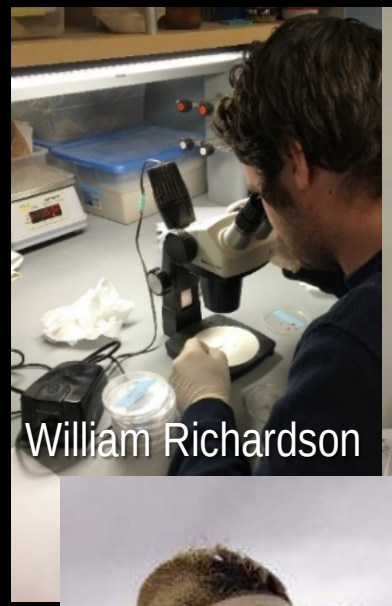
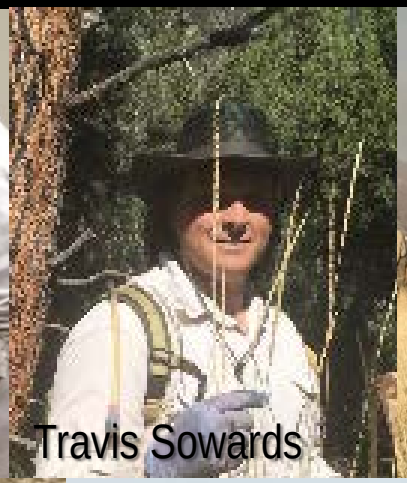
Use of Seed Enhancement Technologies for Overcoming Biotic and Abiotic Limitations Impairing Native Plant Establishment

Matthew Madsen

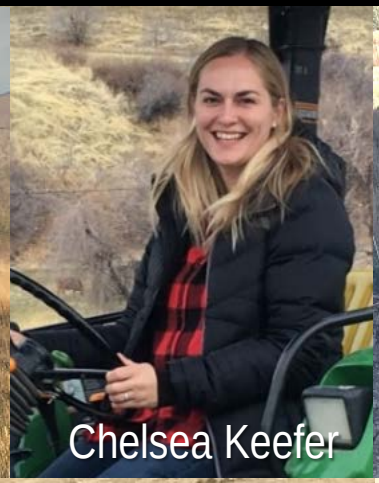
Students


William Richardson


Ryan Call


Travis Sowards


Morgan Parkinson

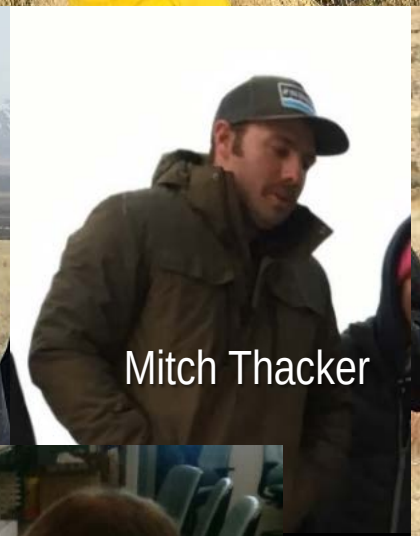

Chelsea Keefer


Tyson Terry


Justin Taylor


Ben Hoose

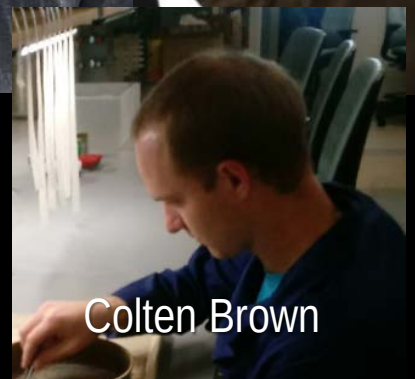
Rhett Anderson


Mitch Thacker


Soren Larson


Dave Tryon


Janae Radke


Colten Brown


Adrian Rivera

Funding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Great Basin
NATIONAL
PARK
SERVICE

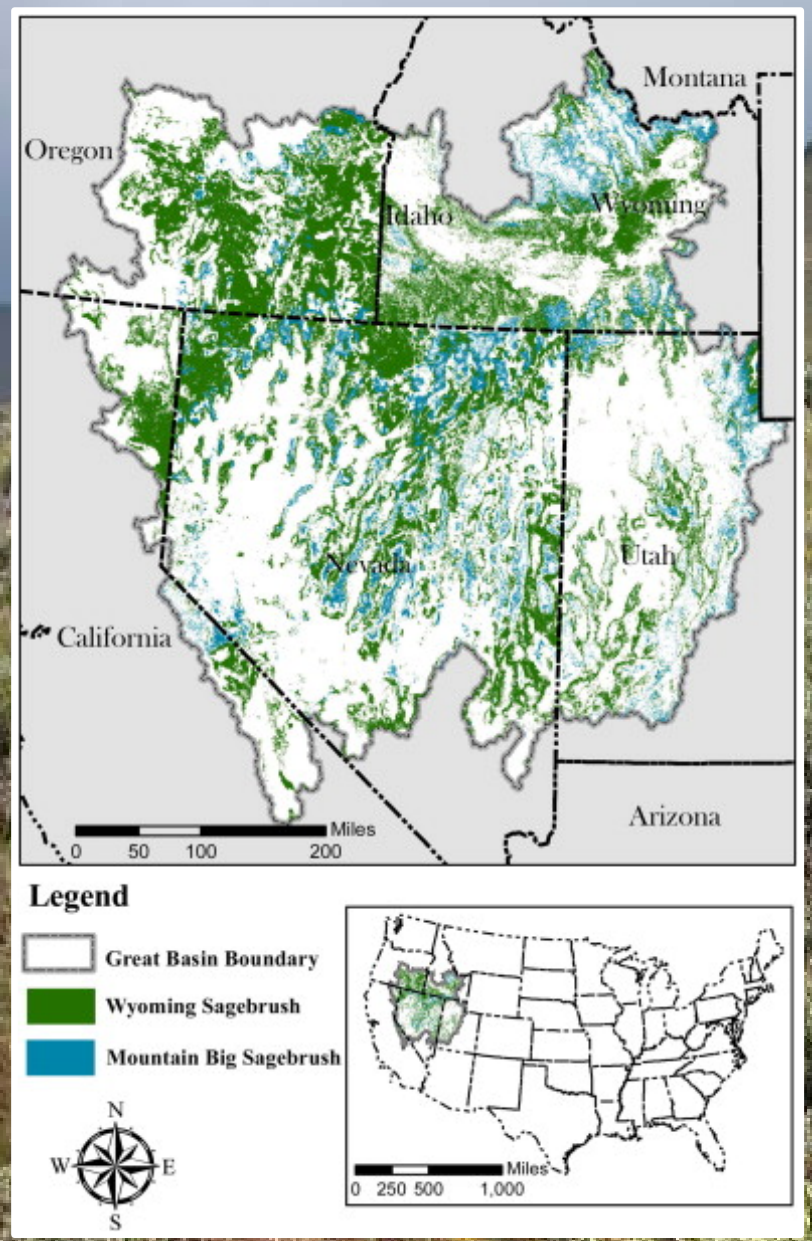

JOINT
FIRE SCIENCE
PROGRAM


LithiumNevada

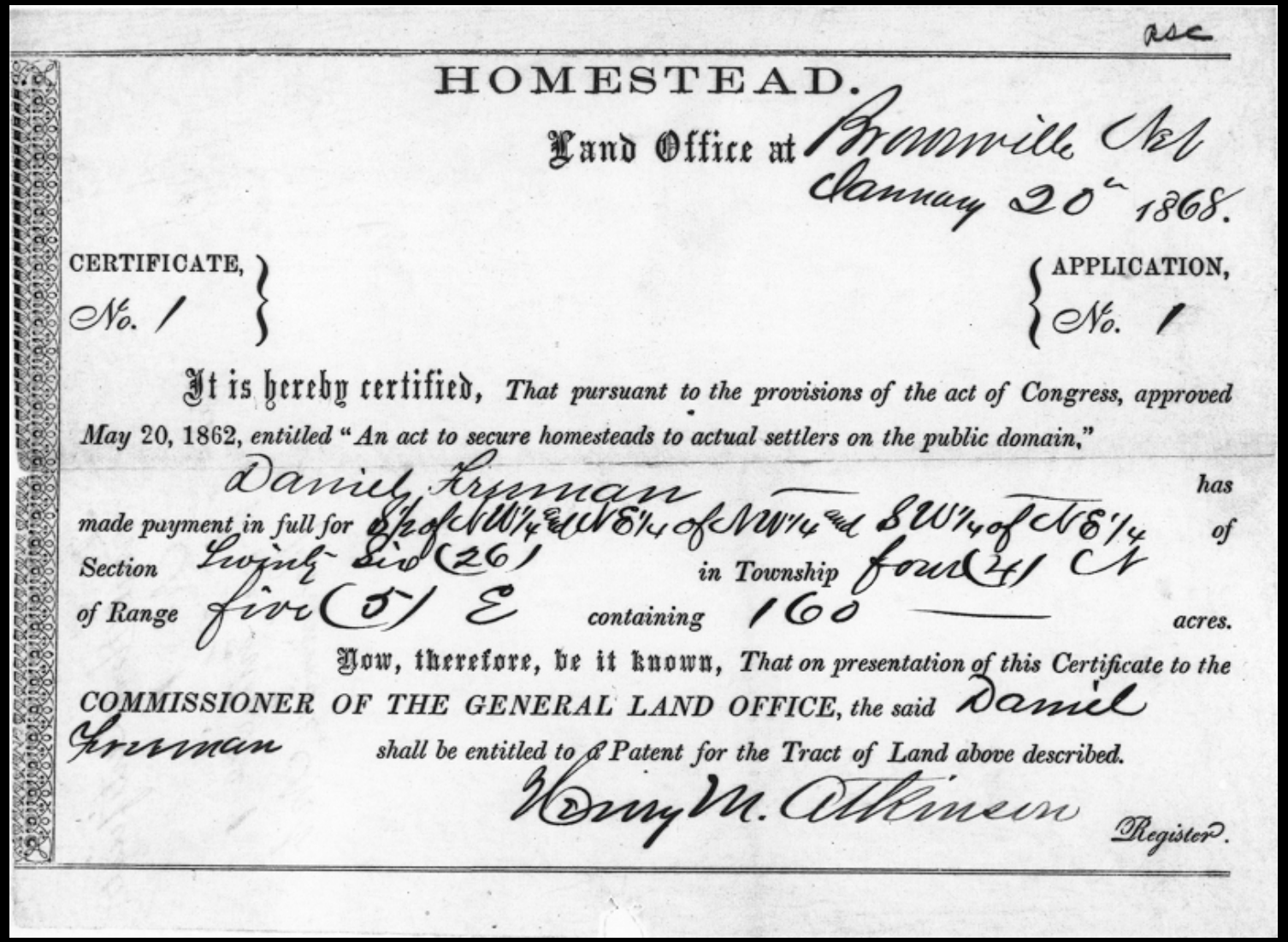
Outline

- History of cheatgrass invasion in the Great Basin
- The importance of seeding degraded rangelands after wildfires to suppress cheatgrass and restore ecosystems
- Factors impairing rangeland seeding success
- Use of seed enhancement technologies for overcoming barriers limiting seeding efforts
- Future research

The Great Basin



Settlement of the western US



asc

HOMESTEAD.

Land Office at Brownville Neb
January 20th 1868.

CERTIFICATE, No. 1

APPLICATION, No. 1

It is hereby certified, That pursuant to the provisions of the act of Congress, approved May 20, 1862, entitled "An act to secure homesteads to actual settlers on the public domain,"

Daniel Freeman has made payment in full for E½ of NW¼ and NE¼ of NW¼ and SW¼ of NE¼ of Section Twenty Six (26) in Township four (4) N of Range five (5) E containing 160 acres.

Now, therefore, be it known, That on presentation of this Certificate to the COMMISSIONER OF THE GENERAL LAND OFFICE, the said Daniel Freeman shall be entitled to a Patent for the Tract of Land above described.

Henry M. Atkinson Register.

History of Grazing in the West


Cheatgrass (*Bromus tectorum*)

Cheatgrass (*Bromus tectorum*)

- Seed was potentially introduced as a contaminate in grain seed, straw packing material, soil used in the ballasts of ships

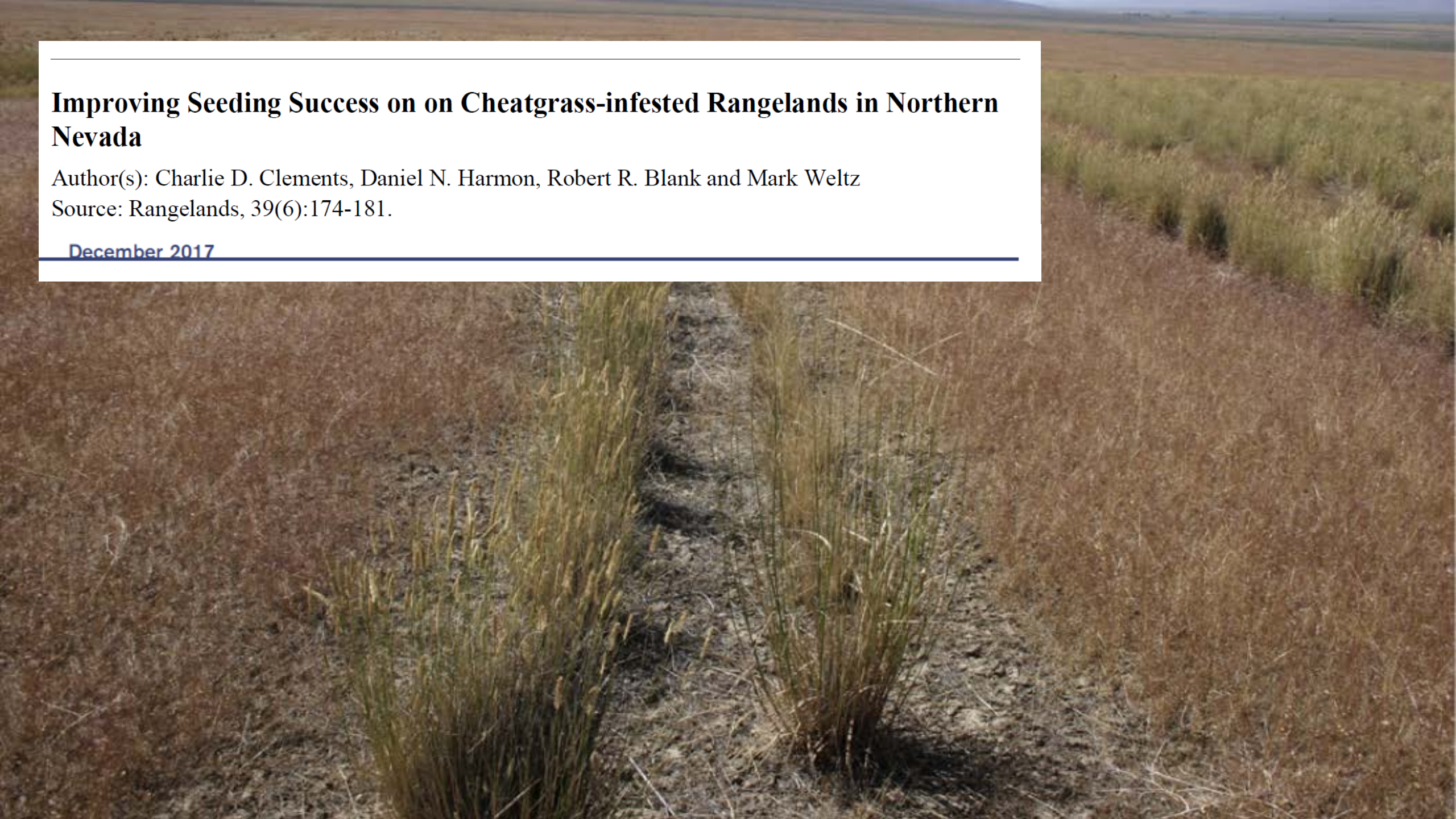
The Cheatgrass-Wildfire Cycle

Do we have a Formidable Opponent to Cheatgrass?

Improving Seeding Success on on Cheatgrass-infested Rangelands in Northern Nevada

Author(s): Charlie D. Clements, Daniel N. Harmon, Robert R. Blank and Mark Weltz
Source: Rangelands, 39(6):174-181.

December 2017



Chad Boyd, Miller Homestead fire

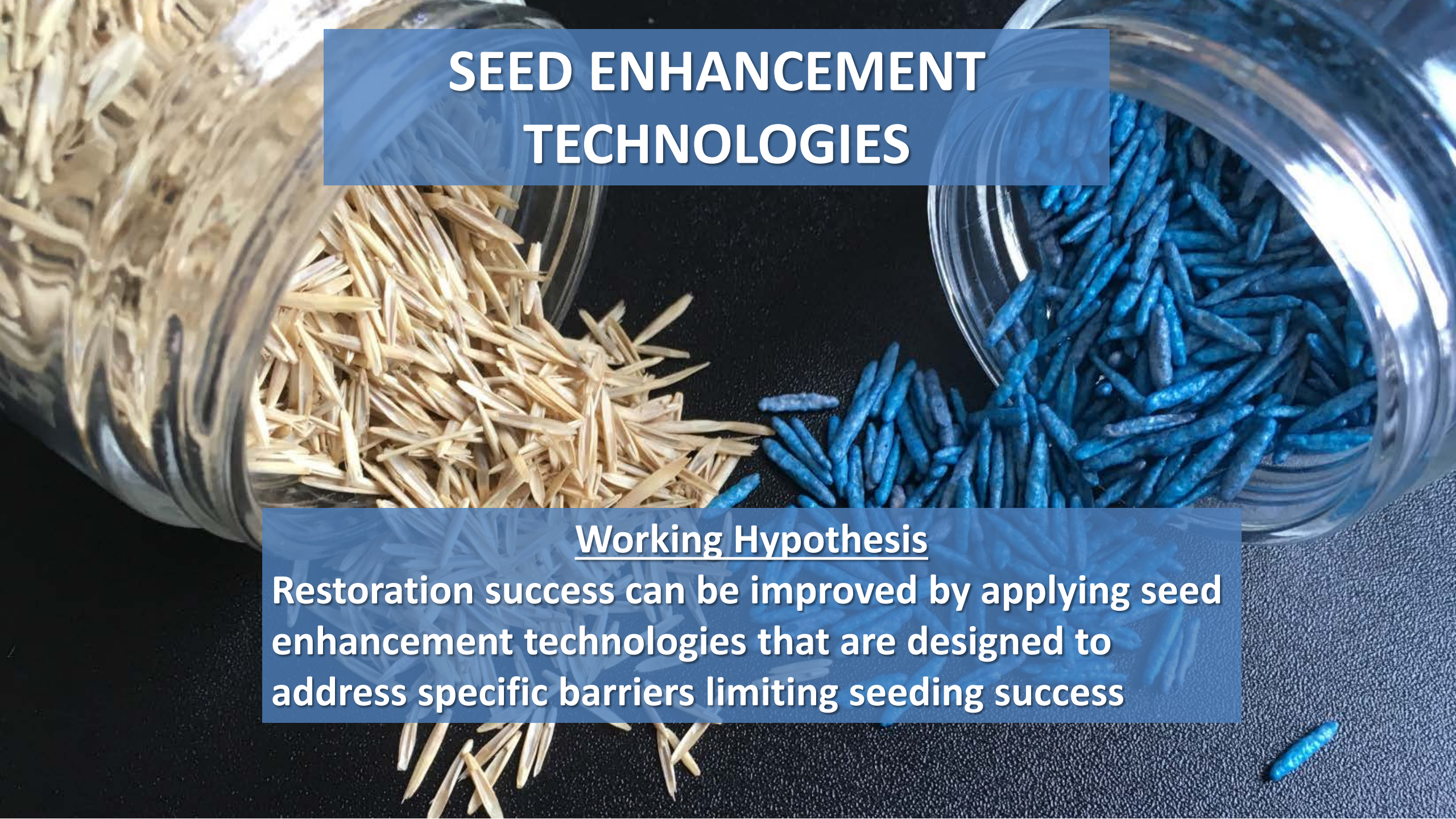
Rangeland drill

- 5-20% success rate in seeding native vegetation in the western US (Sheley et al. 2011)

Seed Enhancement Technologies

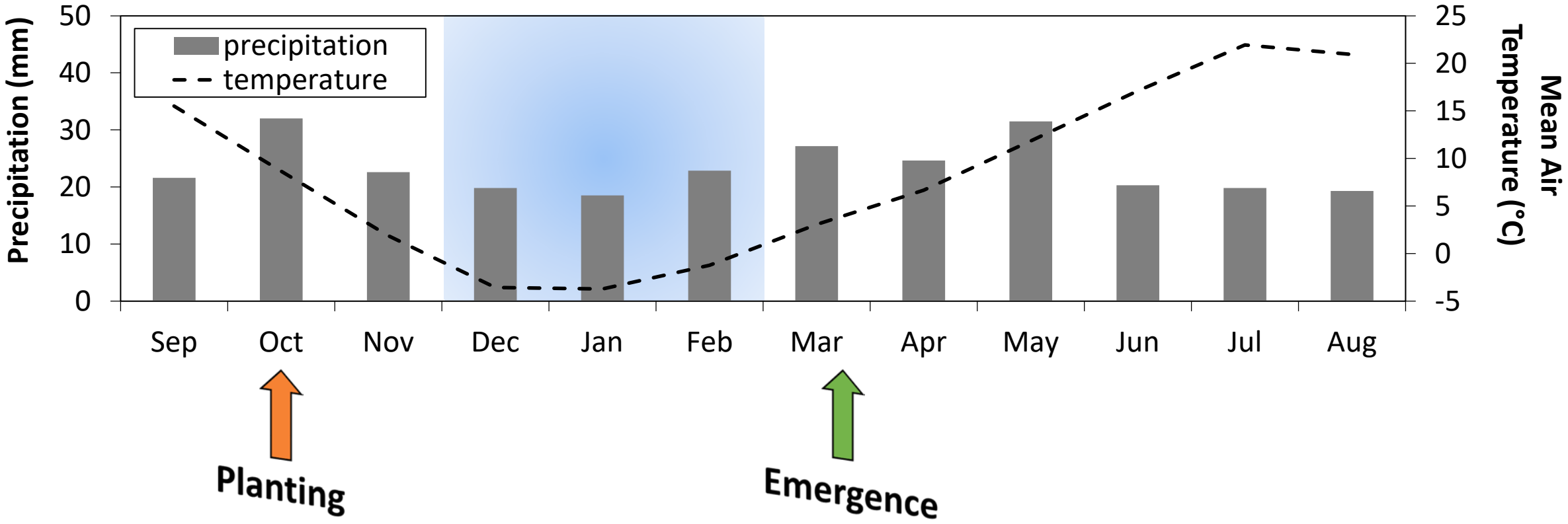
- Allow for the physical manipulation and application of materials to the seed for improving seed germination, emergence, and early seedling growth

SEED ENHANCEMENT TECHNOLOGIES



Working Hypothesis

Restoration success can be improved by applying seed enhancement technologies that are designed to address specific barriers limiting seeding success



- **Between fall and spring, significant seed loss and seedling mortality can occur**

Seed Predation

- Rodents can have a strong top-down effect on seeding success
- Can consume as high as 80% of the seeds

ECOLOGY
ECOLOGICAL SOCIETY OF AMERICA

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Article

Biotic resistance and disturbance: rodent consumers regulate post-fire plant invasions and increase plant community diversity

Samuel B. St. Clair ✉, Rory O'Connor, Richard Gill, Brock McMillan

First published: 1 July 2016 Full publication history

ECOSPHERE
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Article

Rodent herbivory and fire differentially affect plant species recruitment based on variability in life history traits

Tiffanny R. Sharp Bowman, Brock R. McMillan, Samuel B. St. Clair ✉

First published: 8 December 2017 Full publication history

Decreasing Seed Predation

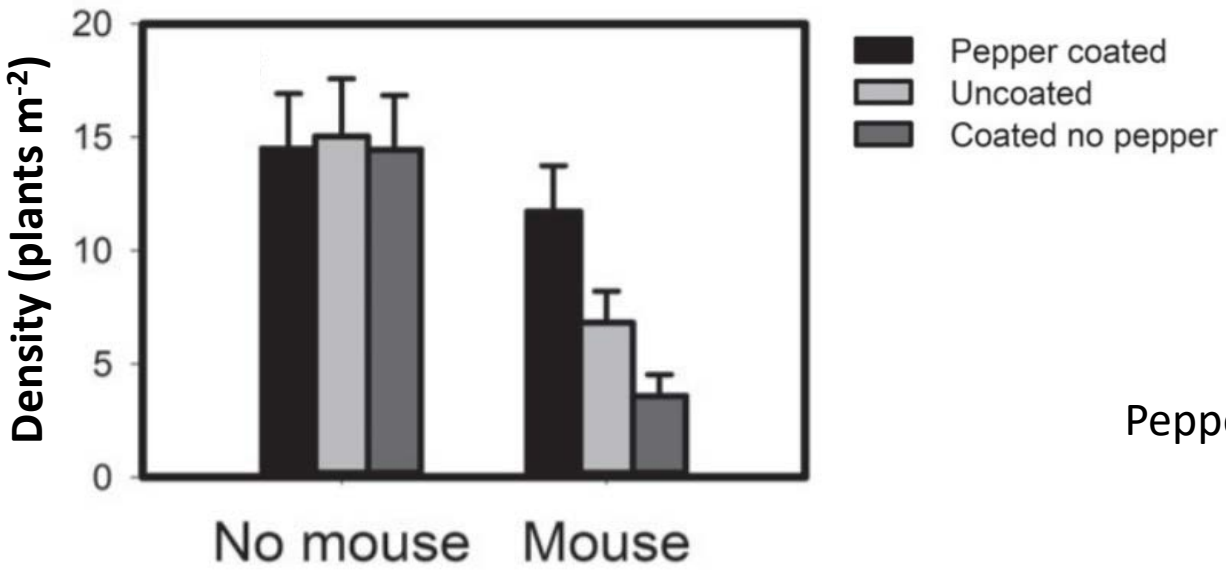
--------IN PRESS--------

Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

TECHNICAL ARTICLE

Spicing up restoration: can chili peppers improve restoration seeding by reducing seed predation?

Dean E. Pearson[1,2,3], Morgan Valliant[3], Chris Carlson[3], Giles C. Thelen[4], Yvette K. Ortega[1], John L. Orrock[5], Matthew D. Madsen[6]



Pepper Coating = Bhut Jolokia/ ghost pepper (*Capsicum chinense*)

Species: PSSP, HEAN, LUSE, PUTR

Location: 5 sites near Missoula MT

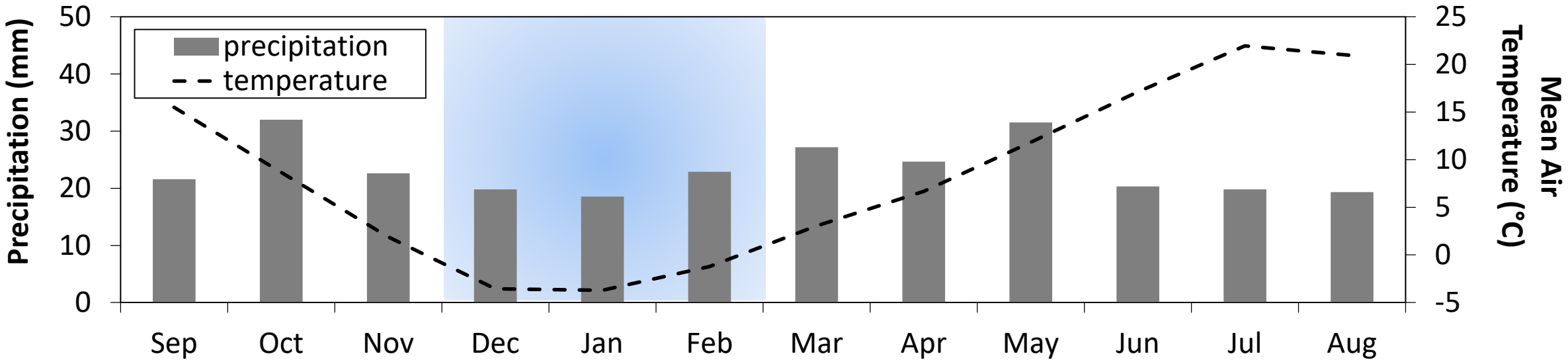
Decreasing Seed Predation

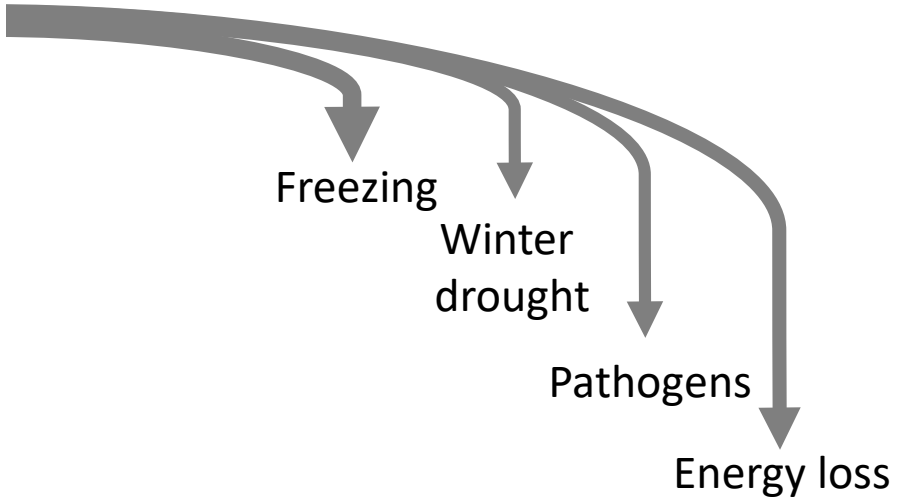
Objective

- Develop seed coatings to decrease rodent granivory
  - Deterrents (e.g. Ghost Pepper powder)
  - Scent masking (e.g. deodorizers, essential oils)

JOINT FIRE SCIENCE PROGRAM

Premature Seed Germination





James et al. 2011

- 50-80% germination by December
- <10% emergence (March)

Boyd and Lemos 2013

- high mortality in freezing soils

Roundy and Madsen 2016

- >60 freeze–thaw cycles Oct. - March

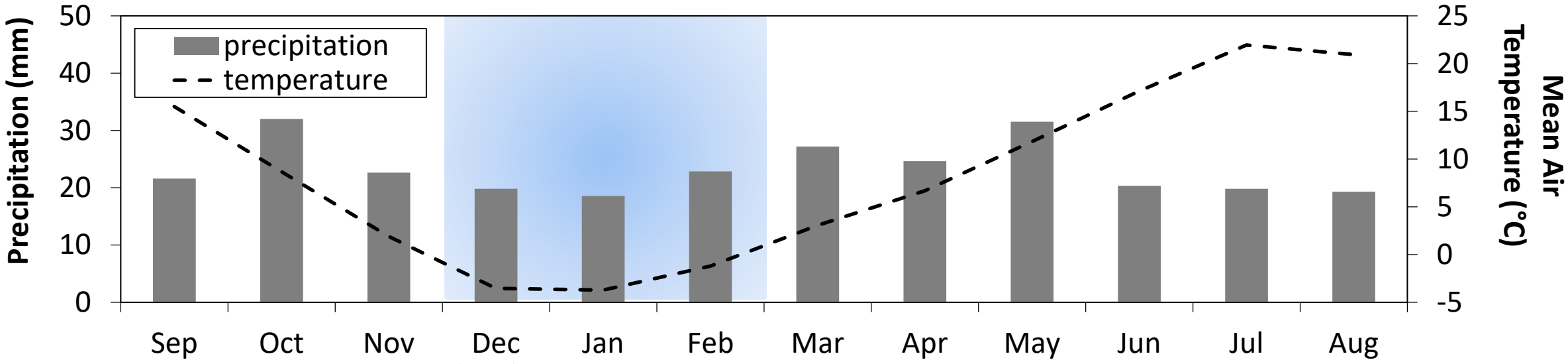
Gornish et al. 2015

- Pathogen attack

Seed Dormancy

- Definition: Mechanism for preventing seed germination within a season that is unfavorable for establishing a new plant
- For water-permeable seed, dormancy is caused from elevated levels of abscisic acid (ABA)
- Dormancy levels decrease as a function of time (dry after-ripening)

Delaying Seed Germination with ABA



Untreated seed

ABA coated seed

Fungicide Coatings

Oecologia
DOI 10.1007/s00442-014-3180-7

GLOBAL CHANGE ECOLOGY - ORIGINAL RESEARCH

Altered snowfall and soil disturbance influence the early life stage transitions and recruitment of a native and invasive grass in a cold desert

Elise S. Gornish · Zachary T. Aanderud · Roger L. Sheley · Mathew J. Rinella · Tony Svejcar · Suzanne D. Englund · Jeremy J. James

- Identified 9 pathogens present on bluebunch wheatgrass seeds

Species	Phylum
*Fusarium tricinctum**	Ascomycota
*Fusarium solani**	Ascomycota
Mycosphaerella macrospora	Ascomycota
Cordyceps sinensis	Ascomycota
*Sclerotinia homoeocarpa**	Ascomycota
Mucor racemosus	Zygomycota
*Gibberella fujikuroi**	Ascomycota
*Verticillium dahlia**	Ascomycota
*Davidiella tassiana**	Ascomycota

Fungicide Coatings

Species

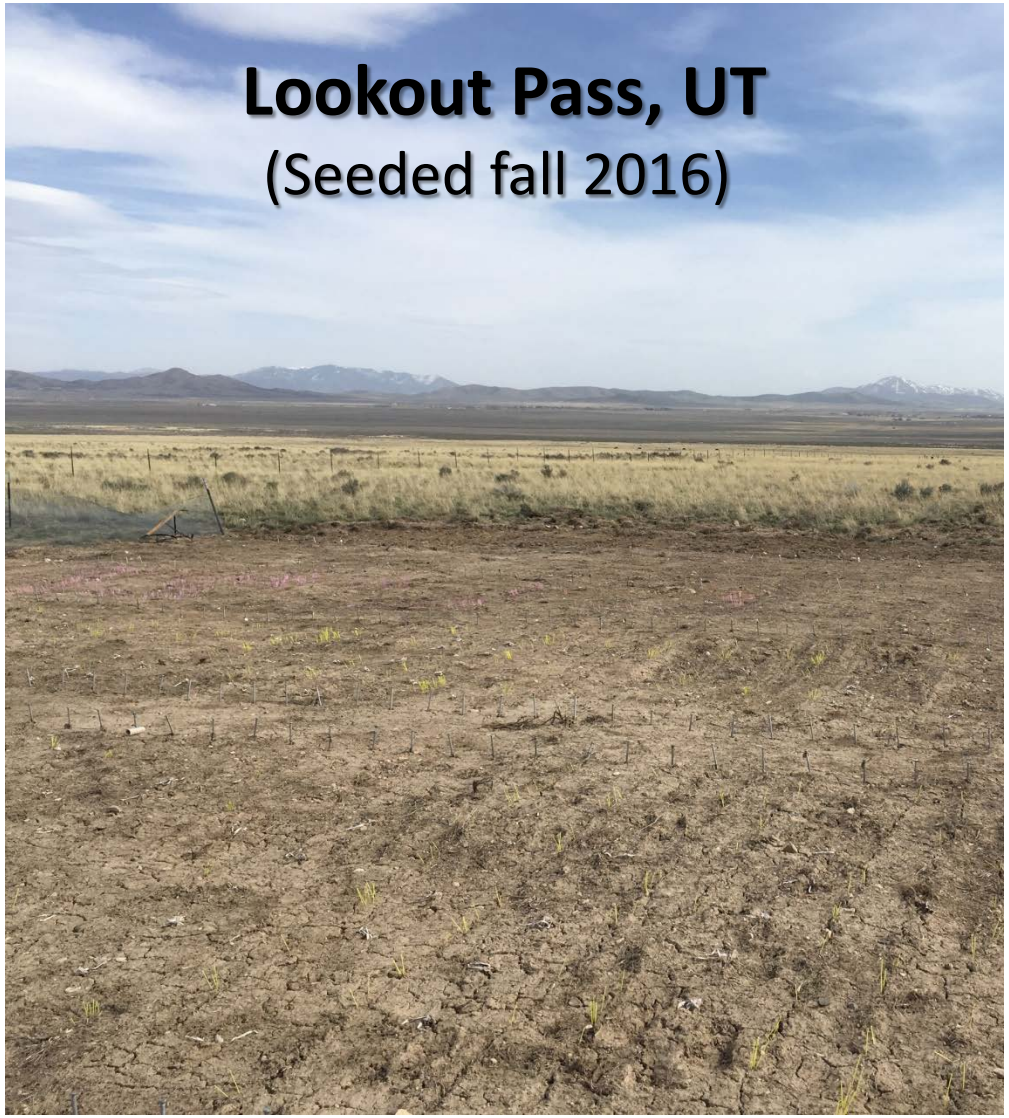
- Bluebunch wheatgrass

Fungicide Coating

- Fungicides were chosen to address pathogens identified by ***Gornish* et al. (2015)**, to be present on bluebunch wheatgrass seeds and treat soil borne fungal diseases

  — Coating formulation: Difenoconazole, Azoxystrobin, Azoxystrobin, Azoxystrobin

Study Site



Field Evaluation

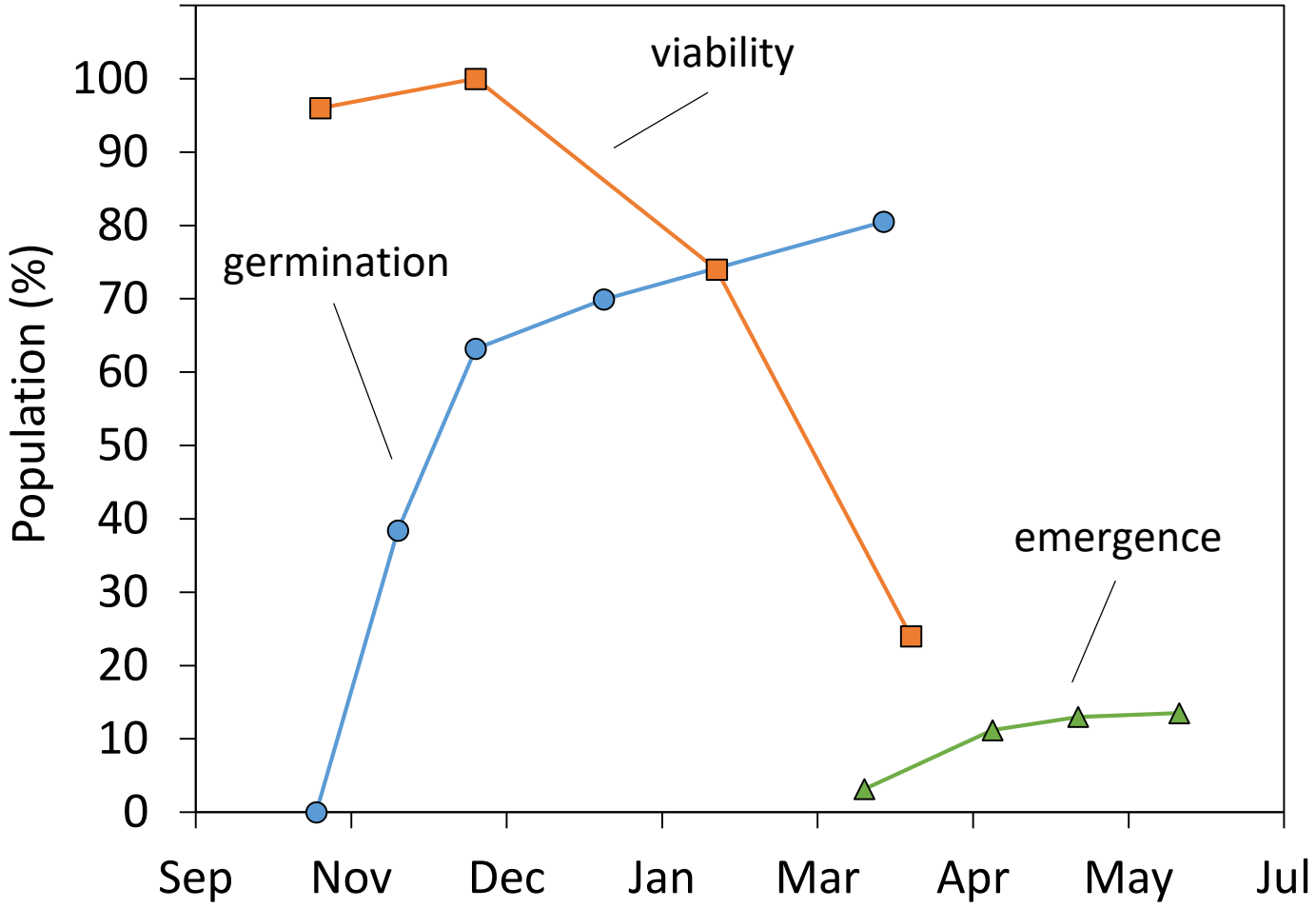
- Collecting germination bags

- Determining germination

- Determining seed viability (TZ)

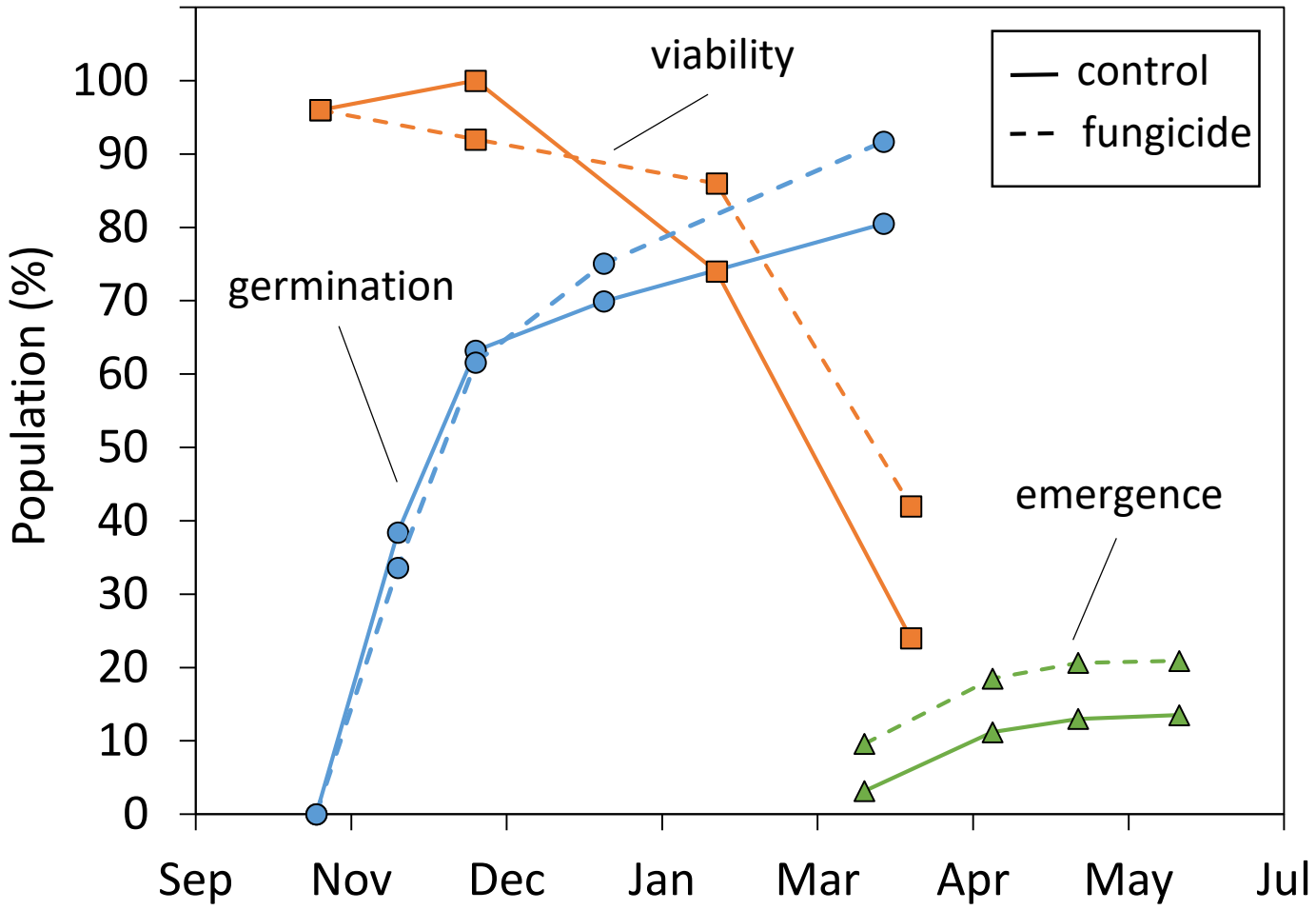
Improving seed and seedling fitness with fungicides

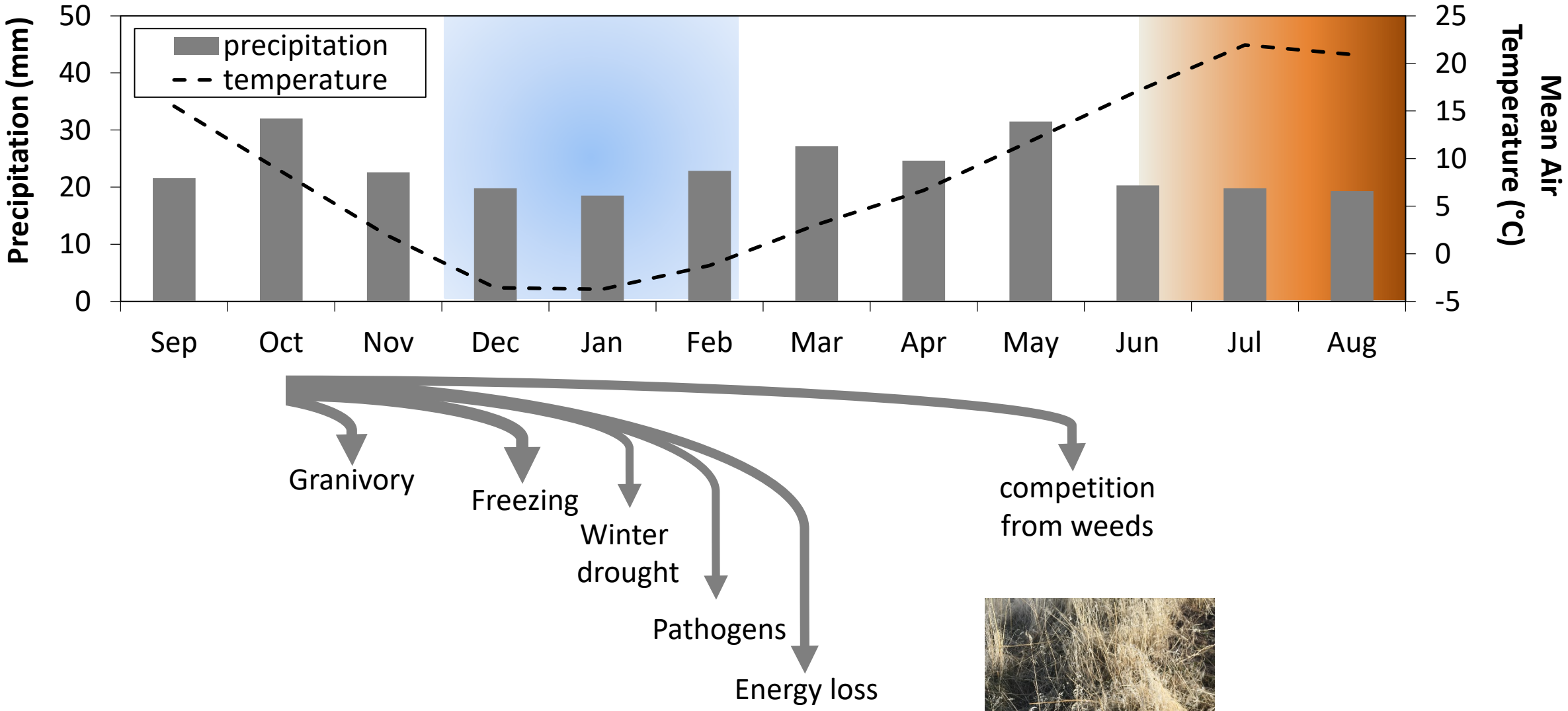
RESULTS



Improving seed and seedling fitness with fungicides

RESULTS




Precipitation (mm)
50
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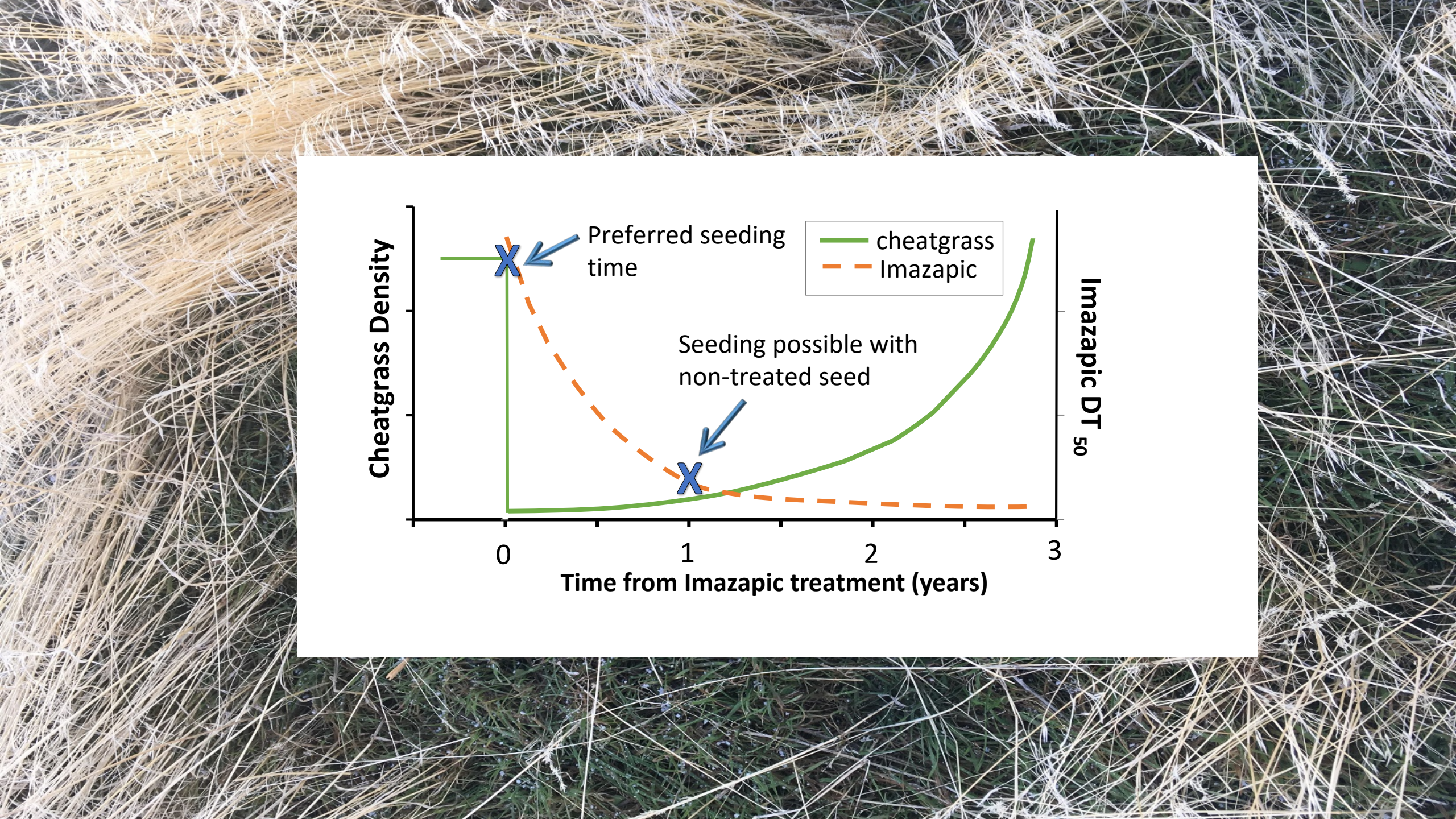
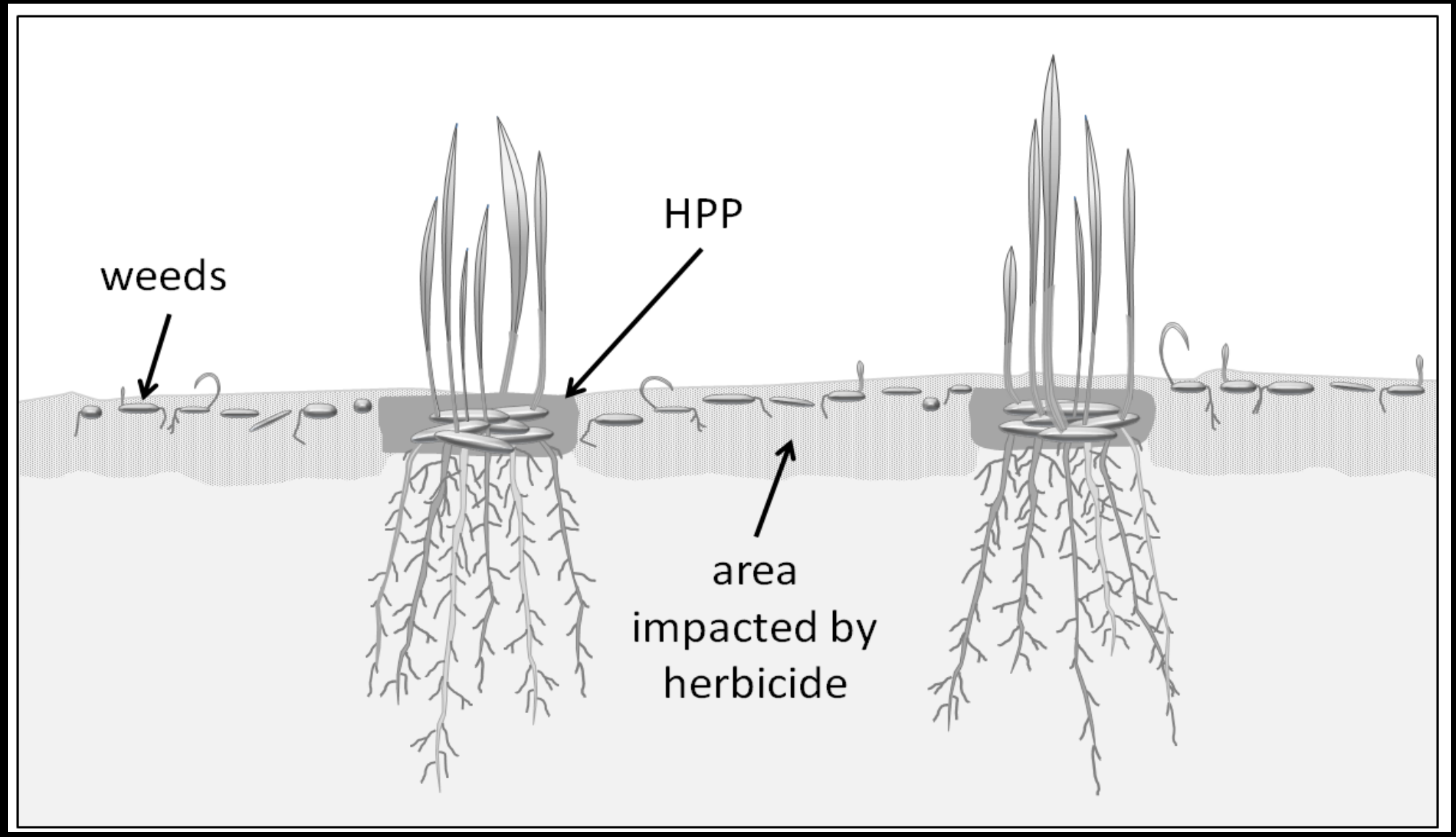
30
20
10
0
precipitation
temperature
25
20
15
10
5
0
-5
Mean Air Temperature (°C)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Granivory
Freezing
Winter drought
Pathogens
Energy loss
competition from weeds


Cheatgrass Density
Preferred seeding time
cheatgrass
Imazapic
Seeding possible with non-treated seed
Imazapic DT 50
0
1
2
3
Time from Imazapic treatment (years)

Herbicide Protection Pod



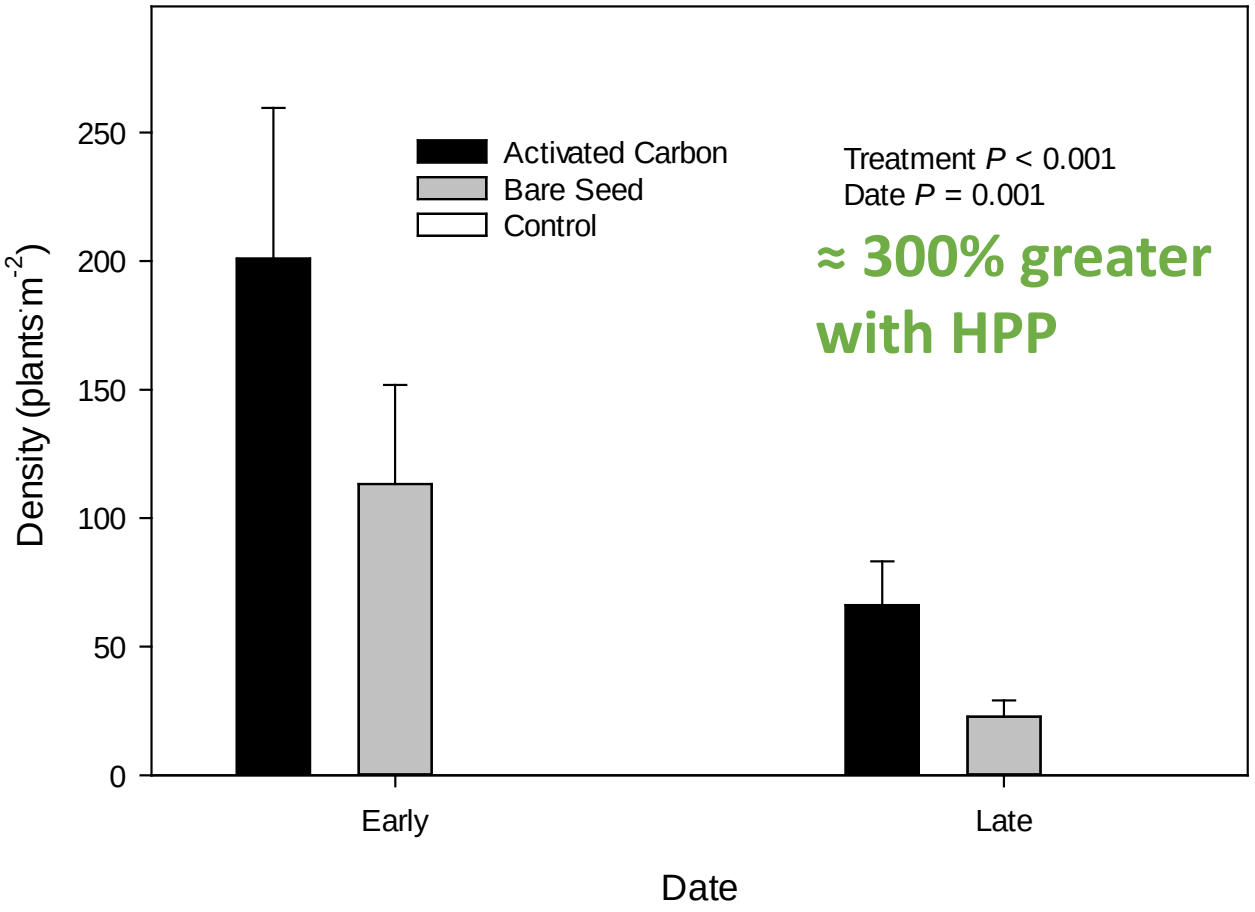
Field Trial

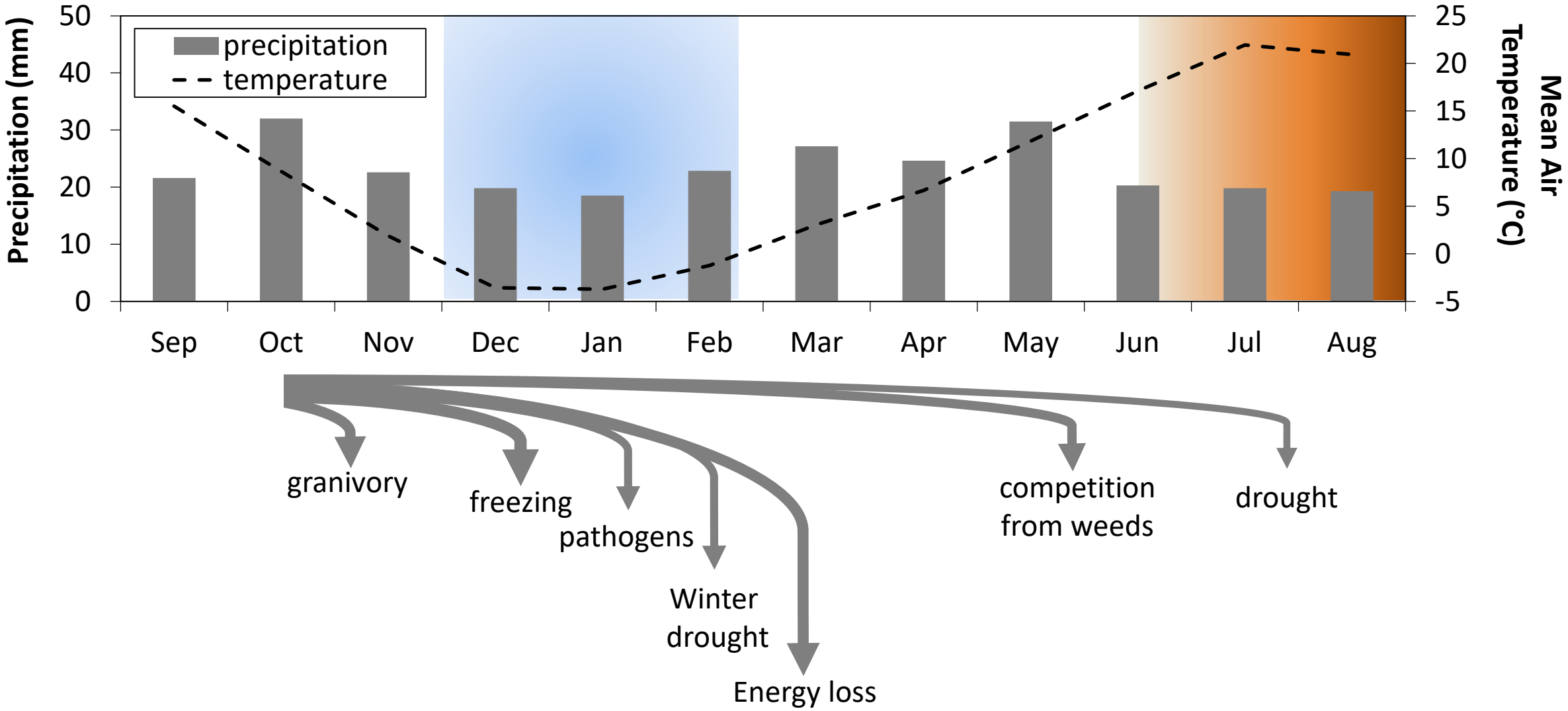
Rangeland Ecology & Management 70 (2017) 604–608

Using Activated Carbon to Limit Herbicide Effects to Seeded Bunchgra
When Revegetating Annual Grass-Invaded Rangelands☆

K.W. Davies [a,*], M.D. Madsen [b], A. Hulet [c]

Davies et al. 2017




Precipitation (mm)
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precipitation
temperature
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15
10
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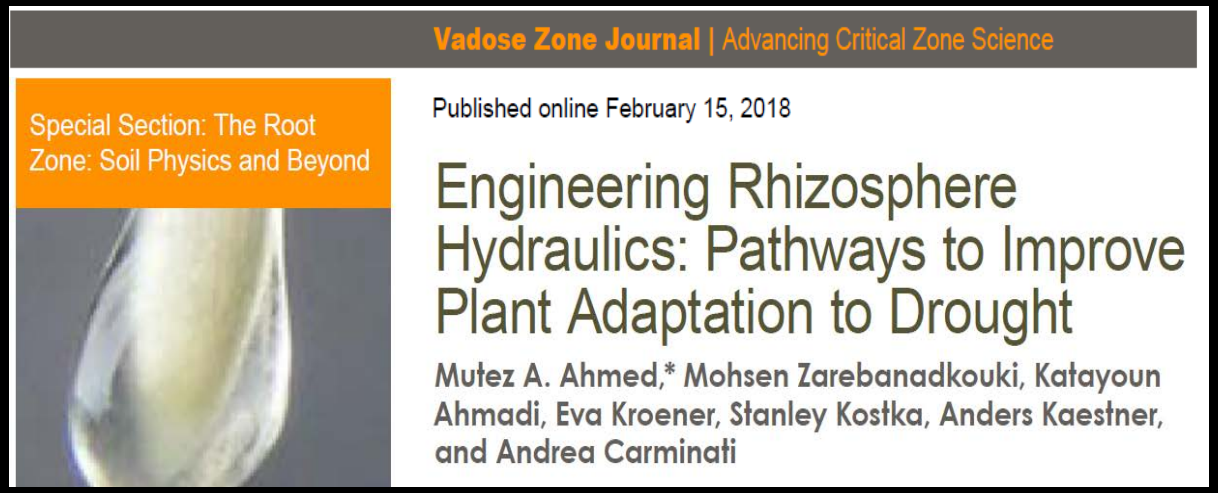
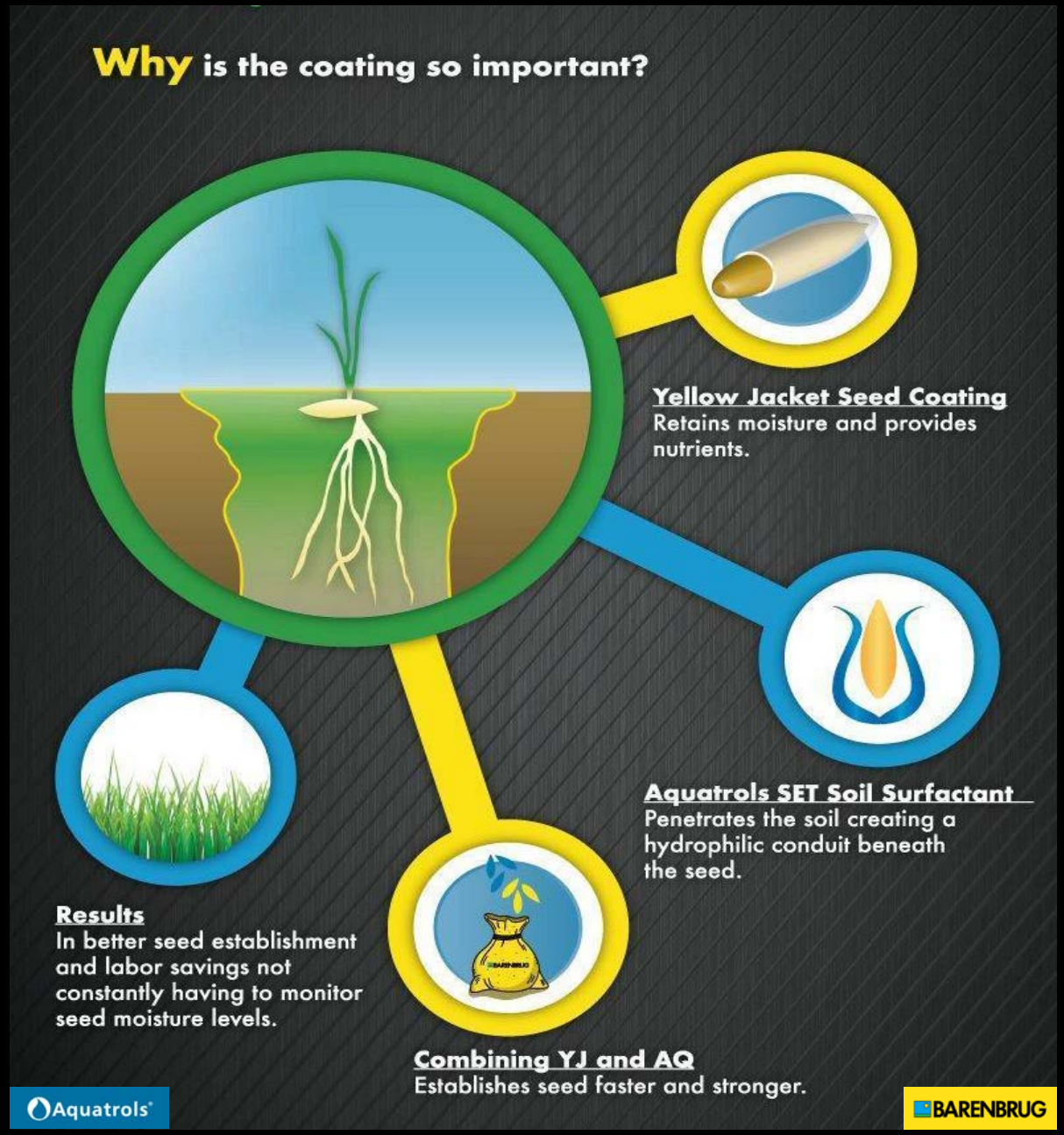
0
-5
Mean Air Temperature (°C)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
granivory
freezing
pathogens
Winter drought
Energy loss
competition from weeds
drought

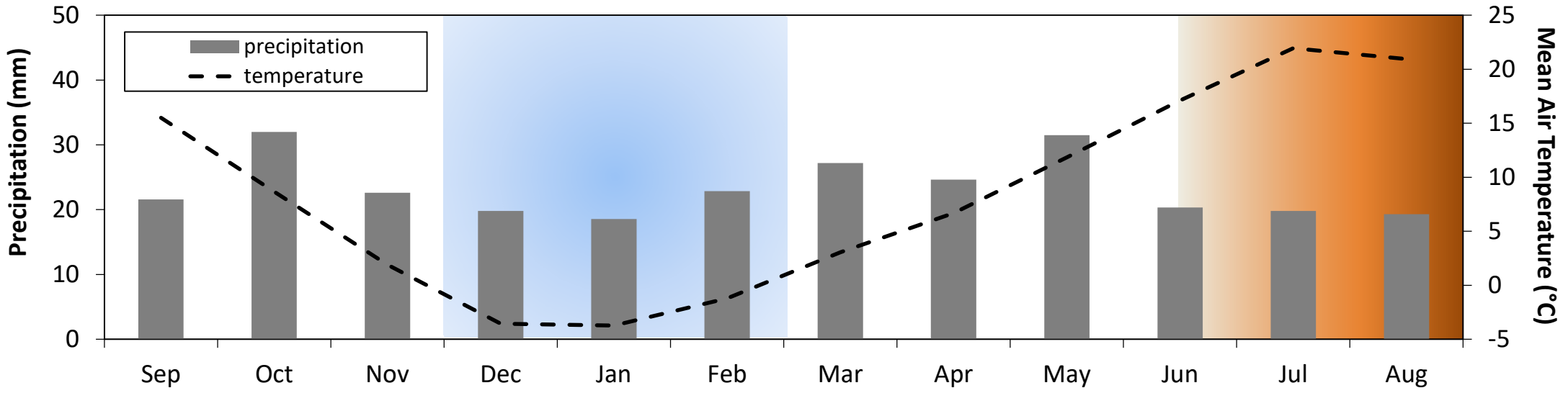
Surfactant Seed Coatings

- Madsen, Petersen, and Taylor. 2010. Patent Application # WO/2010/111309 submitted
- 2017: European accepted (#02410833/EP-B1)
- 2017: Technology commercialized by Aquatrols and Barenbrug





Summary


precipitation
temperature
Precipitation (mm)
Mean Air Temperature (°C)
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May
Jun
Jul
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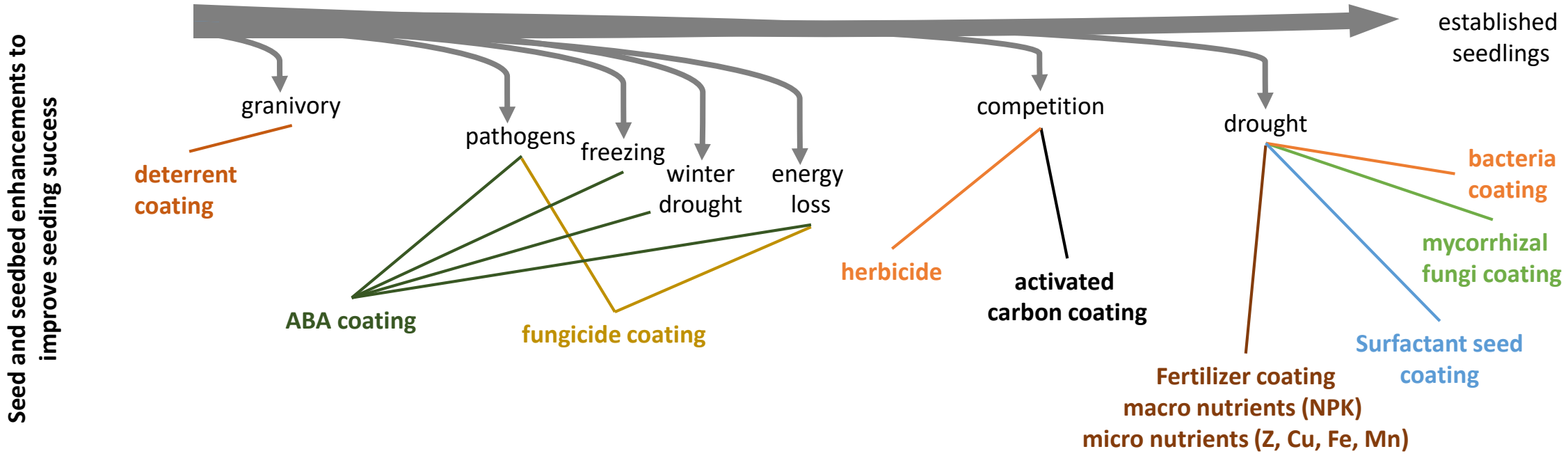
Seed and seedbed enhancements to improve seeding success
established seedlings
granivory
deterrent coating
pathogens
freezing
winter drought
energy loss
ABA coating
fungicide coating
competition
herbicide
activated carbon coating
drought
bacteria coating
mycorrhizal fungi coating
Surfactant seed coating
Fertilizer coating
macro nutrients (NPK)
micro nutrients (Z, Cu, Fe, Mn)

Thank You!