Exploring Biological Solutions to Mitigate Dust near Picacho Peak

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College of Agriculture & Life Sciences

ADEQ Arizona Department of Environmental Quality

USDA United States Department of Agriculture Natural Resources Conservation Service

The University of Arizona Research, Innovation & Impact Arizona Institutes for Resilience

Tank's Green Stuff 100% Organic Compost • Garden Soil • Fertilizer Mulch • Cactus Soil • Wood Chips

SOIL HEALTH

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

USDA NRCS (2012)

Lehmann et al. 2020 *Nature Reviews*

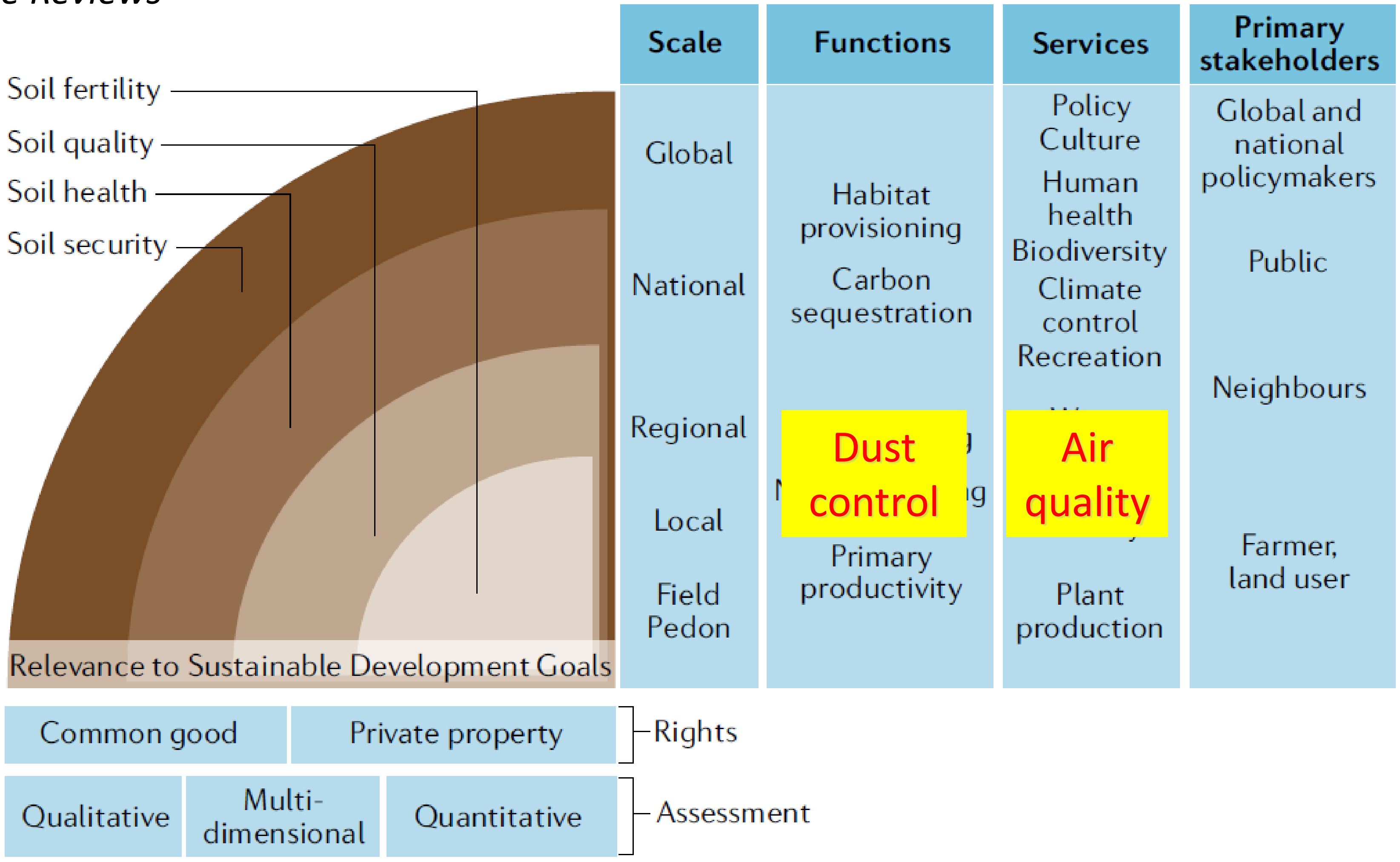


Fig. 1 | **Soil fertility, quality, health and security.** The concepts vary by what relevant spatial scales, functions, ecosystem services and stakeholders they capture (listed as nested concepts on the right of the figure). The concepts also differ in the view of soil rights and assessments. Soil health encompasses a broad range of ecosystem functions, services and actors, impacting a wide array of sustainability goals. The five functions listed here impact overall soil-ecosystem services[3,4,6].

Janzen et al. 2021 *Soil Biology & Biochemistry*

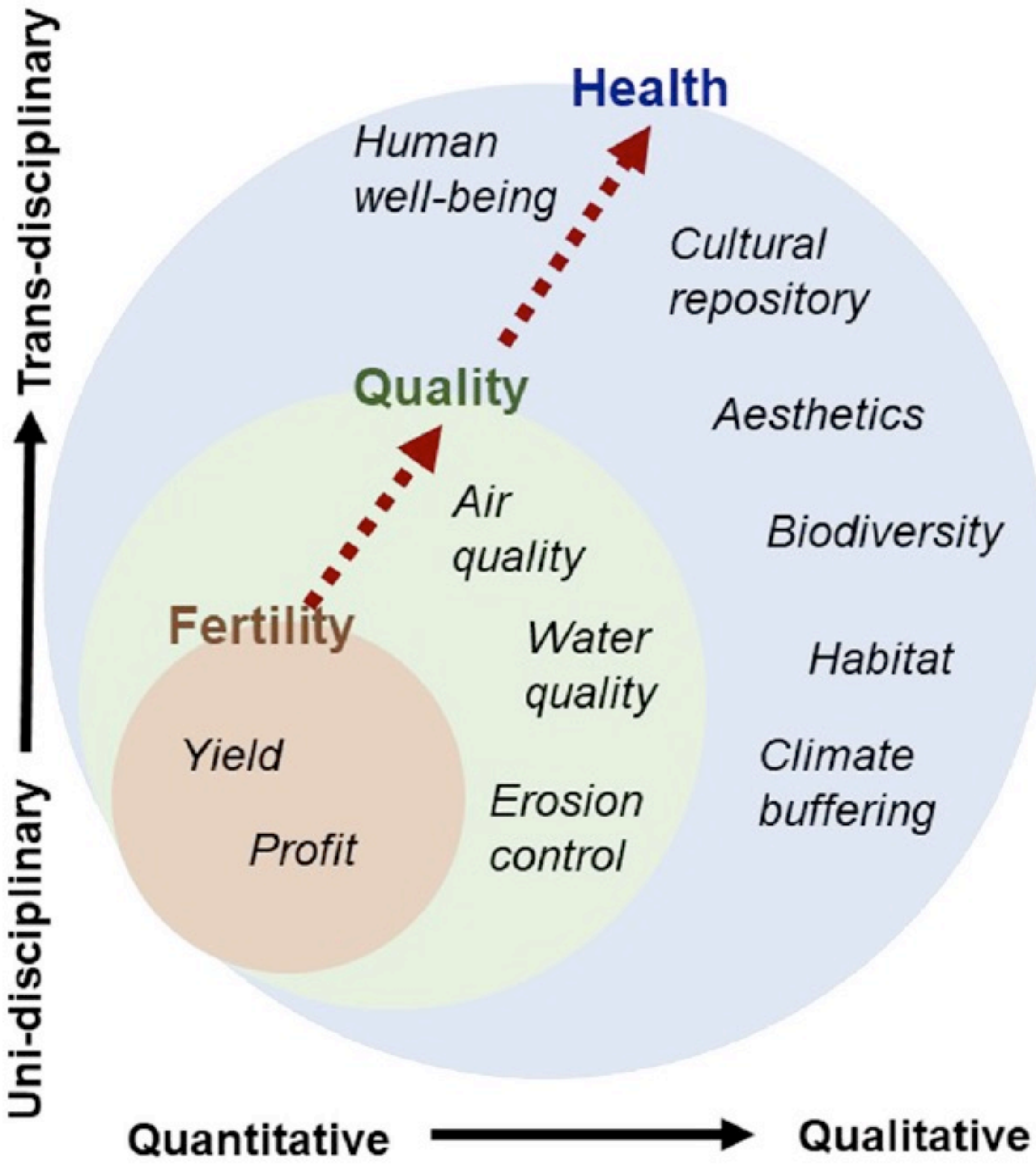
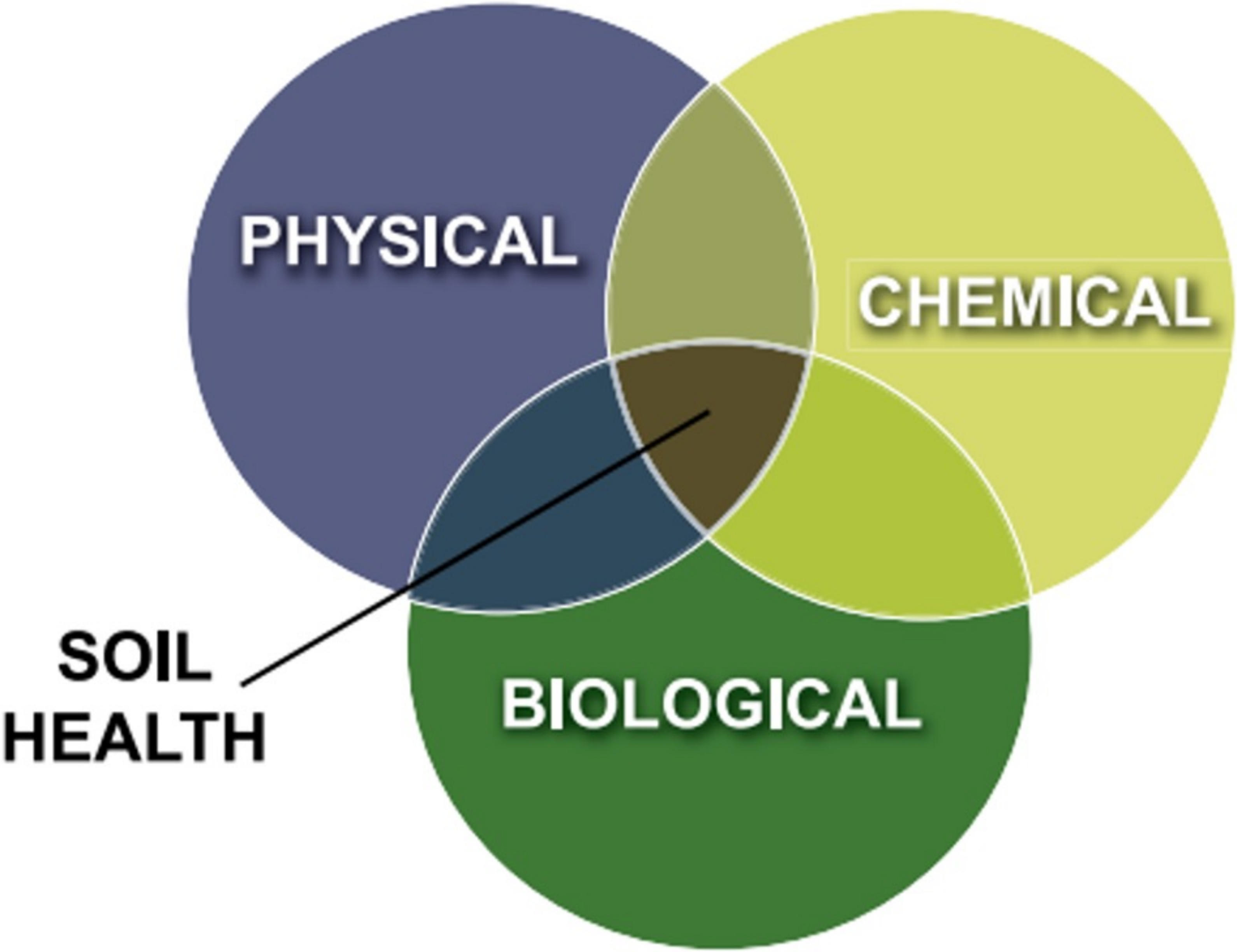


Fig. 2. Conceptual illustration showing the increasing number and range of ecosystem functions considered in the historical succession from soil fertility to soil quality to soil health. The boundaries between the various concepts are not always distinct, accounting for variable interpretations of these terms in the literature; for example, some authors see soil quality and soil health as synonymous. We suggest, however, that a strength of the soil health metaphor is that it enfolds an expanded, more qualitative list of socio-ecological functions, not directly considered in earlier terms. Contemplation of soil health, therefore, requires a deliberate, adventurous transdisciplinary approach.


reThink Soil
A Roadmap to U.S. Soil Health
A roadmap for collective action to secure the conservation and economic benefits of healthy soils
The Nature Conservancy
reThink Soil
A Roadmap to U.S. Soil Health
5. Leverage technological innovation to overcome operational hurdles
7. Create market signals in sustainability programs for soil health
4. Align incentives between landowners and farmers
POLICY
Improve the policy environment to advance soil health
SCIENCE
Overcome the science and research gap to support expansion of soil health management
6. Provide broader access to products and services supporting soil health
8. Reward farmers who optimize long-term soil health with lower crop insurance premiums
ECONOMY
Overcome economic obstacles by providing the market systems to secure soil health
3. Advance the science of soil health benefits
9. Support policies that enable greater investment in soil health
10. Build a more diverse constituency for soil health policy
1. Create cost-effective soil health measurement standards and tools
2. Develop operational management strategies for adaptively integrating soil health practices and systems
Increased coordination and investment in the Soil Health Roadmap will lead to tangible economic and environmental benefits for U.S. farmers, businesses and communities.
Working together, committed partners can help ensure a sustainable future for generations to come.
Visit nature.org/soil or email soil@tnc.org.
The Nature Conservancy
© iStock.com


PHYSICAL
CHEMICAL
BIOLOGICAL
SOIL
HEALTH


“Clods”

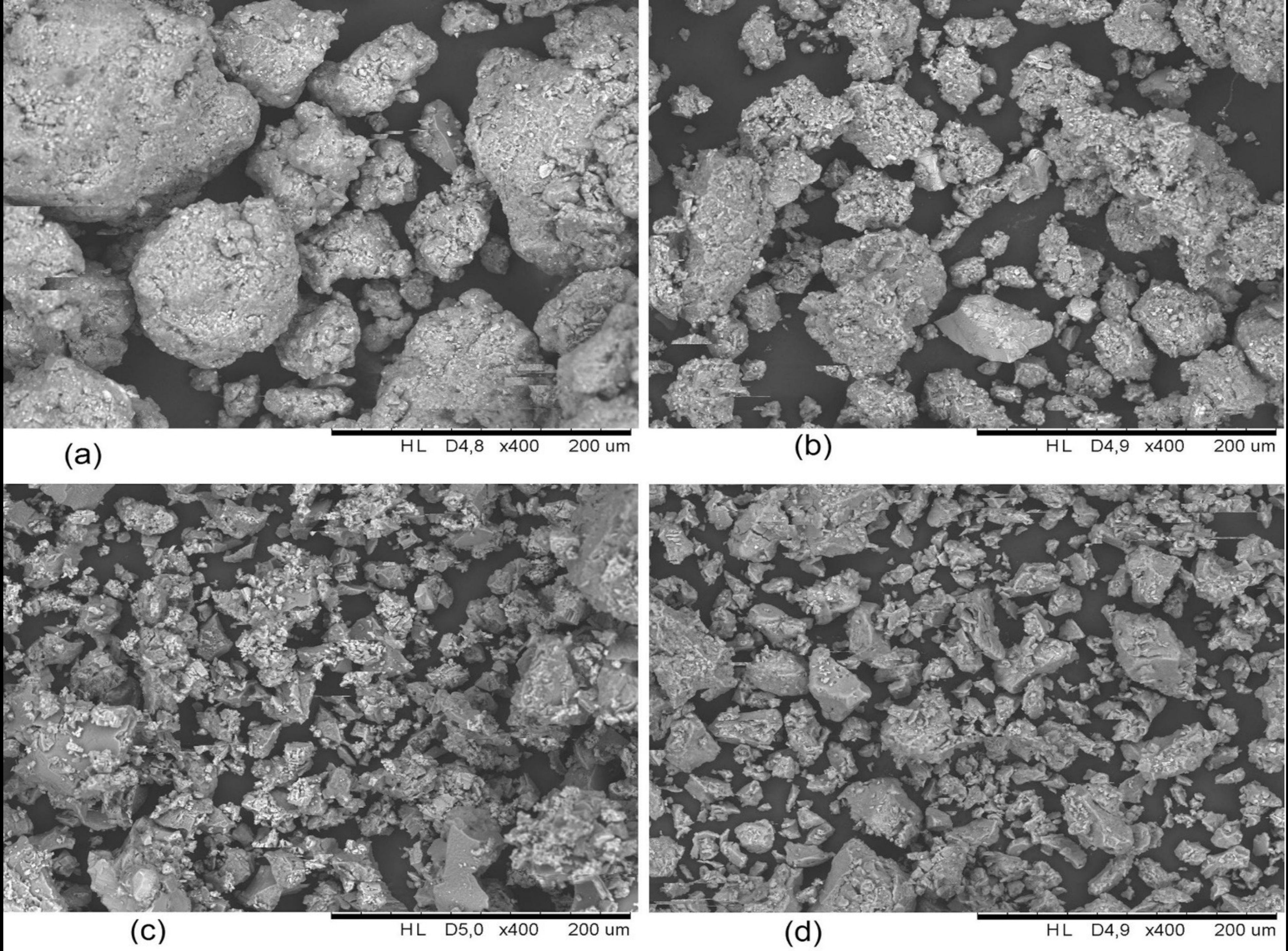
“Water-Stable Aggregates”

Large Macroaggregate = > 2000 µm diameter

Small Macroaggregate = 250—2000 µm

Microaggregate = 53—250 µm

Silt & Clay = < 53 µm


HL D4,8 x400 200 um
(a)
HL D4,9 x400 200 um
(b)
HL D5,0 x400 200 um
(c)
HL D4,9 x400 200 um
(d)

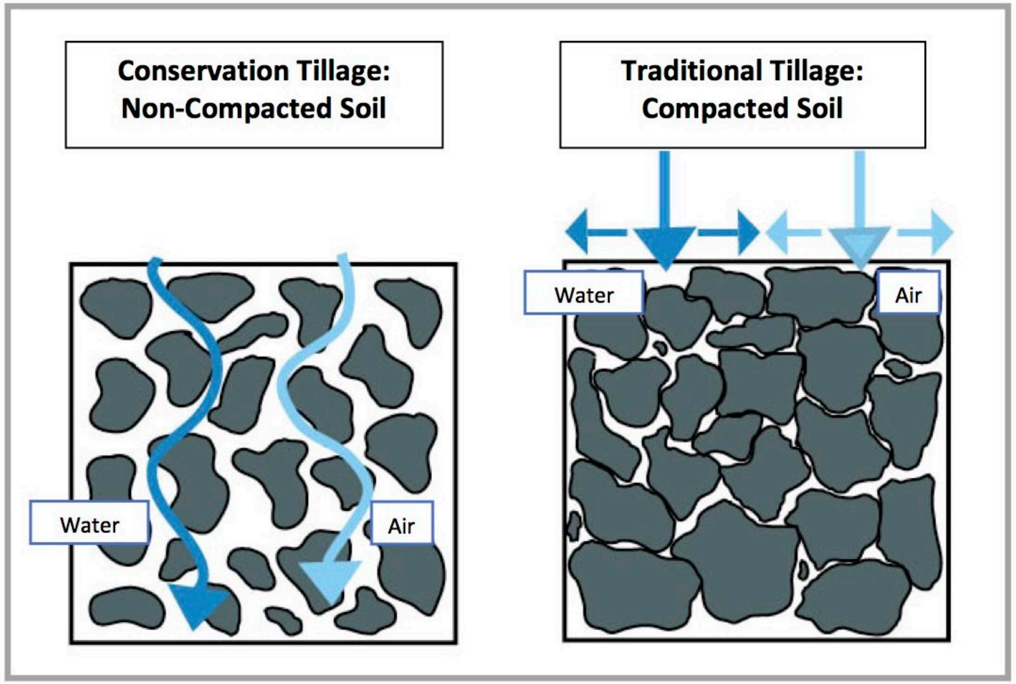
Physical Approaches to Rebuilding Aggregates

- ❑ Mechanical treatment (e.g., berms)

Underlying soil structural instability is not fixed; doesn't operate at appropriate spatial scale

Physical Approaches to Rebuilding Aggregates

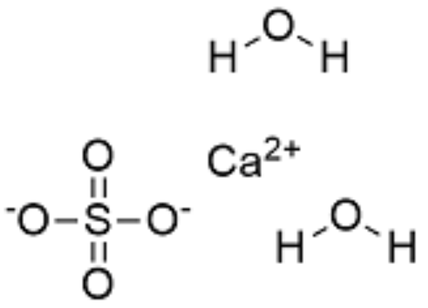
- ❑ Conservation tillage in croplands



But not always…

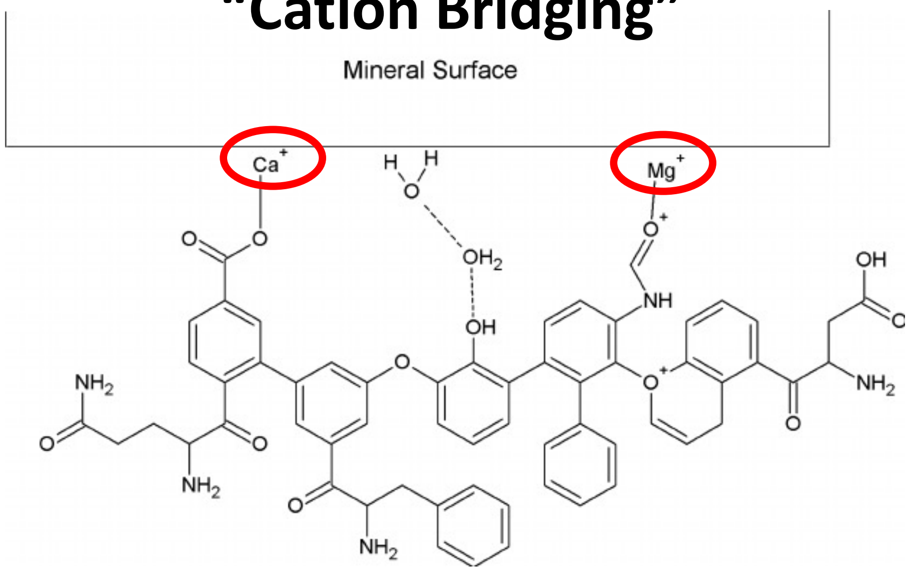
Chemical Approaches to Rebuilding Aggregates

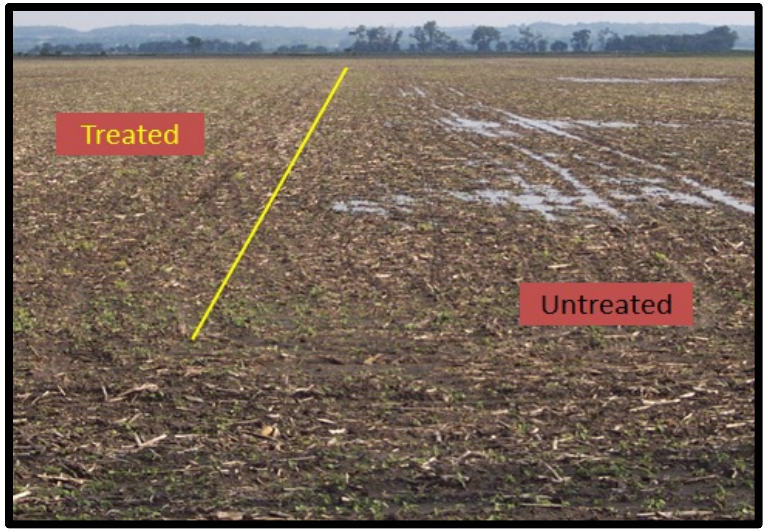
- ❑ Gypsum



Calcium sulfate dihydrate

"Cation Bridging"





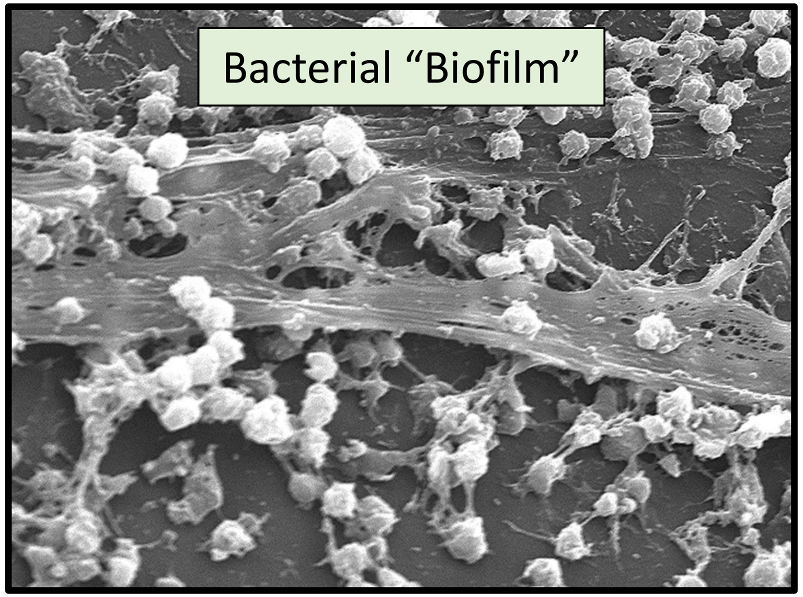
It works but is not a long-term solution, and many desert soils already have high Ca

Chemical Approaches to Rebuilding Aggregates

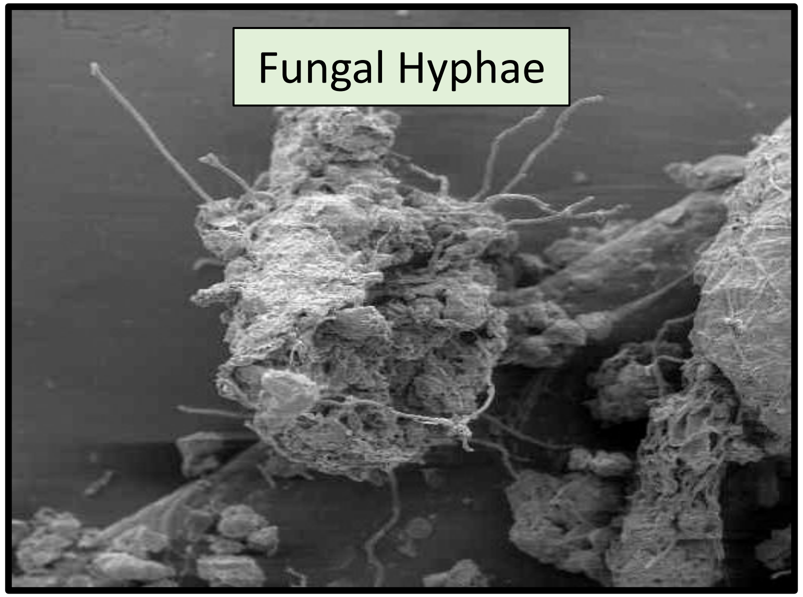
- ❑ Synthetic polymers (e.g., Soil Sement, Gorilla Snot)

Expensive; Can be toxic; Not guaranteed beyond 3 years; Do not promote plant growth

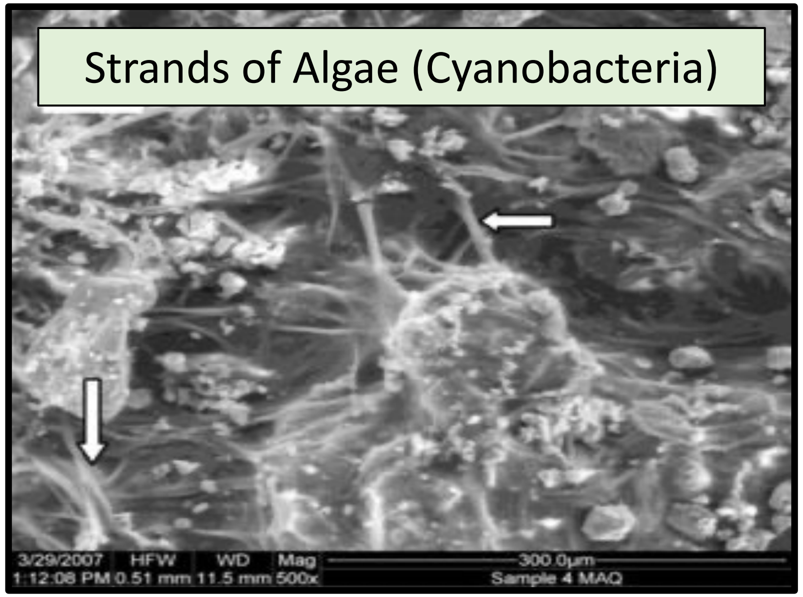
But what about microbial “glues?”



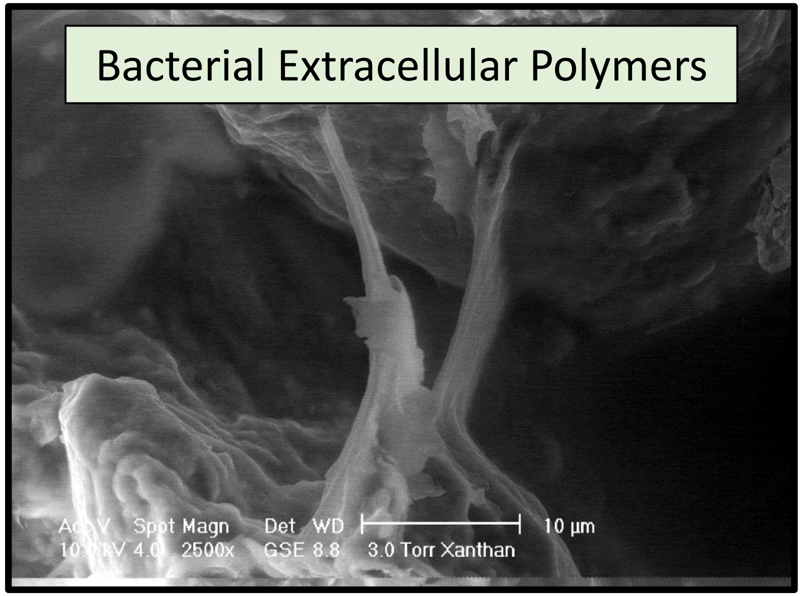
Bacterial “Biofilm”



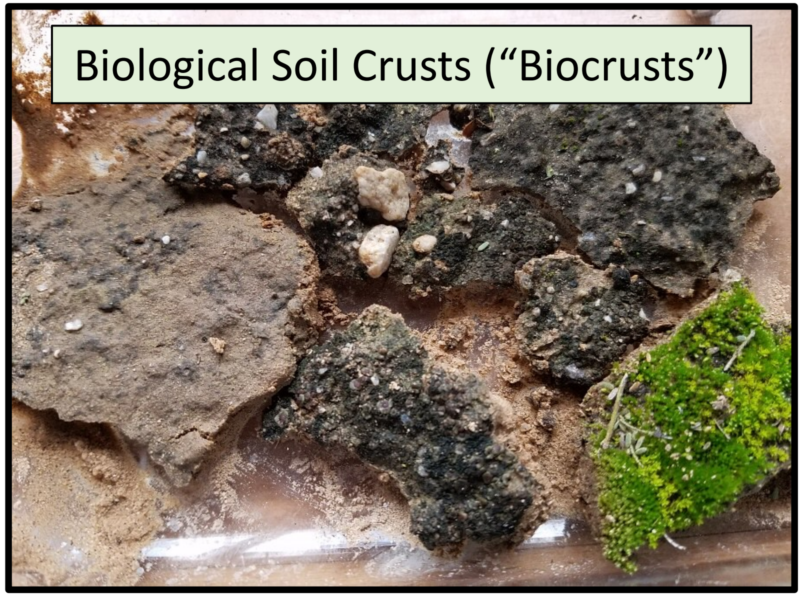
Fungal Hyphae



Strands of Algae (Cyanobacteria)



Bacterial Extracellular Polymers



Biological Soil Crusts (“Biocrusts”)

Phase 1: Laboratory

3 Native Plant Species:
Bush muhly
Low woollygrass
Fourwing saltbush

Plant

Microbe

Soil

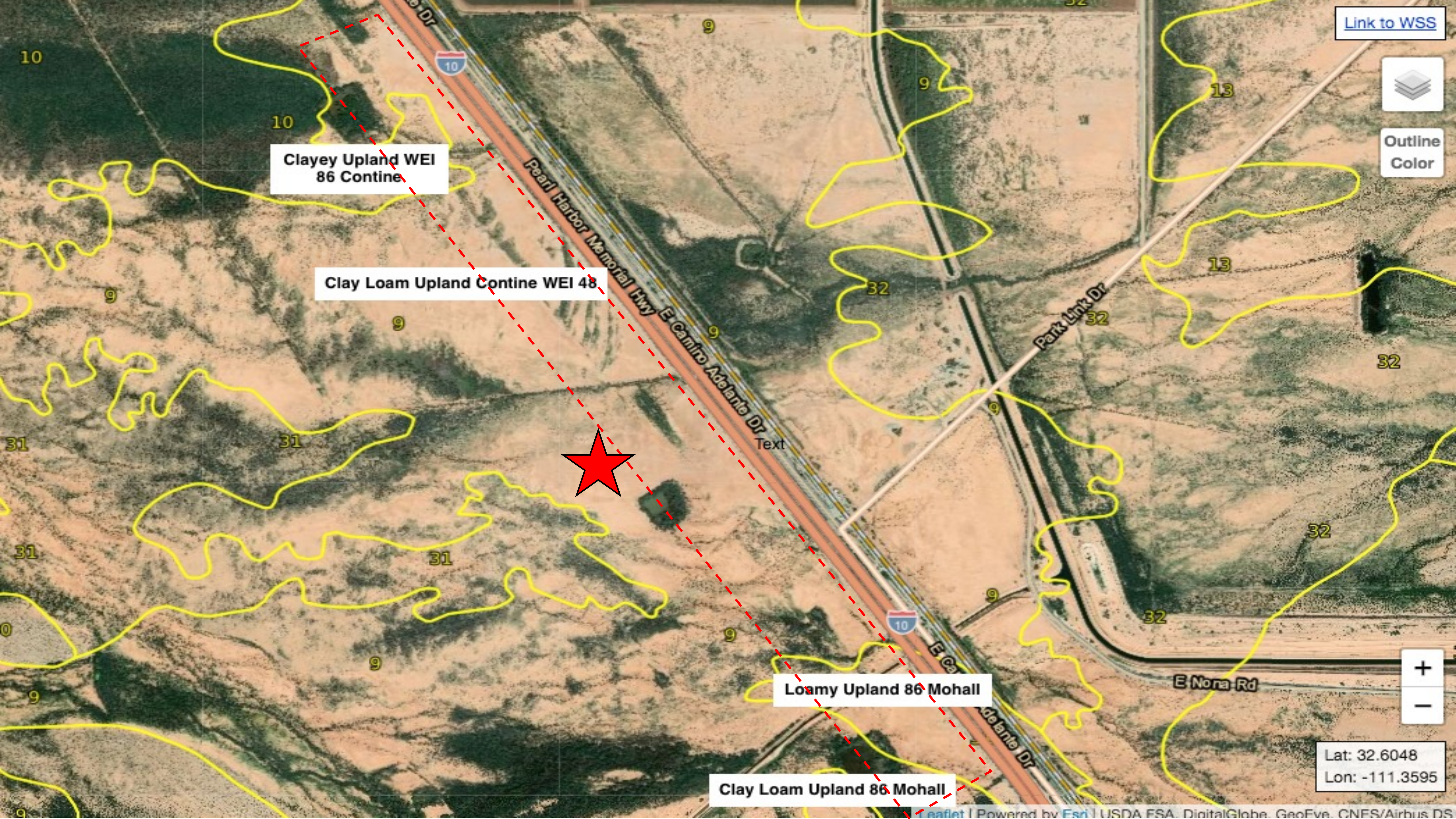
3 Microbial Inoculants:
Cyanobacteria
Mycorrhizal fungi
EPS-producing bacteria

Phase 2: Field Plots

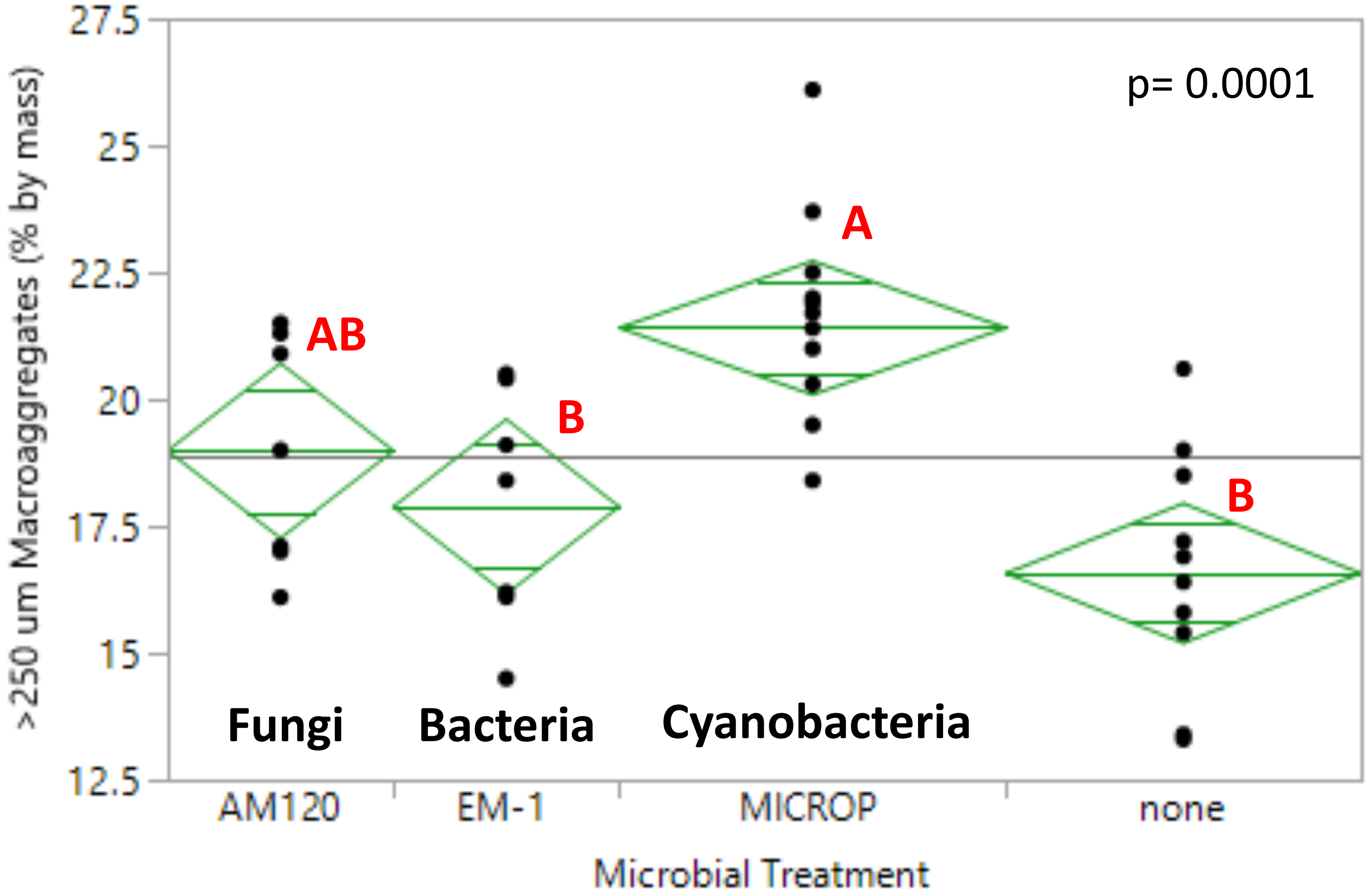
1x1 m plots with 5 replicates of 4 treatments:
Control, Microbial Inoculant, Plant Seeds, Combo

Soil health indicators:
- **Water-stable macroaggregates**
- Microbial/plant EPS "glues"
- Other organic metabolites
- Metagenome
- Nutrients
- Plant/root biomass
- **Dust production**

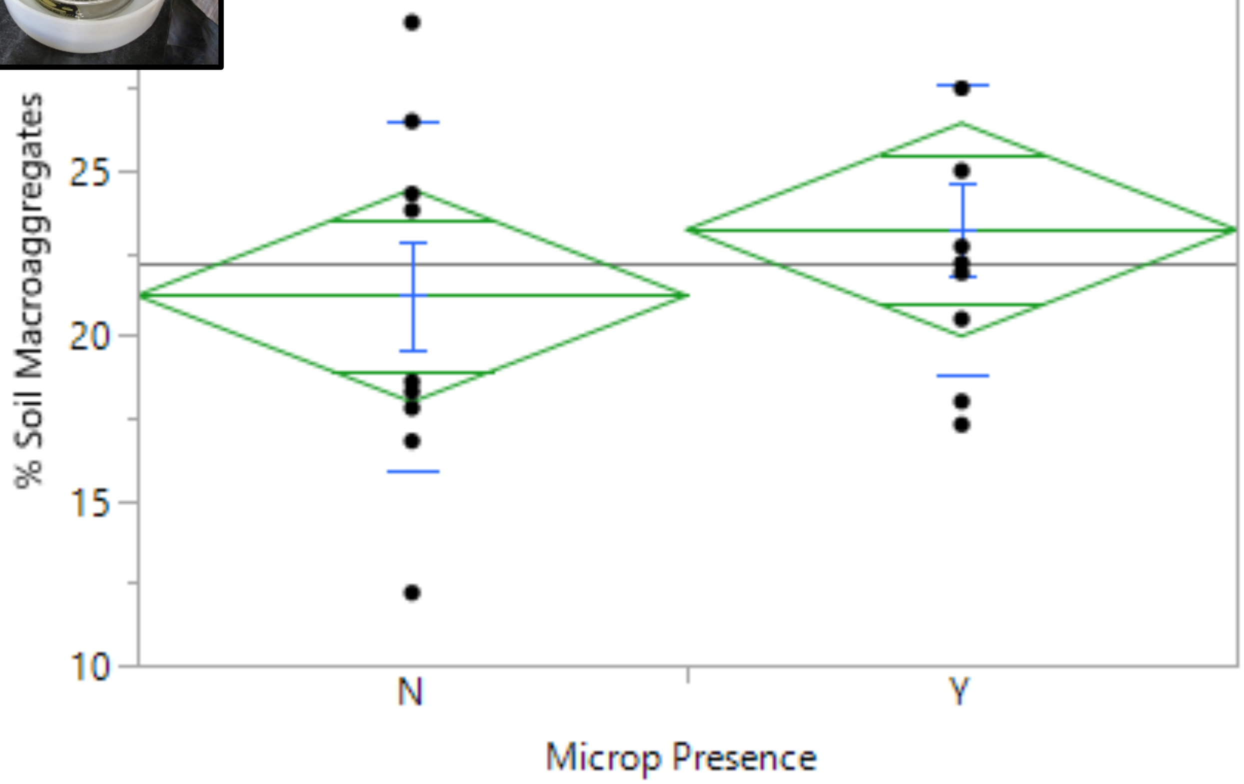
RESEARCH, INNOVATION & IMPACT
Arizona Institutes for Resilience


Clayey Upland WEI 86 Contine
Clay Loam Upland Contine WEI 48
Loamy Upland 86 Mohall
Clay Loam Upland 86 Mohall
Pearl Harbor Memorial Hwy
E Camino Adelanto Dr
Park Link Dr
E Nona Rd
Text
Link to WSS
Outline Color
Lat: 32.6048
Lon: -111.3595
Leaflet | Powered by Esri | USDA FSA, DigitalGlobe, GeoEye, CNES/Airbus DS

Effect of microbial inoculants on water-stable soil macroaggregates across all plant treatments (none = no inoculant)



Conclusion: The cyanobacterial inoculant was the best soil aggregator

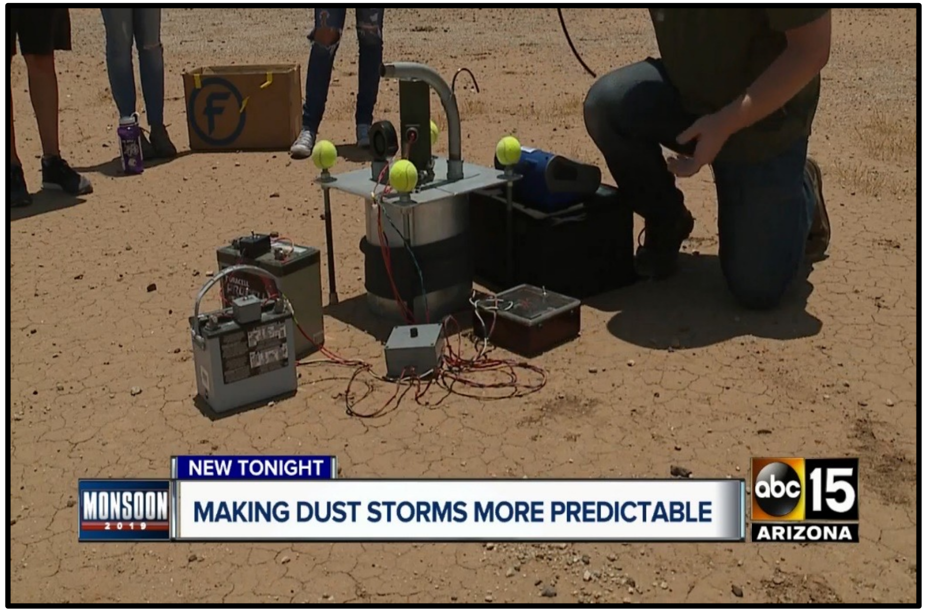


Control Treatment

+ Cyanobacteria

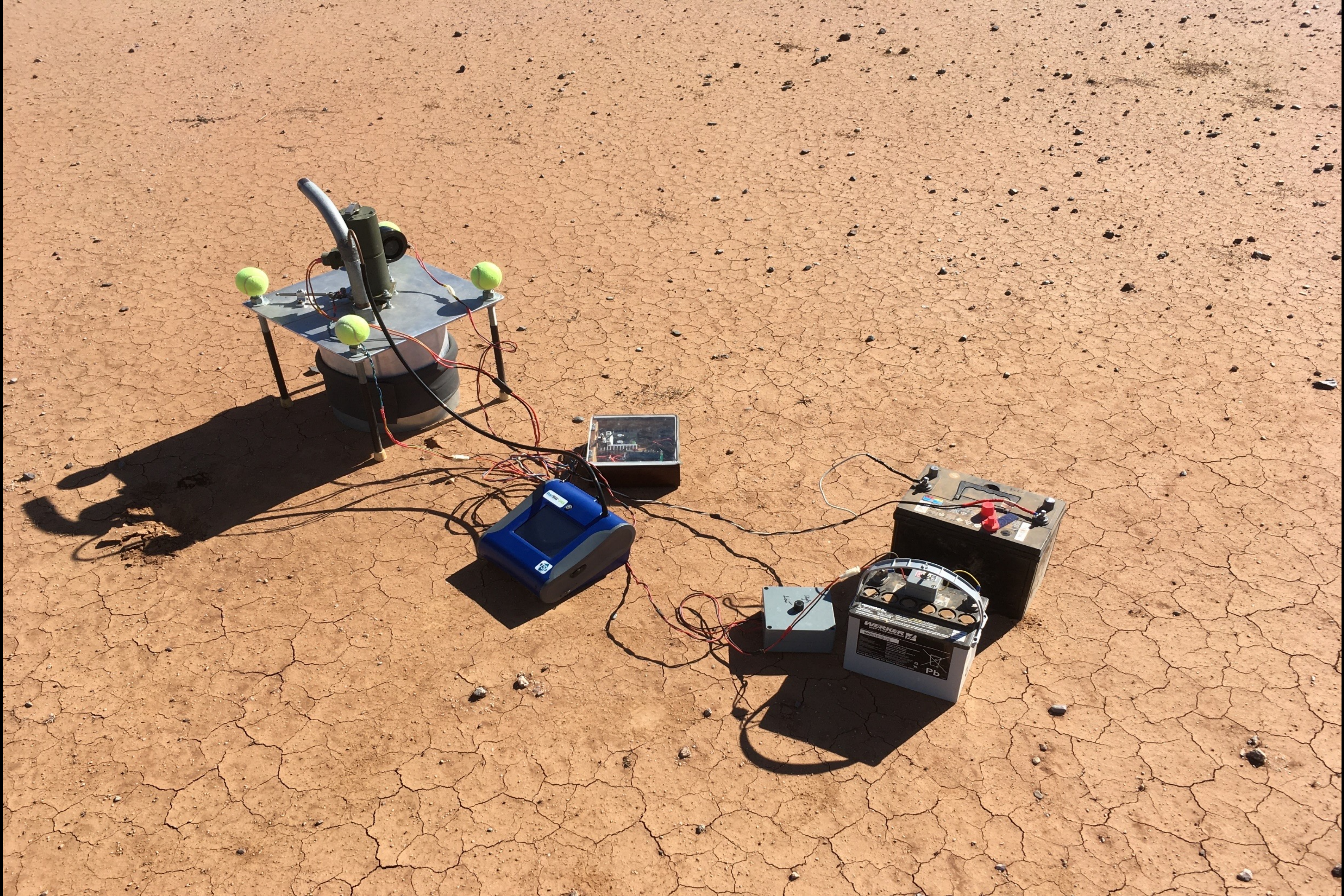
No statistically significant effect of cyanobacterial inoculant on soil macroaggregates under field conditions ($p = 0.37$), but headed in right direction (+9%).

Ground truthing soil dust emission using portable wind tunnel



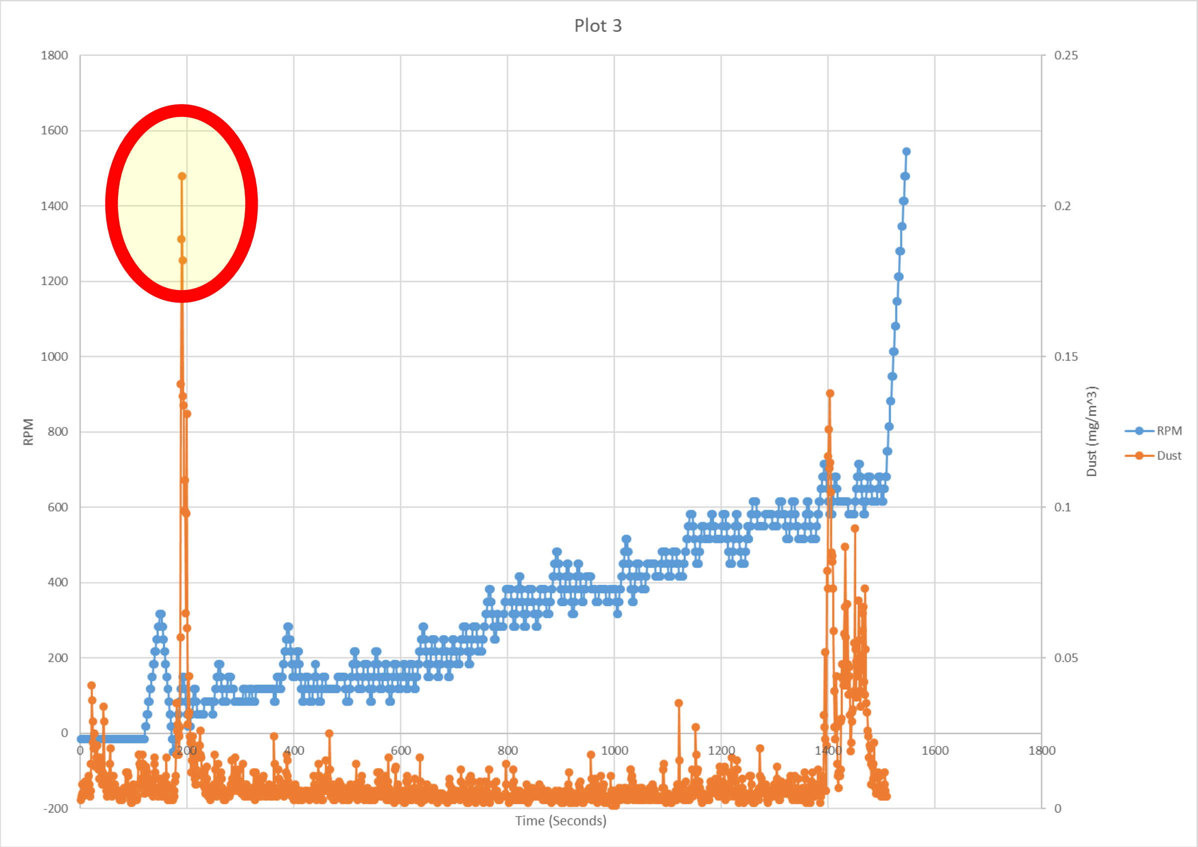
- Measures dust production at various “wind” speeds
- Determines mass of dust produced and threshold friction velocity

**** But can’t sample over plants**

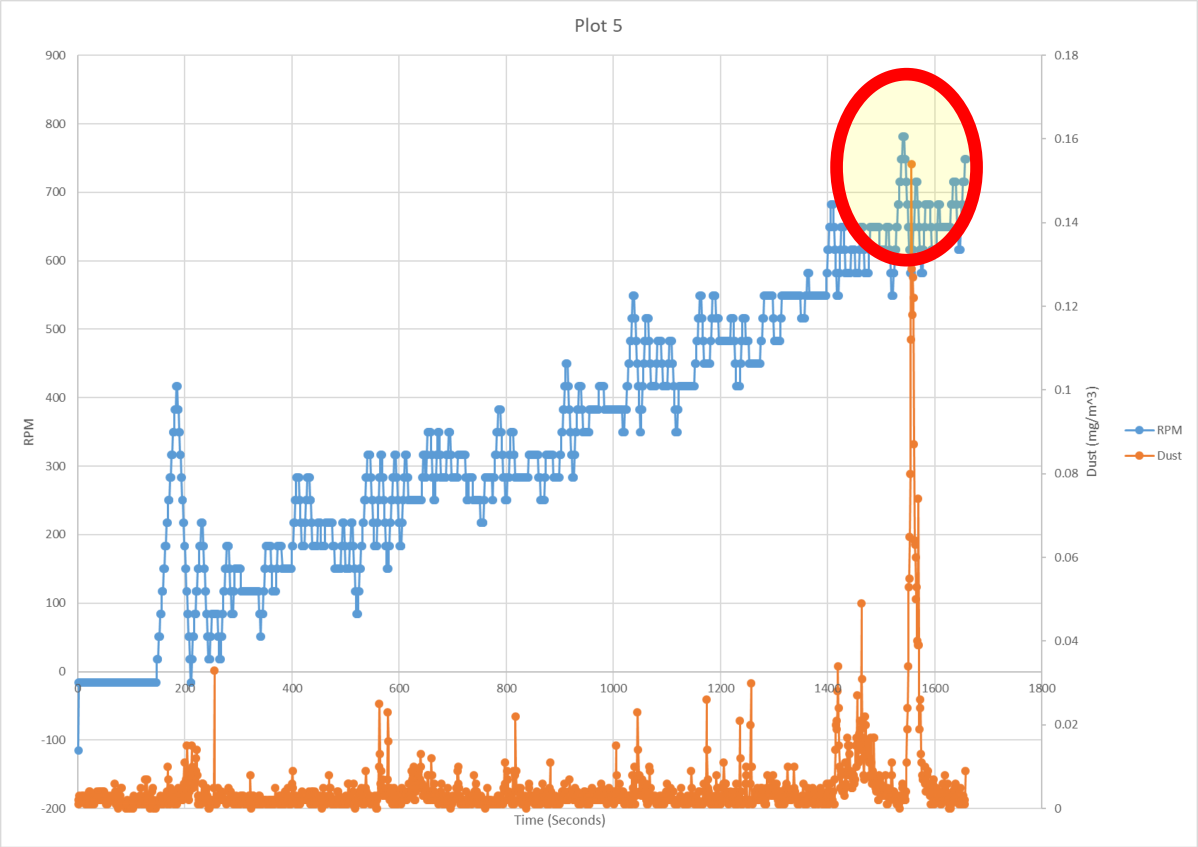

WERKER
Pb

Example raw data from portable wind tunnel

Control

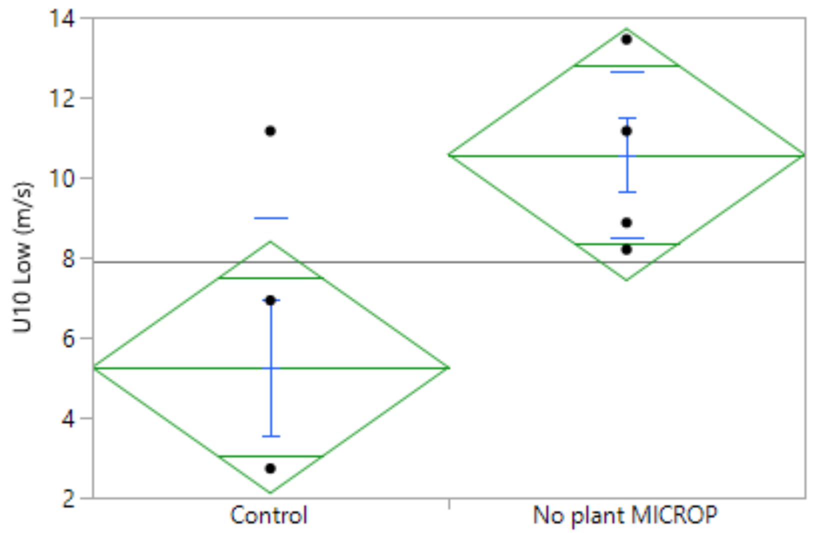


+ Cyanobacteria

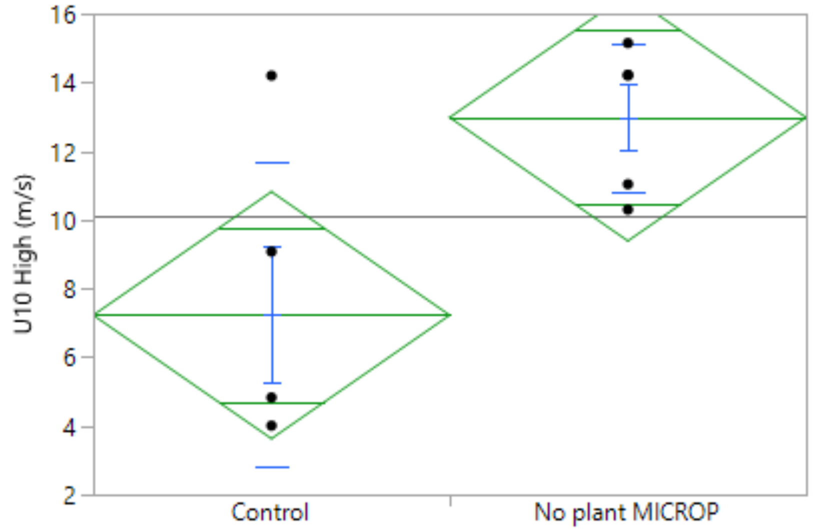


Portable Wind Tunnel Results

U10 Low (m/s)



U10 High (m/s)



Although native grasses did not perform well under field conditions, we found using the portable wind tunnel that plots with cyanobacteria had a threshold friction velocity (TFV) two times greater than the plots without the inoculant, indicating a much lower potential for dust emission from soils with added cyanobacteria. The existing degraded soils at the site began producing substantial dust at wind speeds between 12 and 16 mph. However, the soils we inoculated with cyanobacteria more than 2 months earlier did not begin producing substantial dust until wind speeds between 24 and 29 mph. As far as we know, this is the first study to show the full mechanism and potential for a soil microbial inoculant to decrease dust emission.

In conclusion…