

# Testing Carbon- and Microbial-Based Strategies for Soil Stabilization and Dust Mitigation in Barren Lands of the Sonoran Desert

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# Urgent Need for Dust Mitigation Solutions That Are:

- **Based on improving soil health first**
- **Long lasting**
- **Self-perpetuating using natural processes**
- **Sustainable and environmentally friendly**
- **Economical and scalable**

# SOIL HEALTH

The continued capacity of a soil to **function** as a vital, **living** ecosystem that sustains plants, animals, and humans.

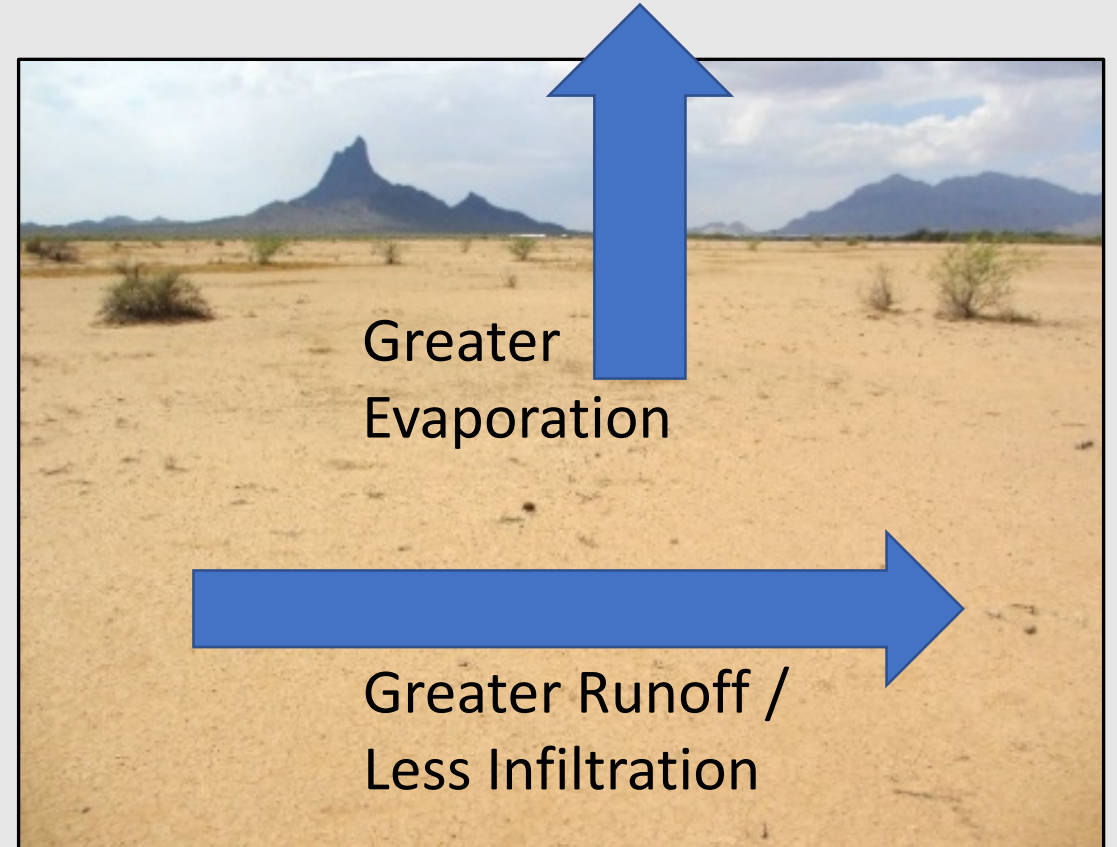


# Symptom #1: Barren lands lack soil cover



Intact Functioning Ecosystem

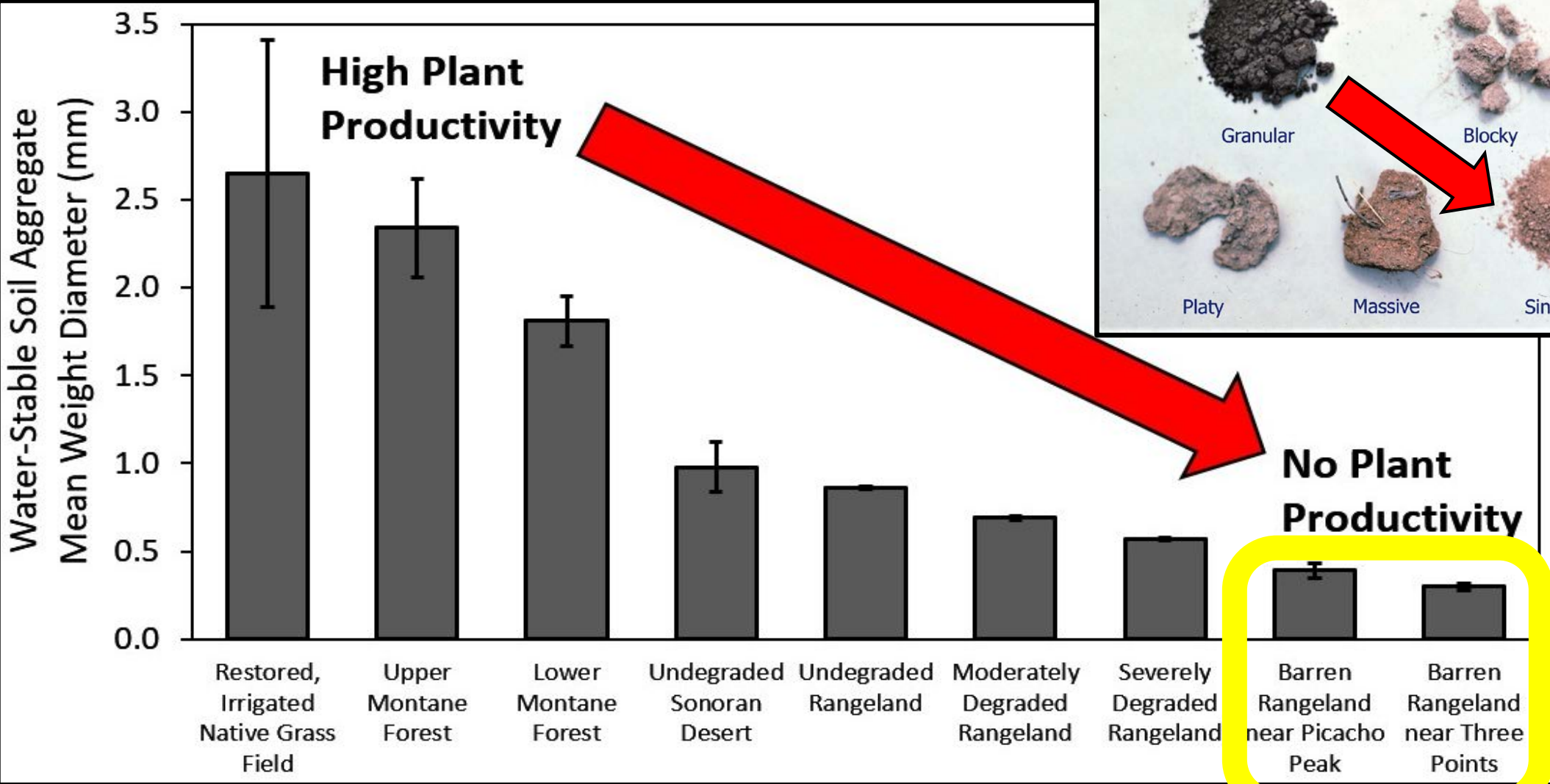
**VS.**



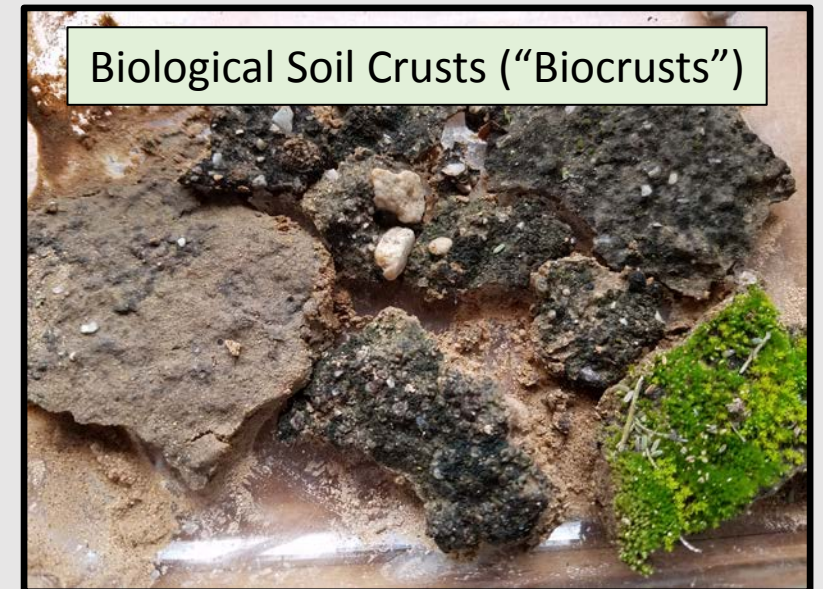
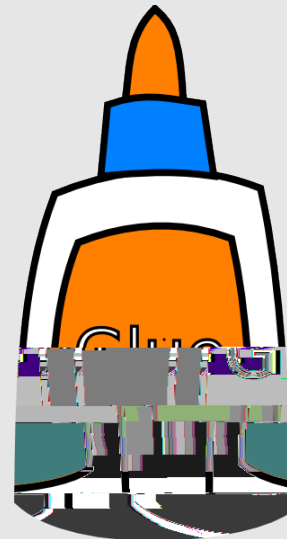
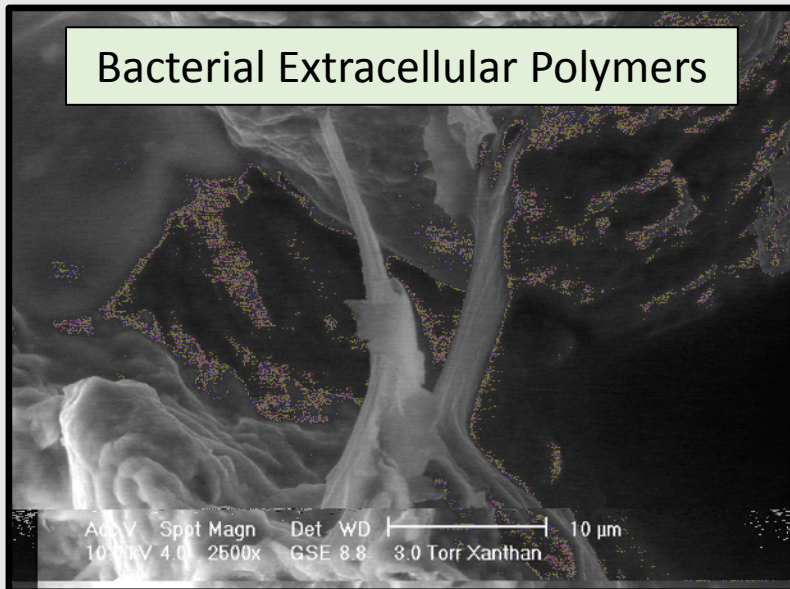
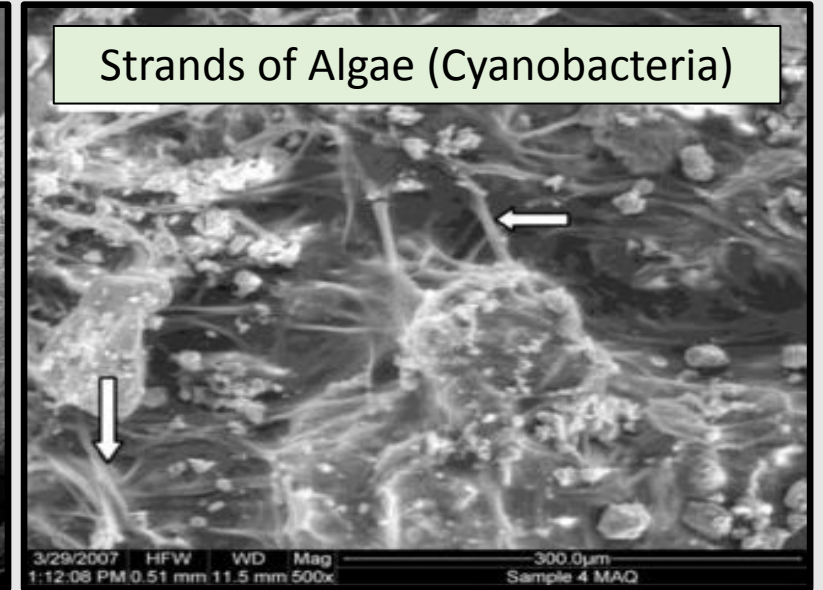
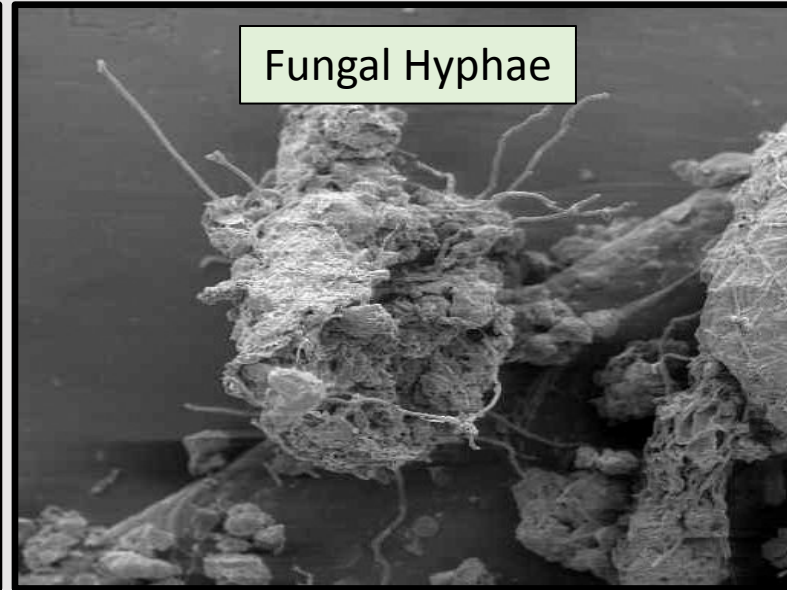
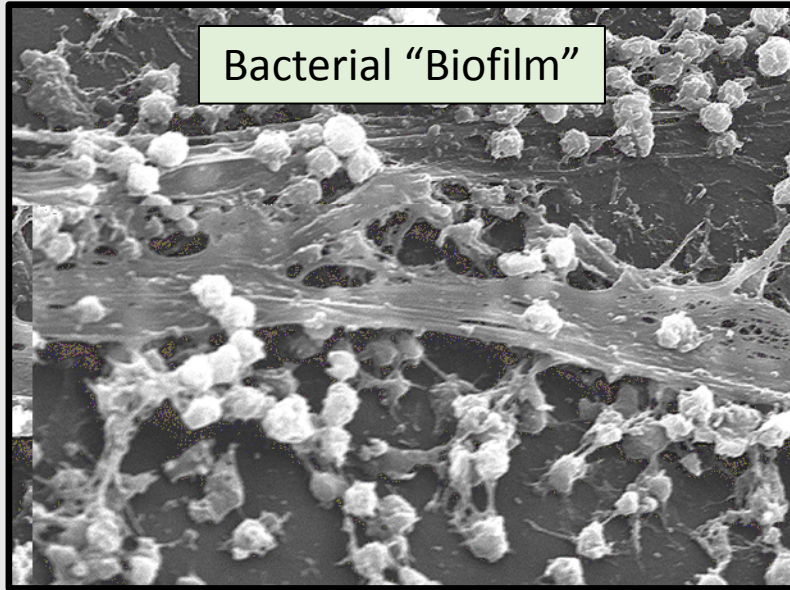
Barren Dysfunctional Land

# Symptom #2: Barren lands lack soil structure

Blankinship et al. (Manuscript in preparation)



# Symptom #3: Barren lands lack soil microbes



# Research Objectives

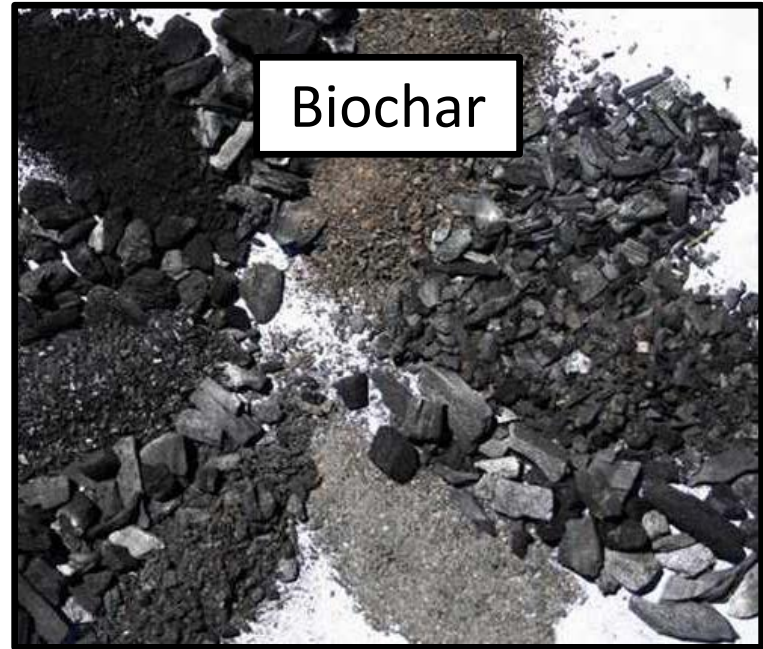
1. What is the potential for recycled green waste to improve soil stability in the Sonoran Desert?
2. What is the potential for microbial inoculants to improve soil stability in the Sonoran Desert?



Woody Mulch



Compost



Biochar



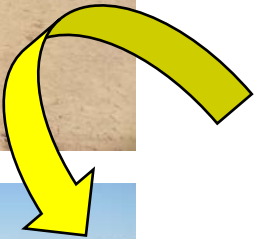
Recycled Green Waste Products  
*How can we best link carbon-rich cities with carbon-poor desert soils?*

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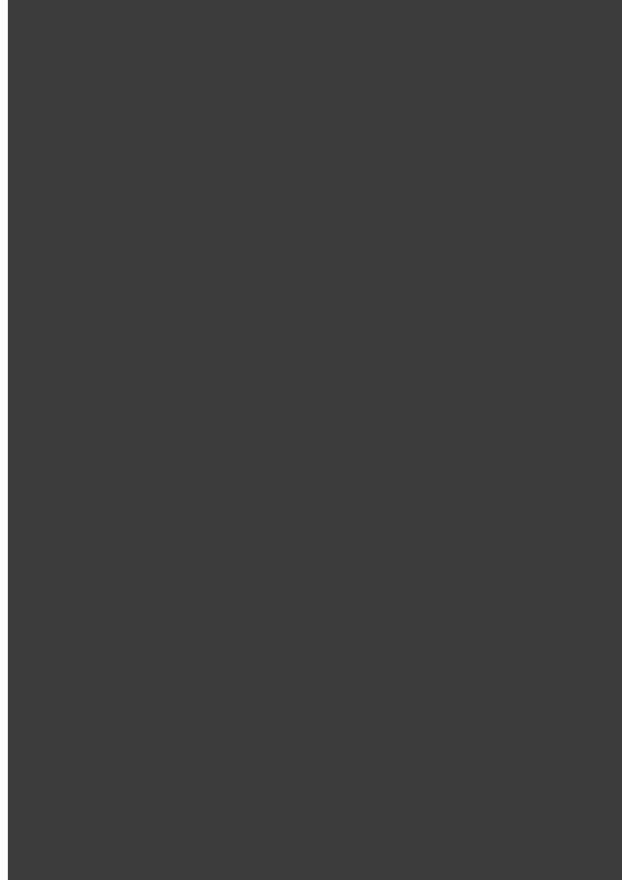




Case Study #1:  
Abandoned cropland  
North Altar Watershed Area (NAWA)



← **Compost only**  
← **Biochar only**  
← **Compost + Biochar**



Case Study #2:  
Degraded grazing land  
Altar Valley, Santa Margarita Ranch

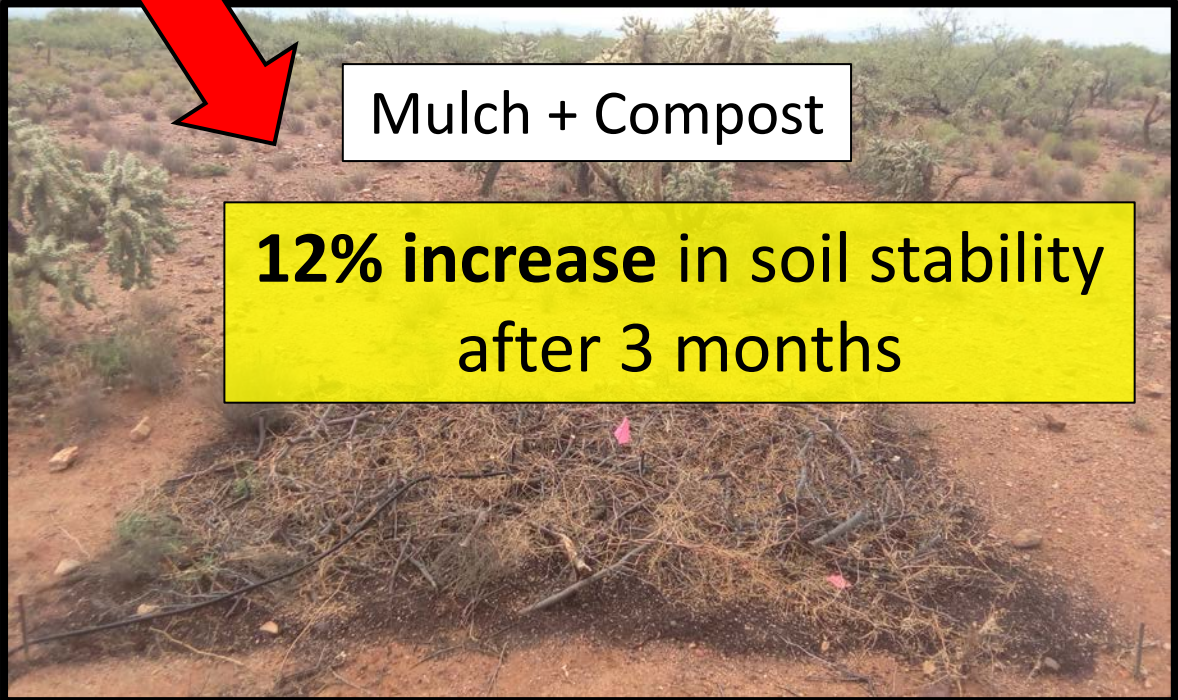


Mulch source



Mulch from  
Mesquite Branches

**31% increase after 3 months**



Mulch + Compost

**12% increase in soil stability  
after 3 months**





# Case Study #3: Monocultures of native perennial grasses NRCS Plant Materials Center, Tucson, AZ

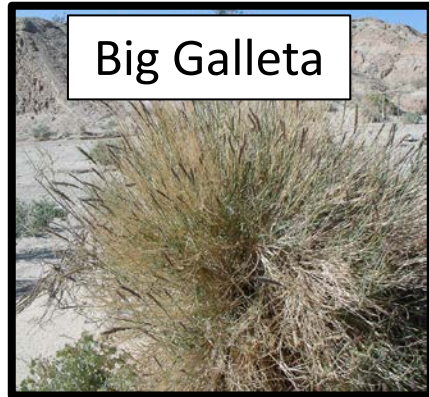
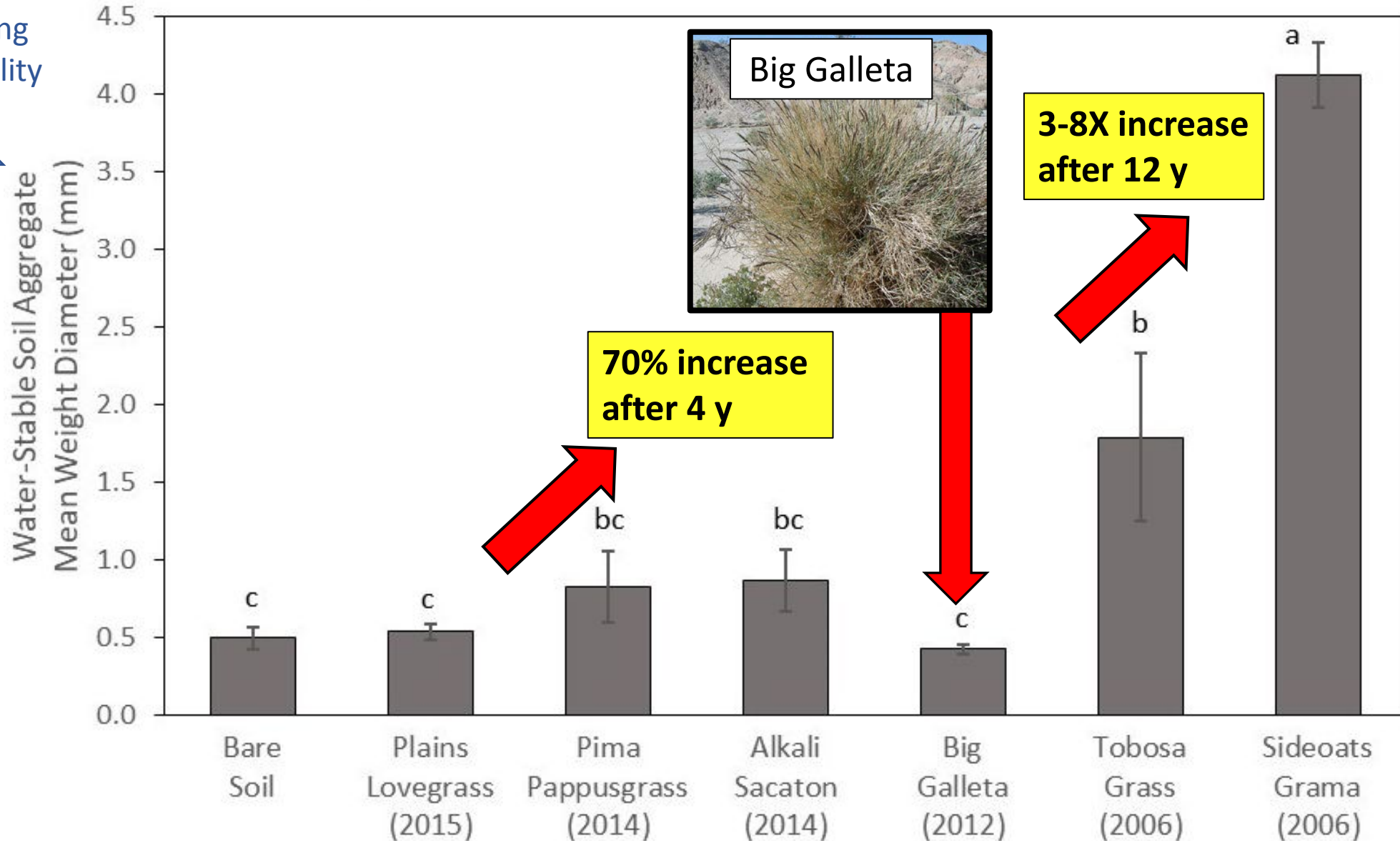
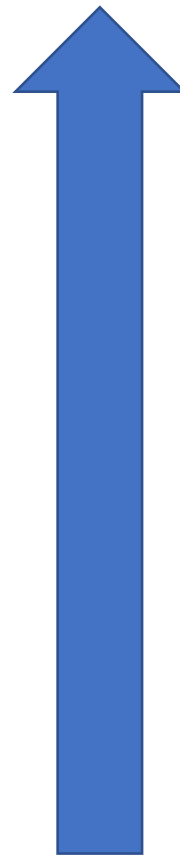


United States  
Department of  
Agriculture

Natural Resources Conservation Service  
Plant Materials Program

# Not all plants are soil stabilizers

Increasing  
Soil Stability



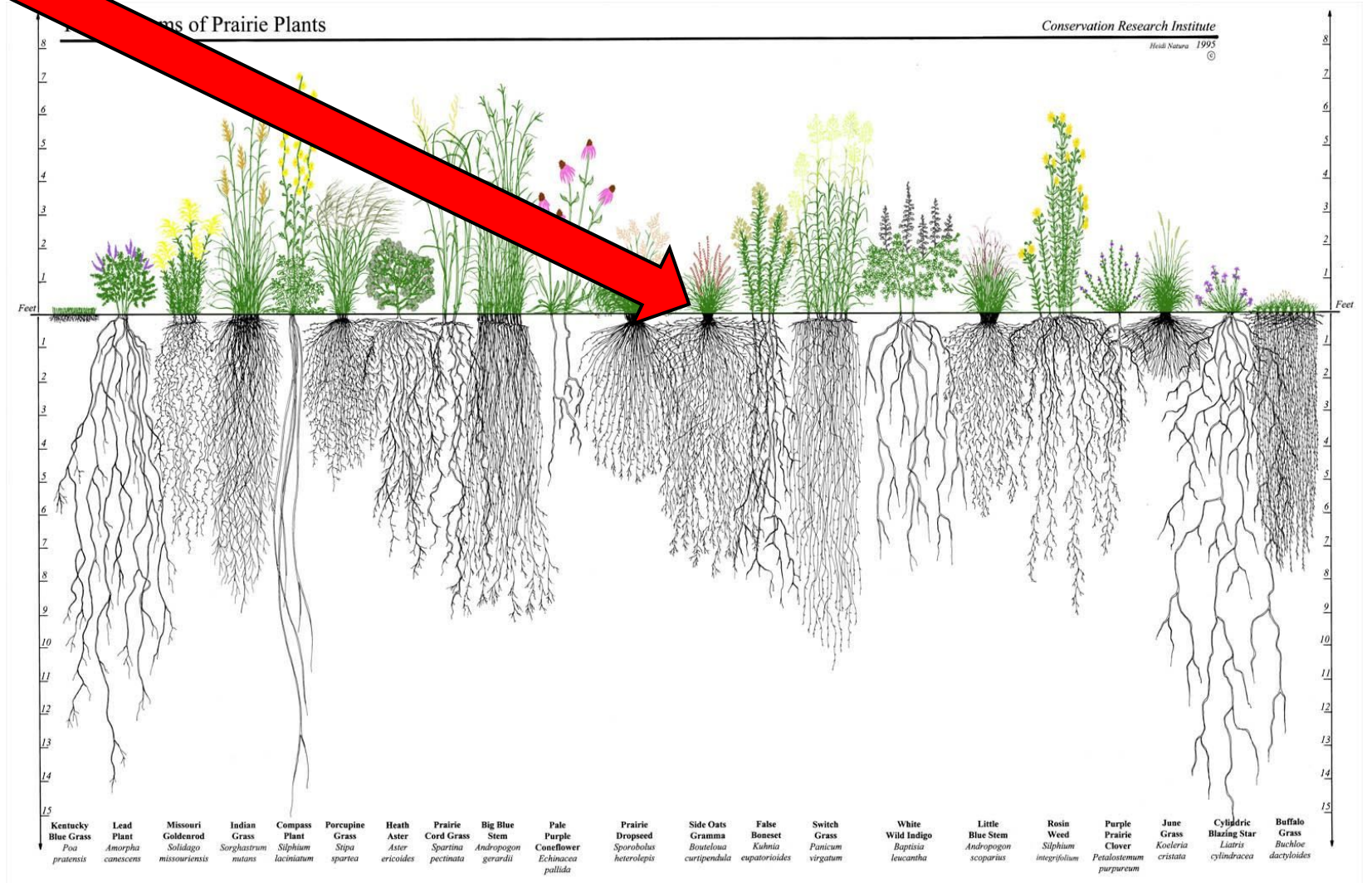
70% increase  
after 4 y

3-8X increase  
after 12 y

Sideoats Grama



# Role of fibrous root architecture?





# Research Objectives

1. What is the potential for **recycled green waste** and **plants** to improve soil stability in the Sonoran Desert?
2. What is the potential for **microbial inoculants** to improve soil stability in the Sonoran Desert?



# “Biocrust” Restoration in Rangelands



Collaborators include Matt Bowker and Anita Antoninka at Northern Arizona University



It is possible to “farm” biocrusts and then transplant established mats or crumbles

Besides stabilizing soil, biocrusts can promote plant growth



# Cyanobacteria (aka “Algae”) as Soil Stabilizers

## MICROP



### NATURE'S BIO-FERTILITY PROGRAM

A new concept in green manures, MICROP provides the effects of a green manure crop without taking the land out of production. Used as a companion planting, the legume-like microalgae and cyanobacteria act as an input for maintaining maximum crop yields. MICROP is a composition of selected dormant photosynthesizing cyanobacteria (blue-green algae) in a base of kaolin clay. Once applied to the soil, these cyanobacteria come out of dormancy and colonize the soil surface by cell division, providing many agronomic benefits including:

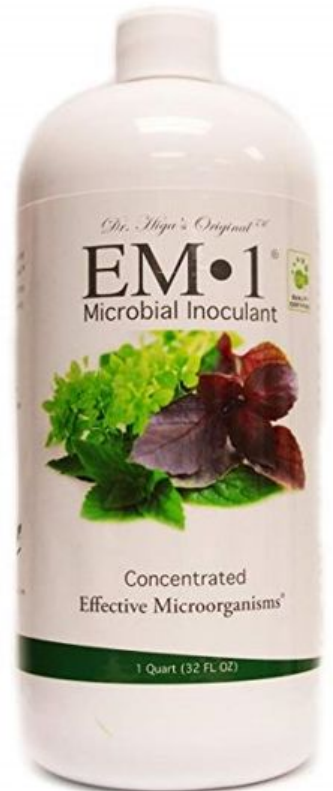
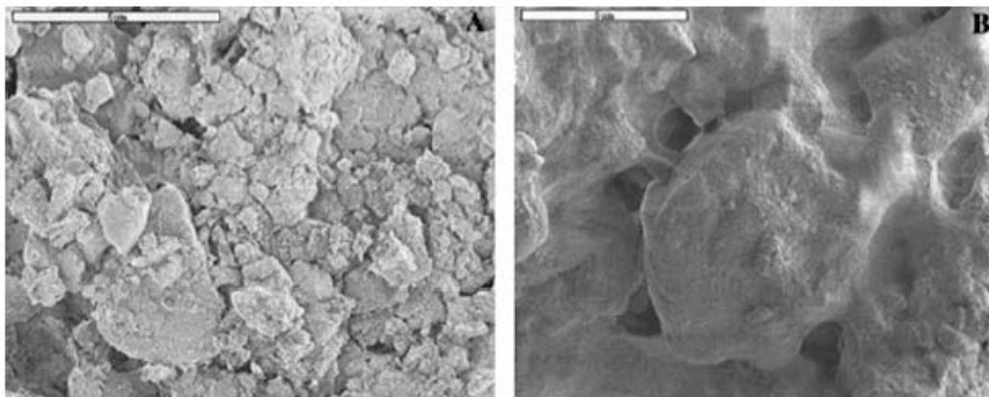
- Fixing nitrogen
- Liberating calcium and phosphates
- Decreasing salinity
- Improving soil tilth, and
- Supplying plant growth hormones

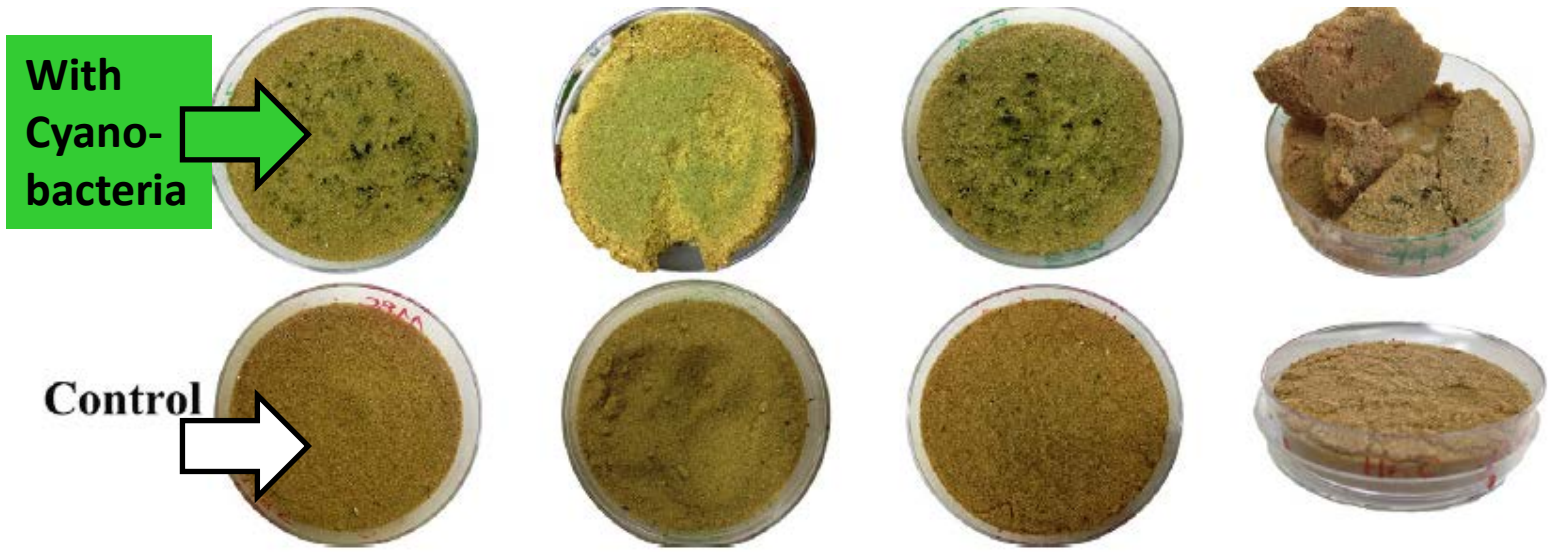
The intercropped microscopic plants add organic matter as they grow in the field with the crops. The added fertility from nitrogen fixation helps to reduce fertilizer needs. This model green manure product offers growers an ecologically sound method to improve soil properties and enhance productivity.

Research has shown that MICROP improves soil tilth, decreases compaction, crusting, and erosion. The growing cyanobacteria produce polysaccharides (humus material) to increase aggregation and build soil crumb structure. Research data also suggests the ability of these microbes to solubilize rock phosphate, making phosphorus more available to the growing crop. The combination of these results makes MICROP an ideal technology for handling a wide range of soil problems.



**Fig. 12.7** SEM images. Microstructure and soil aggregate stability of Guquka soil aggregates inoculated by *Nostoc* 9v; (a) surface of non-inoculated sample; (b) surface of an inoculated sample. Scale bar, 5  $\mu\text{m}$  (Source: Malam Issa et al. 2007)

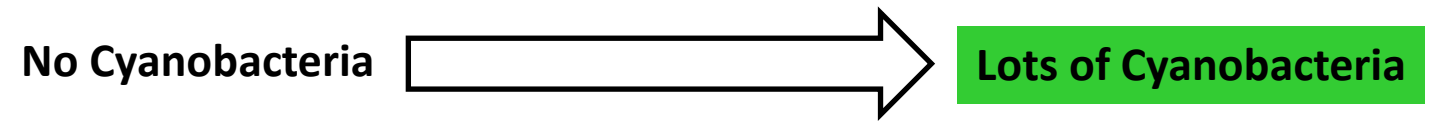




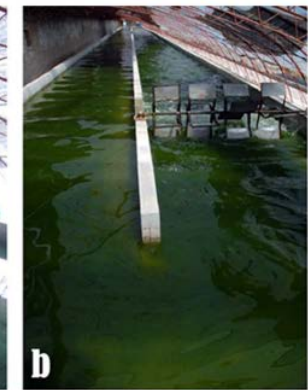
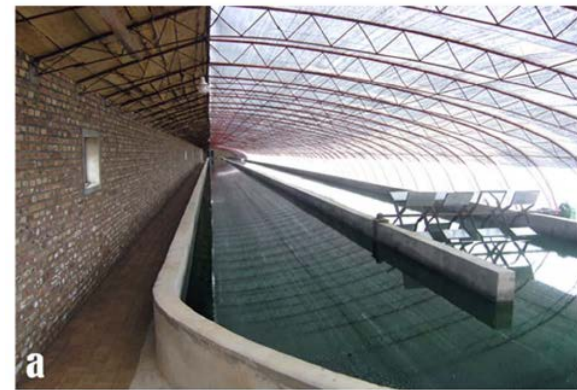
**With  
Cyano-  
bacteria**

**Control**

Mugnai et al (2018) Soil Biology & Biochemistry



It is possible to cultivate cyano-bacteria much faster and in larger quantities than natural biocrusts



D'Acqui (2016) Bioformulations for Sustainable Agriculture

Rossi et al (2017) Earth Science Reviews



# Soil “Bio-Stabilization” Experiment

University of Arizona  
Campus Agricultural Center



# Conclusions & Future Directions

**SOIL HEALTH**



**Dust Mitigation**

**Mulch = Soil protector and slow-release carbon**

**Cyanobacteria = Soil stabilizer and fertilizer**