

Canopy phenology and the coexistence of invasive species in a walnut woodland understory

Joshua J. Paolini and Erin J. Questad

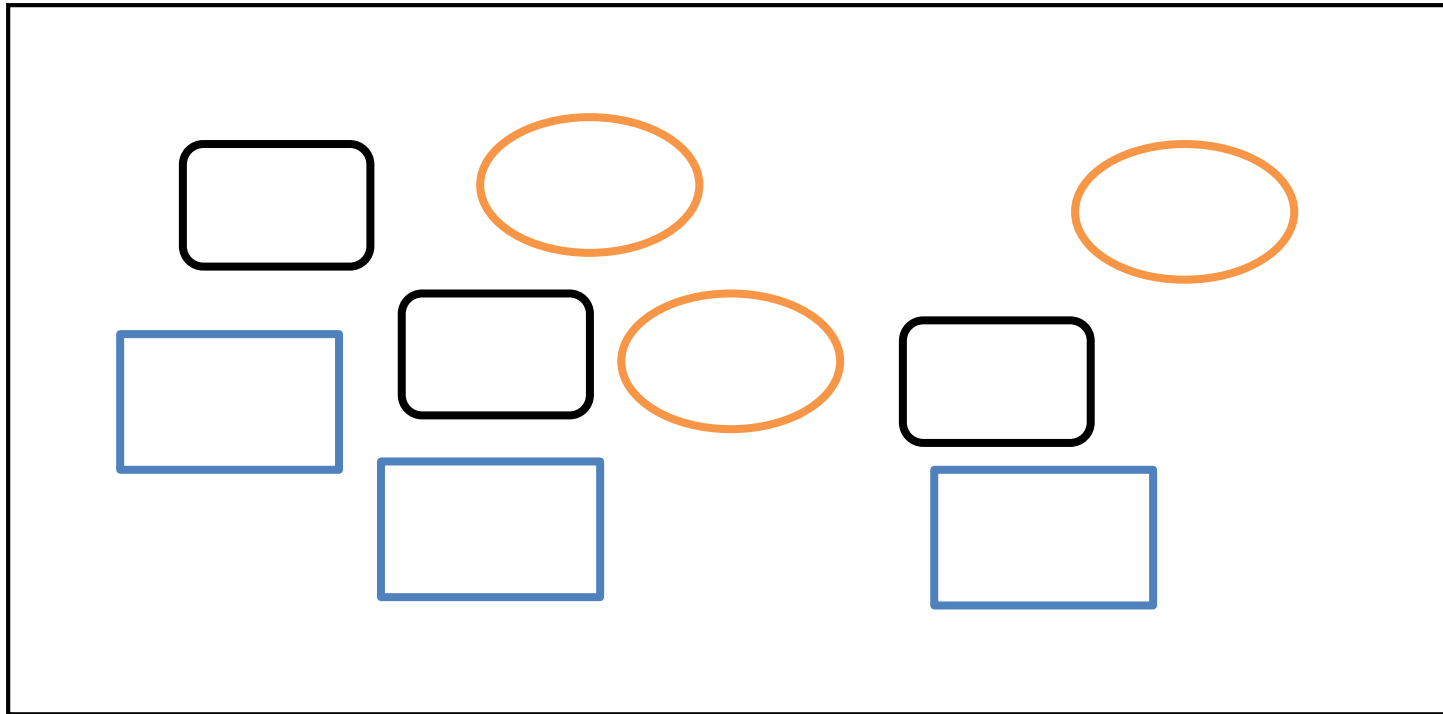
Dept. of Biological Sciences; California State
Polytechnic University, Pomona

Outline

- Environmental Heterogeneity and Coexistence
- Southern California Walnut Woodlands
- Question and Hypotheses:
 - Light and Juglone
- Methods
 - Greenhouse Experiments
- Results
 - Germination, physiology, health, and reproduction
- Conclusions

Environmental Heterogeneity

How does environmental heterogeneity affect the coexistence of species?



Abiotic Filtering

abcdefghijklmnopqrstuvwxyz



de

op

xy

de

op

xy

Species Interactions

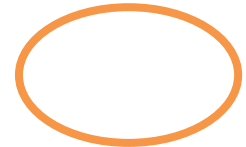
de



op



xy



Species Interactions

de

op

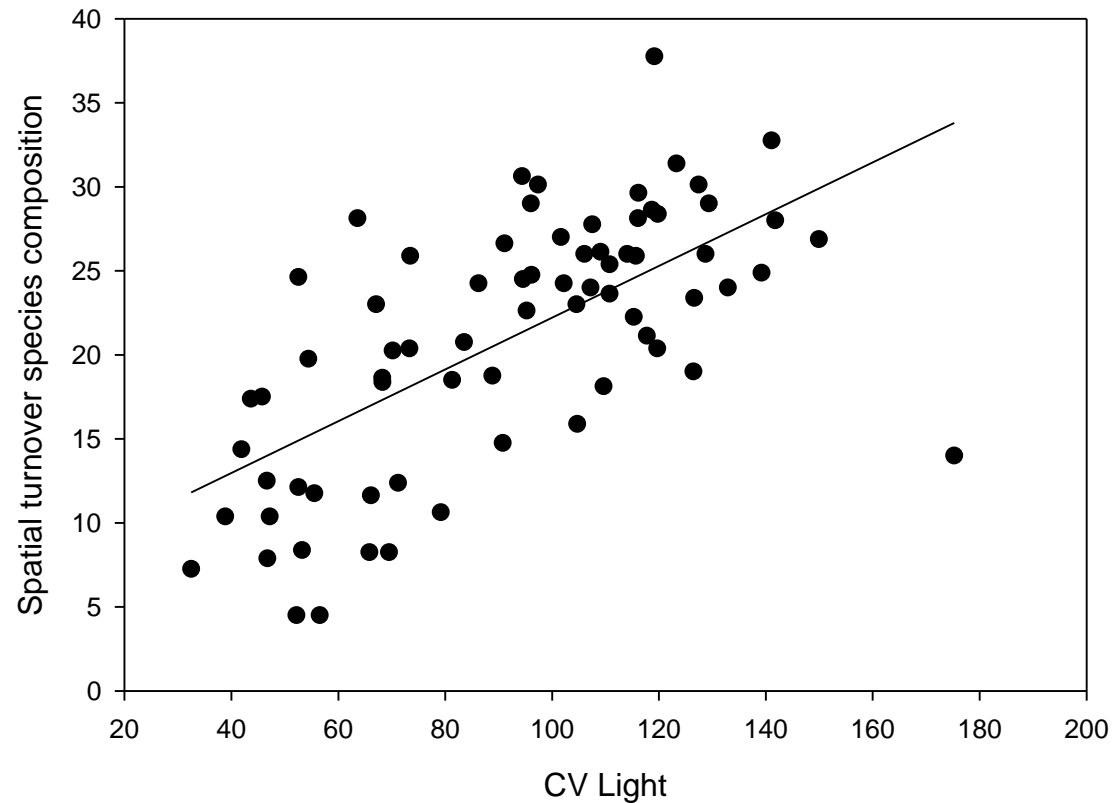
xy

d

o

x

Environmental Heterogeneity

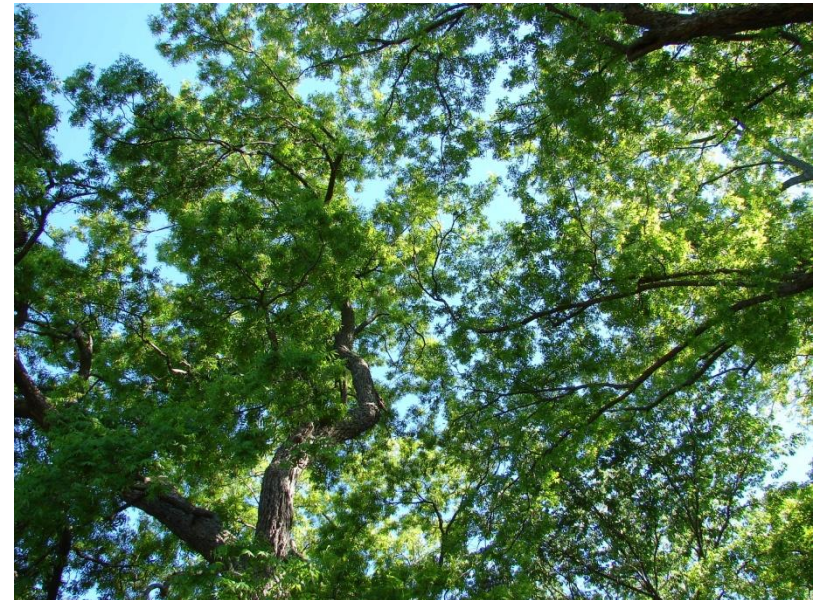


Questad and Foster 2008, *Ecology Letters*

Woodlands and Light



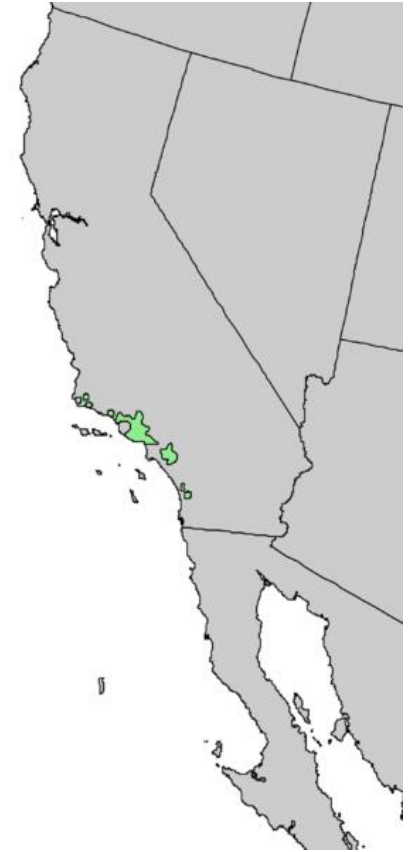
Bernardo Hernández, 2011



David R. Tribble, 2012

Juglans californica S. Watson

- Southern California Walnut Woodland
- Deciduous and allelopathic



1970 Elbert Little, USDA

Invasive Understory



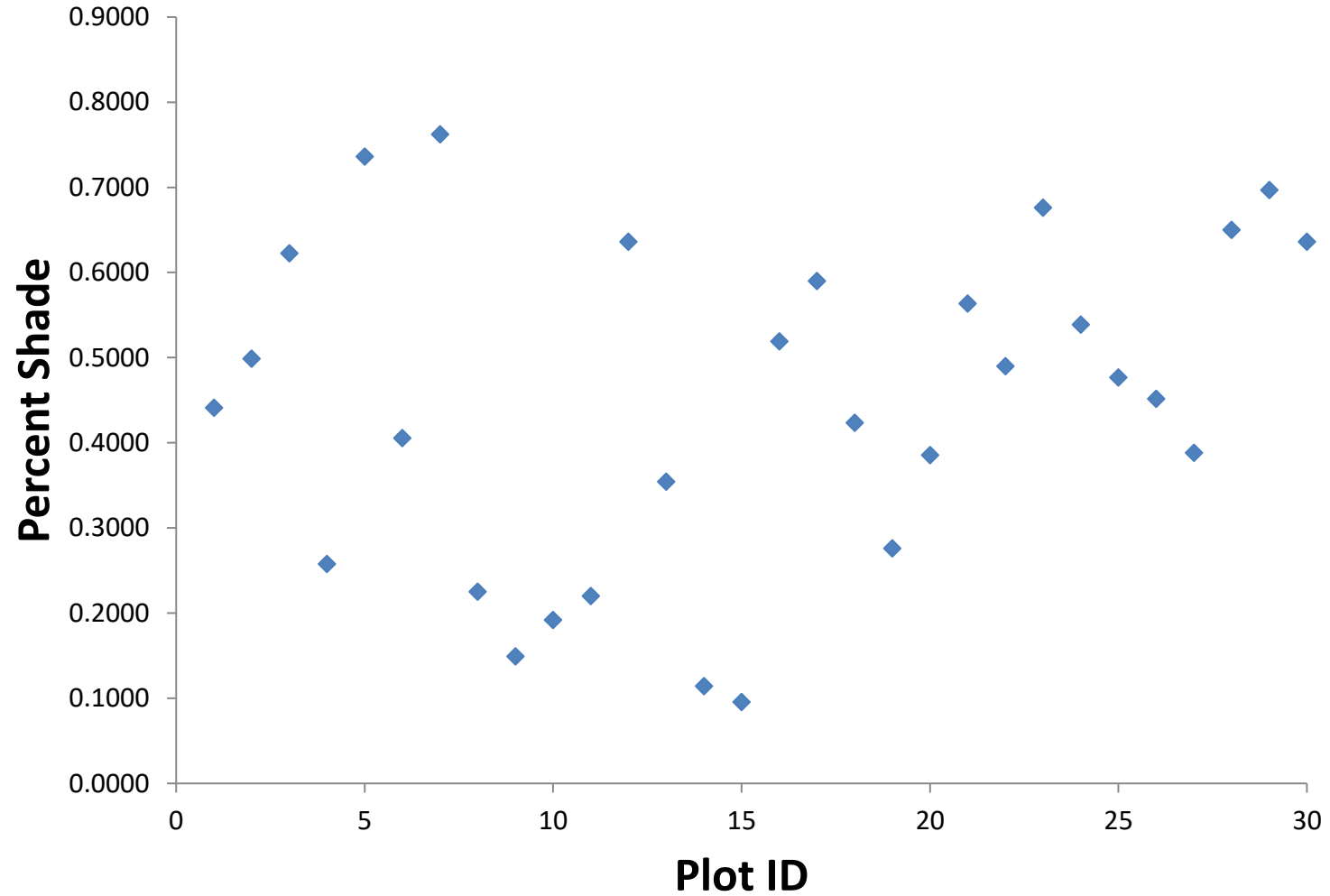
©2011 Zoya Akulova



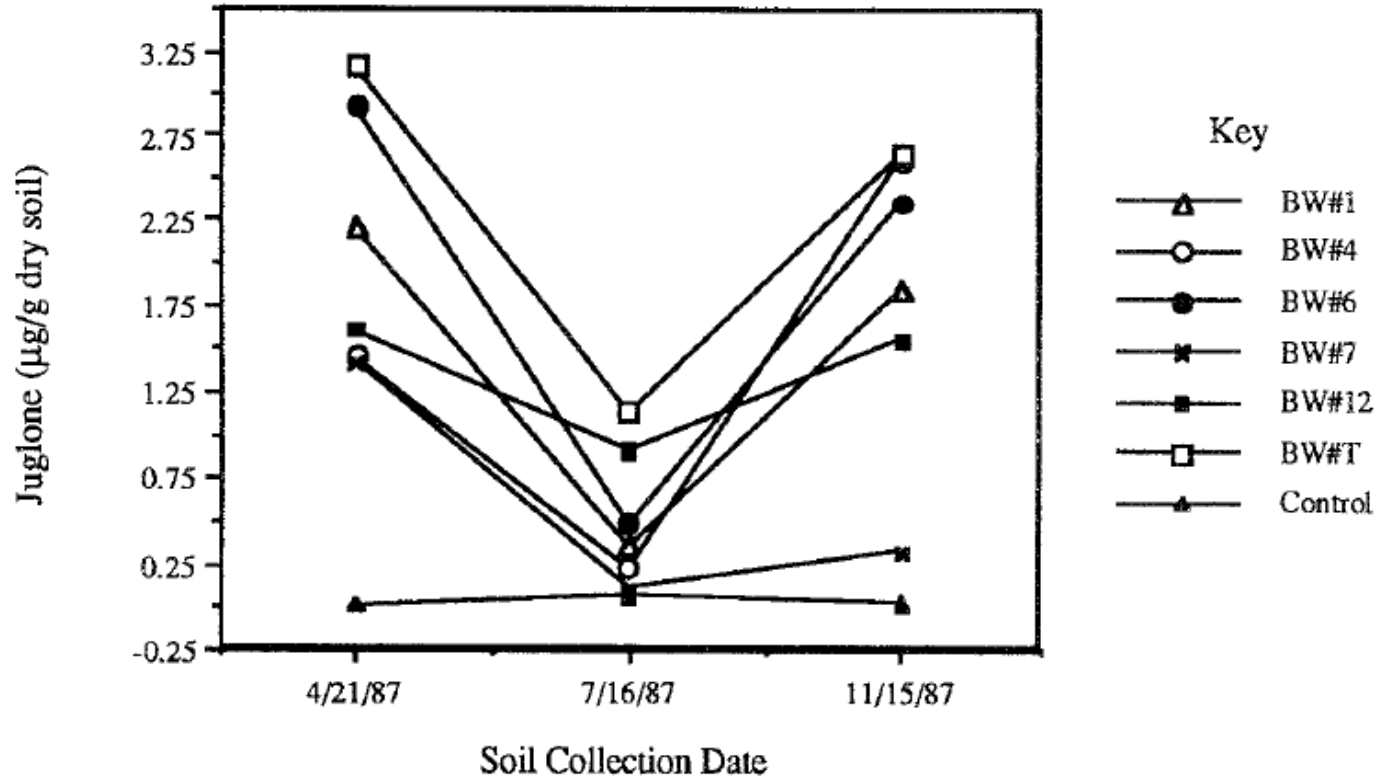
© 2015 Barry Breckling

- Black Mustard (*Brassica nigra*)
- Italian thistle (*Carduus pycnocephalus*)

Light Heterogeneity



Soil Juglone Heterogeneity



Effects of Juglone

Grown in Petri dish with water



Grown in Petri dish with 1 mM solution



Some species do not even germinate in a 1 mM solution

Specific Questions

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?
2. How does light availability affect the health and fitness of black mustard and Italian thistle?
3. How do these environmental factors influence the competition between these two species?

Hypotheses

↑ Light
↓ Juglone

Benefits black
mustard



Dr. Edward Bobich

↓ Light
↑ Juglone

Benefits Italian
thistle

Hypotheses



Dr. Edward Bobich

↑ Light
↓ Juglone

Benefits black
mustard

Competition

↓ Light
↑ Juglone

Benefits Italian
thistle

**Abiotic
Filtering**

Specific Questions

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

2. How does light availability affect the health and fitness of black mustard and Italian thistle?

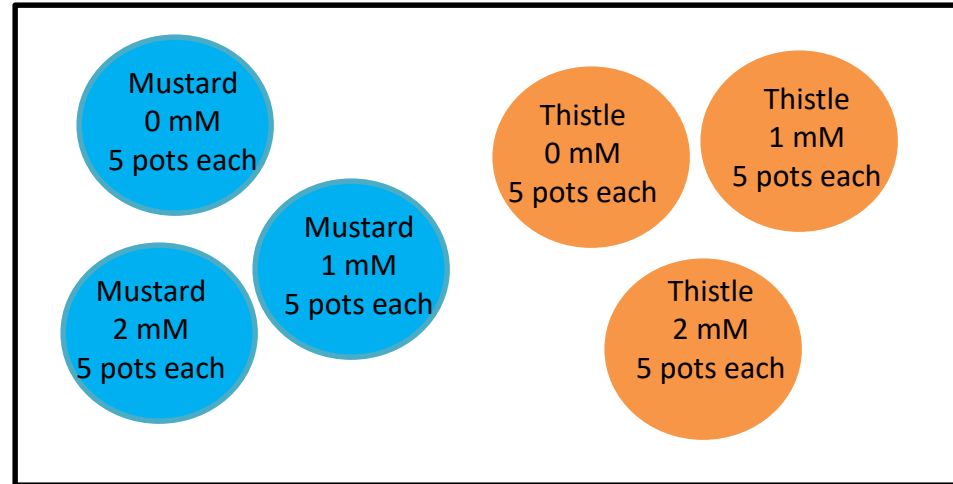
3. How do these environmental factors influence the competition between these two species?

Greenhouse Germination Experiment

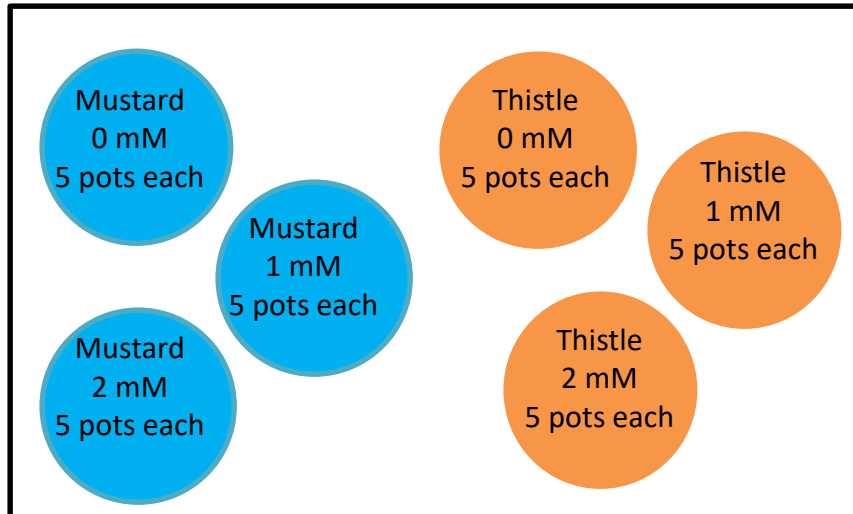
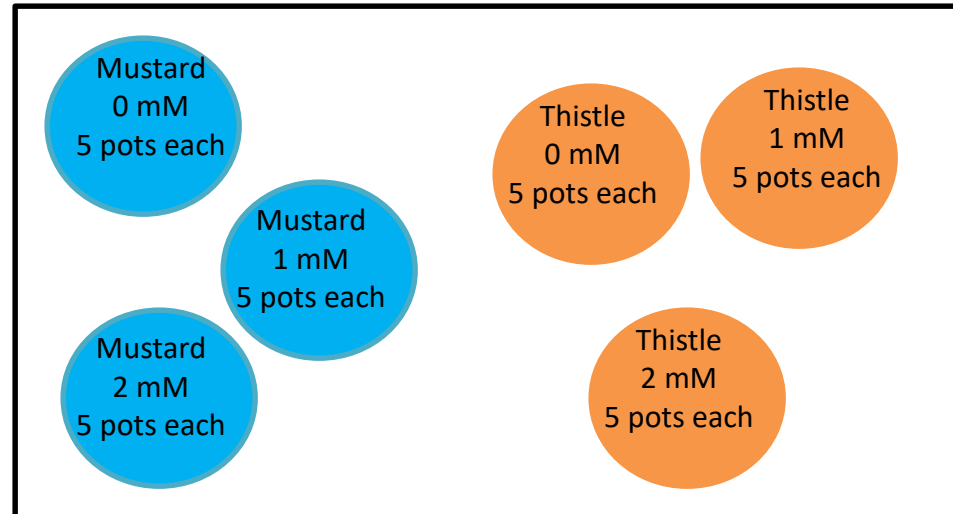


Full Sun (11% Shade)

Dark shade (88%)

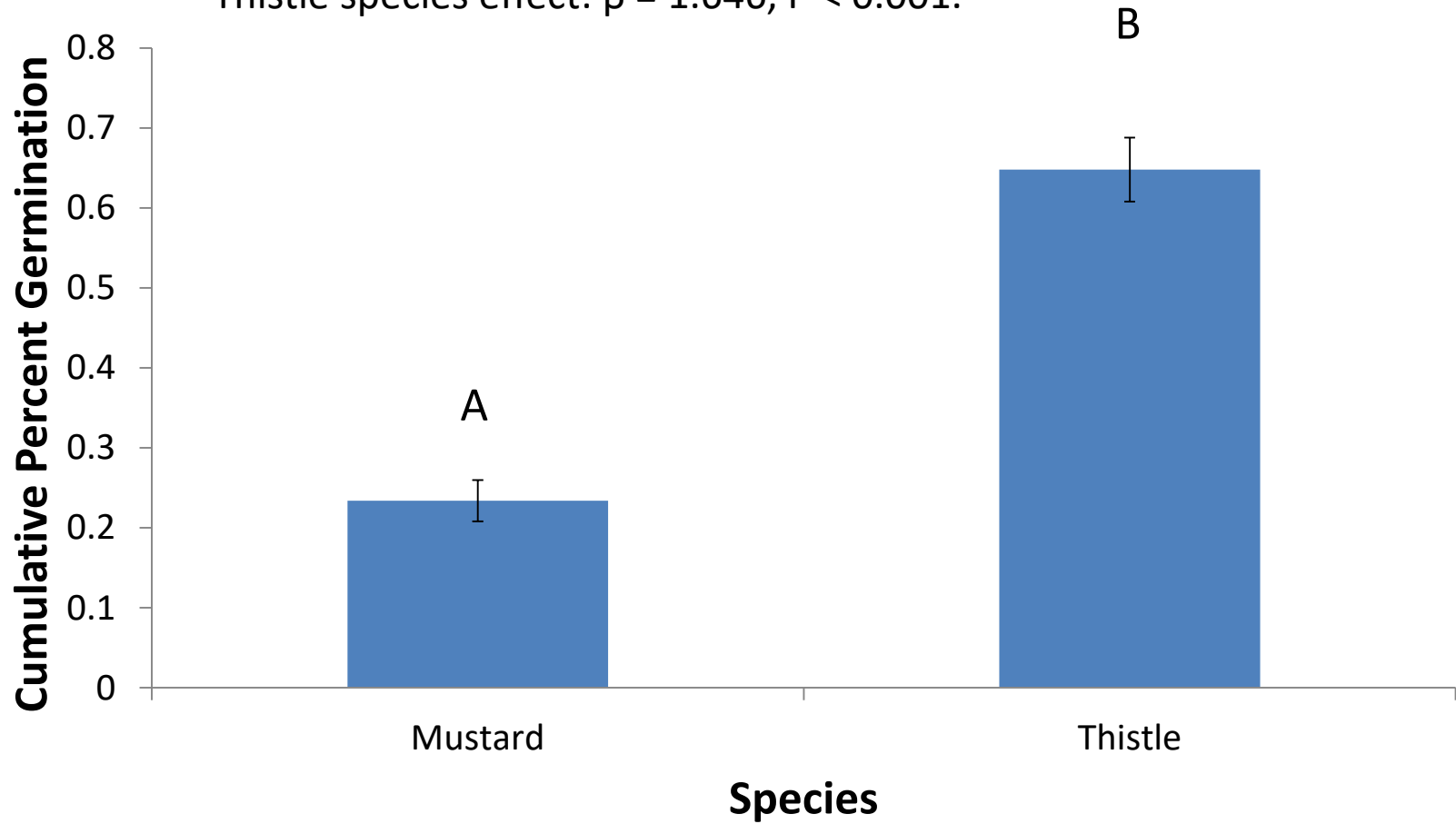


Medium Shade (63%)



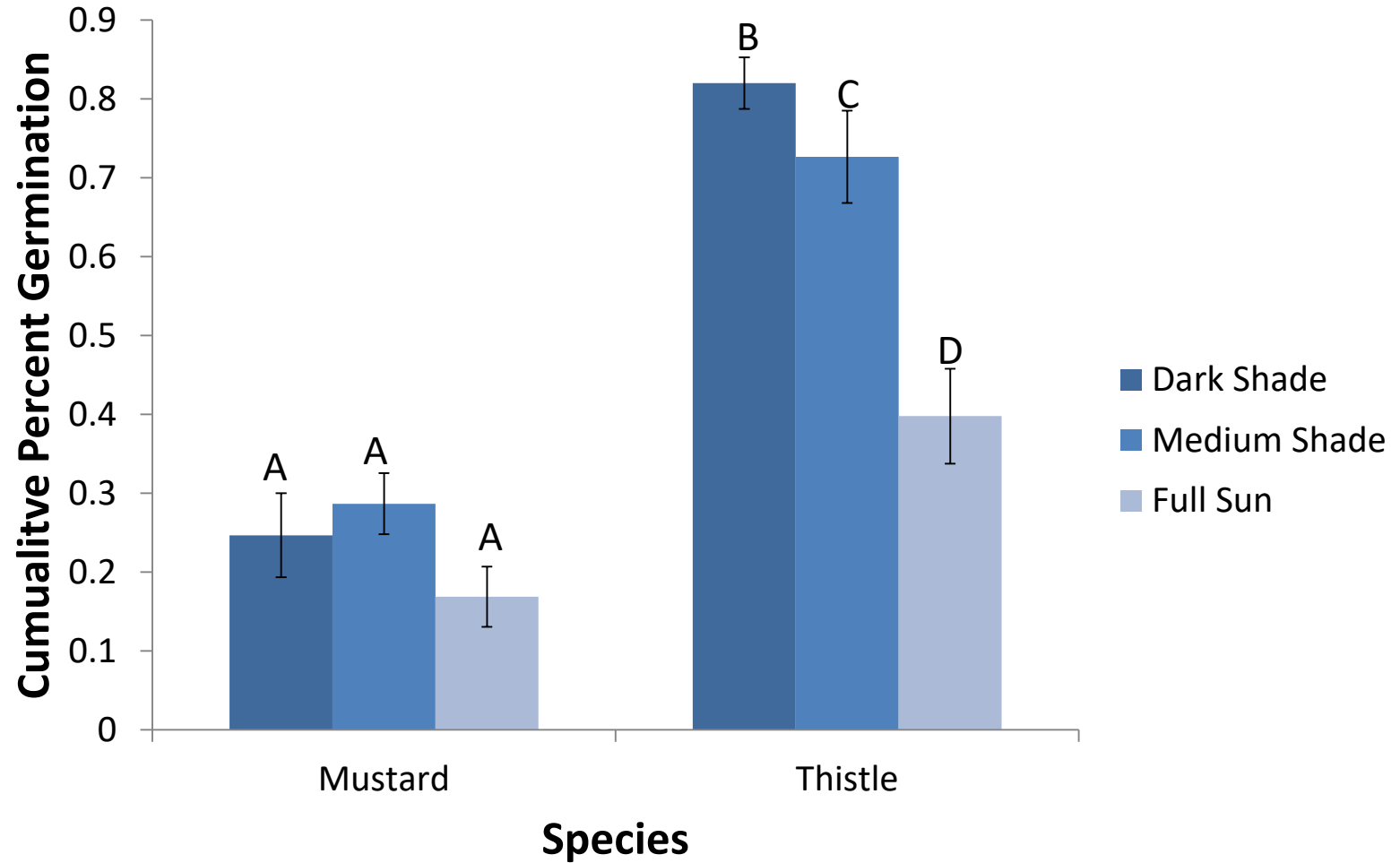
Germination

Thistle species effect: $\beta = 1.646$, $P < 0.001$.



A GLMM using a binomial distribution was used

Germination



A GLMM using a binomial distribution was used

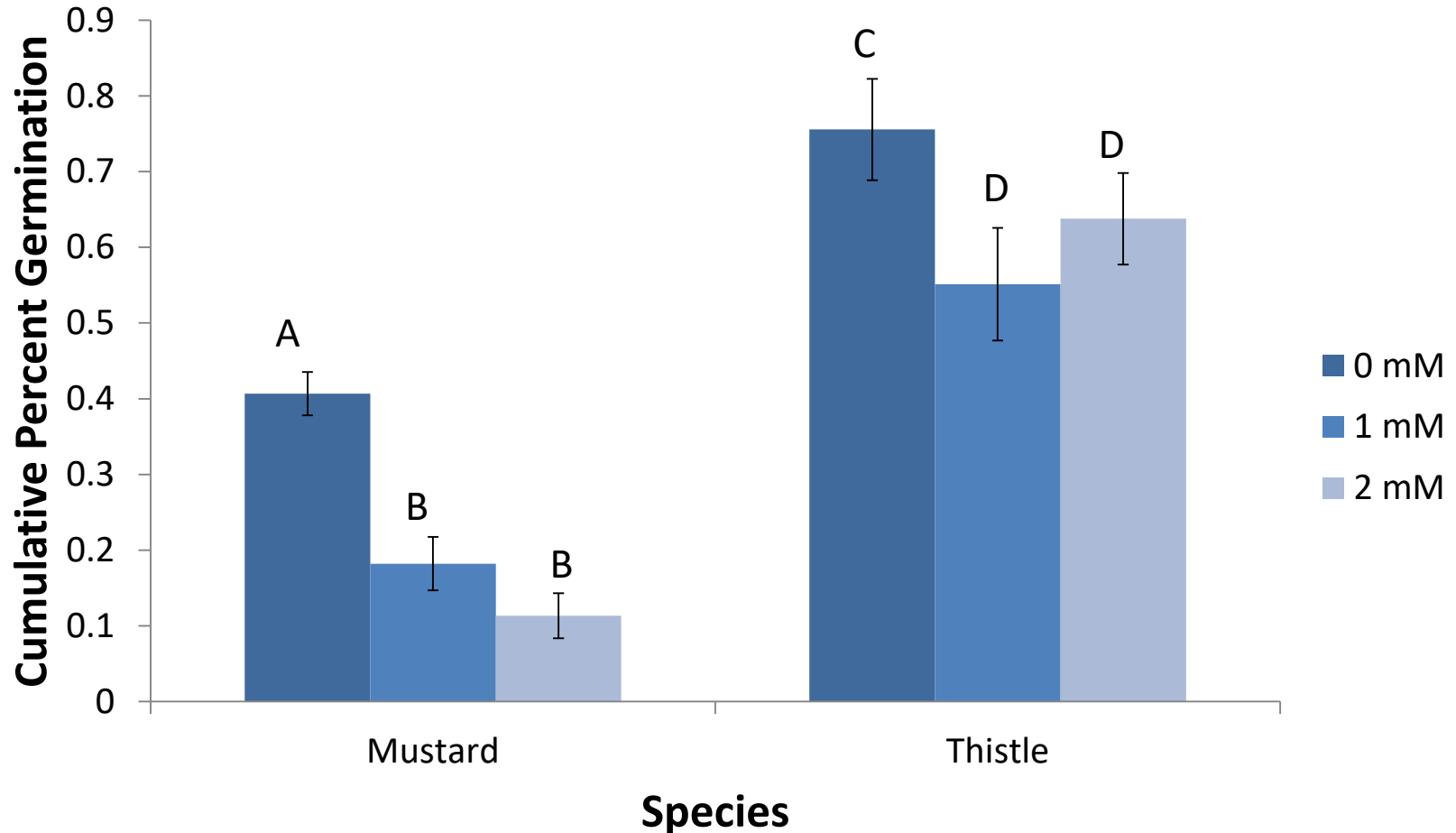
•Full sun effect: $\beta = -0.53280$, $P = 0.0254$

Germination

Effect of Juglone:

1 mM: $\beta = -1.212$, $P < 0.001$

2 mM: $\beta = -1.757$, $P < 0.001$



A GLMM using a binomial distribution was used

Question 1

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?
 - Black mustard had significantly less germination rates than Italian thistle.
 - Italian thistle germination was reduced by increasing light levels.
 - Black mustard and Italian thistle germination was significantly reduced by juglone.

Specific Questions

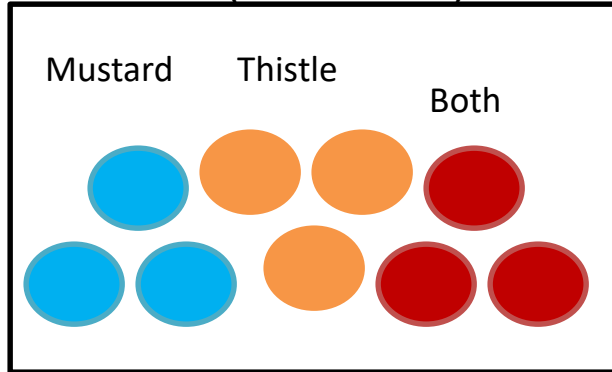
1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

2. How does light availability affect the health and fitness of black mustard and Italian thistle?

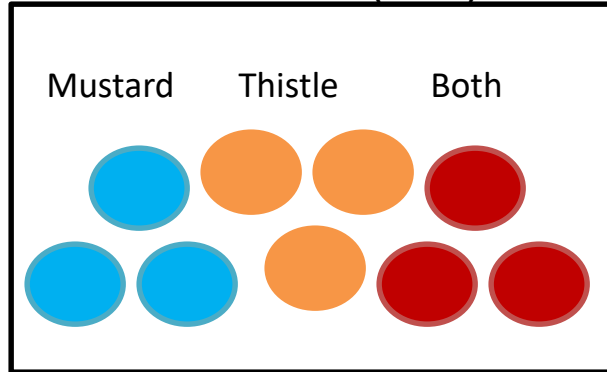
3. How do these environmental factors influence the competition between these two species?

Greenhouse Competition Experiment

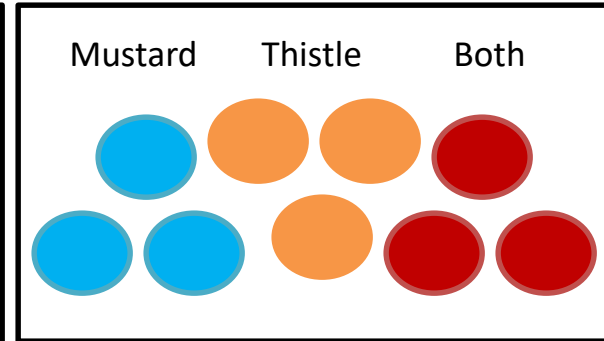
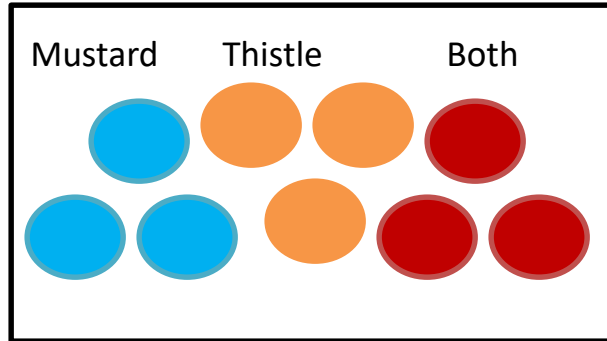
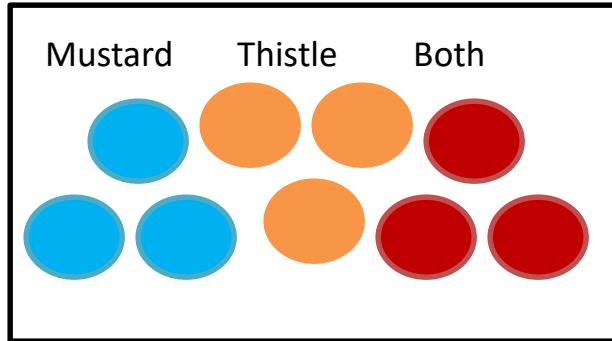
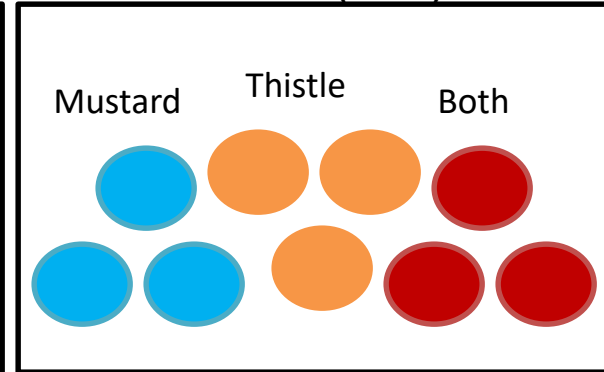
Full Sun (11% Shade)



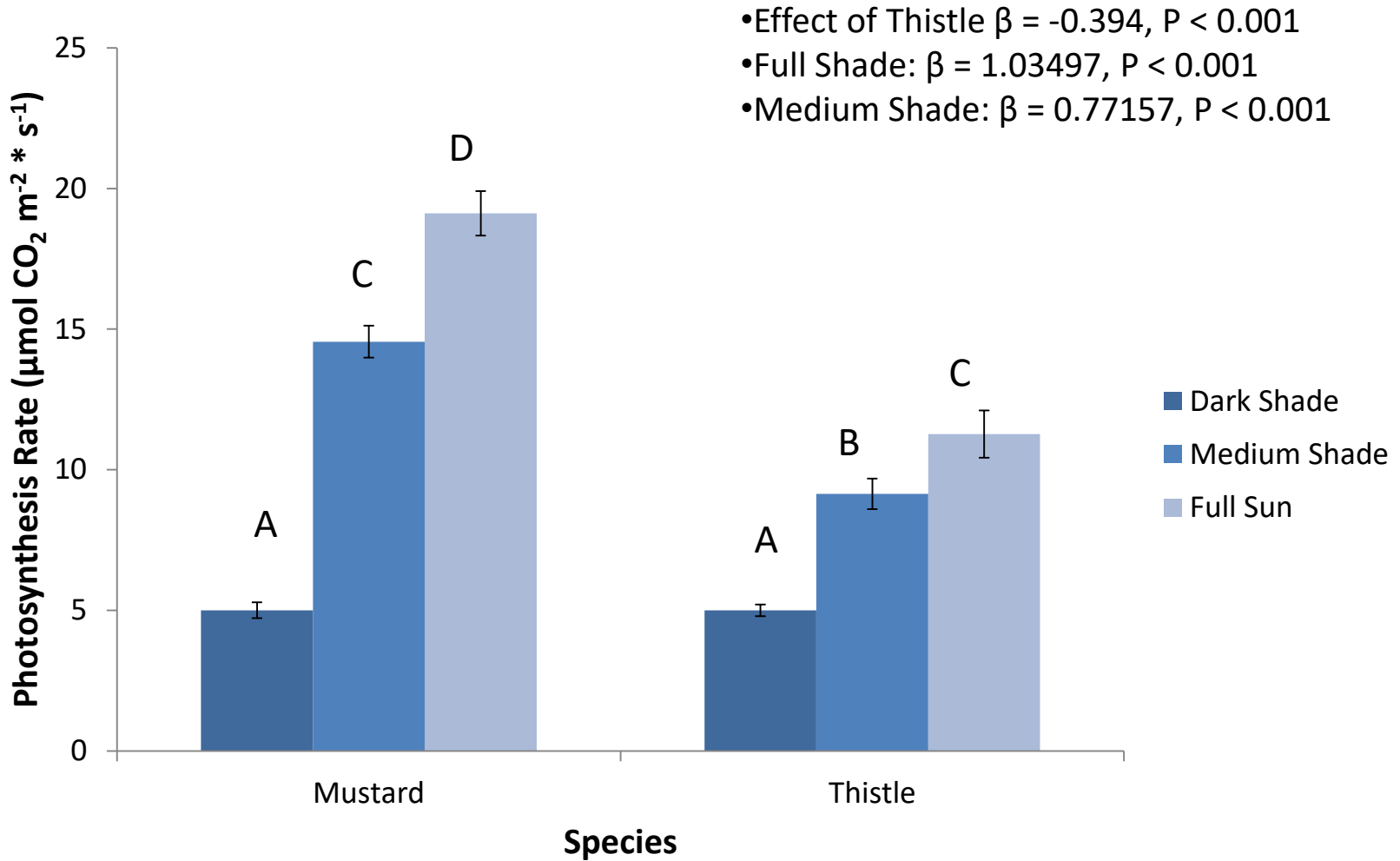
Medium Shade (63%)



Dark Shade (88%)

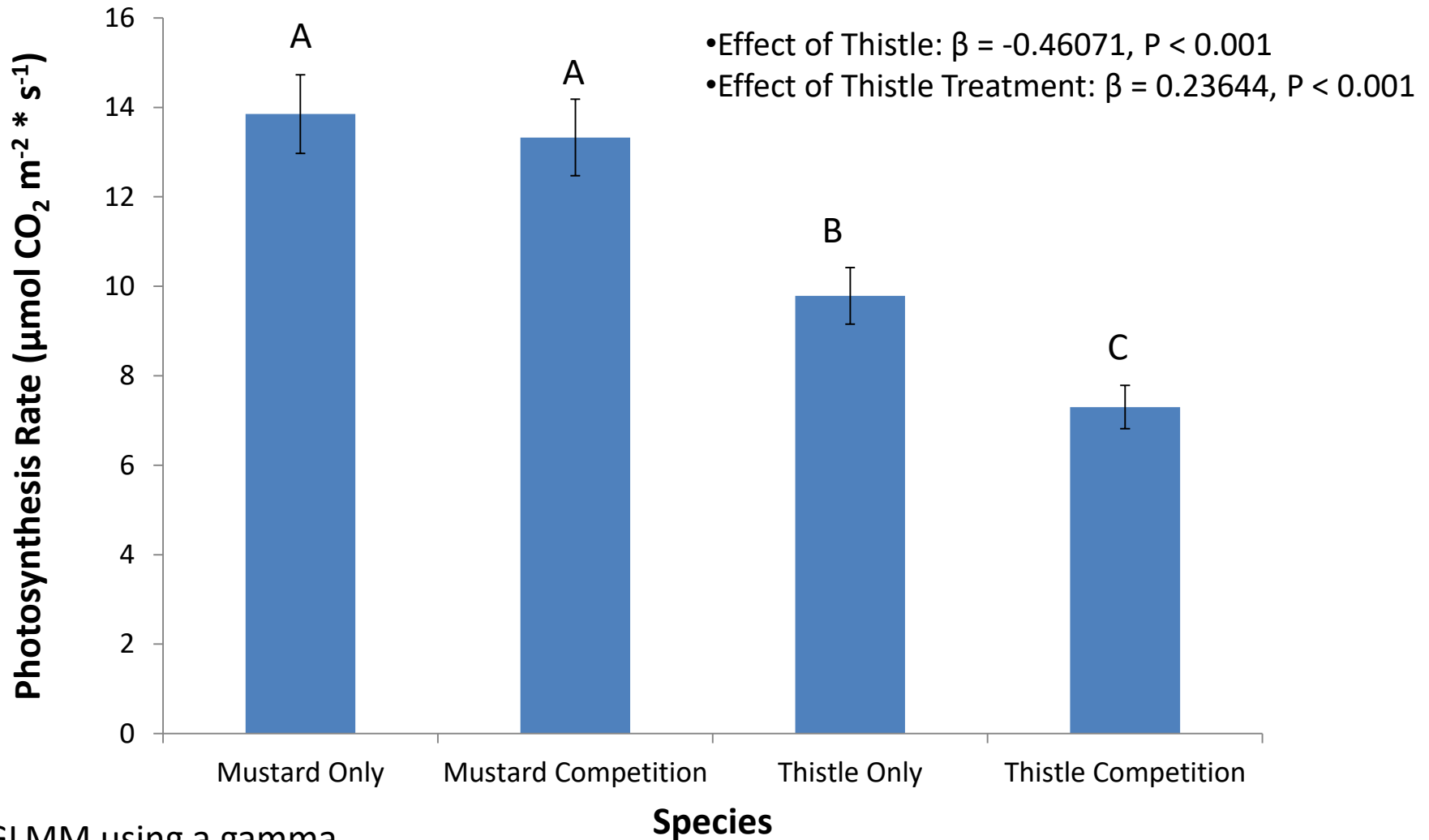


Photosynthesis



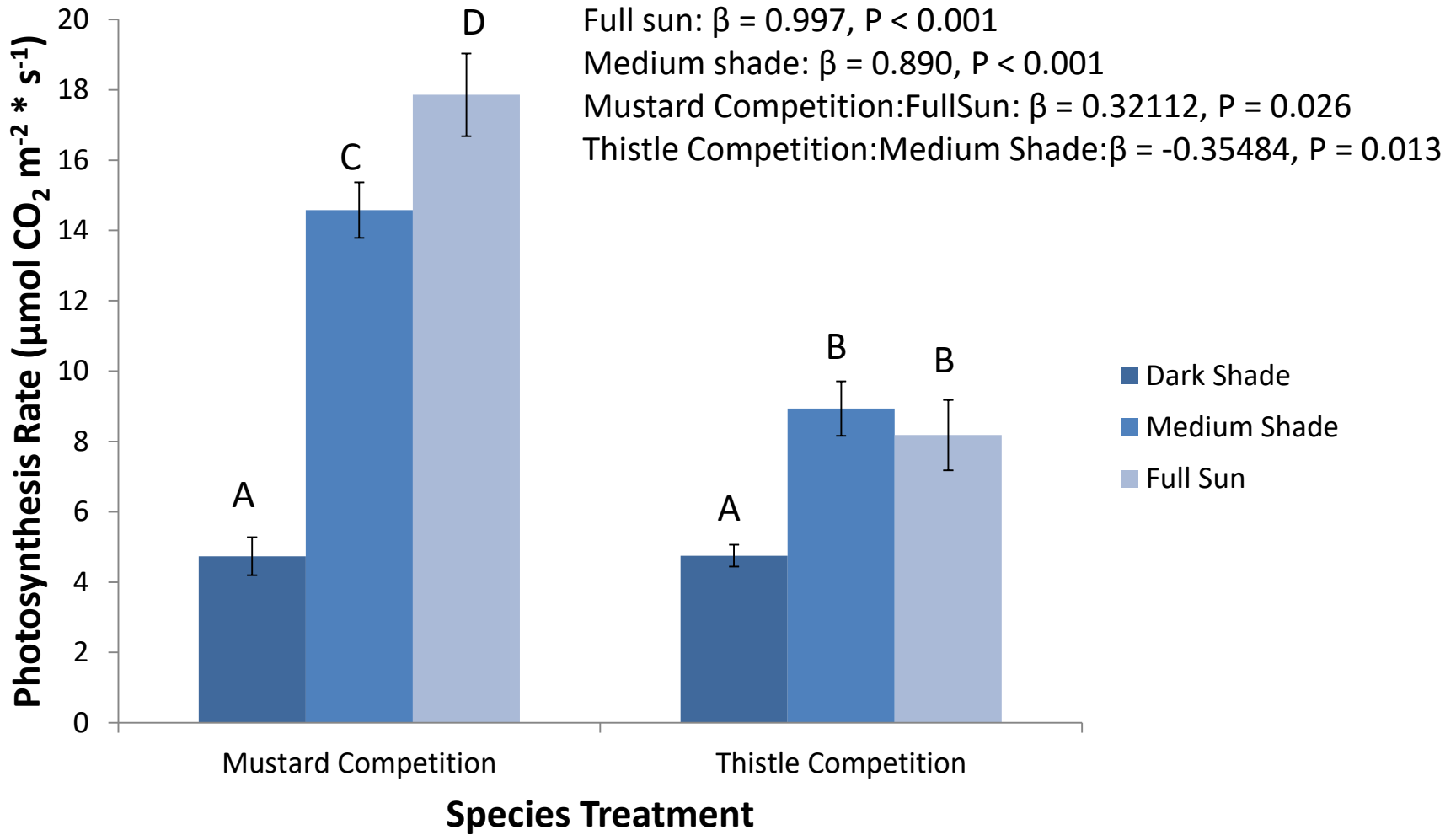
A GLMM using a gamma distribution was used

Photosynthesis



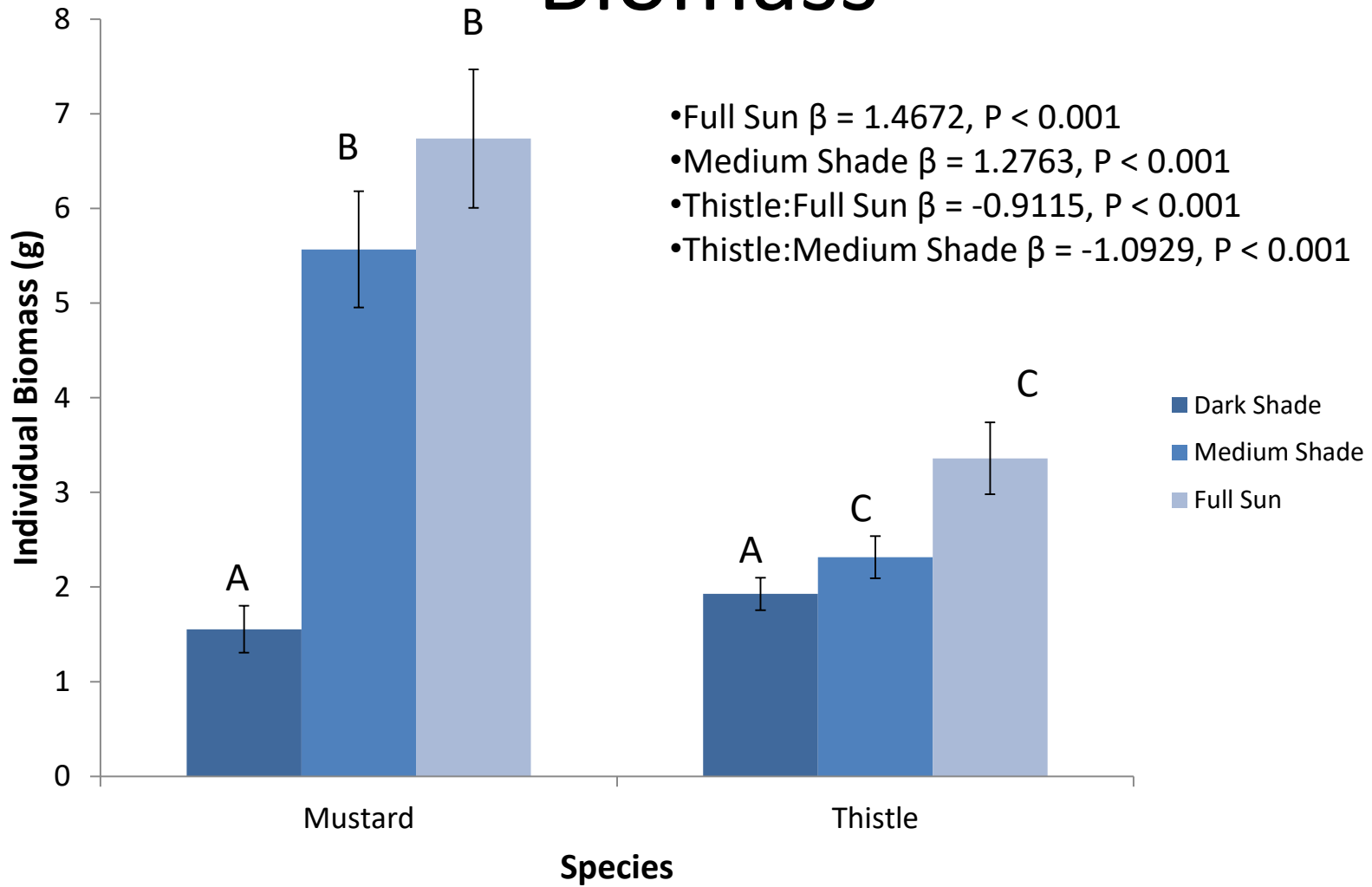
A GLMM using a gamma distribution was used

Photosynthesis



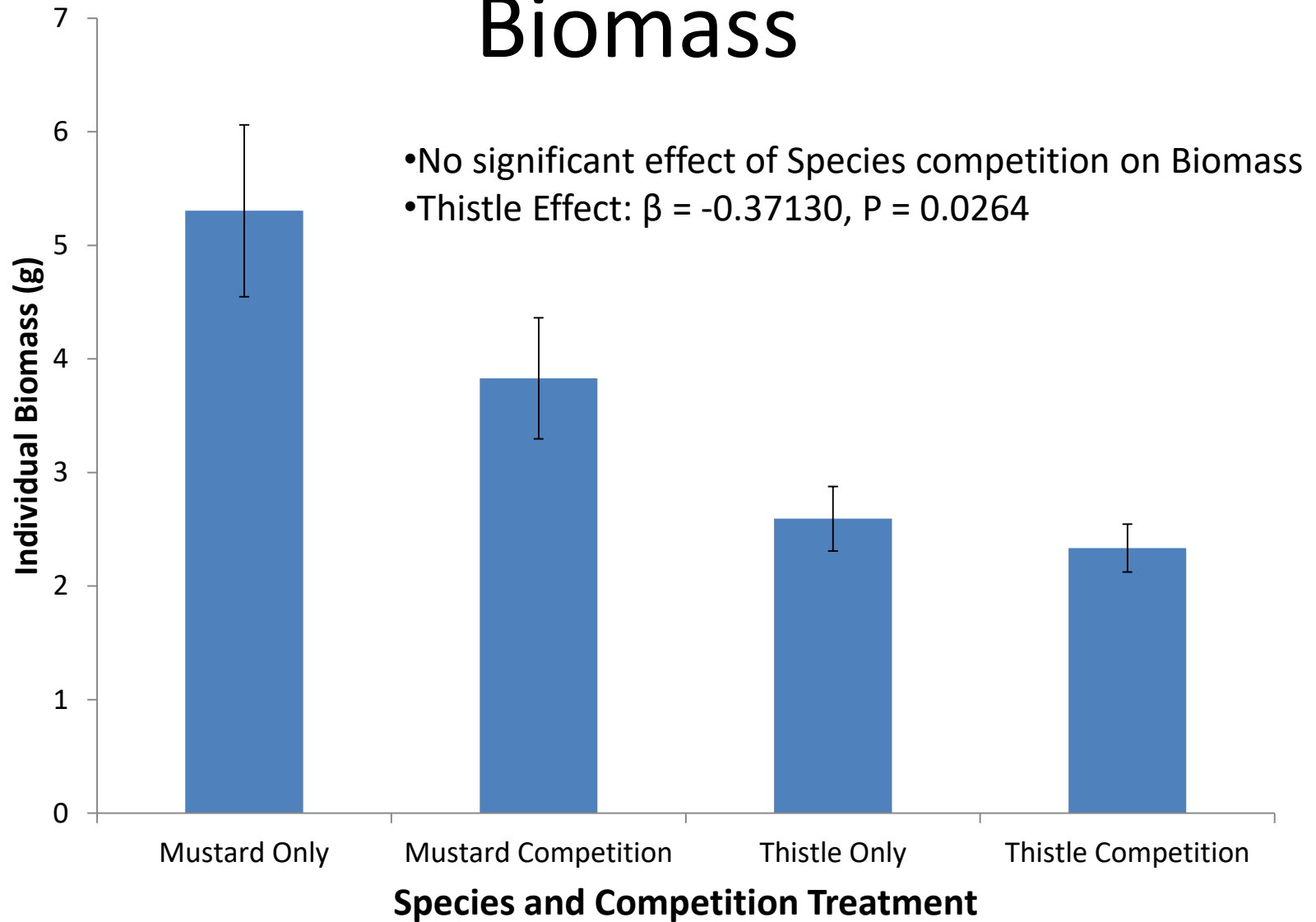
A GLMM using a gamma distribution was used

Biomass



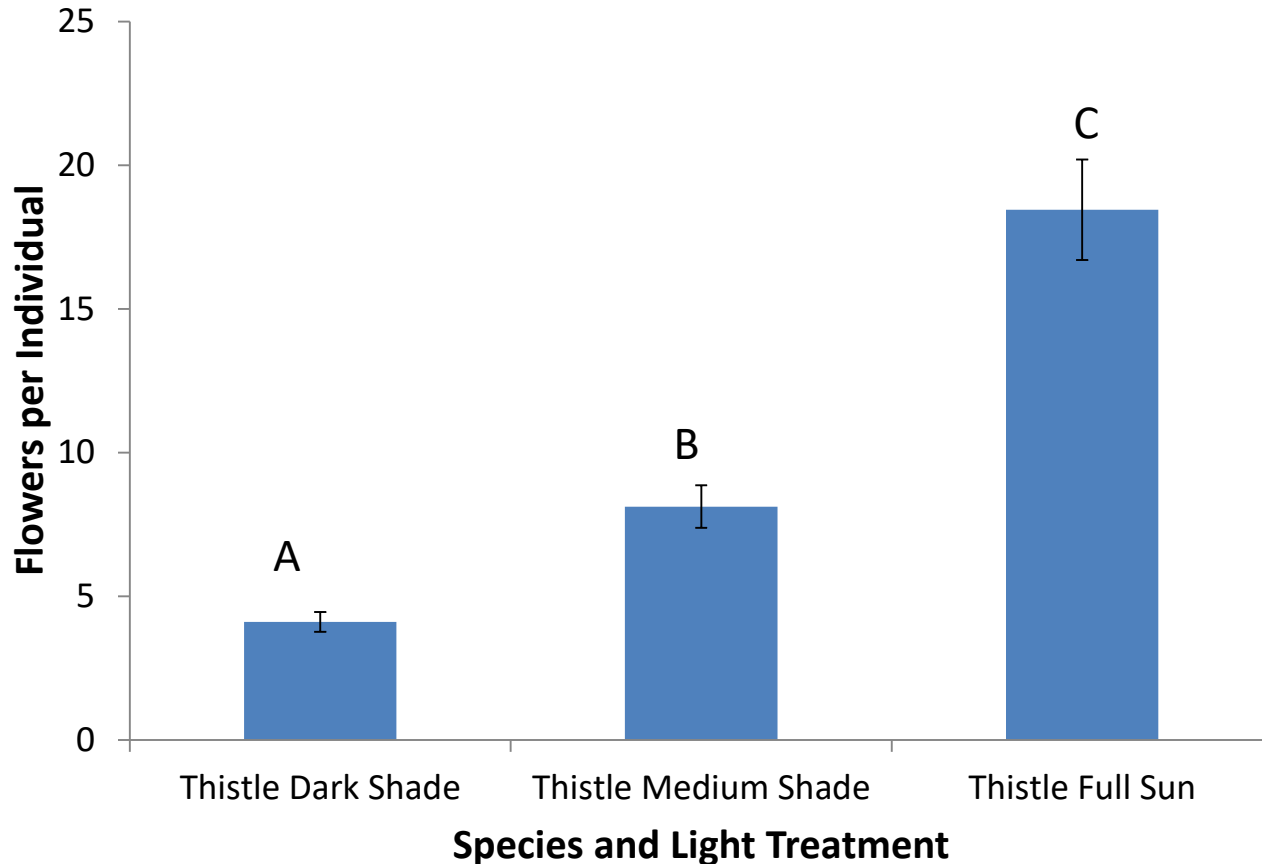
A GLMM using a gamma distribution was used

Biomass



A GLMM using a gamma distribution was used

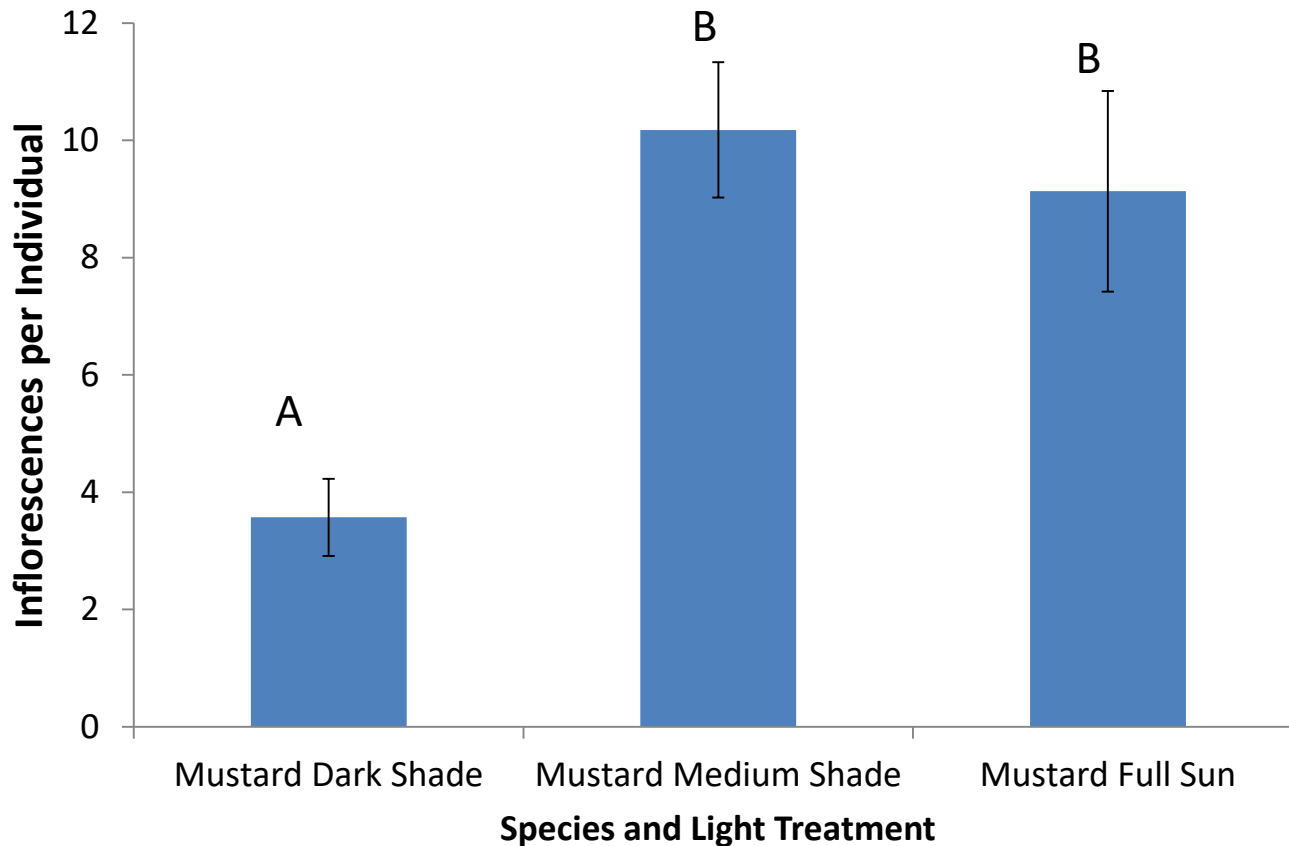
Reproduction



A GLMM using a gamma distribution was used

- Full Sun $\beta = 1.49842$, $P < 0.001$
- Medium Shade $\beta = 0.67492$, $P < 0.001$
- No effect of competition

Reproduction



A linear model was used

- Full Sun $\beta = 5.6370$, $P = 0.011$
- Medium Shade $\beta = 6.5296$, $P < 0.001$
- No effect of competition

Question 2

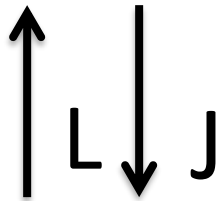
2. How does light availability affect the health and fitness of black mustard and Italian thistle?

- Lower light levels significantly reduced photosynthesis for both species.
 - Thistle was significantly inhibited when in competition with mustard in full sun treatments.
- Lower light levels significantly reduced the biomass and reproduction of both species, but there was no effect of competition on either species.

Question 3

3. How do these environmental factors influence the competition between these two species?

Summary



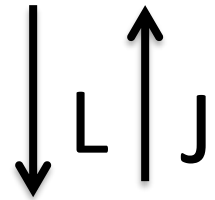
Benefits black
mustard

Competition

- Photosynthetic rate



Dr. Edward Bobich

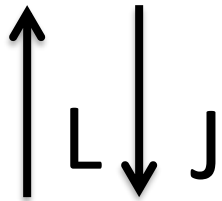


Benefits Italian
thistle

Abiotic Filtering

- Germination rate
- Biomass
- Reproduction

Summary



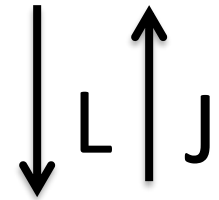
Benefits black
mustard

Competition

- Photosynthetic rate



Dr. Edward Bobich



Benefits Italian
thistle

Abiotic Filtering

- Germination rate
- Biomass
- Reproduction

Environmental Heterogeneity



Acknowledgements



- Many thanks to my awesome committee members:
 - Dr. Edward Bobich
 - Dr. Kristin Bozak
- Funding Sources:
 - Ernest Prete Jr. Environmental Science Student Research Fellowship
 - Rachel Carson Environmental Science Scholarship
 - This project was supported by the California State University Agricultural Research Institute Grant number 15-04-220
- Many thanks to my fellow graduate students: Robert Fitch, Lauren Quon, and Jose Marfori!
- Invaluable undergraduate help: Amanda Lowe, Ka'ala Pacheco, Peter Huthmacher, and Sierra Lauman!