Comparative Analysis of Wild Annual and Herbaceous Perennial *Astragalus* (Fabaceae)

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[1]University of North Texas, [2]Saint Louis University

Rethinking Contemporary Agriculture

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Rethinking Contemporary Agriculture

Annual Monoculture

Perennial Polyculture

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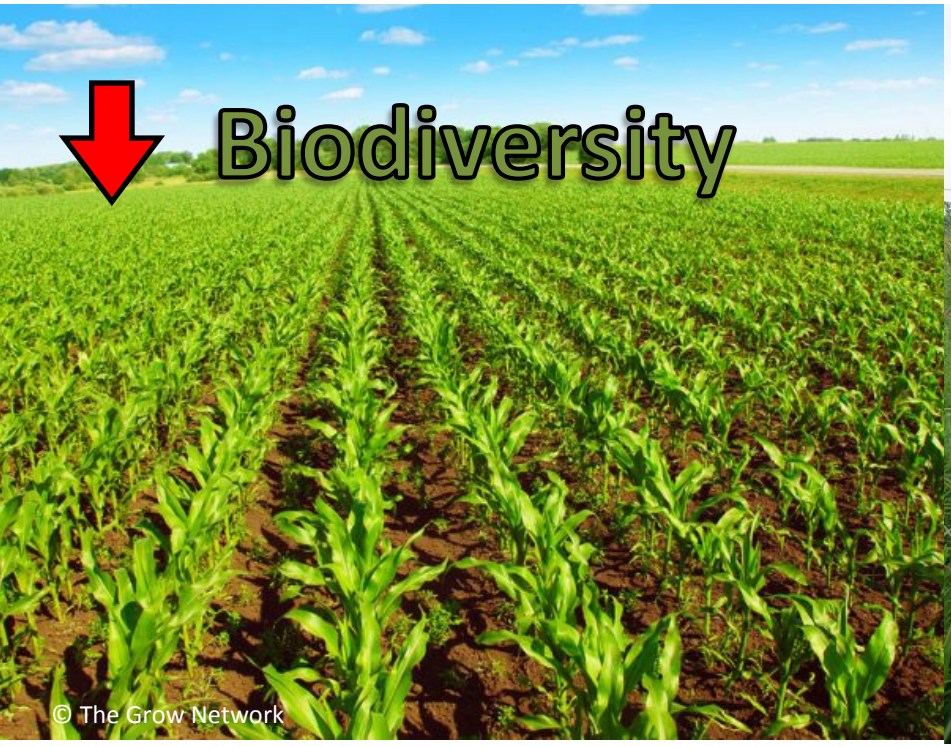
Perennial Polyculture



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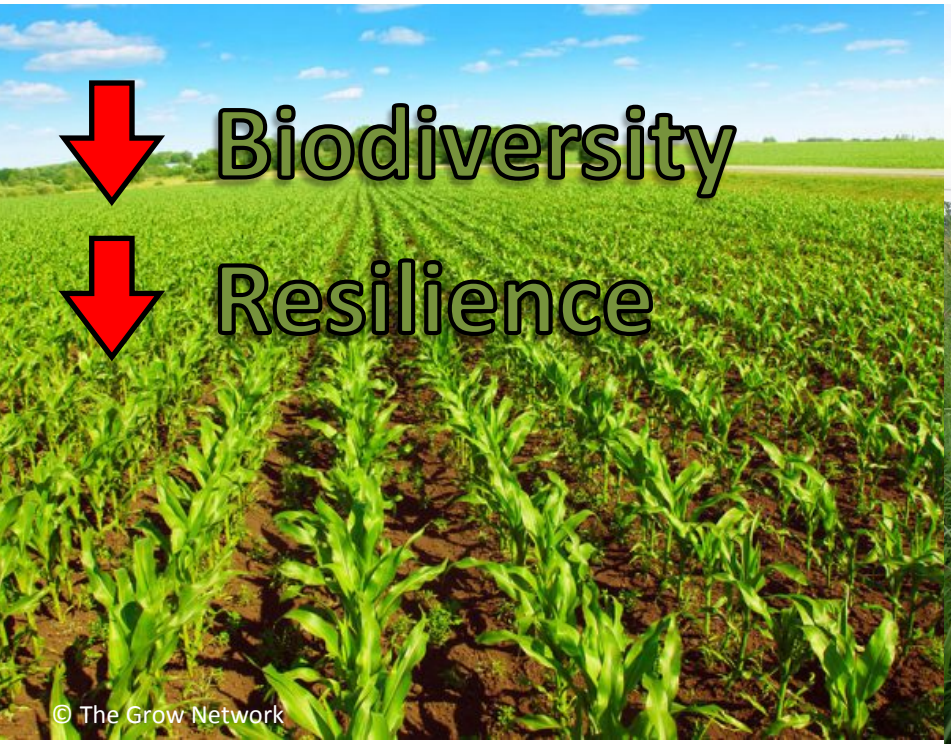

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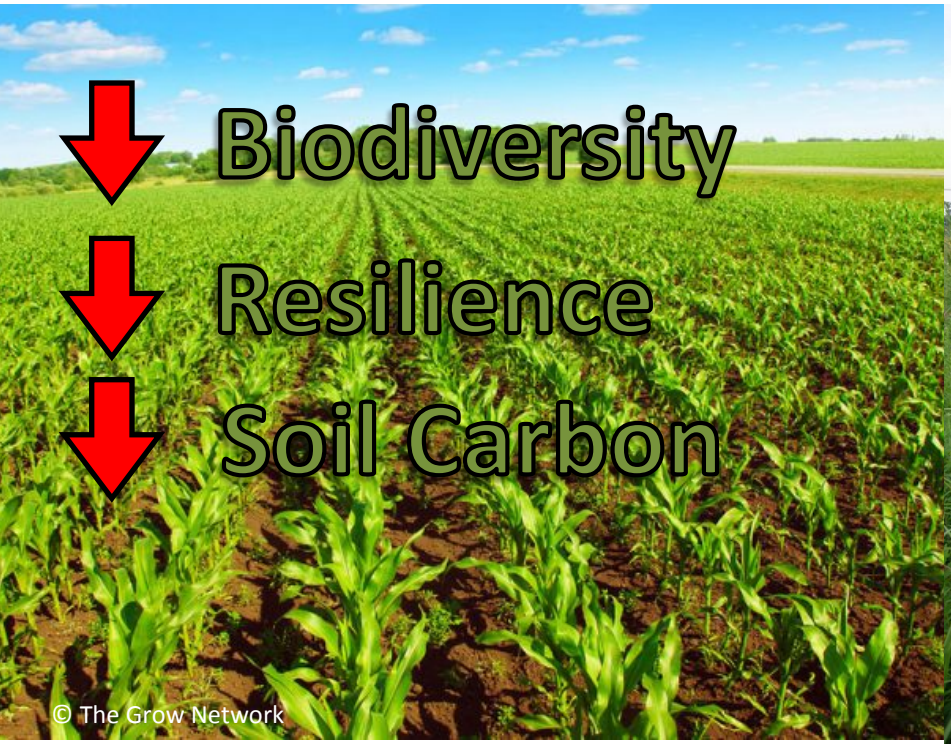

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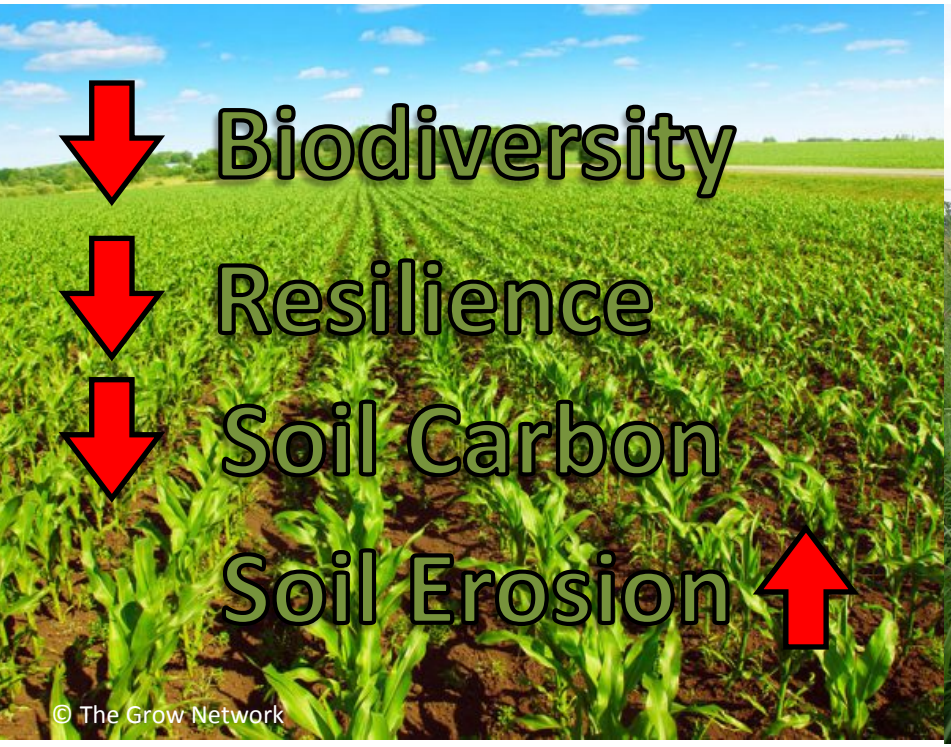

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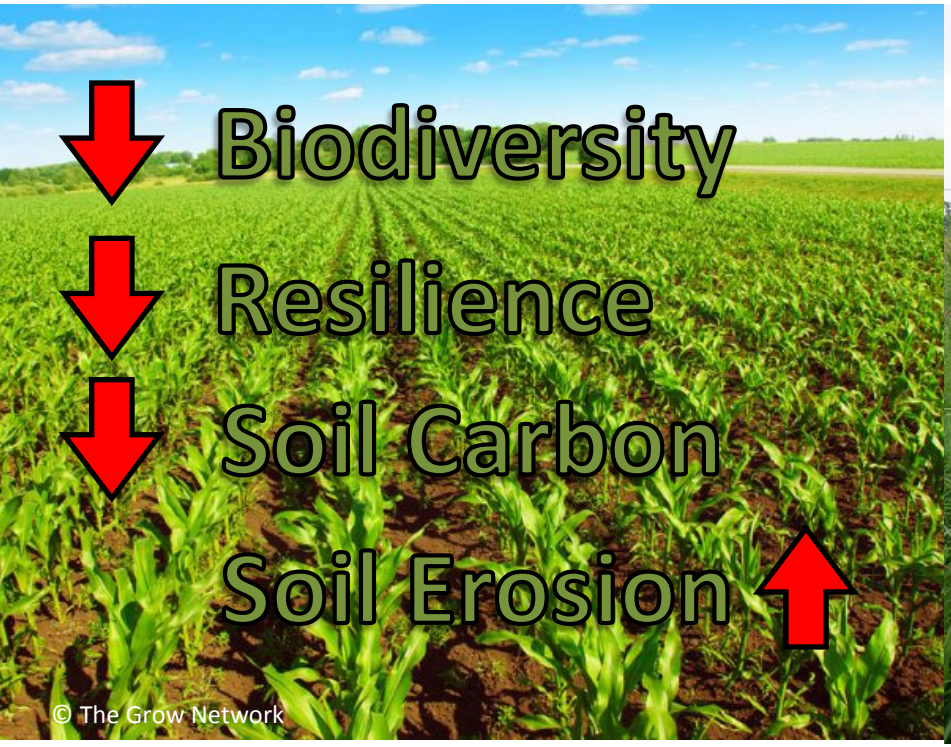

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Key innovations:

1. Perennial crops
2. Grown in mixtures

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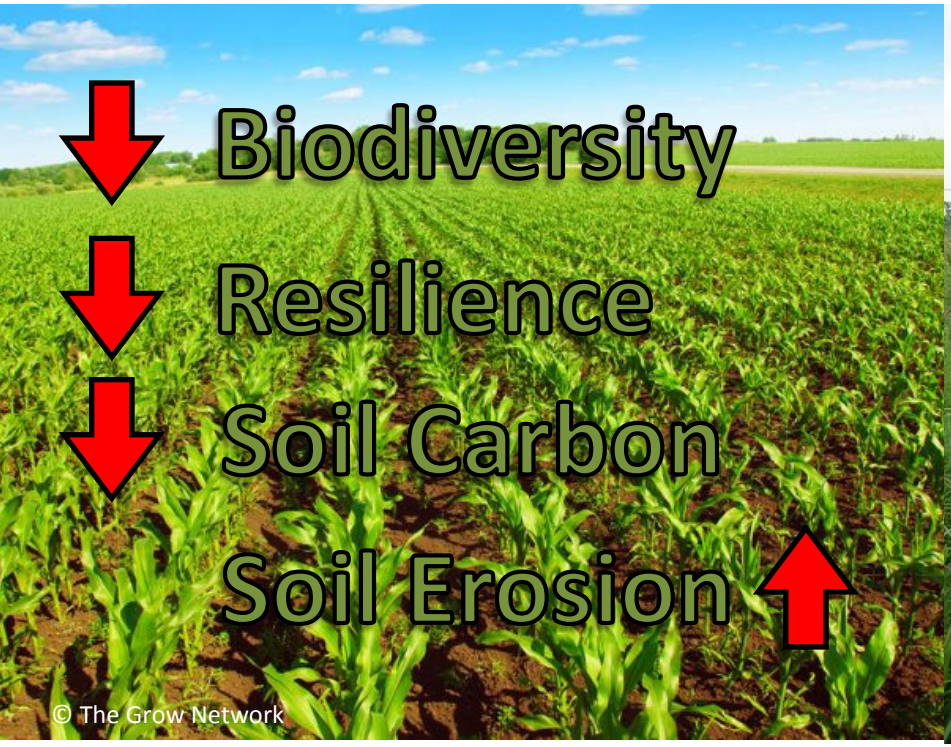

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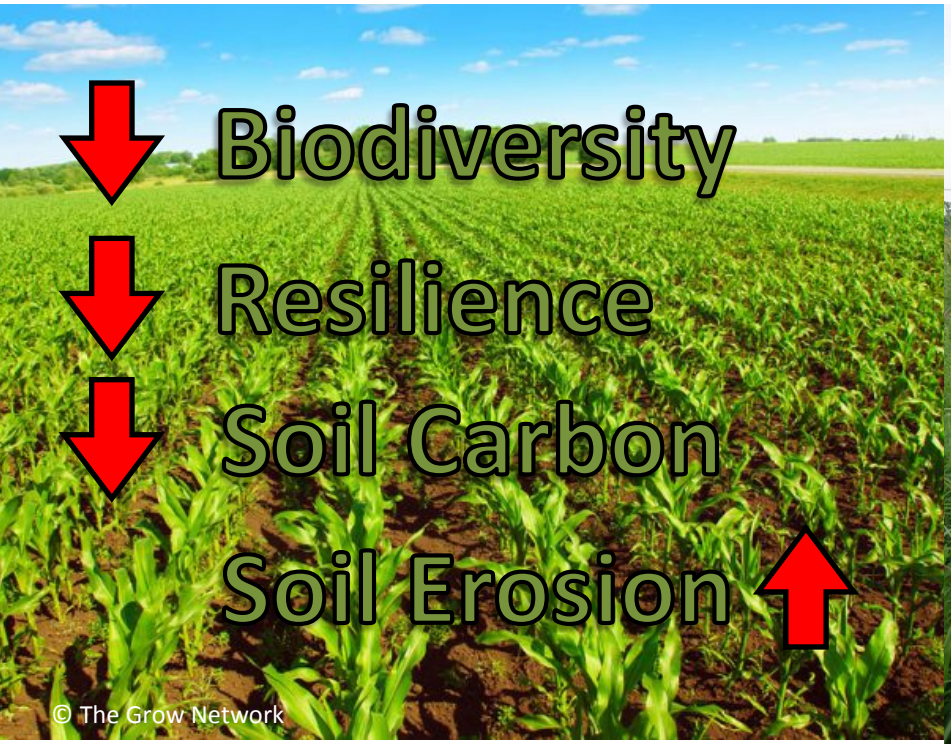

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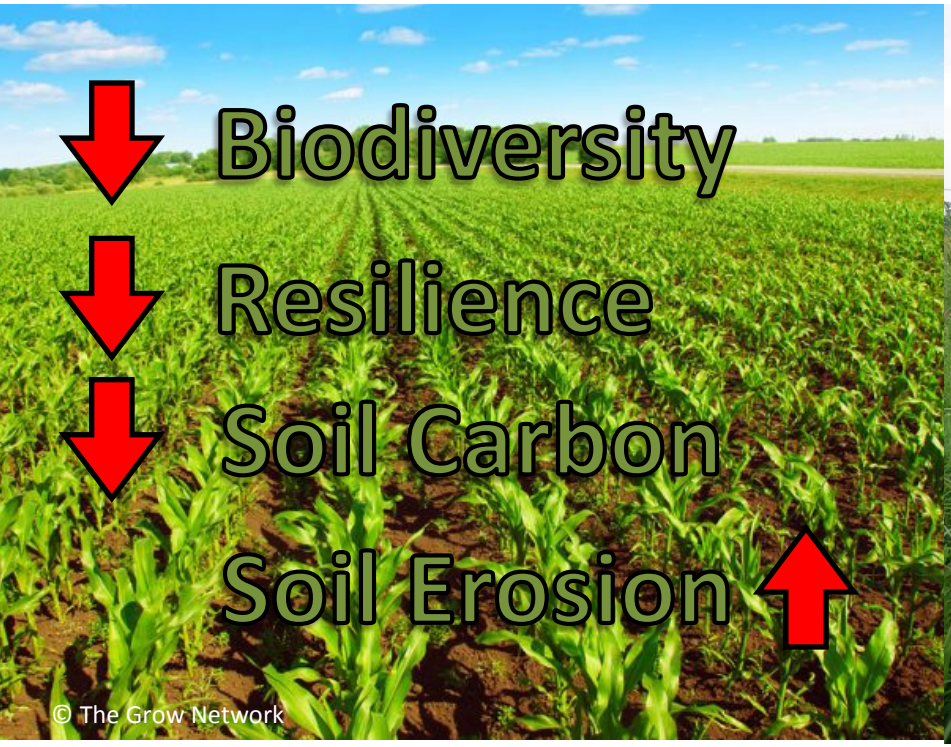

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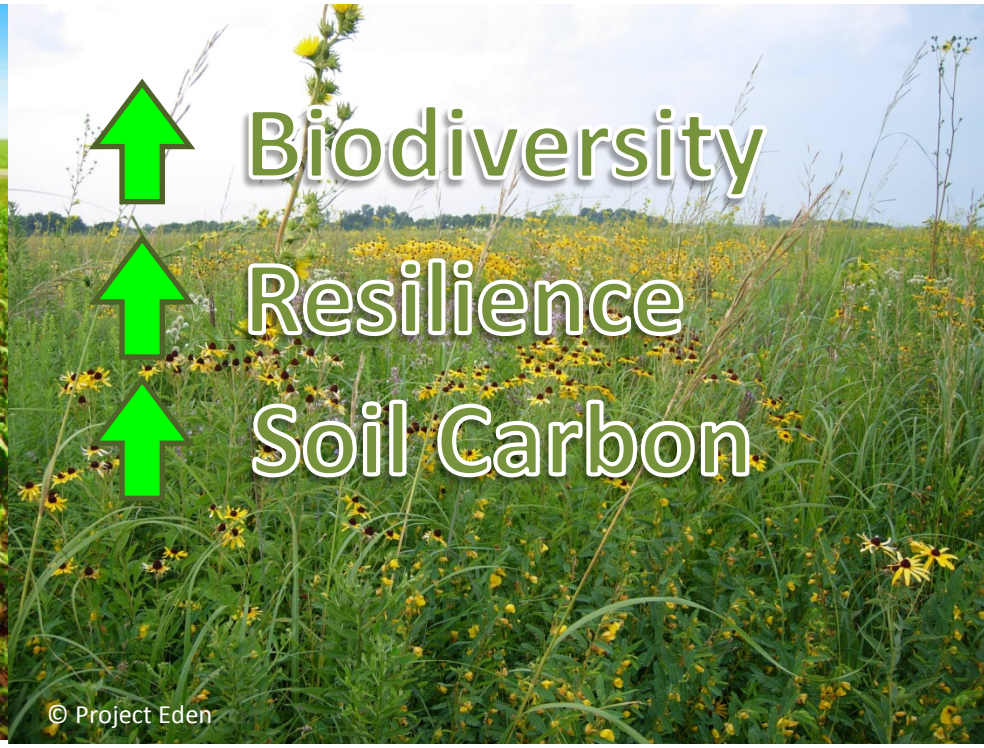

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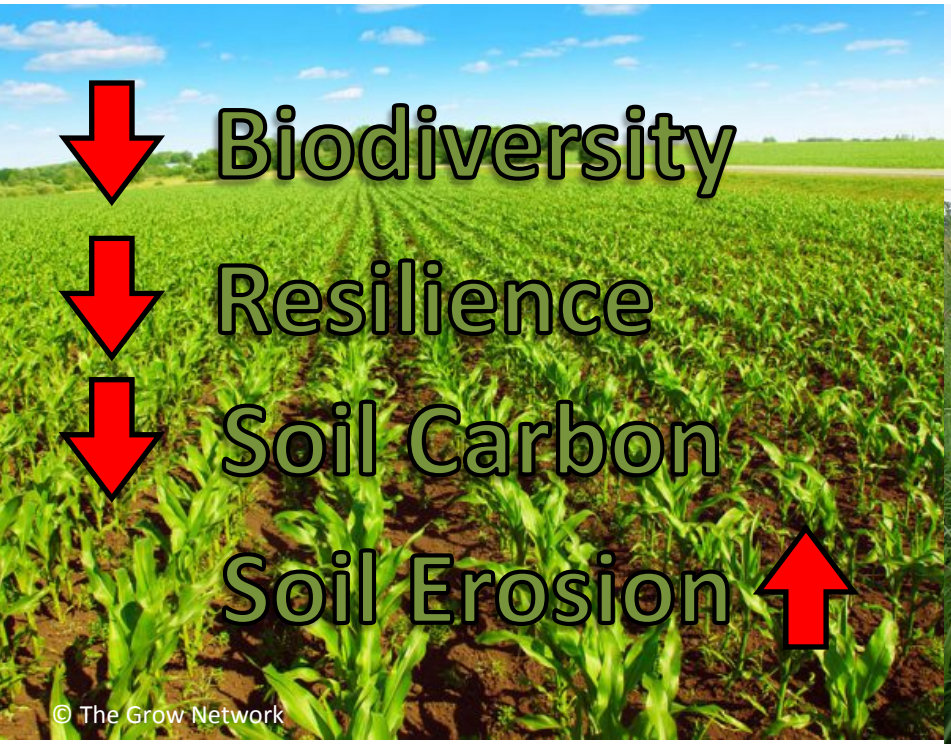

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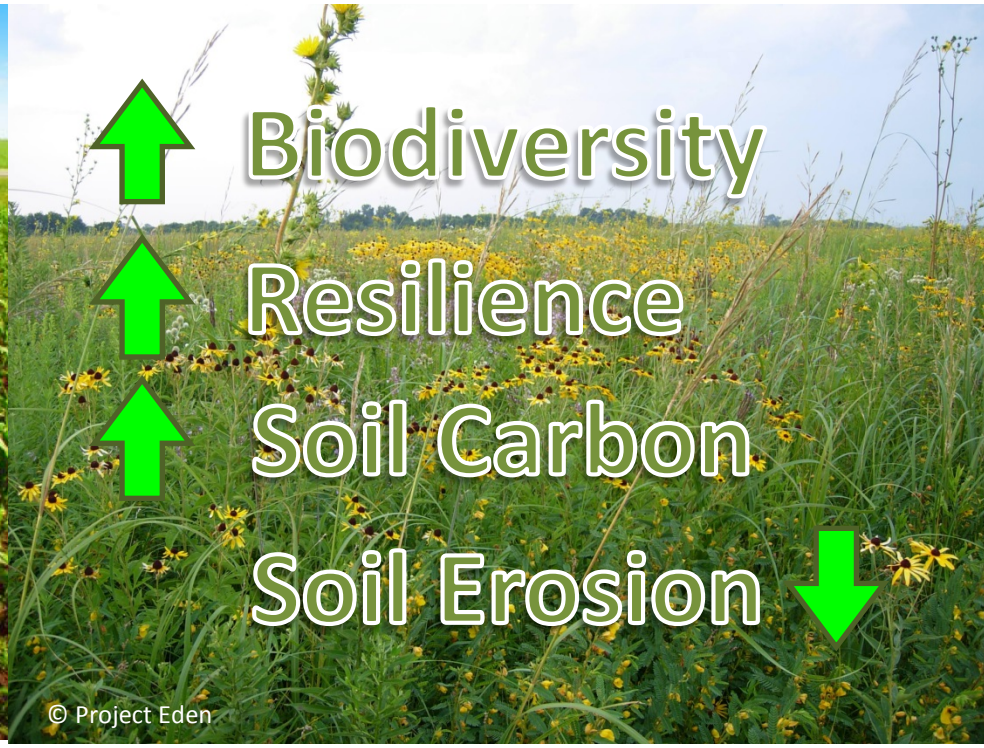

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Herbaceous perennial plants were rarely domesticated

Woody perennials

Multiple growing seasons

Herbaceous perennials

Regrow from roots every year

Annuals

One growing season

Herbaceous perennial plants were rarely domesticated

Woody perennials

Herbaceous perennials

Annuals

Domestication:

Morphological and genetic changes relative to wild progenitors as a result of artificial selection

Herbaceous perennial plants were rarely domesticated

Woody perennials

Herbaceous perennials

Annuals

Domestication:

Morphological and genetic changes relative to wild progenitors as a result of artificial selection

Domestication Syndrome:

Suite of traits (increased fruit size, reduced toxicity, etc.) that characterize domesticated species

Herbaceous perennial plants were rarely domesticated

Woody perennials

20-65%

Herbaceous perennials

?

Annuals

15-45%

Adapted from Van Tassel et al. 2010

Herbaceous perennial plants were rarely domesticated

Woody perennials

Herbaceous perennials

?

Annuals

Trade-offs?

Herbaceous perennial plants were rarely domesticated

Woody perennials

Herbaceous perennials

?

Annuals

Trade-offs?

↑ Fruits

↑ Stems/ Leaves

Herbaceous perennial plants were rarely domesticated

Woody perennials

Herbaceous perennials

Annuals

?

Trade-offs?

↑ Fruits ↑ Stems/ Leaves

↑ Fruits ↓ Stems/ Leaves

Adapted from Van Tassel et al. 2010

Perennial Agriculture Project

Kernza ®

Silphium

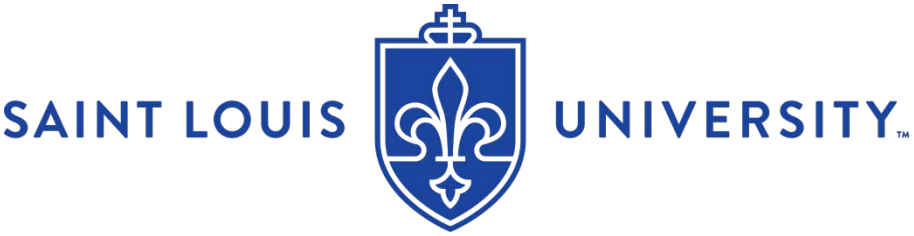
Alfalfa

Perennial Agriculture Project

Goals:

1. Identify wild herbaceous perennials that are good candidates for domestication

2. Test hypotheses about how herbaceous perennials compare to annuals (germination, growth rate, resource allocation, etc.)



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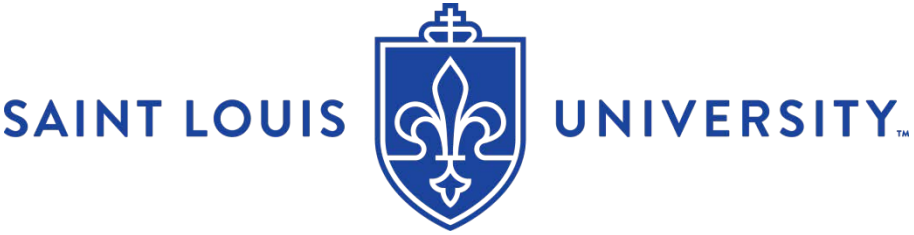
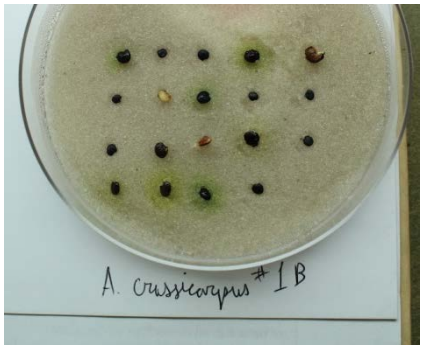


What are the differences between closely related herbaceous perennials and annuals?

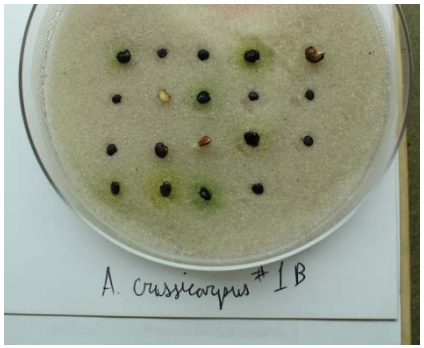
What are the differences between closely related herbaceous perennials and annuals?

- Germination rate?



What are the differences between closely related herbaceous perennials and annuals?

- Germination rate?
- Seedling growth rate?



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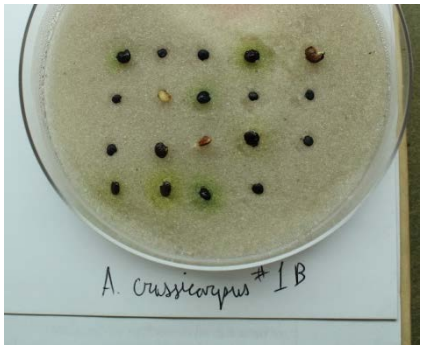
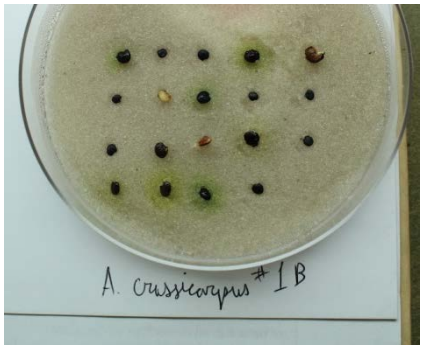
- Germination rate?
- Seedling growth rate?
- Biomass allocation?



What are the differences between closely related herbaceous perennials and annuals?

- Germination rate?
- Seedling growth rate?
- Biomass allocation?
- Correlations between reproductive and vegetative structures?





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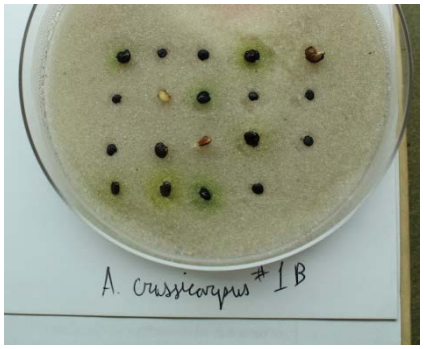
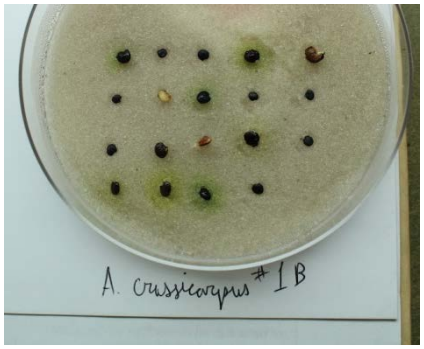
Expected little to no difference for time frame of project and little to no correlations



Two distinct datasets for comparing perennials & annuals



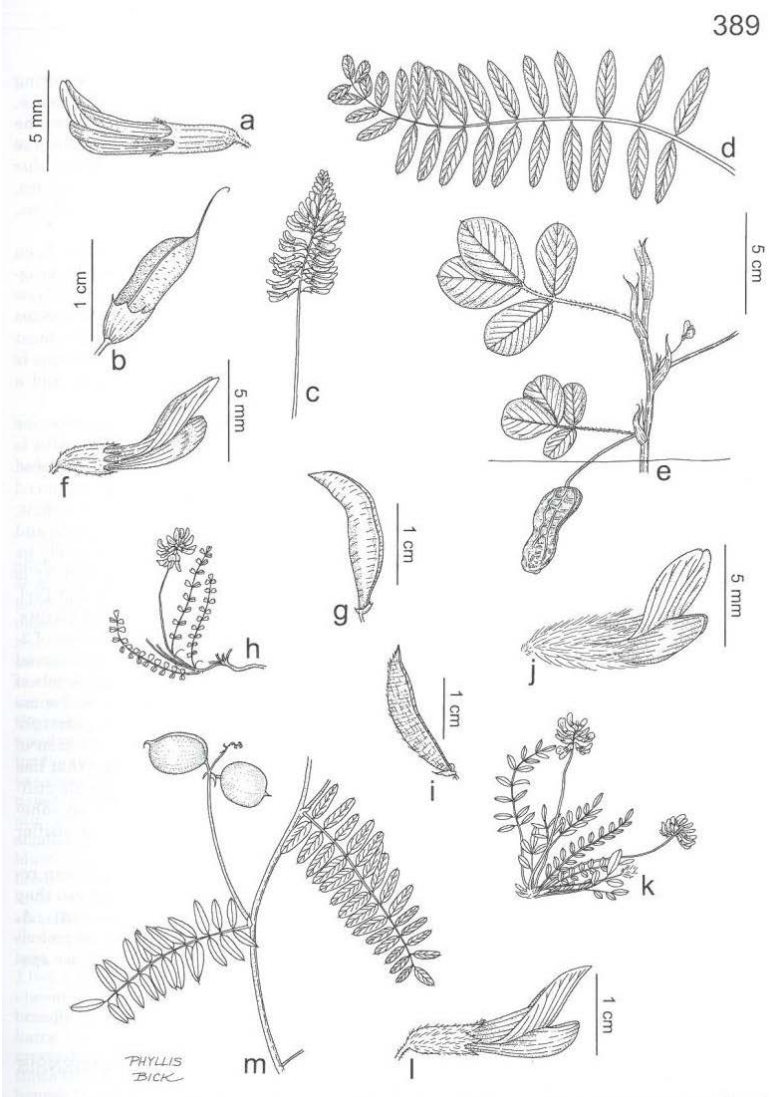
Two distinct datasets for comparing perennials & annuals

Live plants

Herbarium specimens

Astragalus is a model system for studying perennial & annual congeners

- Monophyletic
- 3000+ species
- Nearly all annuals or herbaceous perennials
- Many temperate natives
- Many species have historically been used for food and medicine



Yatskievych, G. 2013. *Flora of Missouri*. Missouri Botanical Garden Press: St. Louis, MO, USA.

Herbaceous Perennials

Canadian milkvetch
A. canadensis
One accession
178 seeds

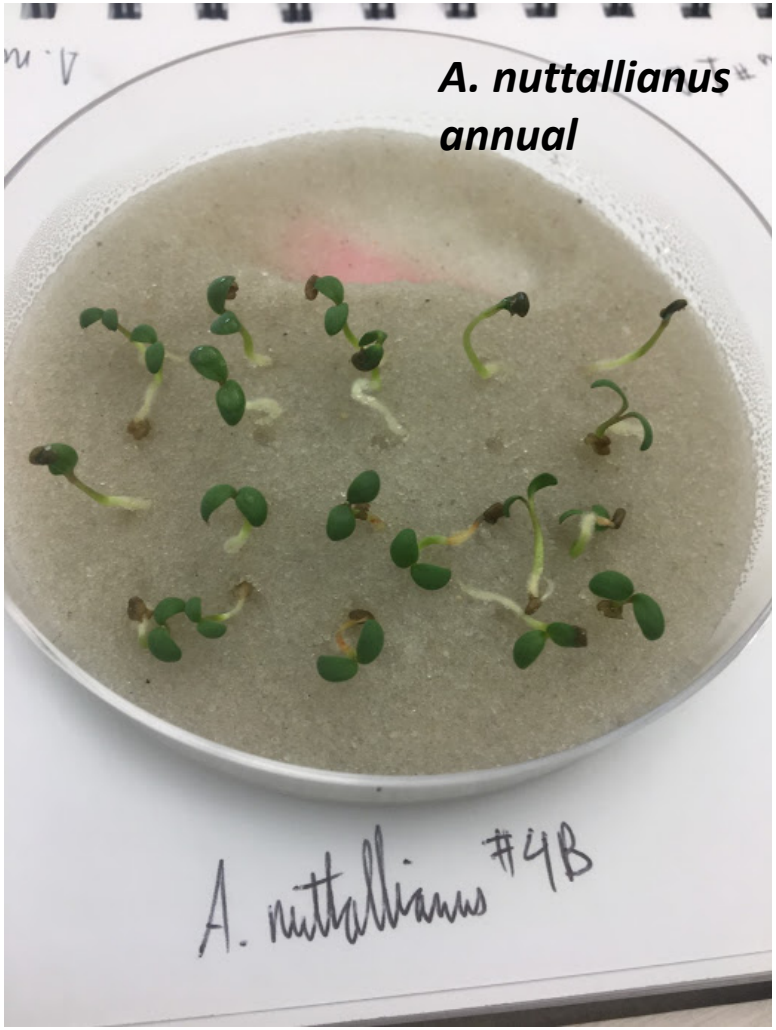
Groundplum milkvetch
A. crassicarpus
Three accessions
118/115/117 seeds

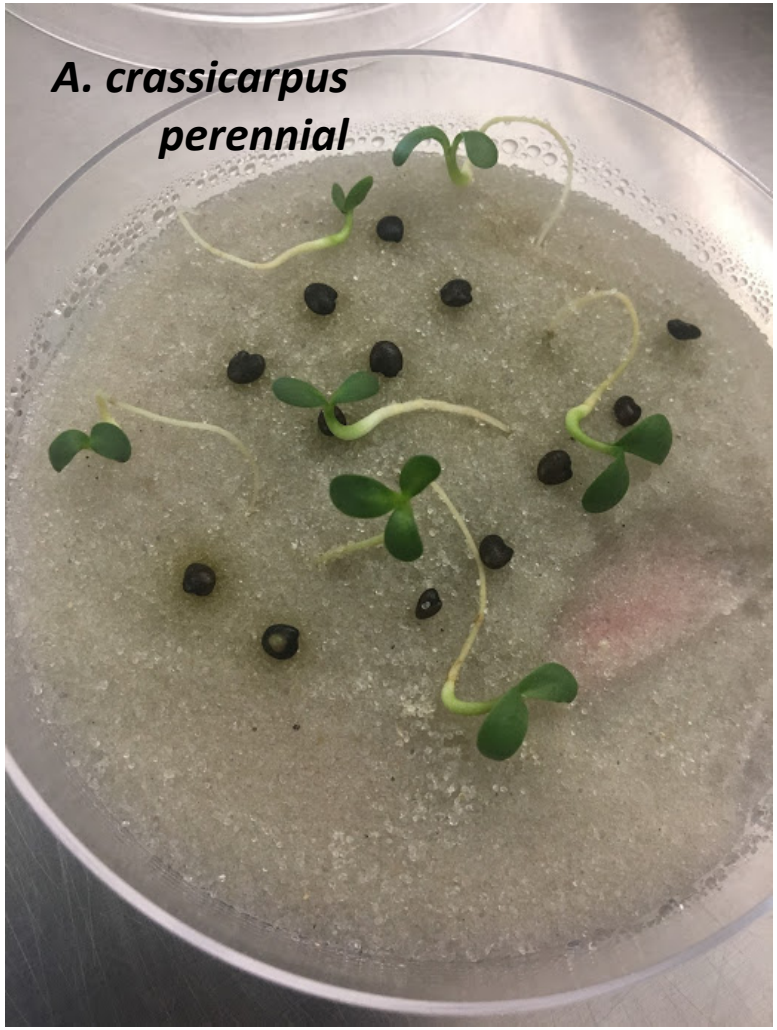
Annuals

Lindheimer's milkvetch
A. lindheimeri
One accession
119 seeds

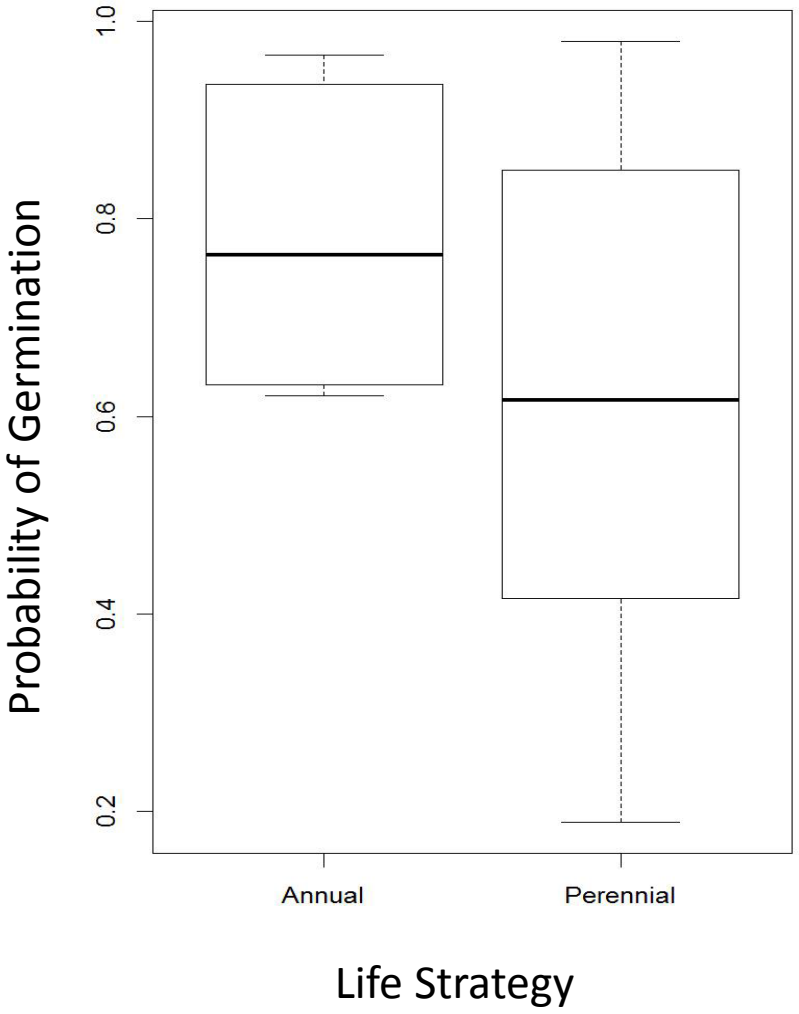
Nuttall's milkvetch
A. nuttallianus
Two accessions
124/119 seeds

Hypothesis 1a: Little to no difference in **germination** between herbaceous perennials and annuals





Hypothesis 1a: Little to no difference in **germination** between herbaceous perennials and annuals



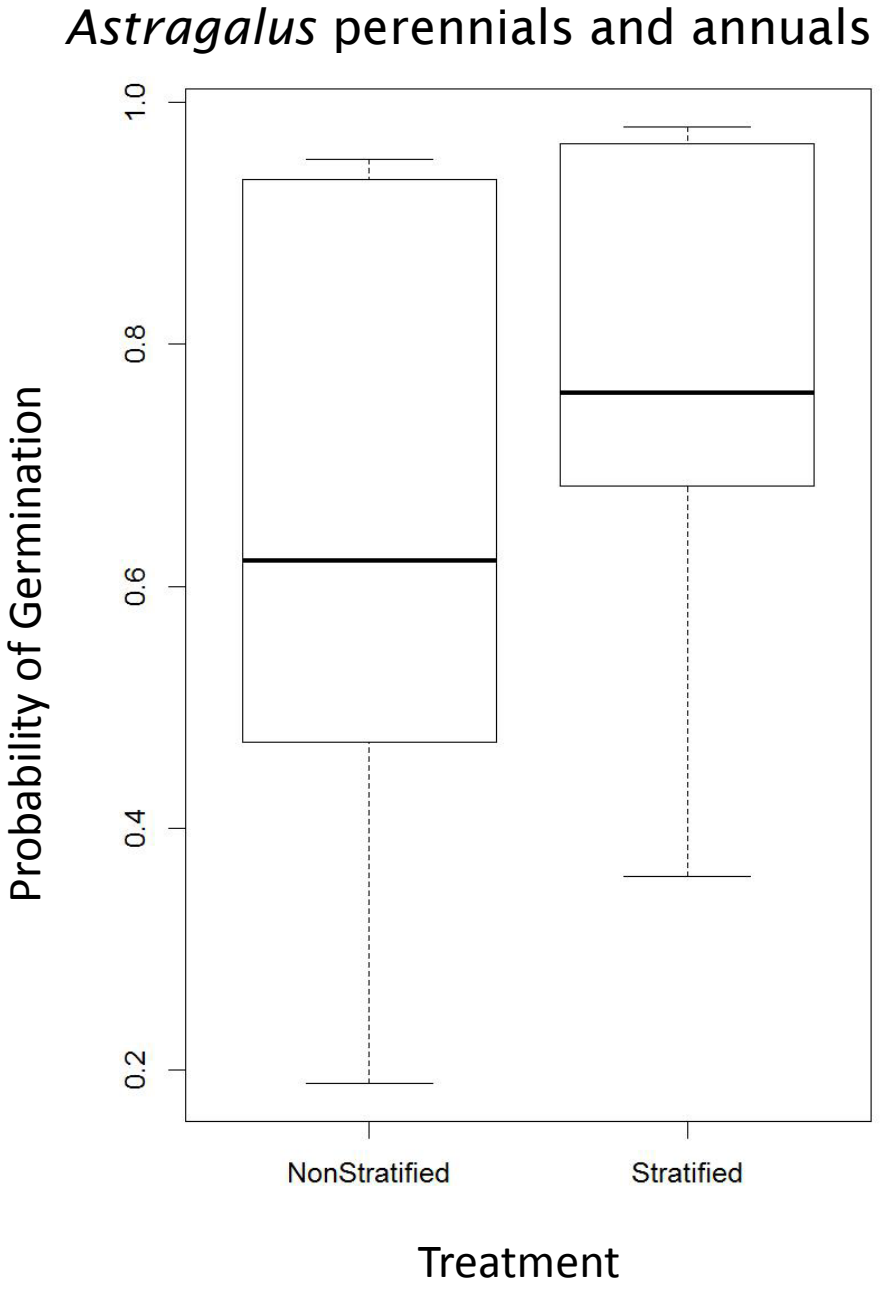
- No statistical difference between the two
- Trend of annuals to germinate more reliably
- Many perennial seed imbibed but did not germinate within allowable time frame

generalized linear mixed-effects model in R

Hypothesis 1b: Little to no difference in **germination** between stratified and non-stratified *Astragalus* seeds

Hypothesis 1b: Little to no difference in germination between stratified and non-stratified *Astragalus* seeds

Stratification has a positive effect on germination in both herbaceous perennials and annuals



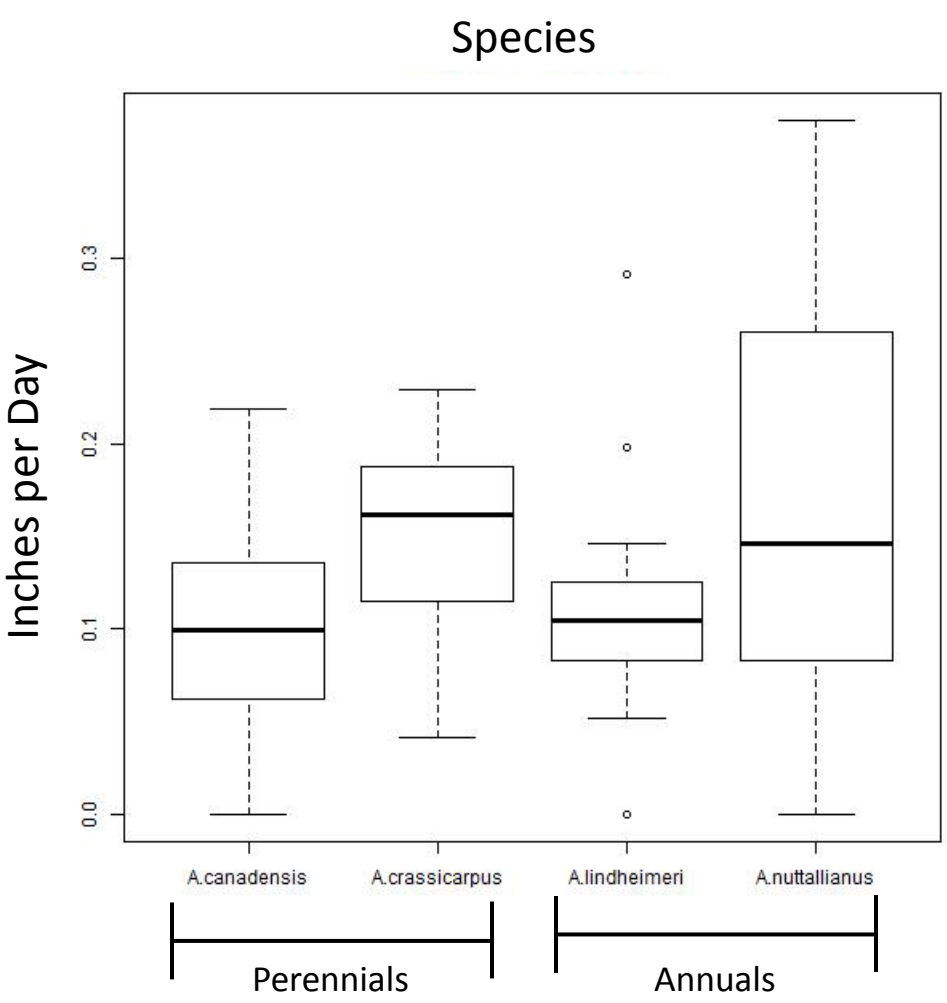
generalized linear mixed-effects model in R

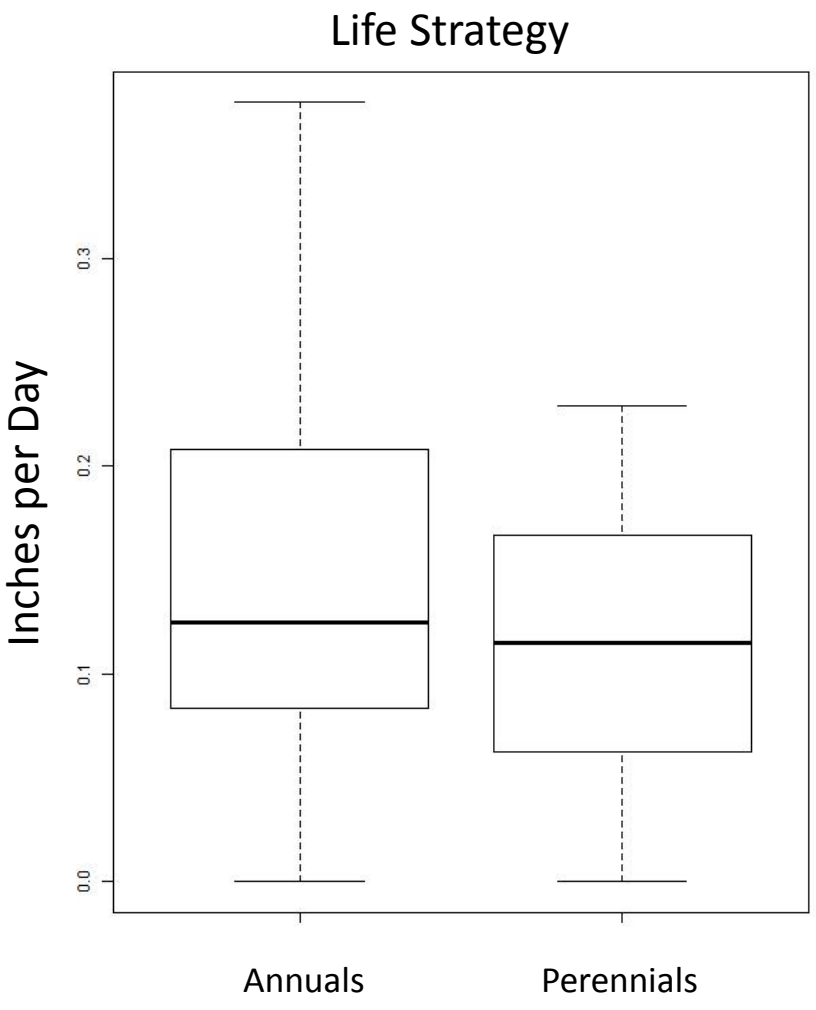
Hypothesis 2: Little to no difference in **seedling growth rates** between herbaceous perennials and annuals

A. canadensis
perennial


A. crassicarpus
perennial

Hypothesis 2: Little to no difference in **seedling growth rates** between herbaceous perennials and annuals





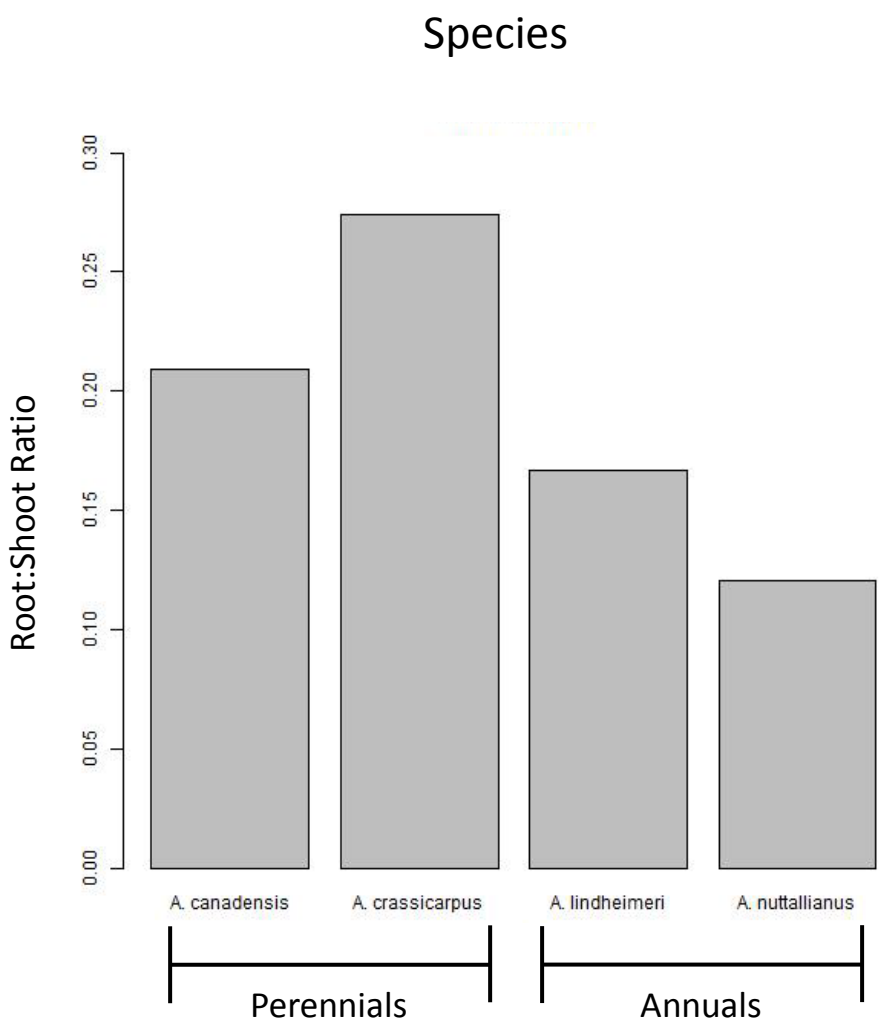
generalized linear mixed-effects models in R

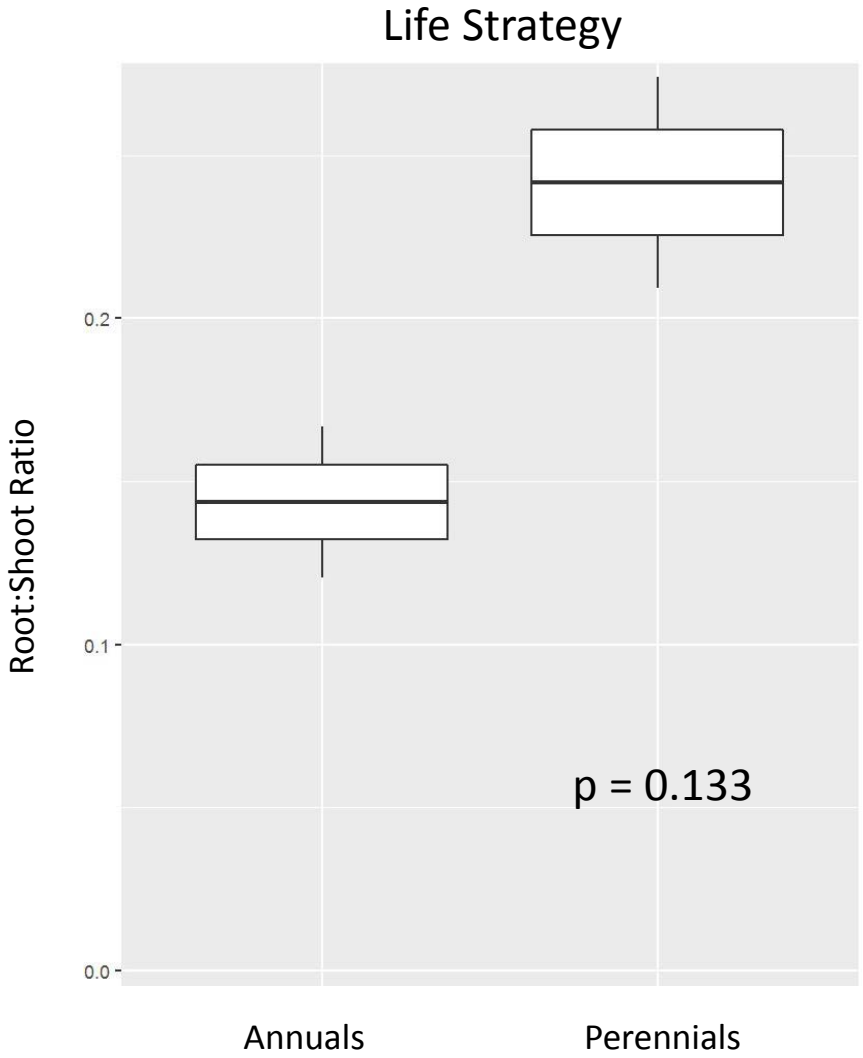
Hypothesis 3: Little to no difference in biomass allocation between herbaceous perennials and annuals

A. nuttallianus
annual

A. canadensis
perennial

Hypothesis 3: Little to no difference in biomass allocation between herbaceous perennials and annuals





factorial analysis of variance in R

Herbarium collections provide an innovative resource for agricultural studies

- Morphological and genetic record
- Catalogue of wild relatives
- Large temporal and geographic sample space
- Document changes in species over time, environmental gradients, etc.
- Preserve species from areas that have been altered

A. crassicarpus
perennial

Hypothesis 4: Little to no correlation between reproductive and vegetative structures in perennials and annuals

10 specimens/species
9 characters/specimen
~5 measurements/character

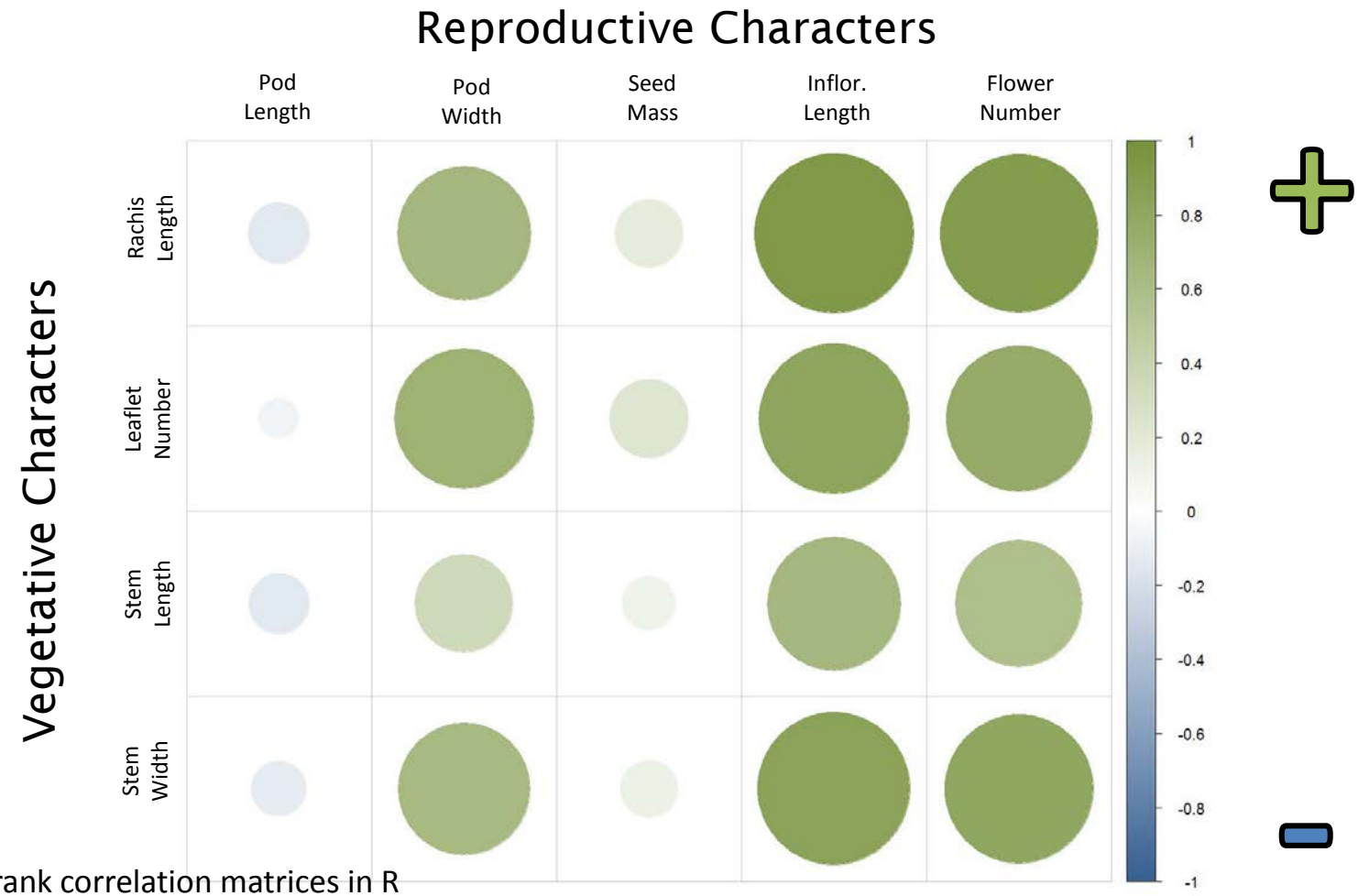
Vegetative:
- Rachis length
- Leaflet number
- Stem length
- Stem width

Reproductive:
- Seed mass
- Pod length
- Pod width
- Inflorescence length
- Flower number

A. crassicarpus
perennial

Hypothesis 4: Little to no correlation between reproductive and vegetative structures in perennials and annuals

Overall positive correlations among *Astragalus*



Spearman's rank correlation matrices in R

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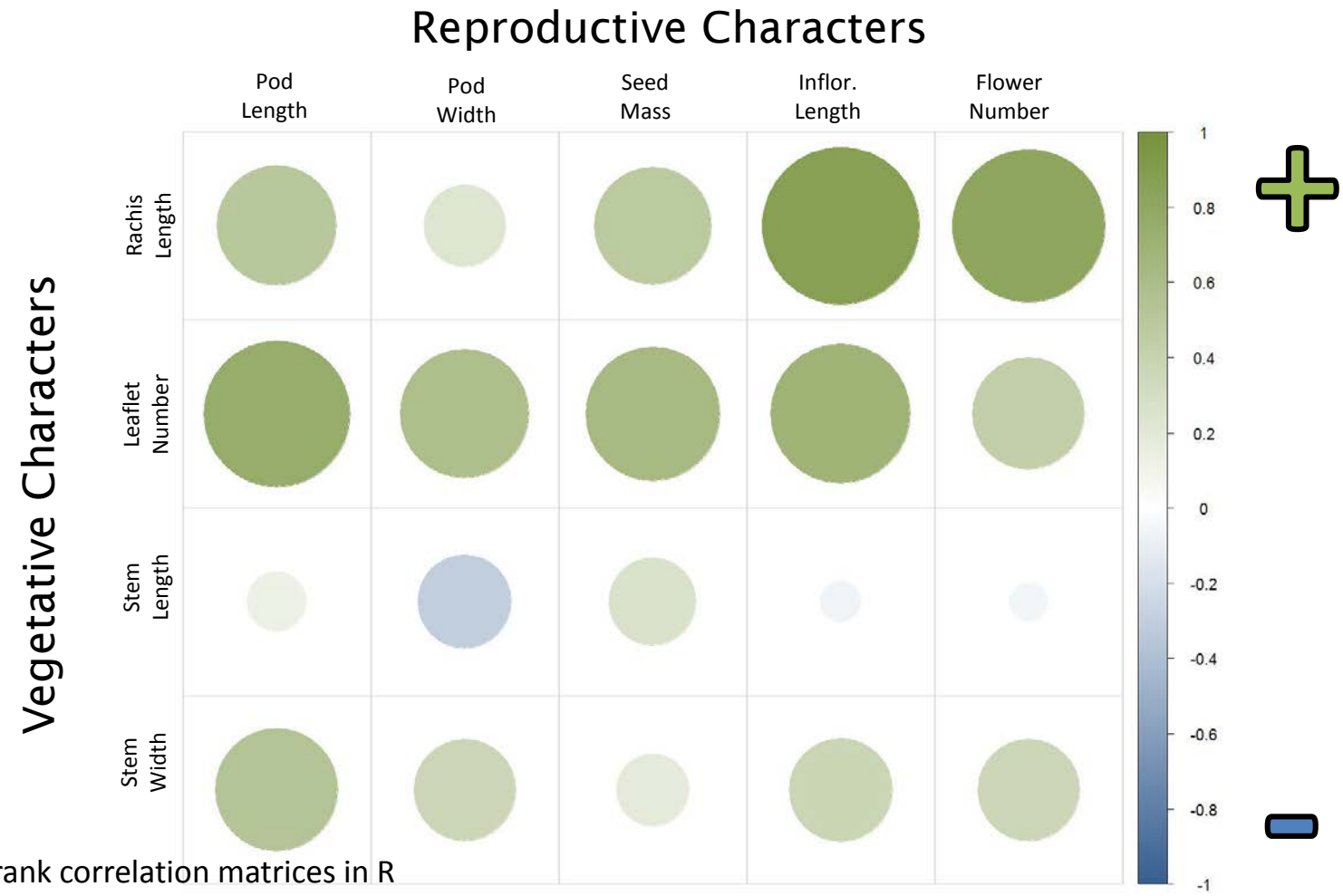
Overall positive correlations among annuals



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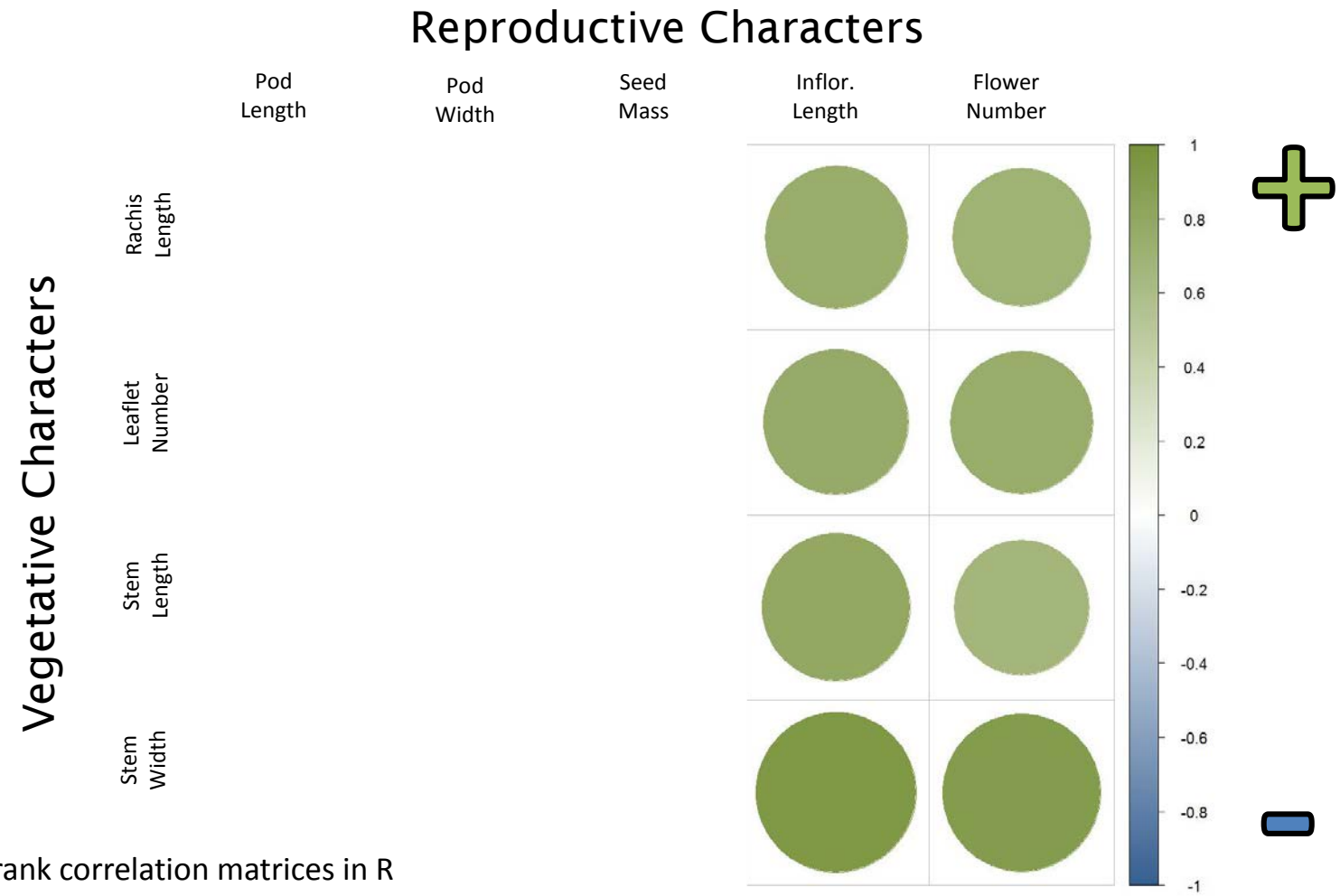
Positive AND negative correlations among perennials



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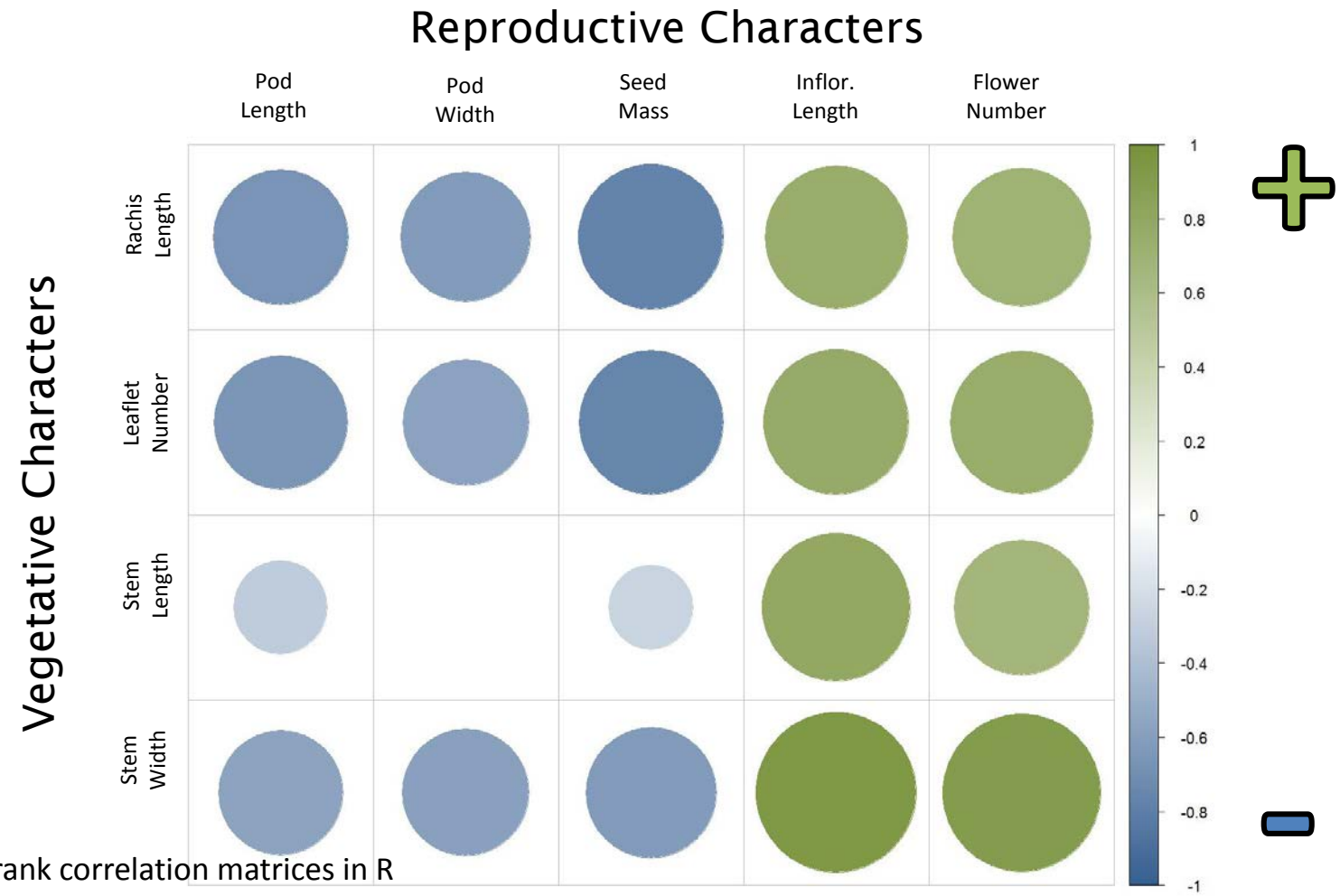

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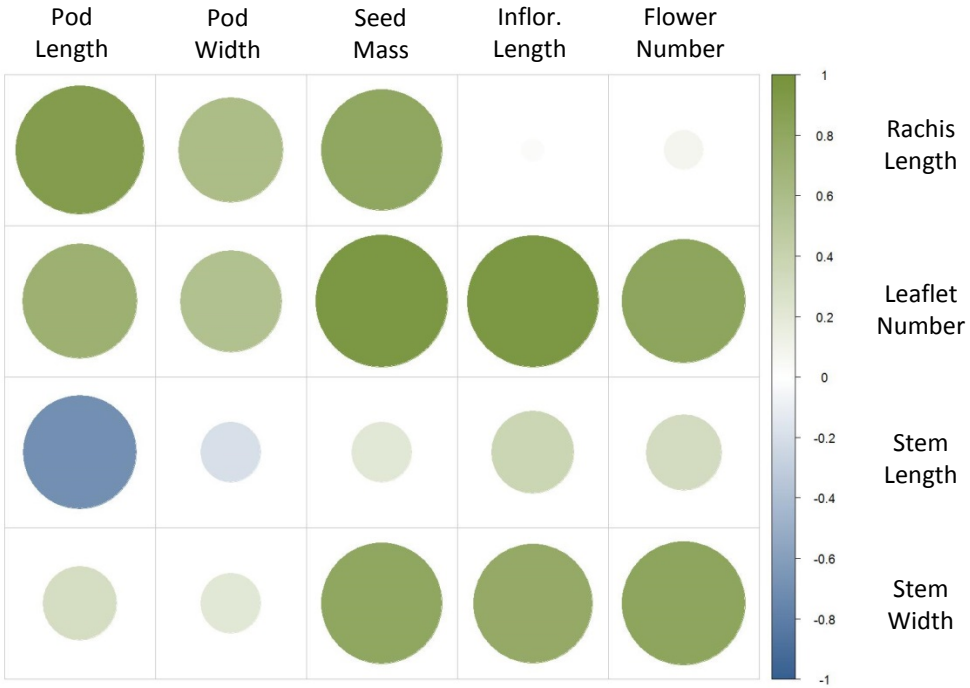
Correlation pattern observed in individual perennial species?

Astragalus canadensis



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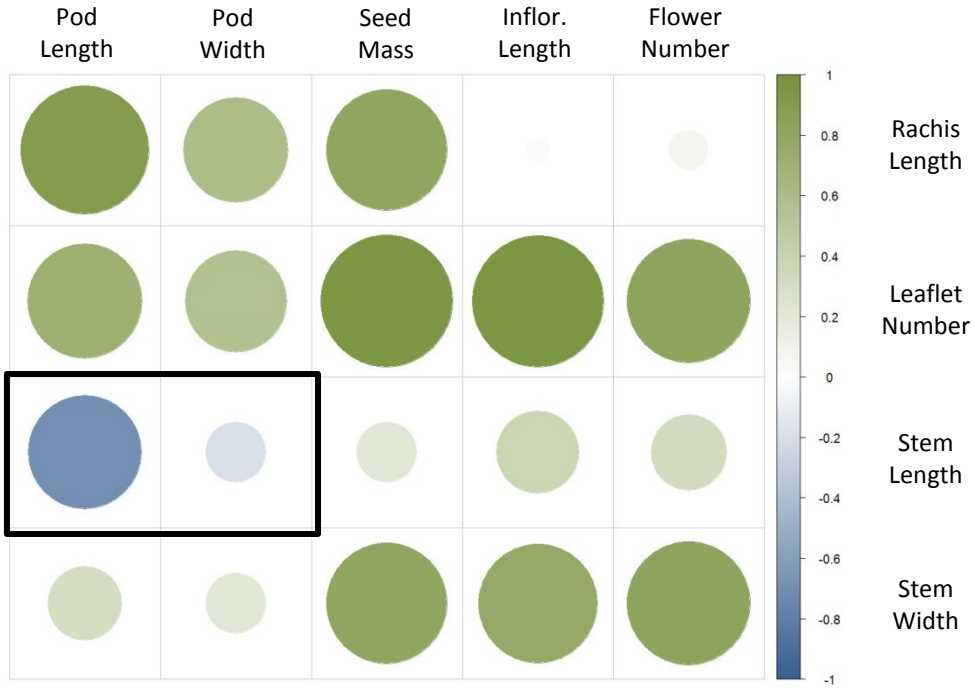


Correlation pattern observed in individual perennial species?

Astragalus canadensis

Astragalus crassicarpus

Rachis Length

Leaflet Number

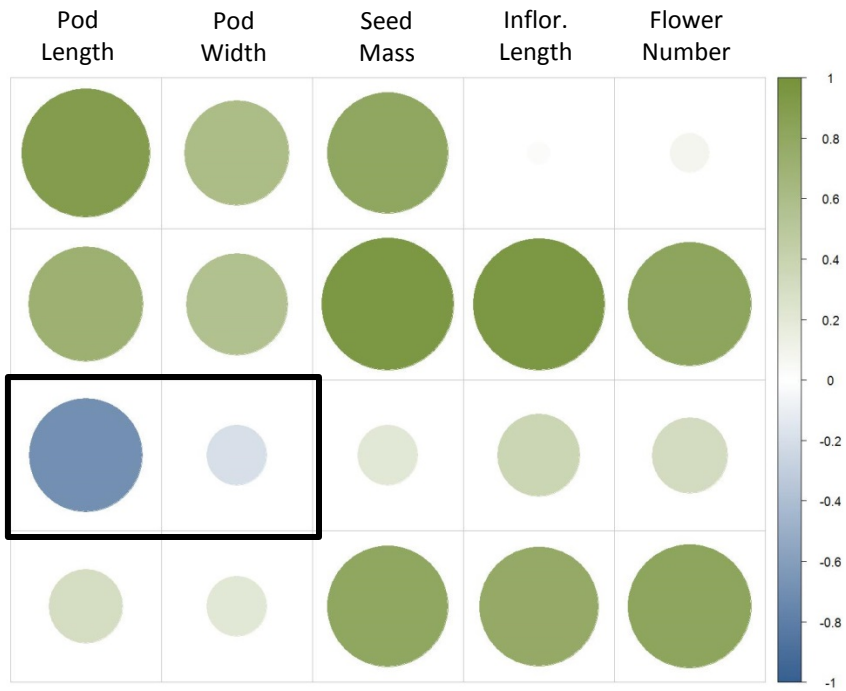
Stem Length

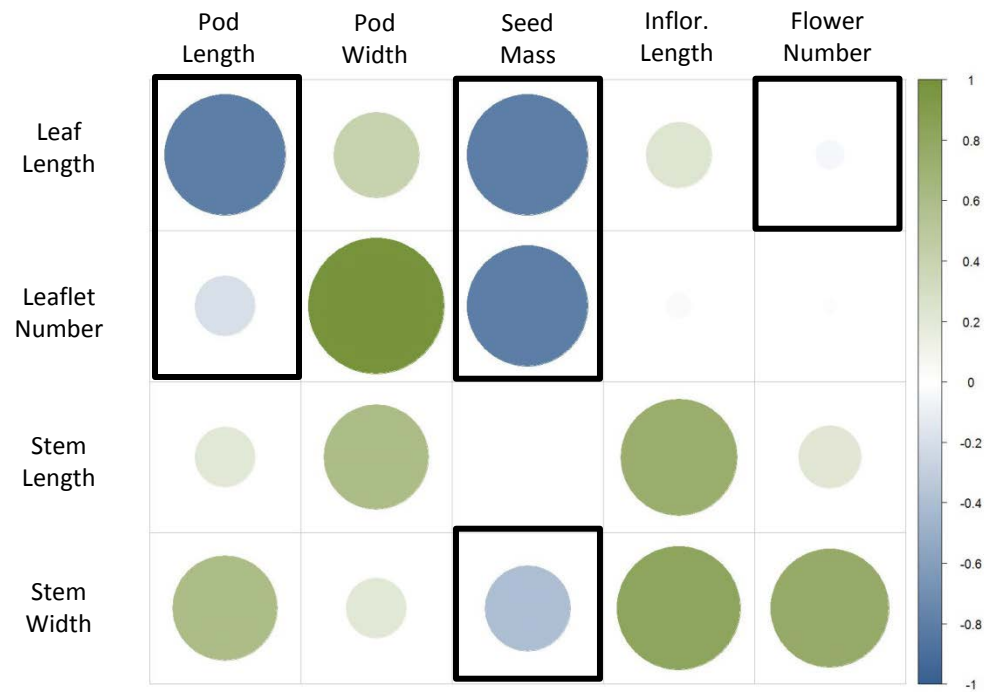
Stem Width

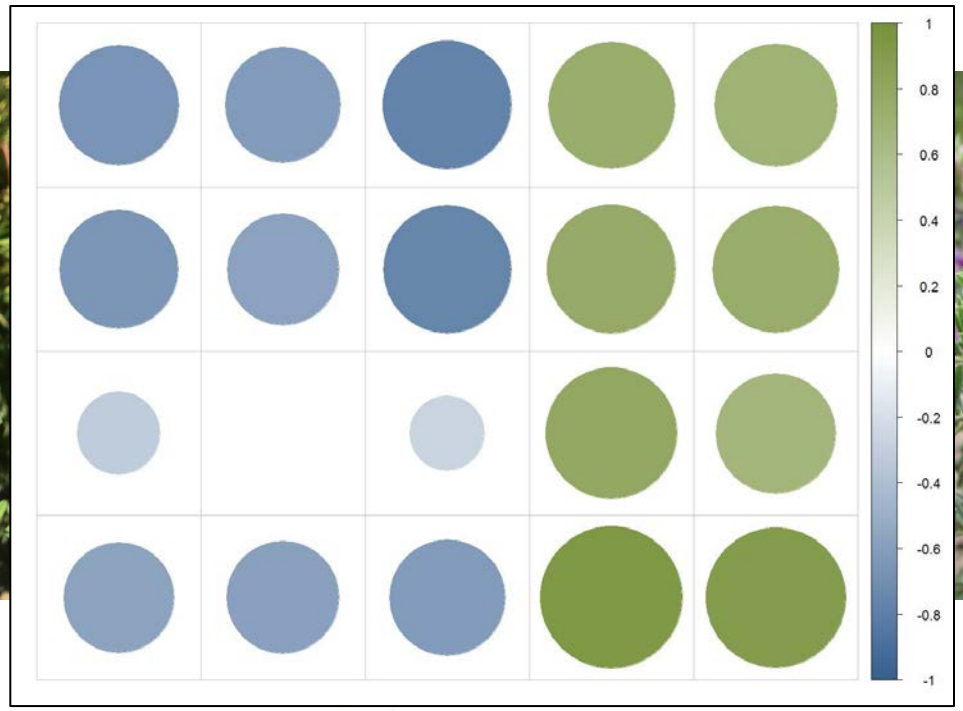
Correlation pattern observed in individual perennial species?

Astragalus canadensis

Astragalus crassicarpus



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-0.8
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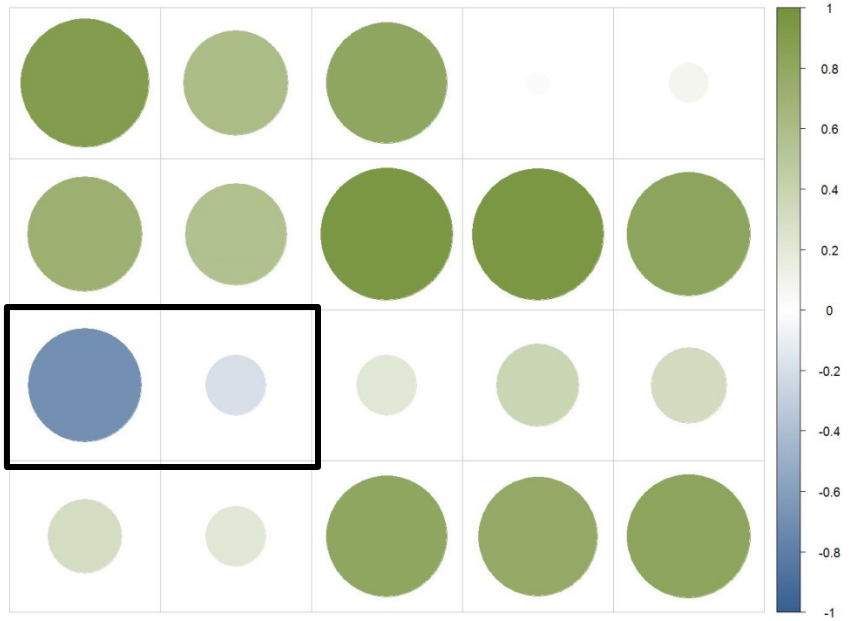
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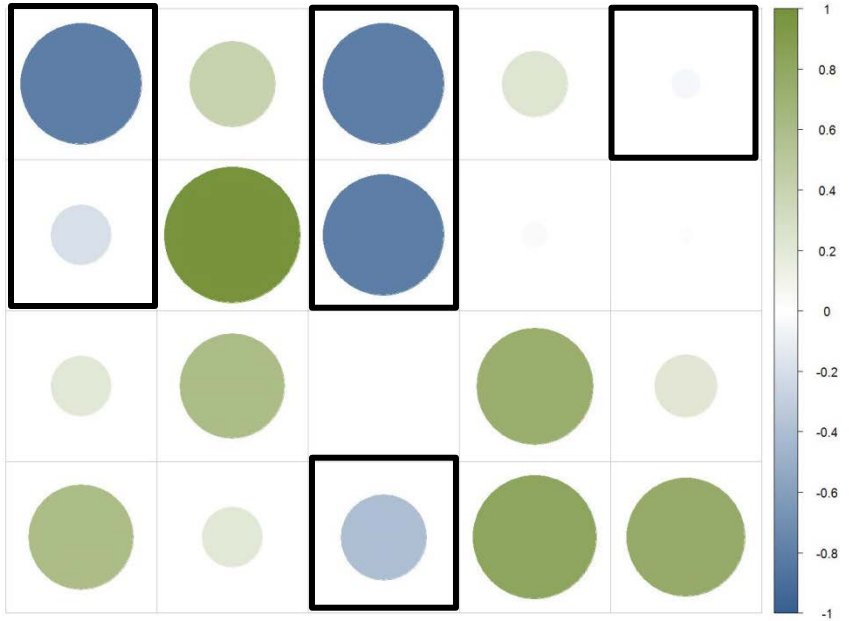
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How do herbaceous perennial species compare to closely related annuals?

1. No difference in germination

How do herbaceous perennial species compare to closely related annuals?

1. No difference in germination
2. No difference in seedling growth rate

How do herbaceous perennial species compare to closely related annuals?

1. No difference in germination
2. No difference in seedling growth rate
3. Trend towards greater root mass allocation in perennials

How do herbaceous perennial species compare to closely related annuals?

1. No difference in germination
2. No difference in seedling growth rate
3. Trend towards greater root mass allocation in perennials
4. Evidence for correlations between reproductive and vegetative structures

How do herbaceous perennial species compare to closely related annuals?

Take-home messages:

- Similar physiological characteristics in young plants

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Take-home messages:

- Similar physiological characteristics in young plants
- More work is needed to confirm correlation patterns observed in reproductive and vegetative structures
- Both live plants and herbarium collections can inform our understanding of herbaceous perennials and agricultural questions

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