The Role of Intraspecific Functional Trait Variation in the Differential Decline of Meadow Species Following Conifer Encroachment

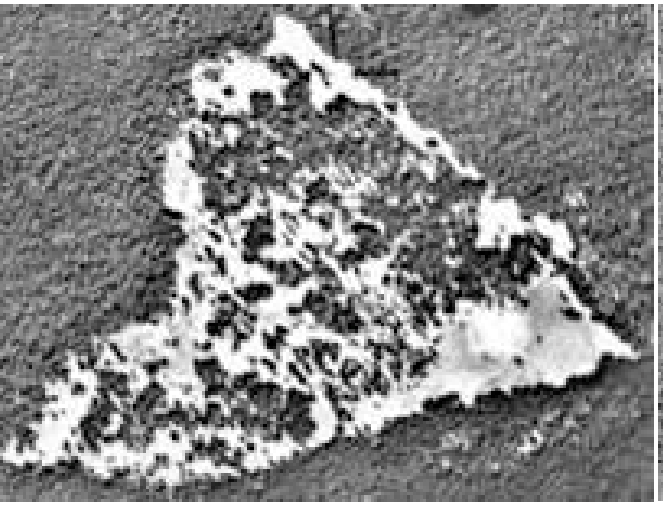
Jessica Celis
M.S. Thesis Defense
Department of Botany and Plant Pathology

Meadows of the Pacific Northwest

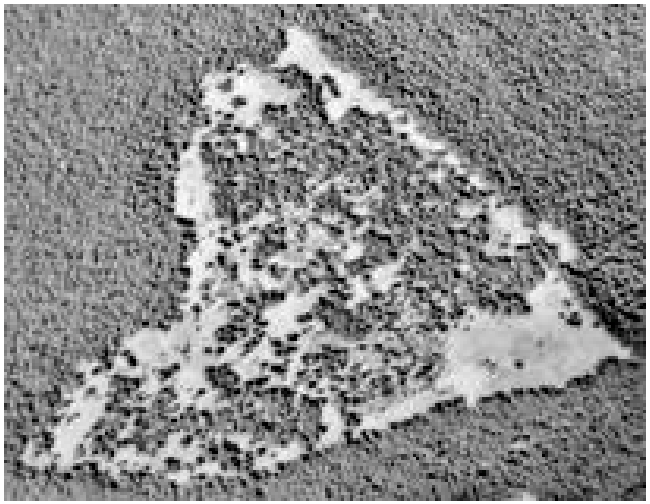
- Communities dominated by herbaceous forbs and graminoid species.
- Occupy only 5% of the Western Cascade Range of Oregon, but contain ~85% of the biodiversity of the region.

Threat to Meadow Communities

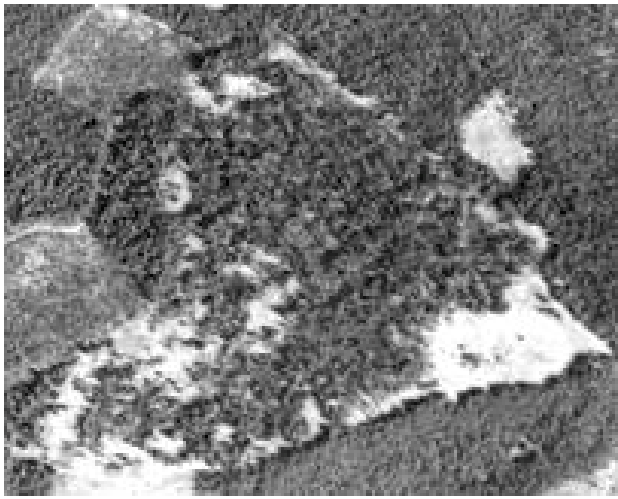
- Woody species encroachment threatens grasslands worldwide: Europe, Australia, South America, and North America.
- Greater than 50% loss of meadows in parts of the Western Cascades between 1946 and 2000.
- With time forest understory species replace meadow species.



1946



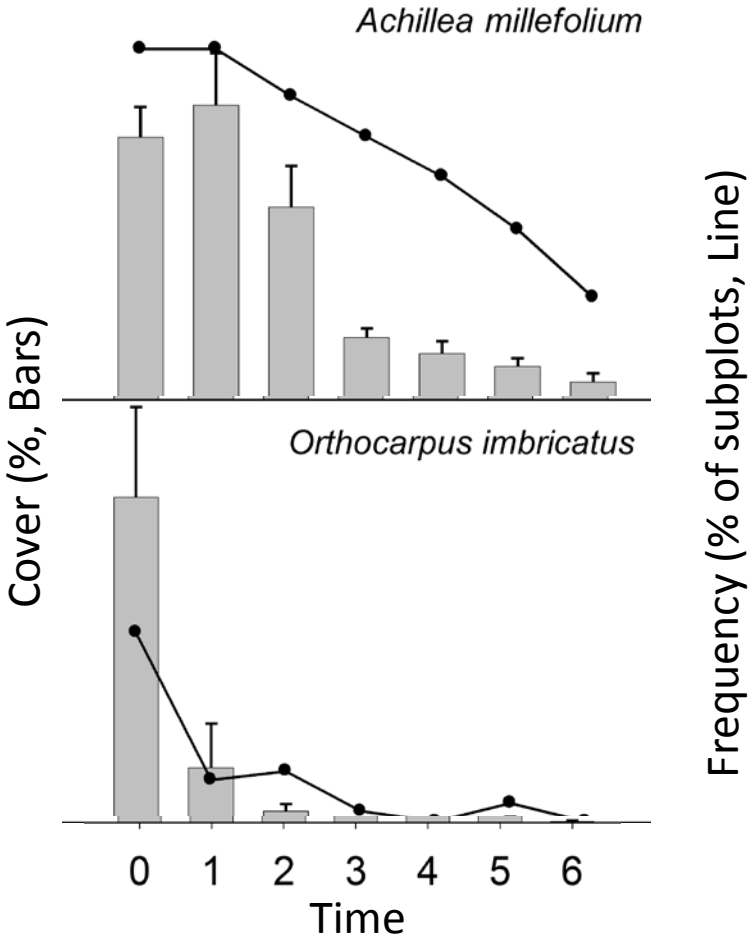
1967



2000

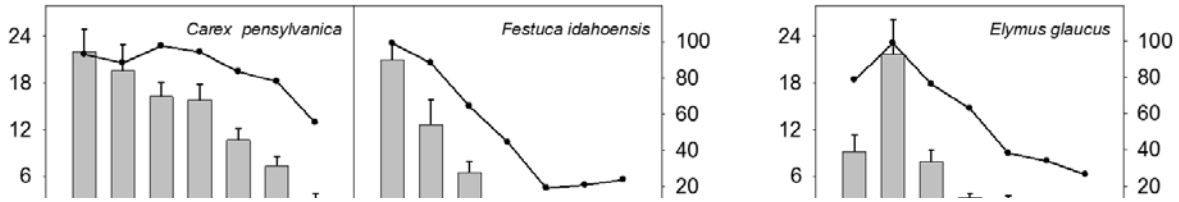
Species Response to Encroachment

- Some meadow species survive in the understory even after a century; some drop out after 10-20 years.

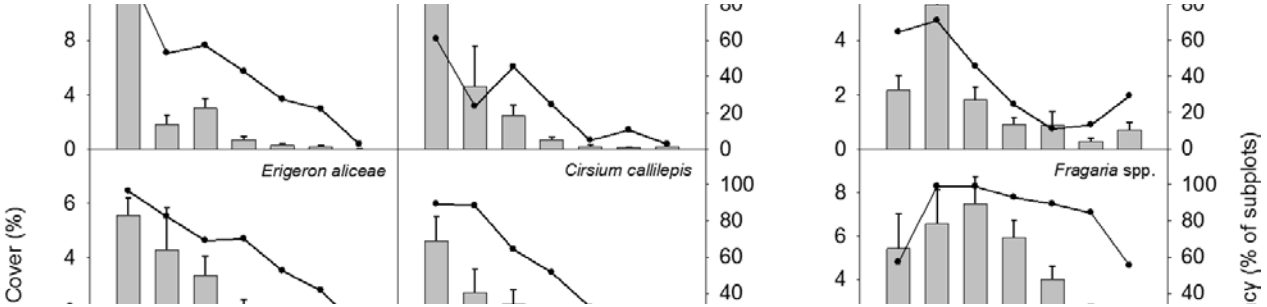


Haugo and Halpern 2007

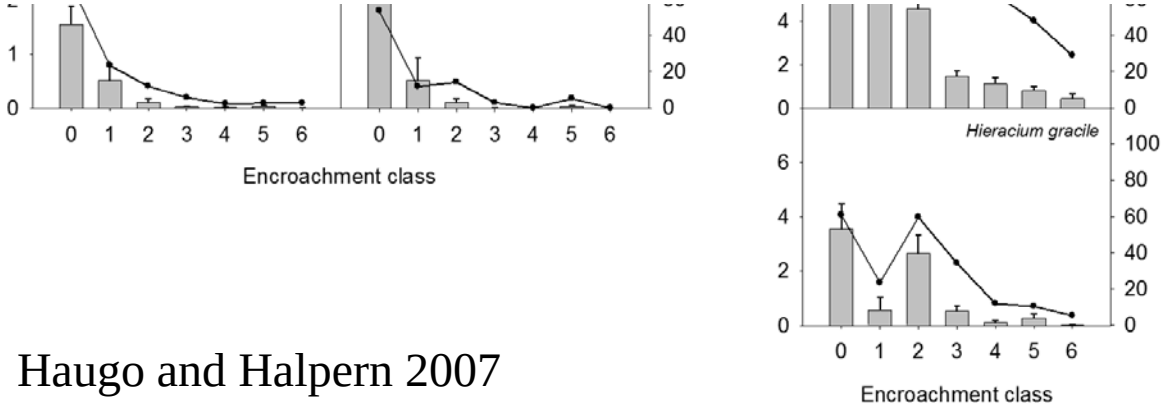
Species Response to Encroachment



Can plant functional traits explain this variation in sensitivity?



Specifically, is species sensitivity to encroachment related to species ability to adjust their traits when light is limited?



Haugo and Halpern 2007

Plant Functional Traits

“Any attribute that has potentially significant influence on establishment, survival, and fitness.” (Reich et al. 2003)

Selected Traits

Specific Leaf Area (SLA) = fresh leaf area/ dry mass

- Allows for more light capture
- Enhances carbon gain

Selected Traits

Shoot:root ratio = leaf and stem mass/ root system mass

Optimal resource partitioning theory: plants allocate biomass to the organ that acquires the most limiting resource.

Selected Traits

Shoot height: shoot base to the tip of the tallest leaf.

Escape competition for light from neighboring species.

Selected Traits

Clonal potential= Ability to spread laterally (non-clonal, limited clonality, and strongly clonal)

Allows plants to forage for resources

Longer internodes between ramets when resources are limited.

Hypotheses

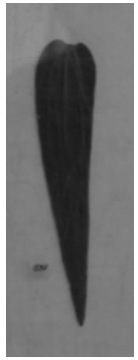
H1= Species that show greater adaptive variation in their functional traits will be less sensitive to encroachment.

H2= Encroachment will act as an environmental filter, reducing the relative abundance of species that show limited variation in their functional traits.

Hypotheses (H1)

Species that are less sensitive to encroachment will…

$$\frac{\text{Leaf Area}}{\text{Leaf Mass}} \xrightarrow{\text{SL}} \frac{\text{Leaf Area}}{\text{Leaf Mass}} \; +\; -$$



$$\frac{\text{Shoot}}{\text{Root}} \xrightarrow{\text{S/R Ratio}} \frac{\text{Shoot}}{\text{Root}} \; +\; -$$

Hypotheses (H1)

Species that are less sensitive to encroachment will…

Shoot Height

…grow taller in the shade

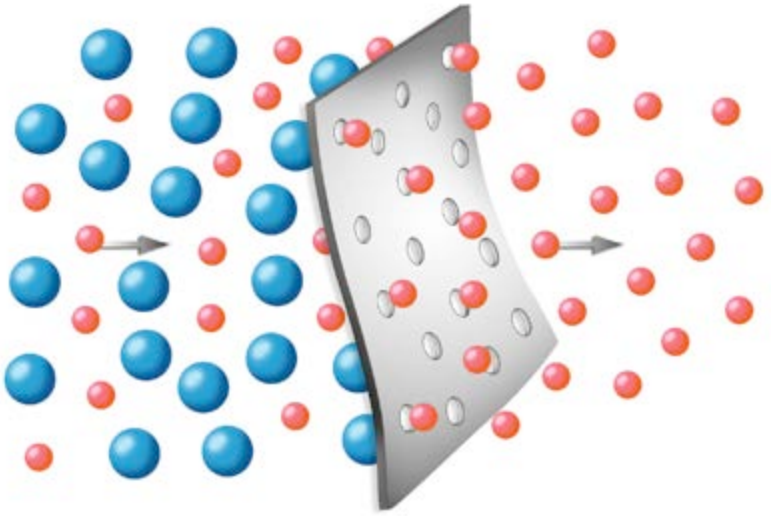
Clonality

… be strongly clonal

Hypotheses (H2)

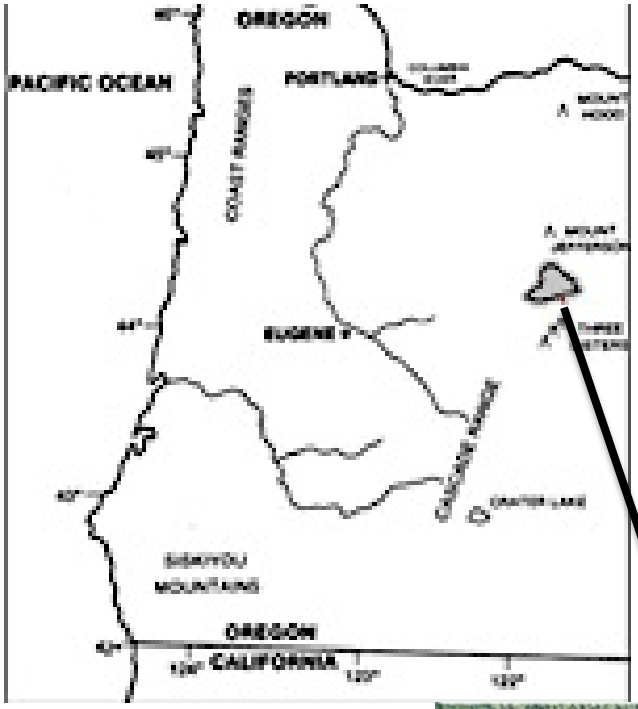
Encroachment will act as an environmental filter on meadow species.

Entire meadow community
(includes full spectrum of functional traits)



Residual meadow community
(includes species with greater intraspecific trait variation)

Bunchgrass Ridge



- Located on the boundary of the Western and High Cascades.
- Contains a mosaic of encroachment states by *Pinus contorta* and *Abies grandis* (open meadows, recent encroachment, and older encroachment).

Methods: Species Selection

- 13 species representing the range of sensitivities to encroachment
- Traits measured on 15-17 mature individuals of each species
- Light measured above each plant (via hemispherical photo)

Hypotheses

H1= Species that show greater adaptive variation in their functional traits will be less sensitive to encroachment.

H2= Encroachment will act as an environmental filter, reducing the relative abundance of species that show limited variation in their functional traits.

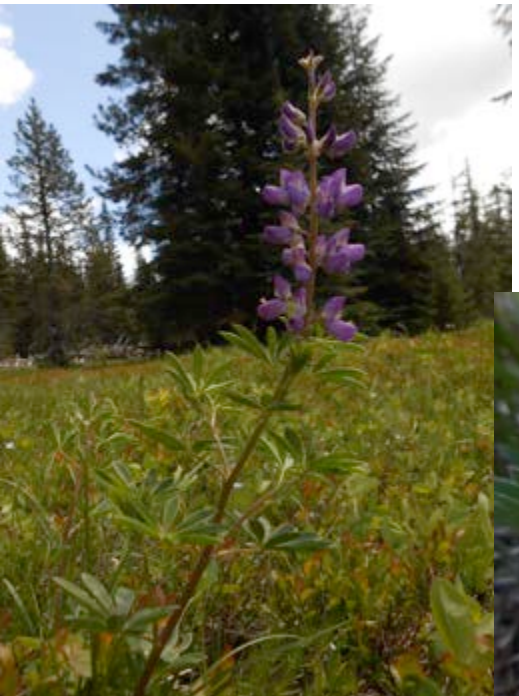
Data Analysis (H1)

Pearson's Correlation (n=13)

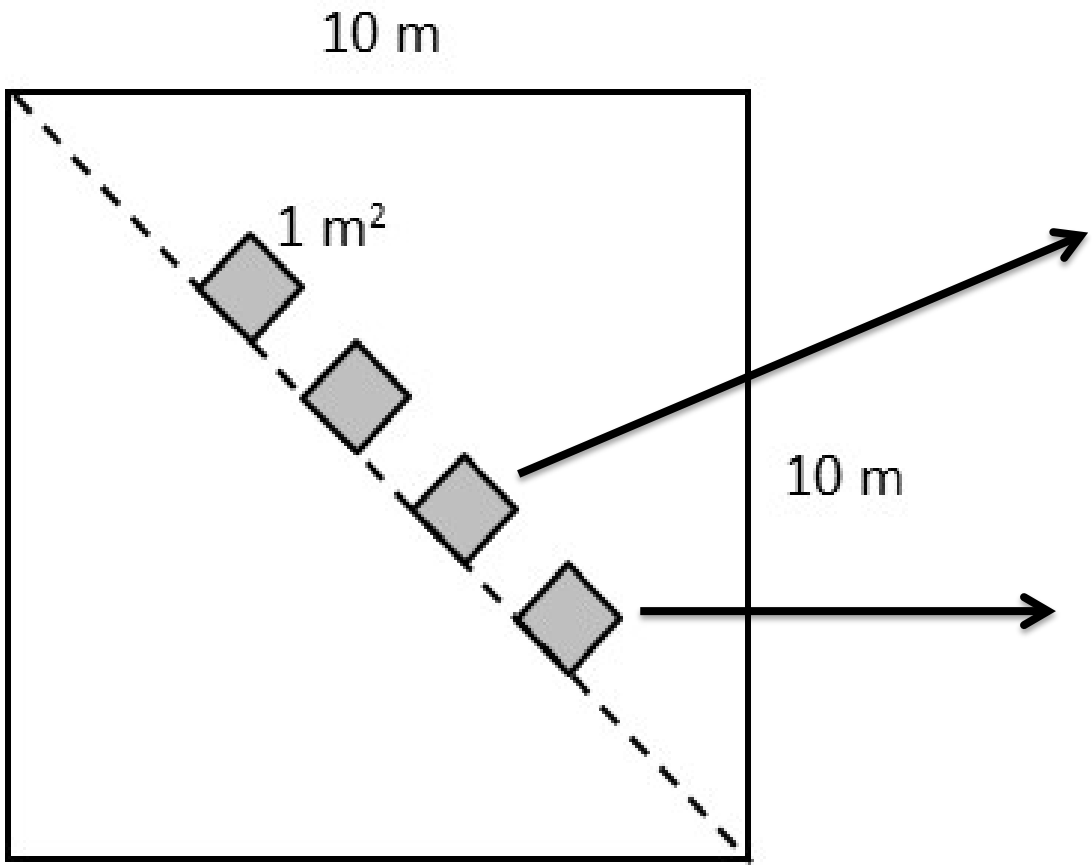
Trait Variability + Sensitivity

Kruskal Test (n= 2,6,5)

Clonal groups + Sensitivity

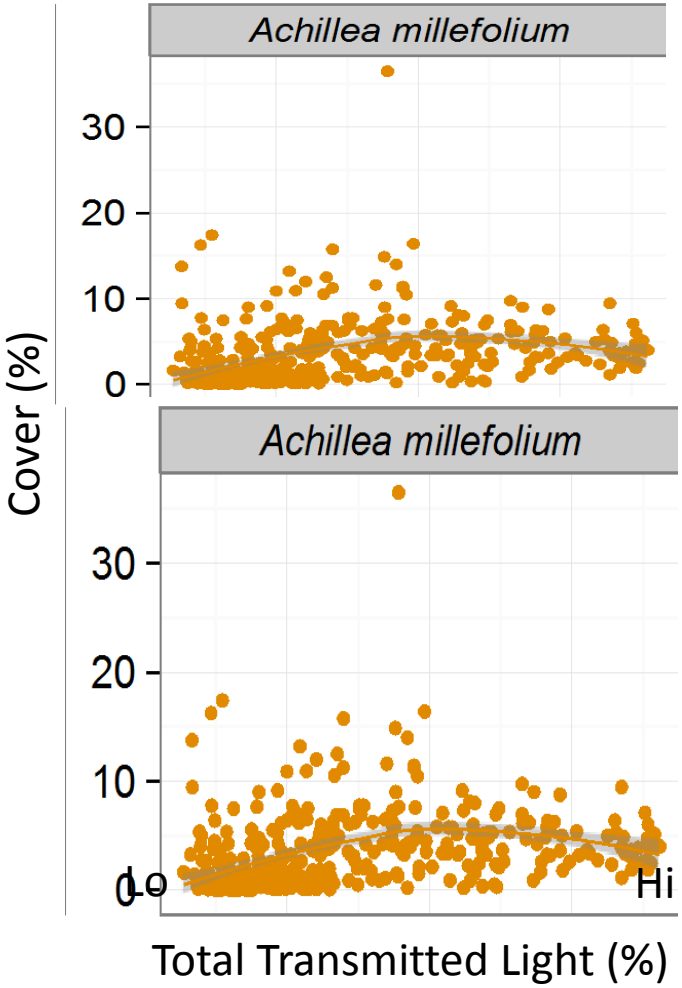


Methods: Species Sensitivity

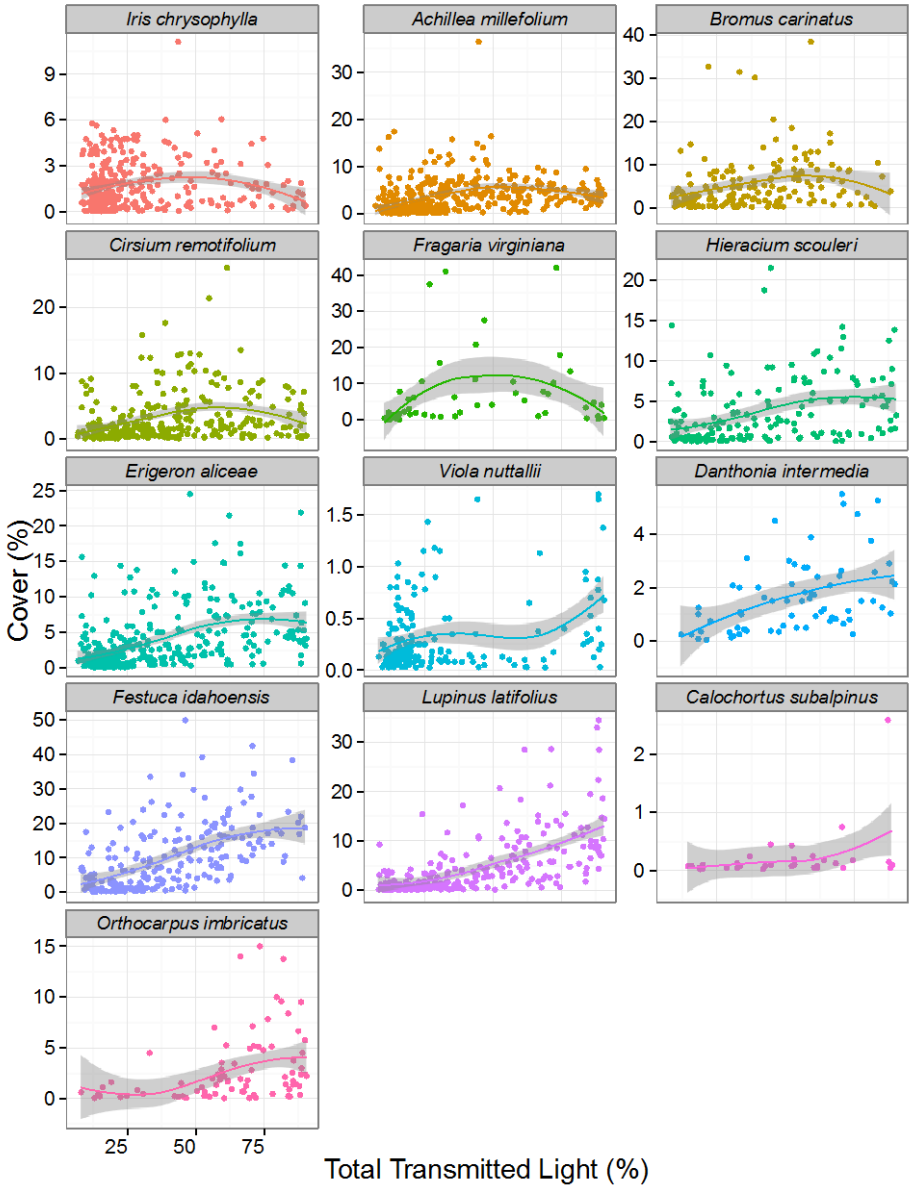


Species Response to Encroachment

- Fit species abundance and light data to a local regression model to describe species' sensitivity to light.

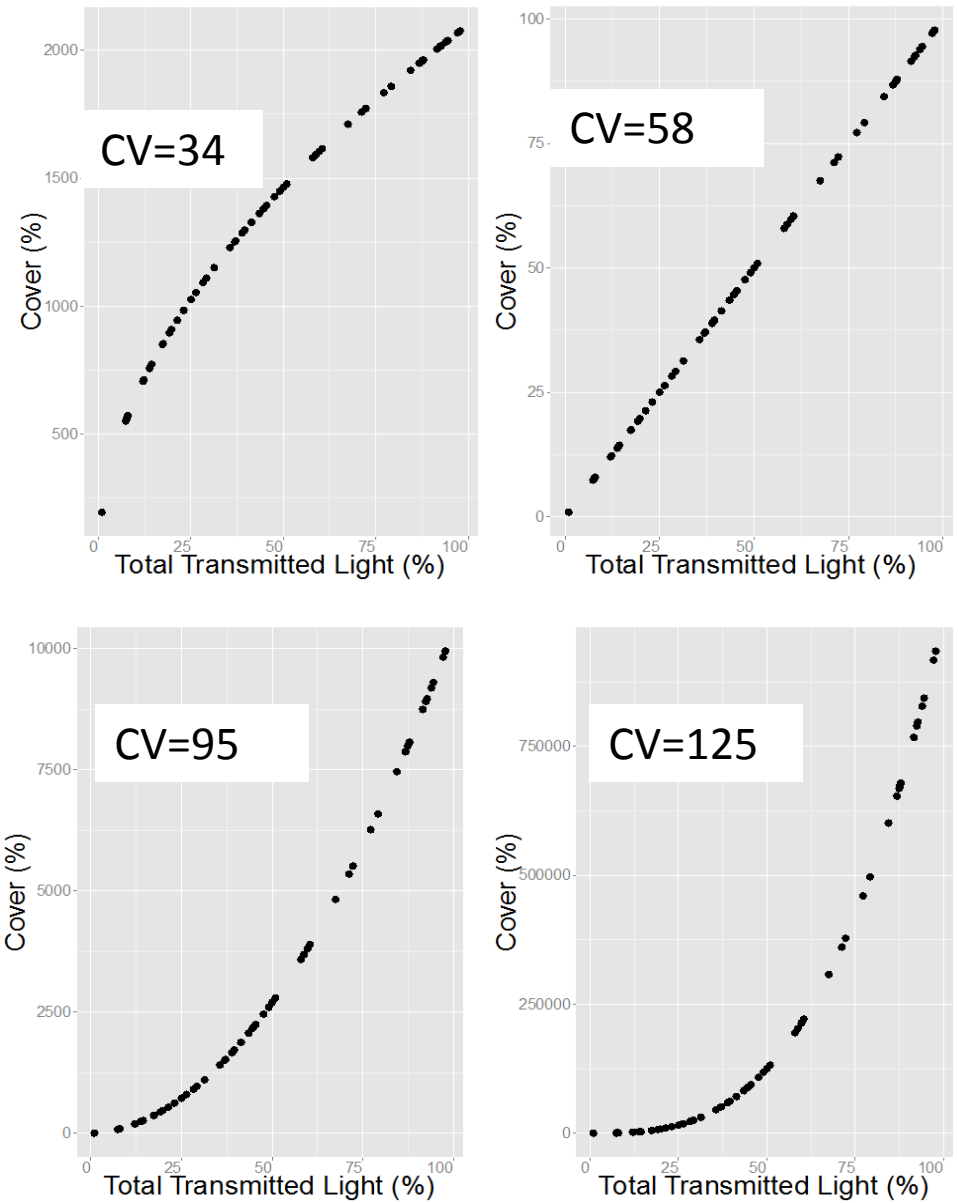


Sensitivity to Encroachment



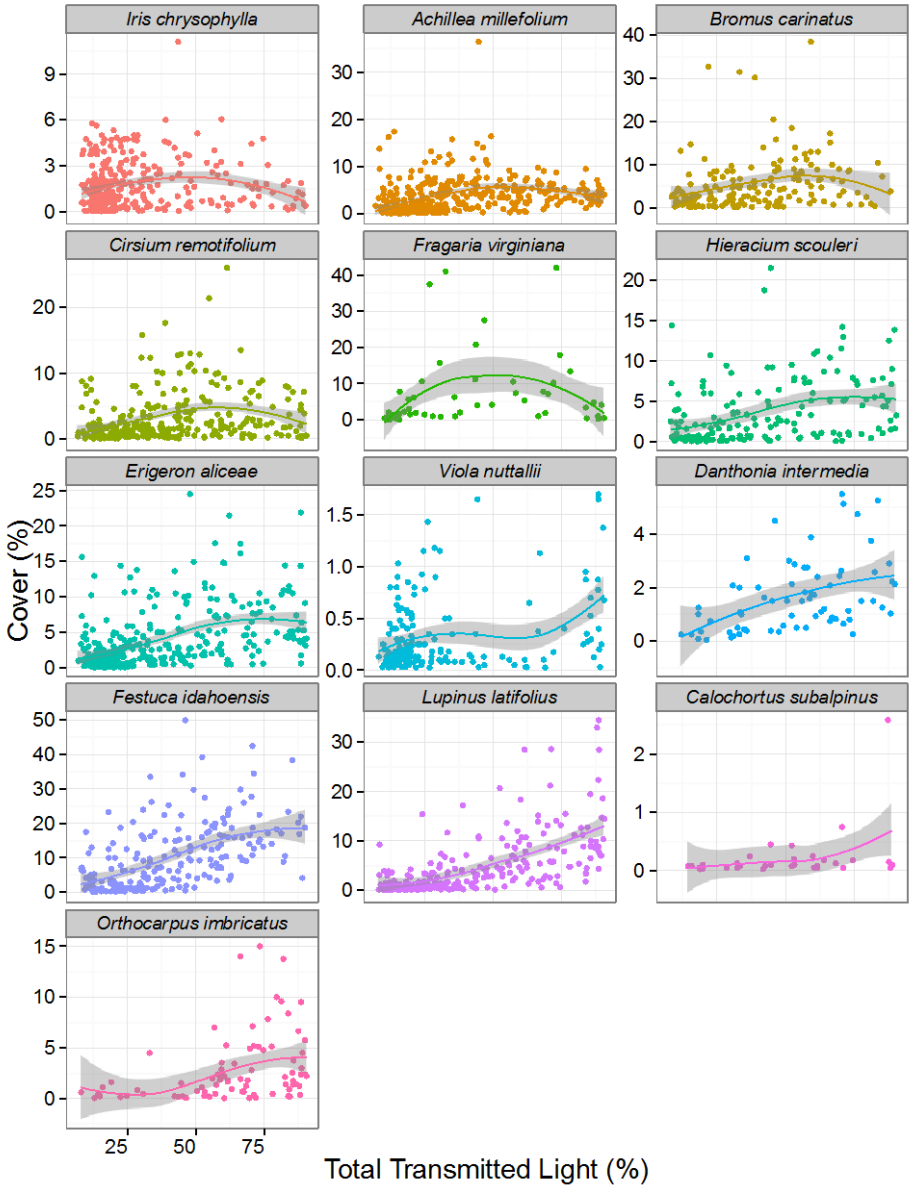
- Fit species abundance and light data to a local regression model to describe species' sensitivity to light.
- Calculated the Coefficient of Variation of the predicted values and used this to describe species sensitivity.

Sensitivity to Encroachment Simulations



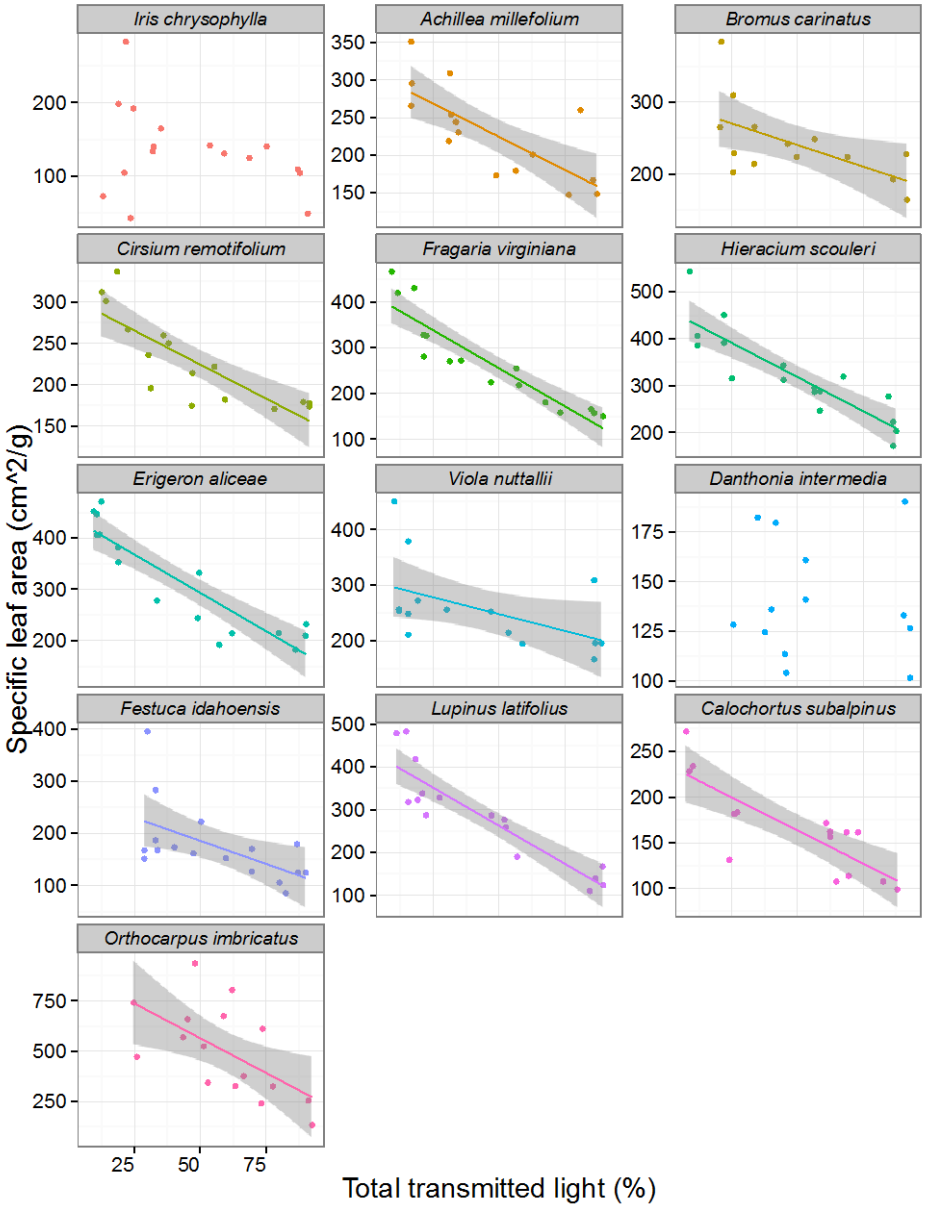
- Simulations confirm that exponential declines in cover generate higher CV values than quadratic or linear distributions.

Sensitivity to Encroachment



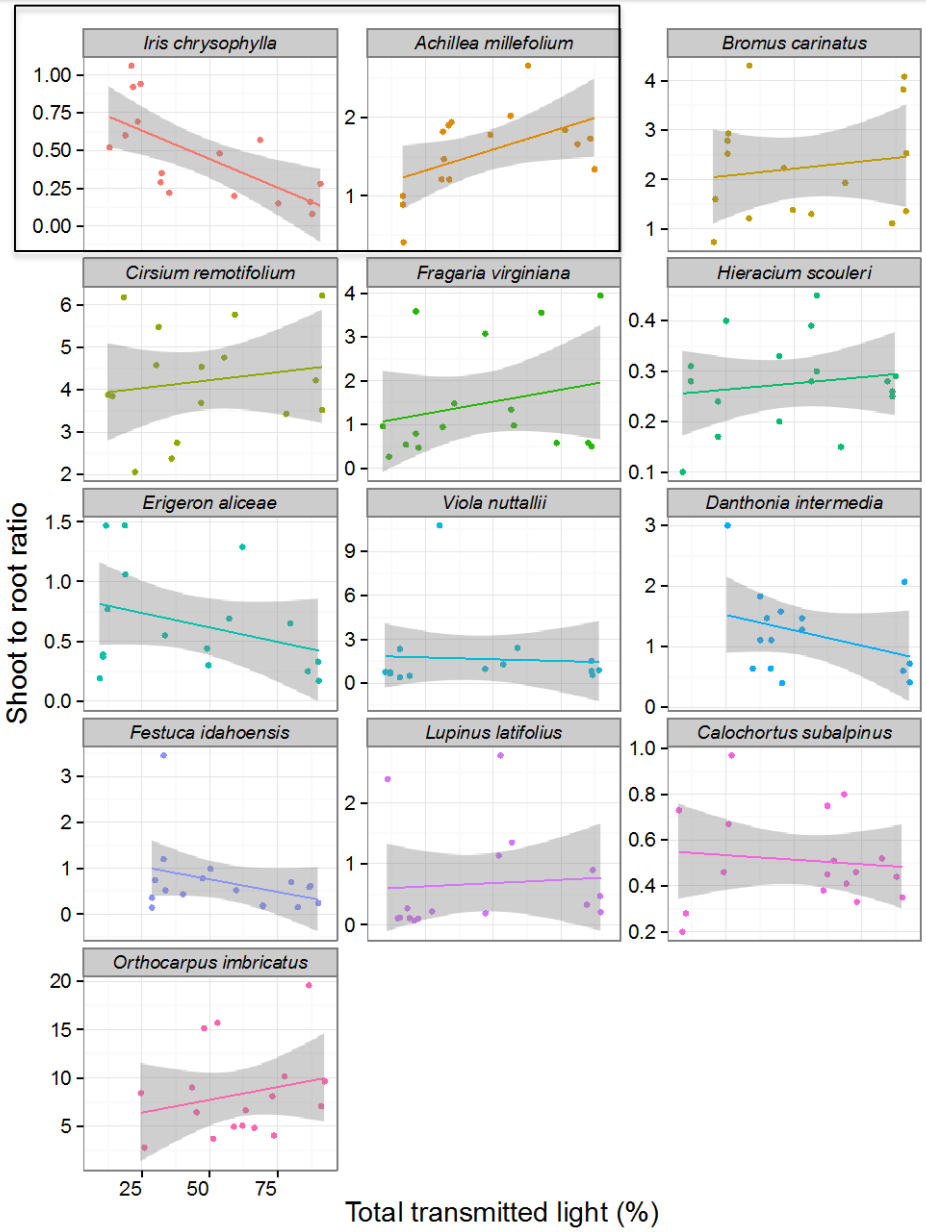
- Fit species abundance and light data to a local regression model to describe species' sensitivity to light.
- Calculated the Coefficient of Variation of the predicted values and used this to describe species sensitivity.

Methods: Trait Variability



- Used slopes of linear models to quantify variability in a trait across the light gradient.
- The steeper the slope the greater the variability
- Direction of slope indicates nature of response
  (+)=stress response
  (-)= adaptive response

Methods: Trait Variability

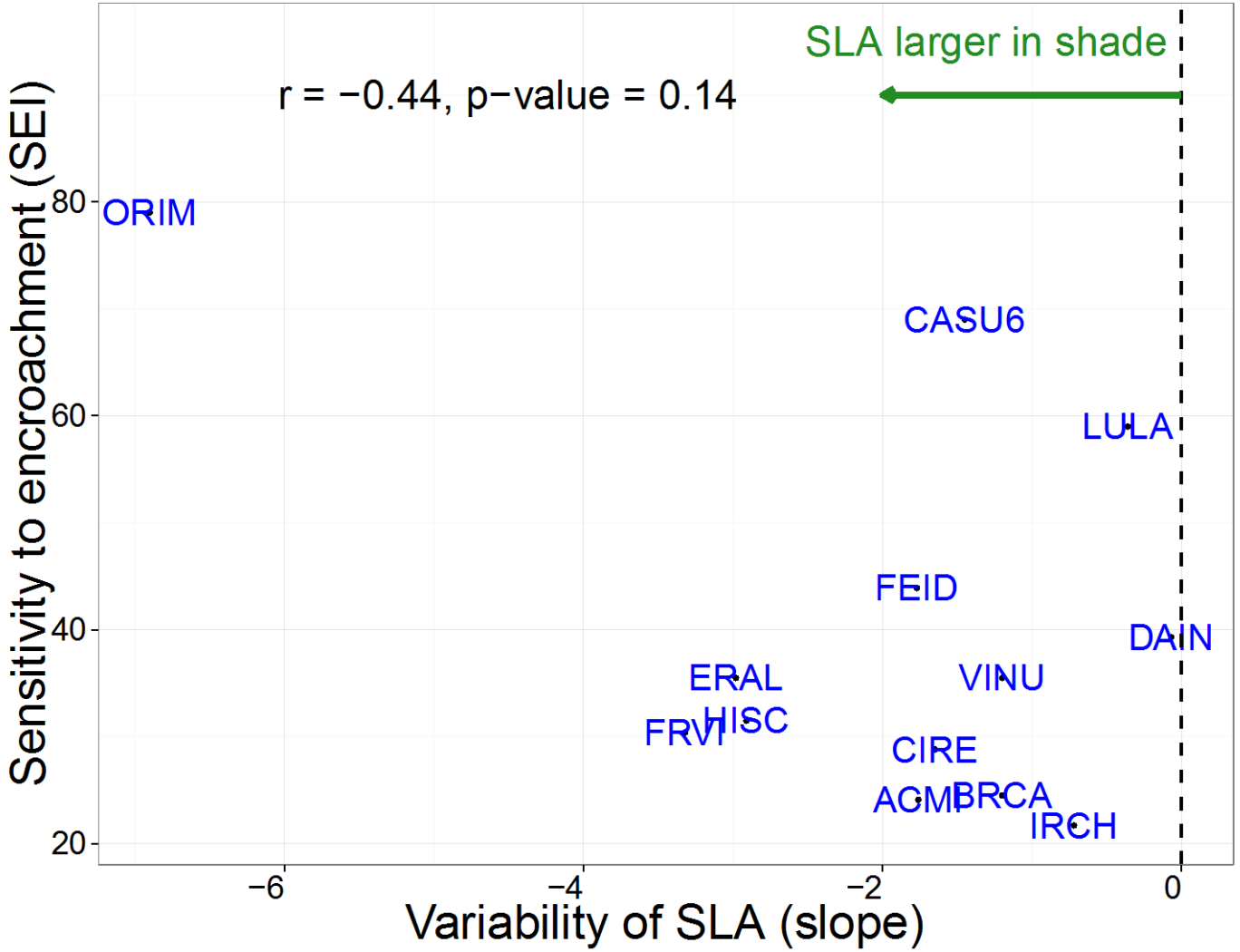


- Used slopes of linear models to quantify variability in a trait across the light gradient.
- The steeper the slope the greater the variability
- Direction of slope indicates nature of response
  (+)=stress response
  (-)= adaptive response

Results (H1)

Is sensitivity to encroachment correlated to variability in…

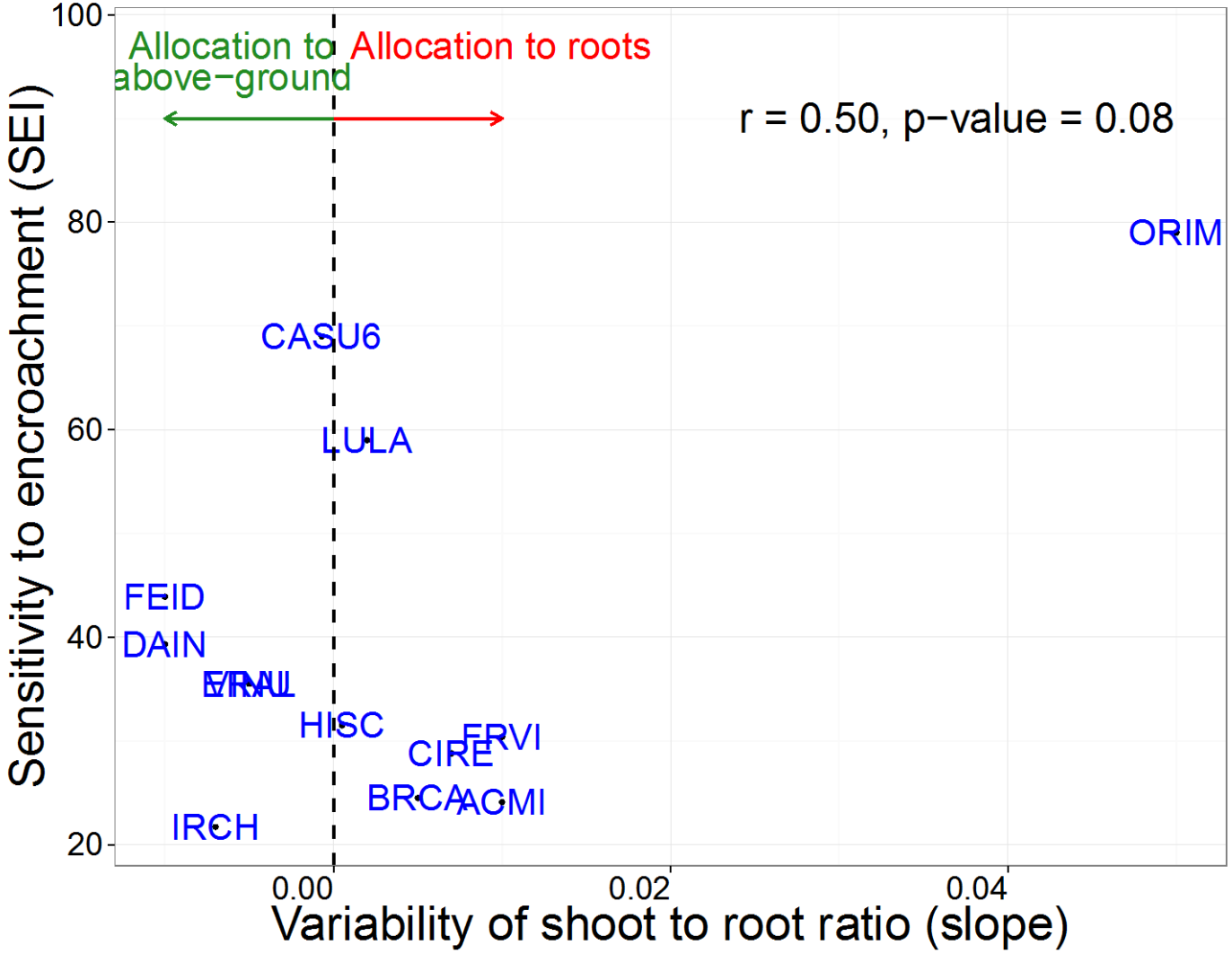
SLA



Results (H1)

Is sensitivity to encroachment correlated to variability in…

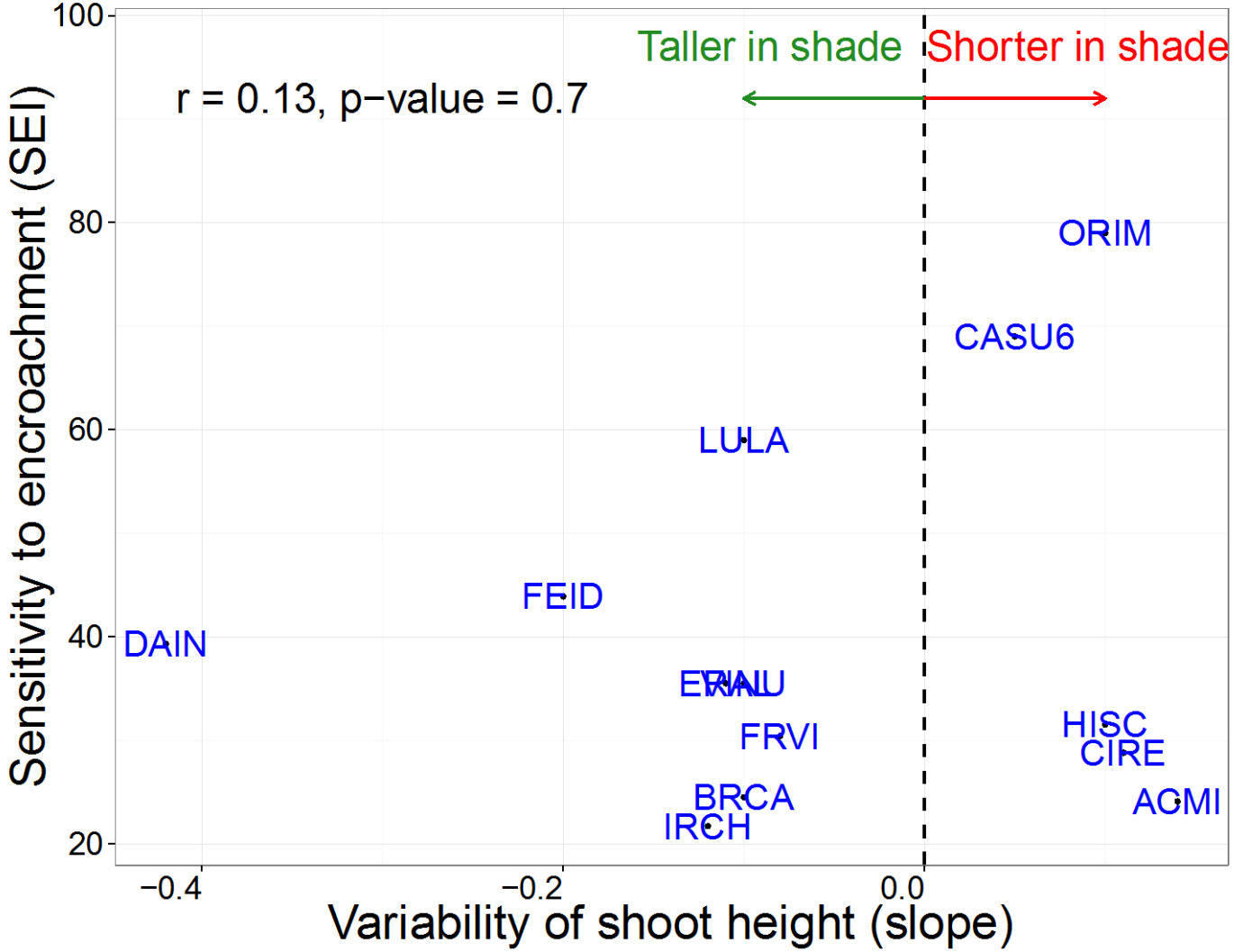
Shoot to Root Ratio



Results (H1)

Is sensitivity to encroachment correlated to variability in…

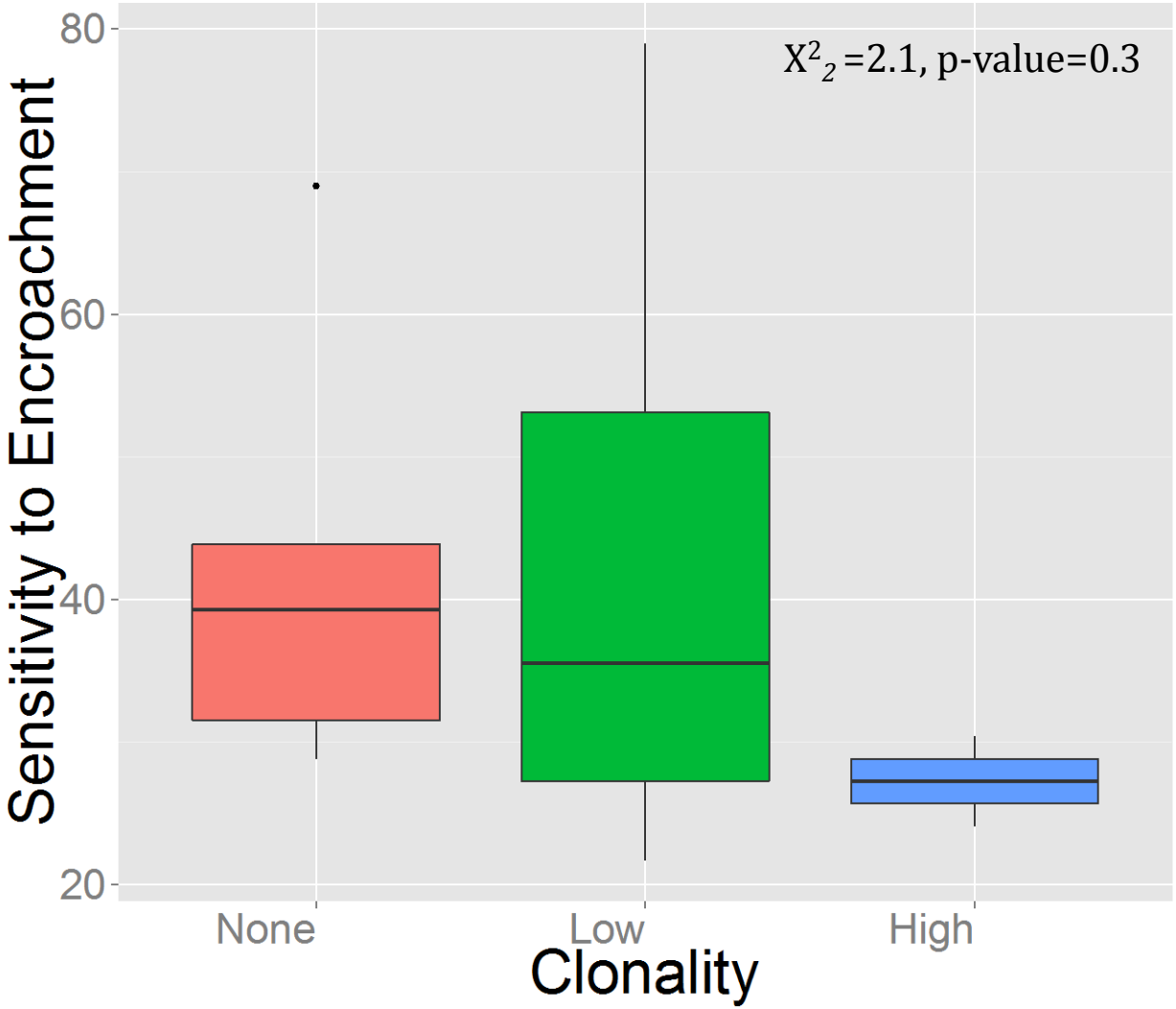
Shoot Height



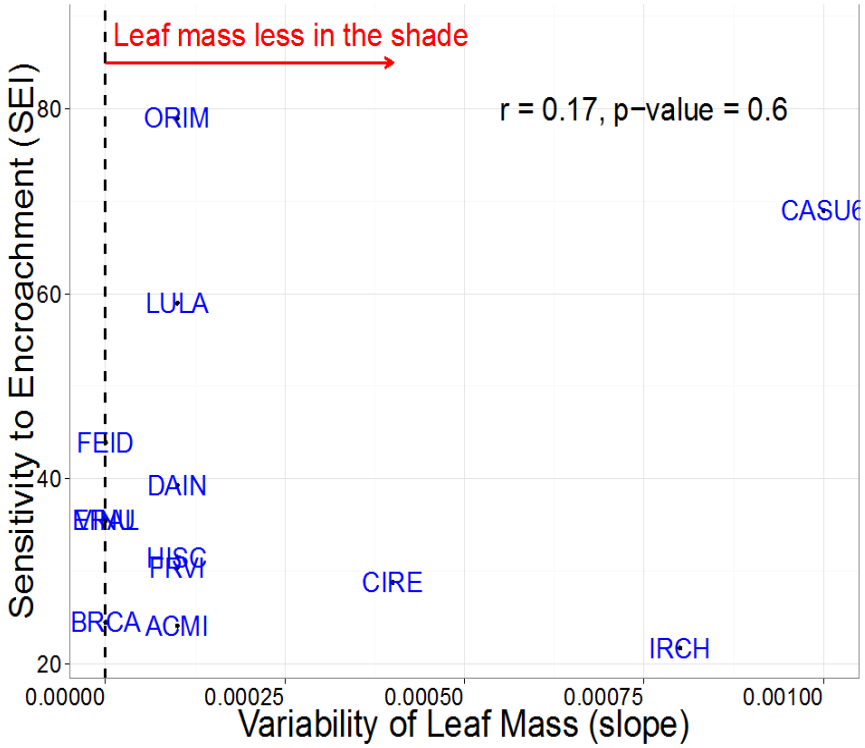
Results (H1)

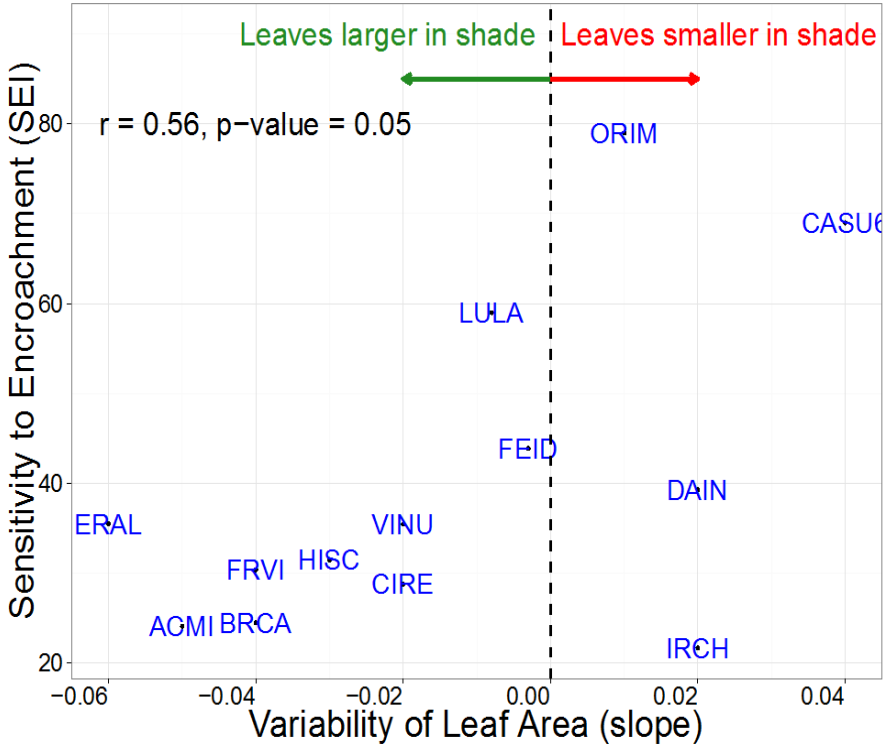
Is sensitivity to encroachment correlated to variability in…

Clonality



Results: SLA components (H1)

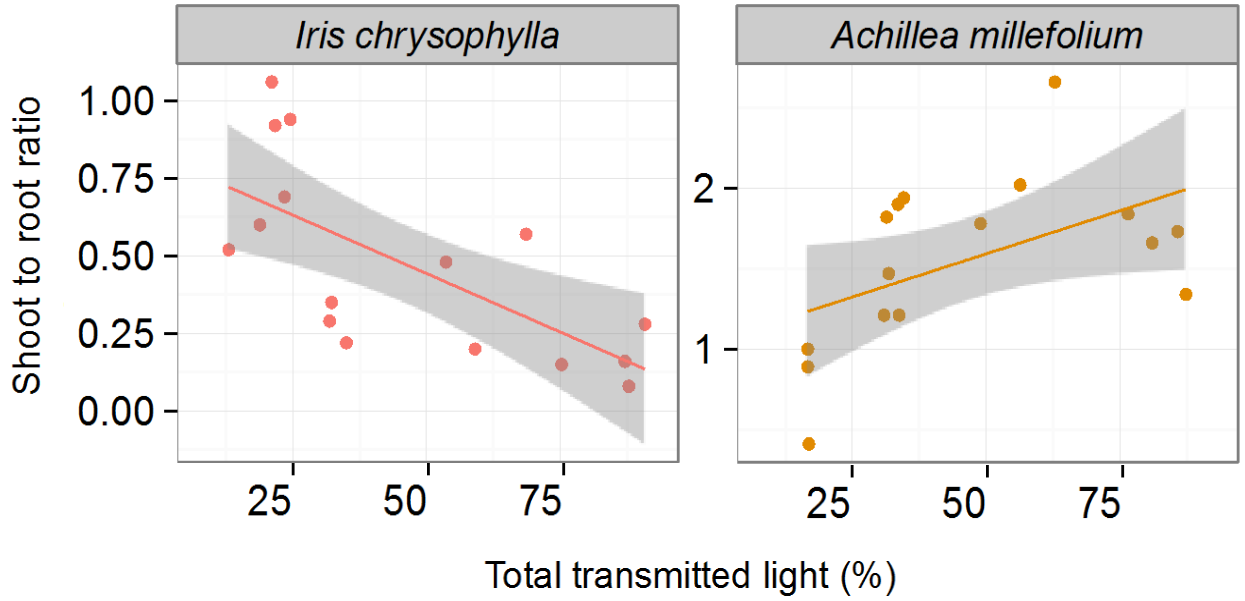




Discussion (H1)

- SLA: while all species had an adaptive response to limited light, leaf area gave a better picture of species response to encroachment.

- Varying responses of species traits to conifer encroachment could indicate that species are responding to more than just changes in light.



Hypotheses

H1= Species that show greater adaptive variation in their functional traits will be less sensitive to encroachment.

H2= Encroachment will act as an environmental filter, reducing the relative abundance of species that show limited variation in their functional traits.

Data Analysis (H2)

Matrix Multiplication

Species

Sample Unit

A

X

Trait variability

Species

S

Trait variability

Sample Unit

AS’

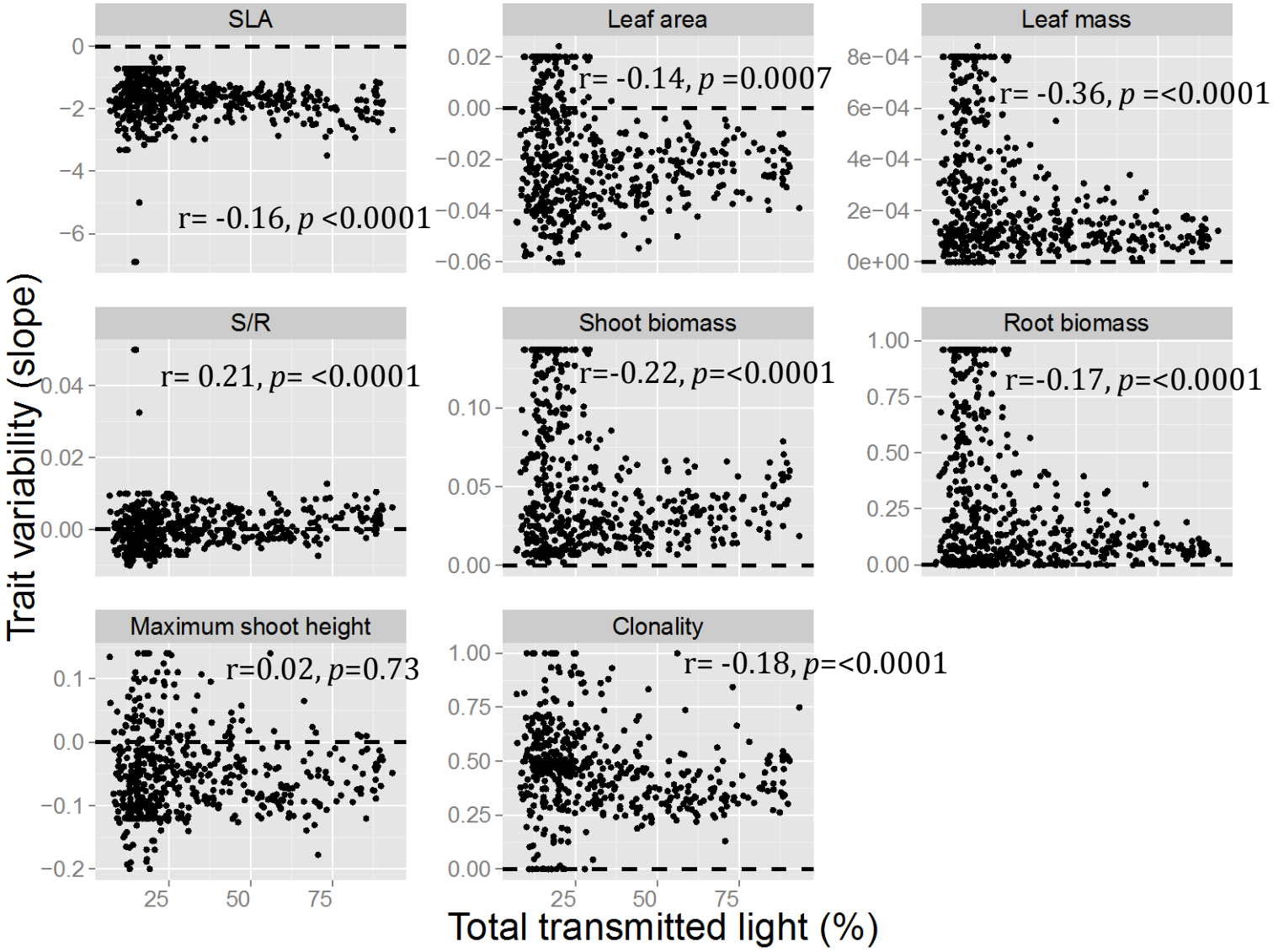
Correlation

Light

Sample Unit

E

Results (H2)


SLA
r= -0.16, p <0.0001
Leaf area
r= -0.14, p =0.0007
Leaf mass
r= -0.36, p =<0.0001
S/R
r= 0.21, p= <0.0001
Shoot biomass
r=-0.22, p=<0.0001
Root biomass
r=-0.17, p=<0.0001
Maximum shoot height
r=0.02, p=0.73
Clonality
r= -0.18, p=<0.0001
Trait variability (slope)
Total transmitted light (%)

In Summary

H1: Leaf area variability was the best predictor of species sensitivity to encroachment.

H2: Indication that encroachment can act as an environmental filter as light availability becomes limited, but that in the shade we saw greater heterogeneity of species with both high and low variability for certain traits.

Conclusions

- Future studies should focus on physiological leaf traits like dark respiration and photosynthetic capacity.
- Resources other than light could also help illustrate species sensitivity to encroachment.

Acknowledgements

Advisors

Andy Jones

Charlie Halpern

Field/Lab Assistants

Katherine Dymek

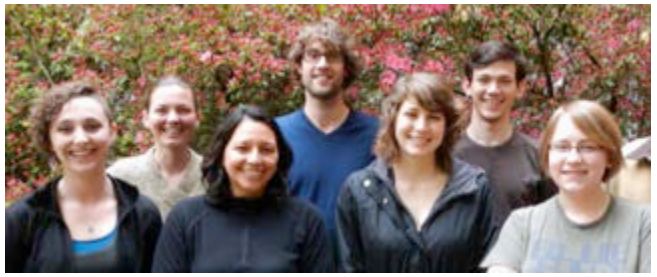
Chris Parson

Statistical Advising and R Support

Ariel Muldoon Bruce McCune Shane Celis

Writing Support Team

The Jones Lab



Ari DeMarco

Funding

H.J. Andrews LTER
Portland Garden Club
OSU's BPP Department

Committee Members:
Julia Jones, Barbara Bond

Friends and Family

Questions?