Identifying Creative Ways to Overcome Constraints to Ecological Restoration

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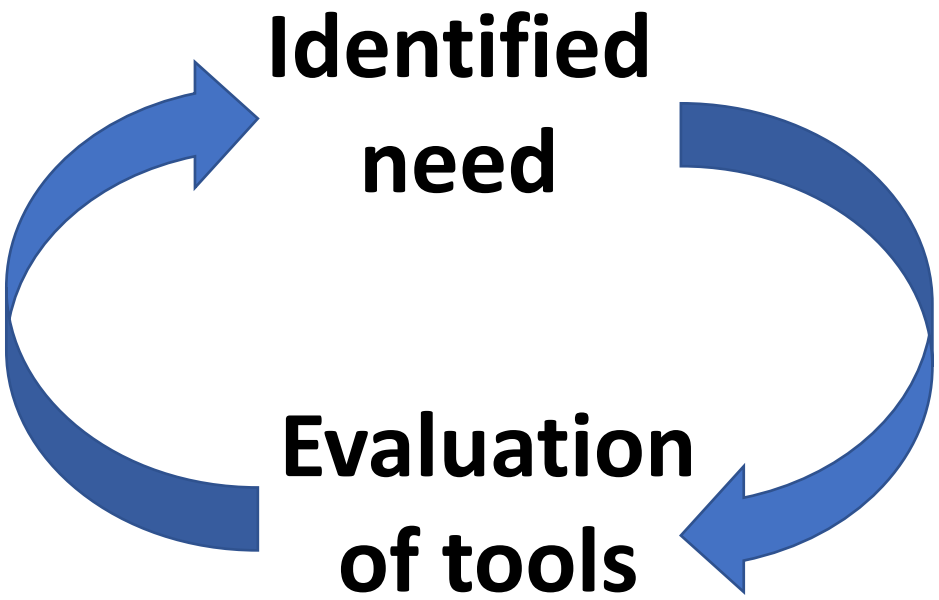
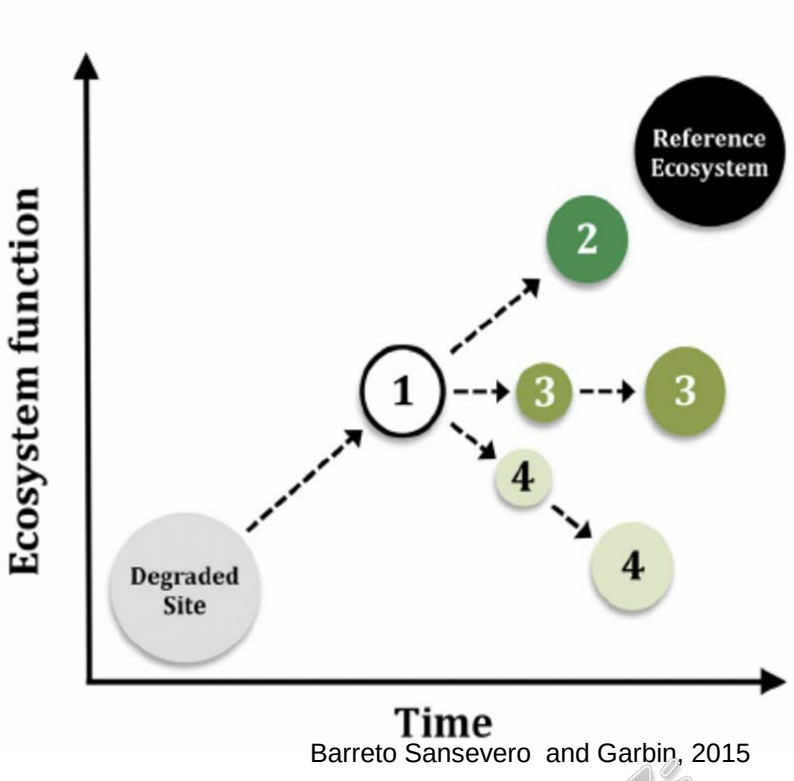
What do we as a research group spend -*a fair amount of*- our time thinking about in ecological restoration?



Identify novel and creative <u>actions</u> to overcome barriers to ecological restoration success

Ecological Restoration

Restoration Ecology

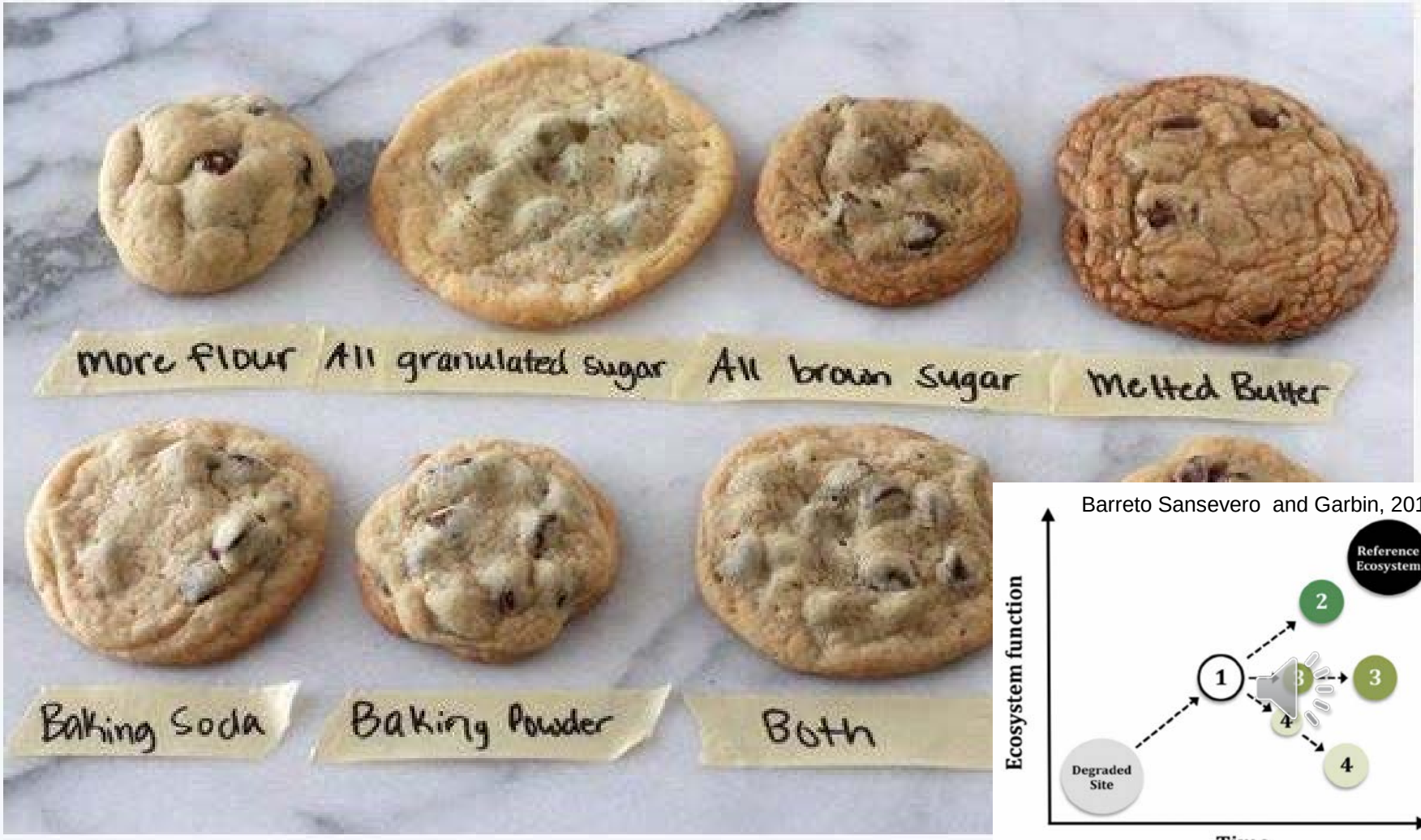


Barreto Sansevero and Garbin, 2015

Actions taken

Create outcomes

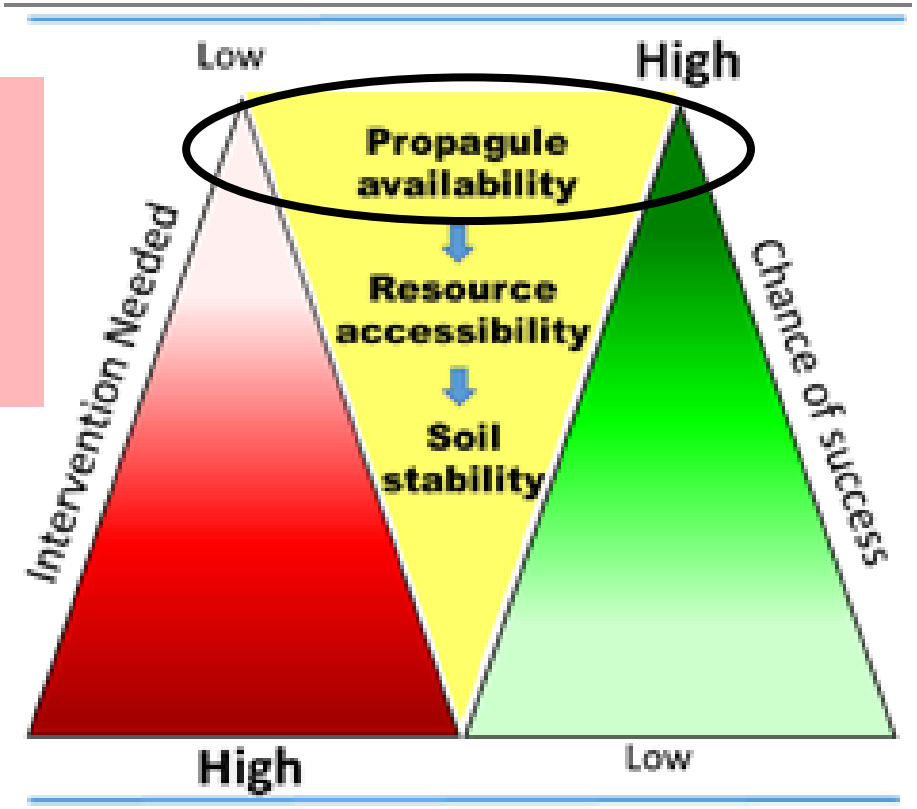
The actions we take can help determine the outcome of the restoration project



Barreto Sansevero and Garbin, 2015

What actions to take?

How much ‘intervention’ is needed?



What are barriers hindering success?

Modified from Bowker 2007

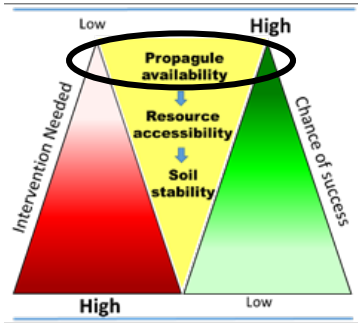
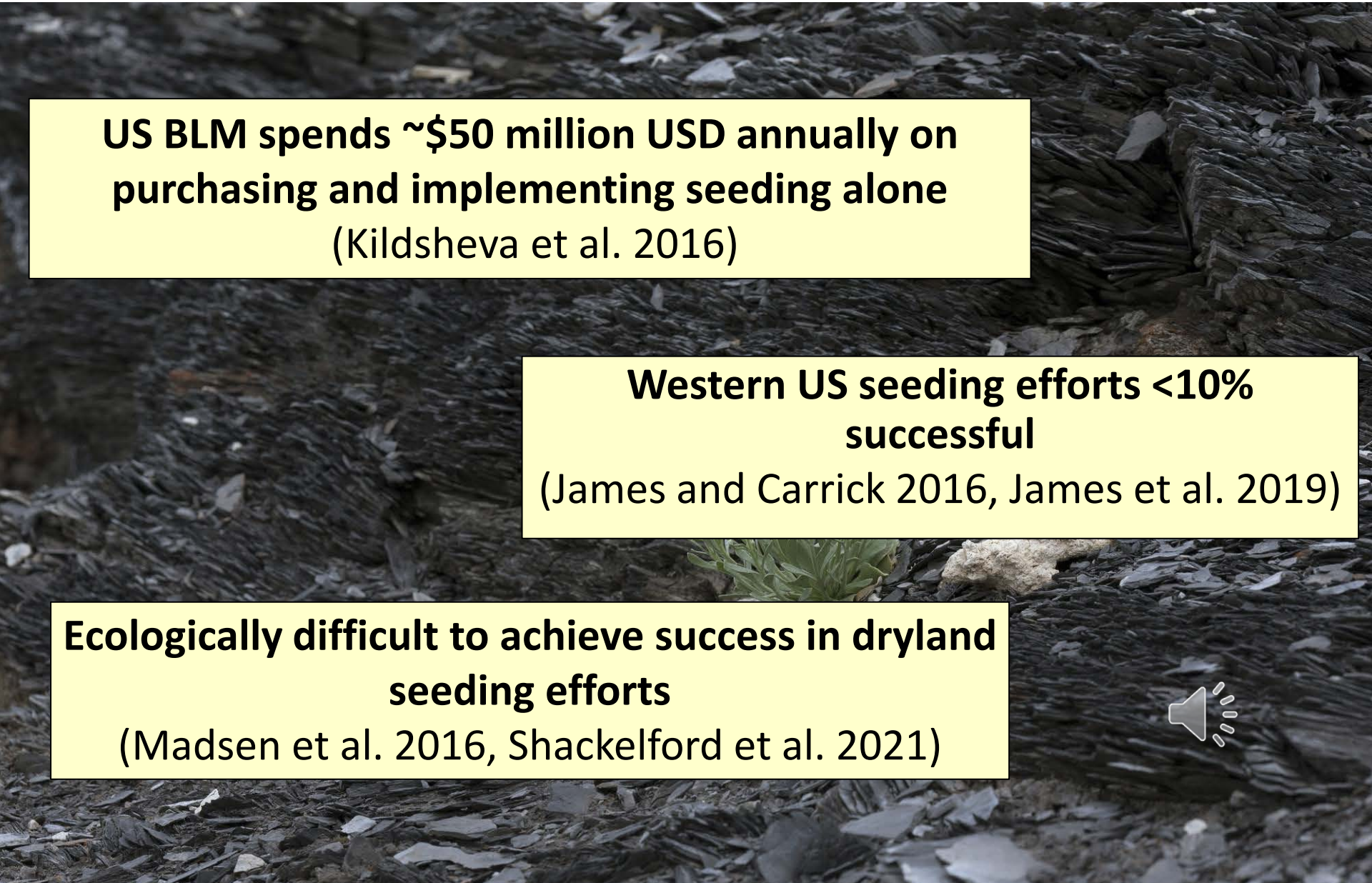


Photo credit: Ellie McCann

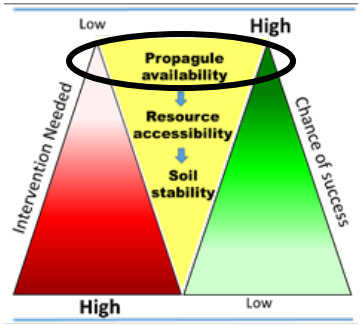
Seed based restoration



US BLM spends ~$50 million USD annually on purchasing and implementing seeding alone
(Kildsheva et al. 2016)

Western US seeding efforts <10% successful
(James and Carrick 2016, James et al. 2019)

Ecologically difficult to achieve success in dryland seeding efforts
(Madsen et al. 2016, Shackelford et al. 2021)

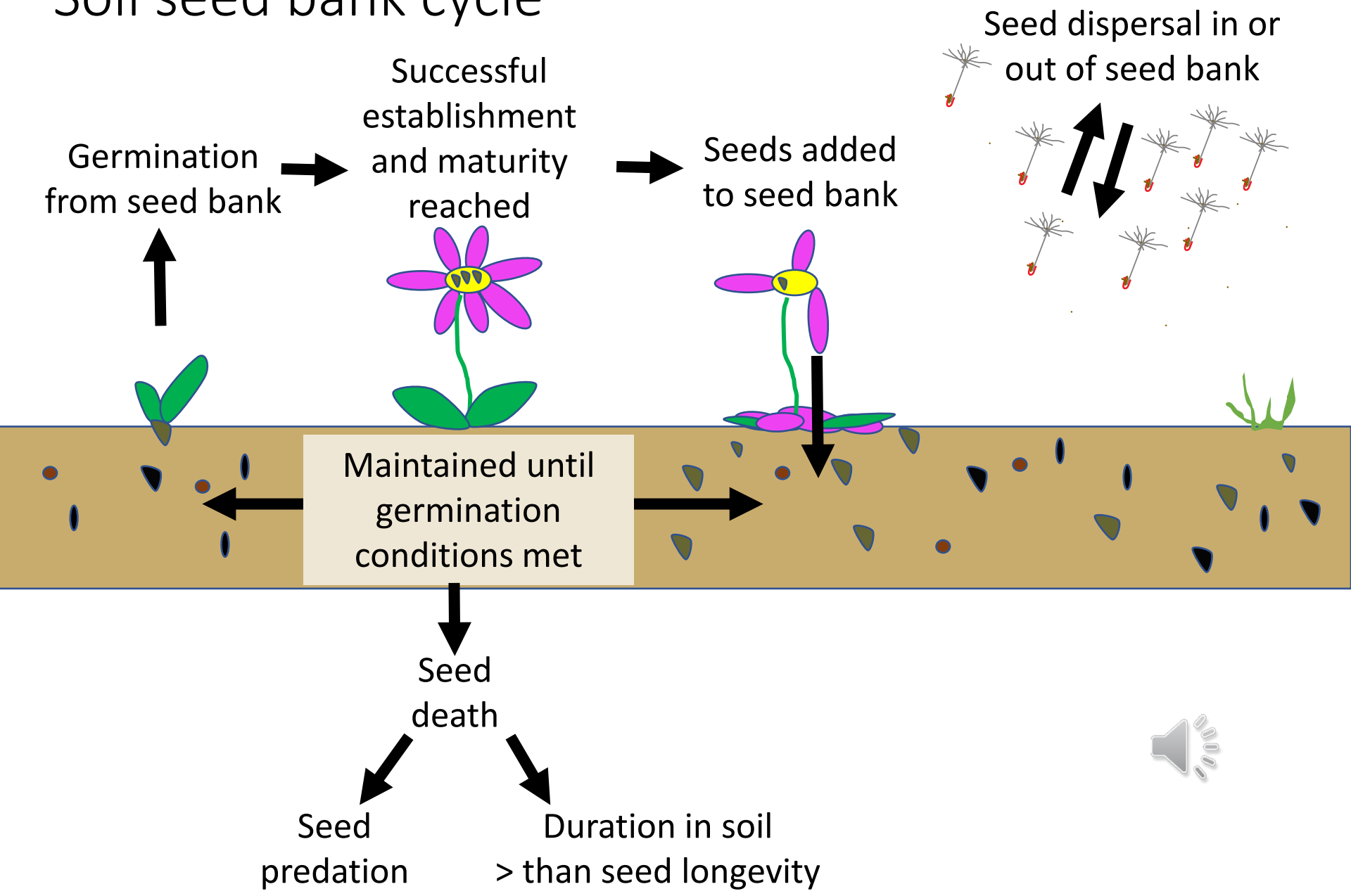


☑Are they already there?

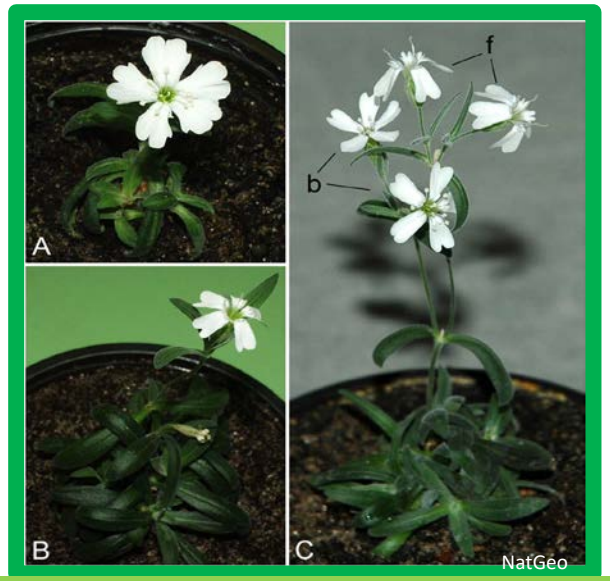
Photo credit: Ellie McCann

Soil seed banks

Soil seed bank cycle



2,000-year-old palms germinated from an extinct species!



32,000-year-old seeds found in squirrel cache in permafrost!

Common Mullein seeds can live >200 years in the soil.

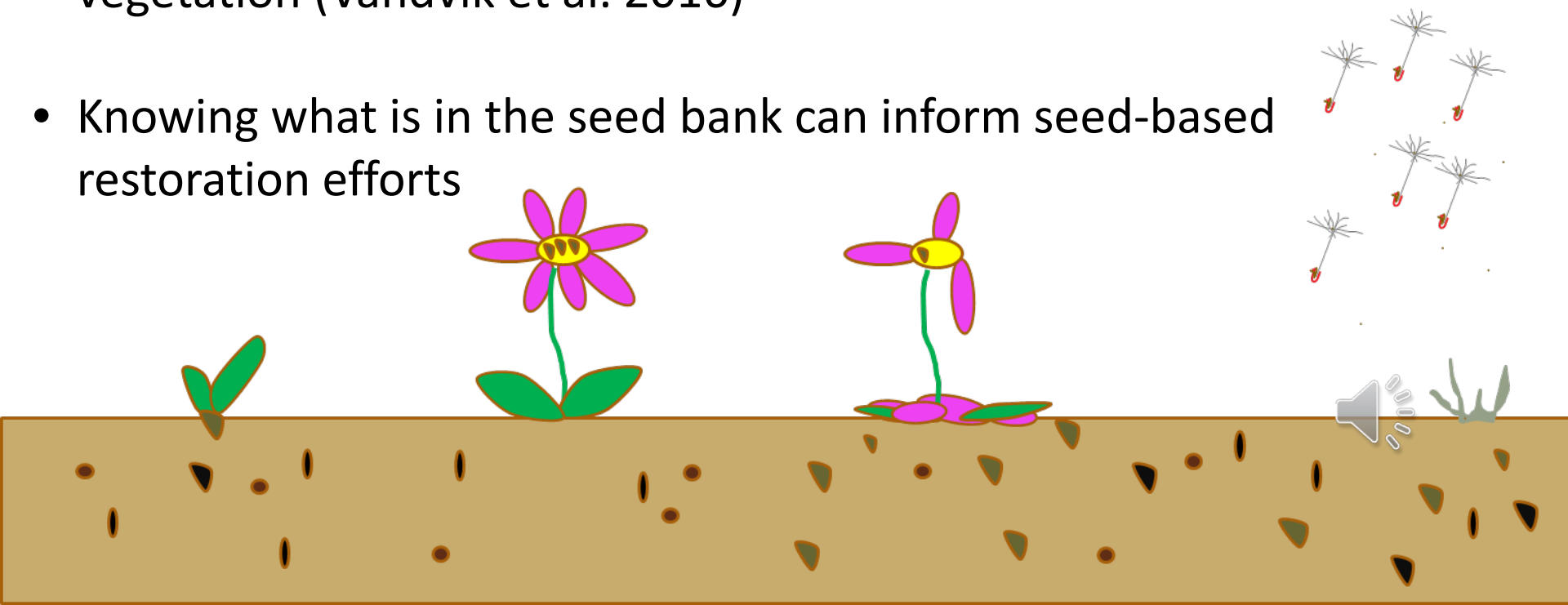
Super Blooms!

California's 2023 superbloom https://www.afar.com/magazine/how-to-see-californias-superbloom

Photo credit: C. Decker

Soil seed banks in restoration

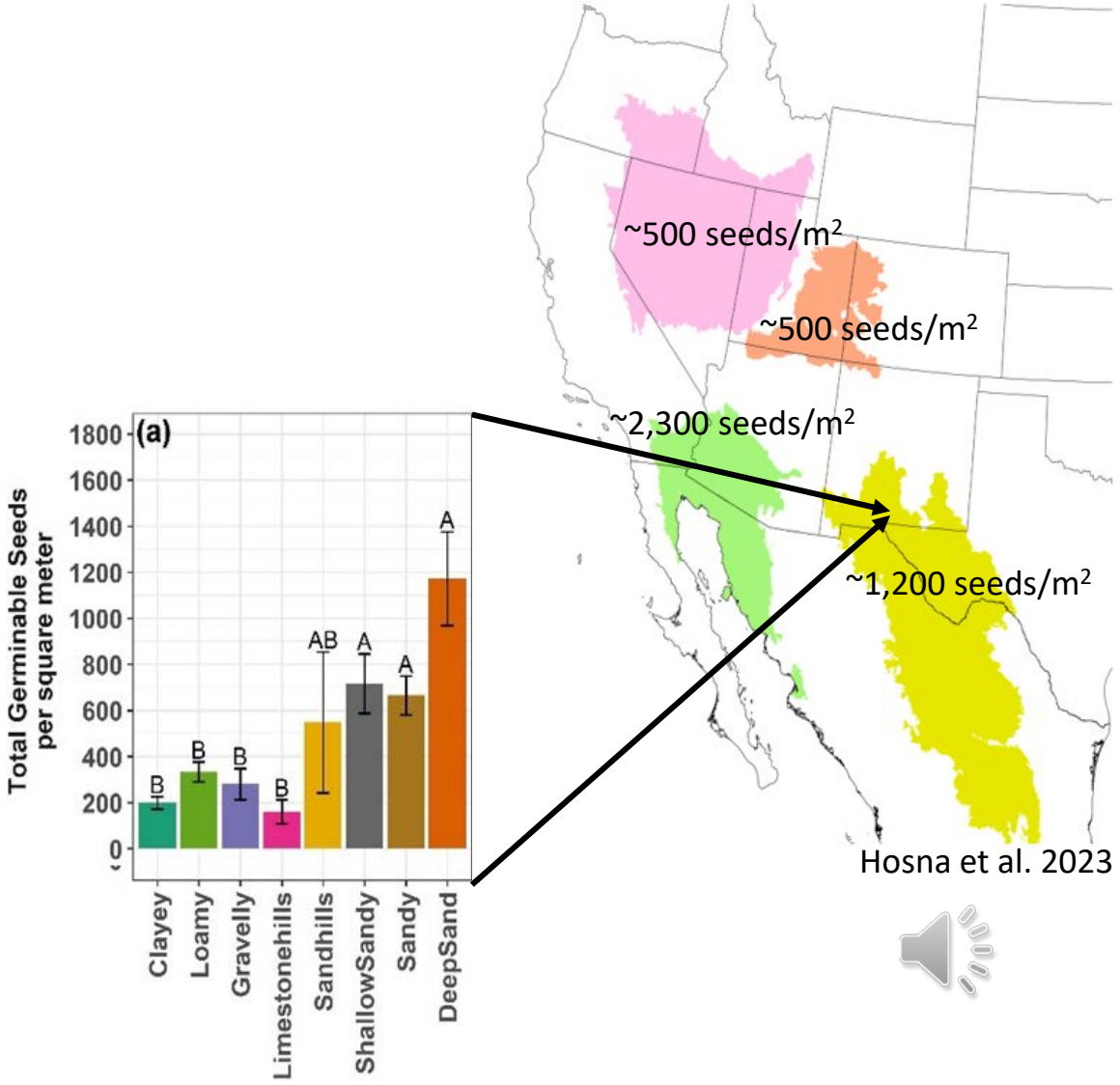
- Insight into both the *history* and the potential *future* of a system
- Commonly show higher diversity than associated aboveground vegetation (Vandvik et al. 2016)
- Knowing what is in the seed bank can inform seed-based restoration efforts



How many seeds are we talking about?

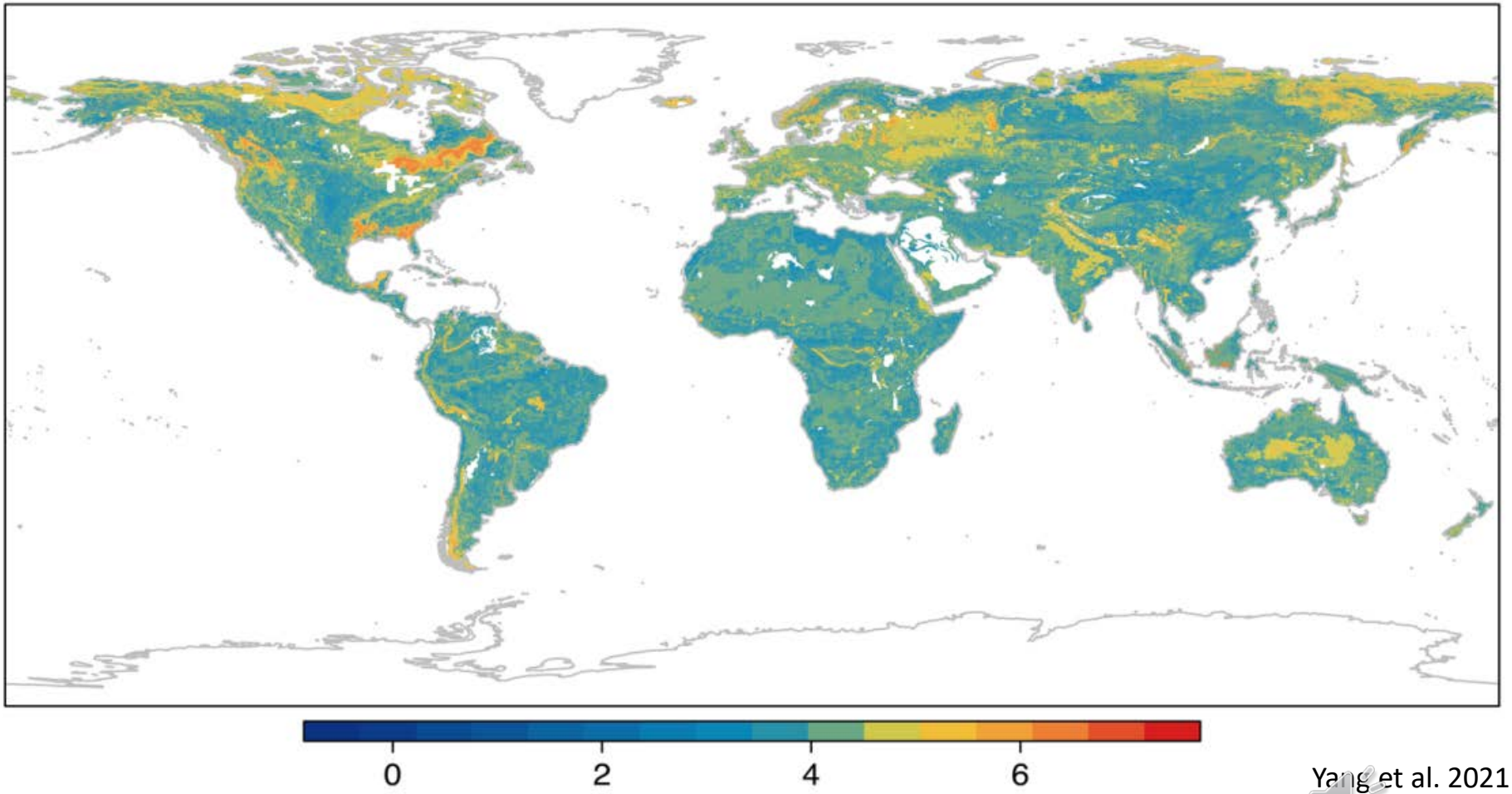
California vernal pools
average of 21,700 seeds/m^2

Faist et al. 2013; Faist and Collinge 2015



Romig et al. *in revision*

How many seeds are we talking about?

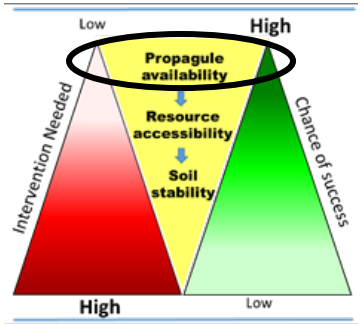


Yang et al. 2021

Seed banks and restoration

- Seed bank composition
  - Similarity to aboveground vegetation can guide efforts
- Minimize duplication of efforts
  - *e.g., some species* are everywhere…
  - Use species that are not already in the seed bank!
- Maximize competitive advantages
  - Add species best able to compete with invasives present (e.g., Uselman et al. 2015)

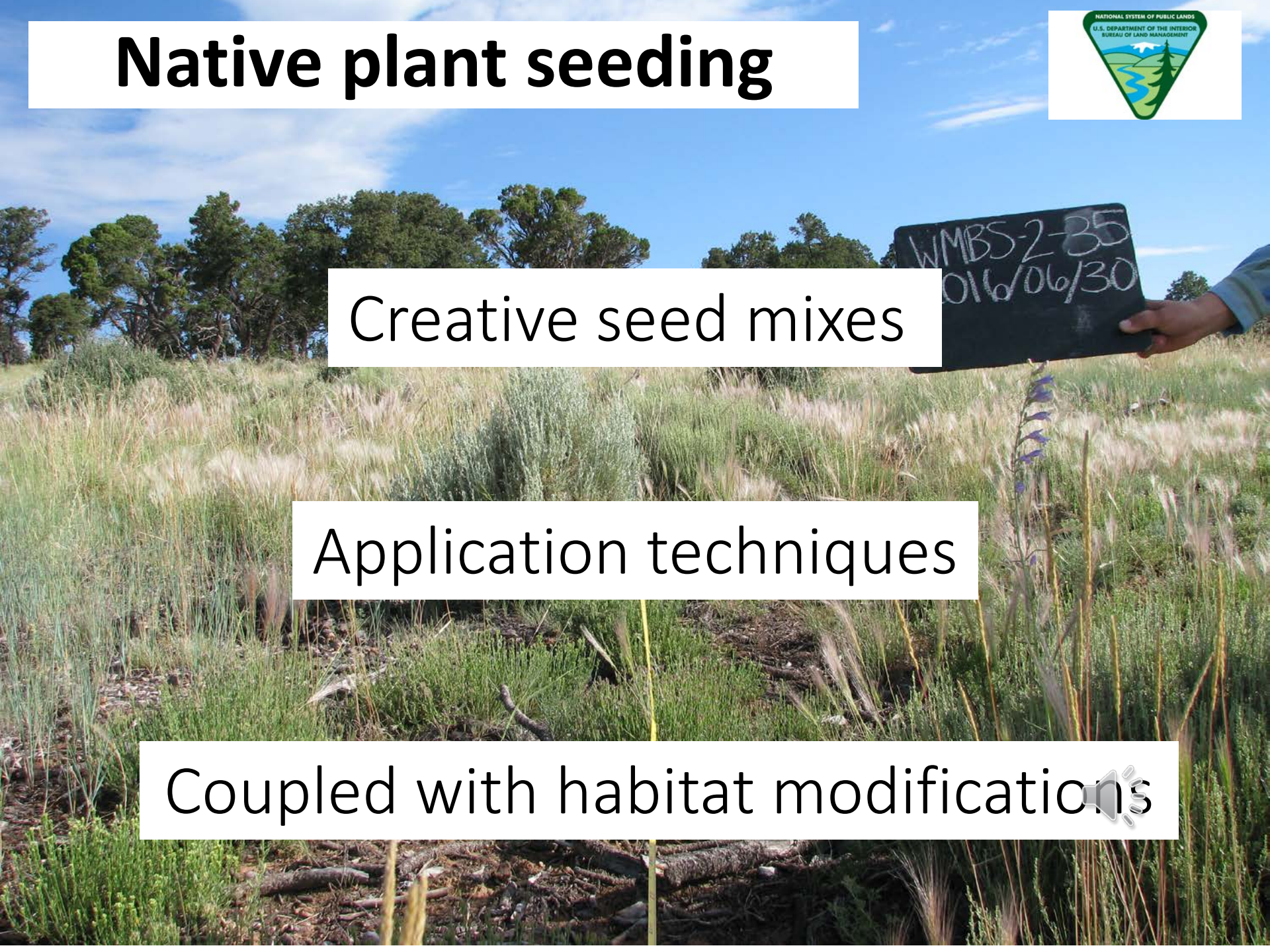
Photo credit: Ryan Schroeder



☑Do we need to add them?

Photo credit: Ellie McCann

Native plant seeding



Creative seed mixes

Application techniques

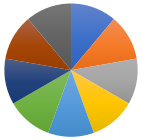
Coupled with habitat modifications

Biotic Interactions

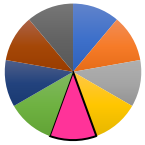
Monoculture

Five species

Nine species



Nine **Species** with n-fixer



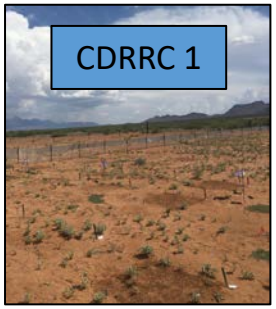
Environment

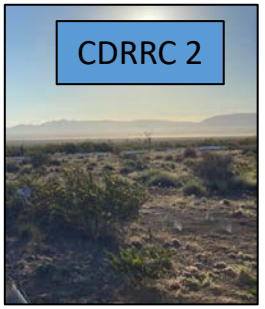
AMBIENT NUTRIENT LEVEL

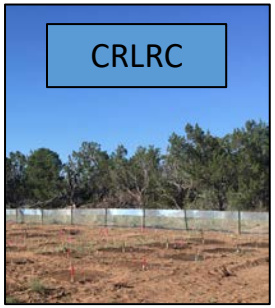
+

ENHANCED NUTRIENT LEVEL

+

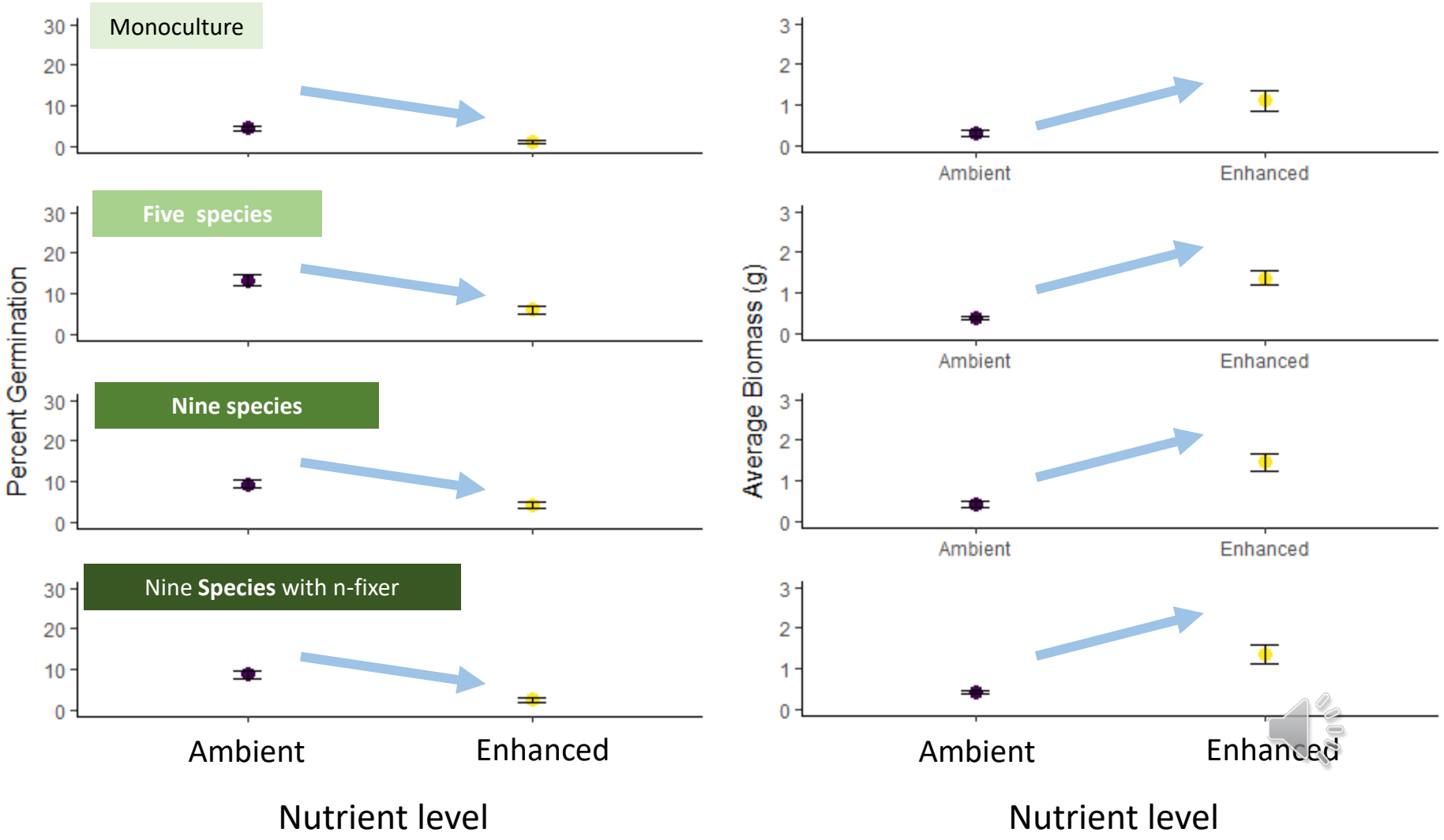




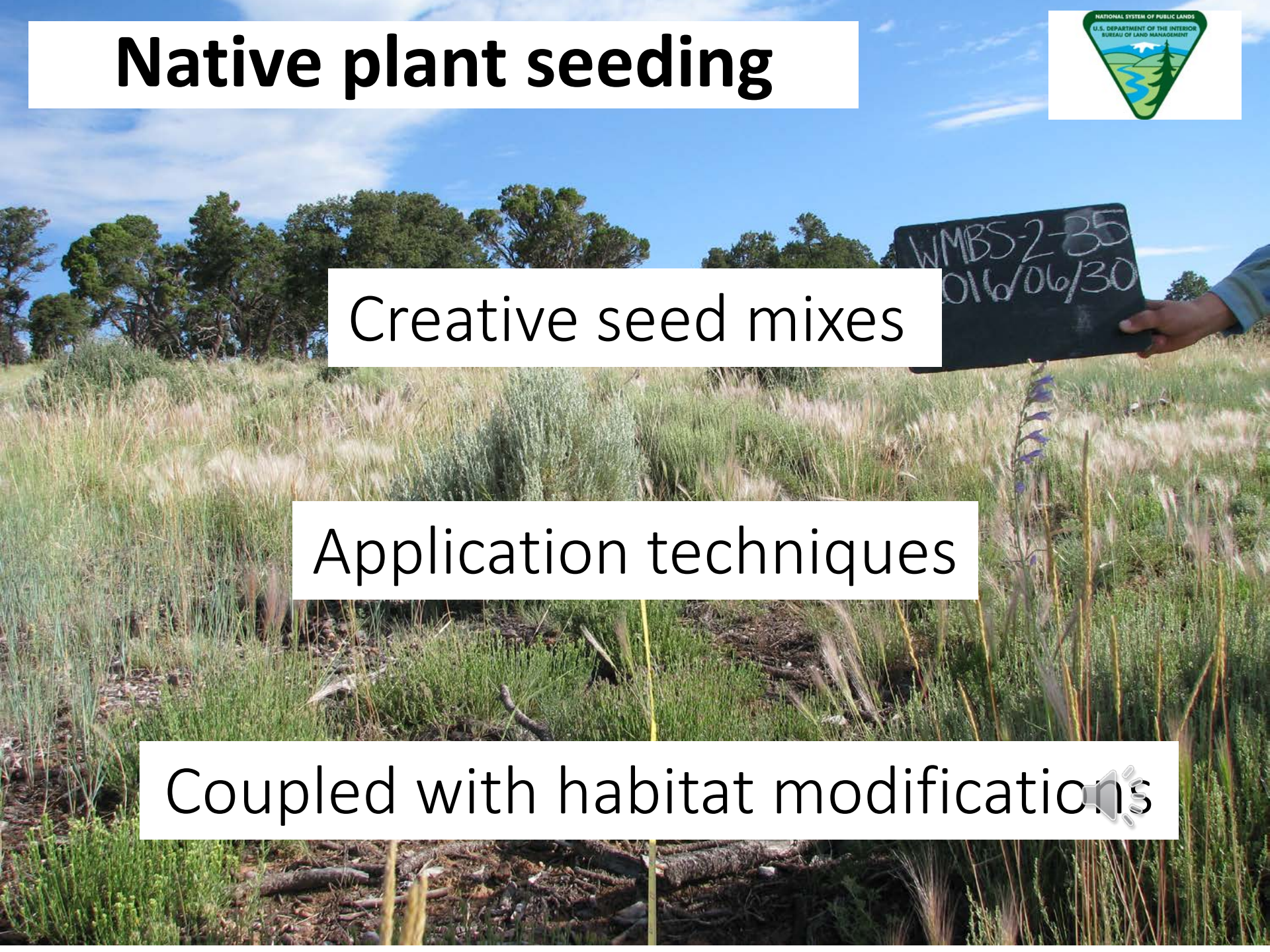


Savannah Meadors

Percent germination and biomass by nutrient additions



Native plant seeding



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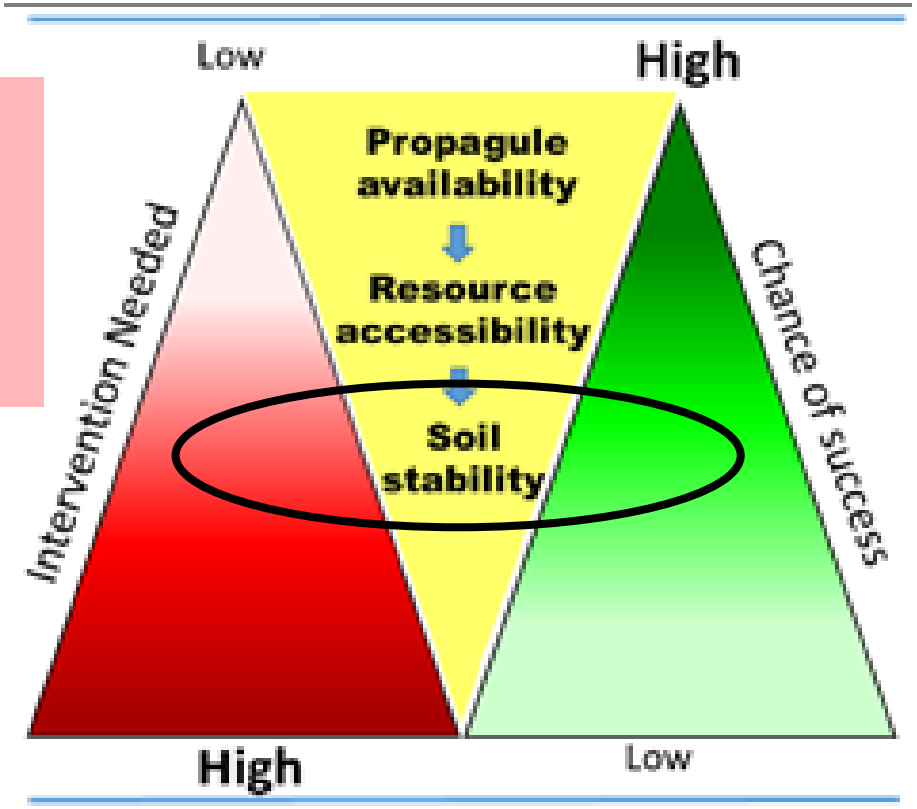
Coupled with habitat modifications

What actions to take?

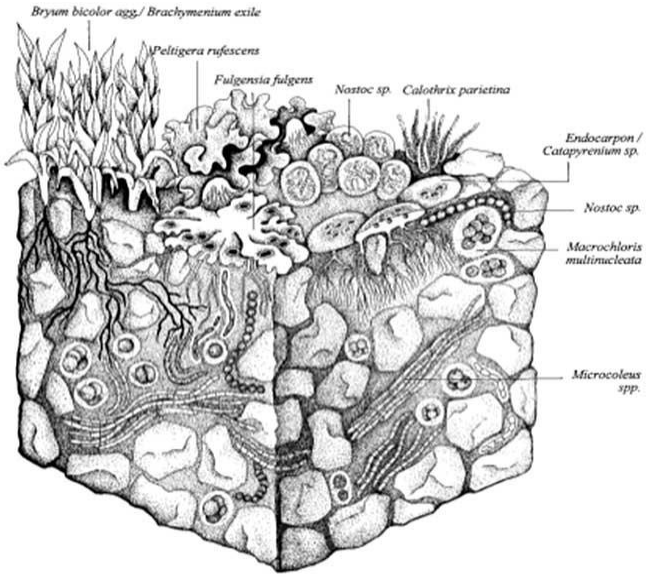
How much ‘intervention’ is needed?



What are barriers hindering success?

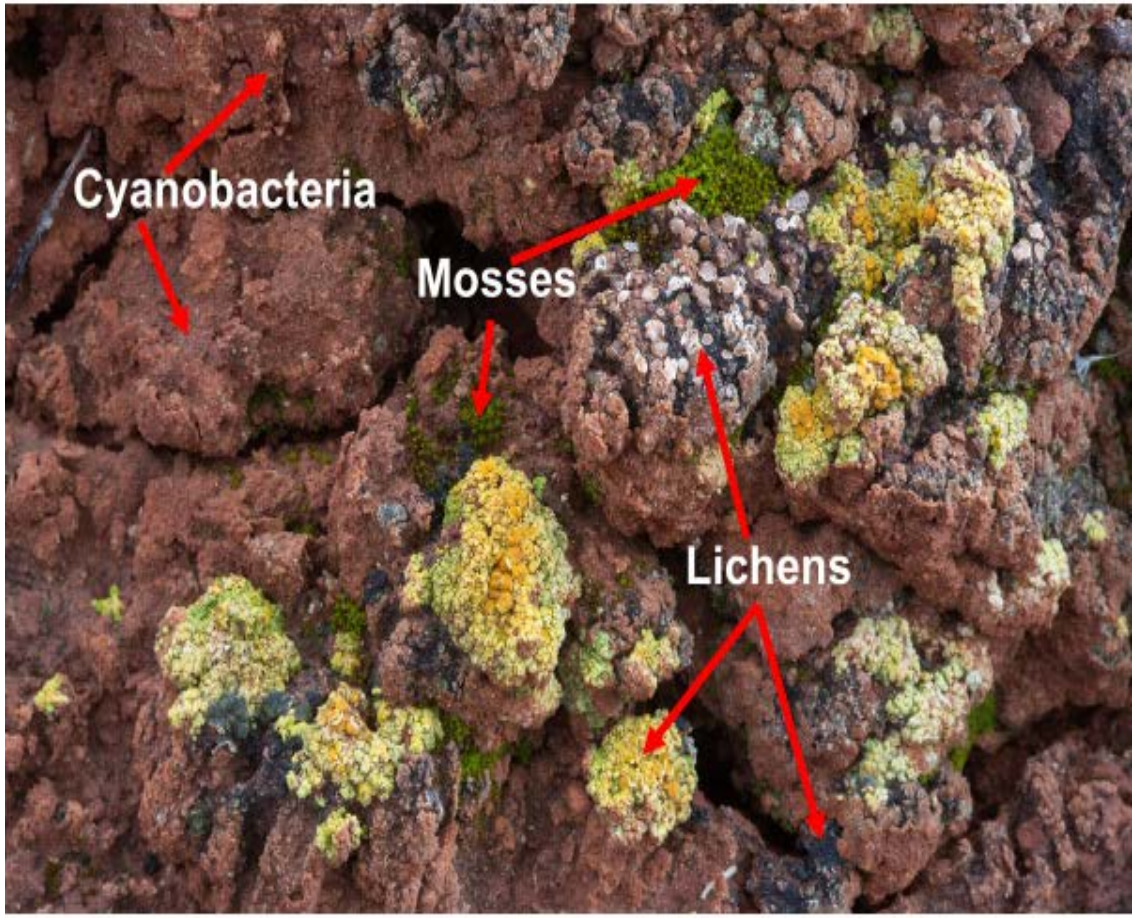
Modified from Bowker 2007

Biological soil crust

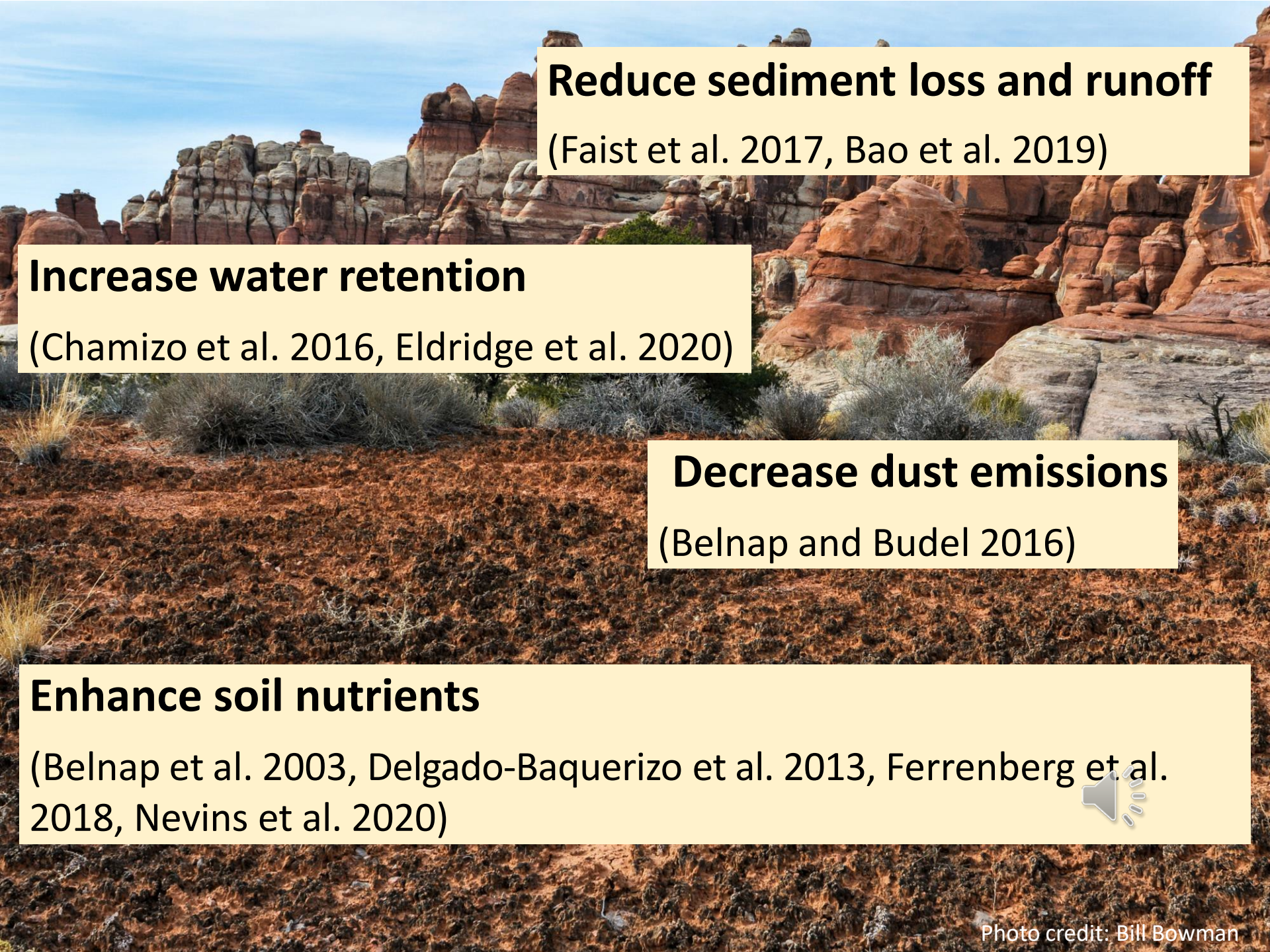


Belnap et al. 2001

Biocrust communities:



Weber et al. 2022



Reduce sediment loss and runoff

(Faist et al. 2017, Bao et al. 2019)

Increase water retention

(Chamizo et al. 2016, Eldridge et al. 2020)

Decrease dust emissions

(Belnap and Budel 2016)

Enhance soil nutrients

(Belnap et al. 2003, Delgado-Baquerizo et al. 2013, Ferrenberg et al. 2018, Nevins et al. 2020)

Photo credit: Bill Bowman

Here in western Montana!

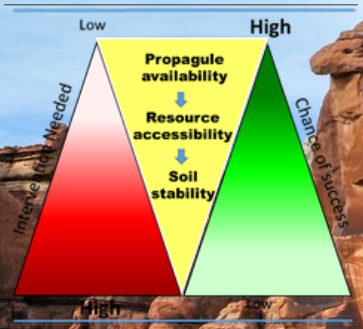
British Columbia

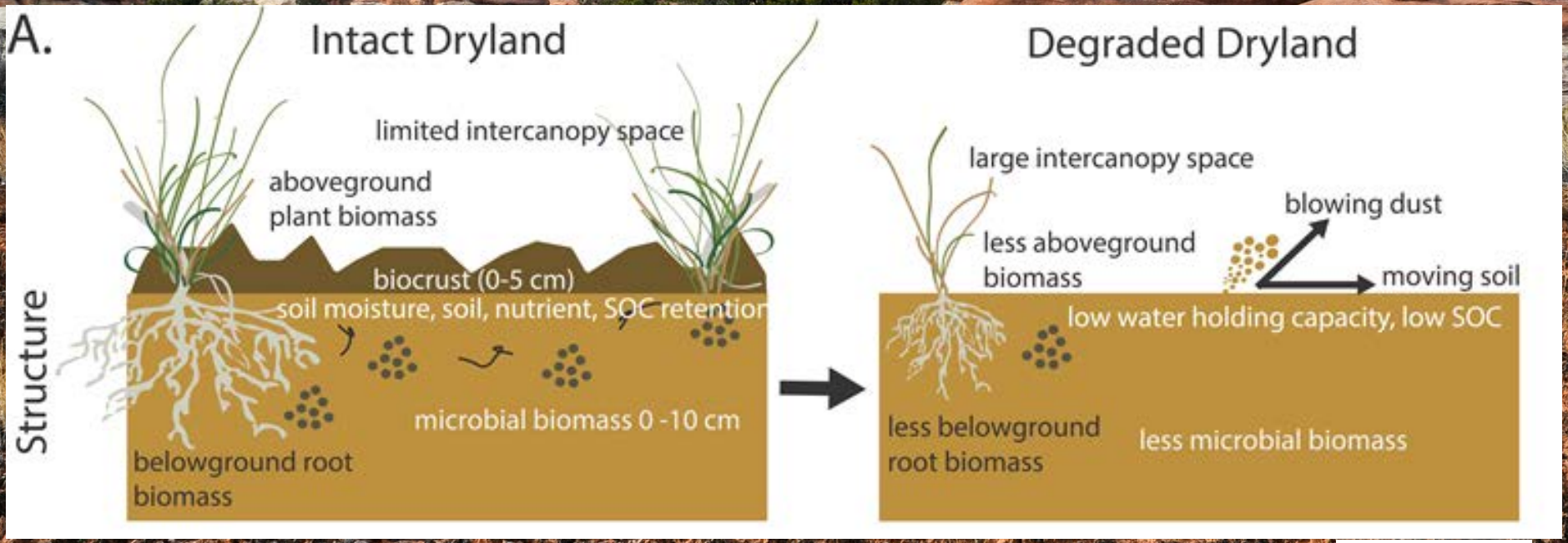
Photos from UNBC plant ecology website: http://www.unbcplantecology.ca/index.php/research/biological-soil-crusts/

Bowker et al. 2022

Great Plains

Warren et al. 2021





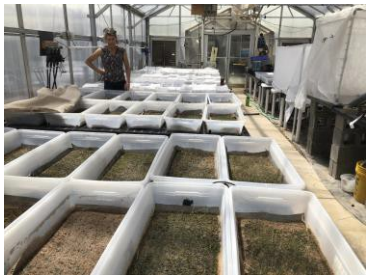
Young et al. 2020

Photo credit: Bill Bowman

Biological soil crust restoration

- Inoculum (propagules)

Photo Credit: A. Antoninka



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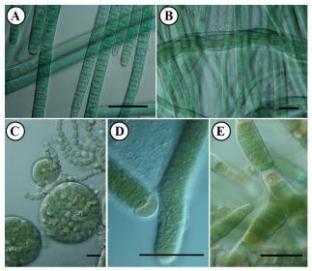


Photo Credit: A. Giraldo-Silva

- Field implementation
  - ❑ **Habitat preparation and modification**
    - ❑ Surface Roughening
    - ❑ Shading
    - ❑ Irrigation and water addition

- Assessment

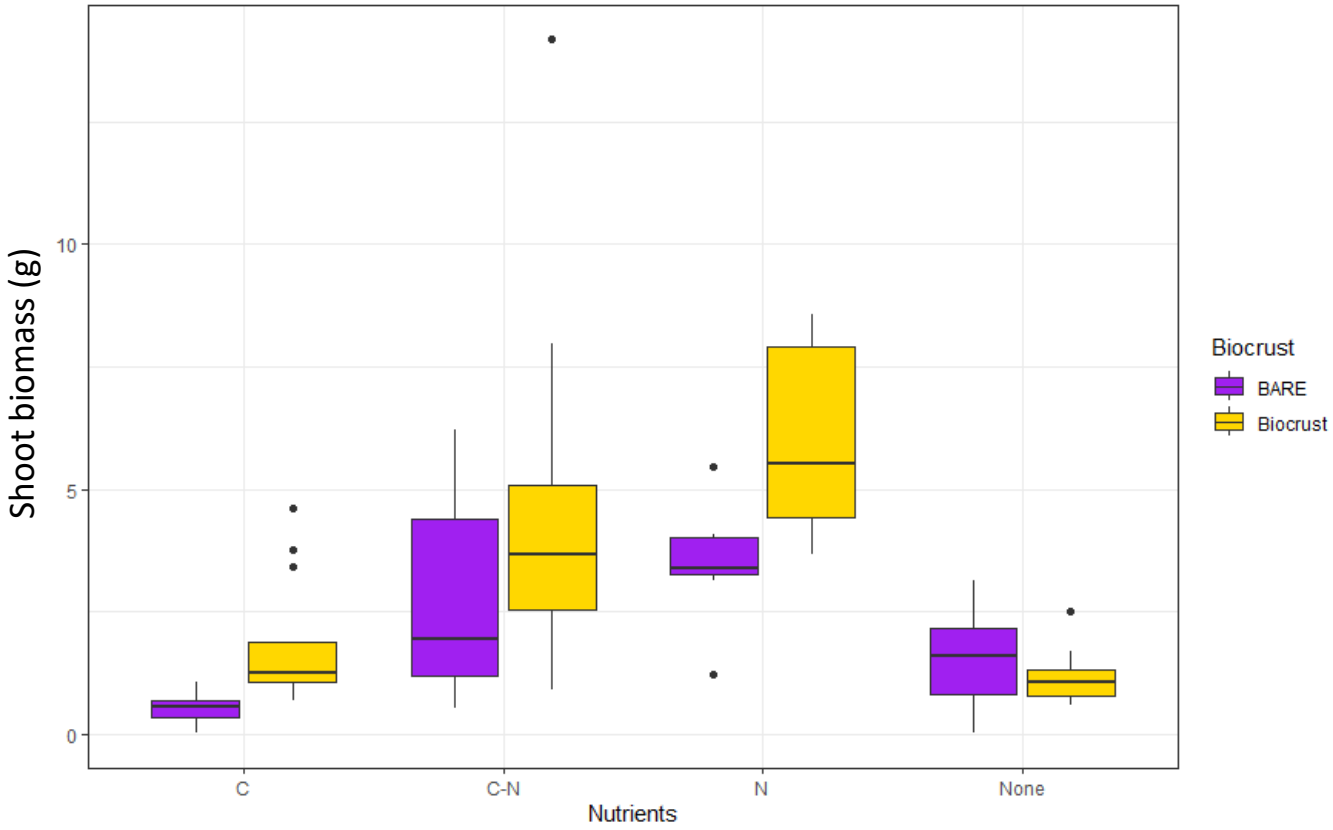
Plant-biological soil crust relationships

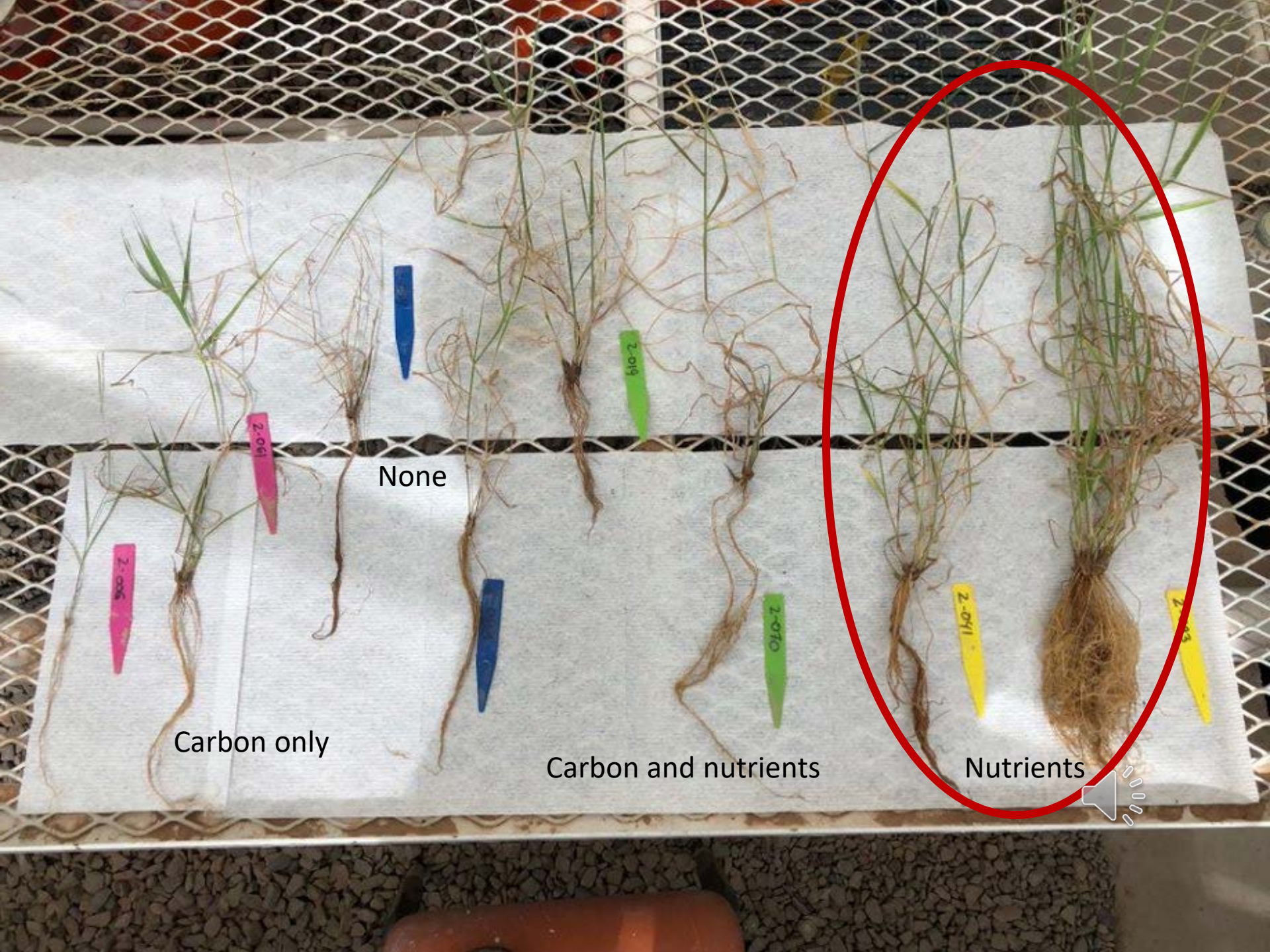
Photo credit: Ellie McCann

Ferrenberg et al. 2018

Biocrust and Nutrient study

Biocrust p = 0.00071
Nutrients p < 0.0001




None
Carbon only
Carbon and nutrients
Nutrients

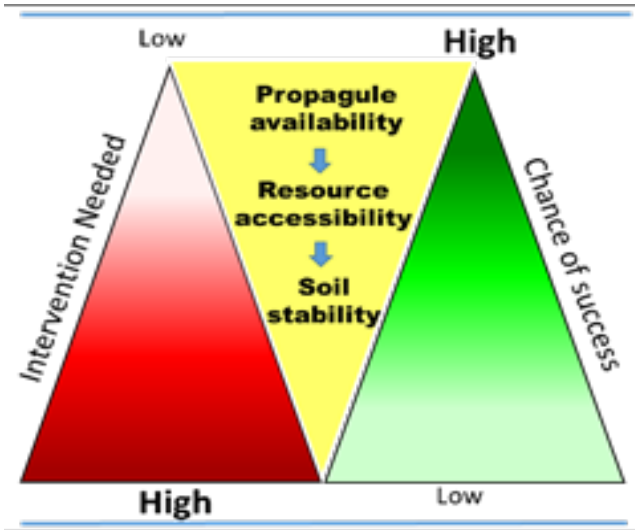
Plant-Biocrust Synthesis

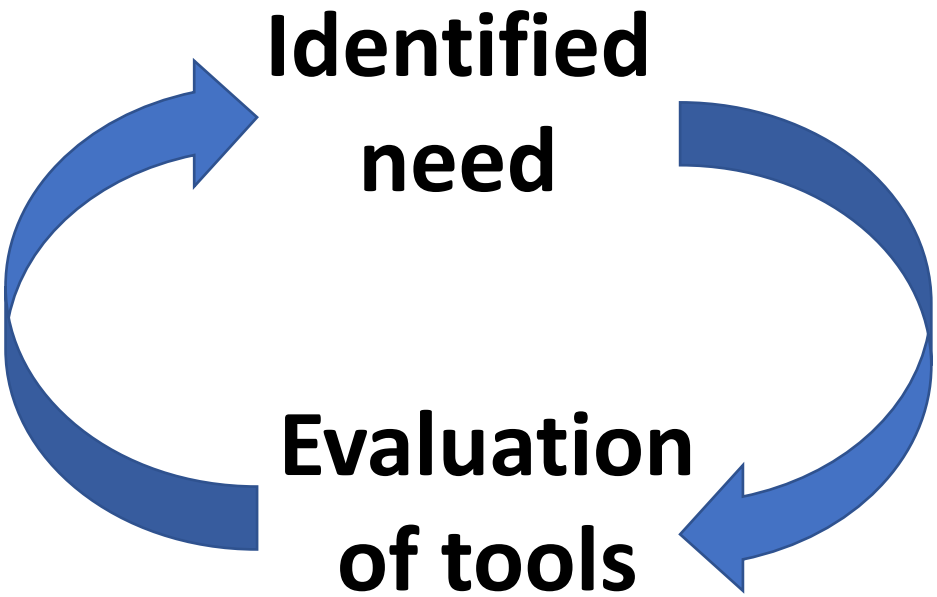
PLANT RESPONSE TO BIOCRUST

- Positive
- Negative
- Neutral
- Not enough data

EXPLANATORY VARIABLES		Germination	Survival	Growth	Cover	Overall Performance
BIOCRUST TYPE	Cyanobacteria					
	Lichen	Negative		Positive		Negative
	Moss				Positive	Positive
	Mixed			Positive		
PLANT FUNCT. GROUP	C3 Grass	Negative		Positive		
	C4 Grass	Negative		Positive		Positive
	Non-N-fix Forb					
	N-fix Forb	Negative		Not enough data	Not enough data	Negative
	Non N-fix Woody			Positive		
	N-fix Woody		Not enough data	Negative	Negative	Negative
	Community			Negative		
PLANT NATIVE.	Native		Not enough data	Positive	Not enough data	
	Non-Native	Negative	Not enough data	Positive	Not enough data	
PLANT REF. STATE	Bare Soil					
	Biocrust removal			Positive	Positive	Positive
	Biocrust disturb.	Negative		Negative		Negative
	Filter paper		Not enough data		Not enough data	

Havrilla et al. 2019





Continue to - Identify novel and creative actions to overcome barriers to ecological restoration success

In your opinion what do you think of these five options is the biggest challenge restoration practitioners/ecologists face?

a) Climate change
b) Ecology is complicated
c) Public perception of restoration working perfectly
d) Differences of opinion of desired outcomes
e) Not enough resources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NM STATE
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FAIST LAB
Science is happening!
RANGELAND RESTORATION ECOLOGY
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service
USDA NIFA
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
Thank you!