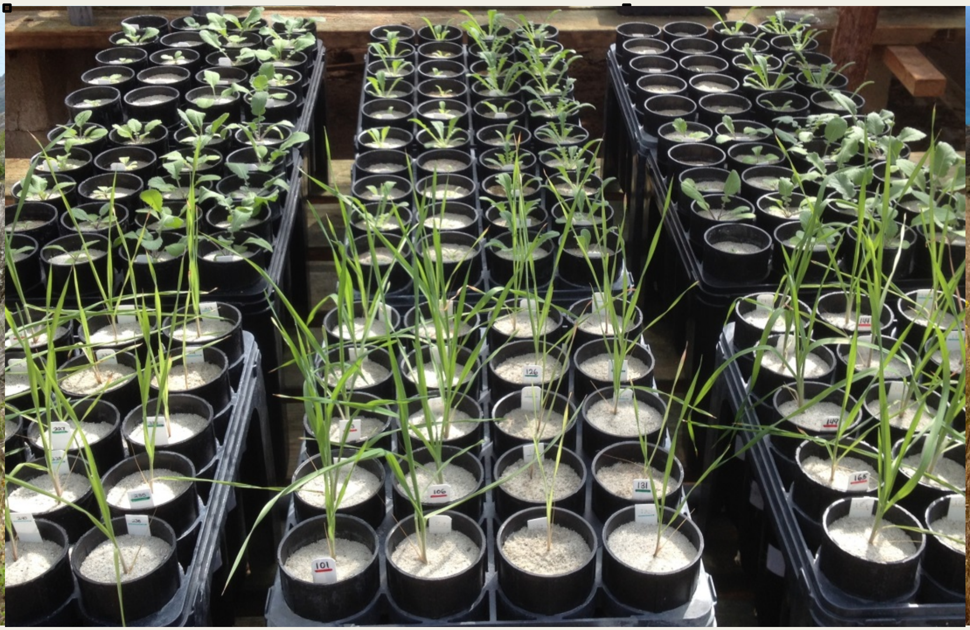
Nitrogen deposition facilitates nonnative plant invasion through increased nitrogen availability and changes to plant-soil feedbacks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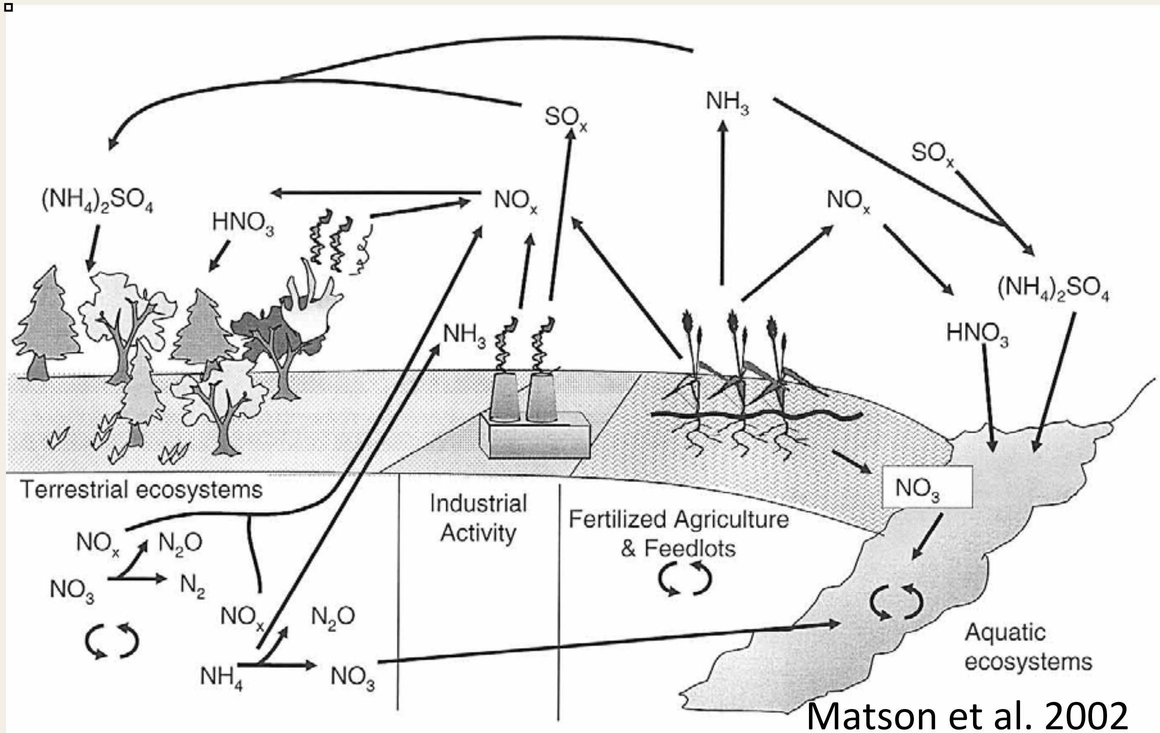
Chico, California
October 9, 2014

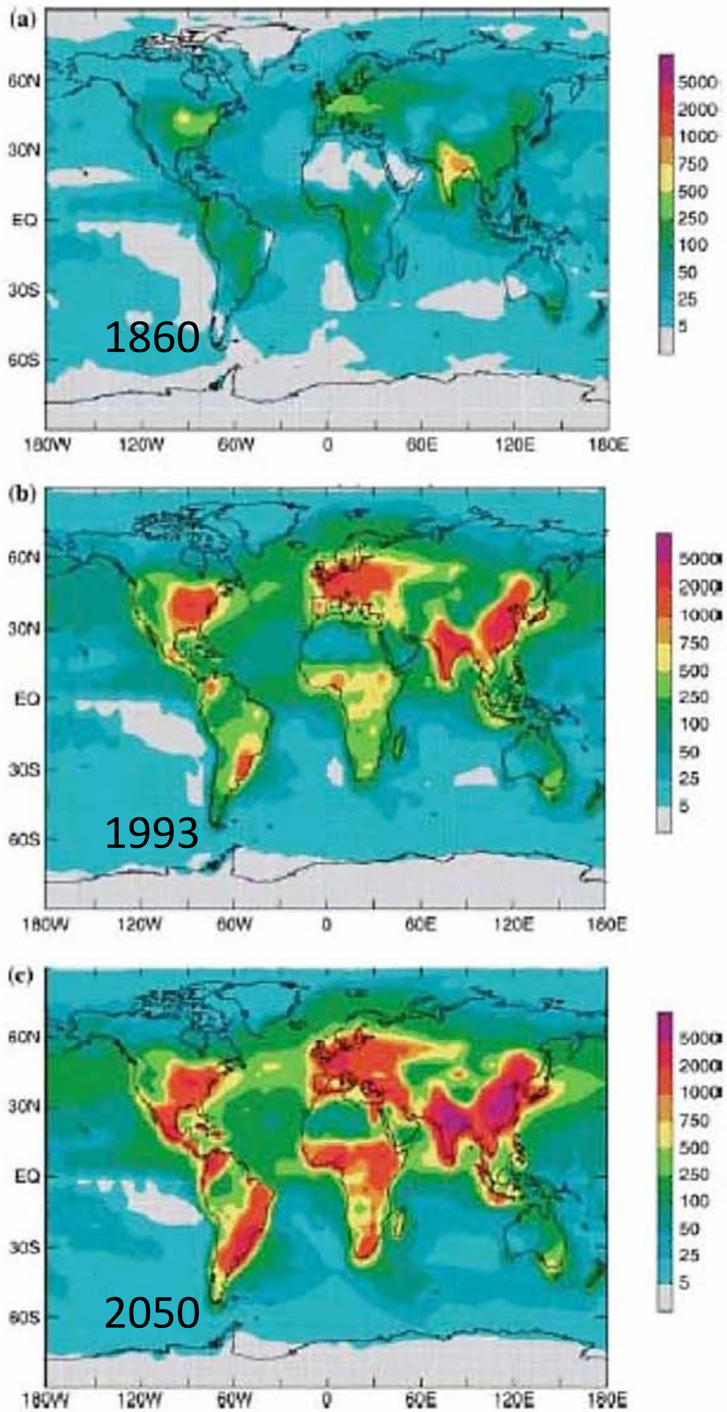
Nitrogen deposition – the input of reactive nitrogen to the Earth's surface from the atmosphere

Human Alteration of the Nitrogen Cycle



- Industrial, vehicular, and agricultural emissions contain ionic and particulate nitrogenous compounds
- This nitrogen settles out of the atmosphere onto the Earth's surface
- In arid systems, this accumulates as dry deposition during the summer and results in an influx of nitrogen with the first rains of the season

Nitrogen deposition

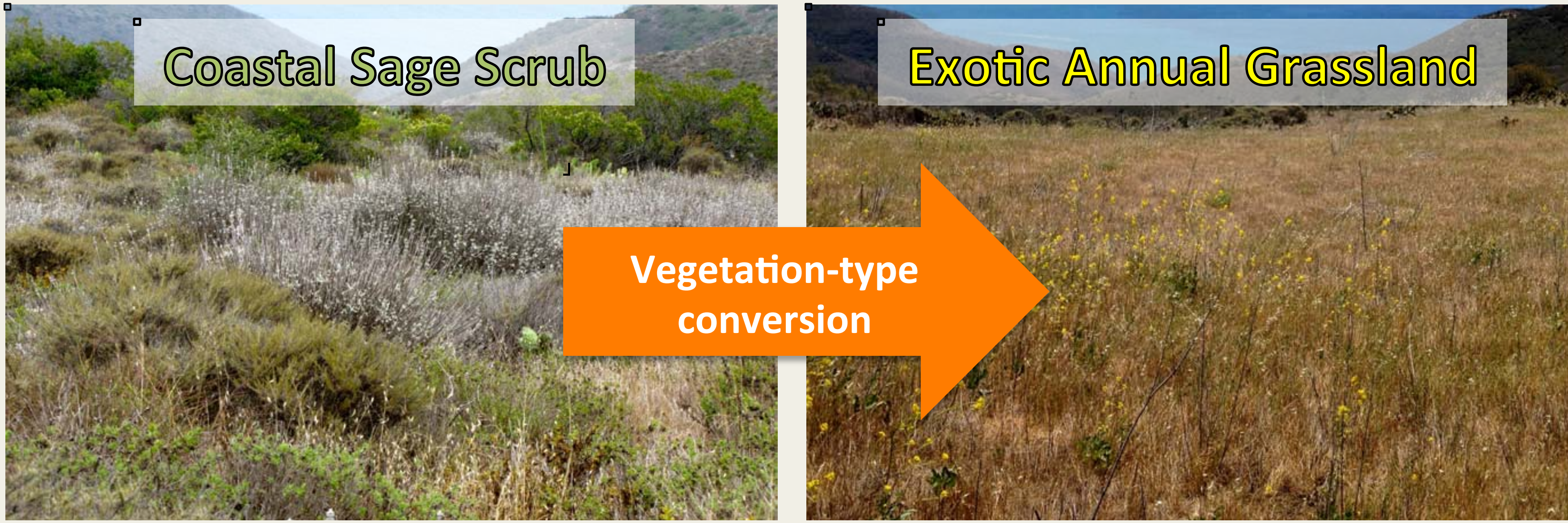


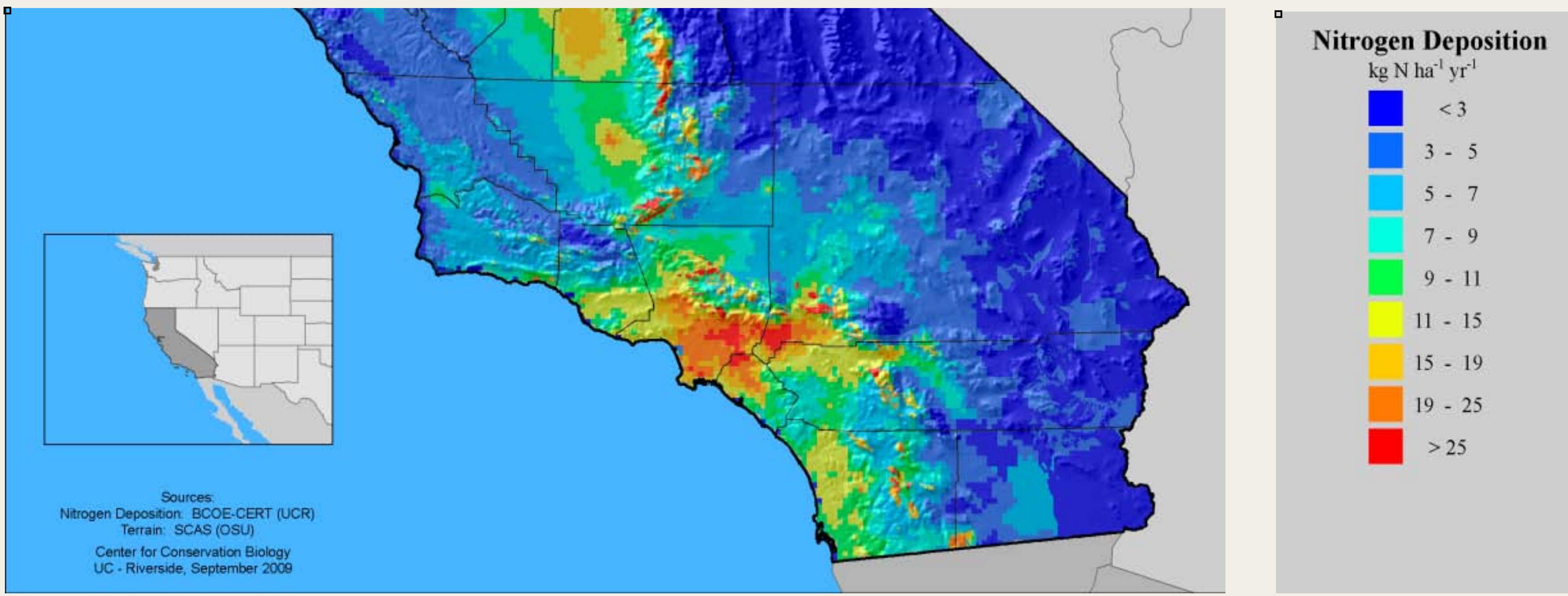
- Most terrestrial ecosystems are nitrogen limited.
- Global inputs of reactive N have more than doubled since the year 1900.
- Nitrogen addition has led to a reduction in terrestrial plant diversity and vegetation type conversion in ecosystems worldwide.

Global N deposition, mg $m^{-2}yr^{-1}$
(100 mg $m^{-2}yr^{-1}$ = 1 kg $ha^{-1}yr^{-1}$)

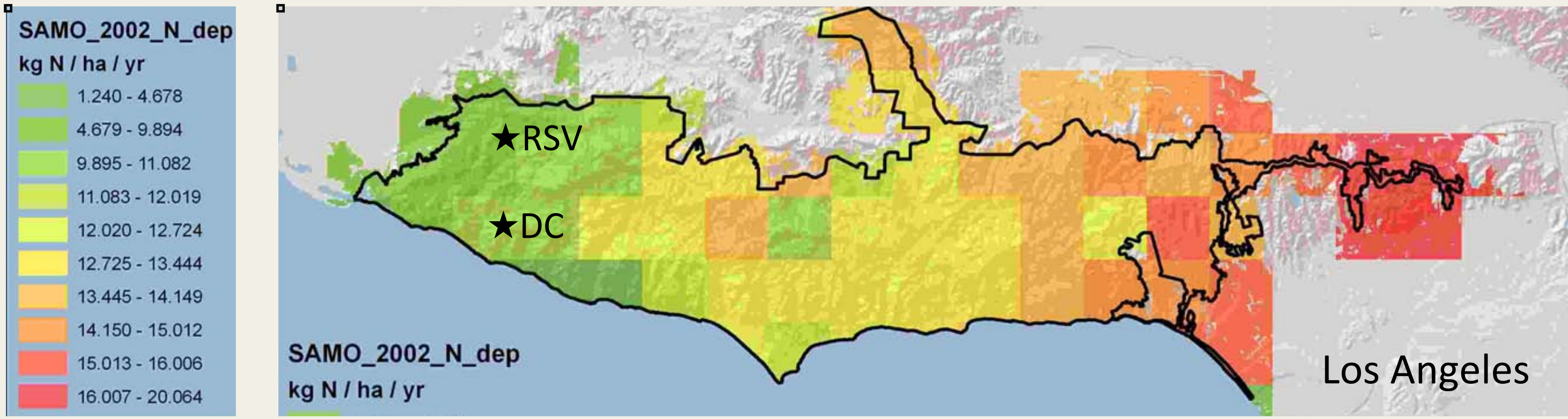
Dentener, F. J. 2006, http://daac.ornl.gov/
Galloway et al. 2006 Ecosystems

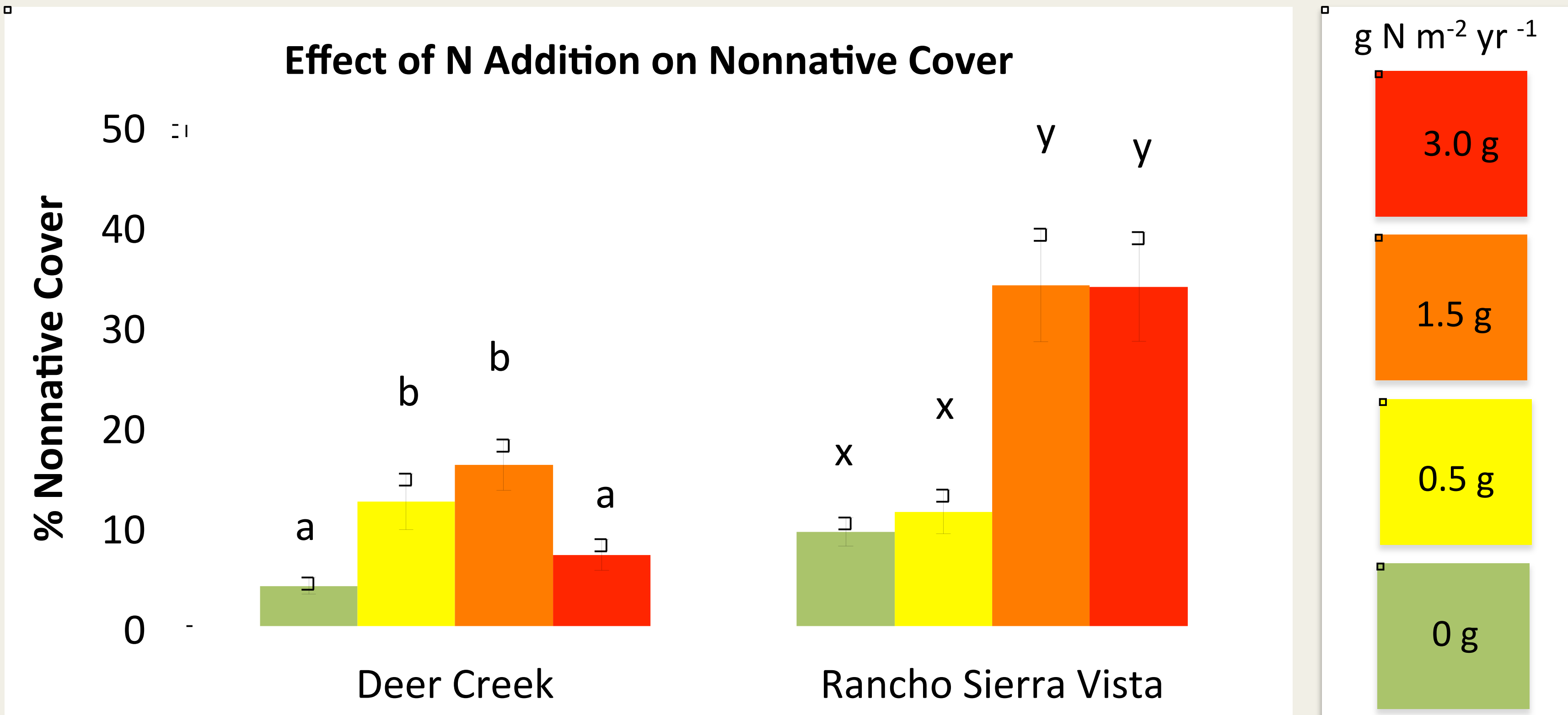
Nitrogen Deposition in Southern California



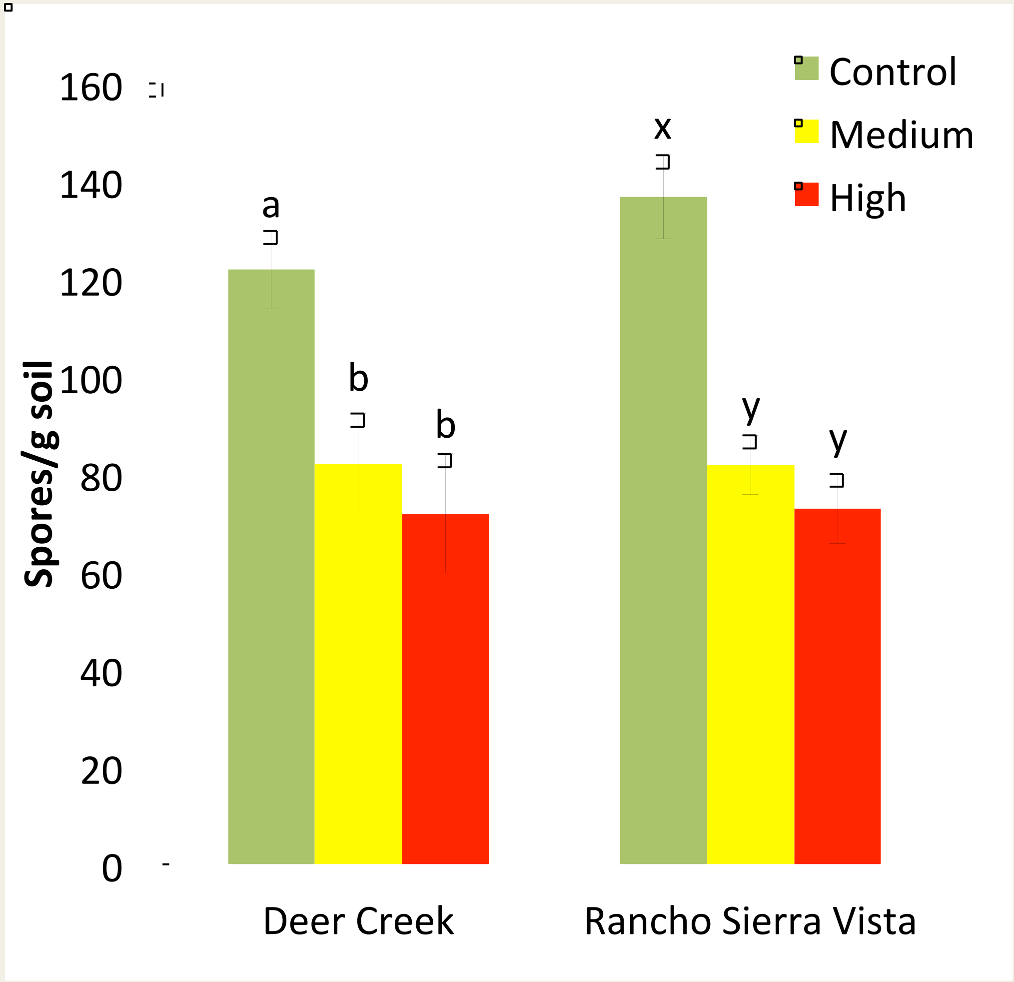


Nitrogen Deposition in the Santa Monica Mountains

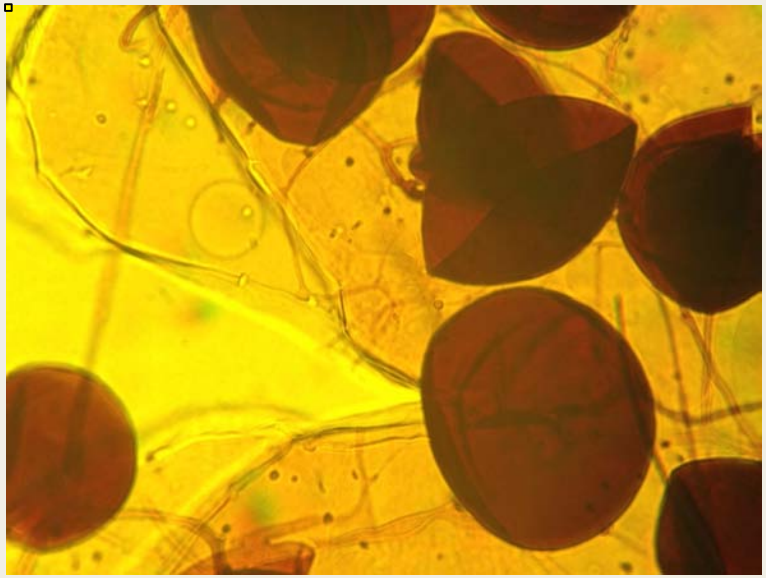


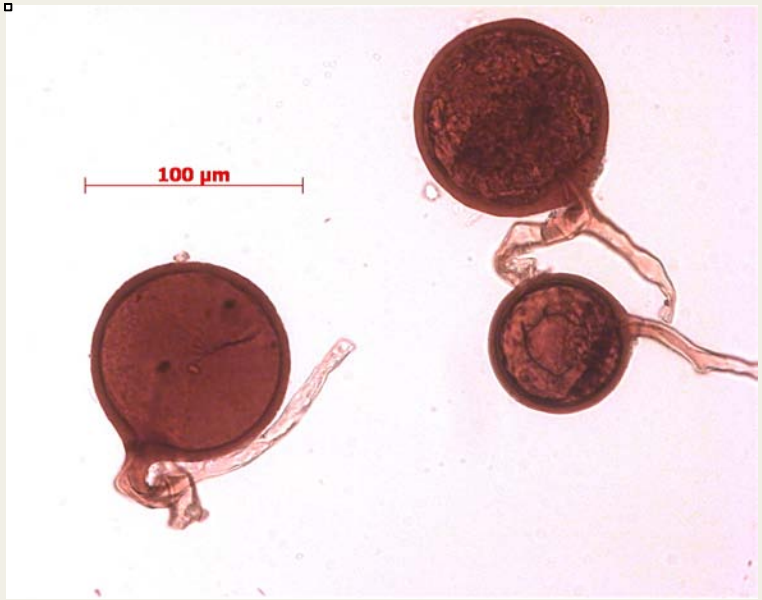


Nitrogen Deposition in the Santa Monica Mountains



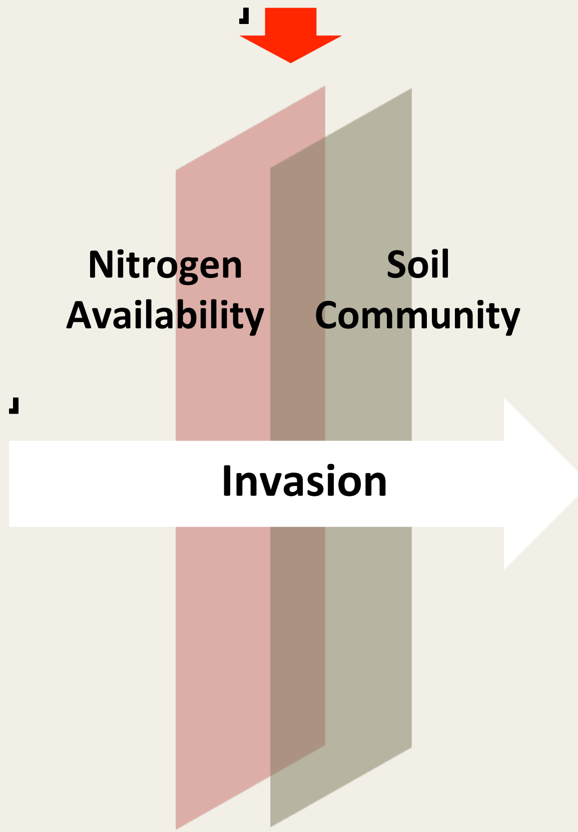
Effect of N addition on AMF spore density at two coastal sage scrub sites after one year of N addition





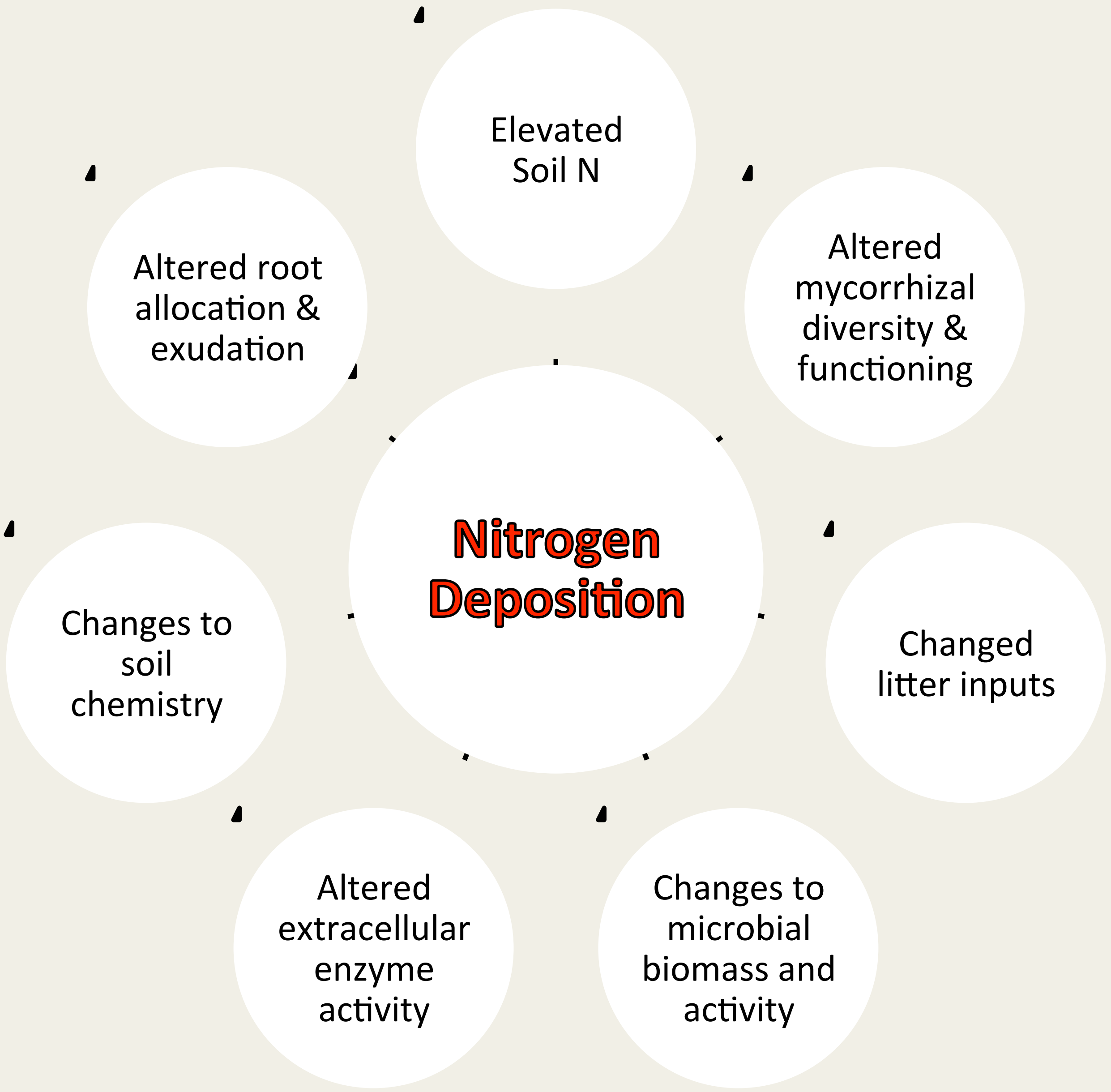
How does N deposition influence the invasion of nonnatives into coastal sage scrub?

Hirschfeldia incana *Bromus diandrus* *Centaurea melitensis*



Coastal Sage Scrub

Belowground effects of N deposition



Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic) which in turn influences plant performance

Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic), which in turn influences plant performance

Plant

e.g. increase in beneficial soil microorganisms

(+) (+)

Soil

Positive plant-soil feedback

Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic), which in turn influences plant performance

Plant

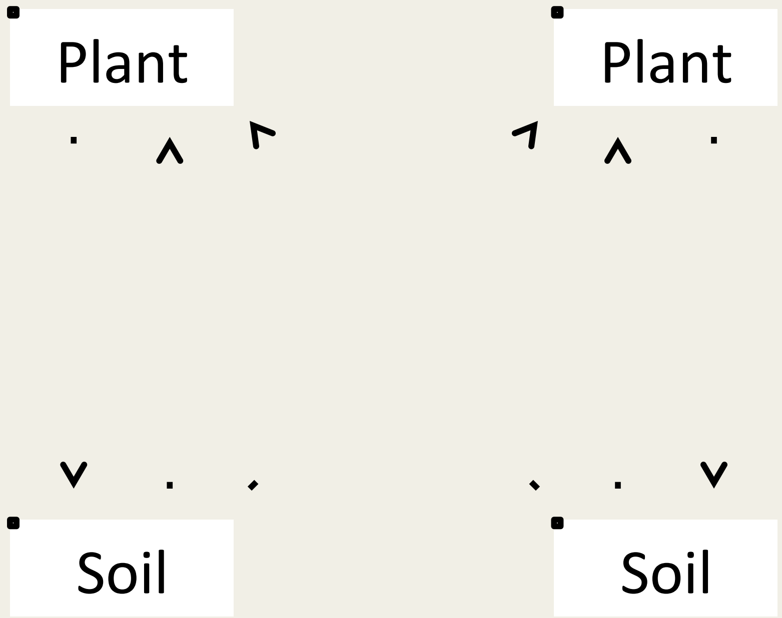
e.g. increase in pathogenic soil microorganisms

(-) (-)

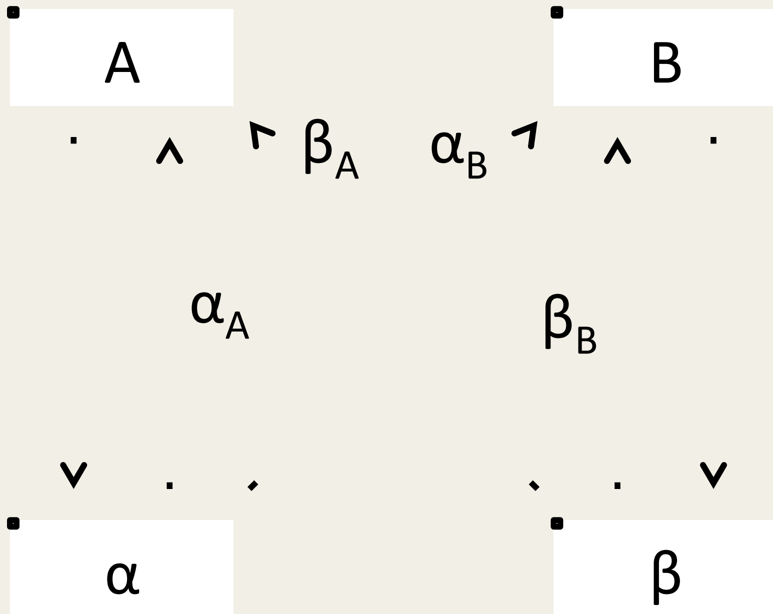
Soil

Negative plant-soil feedback

Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic), which in turn influences plant performance

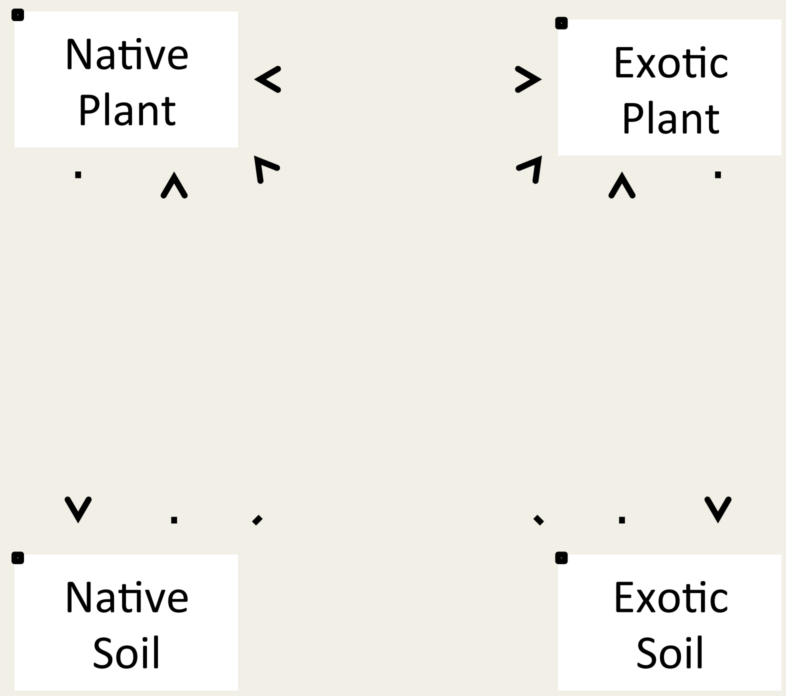


Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic), which in turn influences plant performance

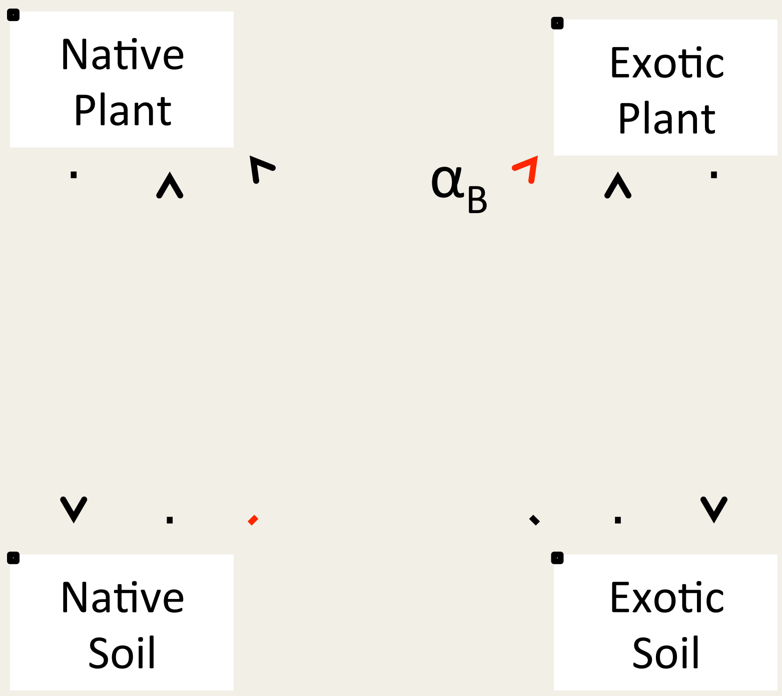


Bever, J. D., K. M. Westover, and J. Antonovics. 1997. Incorporating the soil community into plant population dynamics: the utility of the feedback approach. Journal of Ecology **85**:561-573.

Plant-soil feedback – plants have an influence on soil properties (physical, chemical, biotic), which in turn influences plant performance

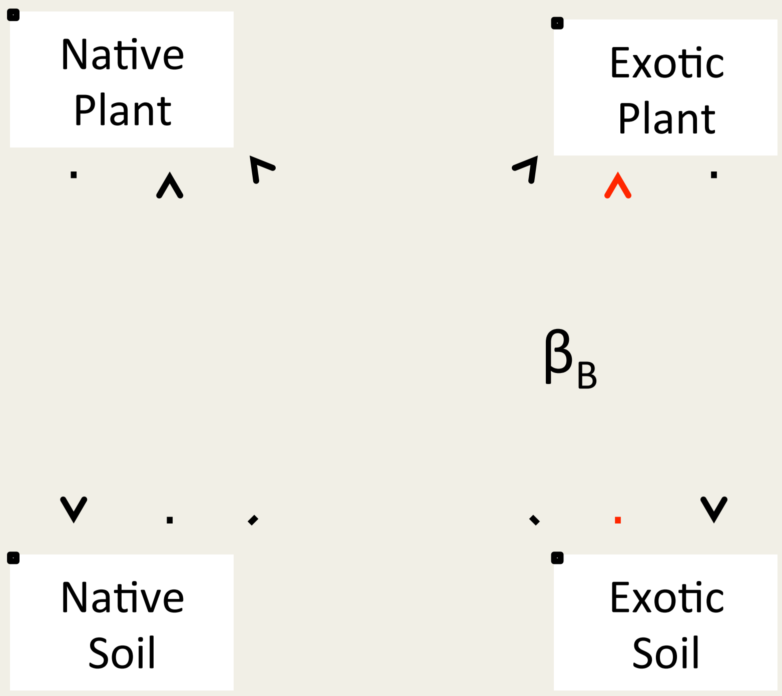


How do three nonnatives respond to soil communities conditioned by a dominant native shrub?



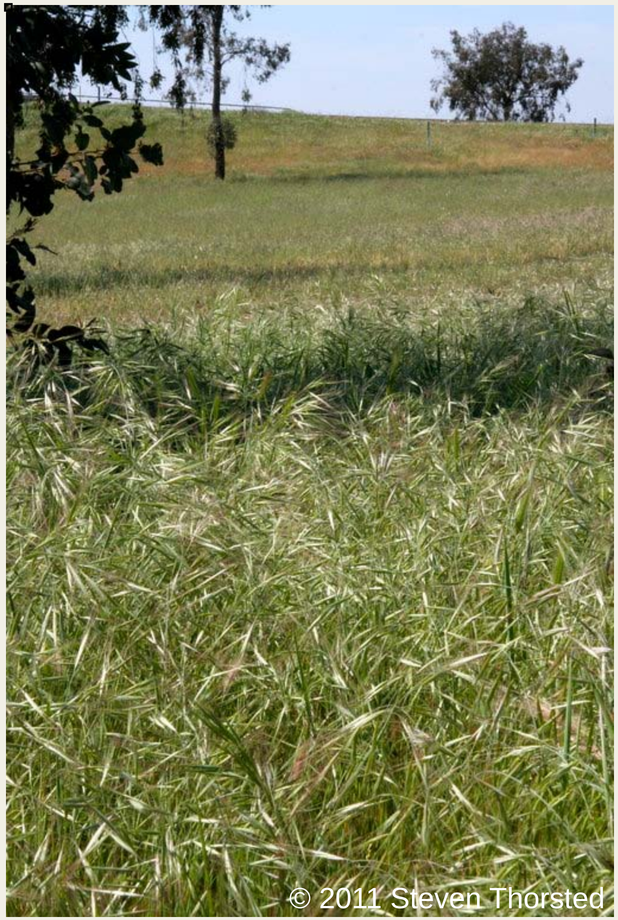
How does N deposition influence these responses?

How do three nonnatives respond to soil communities conditioned by conspecifics?



How does N deposition influence these responses?

Study Species

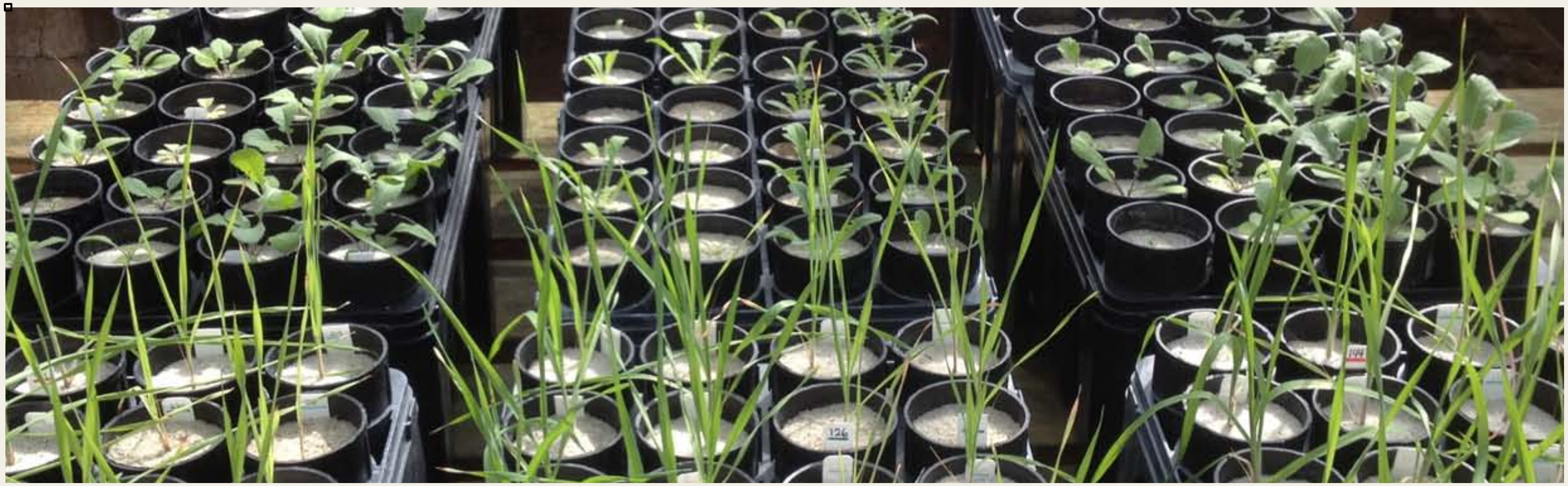


Bromus diandrus
Ripgut Brome

Centaurea melitensis
Tocalote

Hirschfeldia incana
Shortpod Mustard

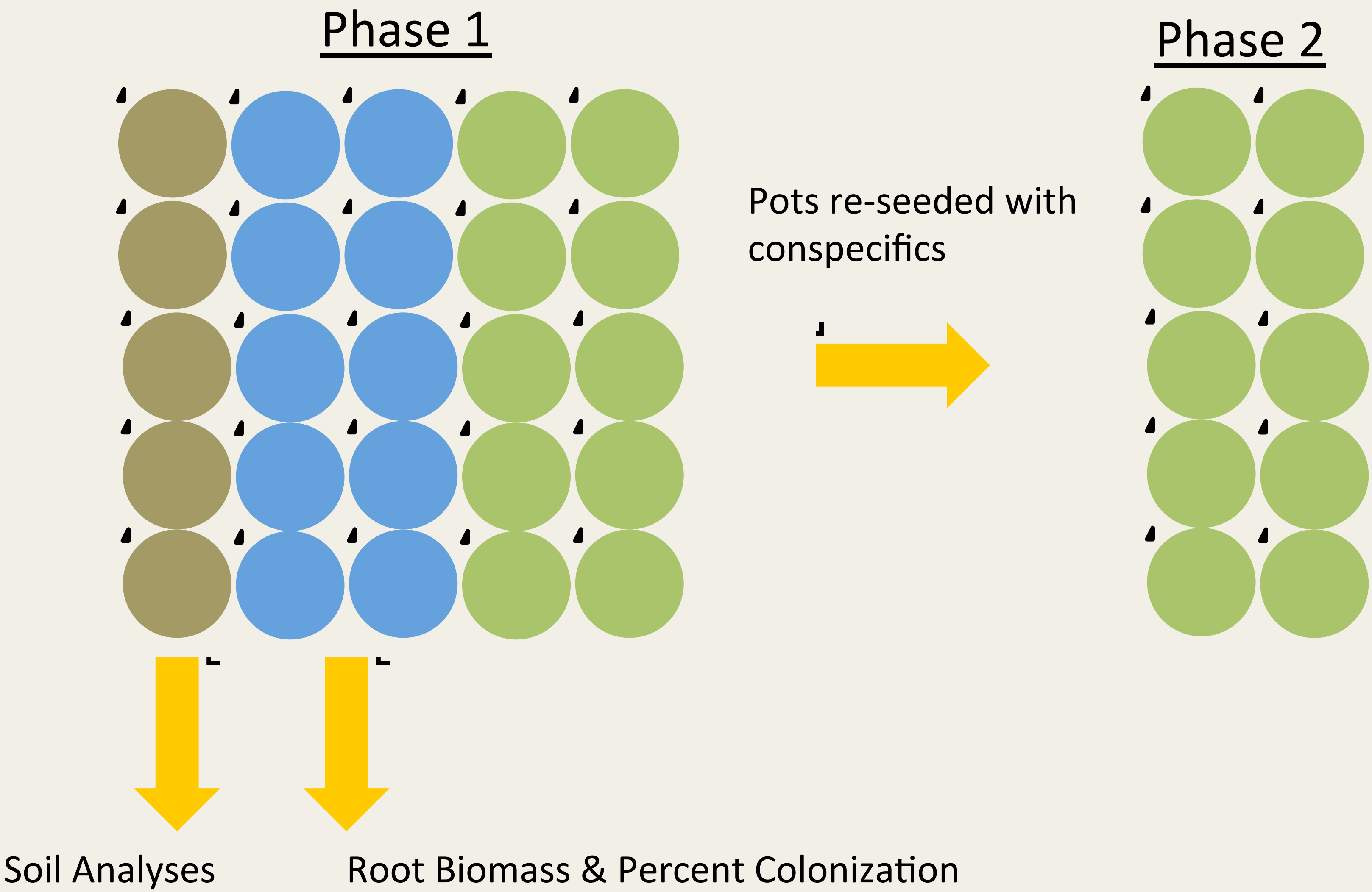
Experimental Design



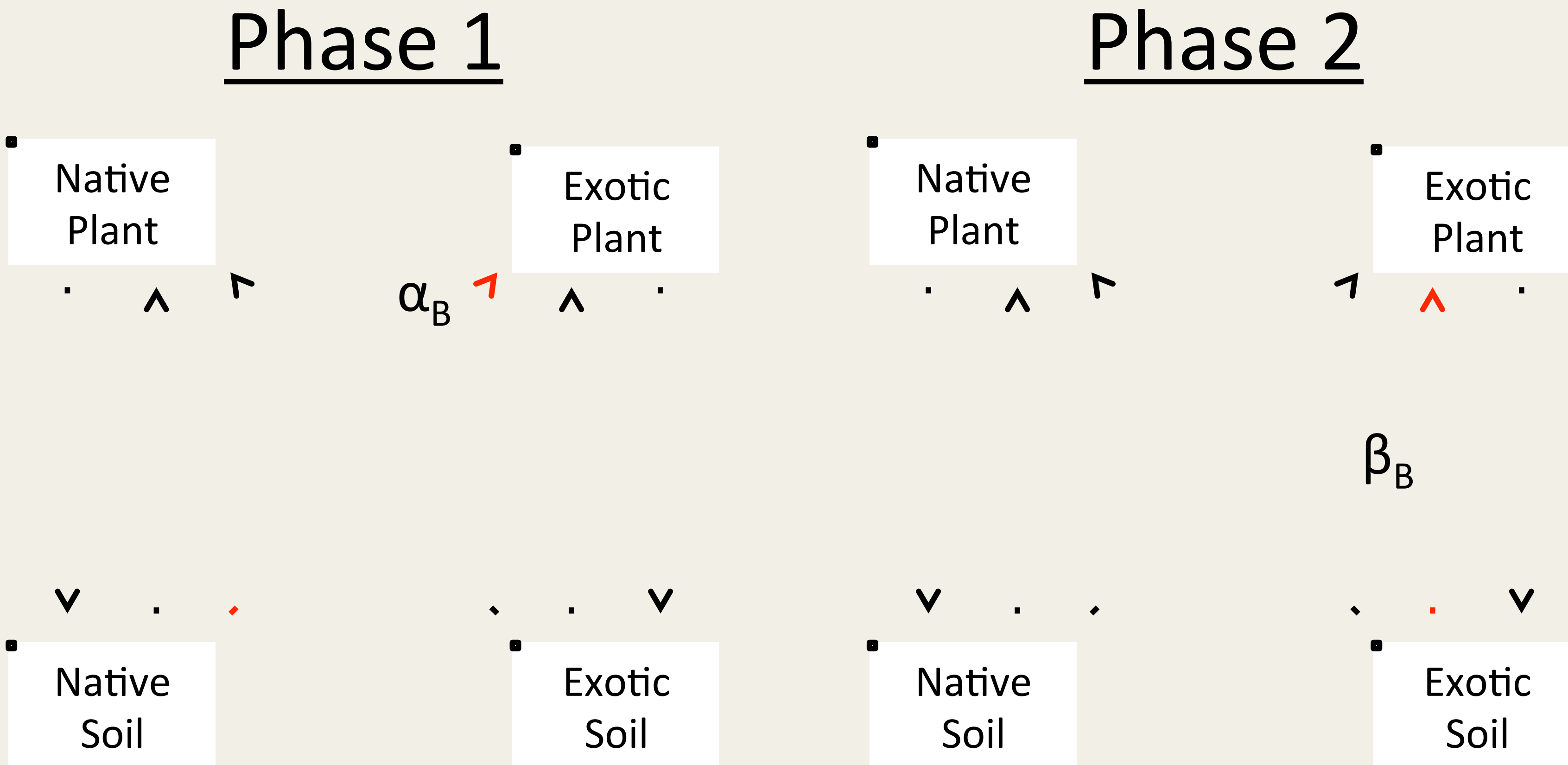
Full factorial greenhouse experiment

3	x	2	x	3
Species:		Nitrogen:		Inoculum:
B. diandrus		High N		Low dep.
C. melitensis		Low N		High dep.
H. incana				Sterile

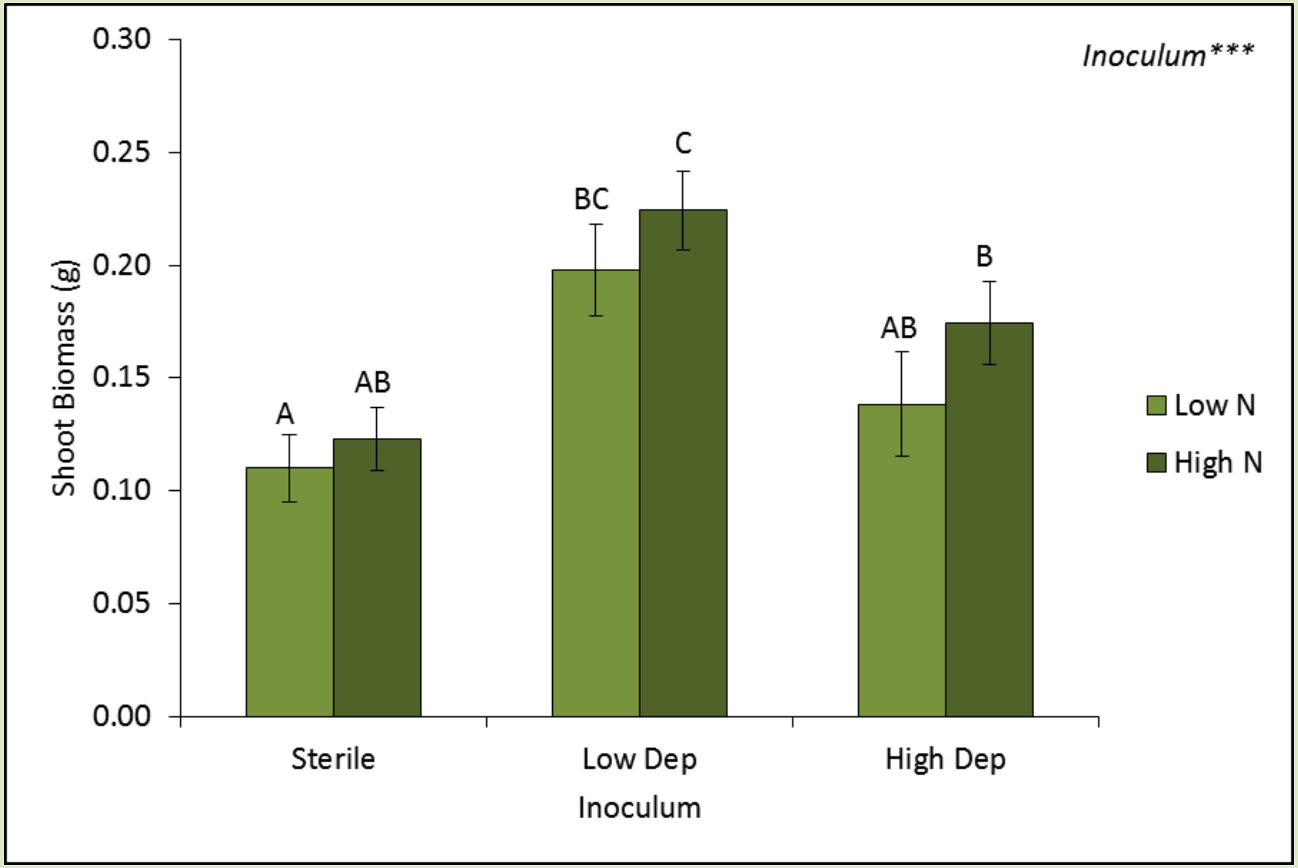
Experimental Design

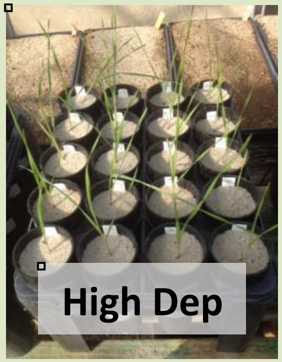


Experimental Design



Bromus diandrus



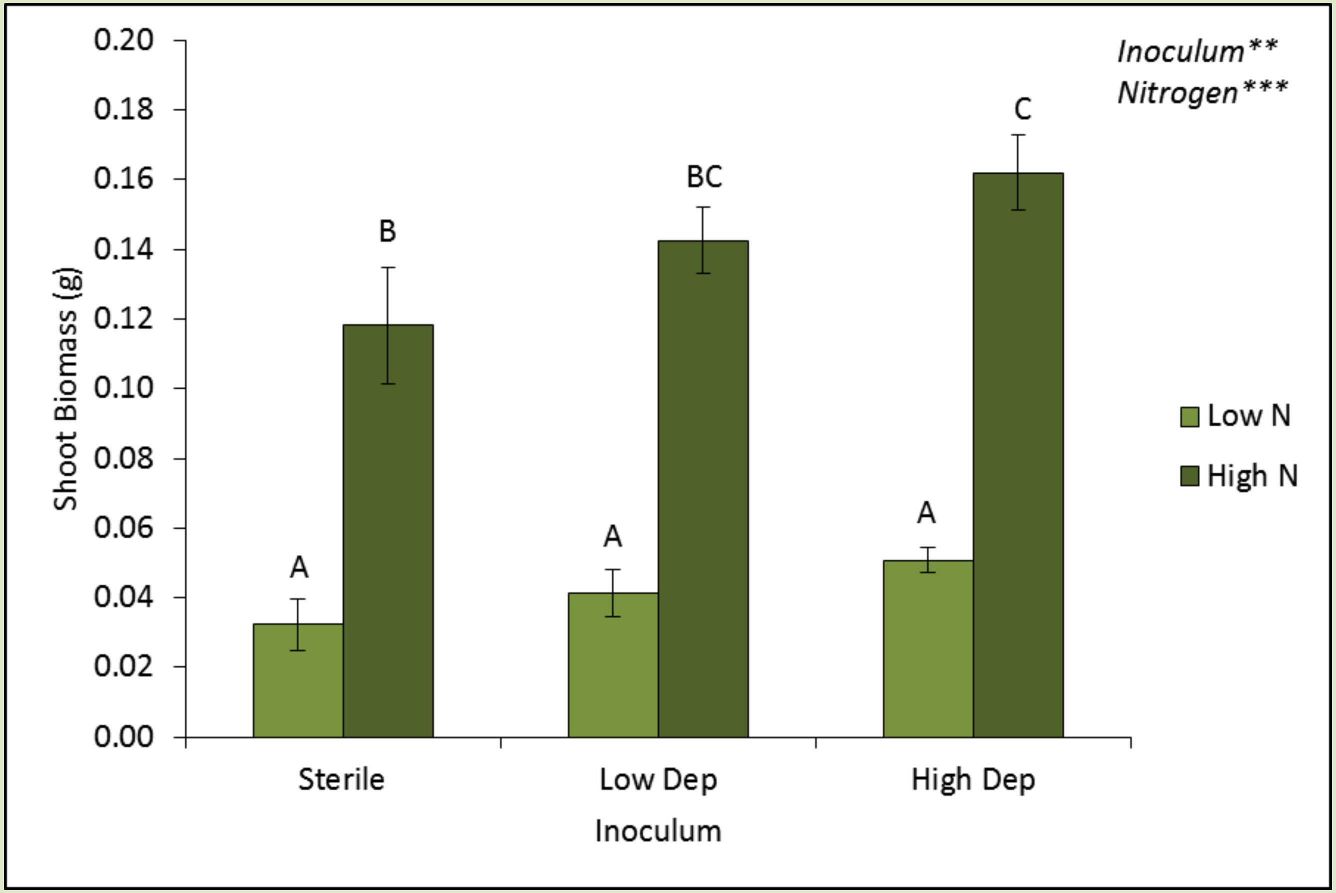


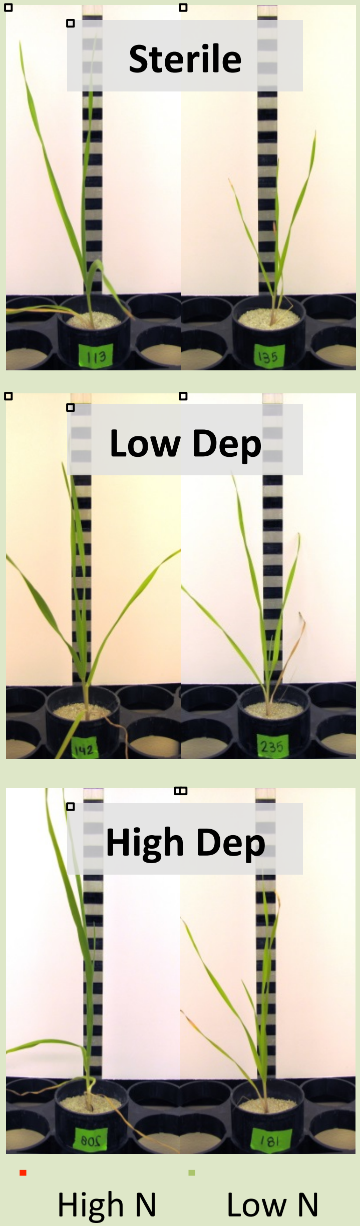
High N Low N

Shoot biomass – Phase 1

- Greatest mean shoot biomass in Low inoculum under high N availability
- Inoculum significantly affects shoot biomass

Bromus diandrus

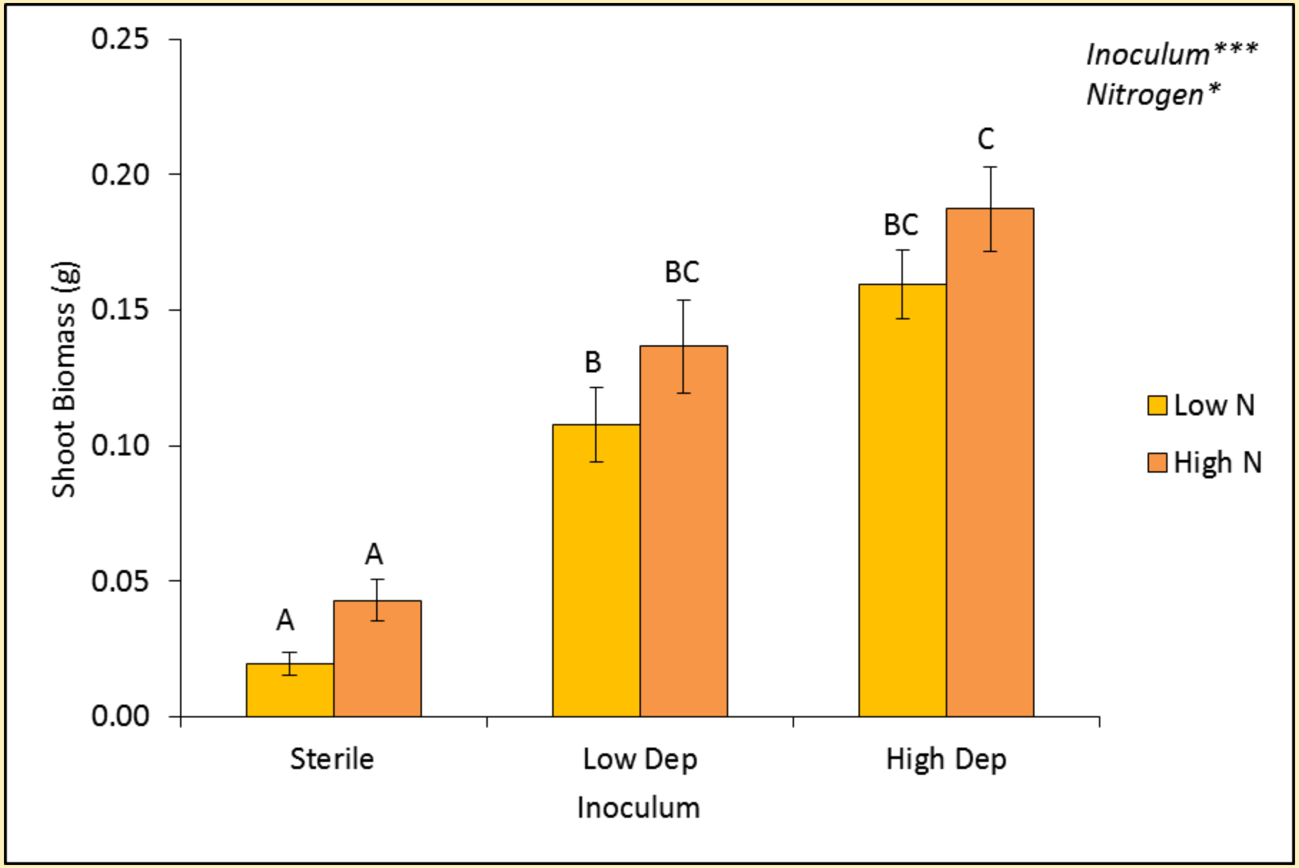




Shoot biomass – Phase 2

- Plants perform best in live inoculum under high N, with greatest mean biomass in High Dep inoculum
- Inoculum and nitrogen significantly affect shoot biomass

Centaurea melitensis

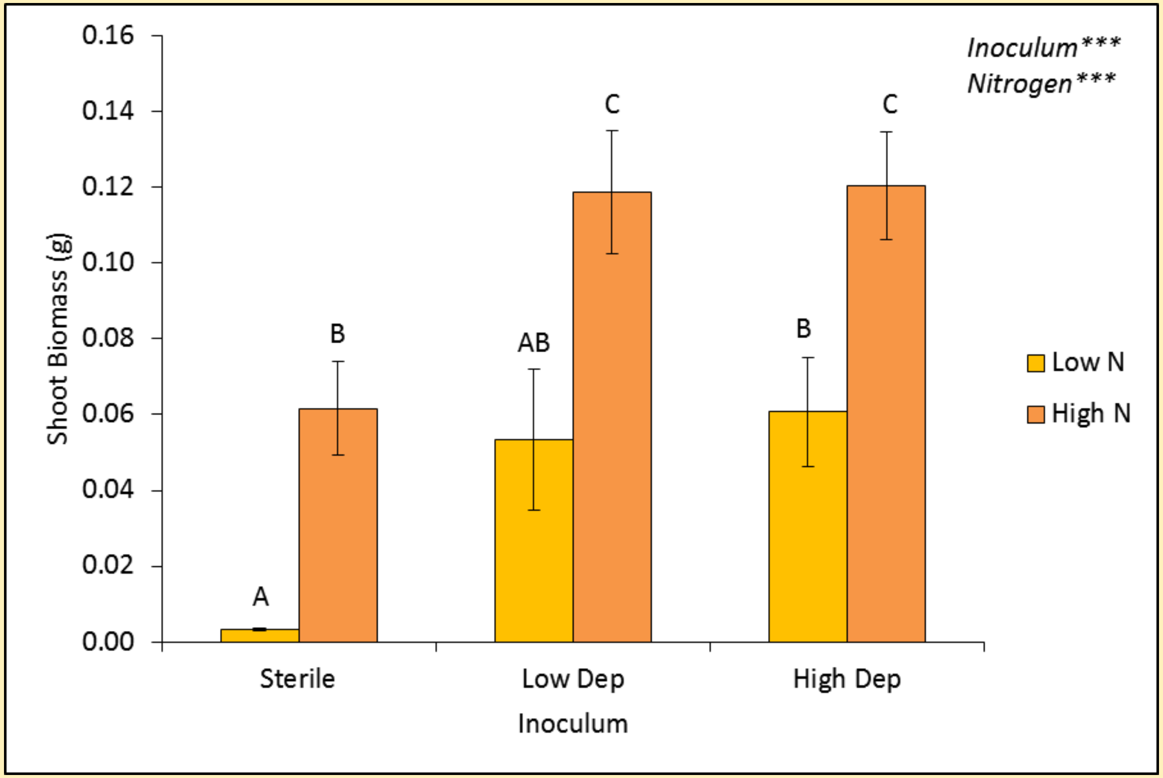


High N Low N

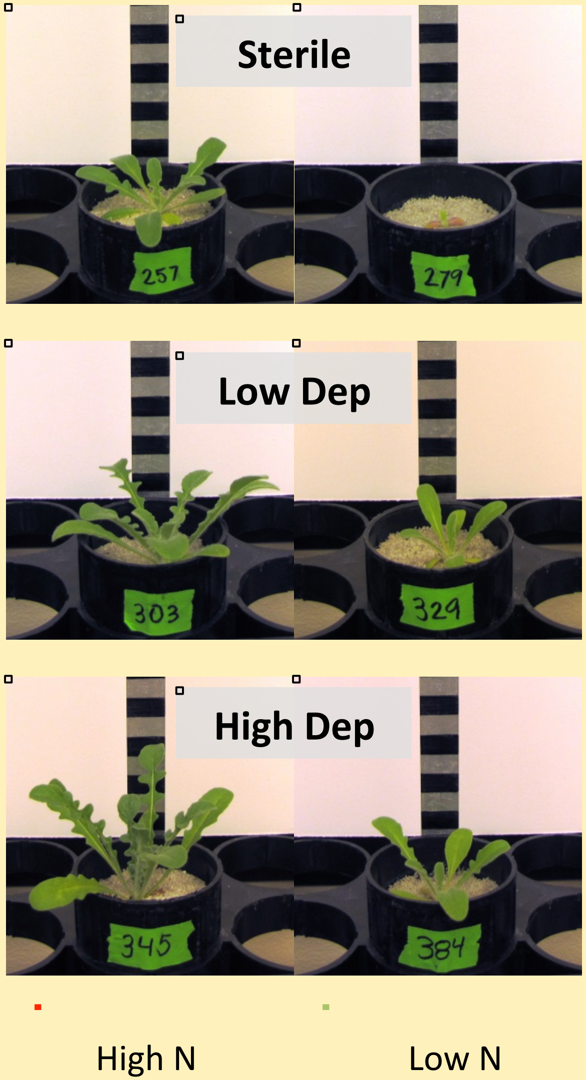
Shoot biomass – Phase 1

- Plants perform better in live inocula
- Greatest shoot biomass in High Dep inoculum, especially under high N
- Inoculum and nitrogen significantly affect shoot biomass

Centaurea melitensis

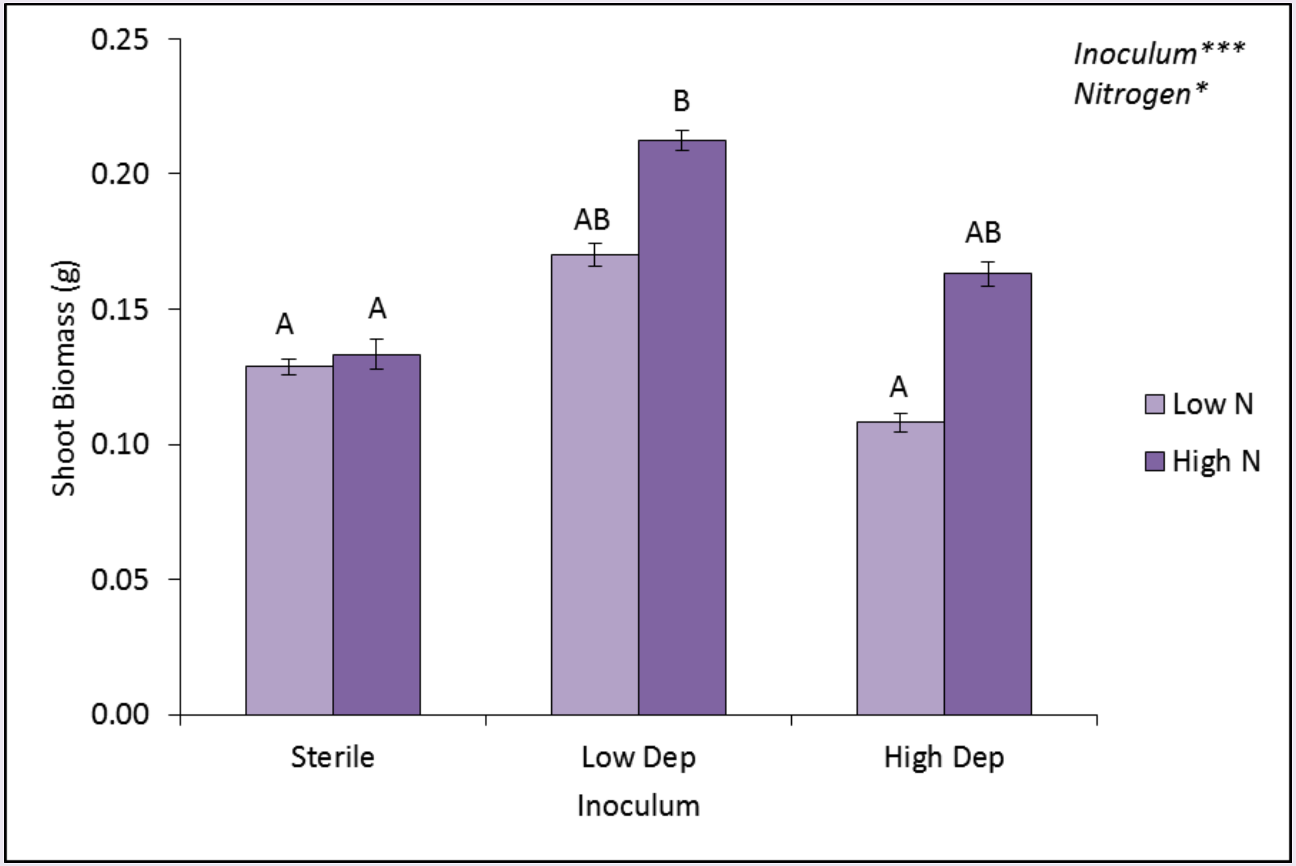


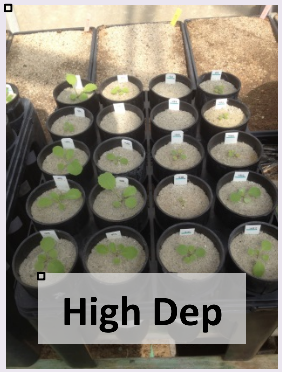
Shoot biomass – Phase 2



- Plants perform best in live inoculum, especially under high N
- Inoculum and nitrogen significantly affect shoot biomass

Hirschfeldia incana



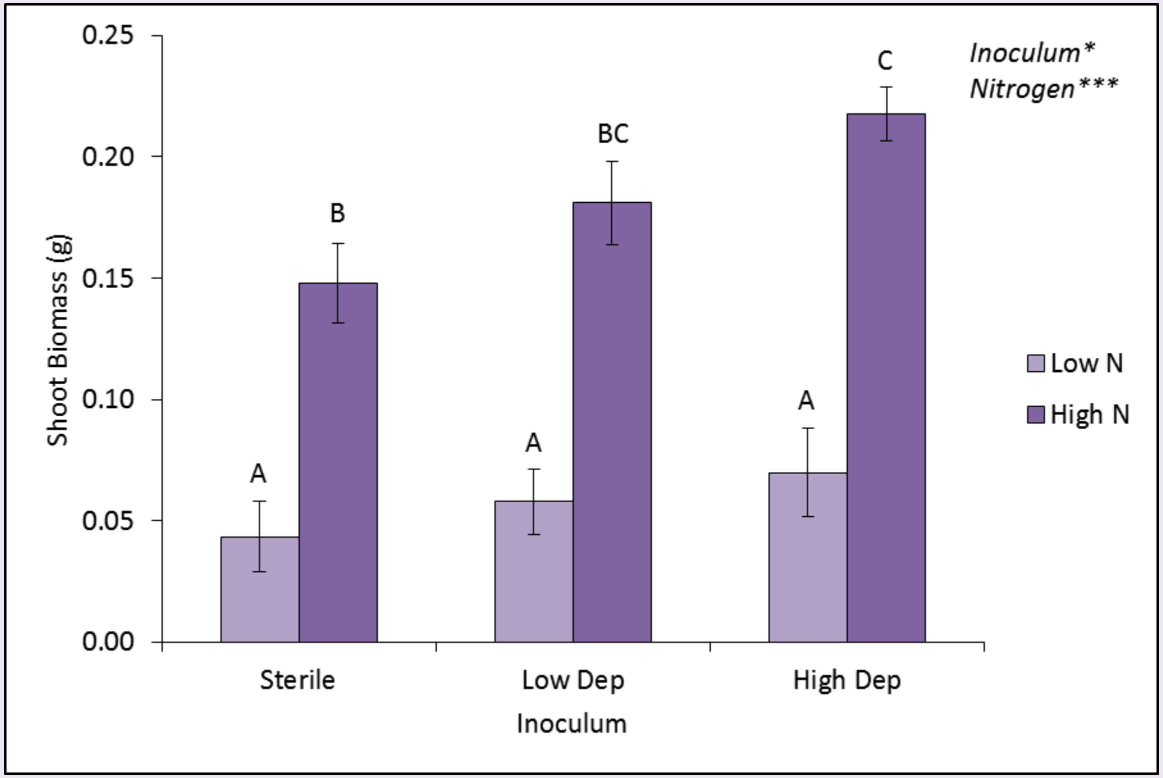


High N Low N

Shoot Biomass – Phase 1

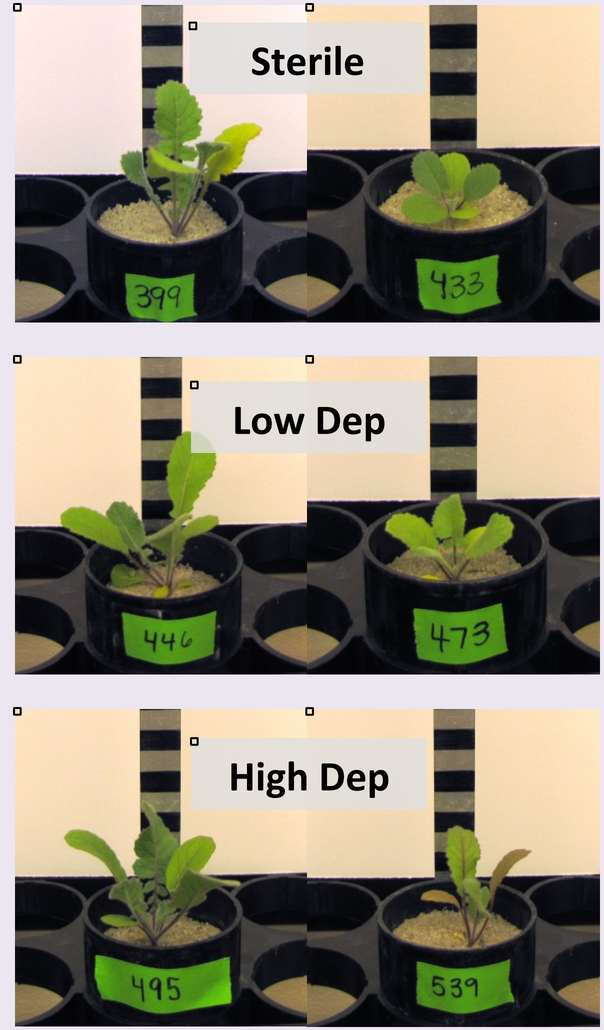
- Highest shoot biomass in Low Dep inoculum under high nitrogen
- Inoculum and nitrogen significantly affect total biomass

Hirschfeldia incana

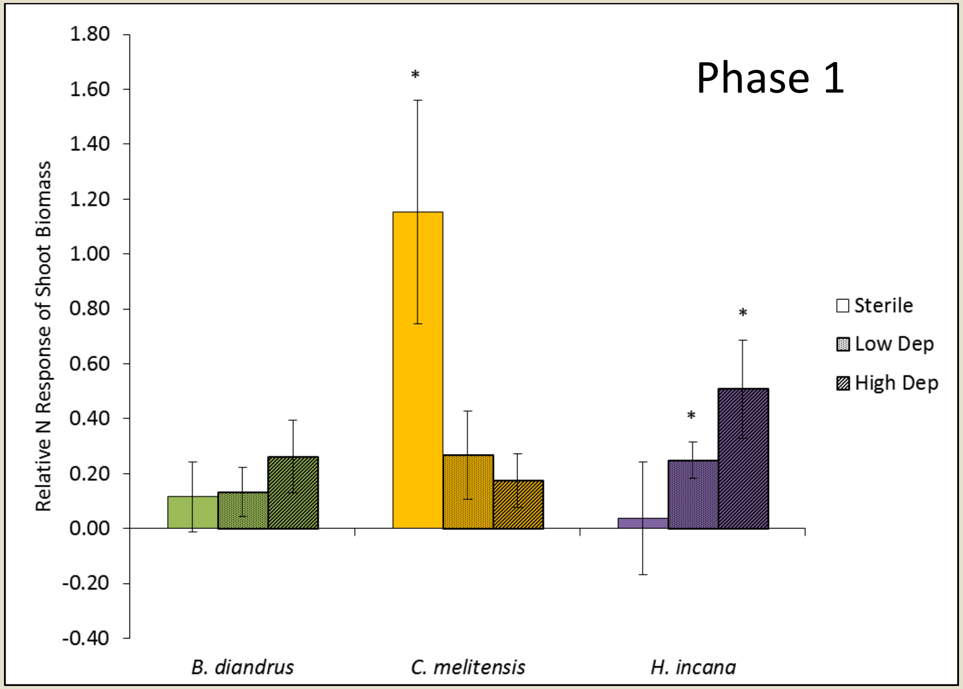


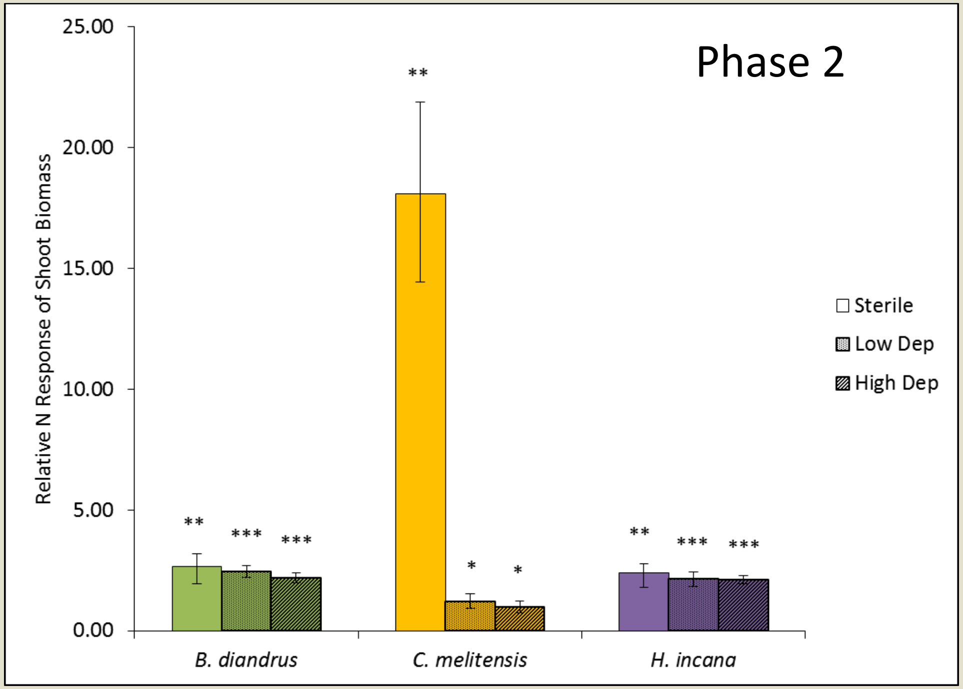
Shoot biomass – Phase 2

- Plants perform best in live soil under high N with highest shoot biomass in High Dep inoculum
- Inoculum and nitrogen significantly affect shoot biomass



High N Low N





Relative Nitrogen Responses

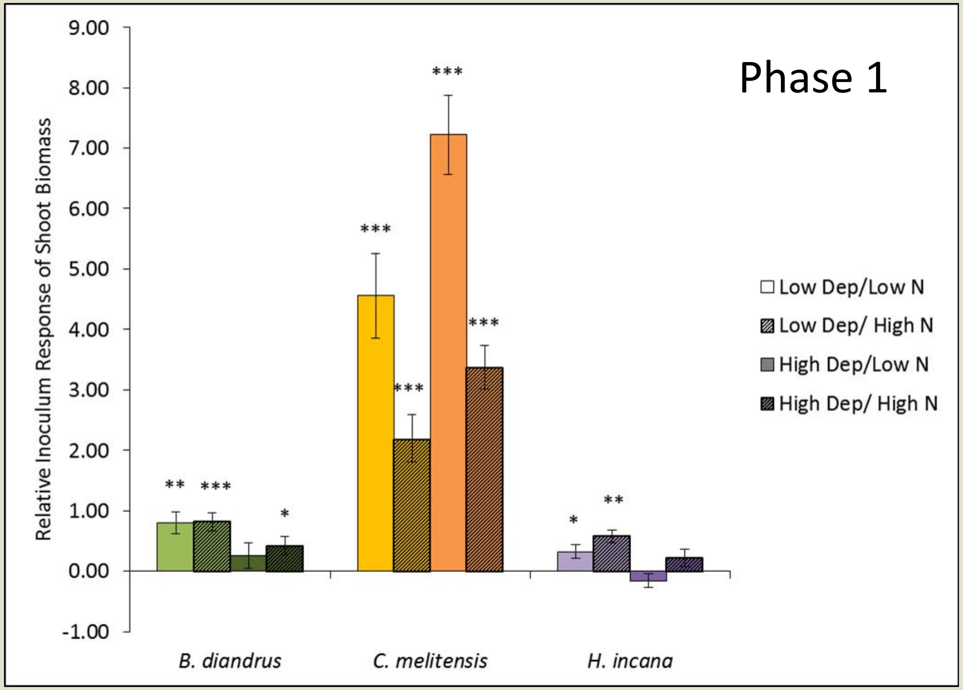
$$\frac{(\text{Biomass}_{\text{High N}} - \text{Mean Biomass}_{\text{Low N}})}{\text{Mean Biomass}_{\text{Low N}}}$$

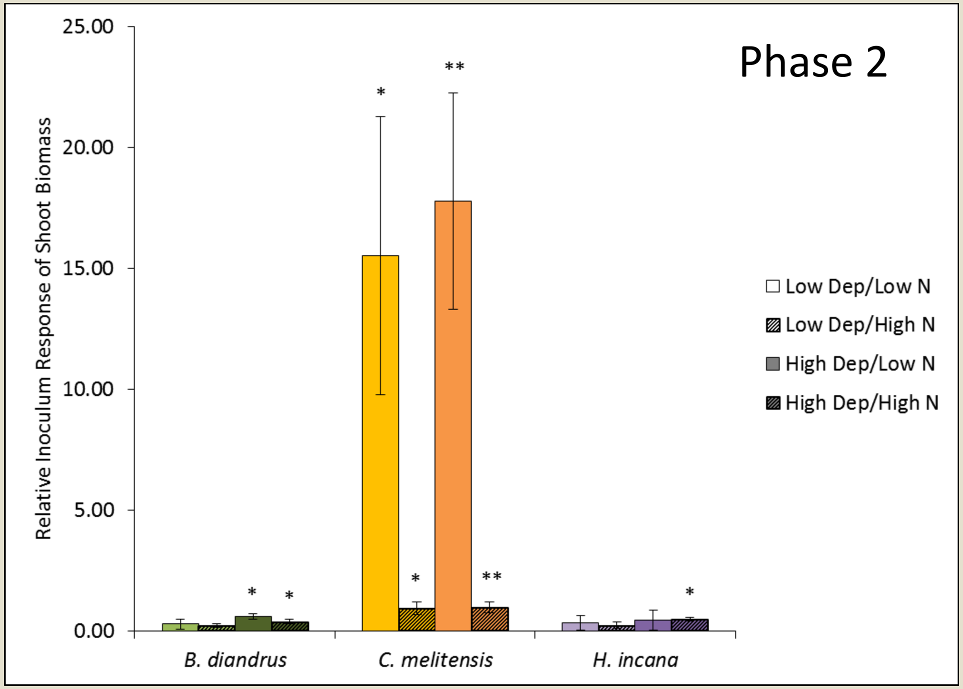
- Species differ in N responses
- N responses are influenced by inoculum type
- Relatively few and weak N responses in Phase 1
- More positive N responses in Phase 2, due possibly to an accumulation of N and released nutrients from decomposing roots, or build up of nitrophilic organisms (from Phase 1)

Relative Inoculum Response

$$\frac{(\text{Biomass}_{\text{Live}} - \text{Mean Biomass}_{\text{Sterile}})}{\text{Mean Biomass}_{\text{Sterile}}}$$

- All species had a neutral to positive inoculum response in all treatments and in both phases of the experiment
- Species differ in inoculum responses
- Inoculum responses changed in Phase 2, after soil is conditioned by conspecifics



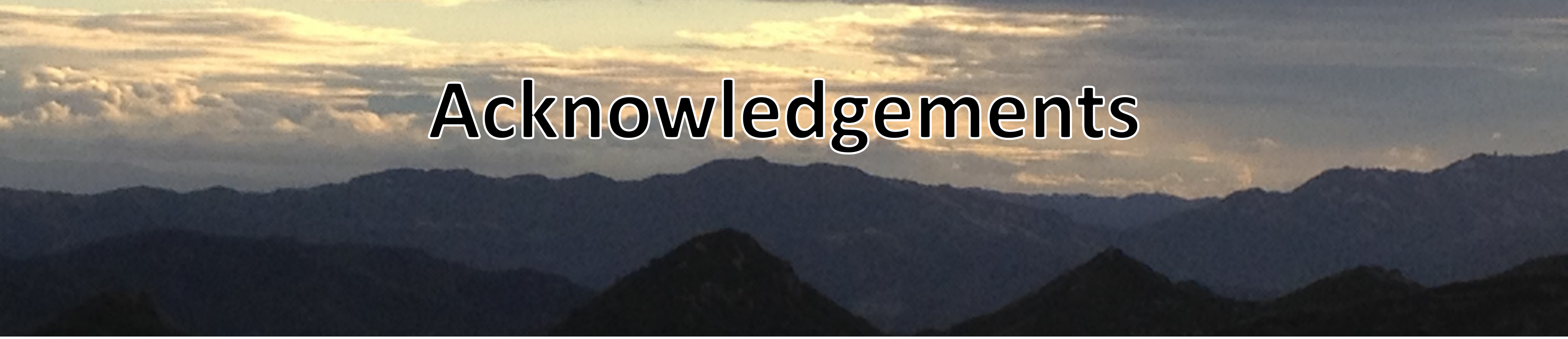


Discussion

- Both soil biota and nitrogen availability mediate plant performance and growth.
- Nonnative species have a positive to neutral response to both native soil communities and soil communities conditioned by conspecifics.
- Plants responded differently to soil communities subject to N addition, independent of N availability.
- Nitrogen deposition has the potential to increase invasion both through increased N availability and changes to the soil community and plant-soil feedbacks.

Discussion

- For some invaders, native soil communities may not have "biotic resistance".
- Once nonnatives invade, they may change soil biota in their favor, further increasing invasion and making eradication more difficult.
- It isn't all about N availability – soil communities matter too!
- May be necessary to prioritize management/restoration of high N deposition sites.



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