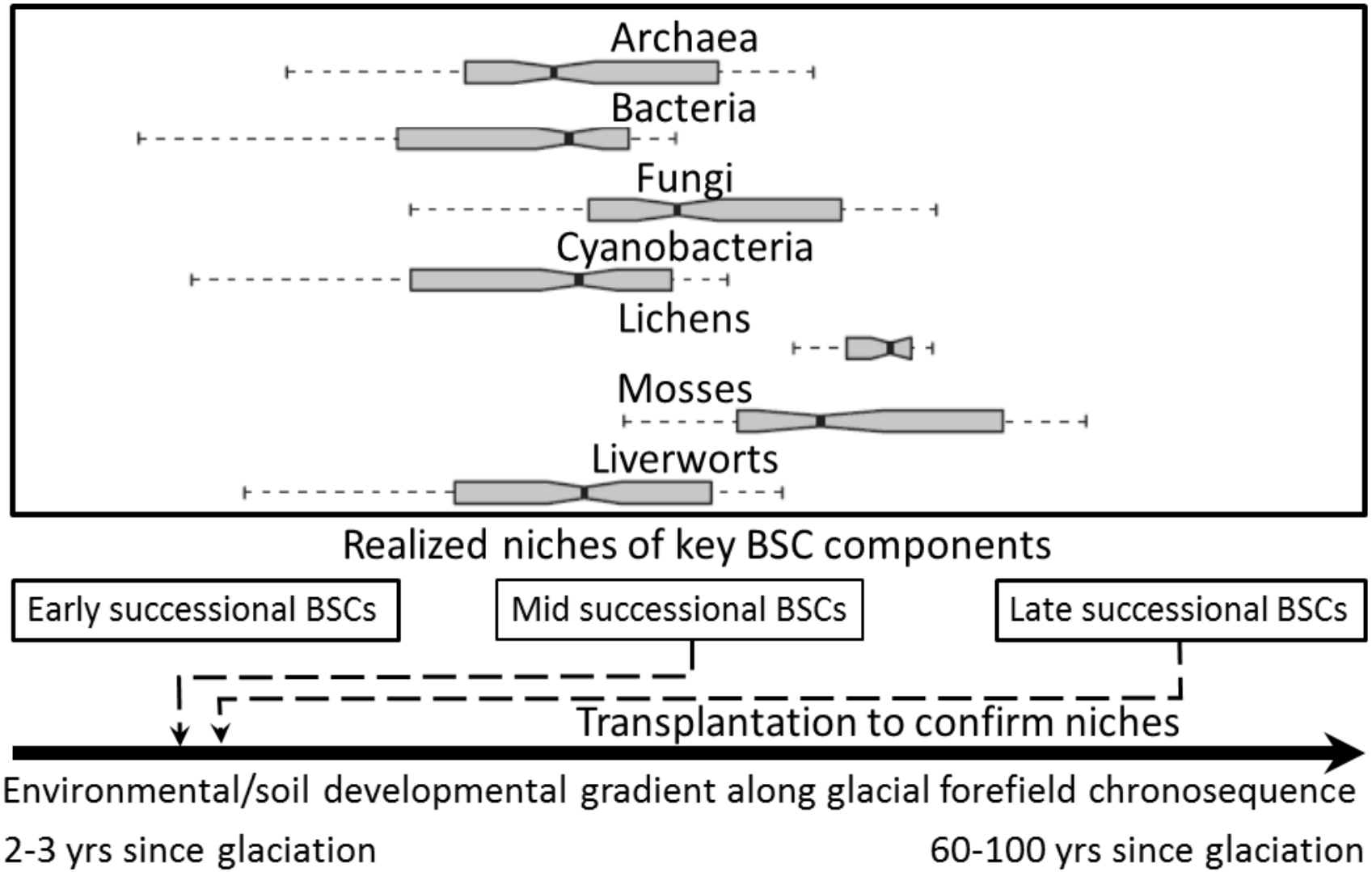
- Higher DOC in soils immediately below BSC inoculated surfaces
- No differences in mineralizable N



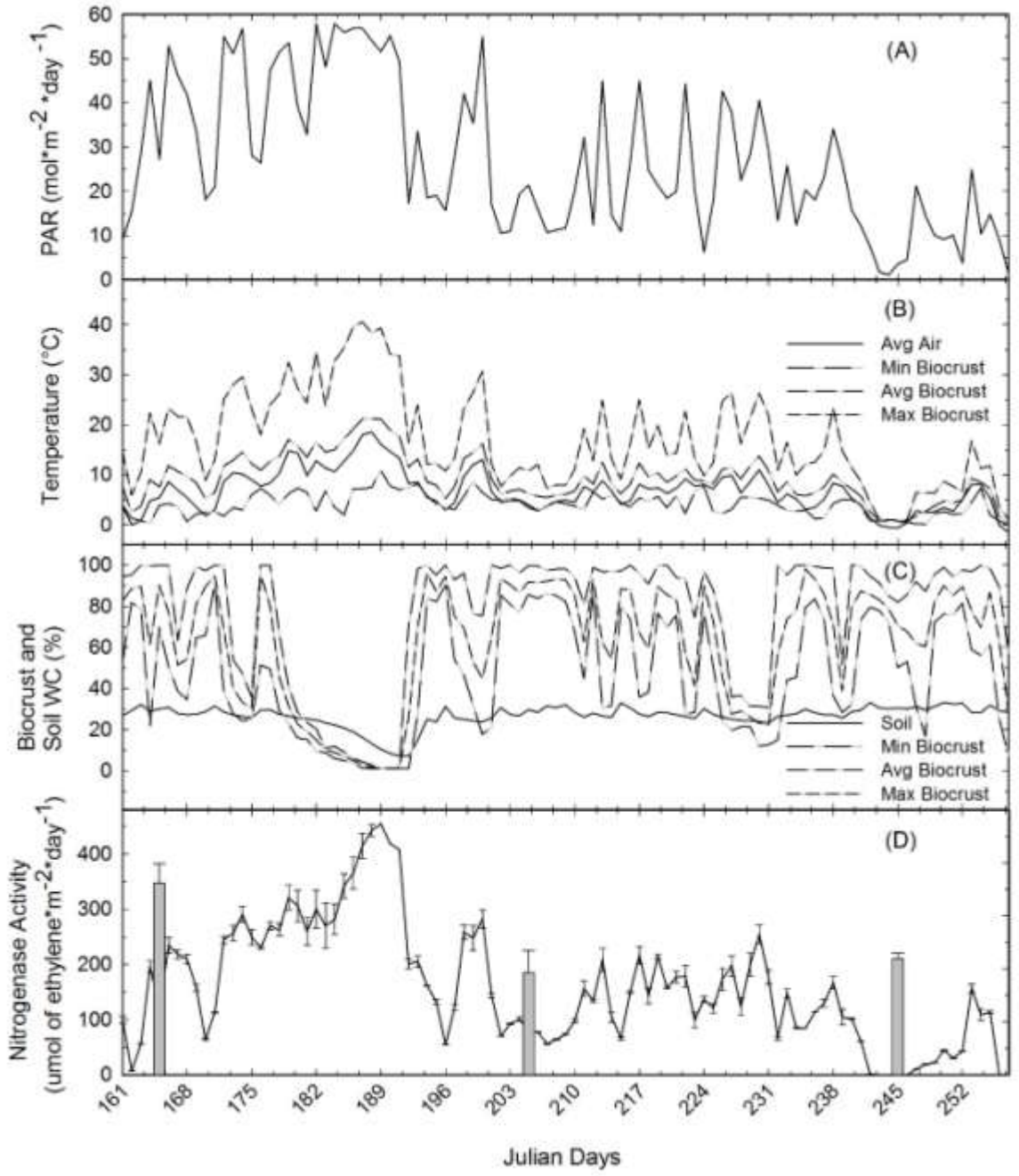
Determine niche ranges for key BSC components

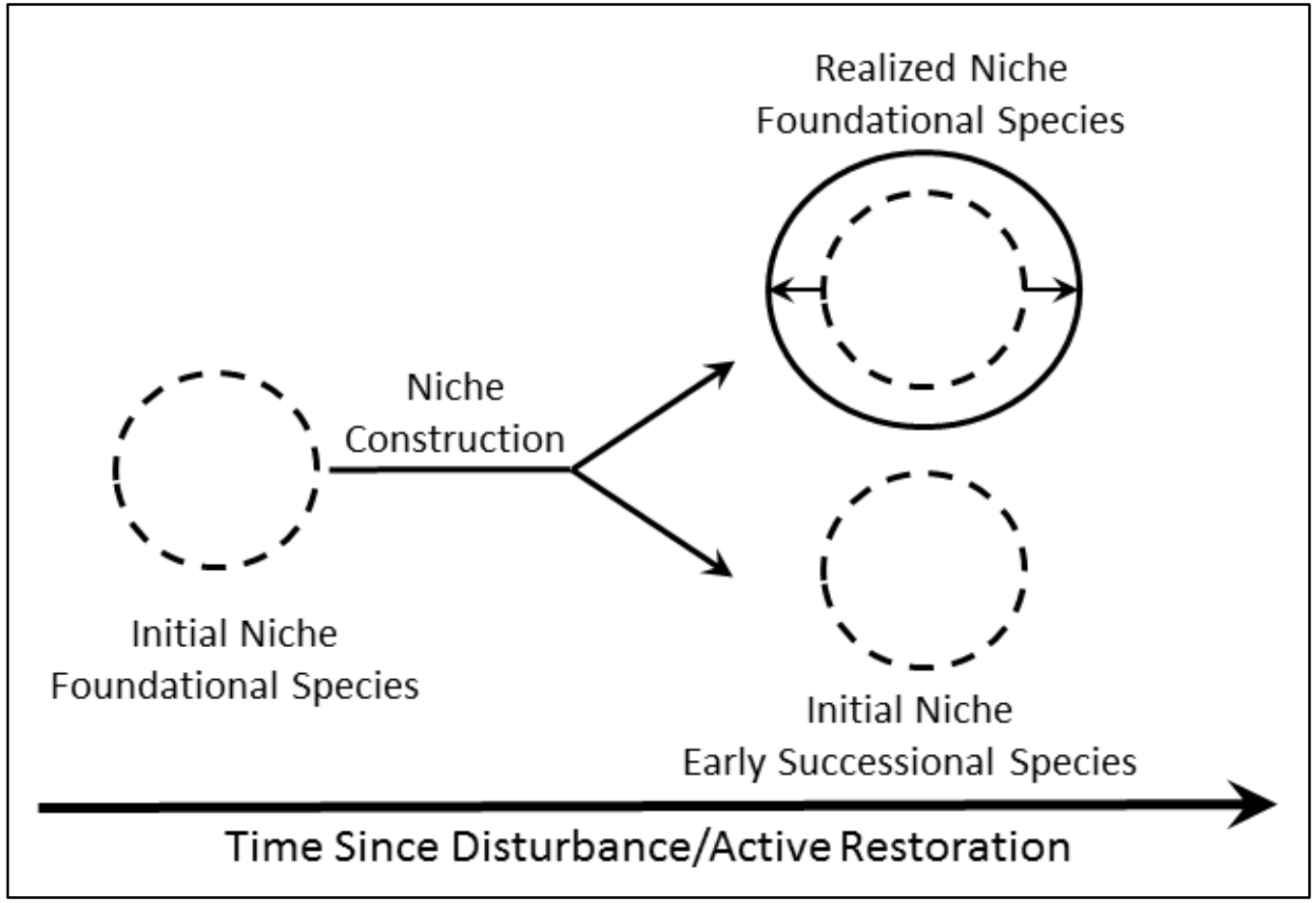


Schulz et al. 2013 The role of microorganisms at different stages of ecosystem development for soil formation. Biogeosciences 10(6):3983-3996 · June


Archaea
Bacteria
Fungi
Cyanobacteria
Lichens
Mosses
Liverworts
Realized niches of key BSC components
Early successional BSCs
Mid successional BSCs
Late successional BSCs
Transplantation to confirm niches
Environmental/soil developmental gradient along glacial forefield chronosequence
2-3 yrs since glaciation
60-100 yrs since glaciation

- Monitoring soil surface microclimate
- Soil physicochemical properties





Drilling Waste Dumps near Rankin Inlet, NU

- Inoculation with BSC may be an effective restoration technique under mesic climate conditions, but may pose challenges in cold xeric environments

- Restoration of biocrust cover may not be indicative of recovery of ecological function, such as soil surface nitrogen fixation

- Niche ranges of key BSC components need to be defined to facilitate use of BSC in restoration

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  S. Siciliano
- Students: A. Letendre
  D. Gordon
  B. Eisenrich

NSERC CRSNG

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