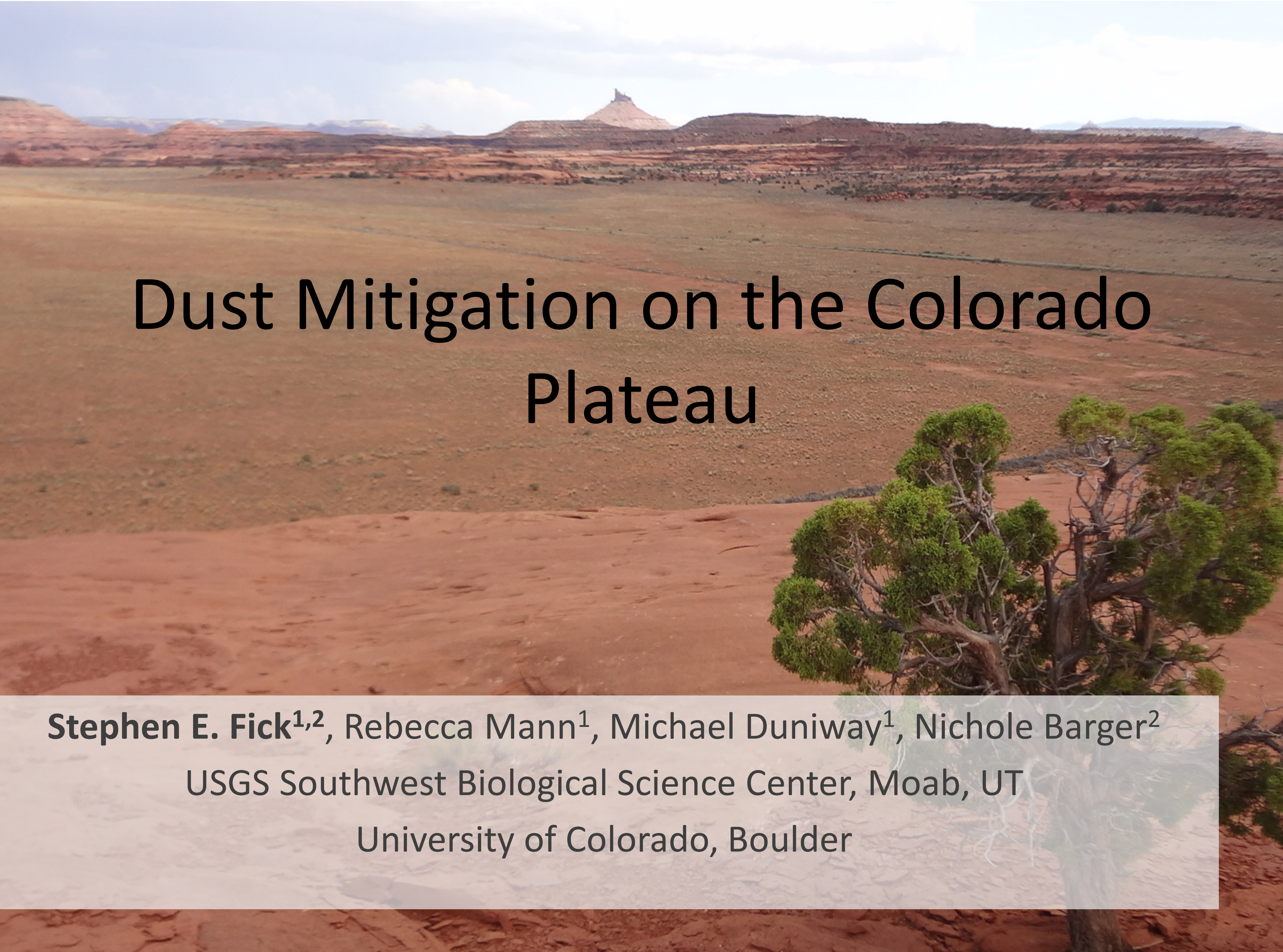
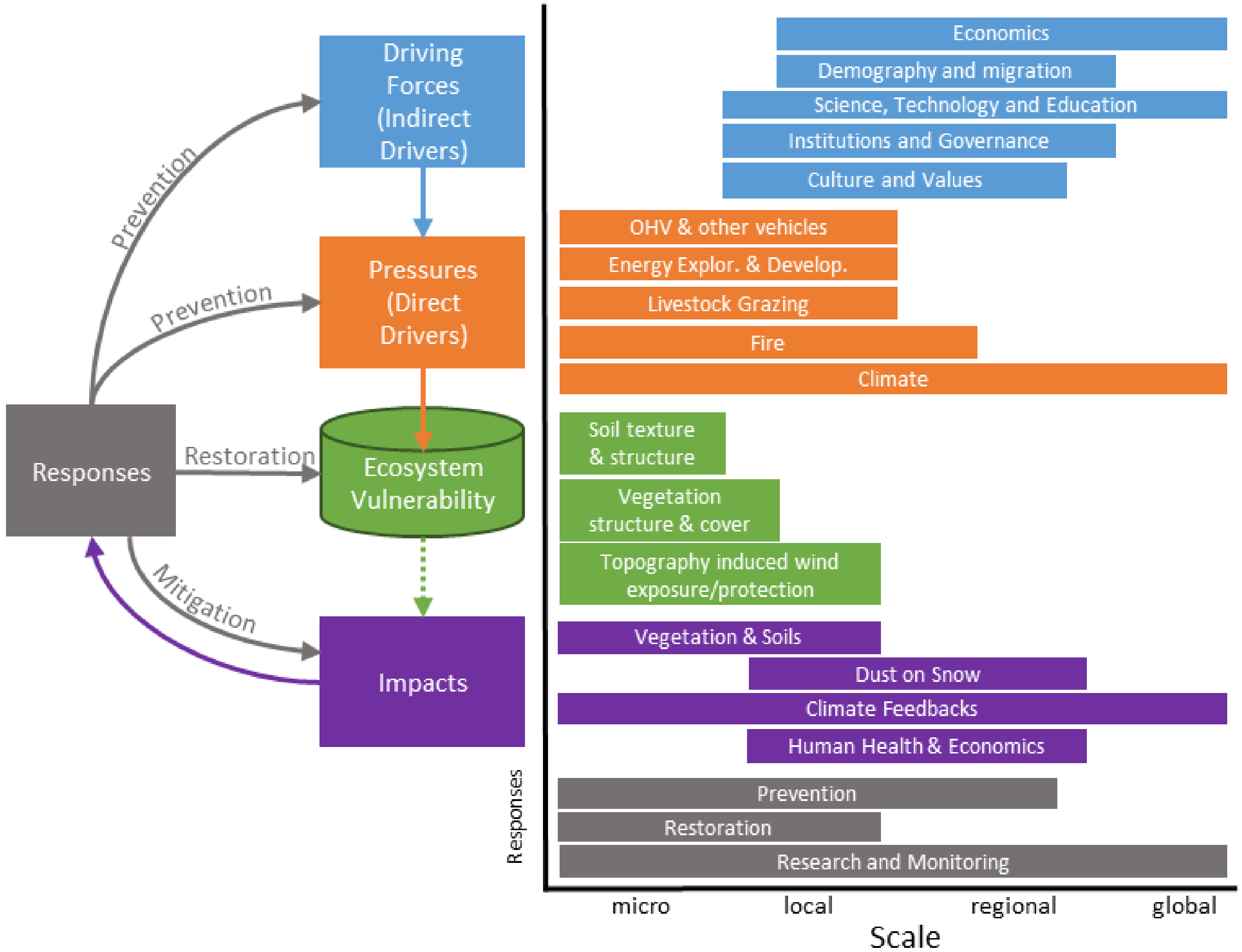
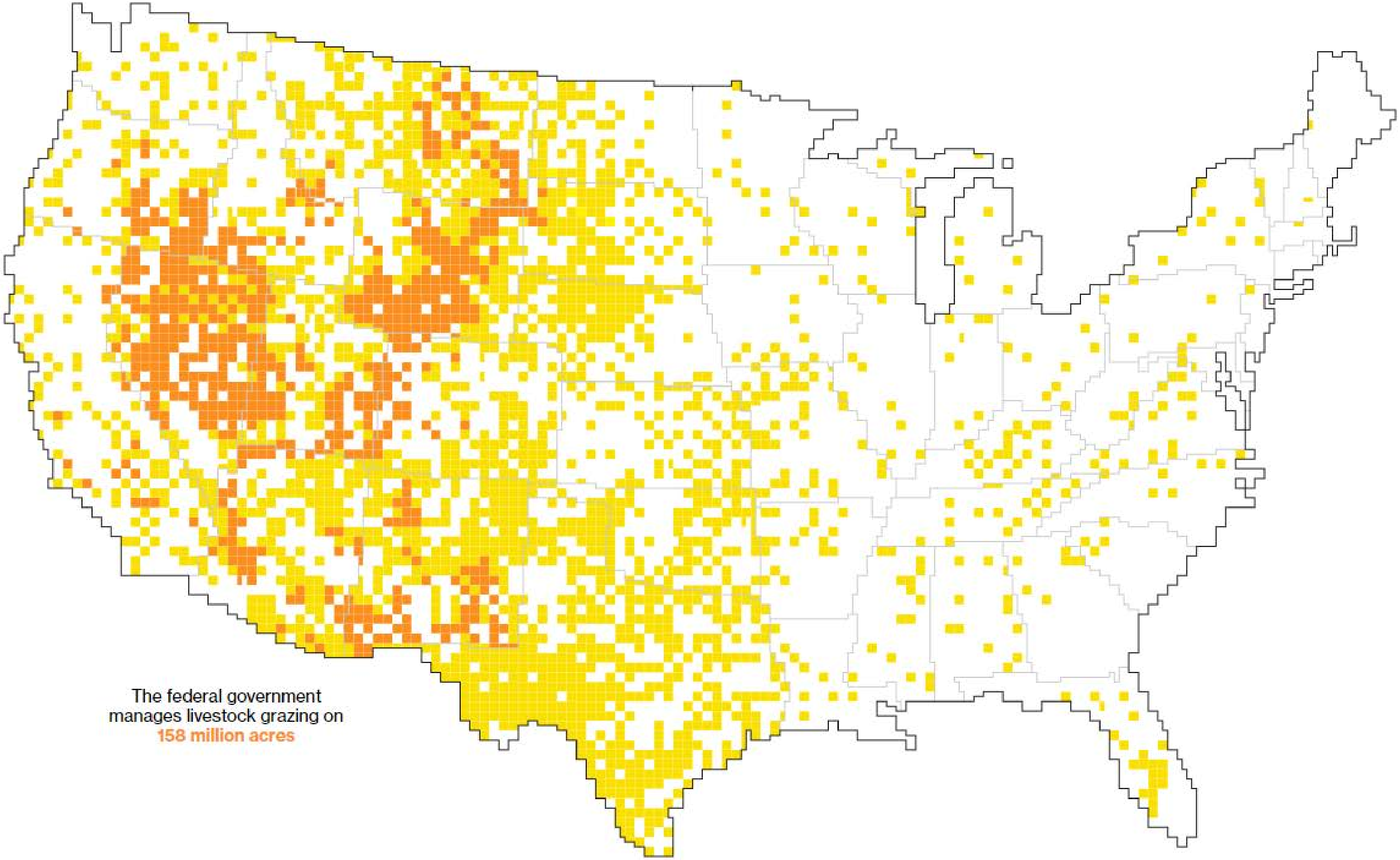


Dust Mitigation on the Colorado Plateau

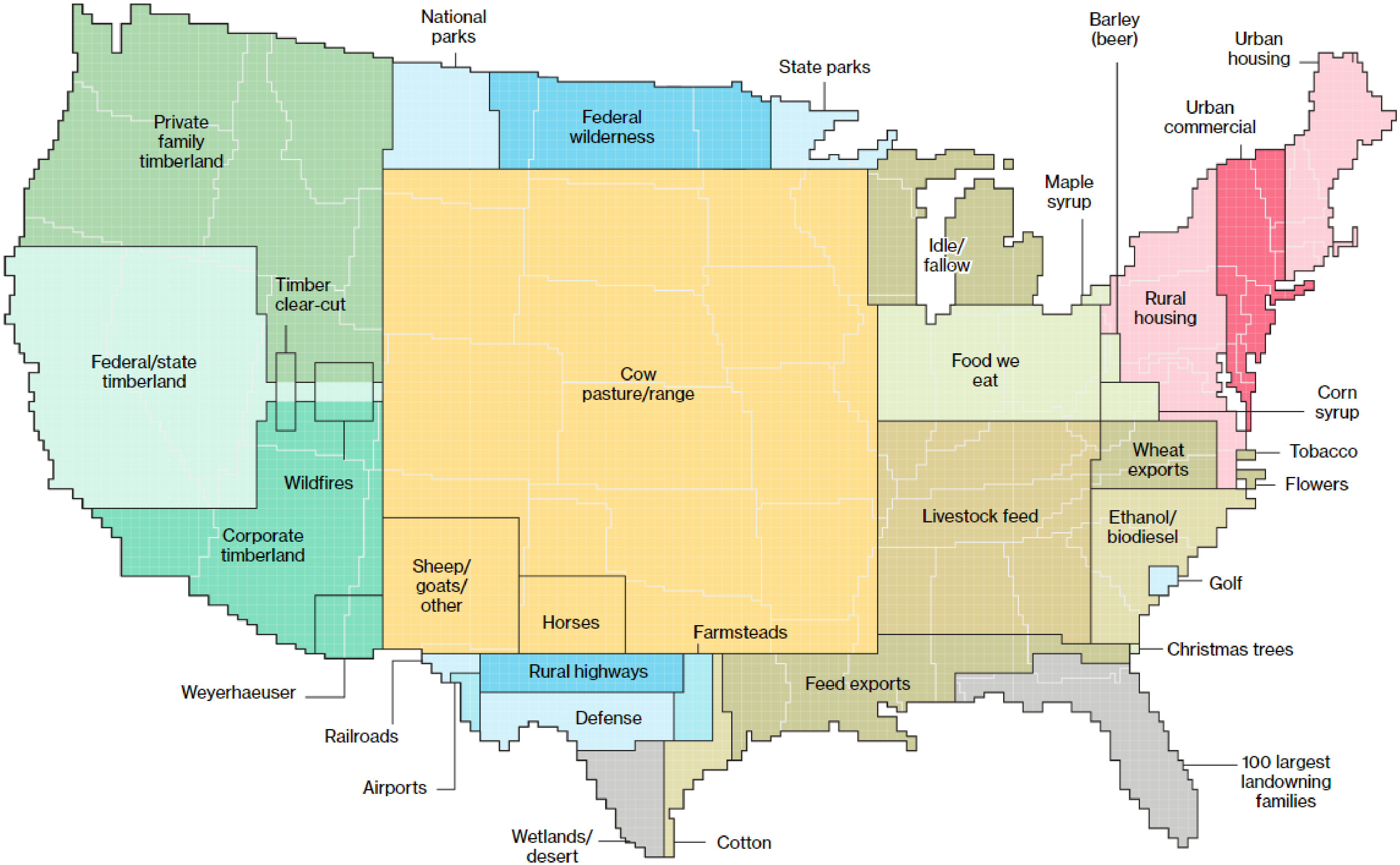
Stephen E. Fick[1,2], Rebecca Mann[1], Michael Duniway[1], Nichole Barger[2]
USGS Southwest Biological Science Center, Moab, UT
University of Colorado, Boulder



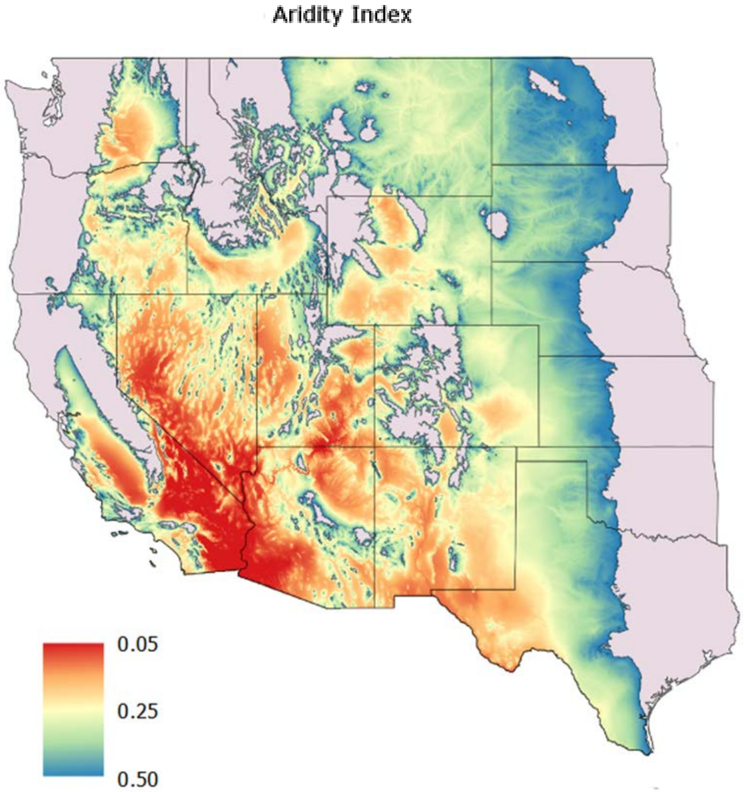
Duniway et al. *in review*



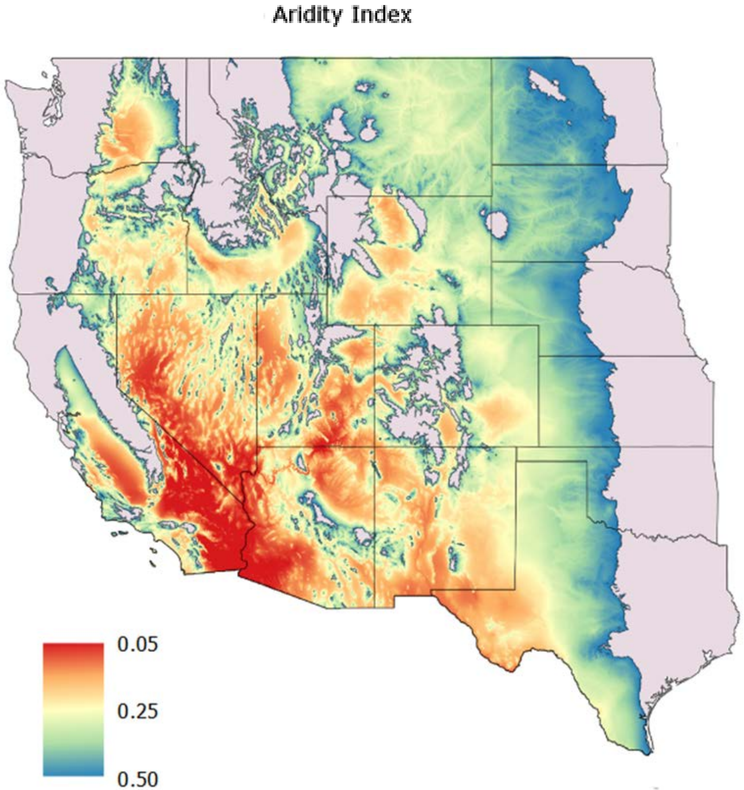
https://www.bloomberg.com/graphics/2018-us-land-use/

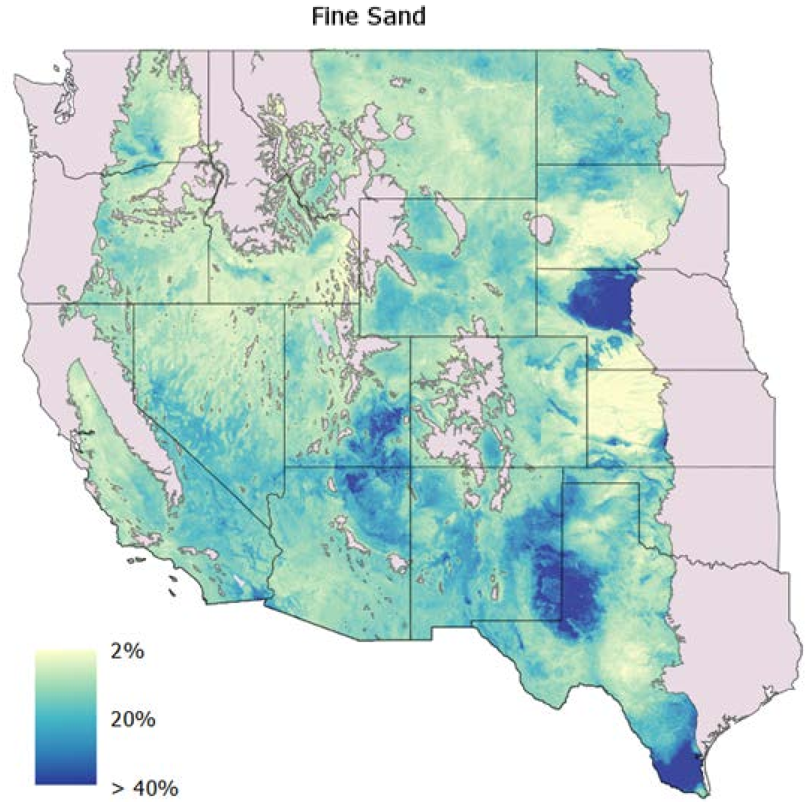


https://www.bloomberg.com/graphics/2018-us-land-use/

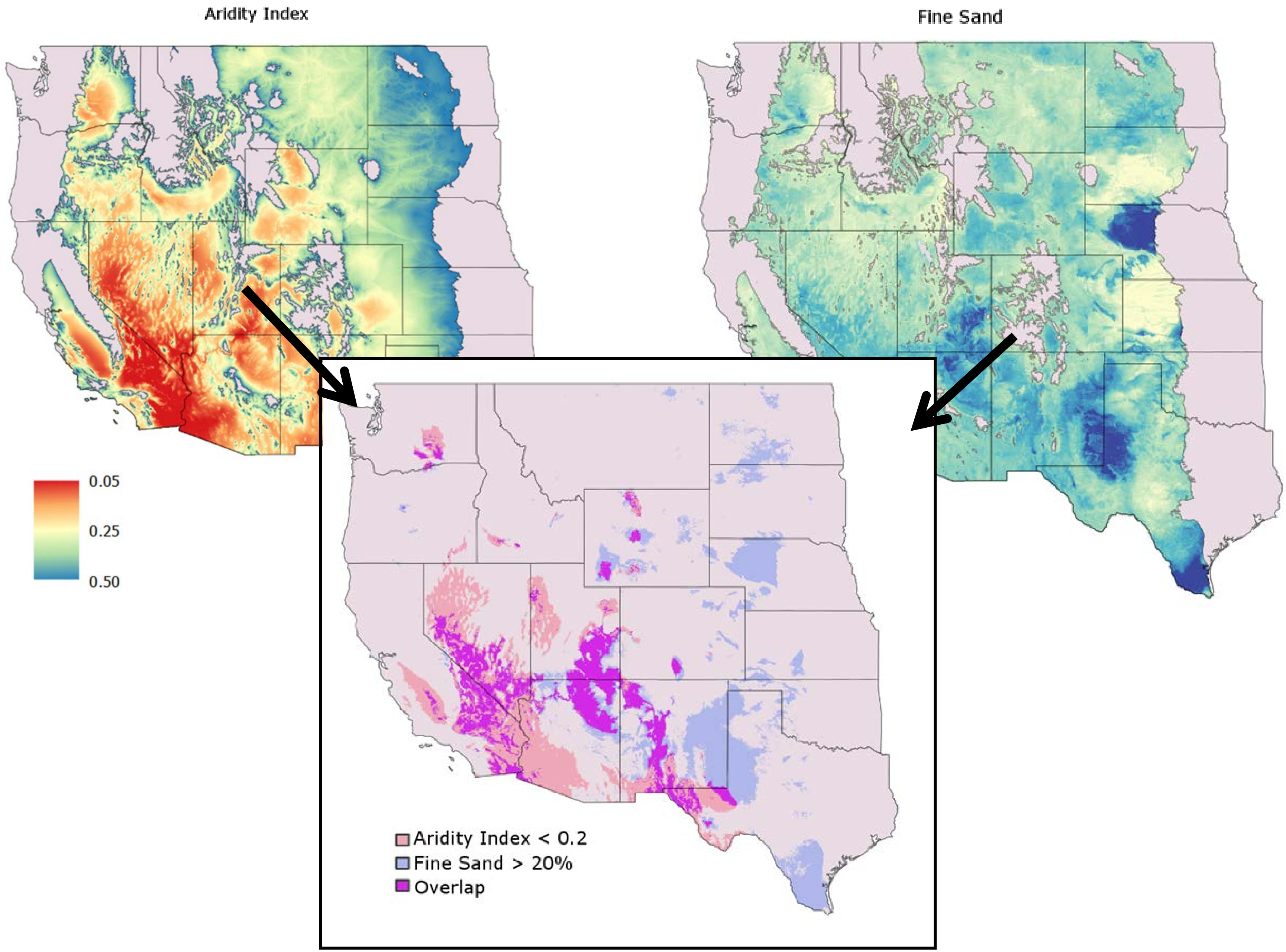


Duniway et al. *in review*

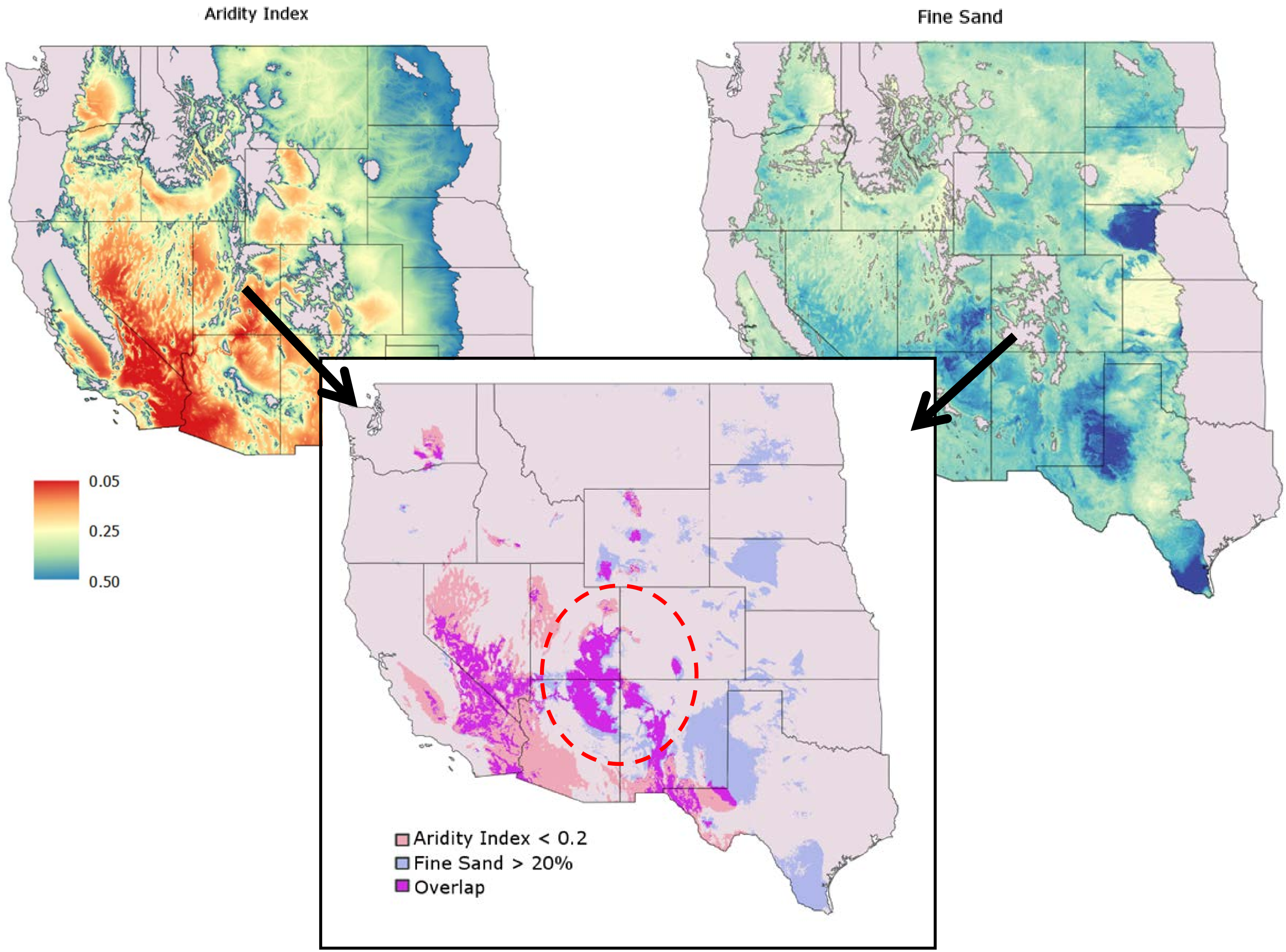




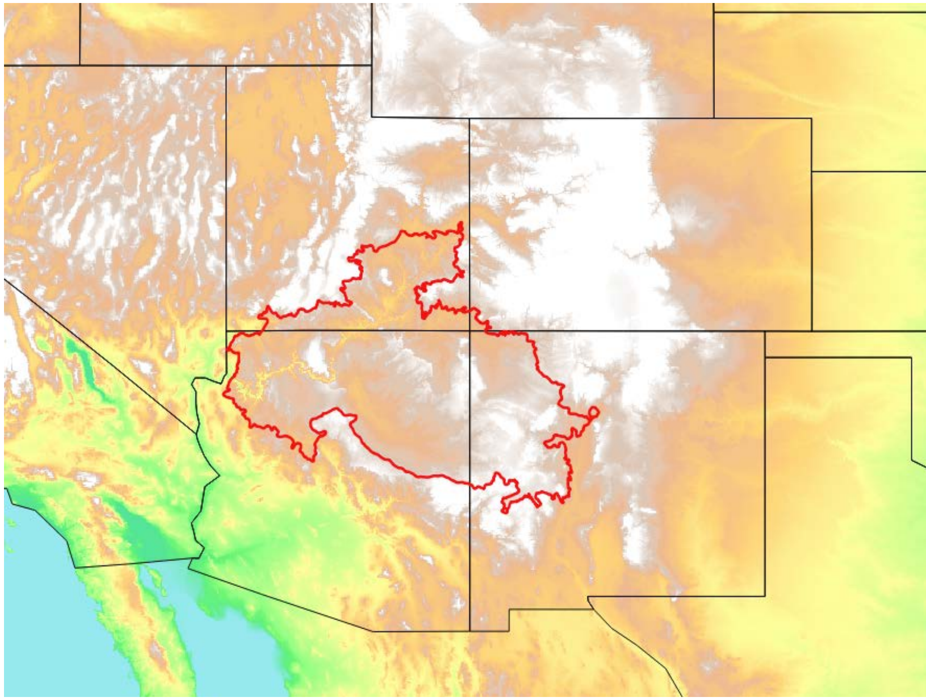
Duniway et al. *in review*

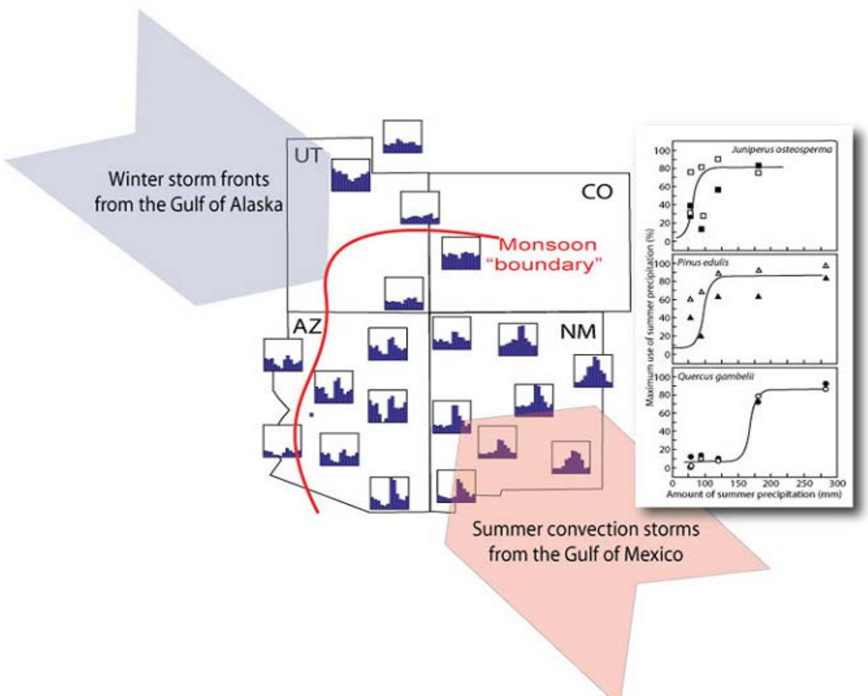


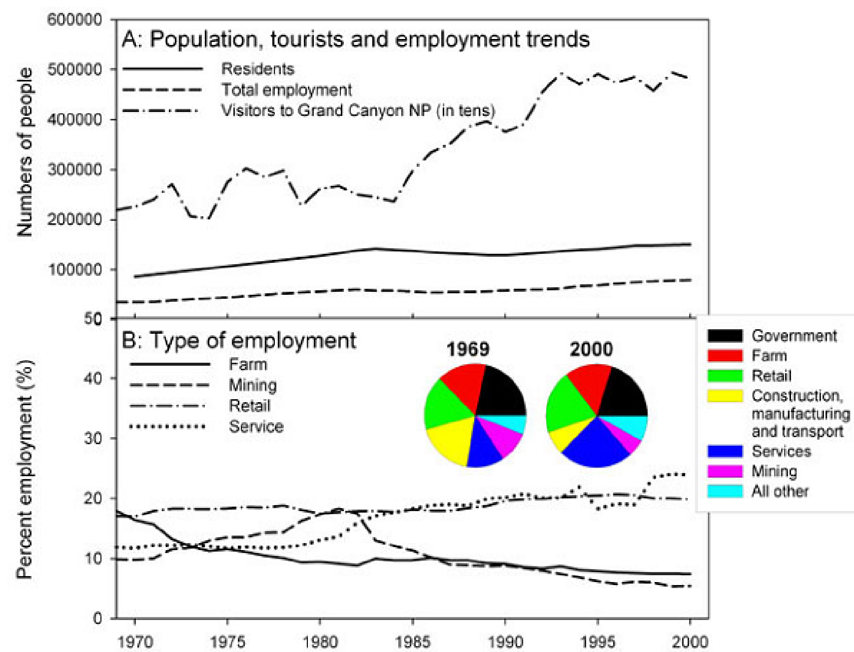
Duniway et al. *in review*



Duniway et al. *in review*

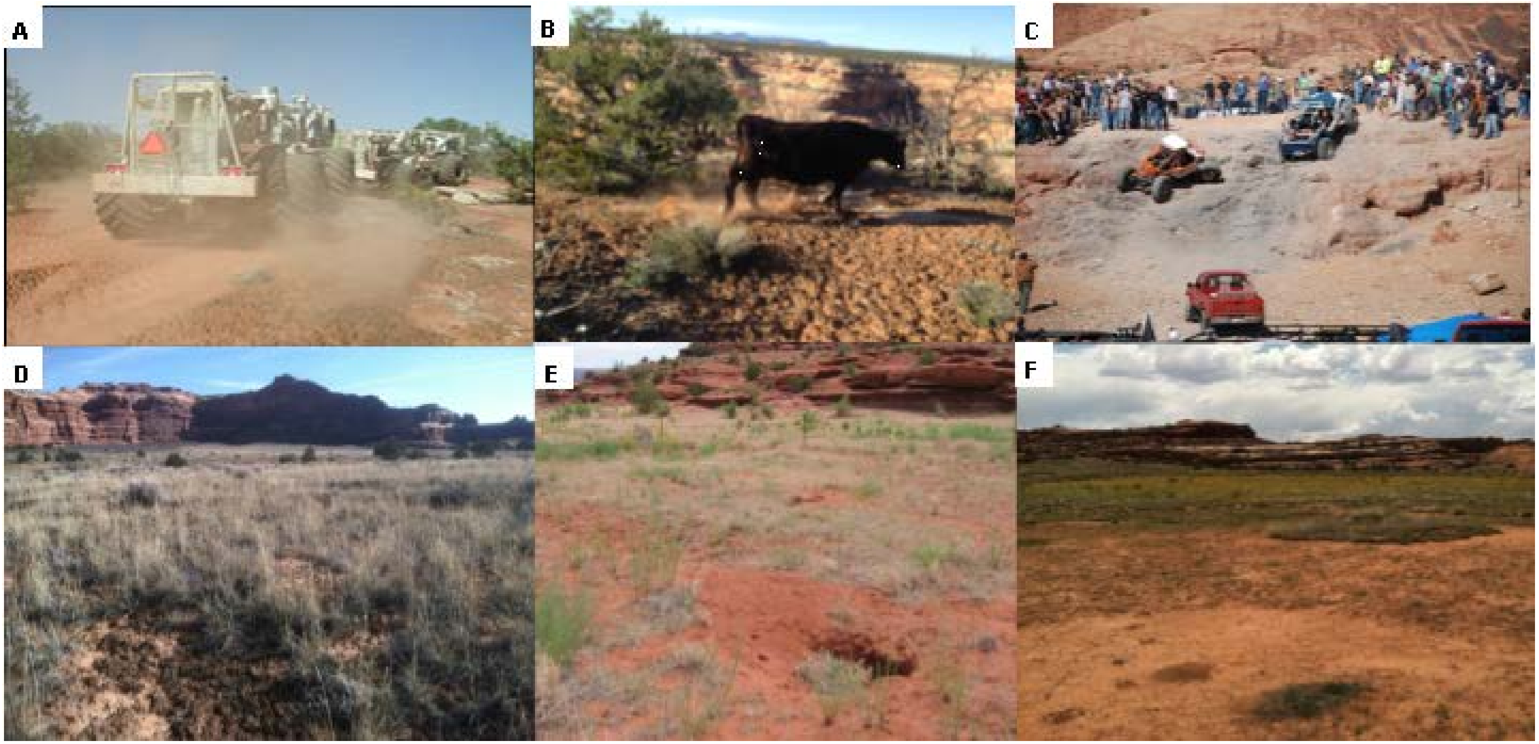






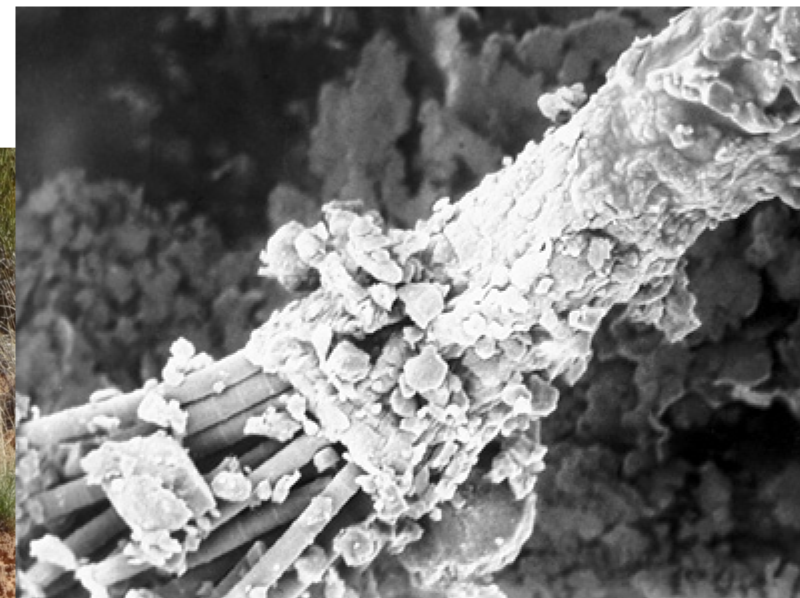
Schwinning et al 2008

Multiple land uses increase emission risk

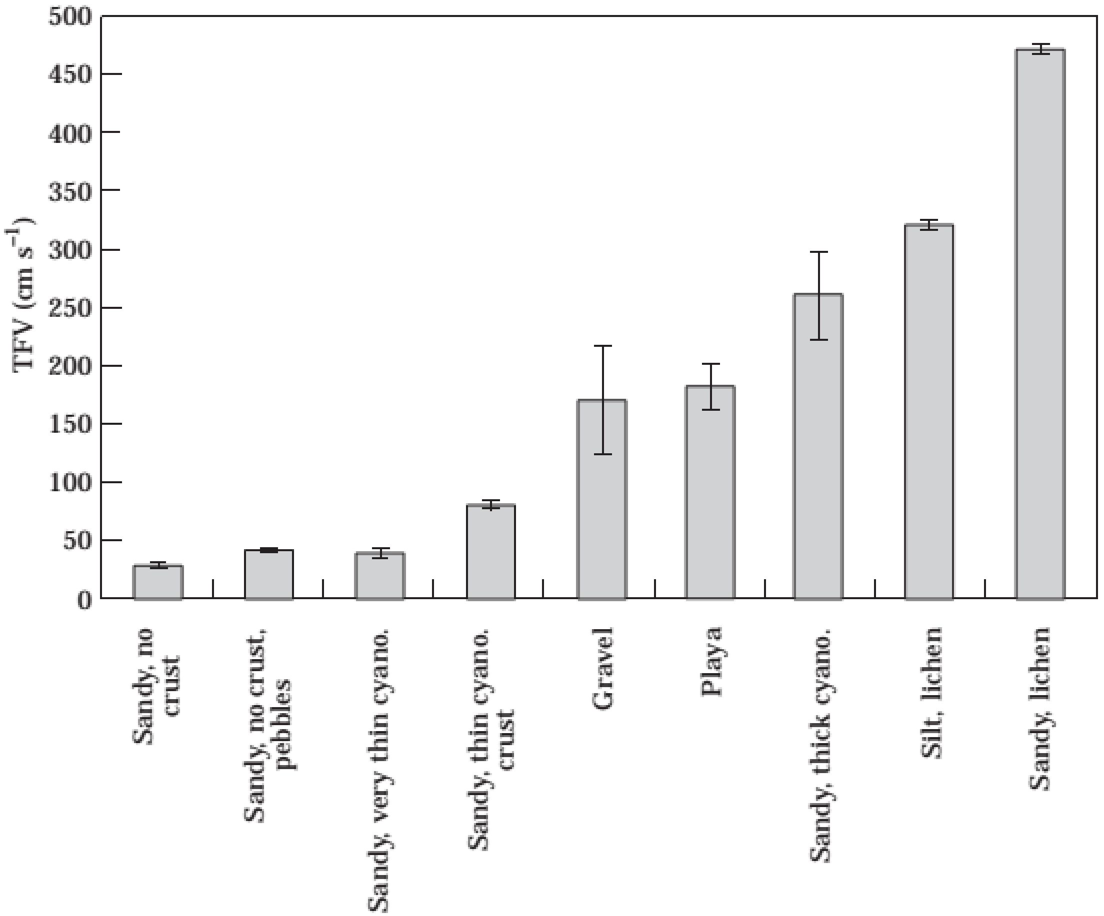


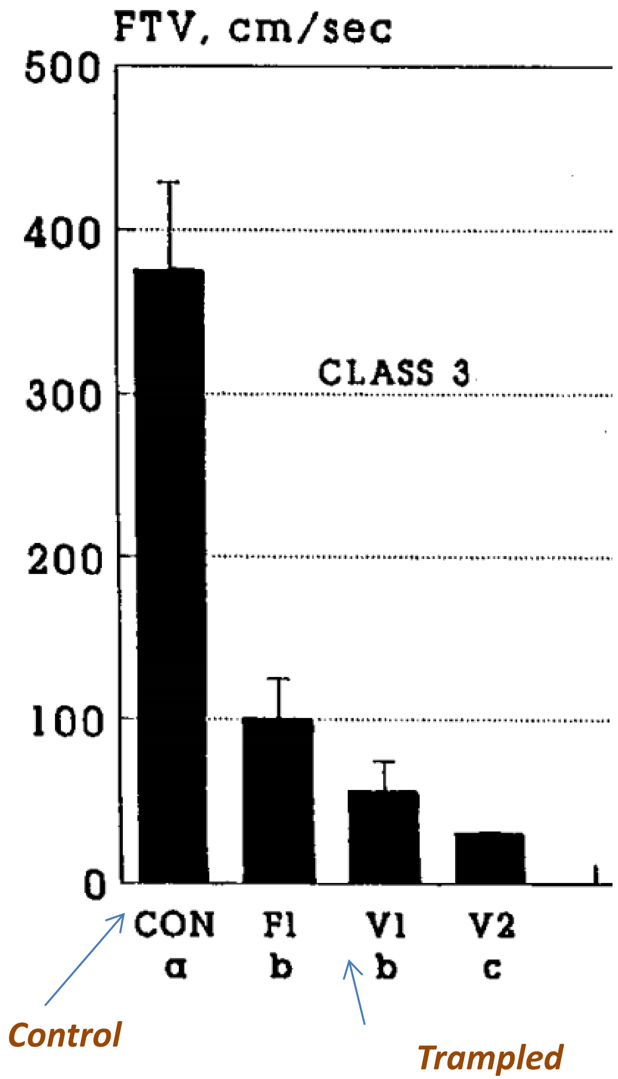
Biological soil Crusts:

- Uniquely prominent, pinnacled formations throughout the Colorado Plateau
- Stabilize the soil
- Easily damaged by trampling (by humans, animals, OHVs)



Biological Soil Crust Reduces Erosion

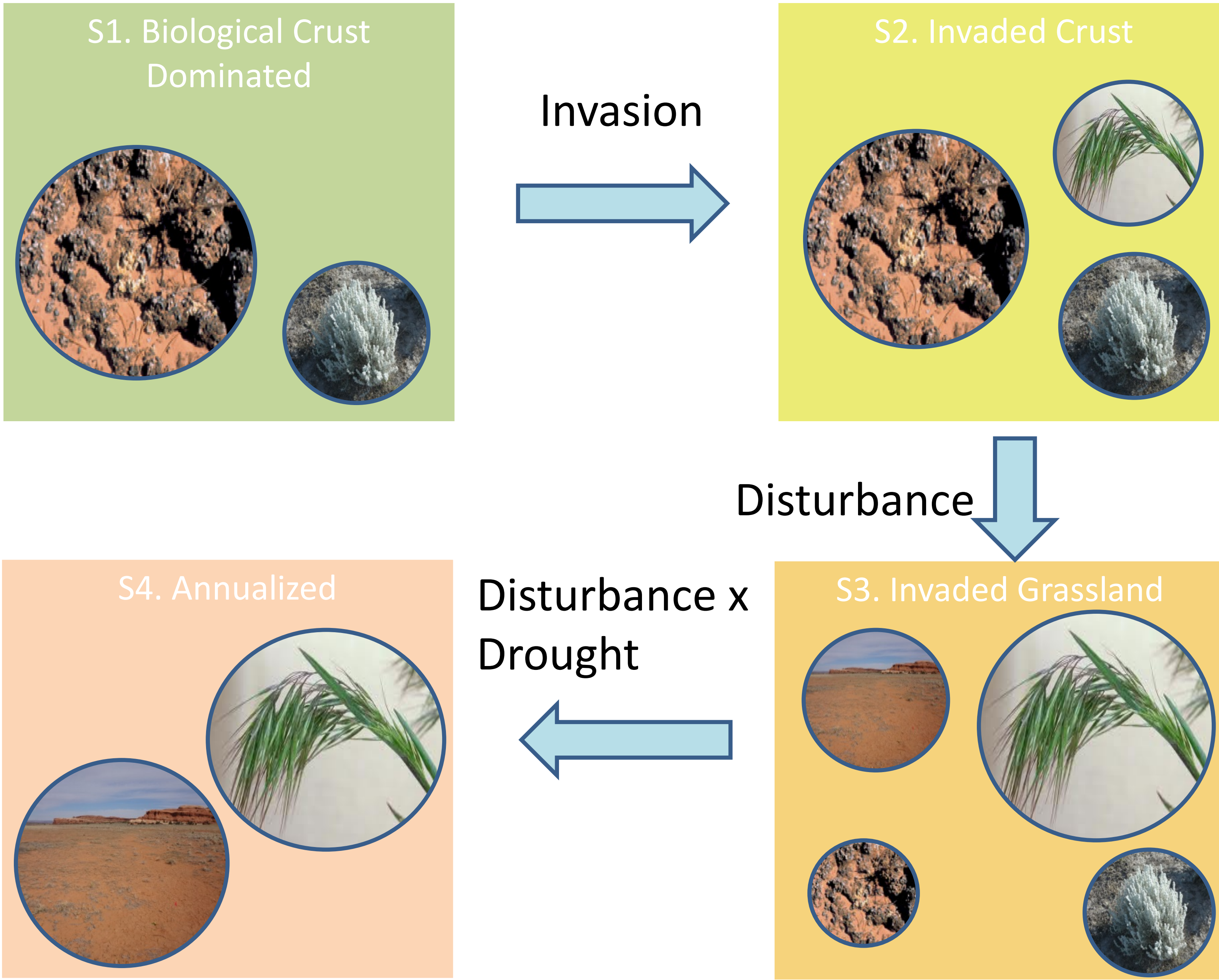




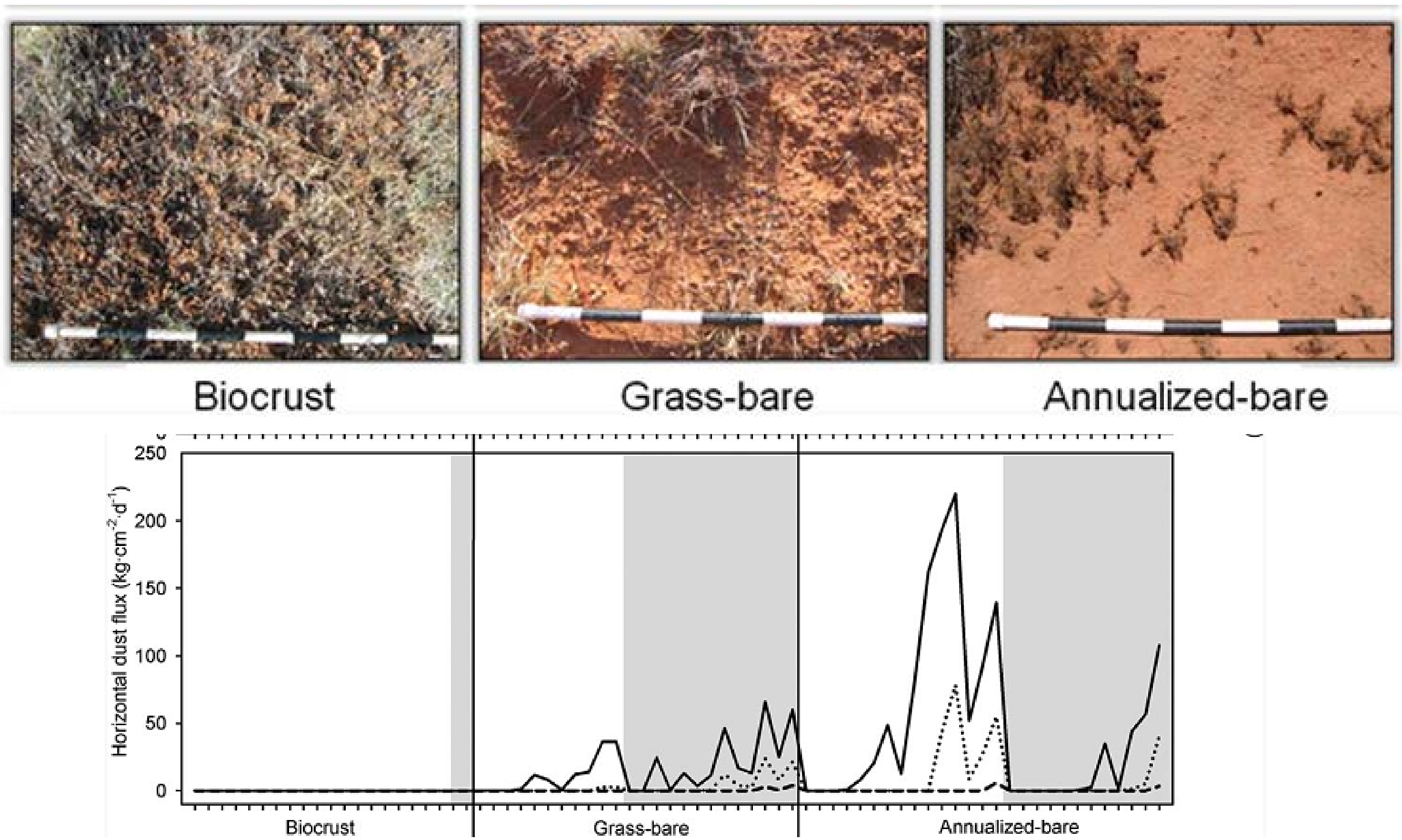
Belnap and Gillette 1998

Belnap and Gillette 1997

Disturbance Affects Ecological State



Erosion potential varies by state



Miller et al. 2011

Result: Threats to Life and livelihood

Dust emissions are a growing, system-wide hazard

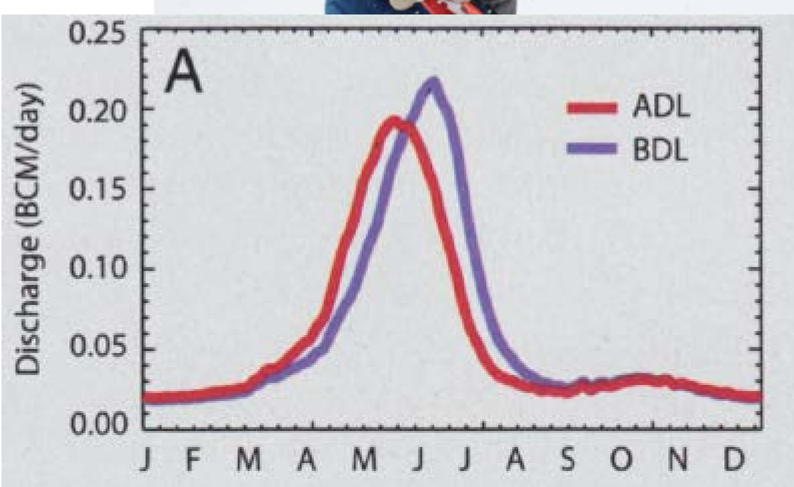

npr set station news arts & life music programs shop

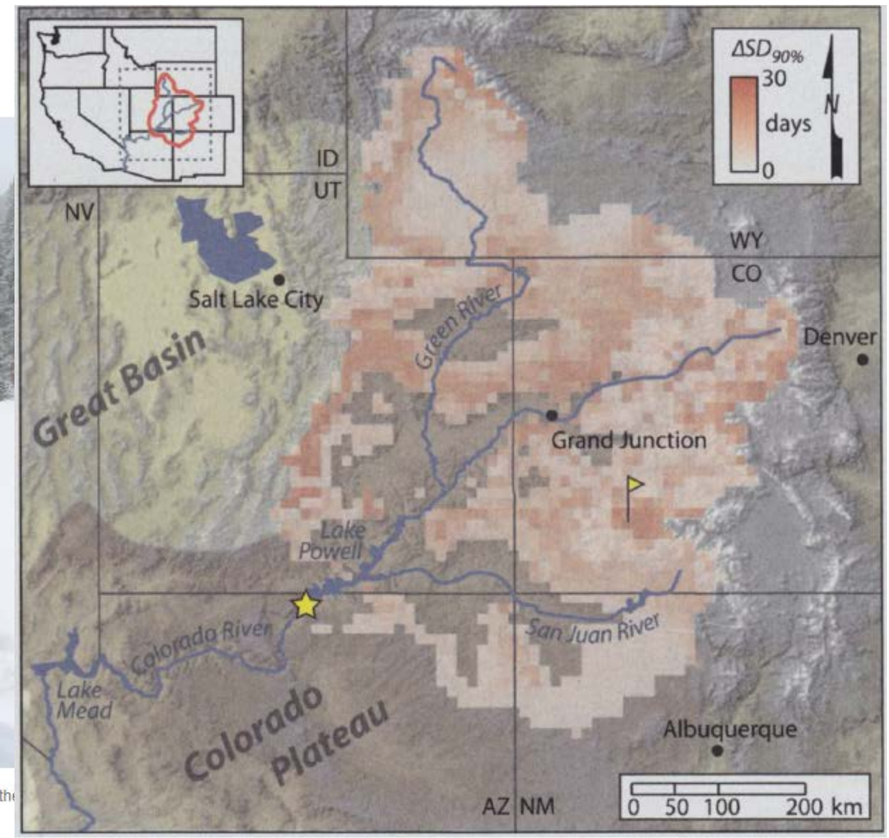
NATIONAL

The Rocky Mountains Have A Dust Problem

April 22, 2018 · 7:24 AM ET

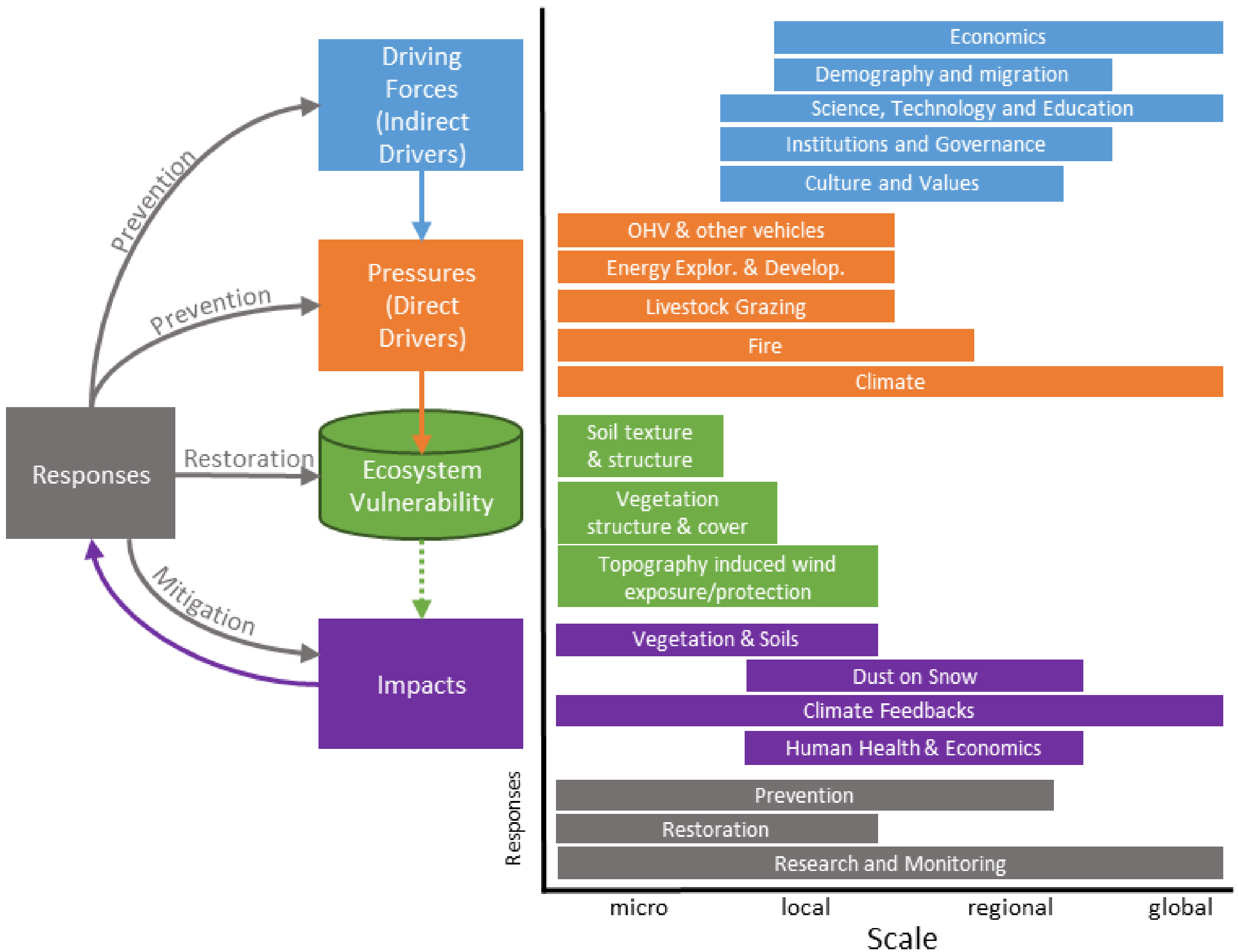
LUKE RUNYON





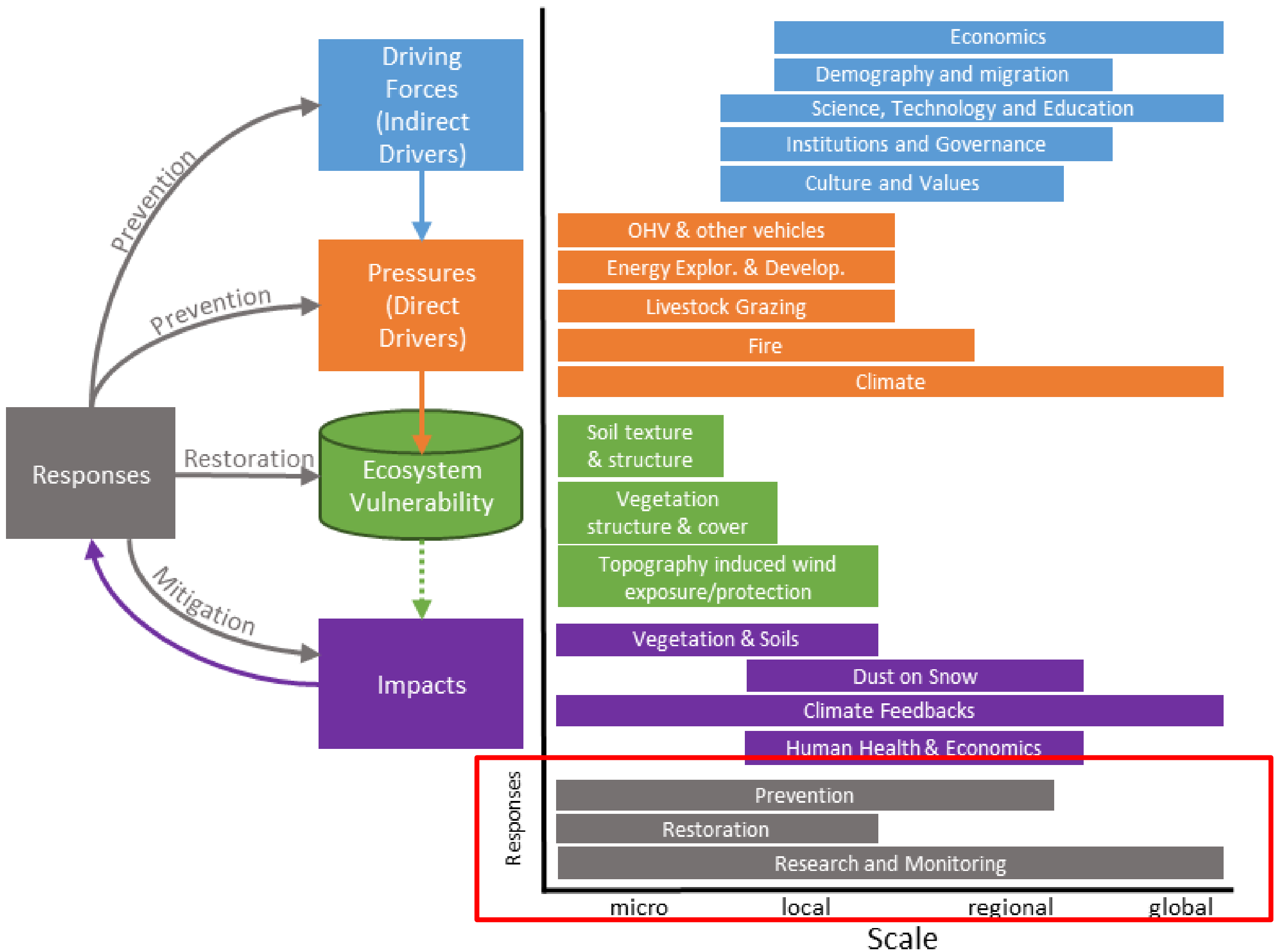
Painter et al. 2010 *PNAS*

Interventions



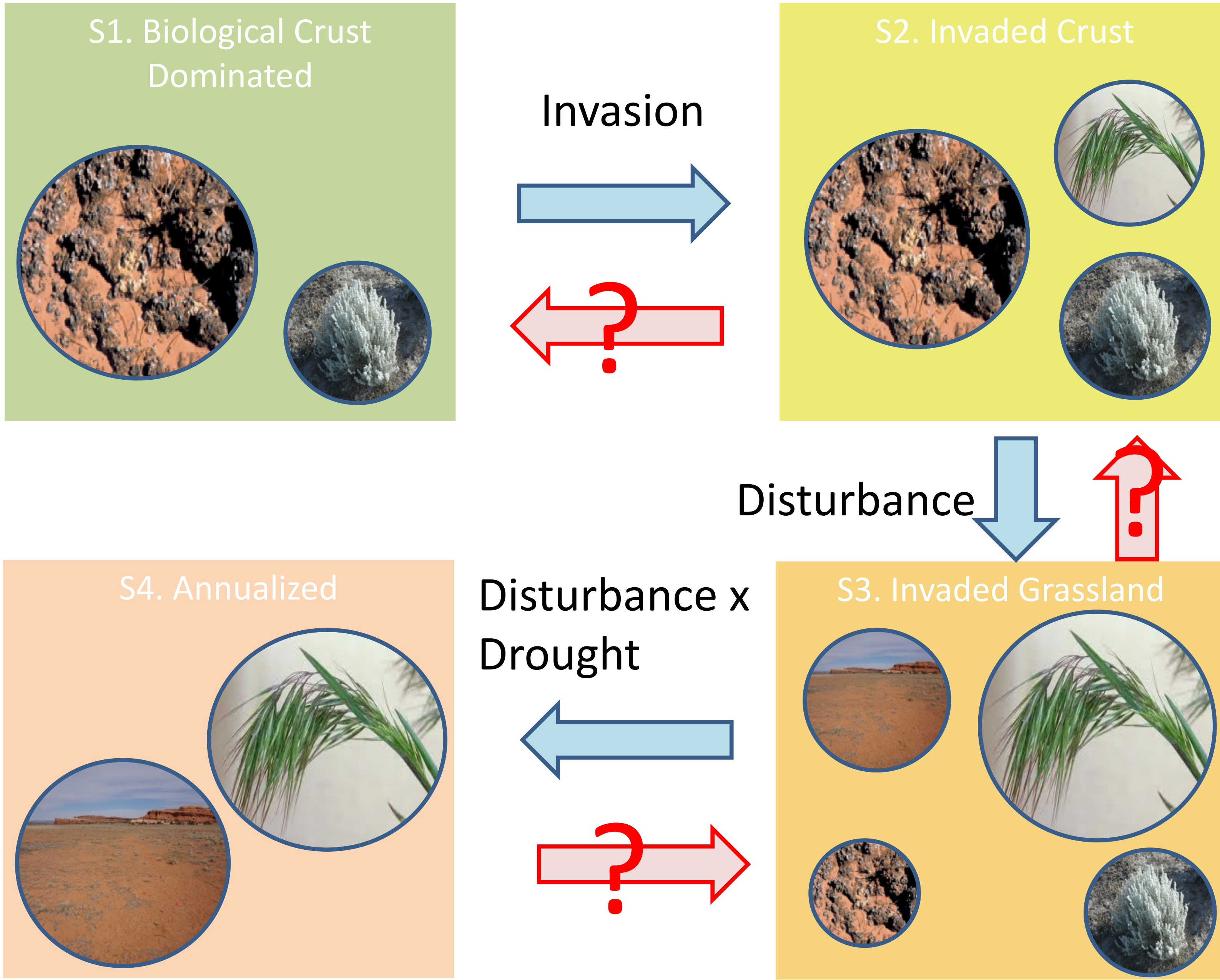
Duniway et al. *in review*

Interventions

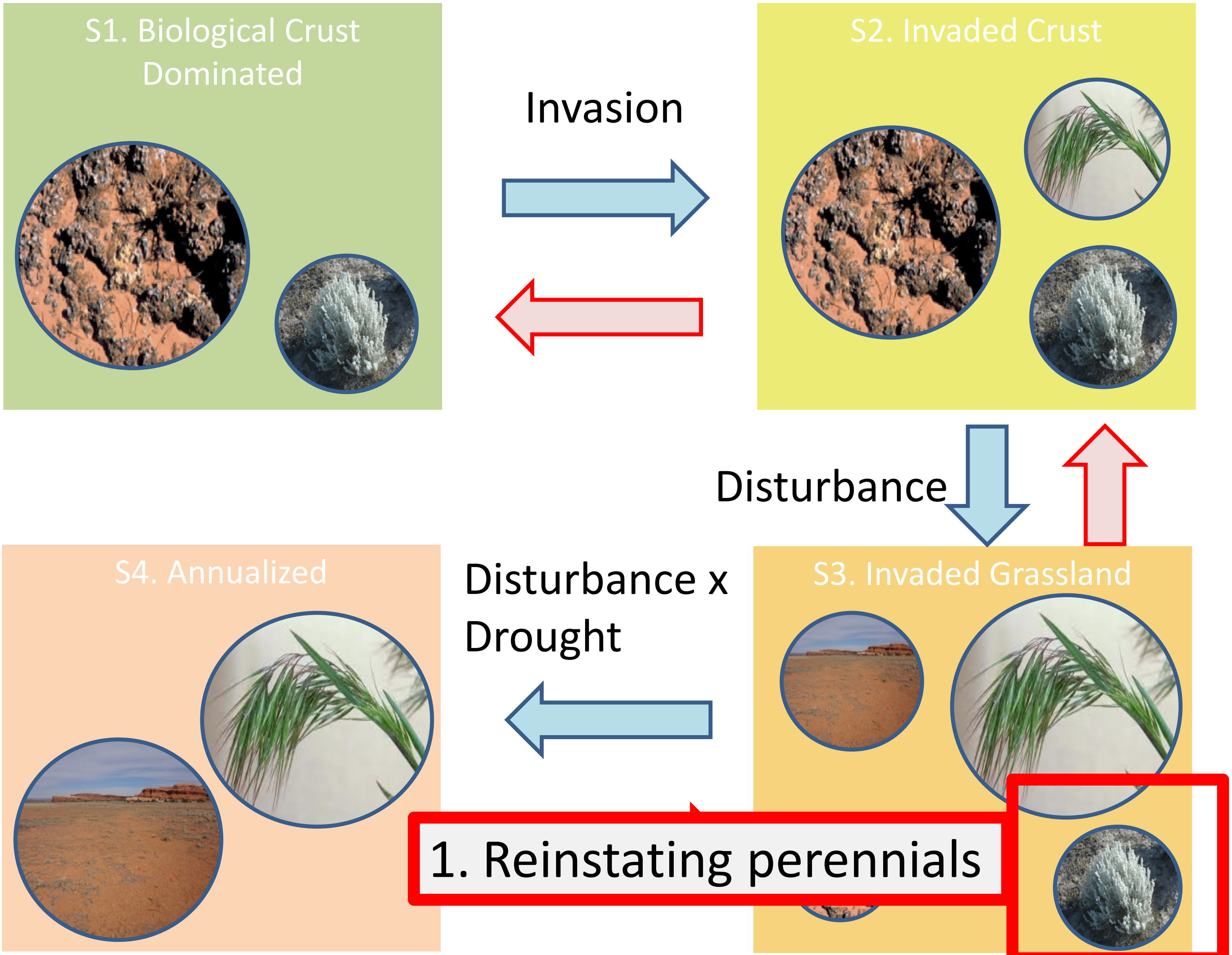


Duniway et al. *in review*

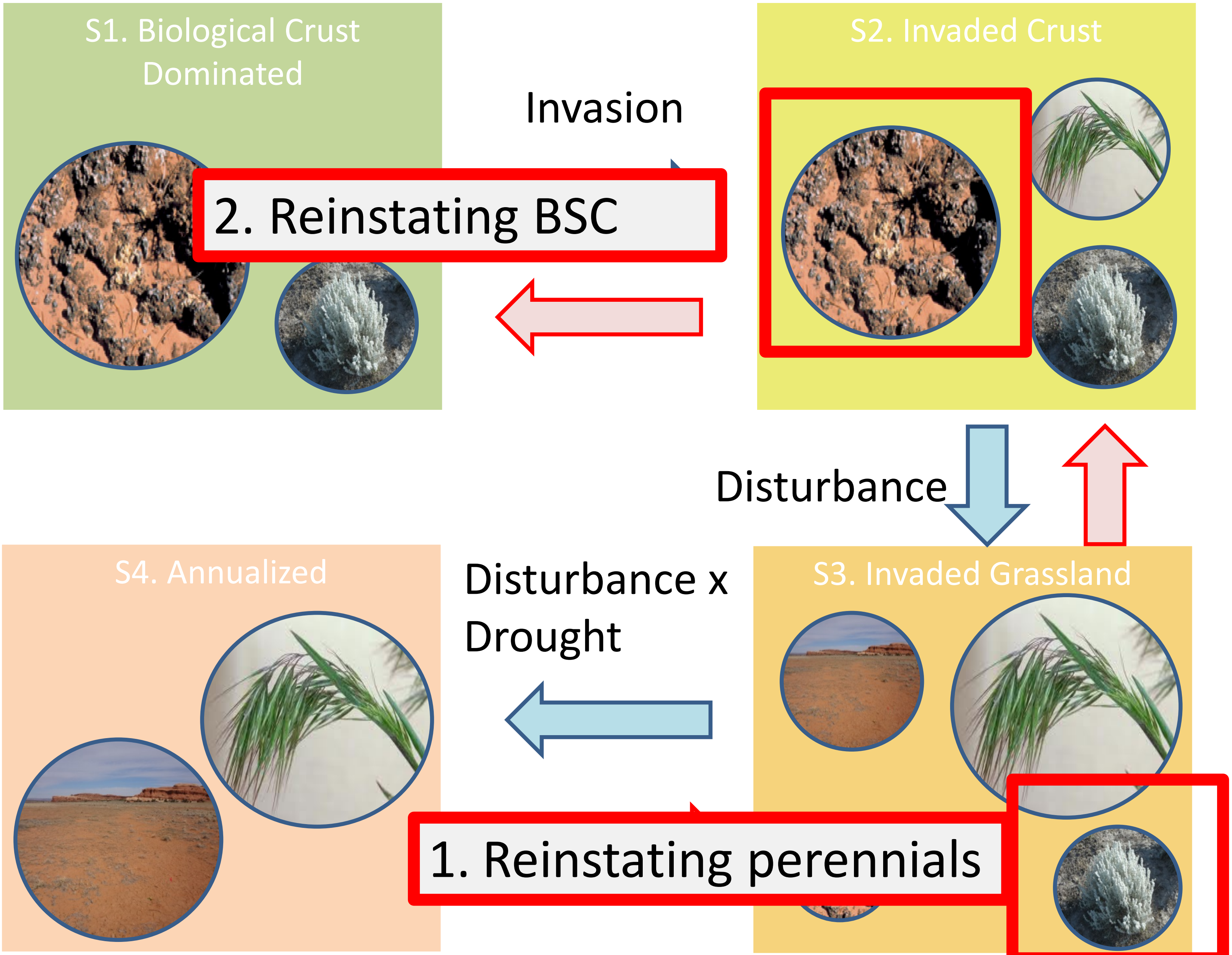
Direct Mitigation Must Alter Ecological State (restoration)



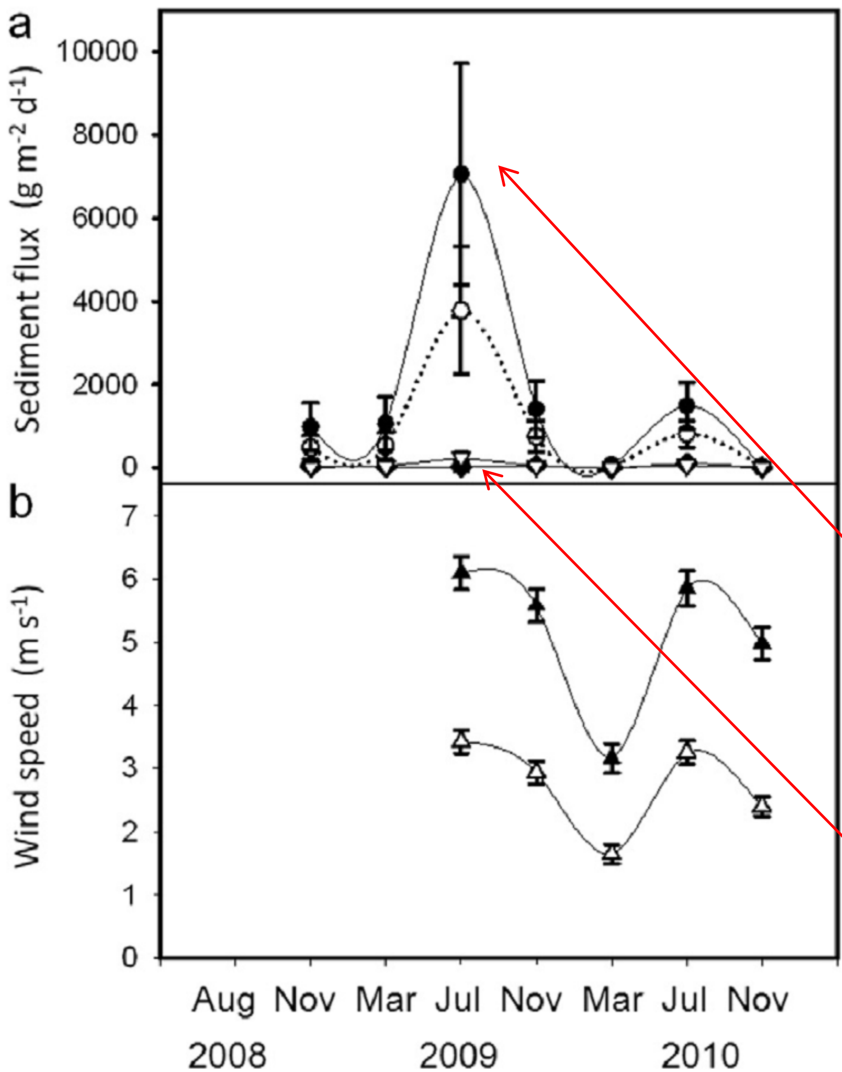
Direct Mitigation must overcome processes maintaining degraded states (restoration)

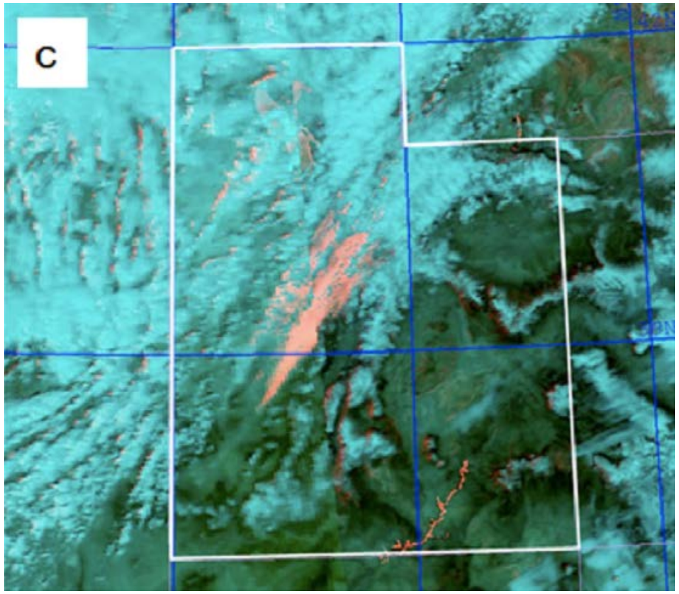


Direct Mitigation must overcome processes maintaining degraded states (restoration)



Soil disturbance + planting : a Cautionary tale





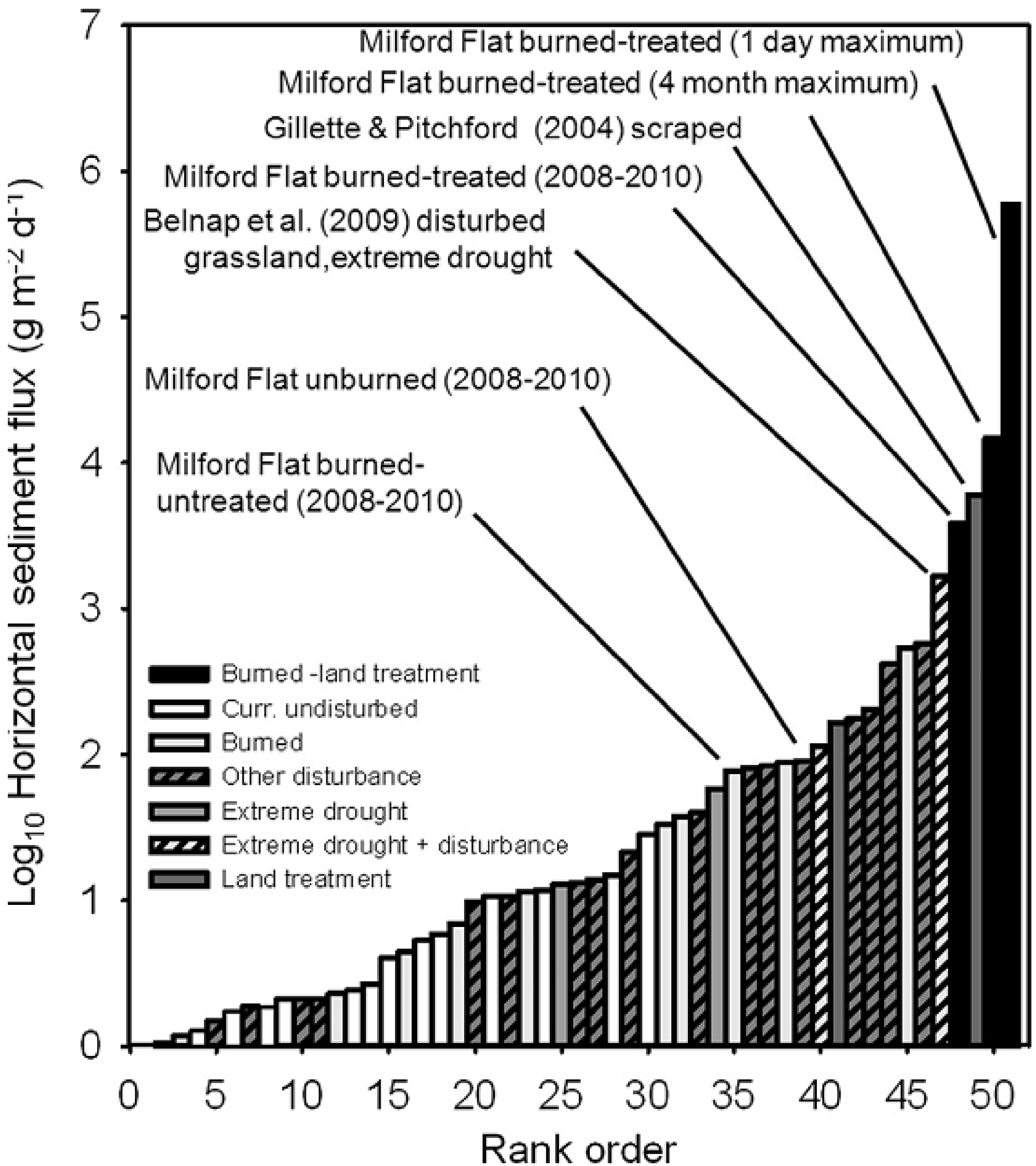
Treated with seeding, chaining, rangeland drill

Burned, untreated

http://rtec.rangelands.org

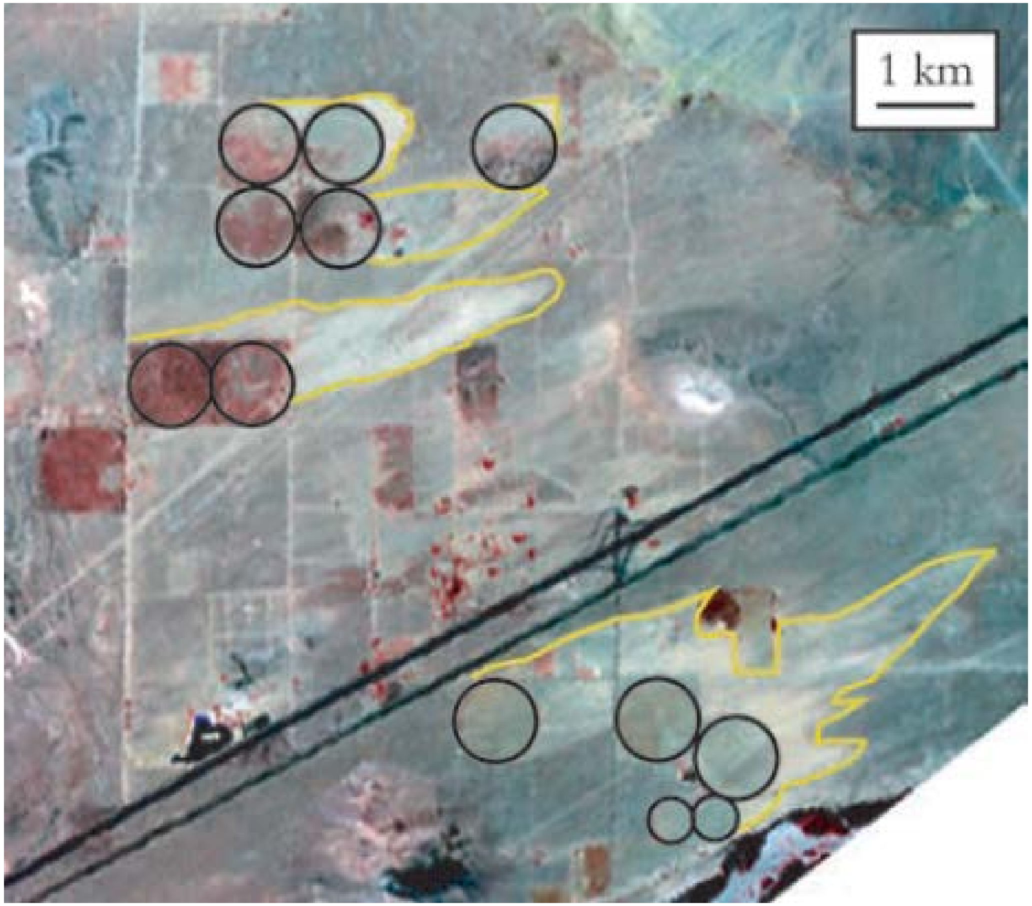
Miller et al. 2012

Observed sediment flux among the highest published

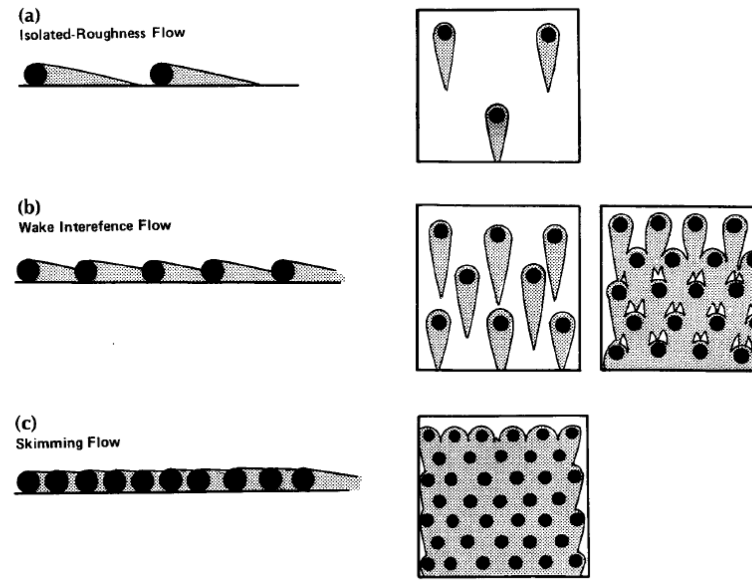


orizontal sediment flux in western North America on a logarithmic scale. Data and sources are tabulated in Appendix 3

Working Hypothesis: Spatial Connectivity perpetuates degradation



Okin et al. 2009



What maintains the degradation syndrome?

- Spatial *Contagion* between degraded patches

  Aka “connectivity”

  – Loss of Seeds

  – Loss of “Safe-Sites”

  – Loss of Coarse / Organic “A” horizon to act as mulch

  – Harsh abiotic conditions (sand scouring, higher evaporation and temperature)

- Biotic factors

  – Weed competition

What can we do to reverse the degradation syndrome?

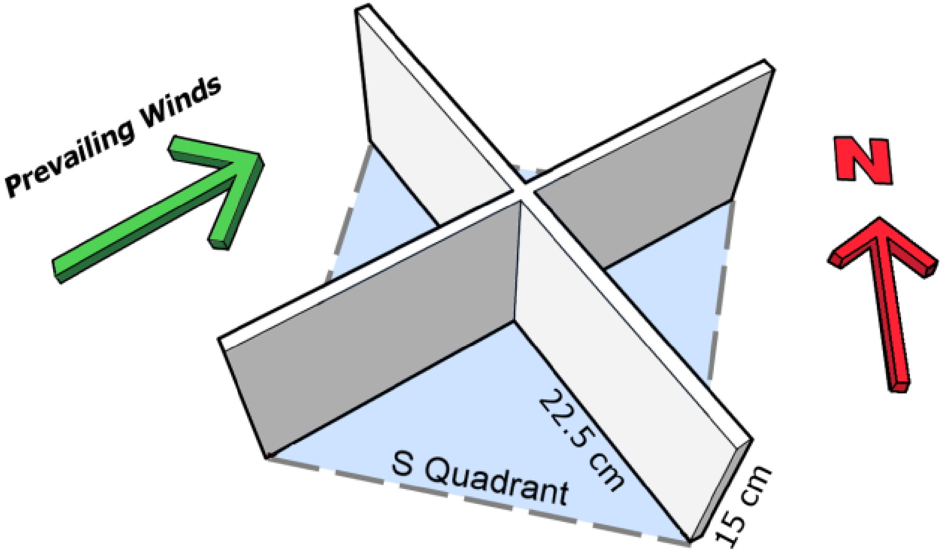
- Spatial *Contagion* between degraded patches

  Aka "connectivity" : Create barriers to overland flow

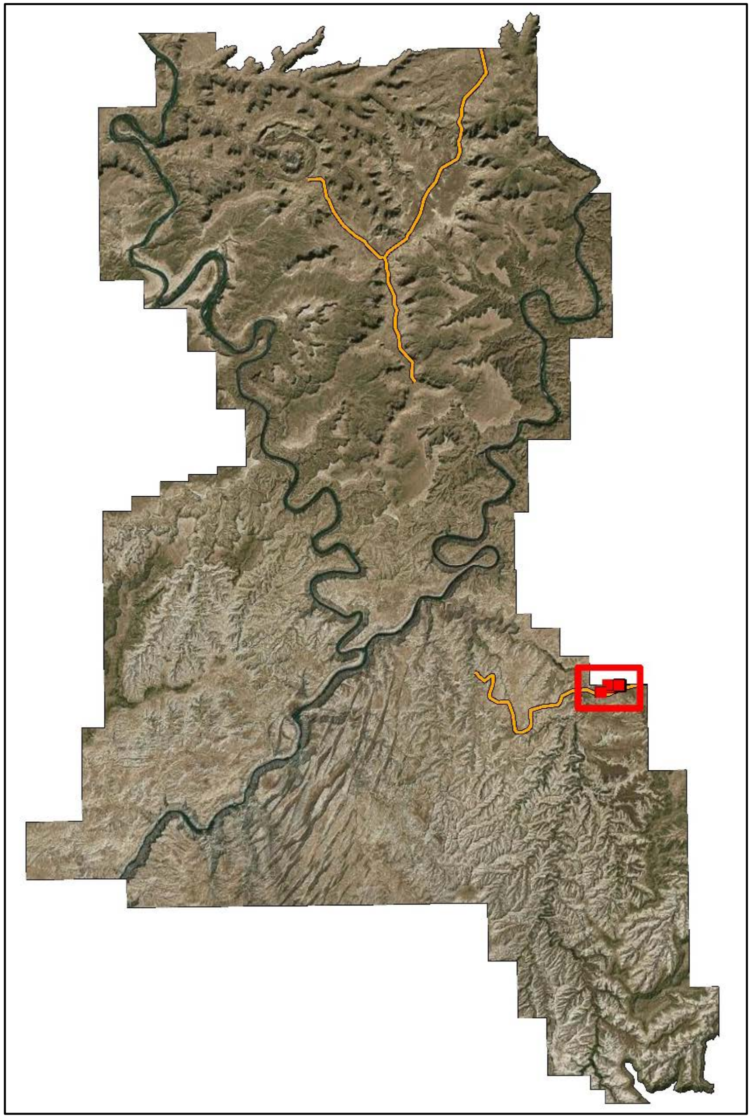
  - Loss of Seeds Add Seeds
  - Loss of "Safe-Sites" Rake Seeds into Soil
  - Loss of Coarse / Organic "A" horizon to act as mulch
  - Harsh abiotic conditions (sand scouring, higher evaporation and temperature)
- Biotic factors
  - Weed competition Weed Control

Barrier Structures

"Con-Mods"



Grassland Restoration – I. Pilot Study 2012-2016



Three crossed experimental factors:

1. Seeding dropseed (*Sporobolus* spp.)

2. Raking soil surface

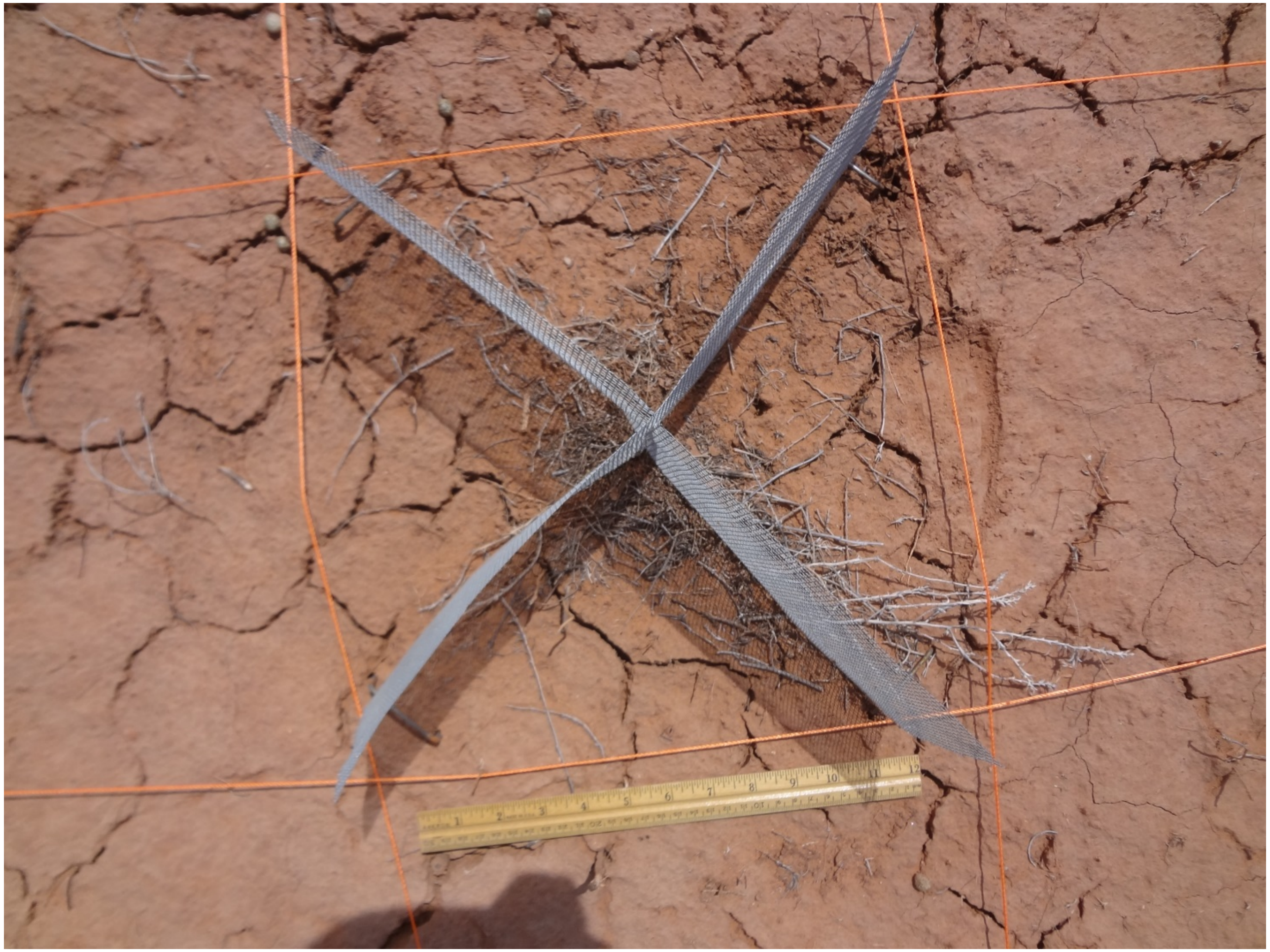
3. ConMod barrier

X 10 blocks

0.1 m^2 plots
Response: Density of all species in plots

Fick et al. 2016. Ecosphere

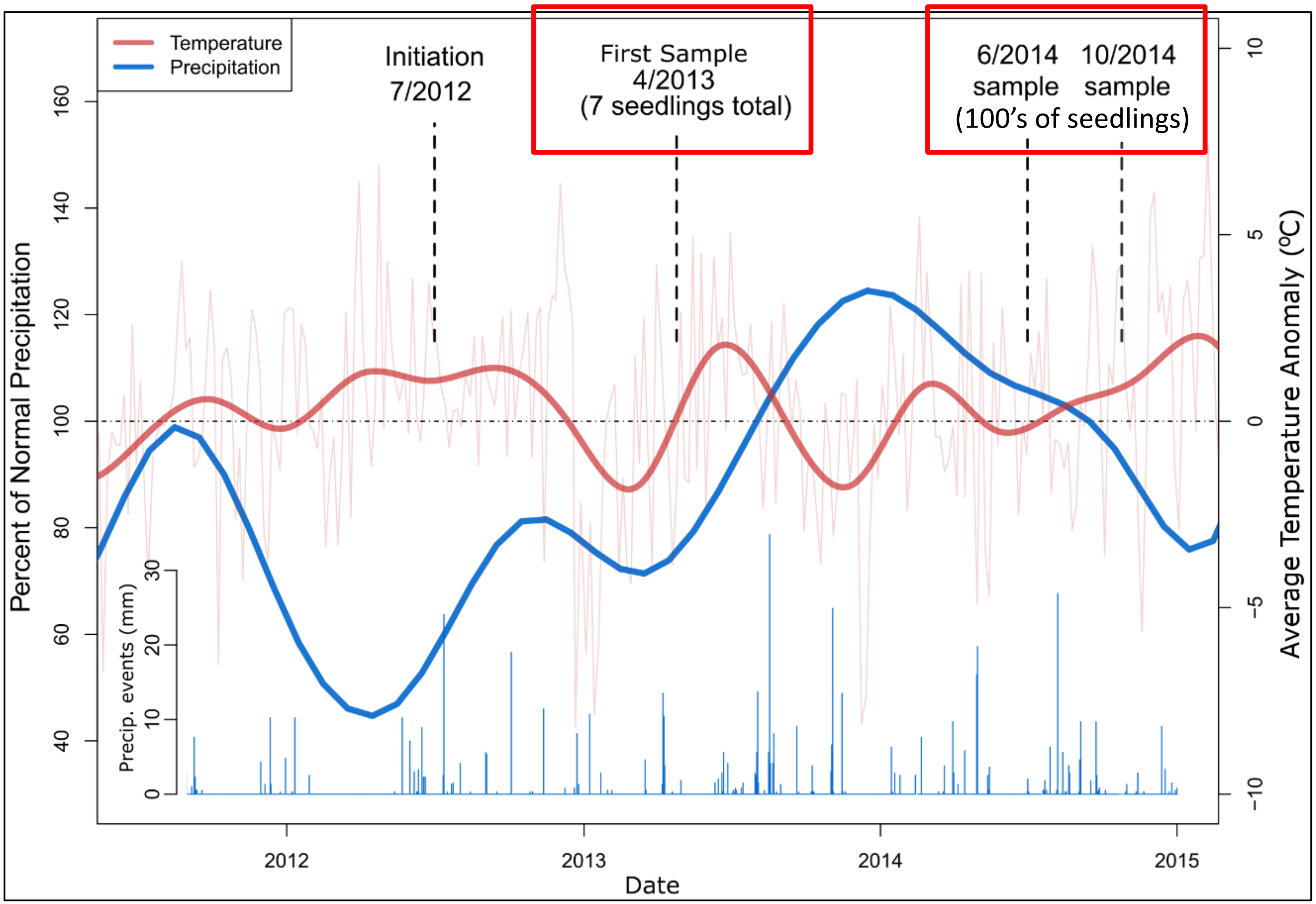
Results – 1 year later



7 Dropseed seedlings… Total!!

Debris Accumulation Occurring

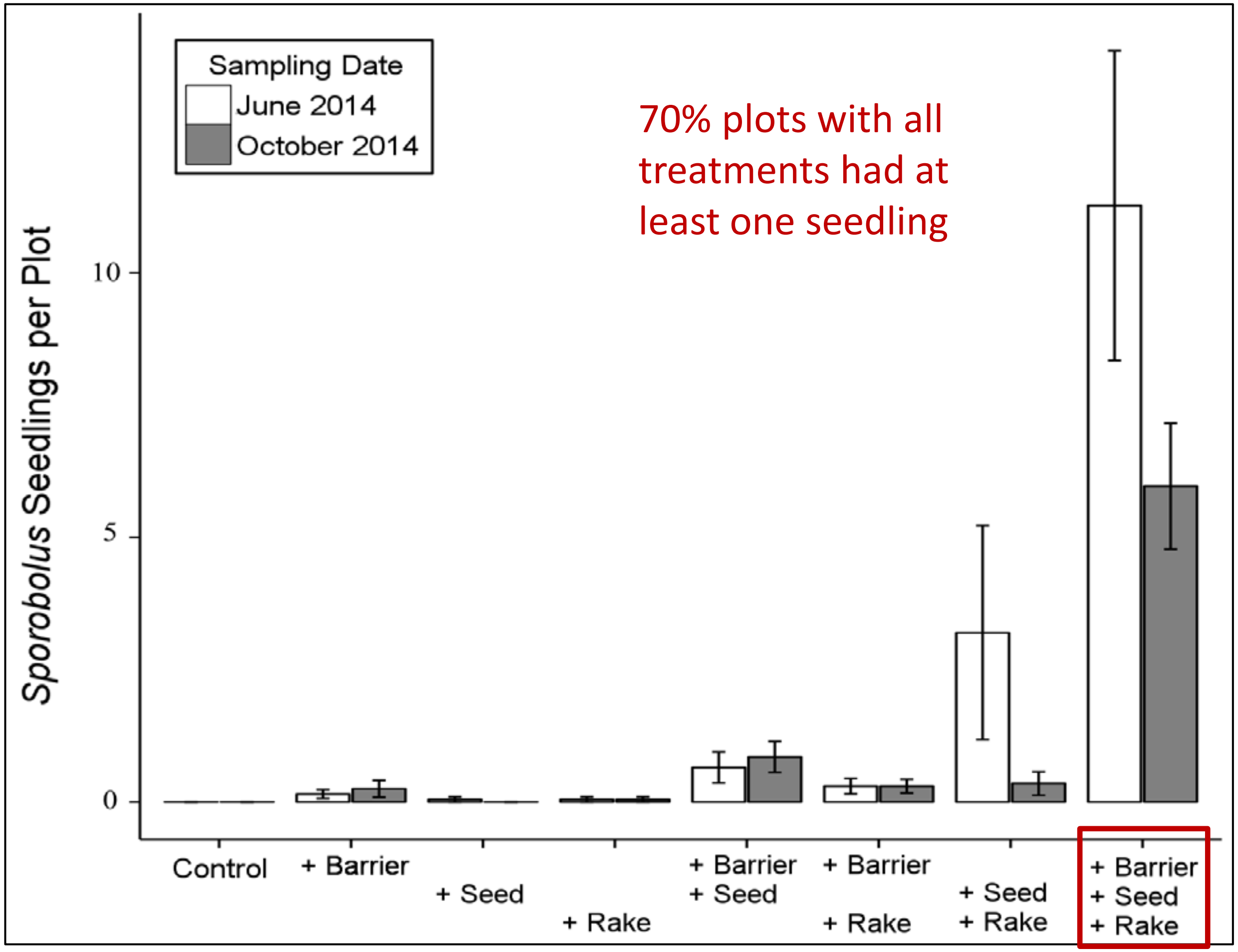
Grassland Restoration – I. Pilot Study 2012-2016



Fick et al. 2016. Ecosphere

Grassland Restoration – I. Pilot Study 2012-2016

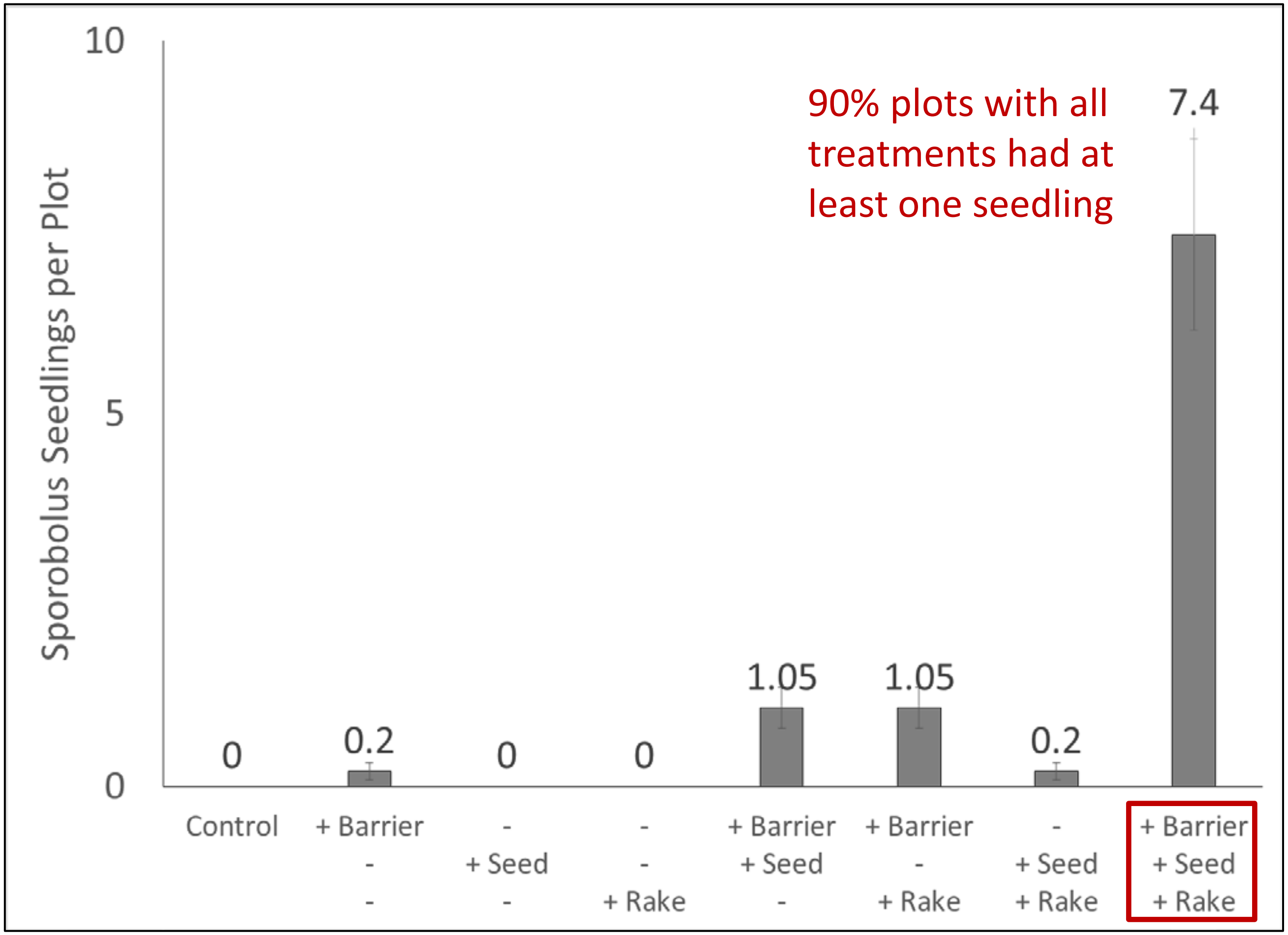
2014 Establishment



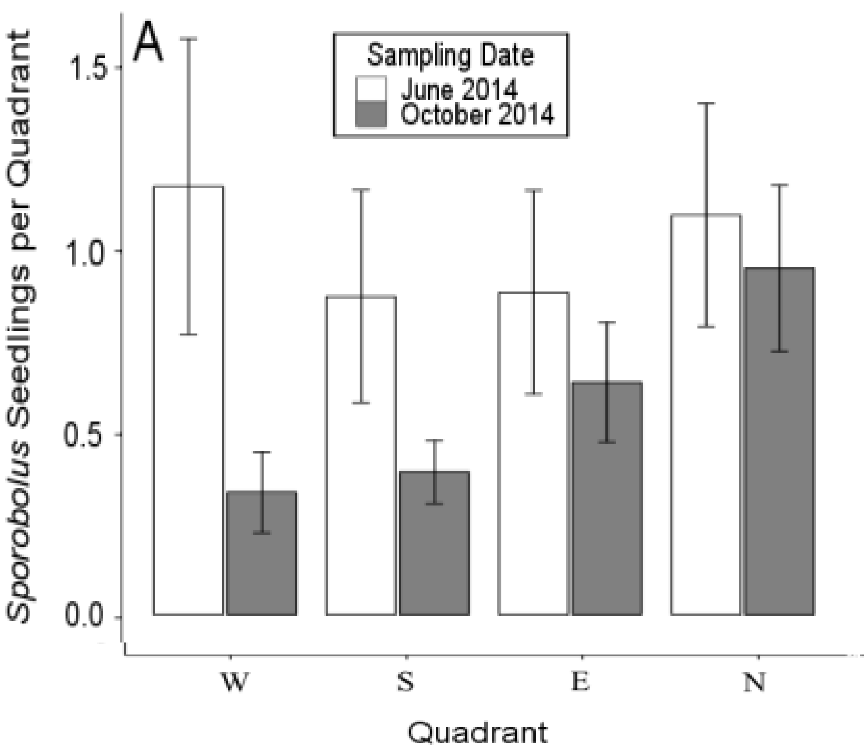
Fick et al. 2016. Ecosphere

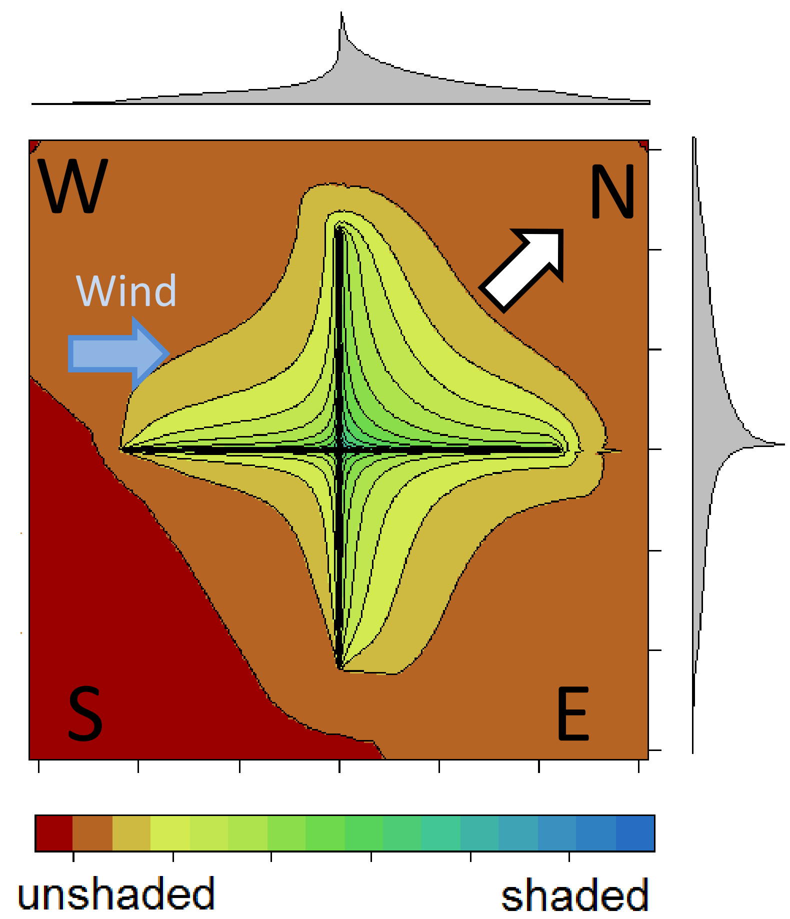
Grassland Restoration – I. Pilot Study 2012-2016

2016 Establishment



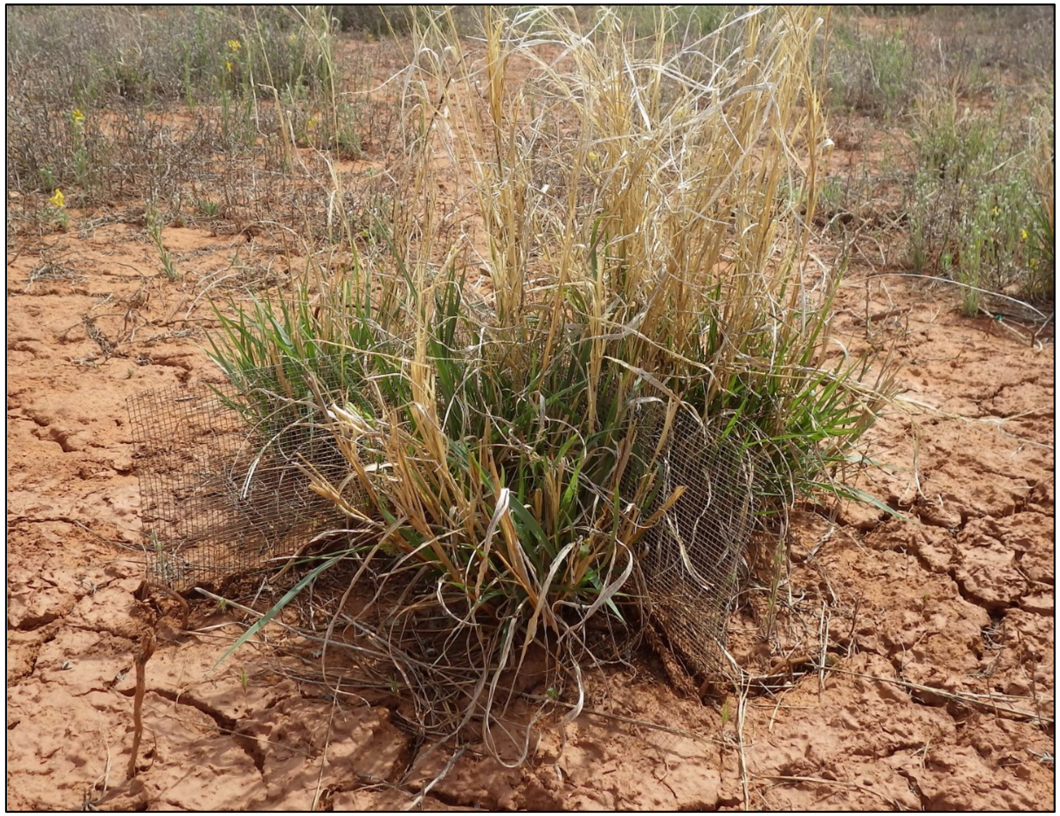
Mechanisms underlying effect of barrier structures





Grassland Restoration – I. Pilot Study 2012-2016

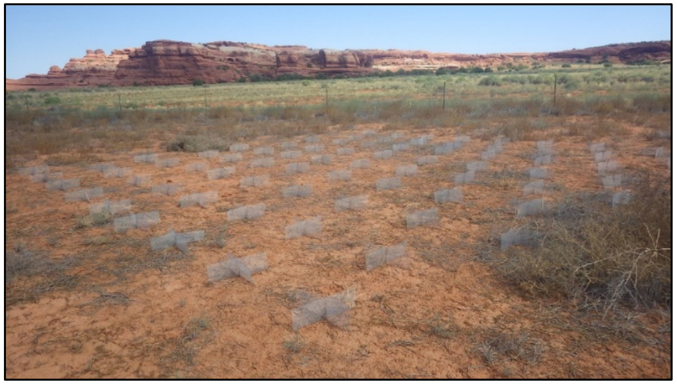
2016 Establishment



It worked!

(at the small scale)

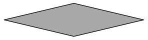
Scaling up: How close together should the ConMod plots be?



4 study areas (3 in CANY, 1 in ARCH)

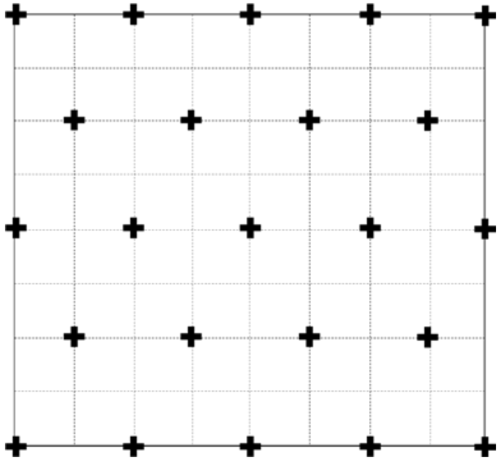
3 Density Levels + Control

8 m x 8 m "patches"

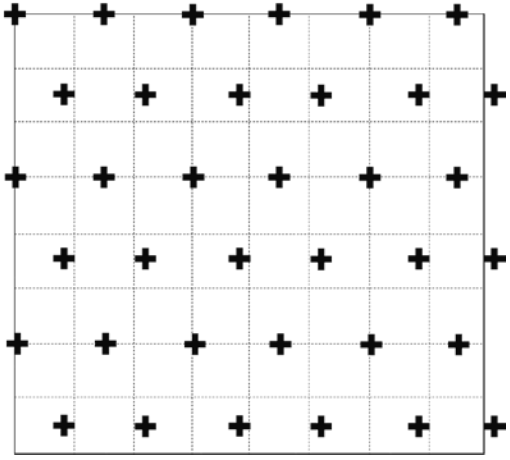


Establishment <u>in & between</u> ConMods

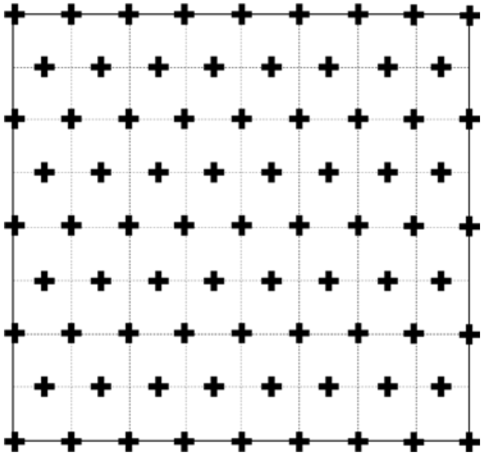
Low density
2m spacing



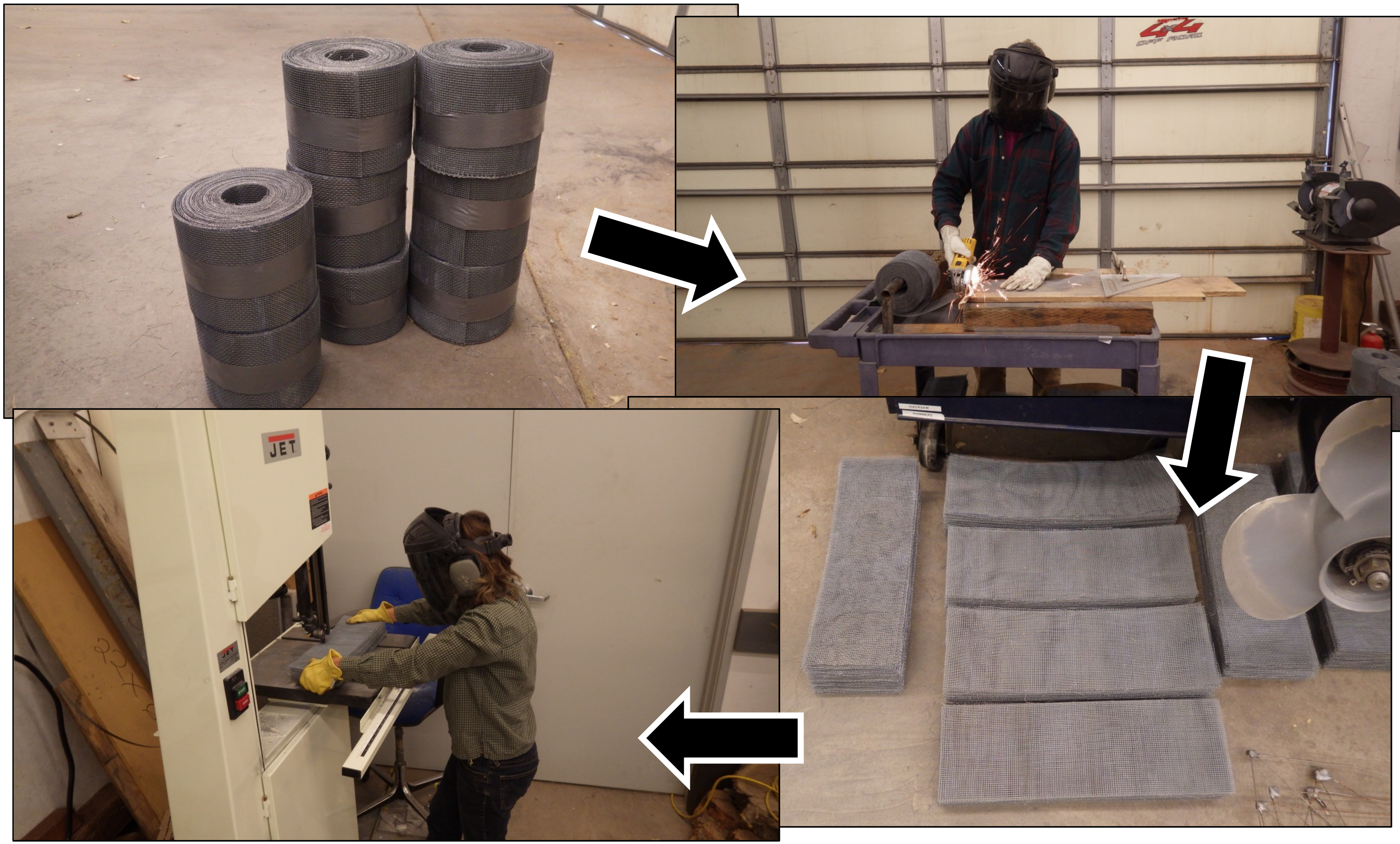
Medium density
1.5m spacing



High density
1m spacing

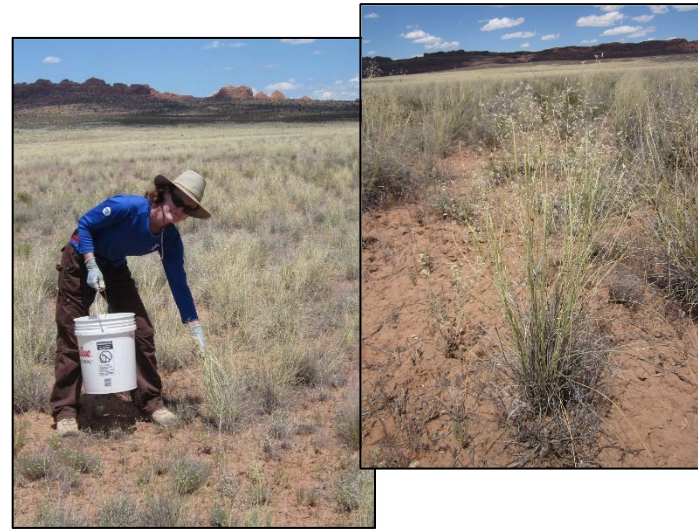


Grassland Restoration – III. Implementation

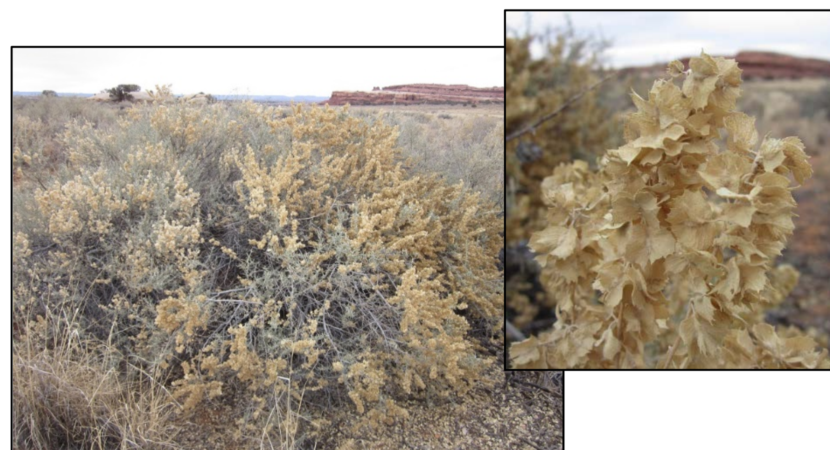


Grassland Restoration – III. Implementation

dropseed



Indian ricegrass



Fourwing saltbush

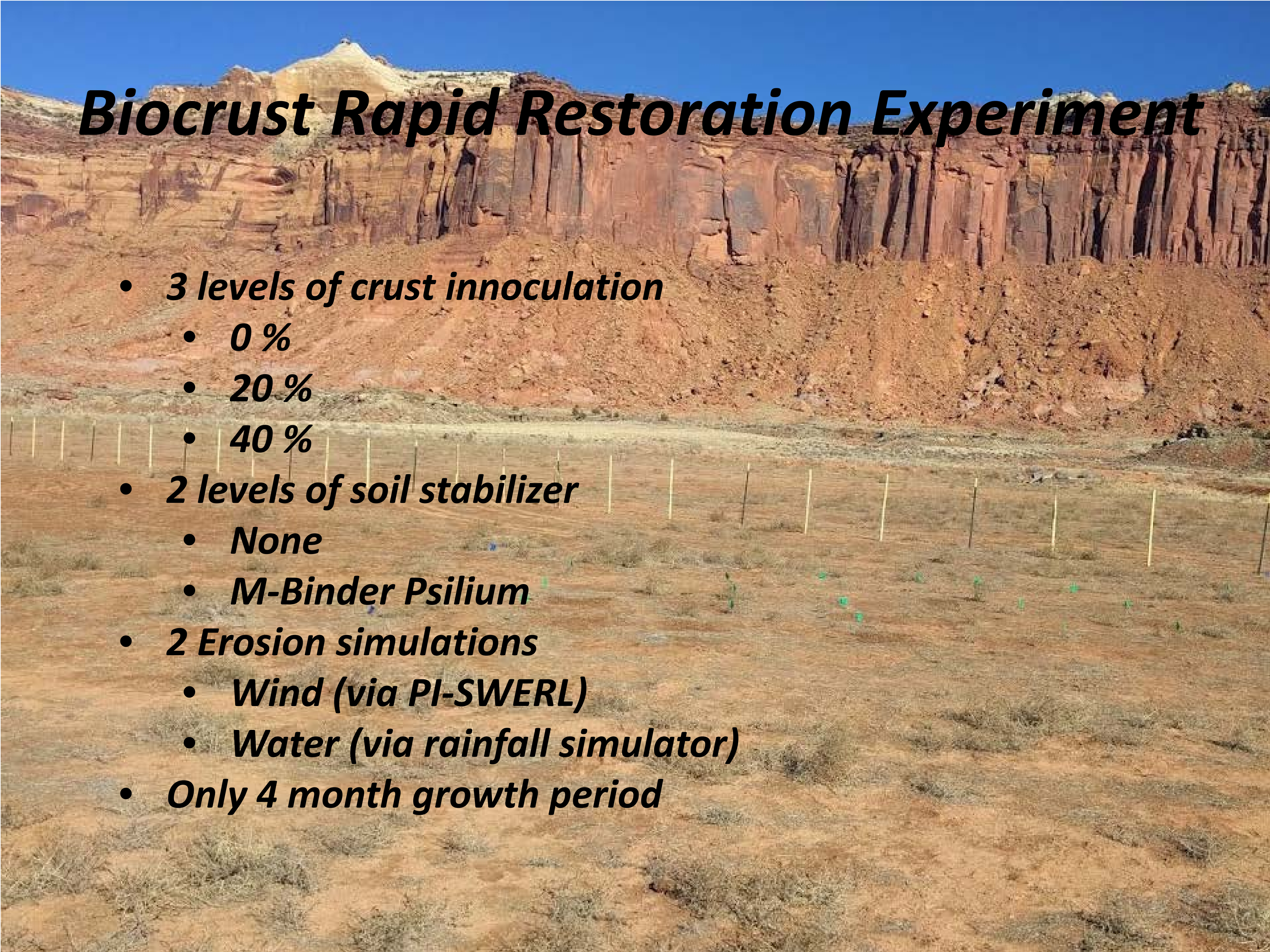
Grassland Restoration – III. Implementation

Canyon Country Youth Corps, Sept. 2016

Seeding *Sporobolus* spp. (dropseed grass) &
Achnatherum hymenoides (Indian ricegrass)

Grassland Restoration – Comparison or Approaches

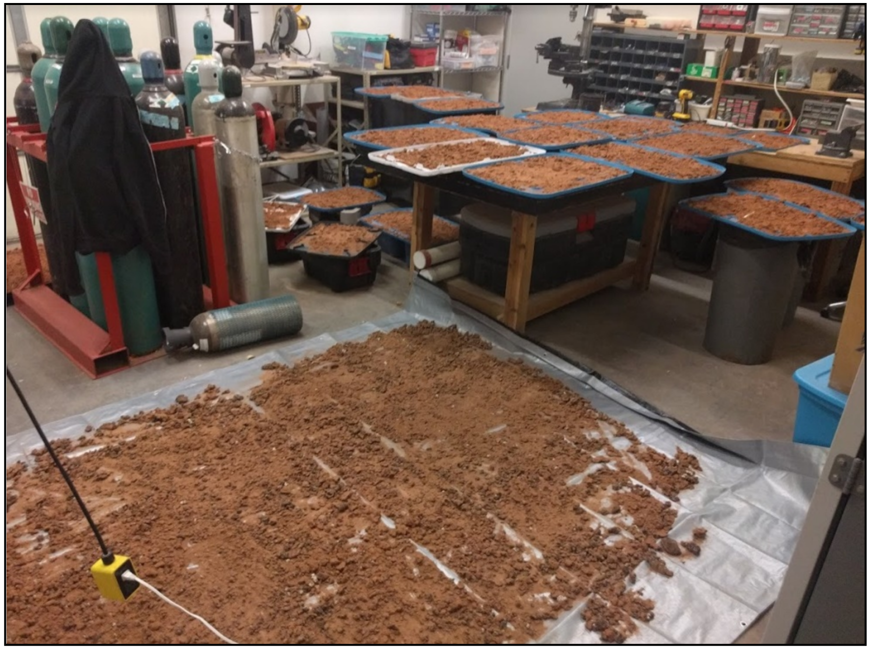
	Traditional **Drill seed**	*Process Oriented* **ConMods**
Erosion Risk	High	Low
Establishment	depends on the weather	waits for the weather
$/acre - labor	<$100s	$2,400
Climate	Subhumid, humid climates	Semi-arid & arid climates
Application	Large scale areas 1,000's of acres	Small, high value areas 10-100's of acres



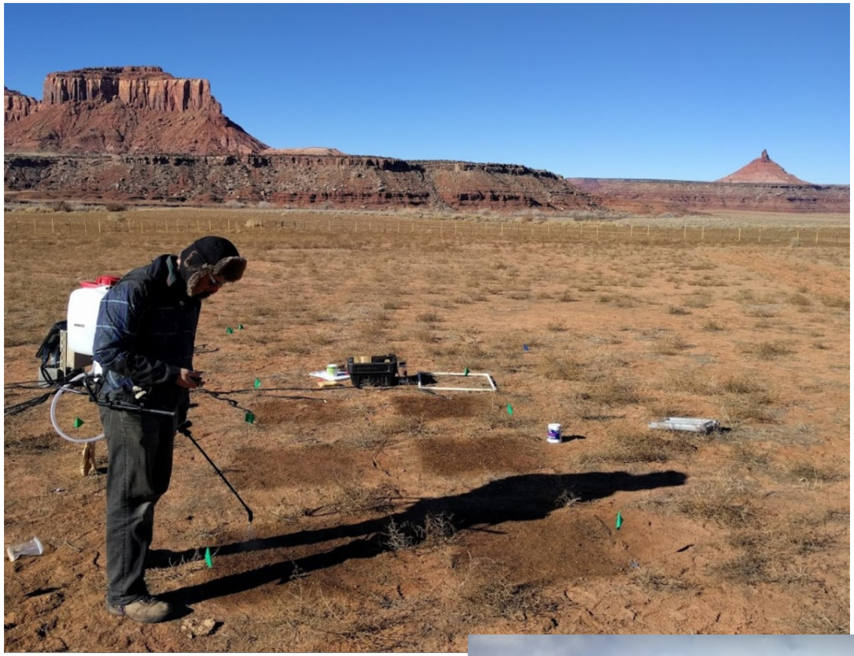
Biocrust Rapid Restoration Experiment

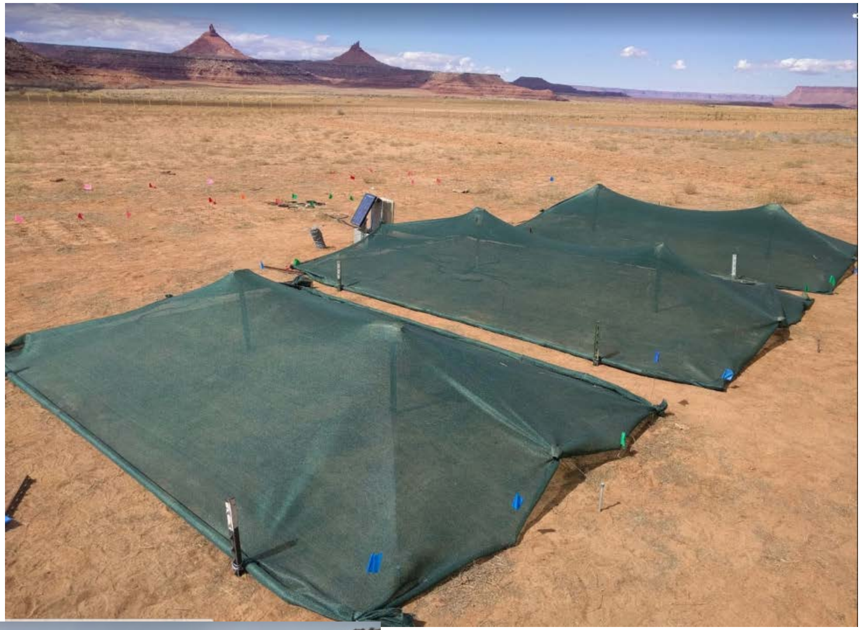
- *3 levels of crust innoculation*
  - *0 %*
  - *20 %*
  - *40 %*
- *2 levels of soil stabilizer*
  - *None*
  - *M-Binder Psilium*
- *2 Erosion simulations*
  - *Wind (via PI-SWERL)*
  - *Water (via rainfall simulator)*
- *Only 4 month growth period*

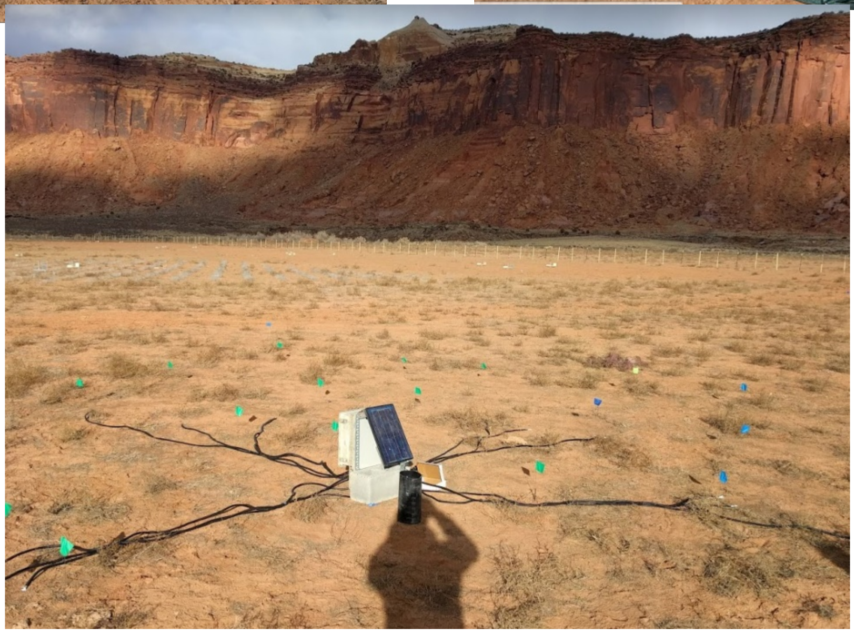
Field collection and processing



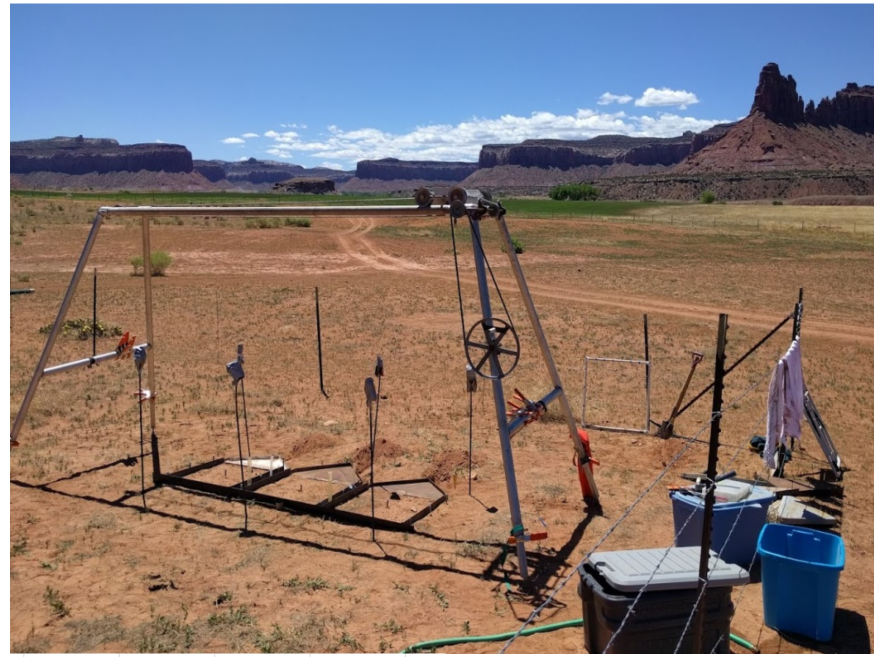
“Crust Farming”

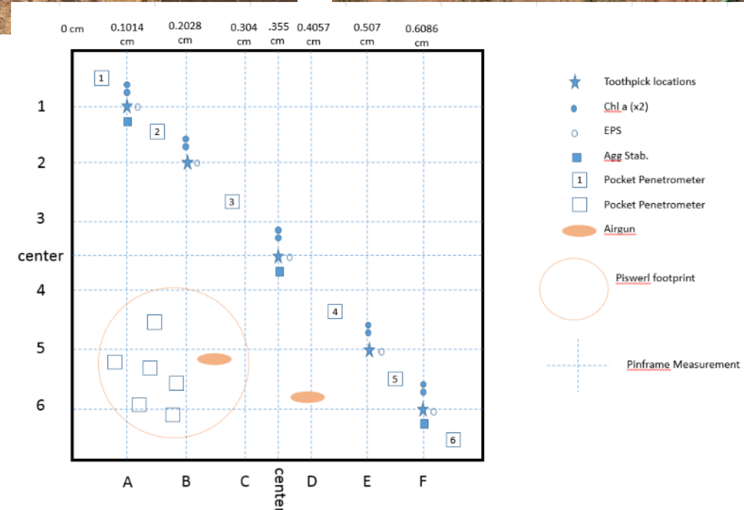


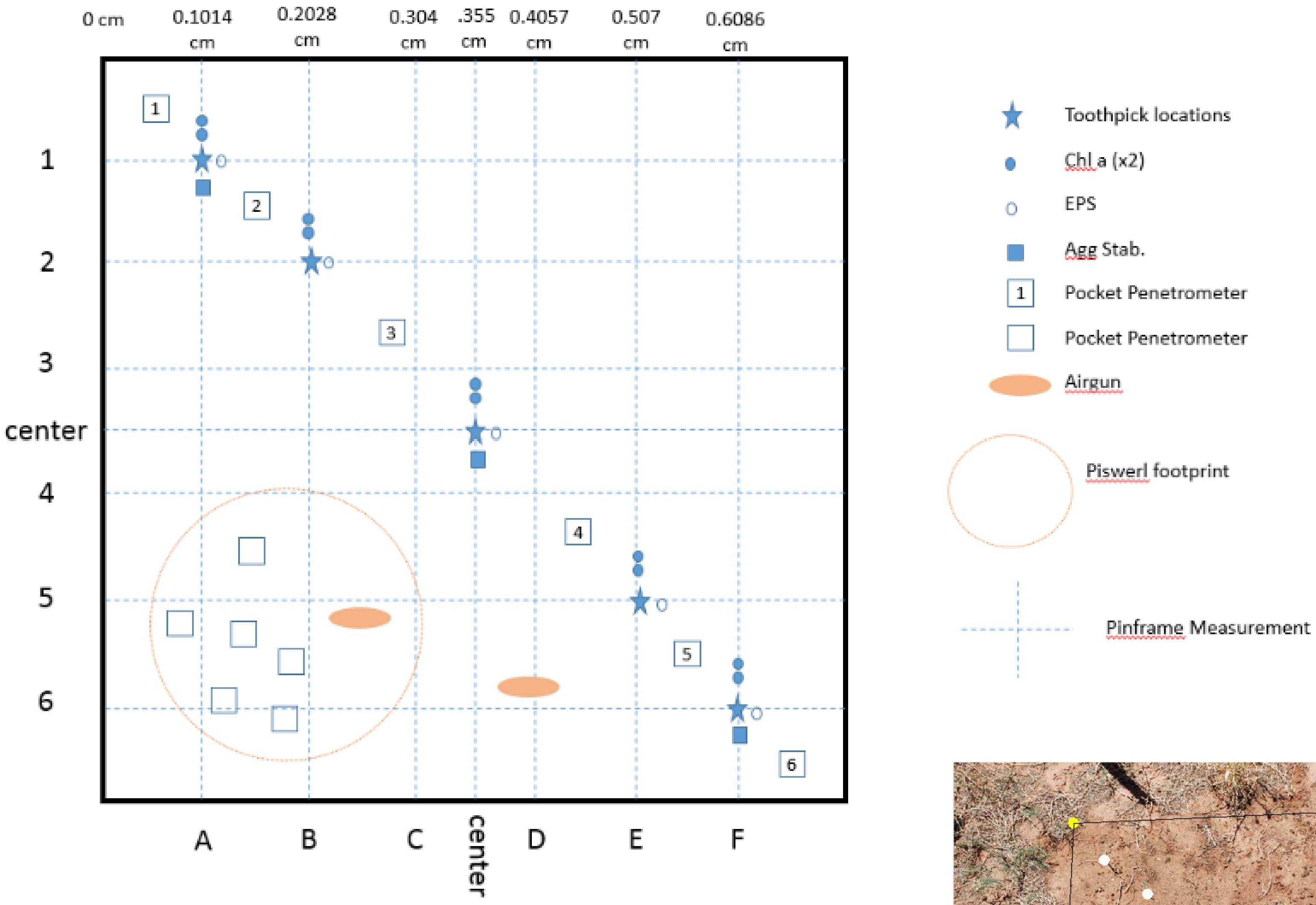




Sampling




0 cm
0.1014 cm
0.2028 cm
0.304 cm
.355 cm
0.4057 cm
0.507 cm
0.6086 cm
1
2
3
center
4
5
6
A
B
C
center
D
E
F
1
2
3
4
5
6
Toothpick locations
Chl a (x2)
EPS
Agg Stab.
Pocket Penetrometer
Pocket Penetrometer
Airgun
Piswerl footprint
Pinframe Measurement



0 cm
0.1014 cm
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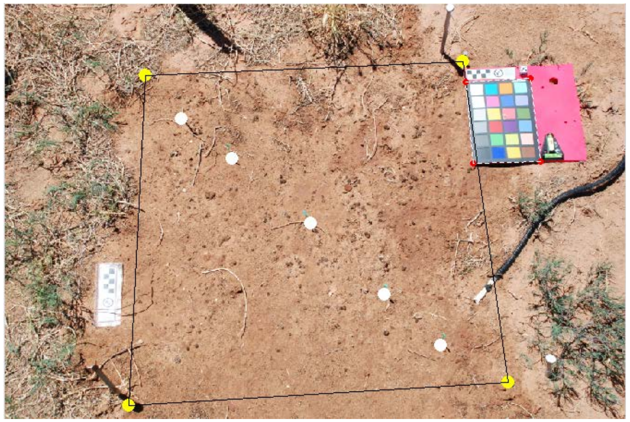
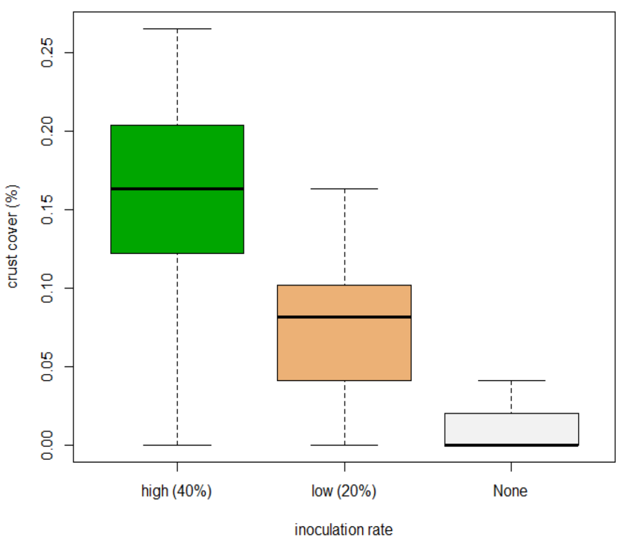
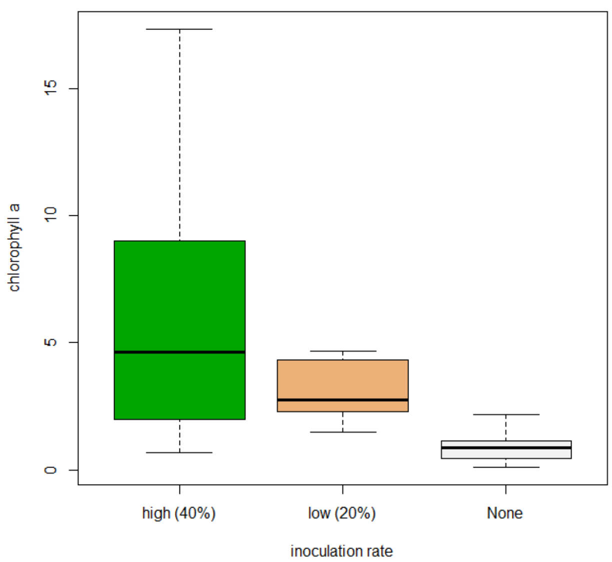
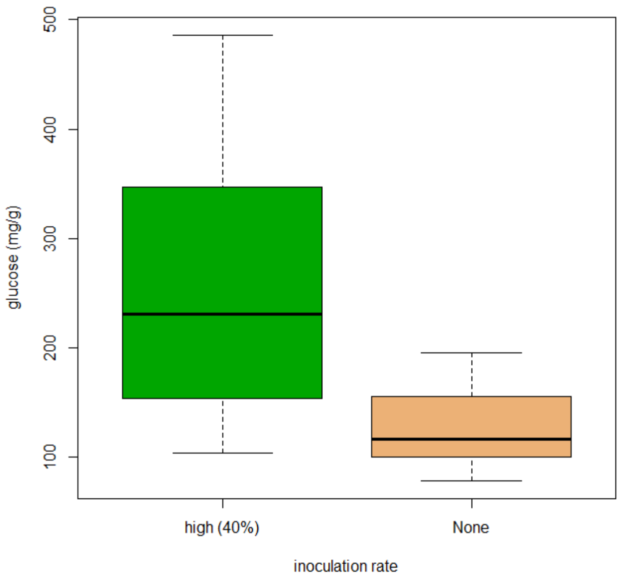


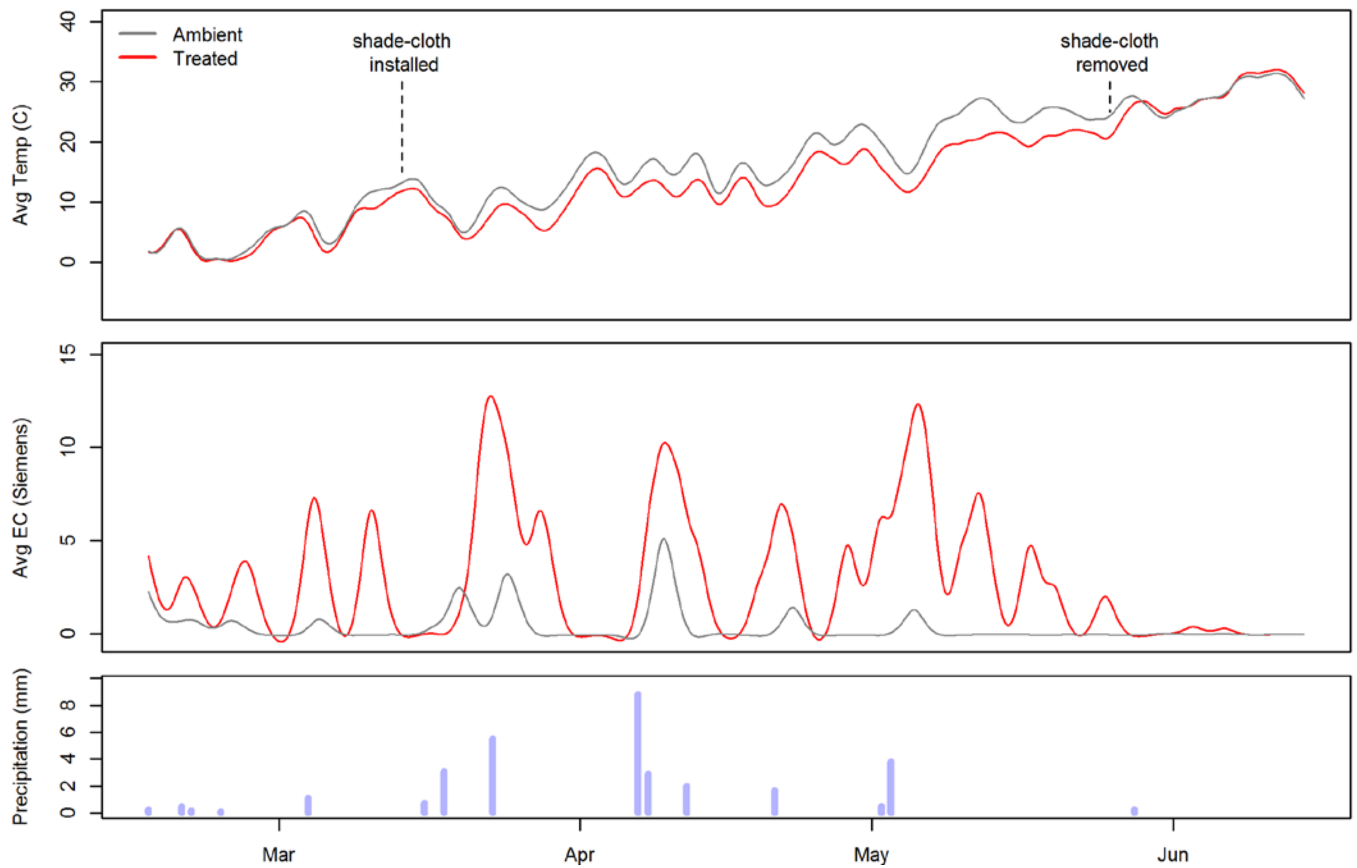
Initial Results – higher chl a and EPS in inoculated plots – inoculation worked!







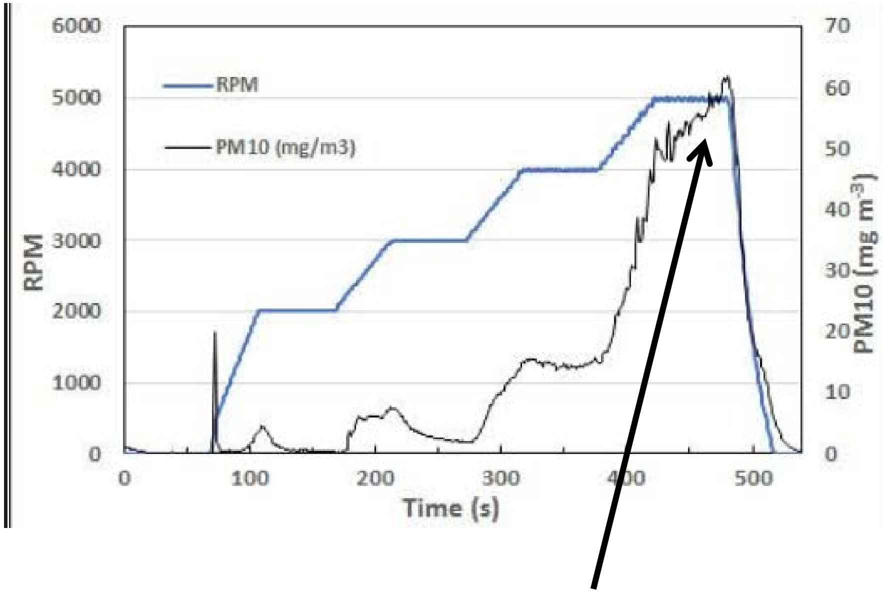
Shading and watering likely important factors



Moist conditions 30% of the time (vs. 7% otherwise)
~ +650 hours of activity

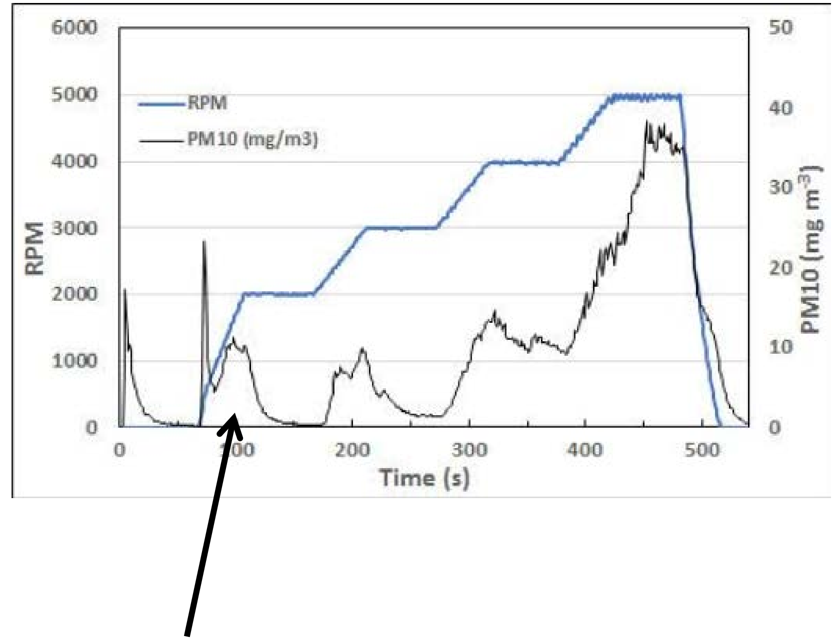
Evidence for higher TFV with crust + tackifier

20% inoc + tackifier



Higher emission at high velocity, due to flaking?

control



More initial emissions @ low friction velocity

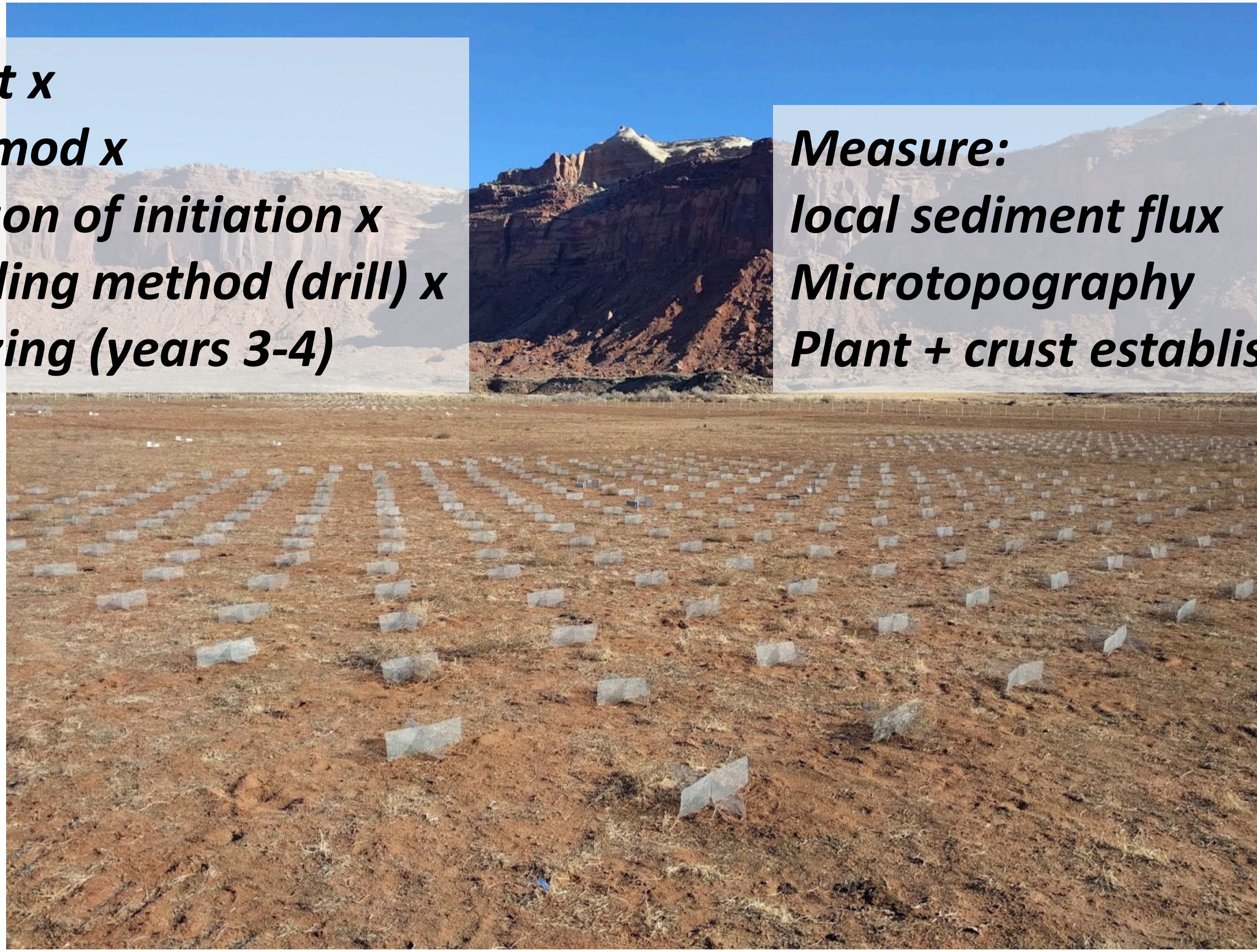
Grassland Restoration – Comparison or Approaches

	Traditional Drill seed	*Process Oriented* ConMods	Rapid Biocrust
Erosion Risk	High	Low	low
Establishment	depends on the weather	waits for the weather	Makes the weather
$/acre - labor	<$100s	$2,400	← More than this
Climate	Subhumid, humid climates	Semi-arid & arid climates	Semi-arid & arid
Application	Large scale areas 1,000's of acres	Small, high value areas 10-100's of acres	Very small, high value areas 1- 10's of acres

Ongoing experiments examining interactions at large scales

Crust x
Conmod x
Season of initiation x
Seeding method (drill) x
Grazing (years 3-4)

Measure:
local sediment flux
Microtopography
Plant + crust establishment



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