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Reducing erosion, ameliorating stress, resisting invasion: roles for soil organisms in ecological restoration

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In drylands, vegetation is patchy

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In drylands, vegetation is patchy

B. Chaudhary

How important are soils?

- Soils are the foundation of terrestrial ecosystems
- Soils should be a focal point in ecological restoration activities

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How important are soil organisms?

- What roles might soil biota play in ecological restoration?
- Which groups of soil biota might play them?
- How can we manipulate soil biota for restoration purposes?

What roles might soil biota play? Which groups will play them?

- Physical stabilization of soil surface – Biocrusts
- Acquisition of water and nutrients for native plants – Mycorrhizal fungi
- Creation of conditions that are unfavorable for exotic plant growth – Soil community

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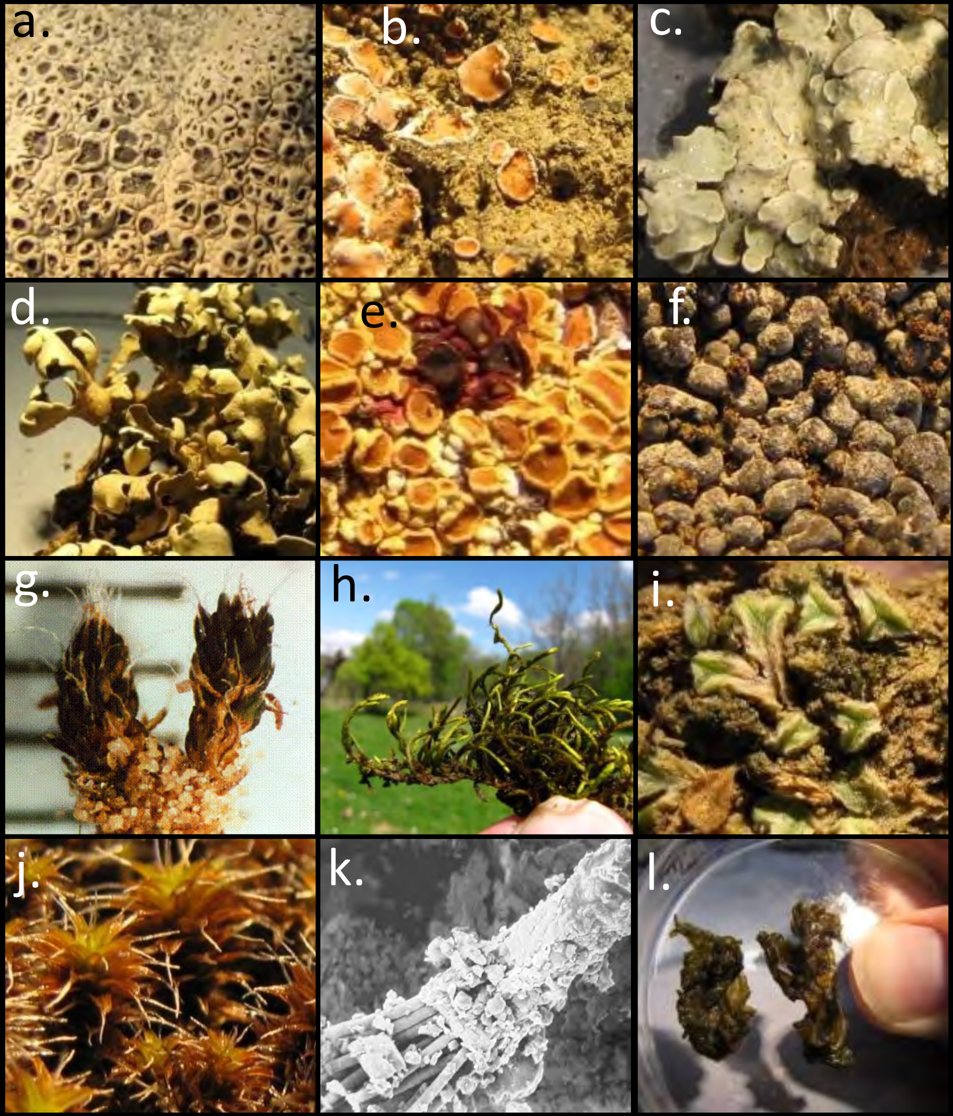
How can we manipulate soil biota for restoration purposes?

Biological soil crusts (BSCs):

The charismatic microflora of the desert

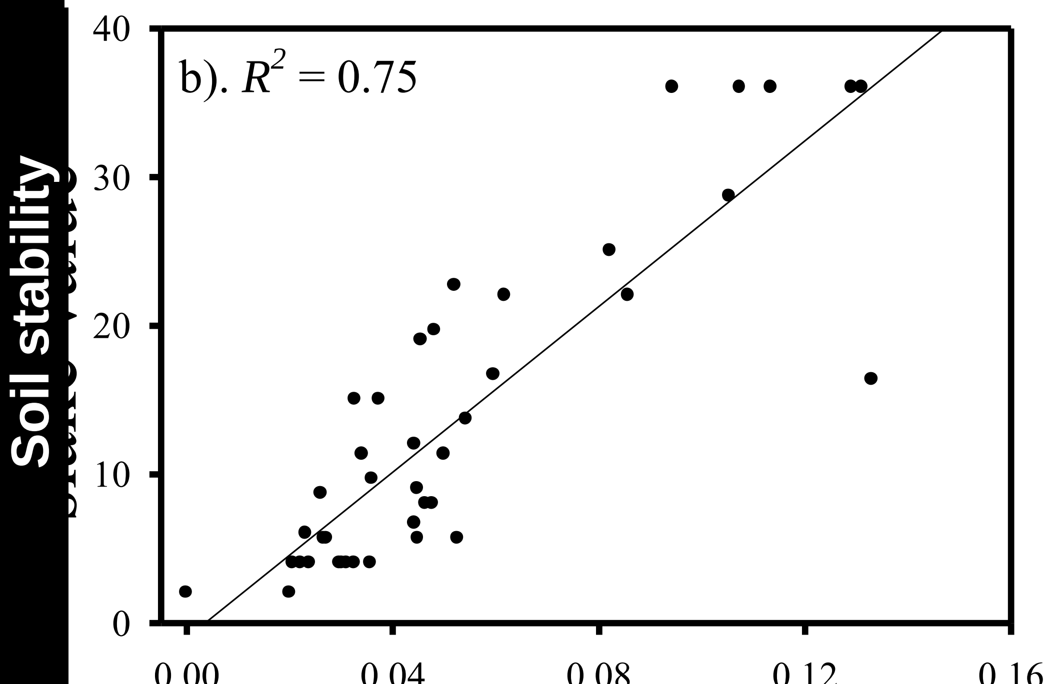


photos: g) L. Stark; k) J. Belnap; all others R. Mau

Mosses, lichens & cyanobacteria...

microfungi, liverworts, archaea, bacteria, chlorophytes, flagellates, diatoms, and a dependent food web of soil invertebrates

Biocrusts *strongly* regulate resistance of drylands to erosion

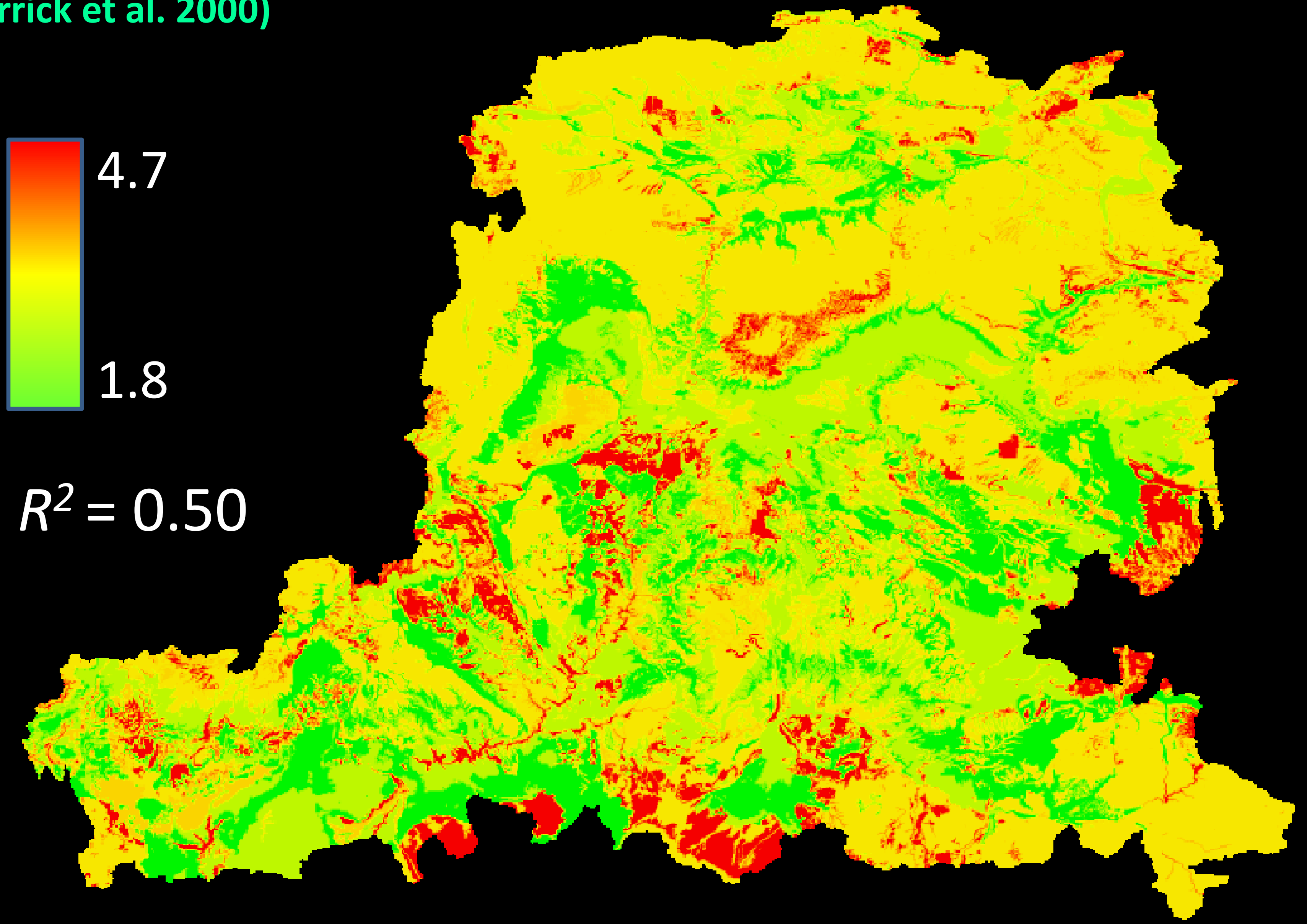


f). R^2 = 0.21

0.00 0.04 0.08 0.12 0.16

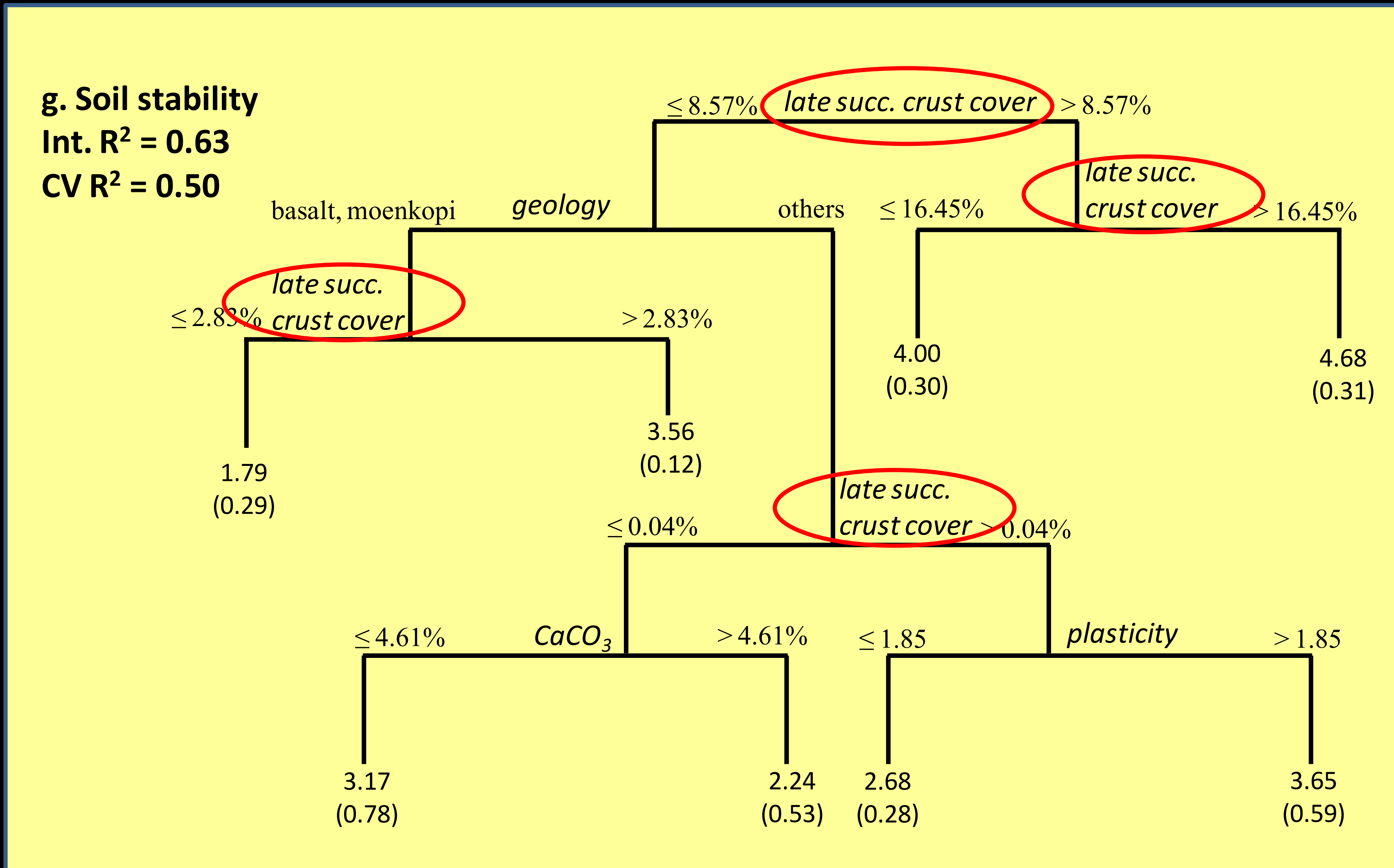
ry et al. 2008, Bowker et al. 2008; Images: J. Belnap

Potential soil stability of the Colorado Plateau
(Herrick et al. 2000)



Bowker & Arundel *unpublished*

Soil stability…



…clearly depends on biocrust potential

Rehabilitation of eroded Colorado Plateau landscapes *must* incorporate biocrusts

Can it be done?

Rehabilitation of eroded Colorado Plateau landscapes *must* incorporate biocrusts

yes!

Dry crumbled crust
(Belnap 1993, Chaudhary et al. unpub.)

Wet slurry
(St. Clair et al. 1986, Maestre et al. 2006)

Rehabilitation of eroded Colorado Plateau landscapes *must* incorporate biocrusts

The "next gen" of biocrust rehab technology

Cyanobacteria & mosses amenable to *ex situ* mass culture
(Buttars et al. 1993, Xu et al. 2008)

What we need to learn:
Are crusts locally adapted and is it a restoration concern?

Ideal mixtures of organisms & sequence of application

Ideal application procedures – *how do we help them live?*

Can crusts and mycorrhizal fungi promote native plant growth?

Benefits of mycorrhizae exist on a continuum

1. Plant host
2. Fungal partners
3. Environmental conditions

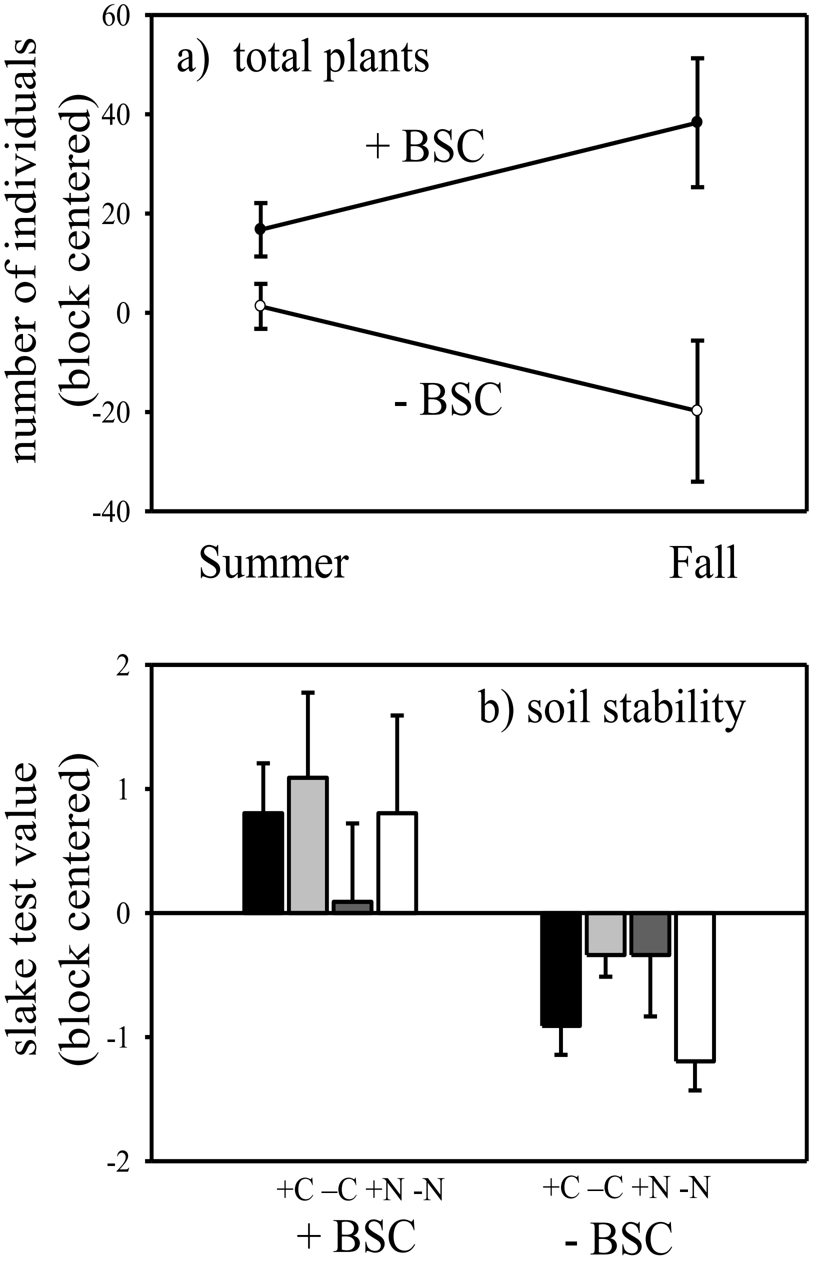
Full factorial

+/- BSC

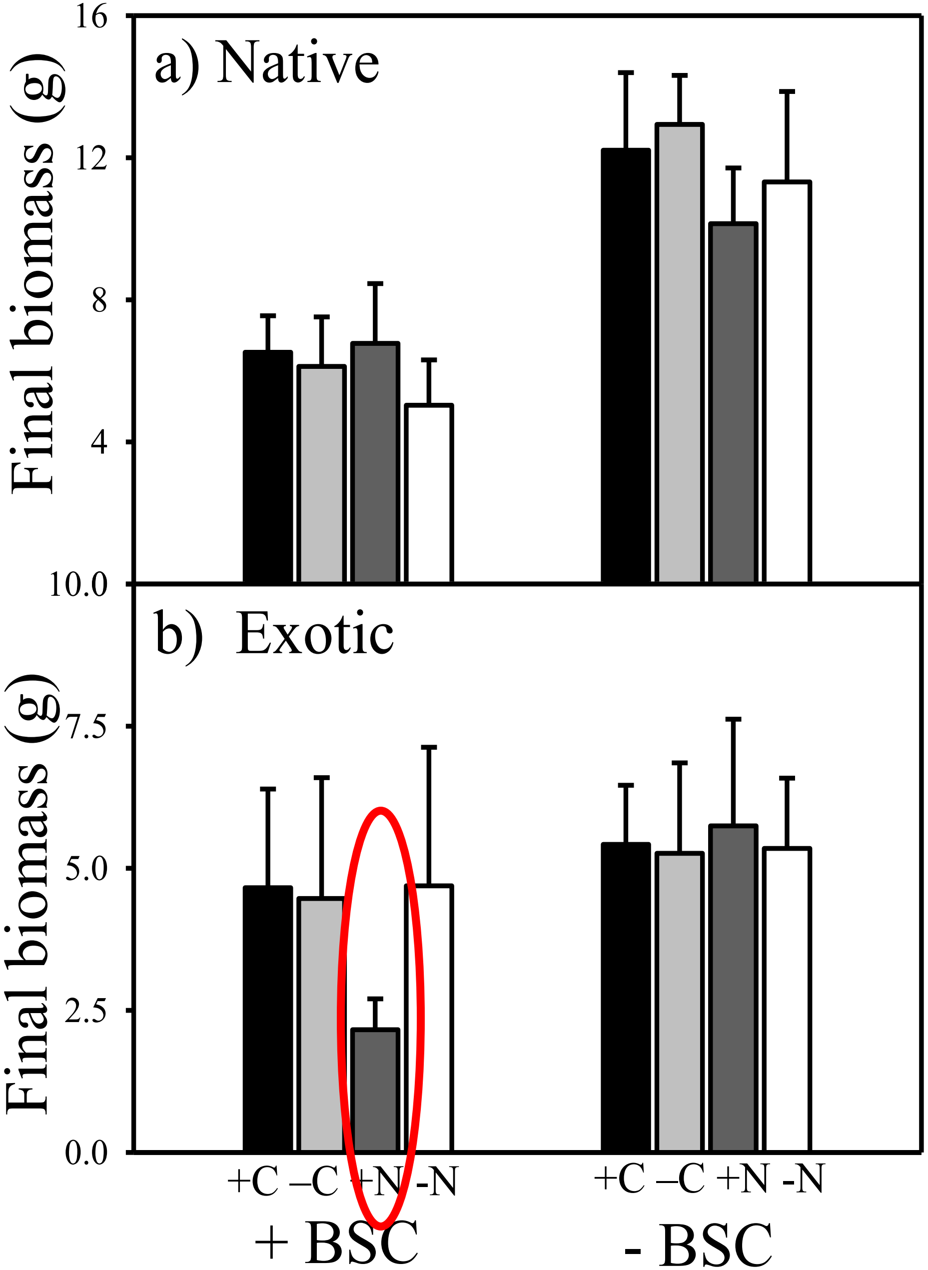
+/- AMF

Seed mixes

Greenhouse & field



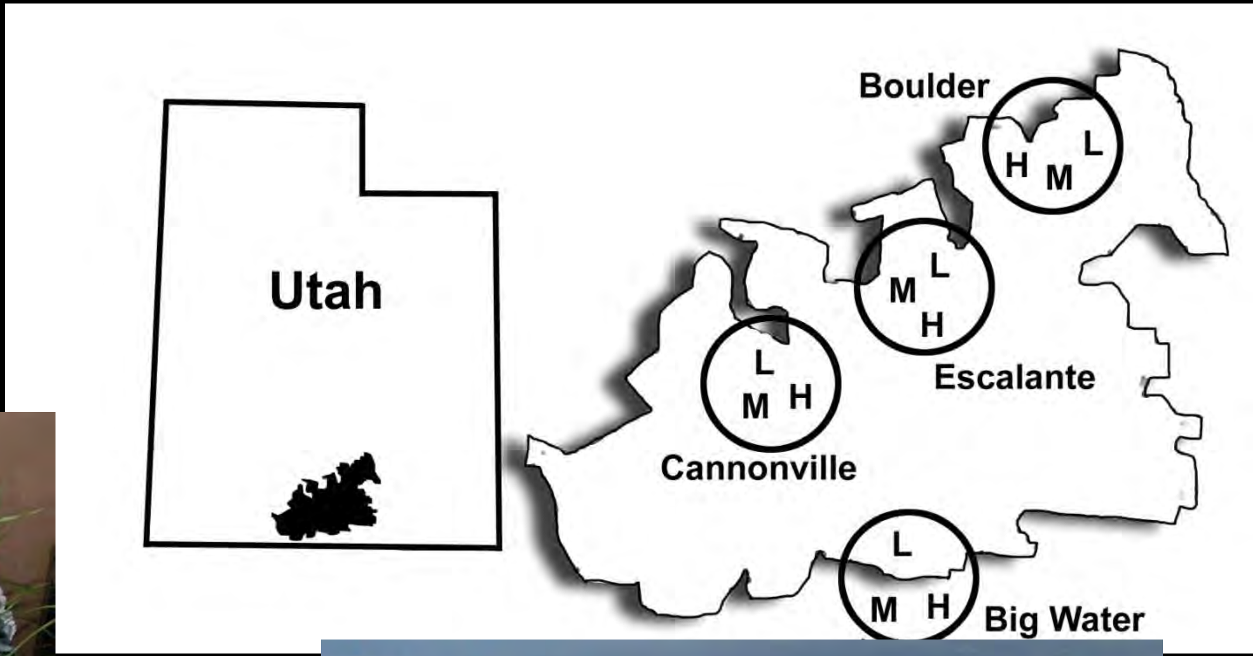
In the field, BSC promoted native plant establishment and soil stability



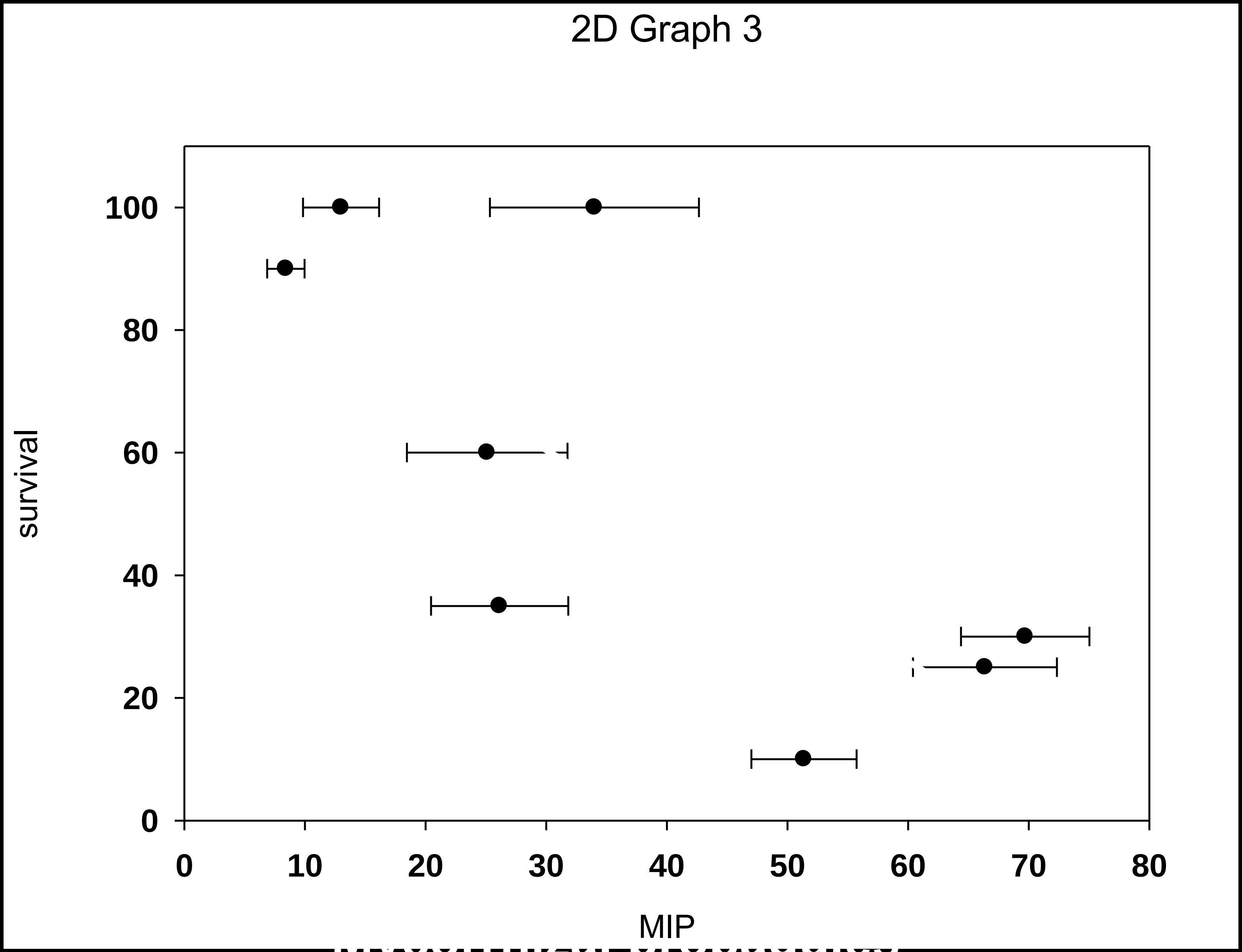
In the greenhouse, only most diverse and complex soil community suppressed exotic grasses

Can mycorrhizae suppress exotic plants in the field?

2 year field experiment at GSENM

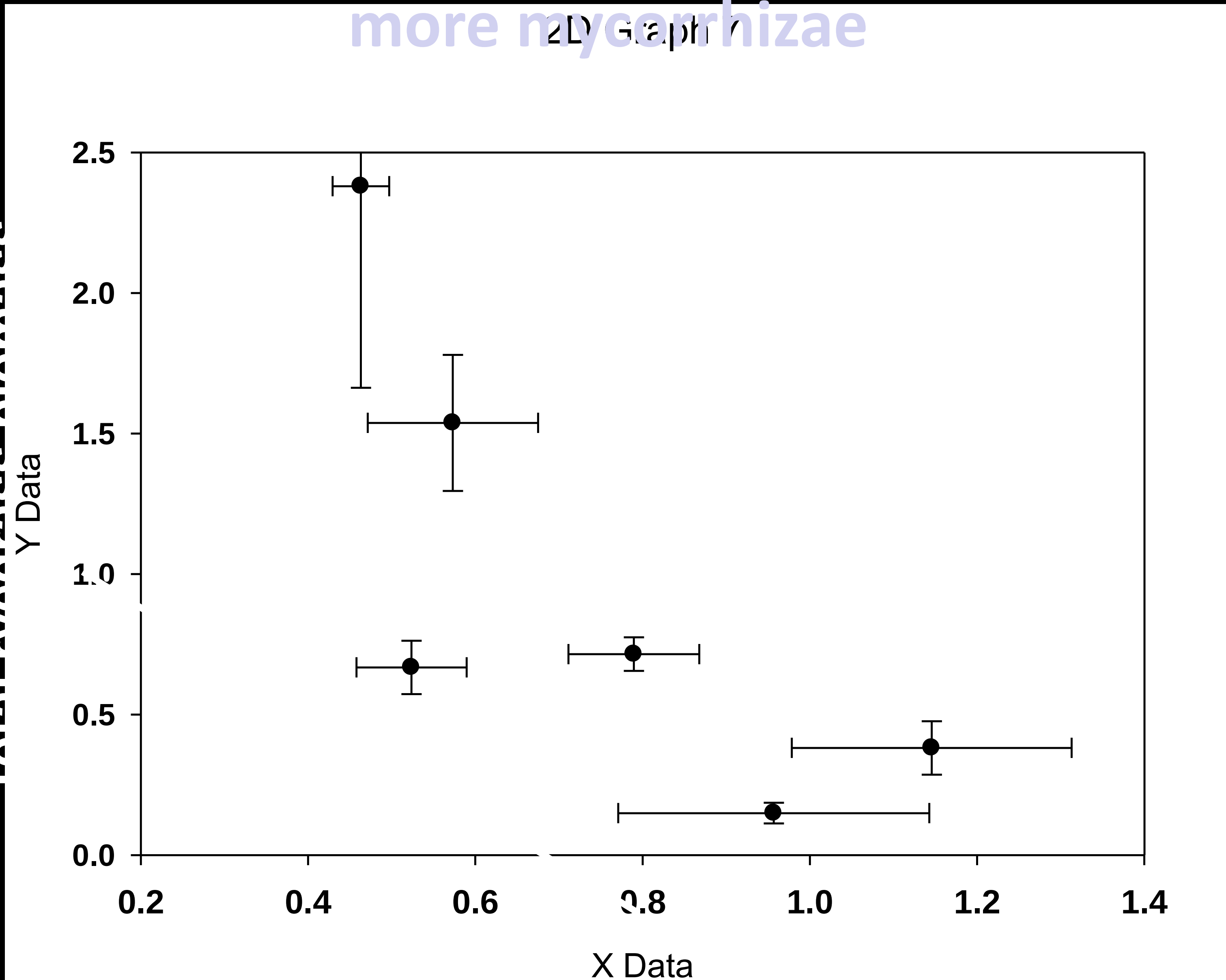


In the field, exotic plant survival decreased with



Mycorrhizal propagules

In the field, exotic plant biomass decreased with more mycorrhizae



Creating unfavorable conditions for exotic plant growth

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Creating unfavorable conditions for exotic plant growth

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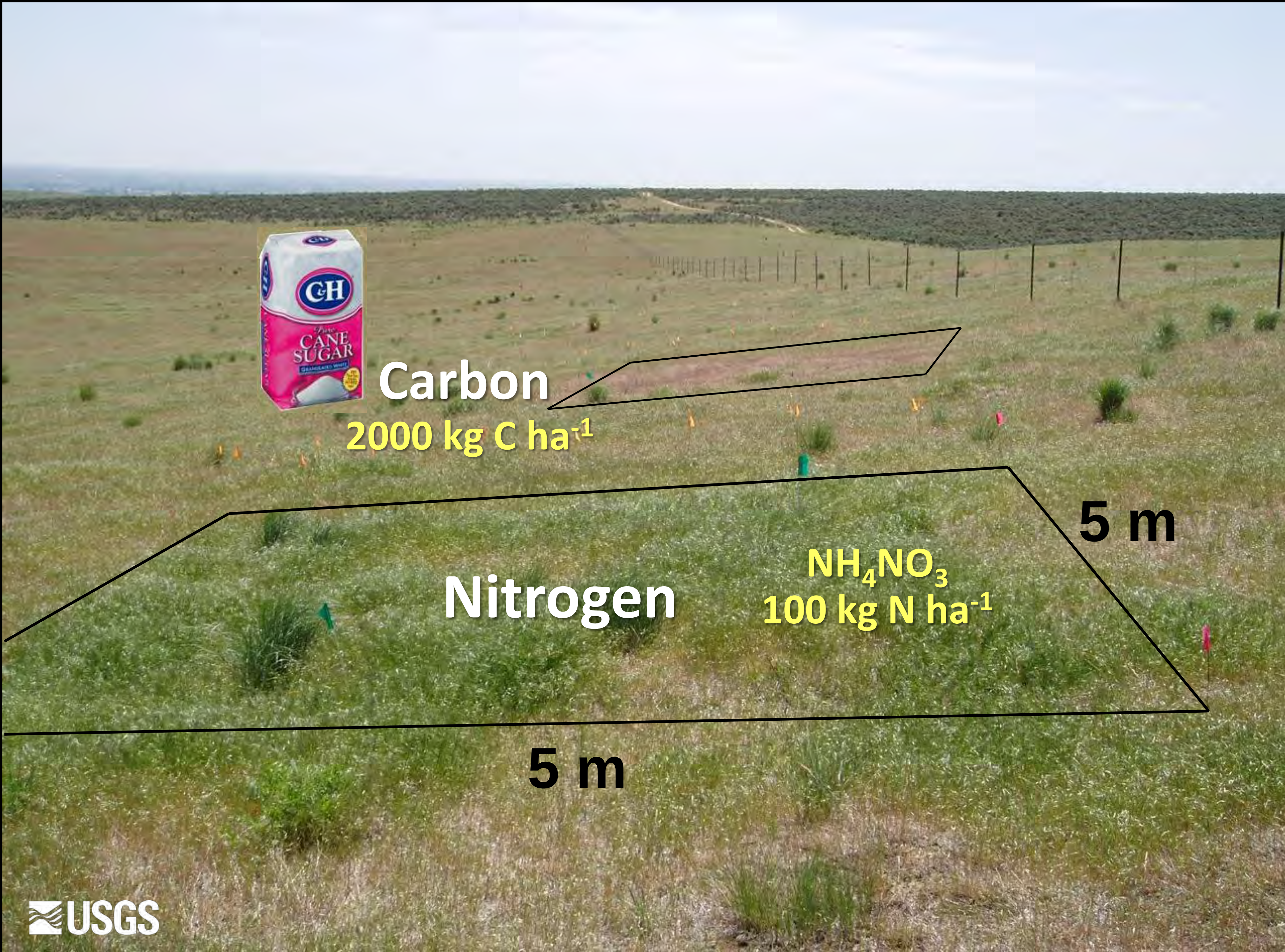
CANE SUGAR
Carbon
2000 kg C ha-1
Nitrogen
NH4NO3
100 kg N ha-1
5 m
5 m
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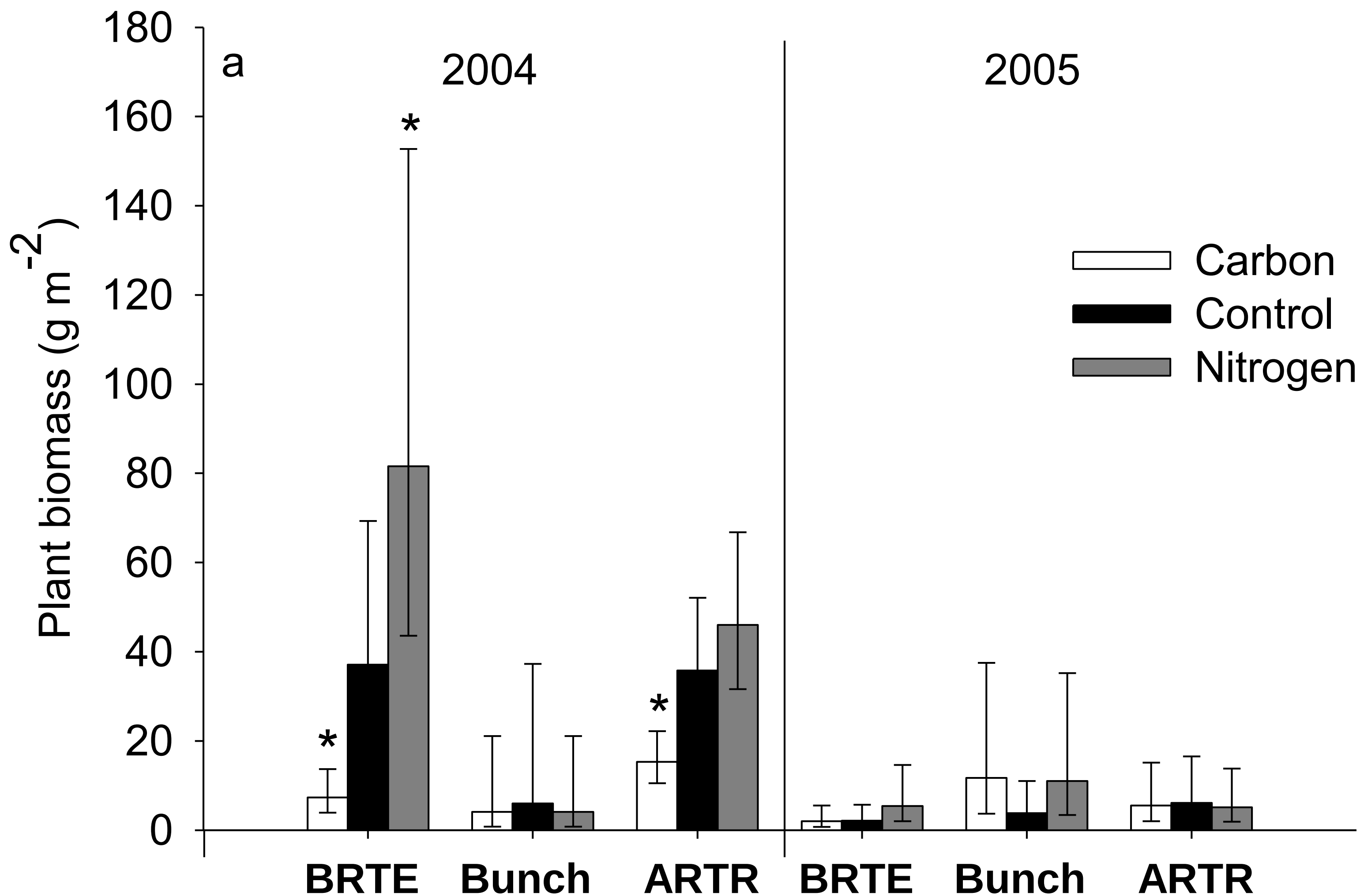
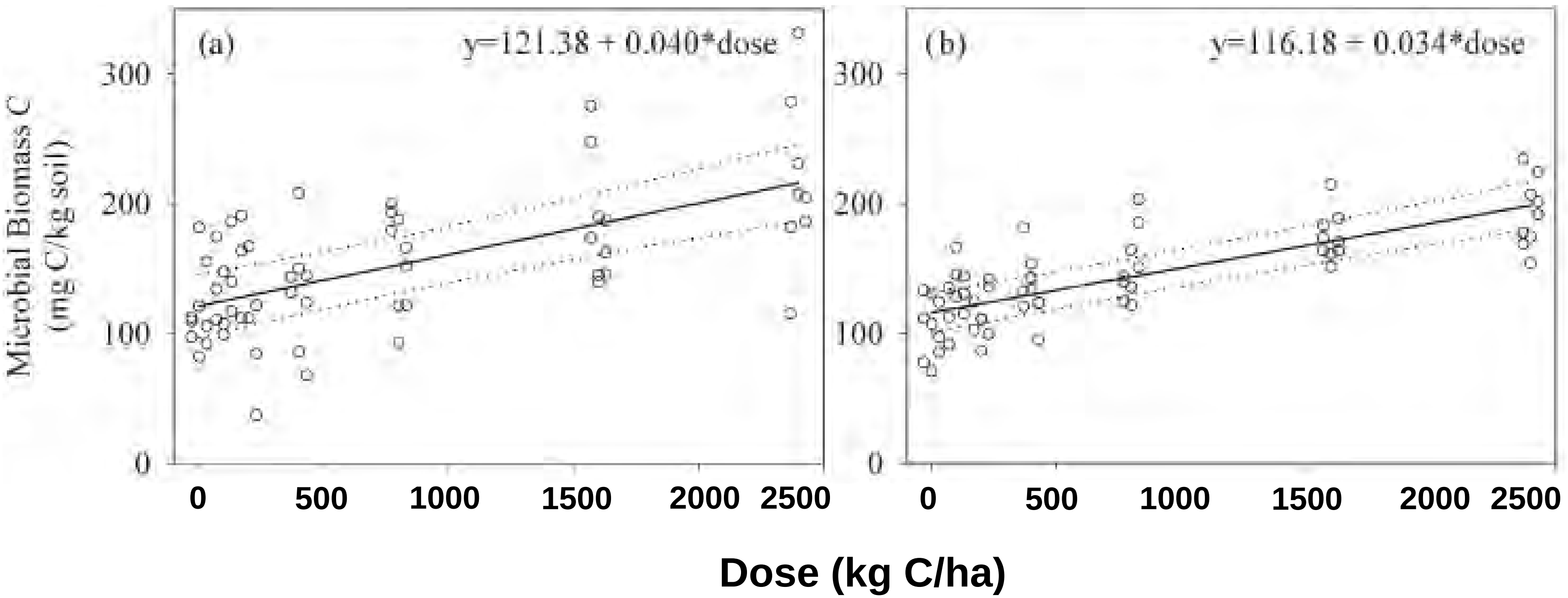
Carbon addition reduces cheatgrass biomass



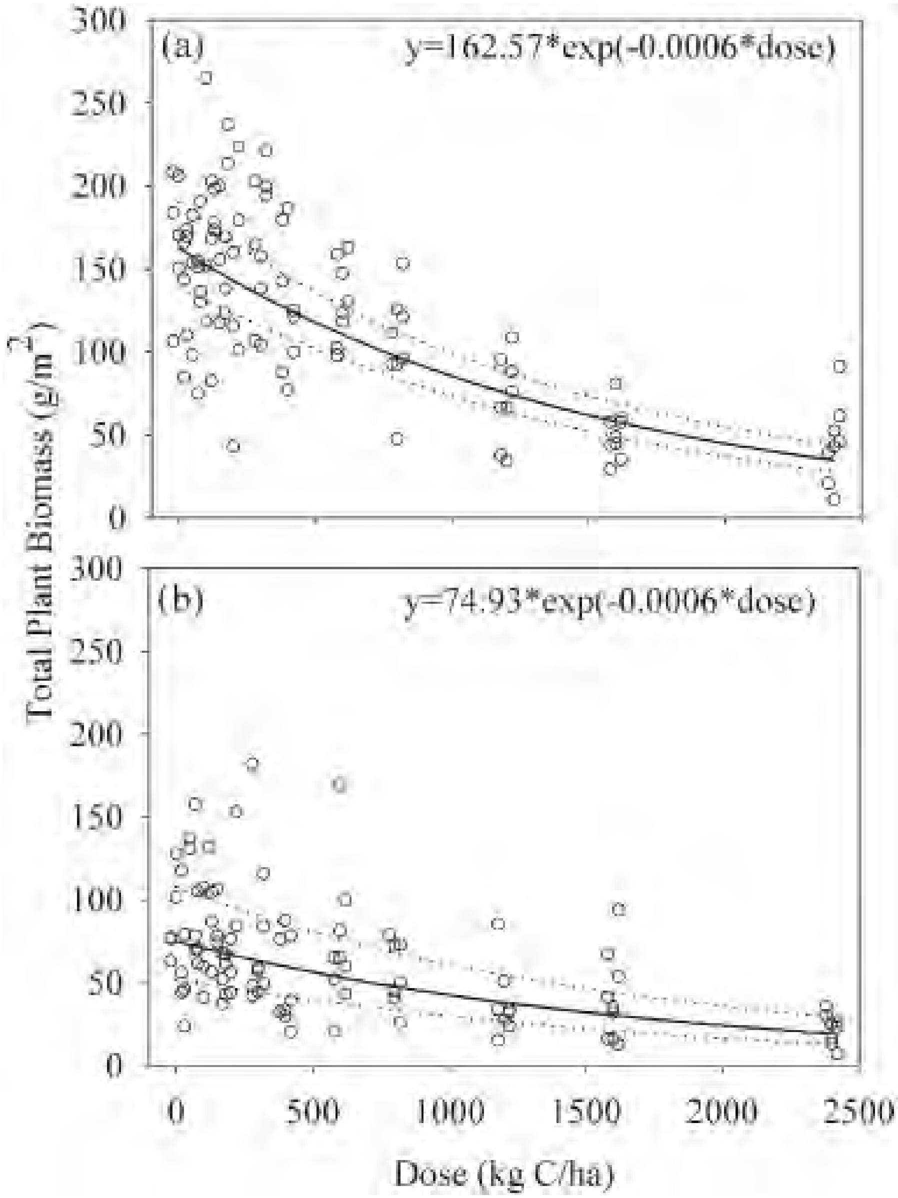
Witwicki et al. submitted

Carbon addition increases microbial biomass



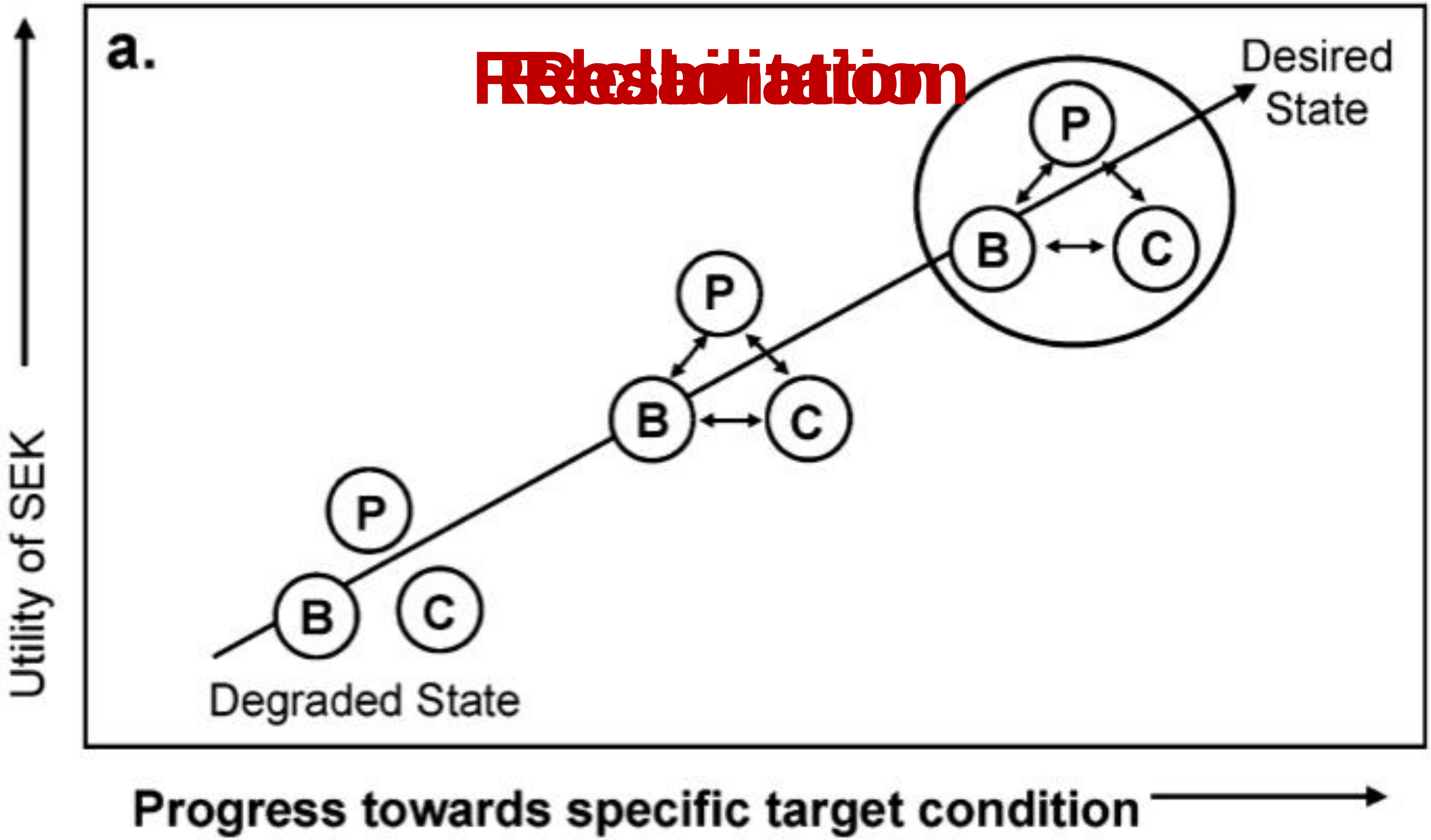
Brunson et al. 2010

Carbon addition reduces BRTE & TACA biomass



Brunson et al. 2010

Soil Ecological Knowledge (SEK)



From Heneghan et al. 2008

Questions?