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The webinar will begin promptly at
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SERDP and ESTCP Webinar Series

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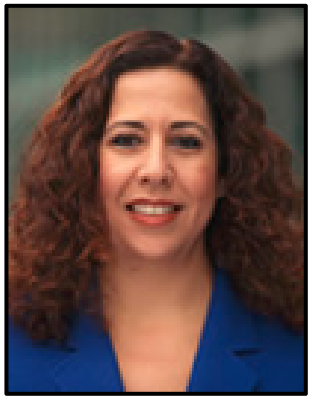
Roles of Soil Microbial Communities in Ecosystem Restoration

May 9, 2019

Welcome and Introductions

Rula A. Deeb, Ph.D.
Webinar Coordinator



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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Native Mycorrhizal Fungal Inoculation Improves Restoration of Native Grassland Diversity and Function** (25 minutes + Q&A)
  Dr. James Bever, University of Kansas
- **Achieving Dryland Restoration Through the Deployment of Enhanced Biocrusts to Improve Soil Health** (25 minutes + Q&A)
  Dr. Nichole Barger, University of Colorado
- **Final Q&A session**

In Case of Technical Difficulties

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  - Key in Ctrl + F5 to do a hard refresh of your browser
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- Find the Q&A button on your control bar and type in your question(s)
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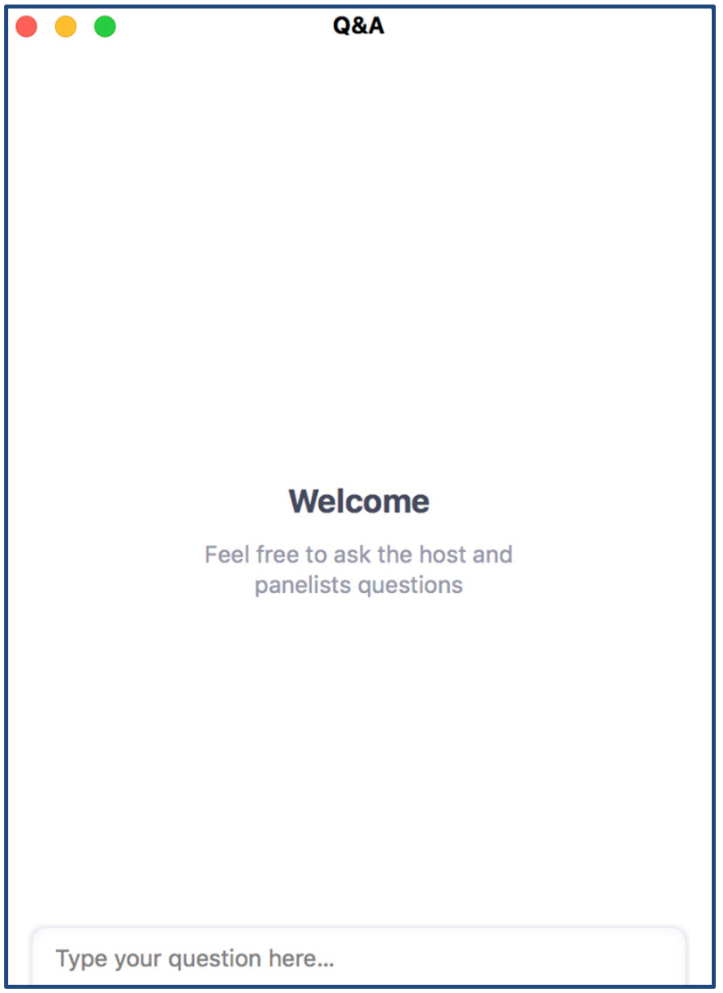

SERDP and ESTCP Overview

Kurt Preston, Ph.D.
Resource Conservation and Resiliency Program Manager

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SERDP

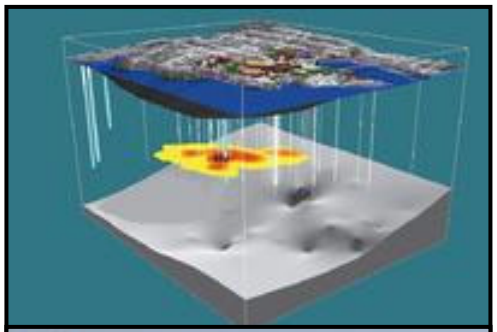
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

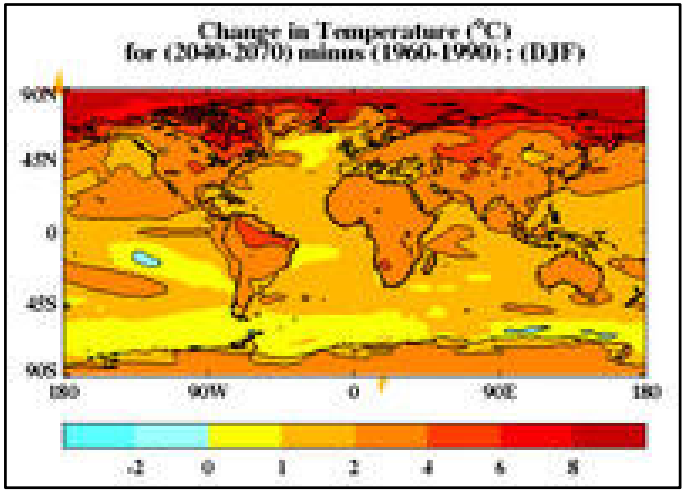
1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms





Resource Conservation and Resiliency

- Natural resources
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- Resilience
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Wildland fire dynamics
  - Fugitive dust



SERDP and ESTCP Webinar Series

Date	Topic
May 23, 2019	Treatment Options for the Emerging Contaminants 1,2,3-Trichloropropane and 1,2-Dibromoethane
June 6, 2019	Developing and Demonstrating Non-Toxic Paints for Corrosion Protection
June 20, 2019	Developing Adaptation Strategies to Address Climate Change and Uncertainty
July 11, 2019	Vapor Intrusion: Modeling Tools and Cost Effective Mitigation
July 25, 2019	Understanding Underwater Munitions Mobility and Behavior on the Beach Face and in Shallow Muddy Environments

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date!

SERDP • ESTCP
SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open

Native Mycorrhizal Fungi Improve Native Grassland Restoration

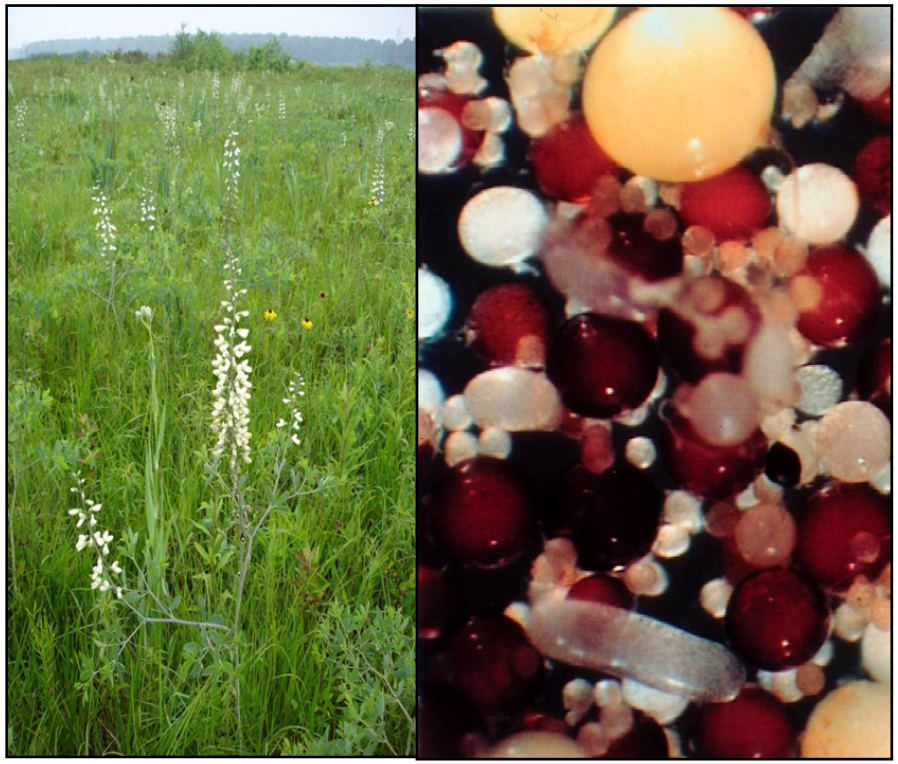
James D. Bever, Ph.D.
University of Kansas

SERDP DOD • EPA • DOE | ESTCP

Agenda

- Project objective
- Arbuscular mycorrhizal fungi (AMF)
- Disturbance degrades AMF
- Native, desirable plants need AMF
- AMF reintroduction improves restoration
- Conclusions
- Benefits to DoD

Project Objective

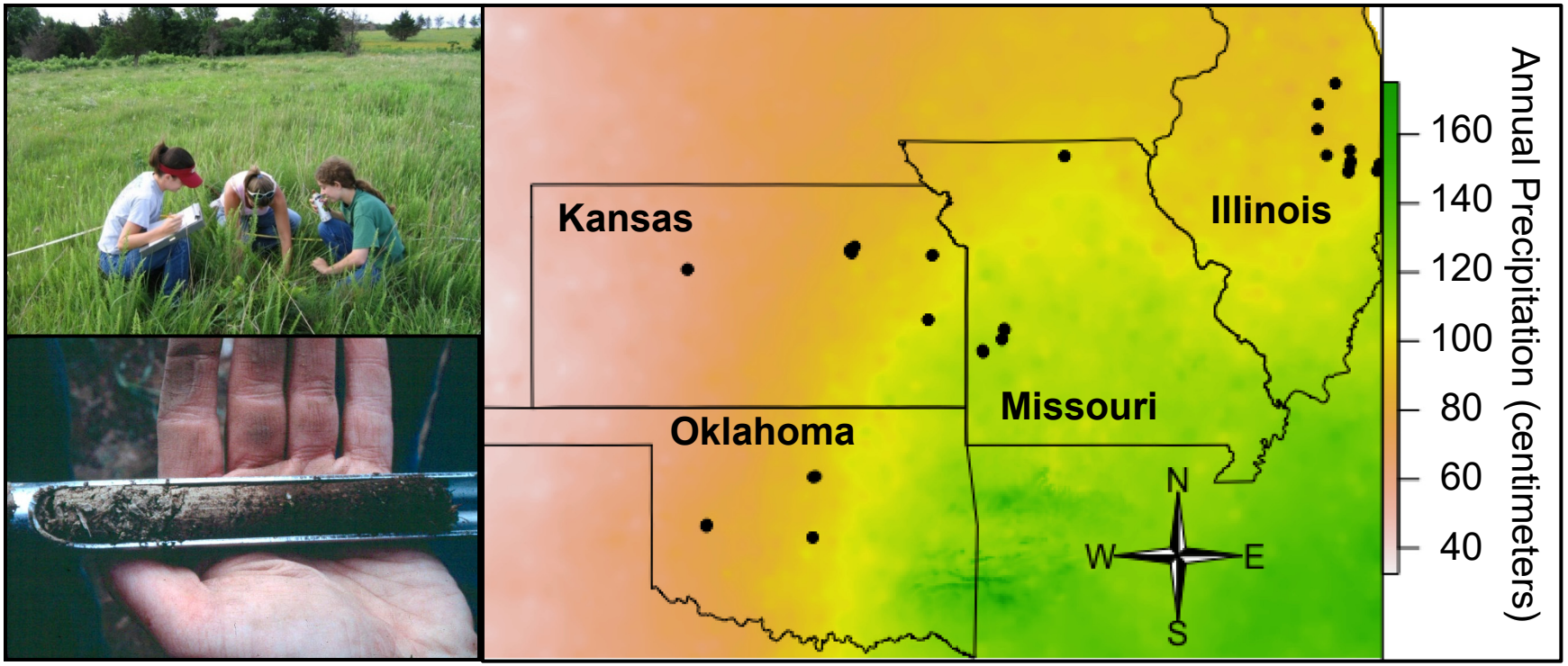


- Disturbance lead to plant species invasions
- Can reintroducing native soil microbes facilitate restoration?

Arbuscular Mycorrhizal Fungi (AMF)

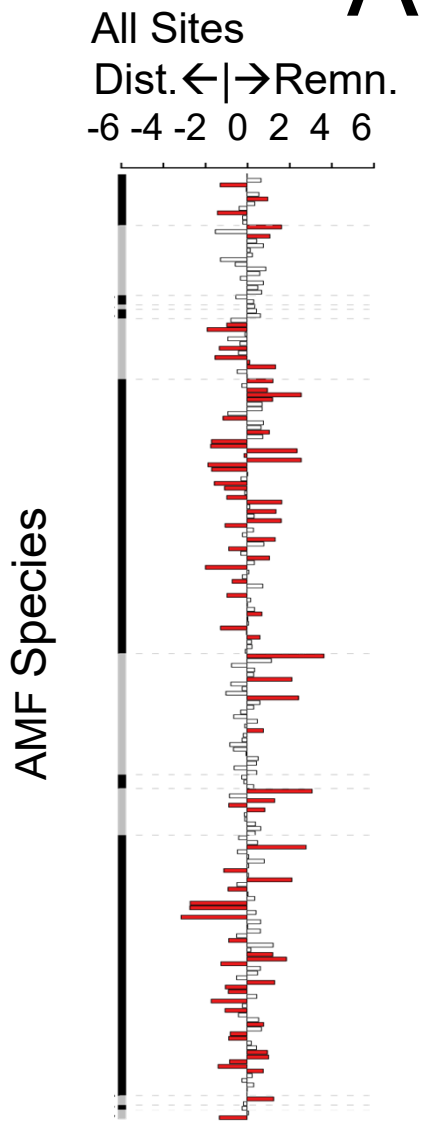
- Promote plant growth
- Stabilize soil

Degradation of AMF?



- 19 native, 16 invaded sites
- DoD property sampling 2013, 2015

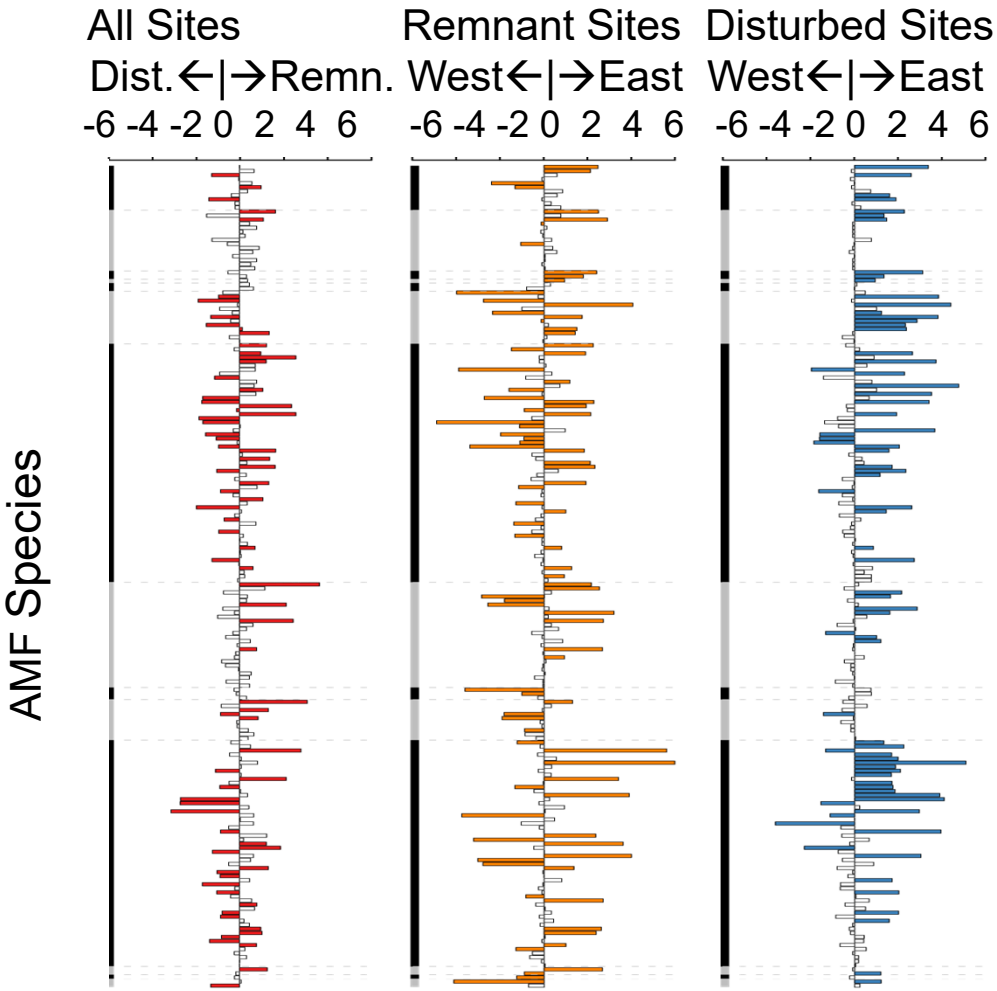
AMF Composition



- AMF degraded by disturbance

Note: dist. = disturbed; remn. = remnant

AMF Composition



- Degraded by disturbance
- Native AMF differentiated along rainfall gradient
- Differentiation lost with disturbance

House and Bever, 2018

Implications for DoD

- Military training can degrade AMF community
- Native AMF may be important to adaptation of plants to climate
- Degraded AMF are not likely to facilitate adaptation to climate or soils

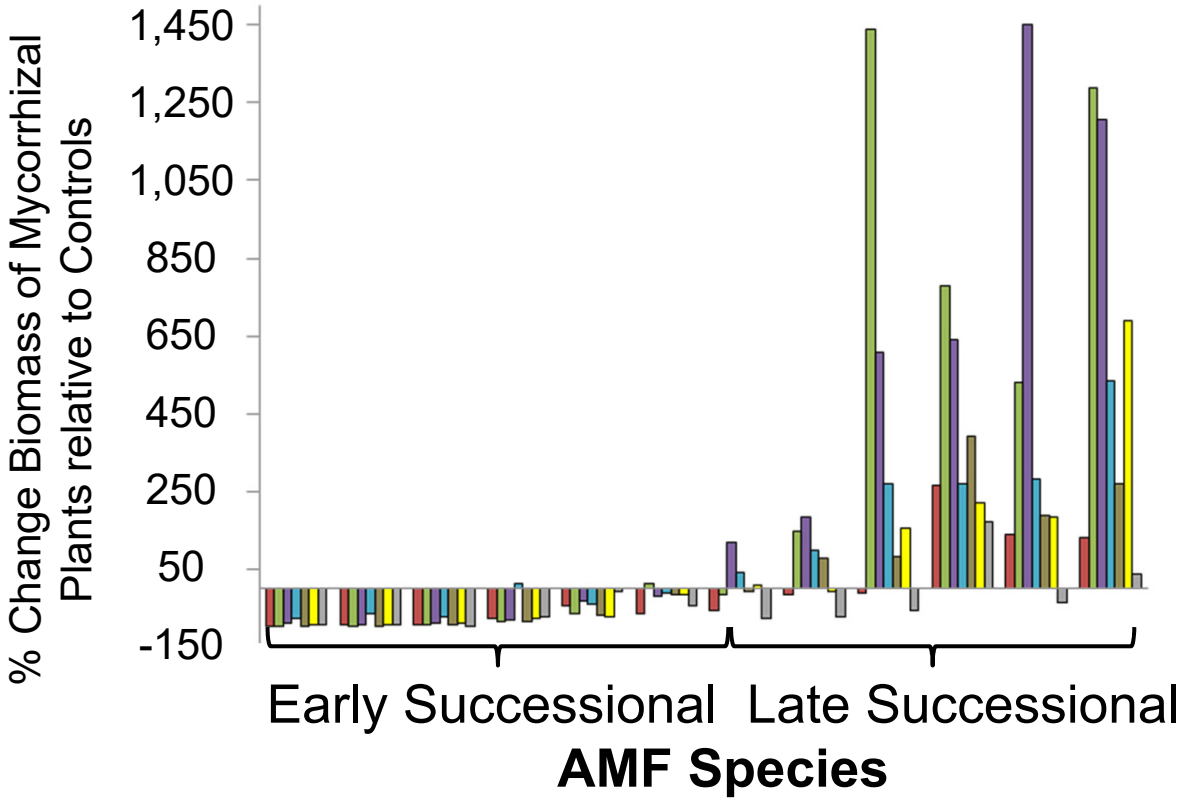
Response to AMF

Invasive vs. Native Plant Species

- Tall fescue, invasive
- Canada wild rye, early successional native
- Big Bluestem, late successional native

Plant Response to AMF

Biomass % Change from Native Species



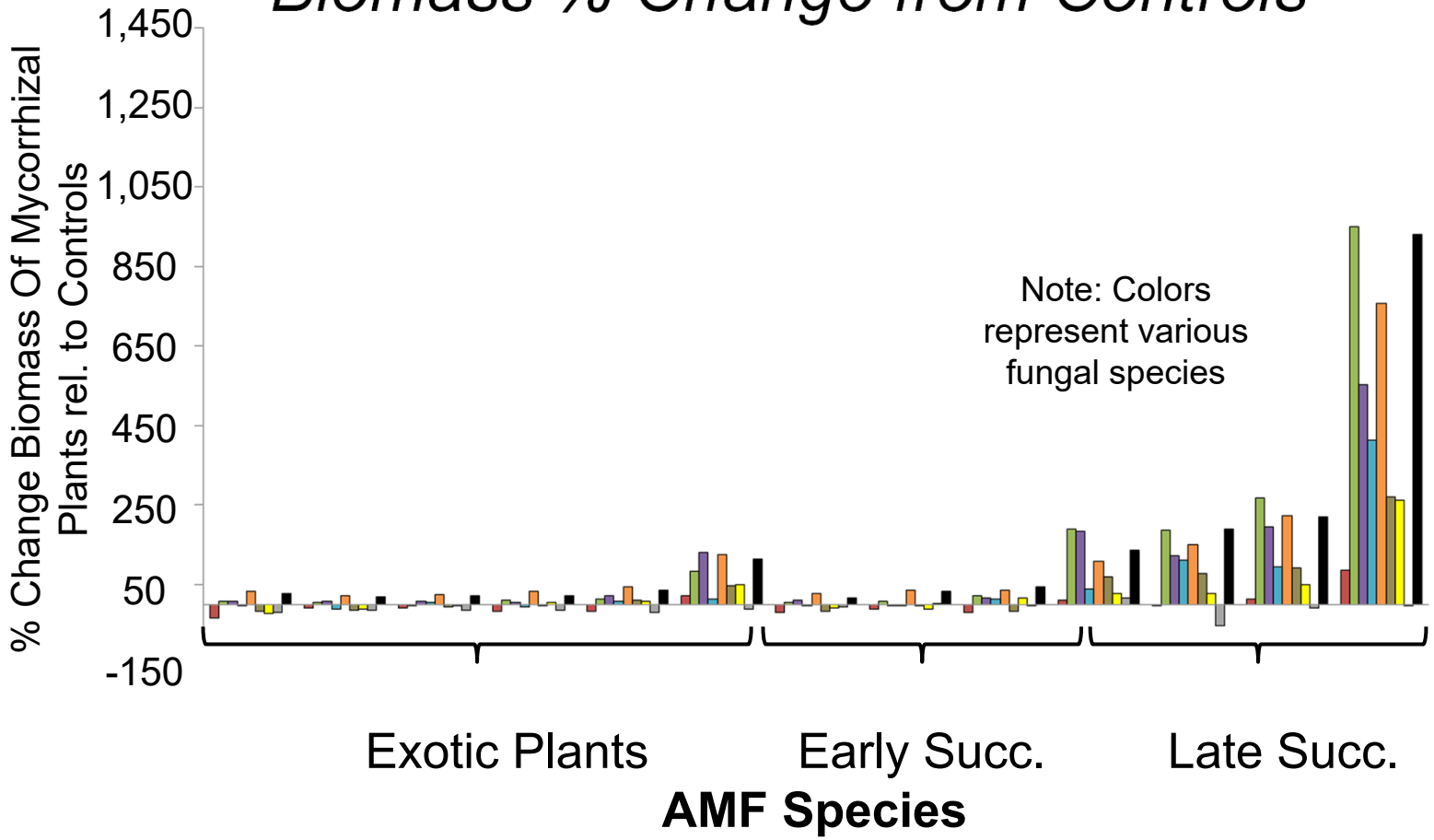
Note: Colors represent various fungal species

Late successional plants more responsive to AMF and vary more in response to AMF isolates

Koziol and Bever, 2015; 2016

Plant Response to AMF

Biomass % Change from Controls



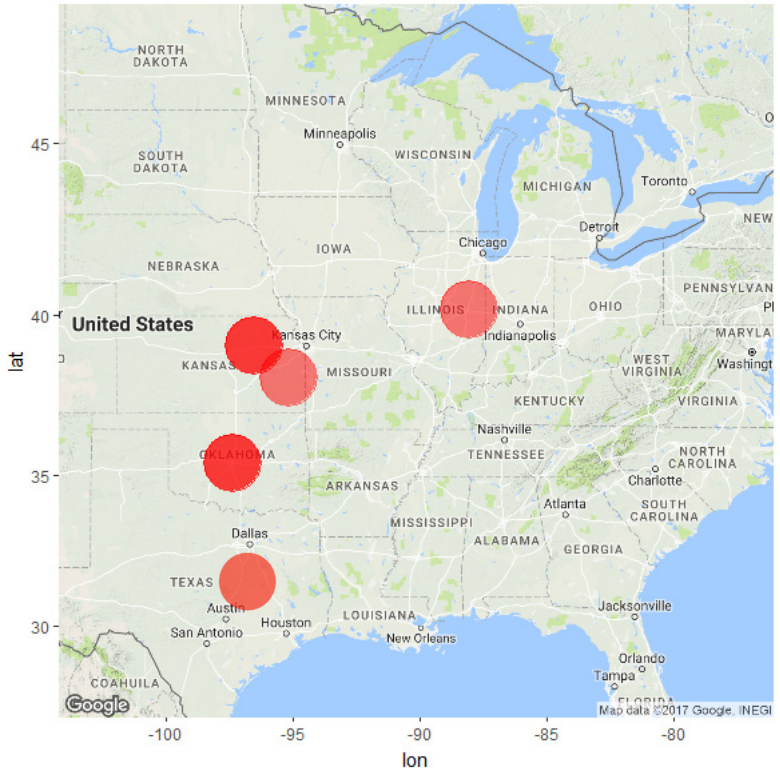
Non-native plant species, like early successional native plants, do not benefit from AMF

Inoculation with Native AMF

Invaded Site Locations

- Tinker Airforce Base
- Ft Riley Army Base
- Chanute Airforce Base (retired)

- Five experiments total

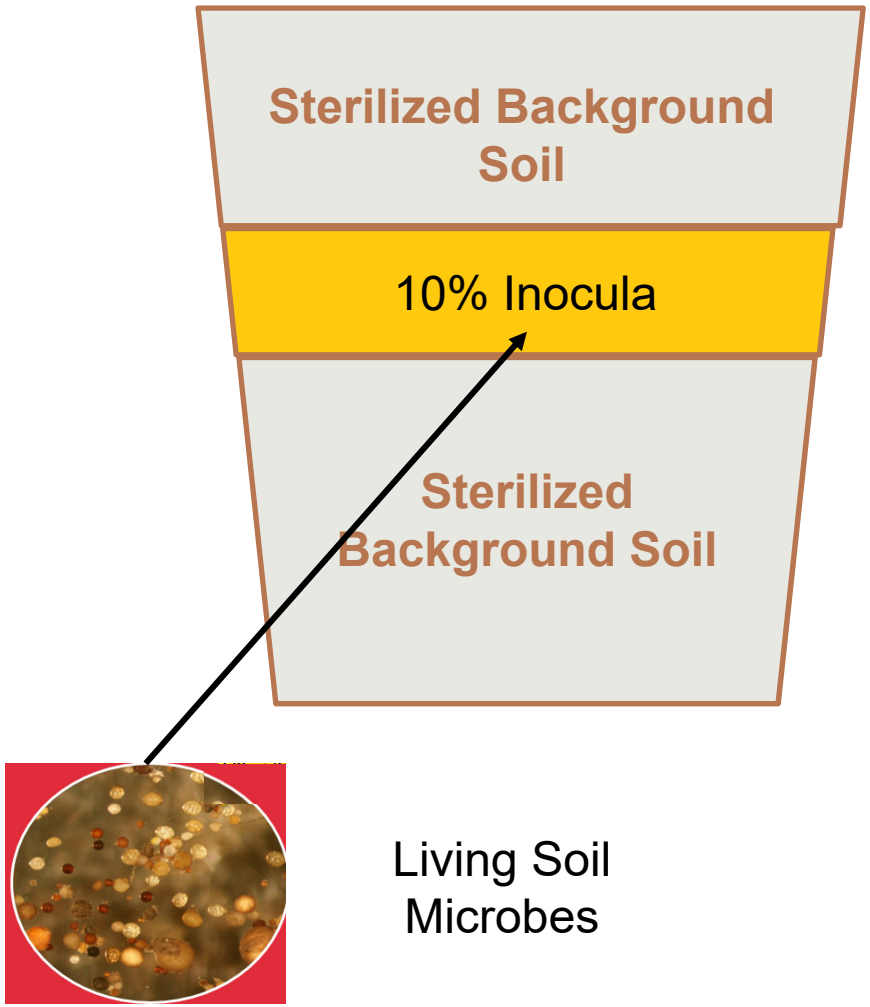


***Objective**: Facilitate native plant species and suppress invasive species*

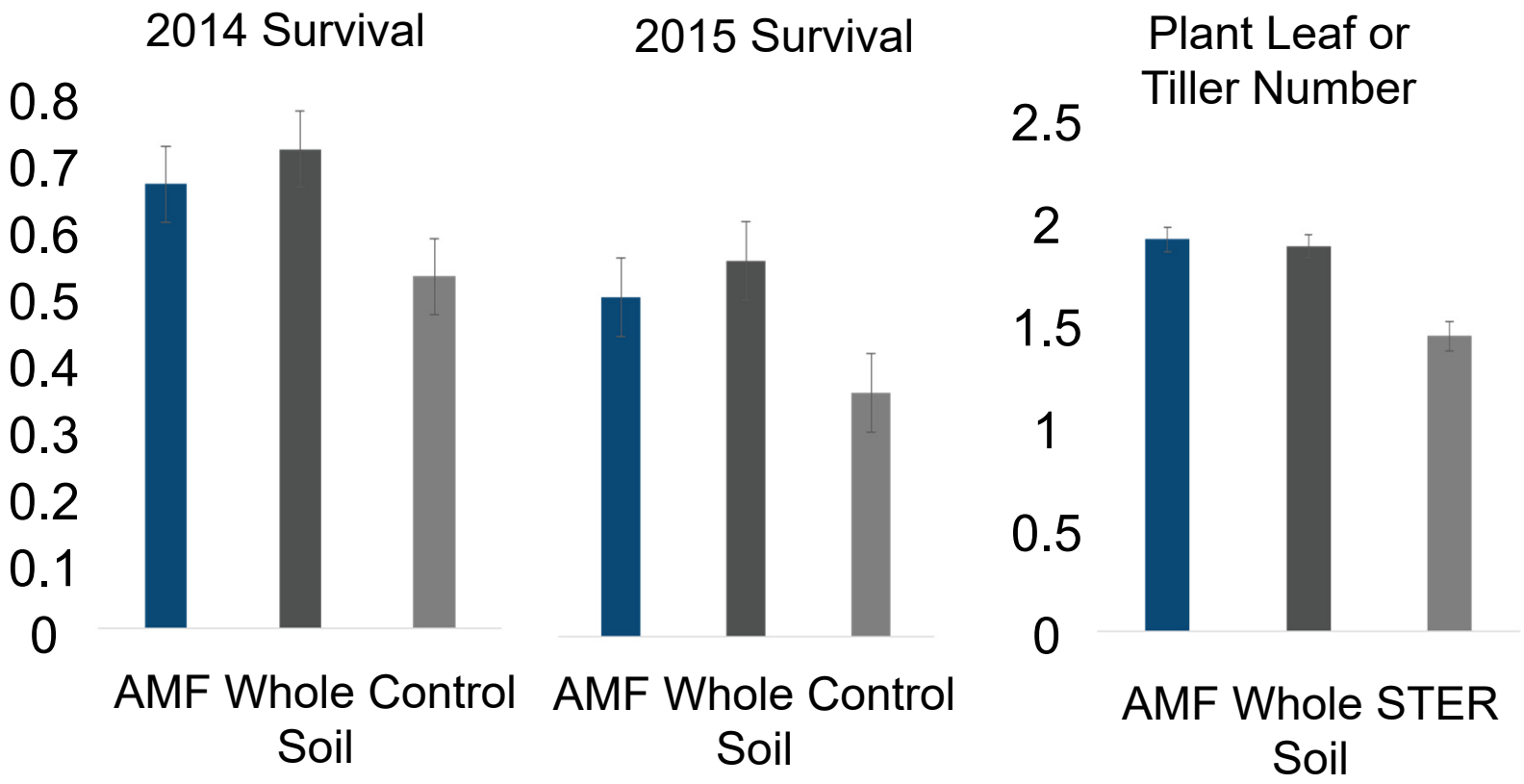
Inoculation with Native AMF

Treatments and Methods

- Inoculation treatments
  - Prairie soil microbes
  - Prairie AMF
  - Uninoculated controls
- 8 native plant species
  - 1,824 plants
- All plots seeded with diverse native seed mix



Response to Native Inocula



Inoculation facilitates native species establishment and growth

Illustration of Native AMF Benefits

At Planting

AMF or WHOLE SOIL INOCULATED

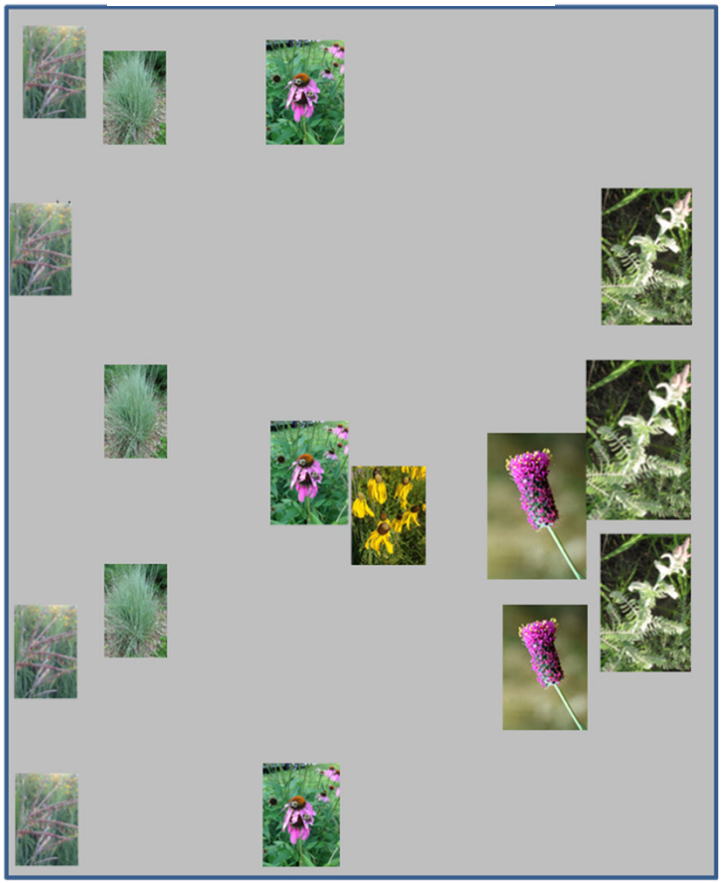
UN-INOCULATED

Illustration of Native AMF Benefits

Survival to Second Year

AMF or WHOLE SOIL INOCULATED

UN-INOCULATED



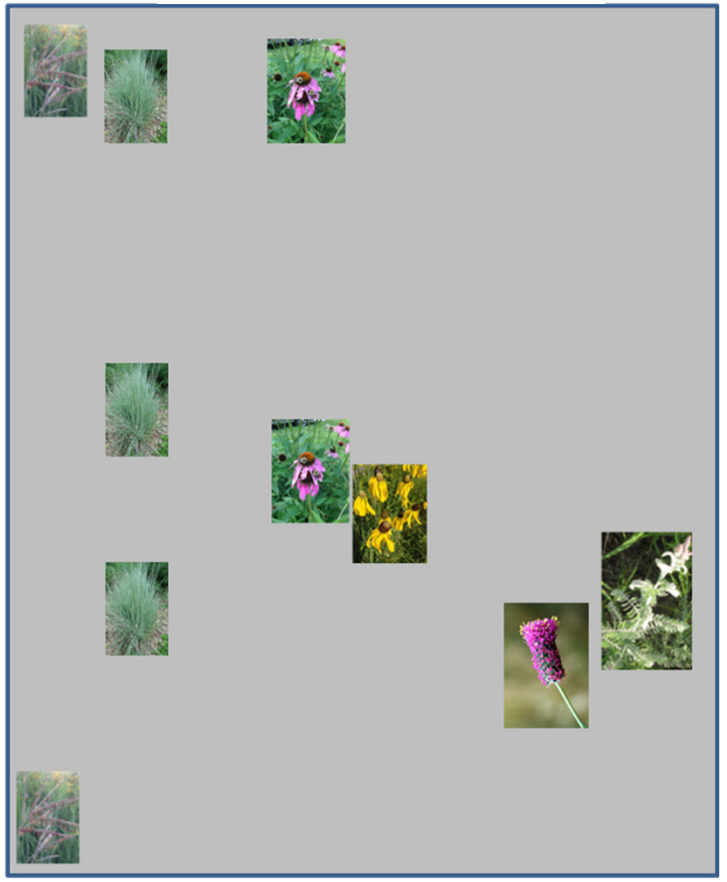
Inoculation with native AMF increases survival to second year

Illustration of Native AMF Benefits

Survival to Third Year

AMF or WHOLE SOIL INOCULATED

UN-INOCULATED



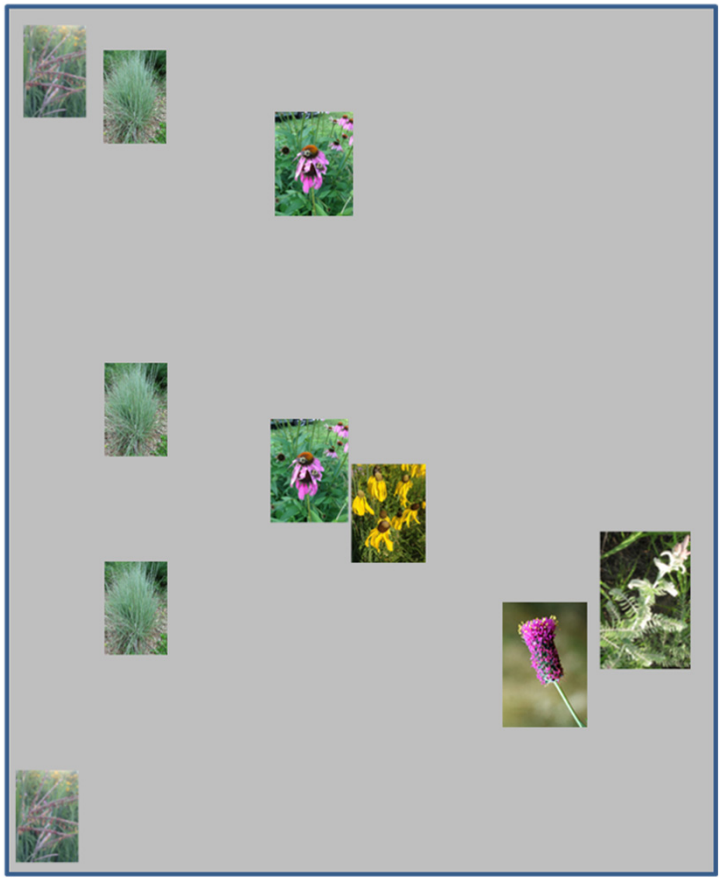
Inoculation with native AMF increases survival to third year

Illustration of Native AMF Benefits

Growth Benefit

AMF or WHOLE SOIL INOCULATED

UN-INOCULATED



Inoculation with native AMF increases growth of plants that survive

Field Results

AMF or WHOLE SOIL INOCULATED

UN-INOCULATED

Inoculated plots closer resemble restoration target

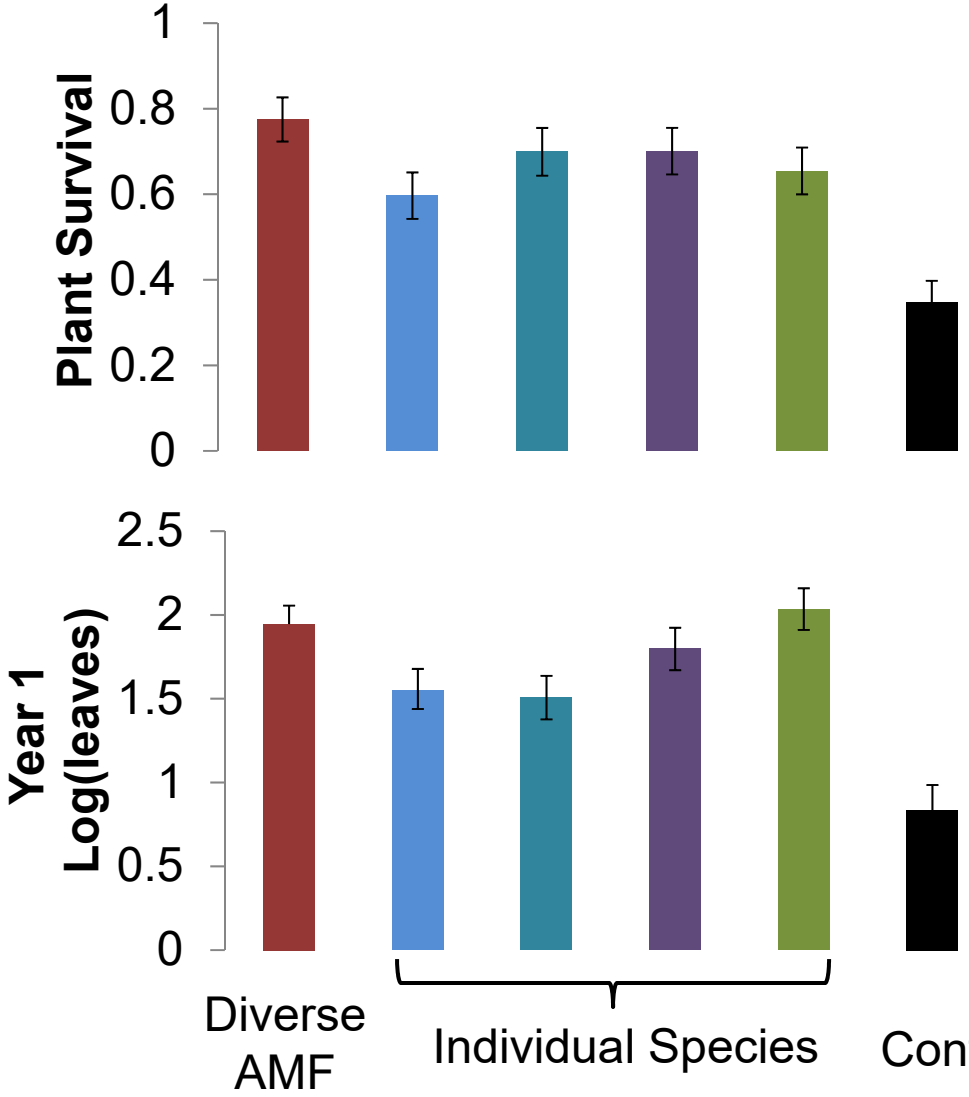
Inoculation with Native AMF

Invasive Plant Suppression?

- Six inoculation treatments
  - 4 individual AMF species
  - Diverse treatment (Mix of all 4)
  - Uninoculated control
- Diverse (60 species) native seed mix
- All plants in plot similarly inoculated

Image source: L. Koziol

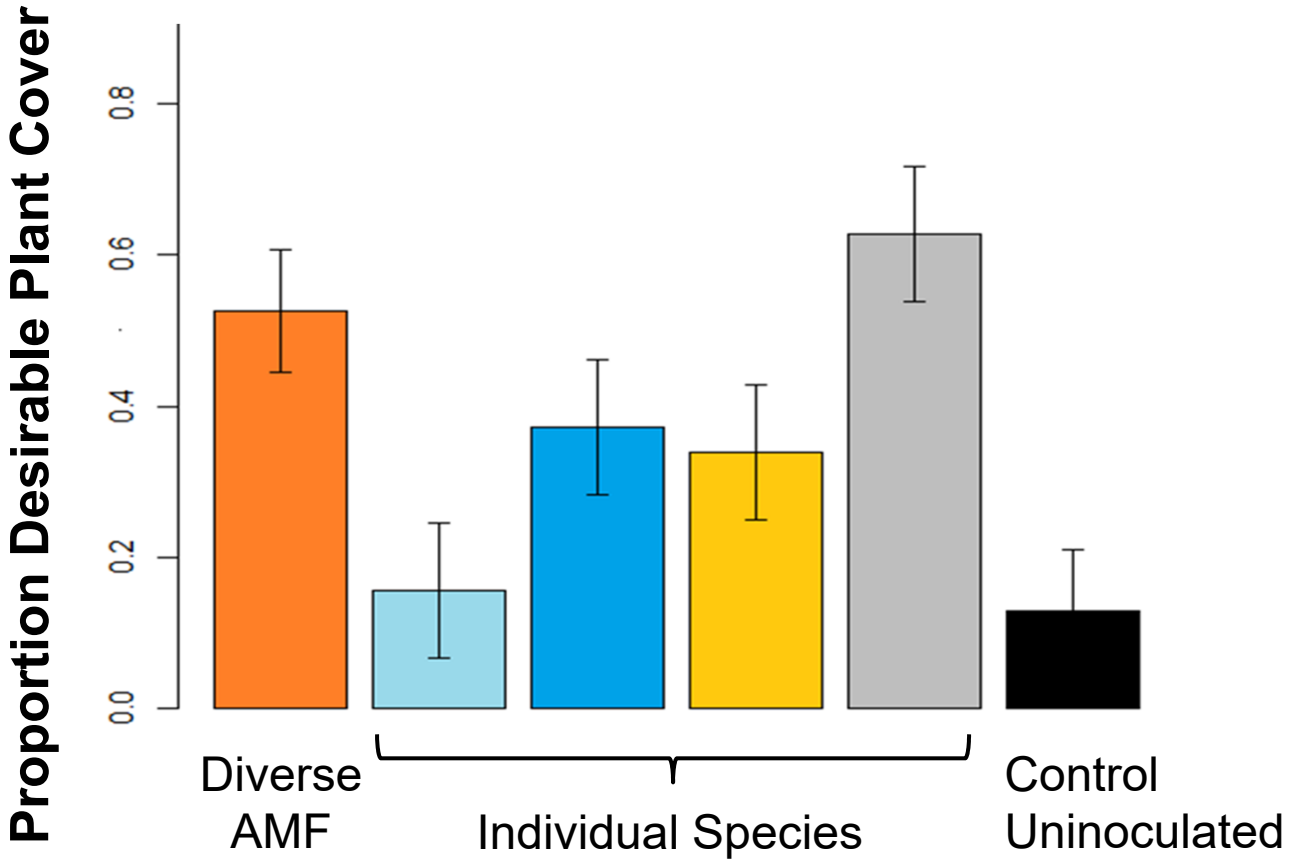
Native Plant Survival and Growth



Diverse native AMF best promote native plant survival and growth

Koziol and Bever, 2017

Cover of Undesirable Plant Species



Diverse native AMF inhibits weeds establishment

Koziol and Bever, 2017

Conclusions

- AMF degrades with disturbance
  - Degradation promotes plant invasion
  - Inhibits native plant re-establishment
- Reintroduction of native AMF can accomplish the following
  - Increase native plant establishment
  - Inhibit weeds

Benefits to DoD

- Better native plant reestablishment after training activities
- Decreased invasive plants (weeds) reduces management workload
- Improved adaptation to climate change
- Supports other land management goals
  - e.g., habitat for butterflies

SERDP & ESTCP Webinar Series

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Species-Ecology-and-Management/RC-2330

Speaker Contact Information

jbever@ku.edu; 785-864-3514

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Q&A Session 1

Achieving Dryland Restoration Through Deployment of Enhanced Biocrusts to Improve Soil Health

Nichole Barger, Ph.D.
University of Colorado

SERDP DOD • EPA • DOE | ESTCP

Agenda

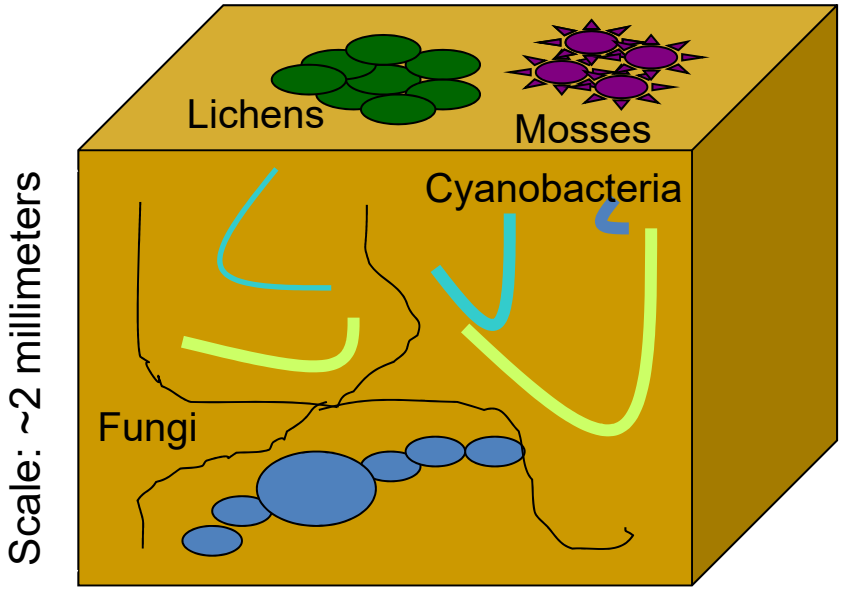
- Objectives
- Biocrusts explained
- Establishing biocrust nurseries
- Successes and challenges with biocrust restoration
- Conclusions
- Benefits to DoD

Objectives

- Facilitate recovery of degraded arid and semi-arid DoD lands by restoring biocrust communities
  - Establish biocrust nursery
    - Inoculum testing and supply center for biocrust restoration
  - Identify field methods for applying biocrust inoculum
  - Evaluate soil and plant response to biocrust restoration in field experiments

What are Biocrusts?

- Communities of microorganisms
  - Lichens
  - Fungi
  - Mosses
  - Cyanobacteria
- Grow on soil surfaces in dryland environments



Why are Biocrusts Important?

- Soil stability
- Soil fertility
- Hydrologic cycles

Image Sources: Jayne Belnap, Jim Boone

Military Activity Effects on Dryland Soils

- Military training = soil disturbance
  - Biocrust community declines
  - Ecosystem level effects
- Affects 70% of DoD installations in dryland West regions

Mojave Desert tank tracks from Operation Desert Strike, 1964 (*Image Source: Richard Hereford*)

Military Activity Effects on Dryland Soils

- Slow recovery
- Limited capacity for natural recovery

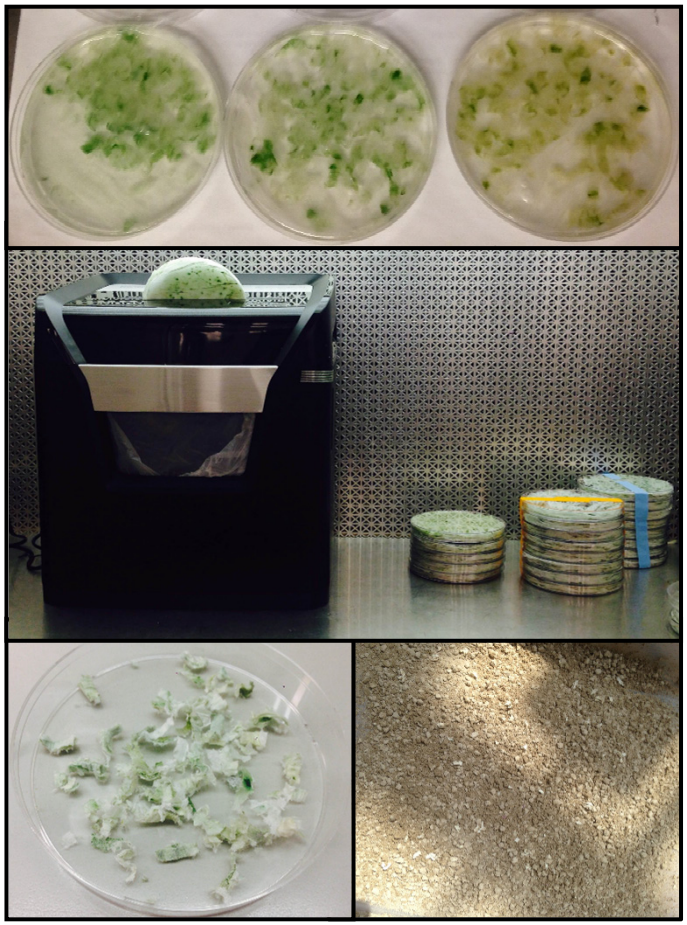
Biocrust Functional Group	Recovery after 55 Years (%)*
Cyanobacteria	46 - 65
Lichens	3 - 6

Data Source: Belnap and Warren, 2002

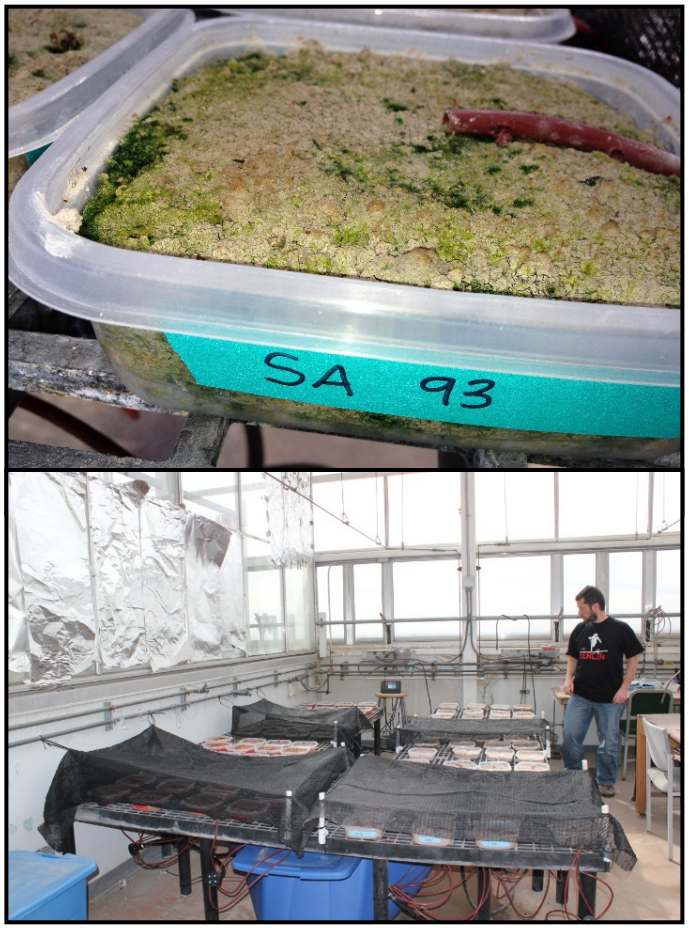
Research Sites

Establishing Biocrust Nursery

Lab Grown



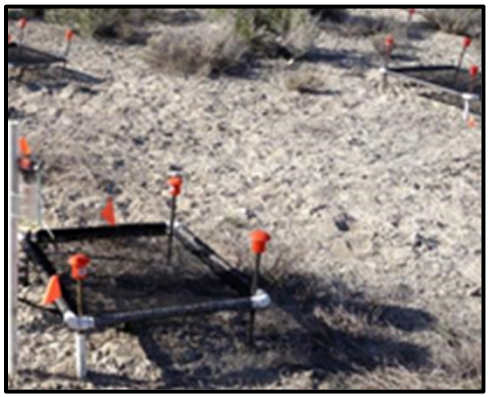
Greenhouse Grown



Field Trials

Identify Best Candidate Approaches

Inoculum addition

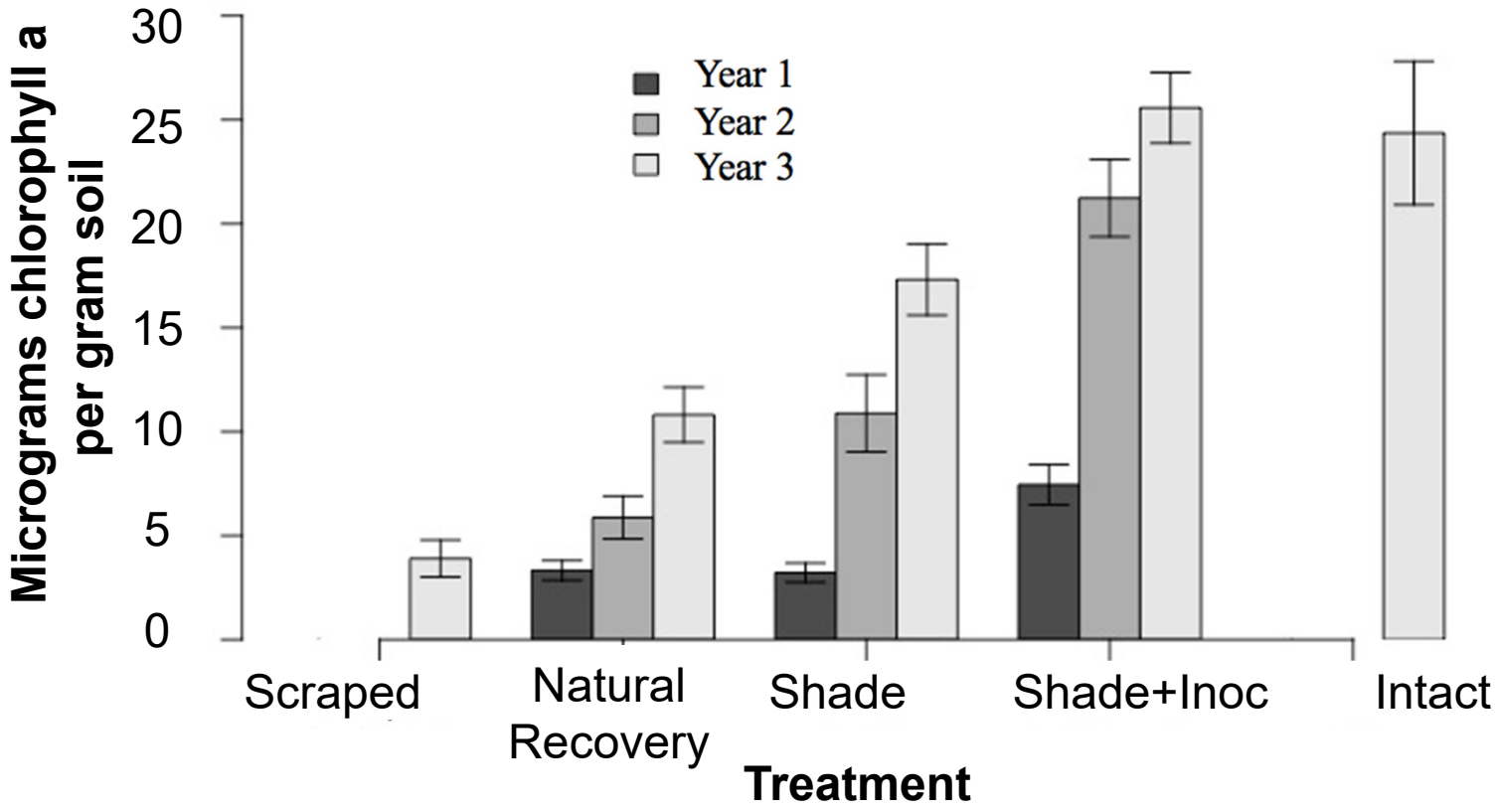


Habitat modification

Soil stabilization

Biocrust Growth

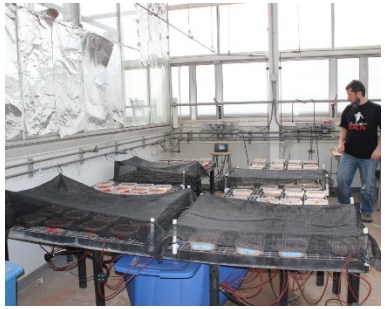
Inoculum and Shading Promoted Recovery

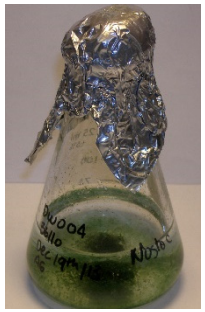


Different Inoculum Types

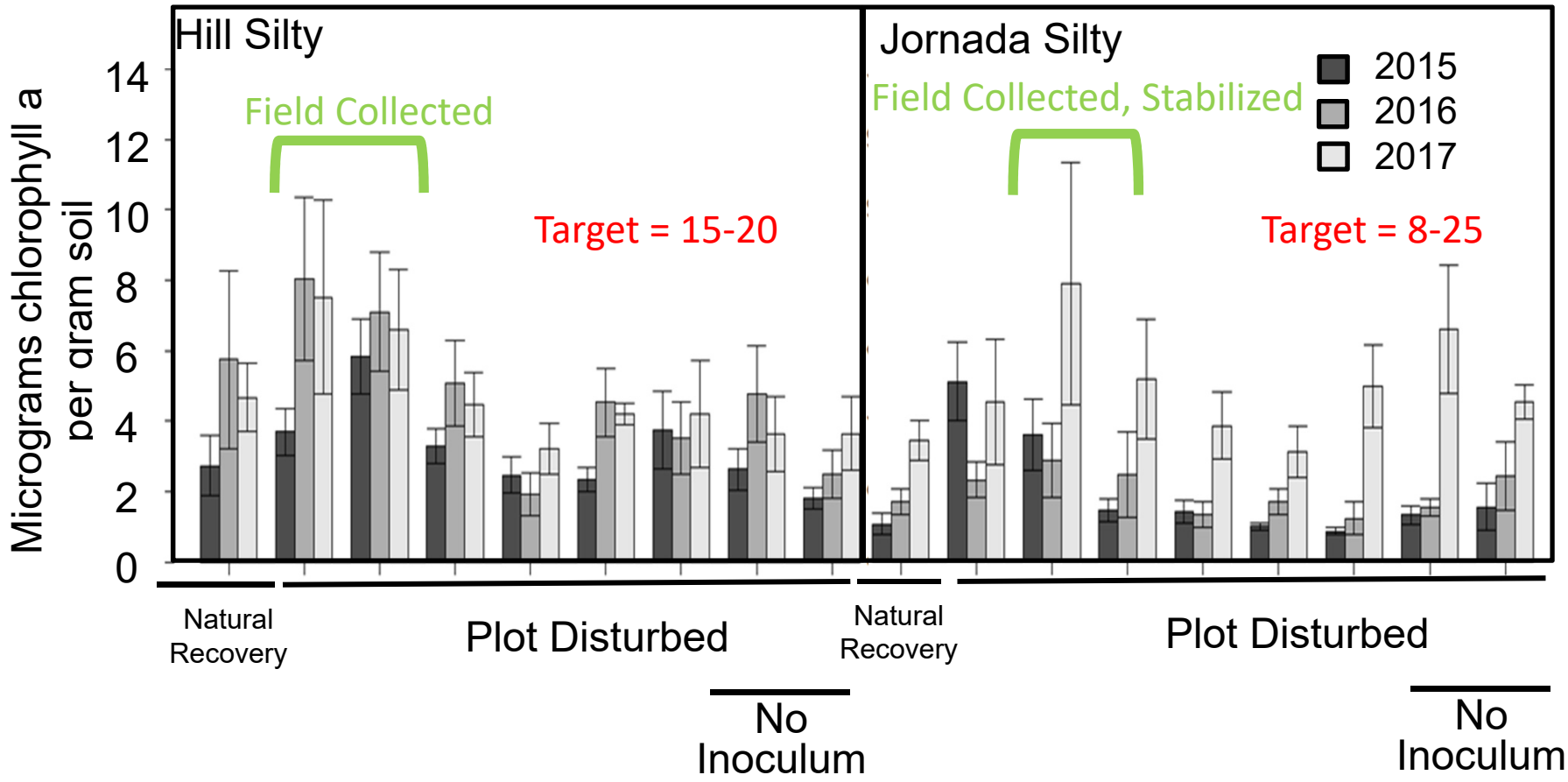
Trade-Offs

Parameter	Field Collected (FC)	Greenhouse Grown	Laboratory Grown
Overharvesting Risk	High	Medium	Low
Local Resource Adaptation	High	Medium	Low
Time/Resource Investment	Low	Medium	High



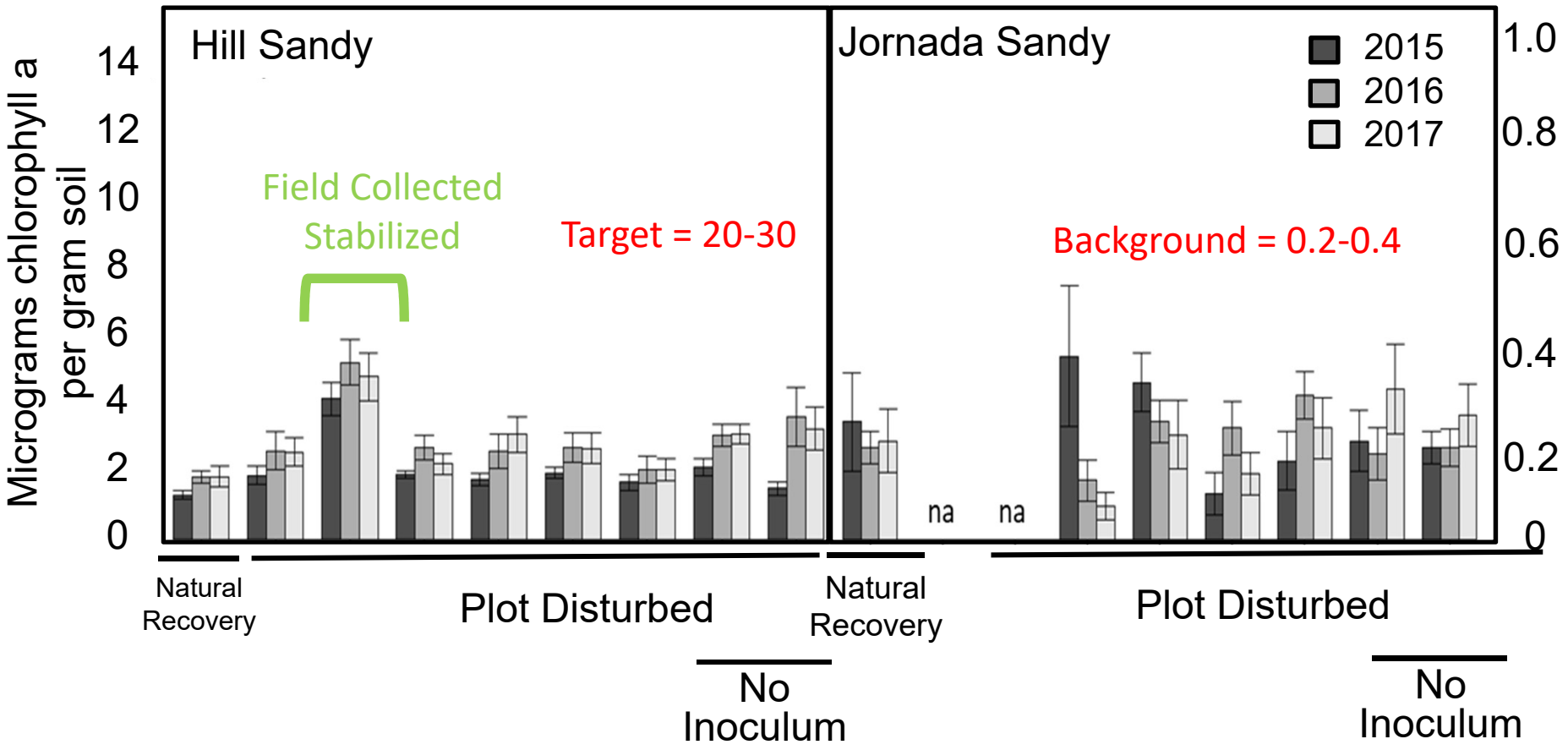


Biocrust Growth Response



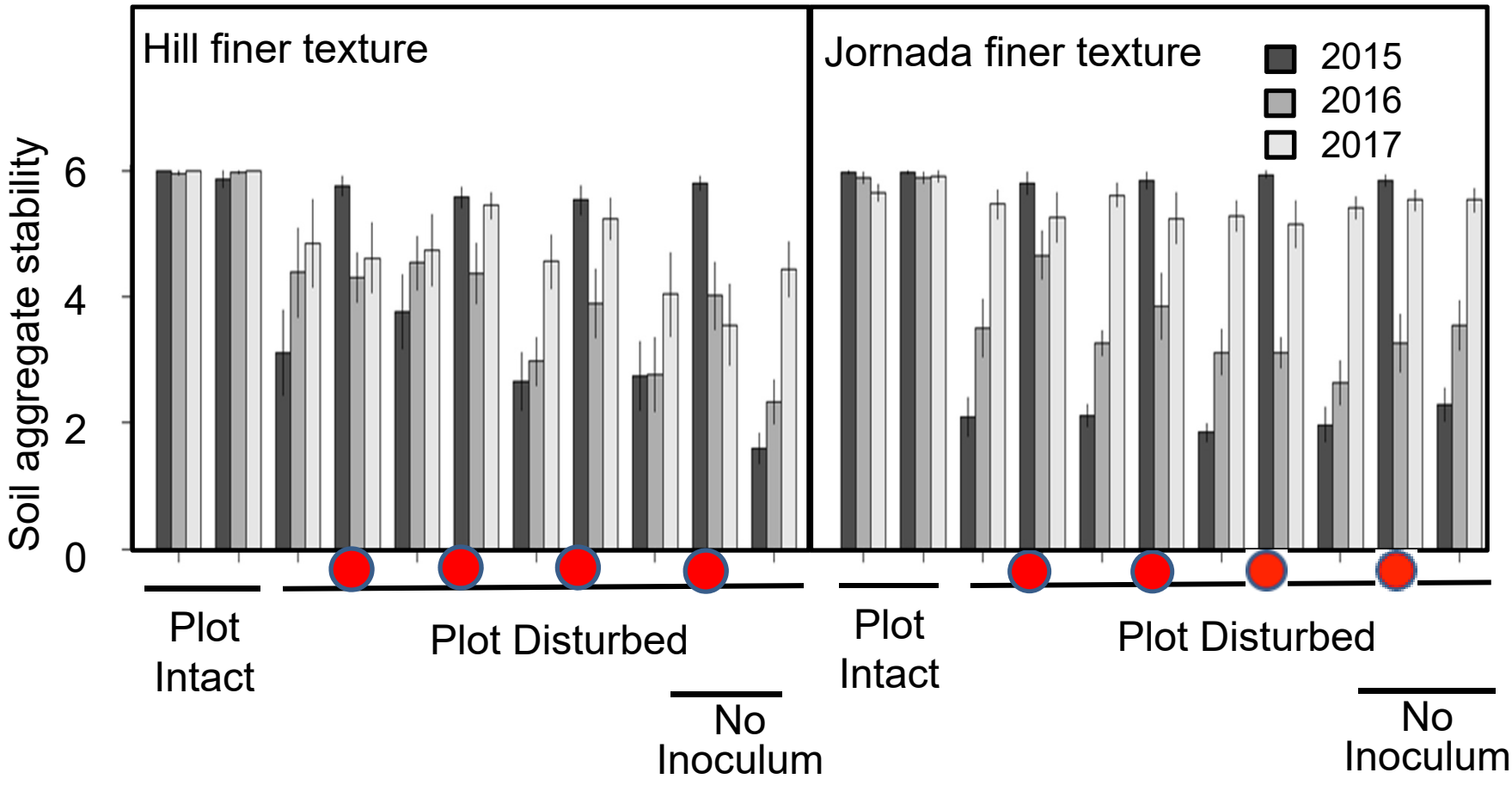
Limited response to inoculation and soil stabilization

Biocrust Growth Response



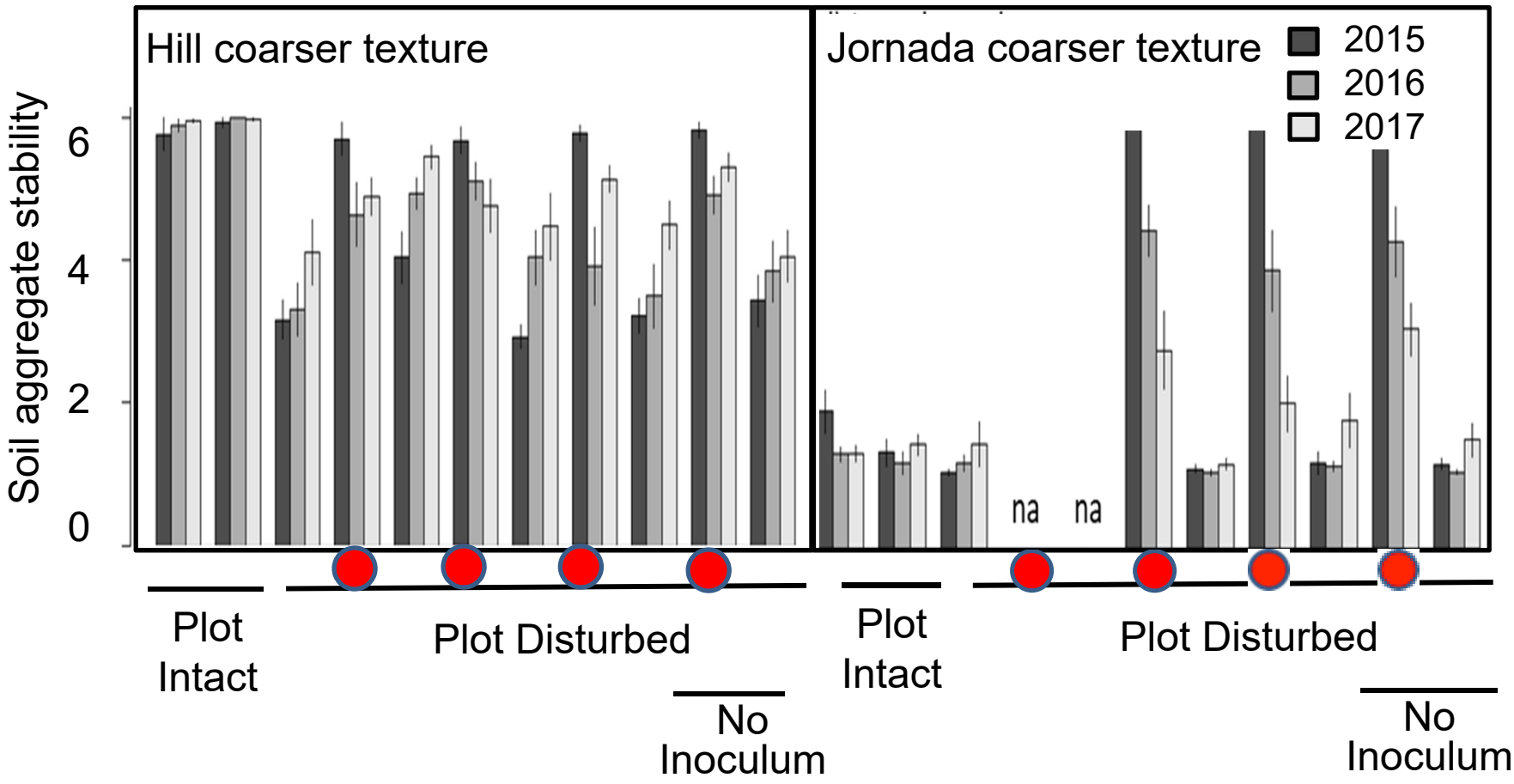
Limited response to inoculation and soil stabilization

Polyacrylamides Stabilize Soils



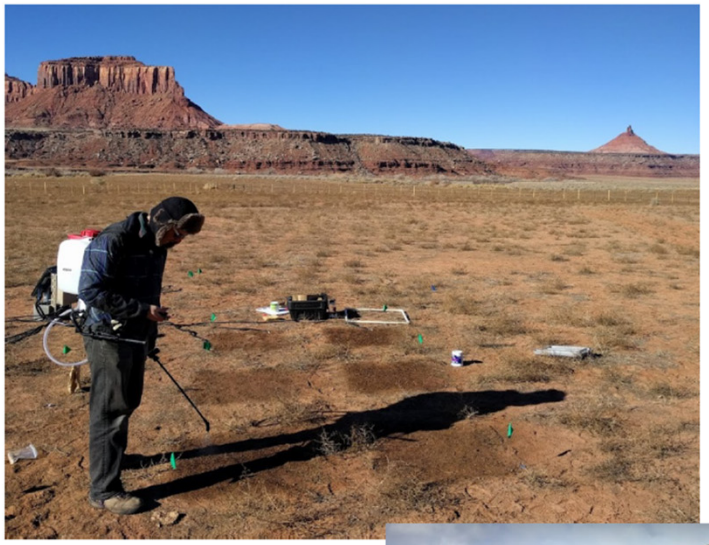
Polyacrylamides effectively stabilize soils after disturbance

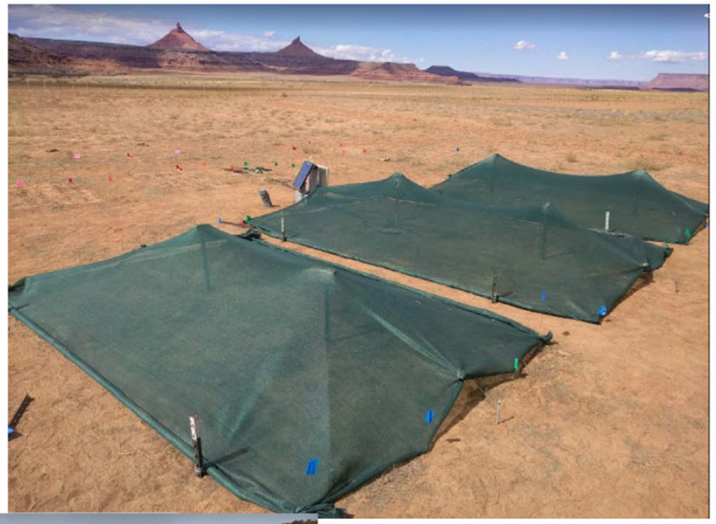
Polyacrylamides Stabilize Soils

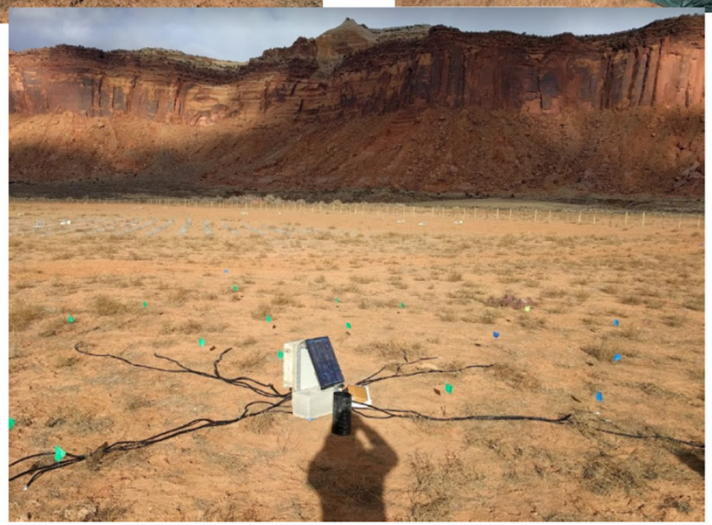


Polyacrylamides effectively stabilize soils after disturbance

Biocrust Rapid Restoration Experiment

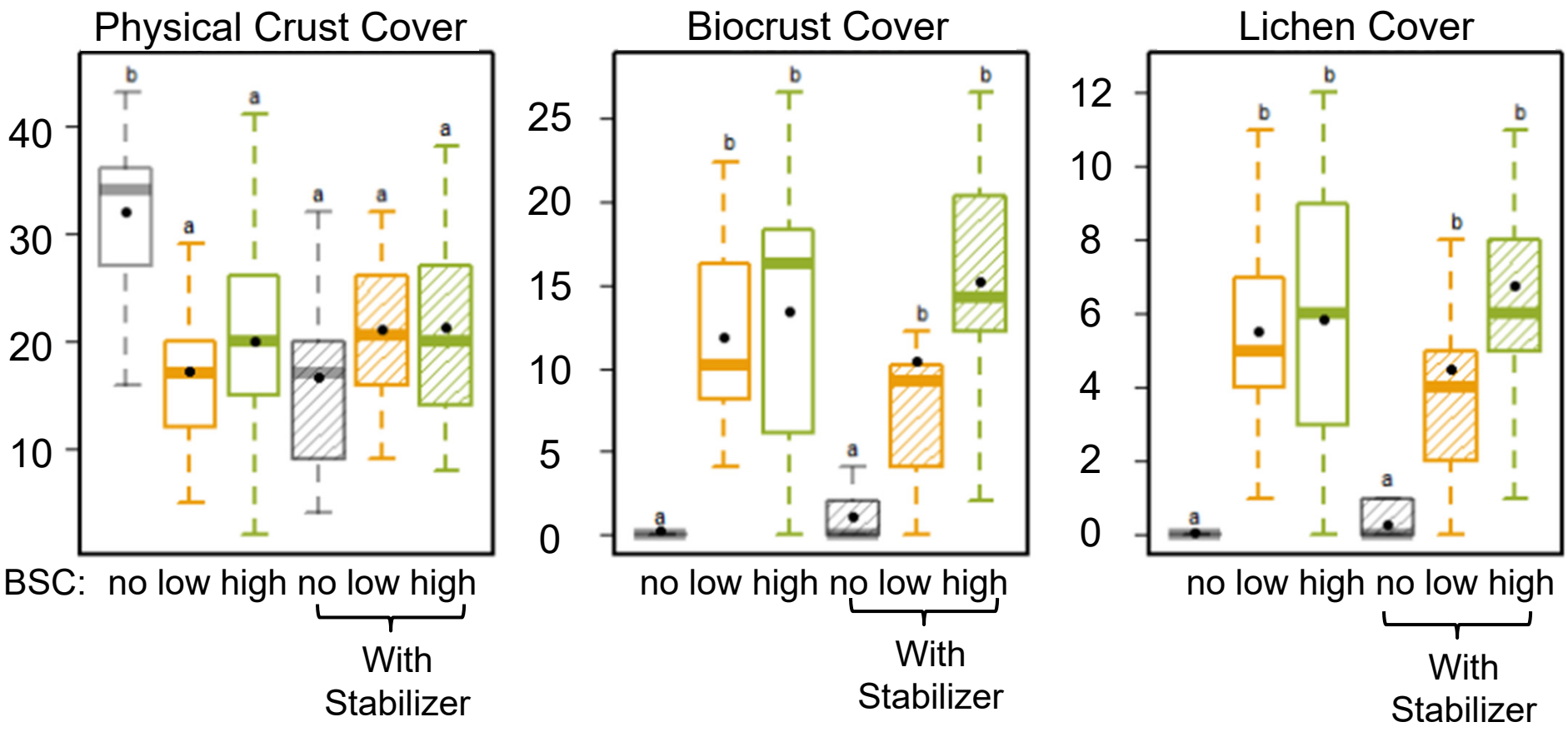






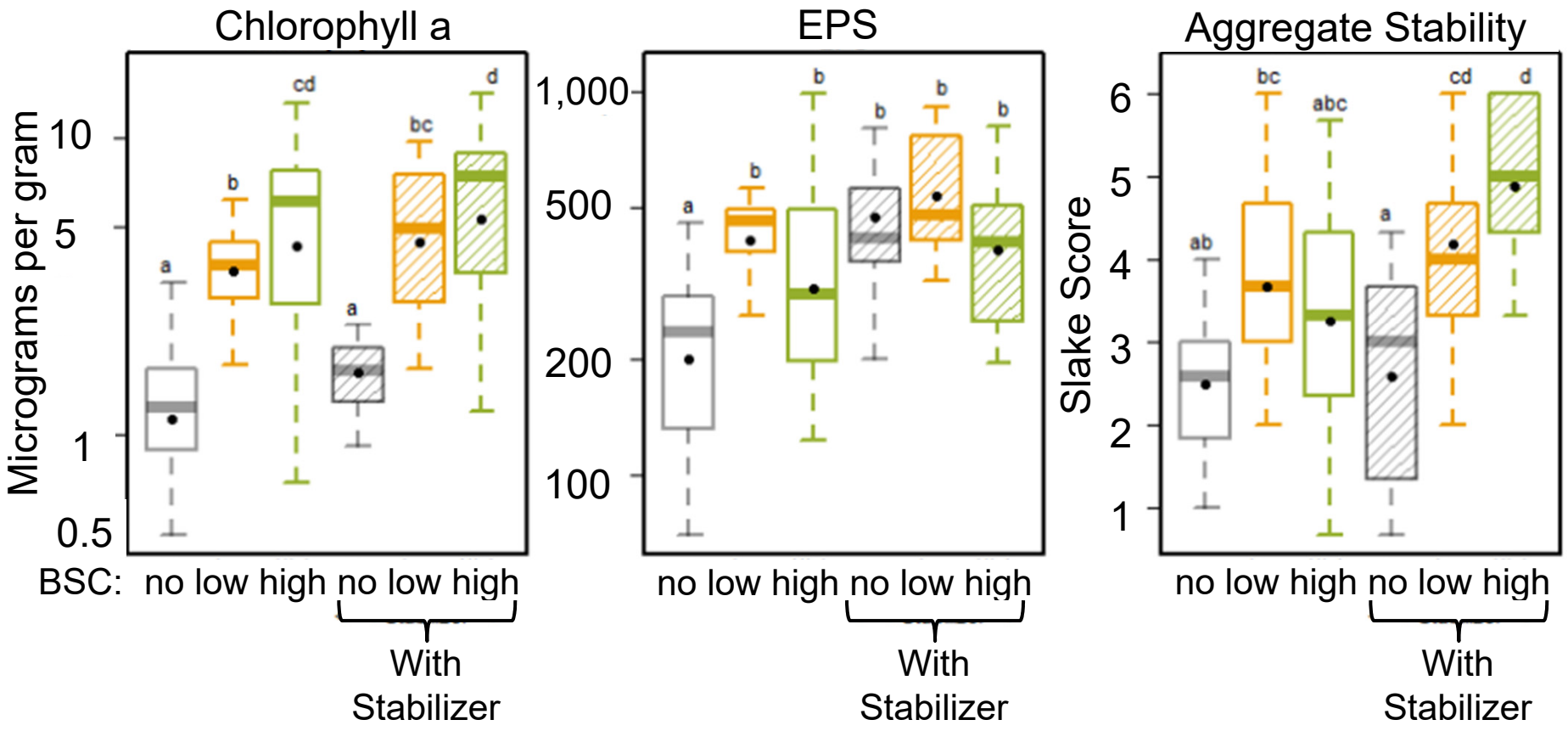
Biocrust Recovery

Percentage



Inoculation promotes biocrust recovery

Biocrust Recovery



Inoculation and soil stabilization promotes recovery and stability

Conclusions

- Fast, effective methods to grow biocrust inoculum from field collected samples
- Slower methods from lab cultures of mixed isolates
  - Limited time/resources for biomass scale-up
- Biocrust recovery enhanced when
  - Soil inoculation with shading and inoculation
  - Inoculation and soil stabilization when irrigated and stabilized with synthetic products

Benefits to DoD

- Novel approaches to biocrust inoculum
  - Restoration of degraded dryland ecosystems
- Important function in dryland
  - Rehabilitation benefits ecosystems impacted by land based training activities
- Future challenge
  - Scaling approach to landscape-scale

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Arid-Lands-Ecology-and-Management/RC-2329

Speaker Contact Information

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Q&A Session 2

The next webinar is on May 23, 2019

Treatment Options for the Emerging Contaminants 1,2,3-Trichloropropane and 1,2-Dibromoethane

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends