



The function of plant-plant interactions in the community dynamics of a native grassland: Insights and opportunities for restoration planning

Emily Holden
GRF Winter Webinar Series
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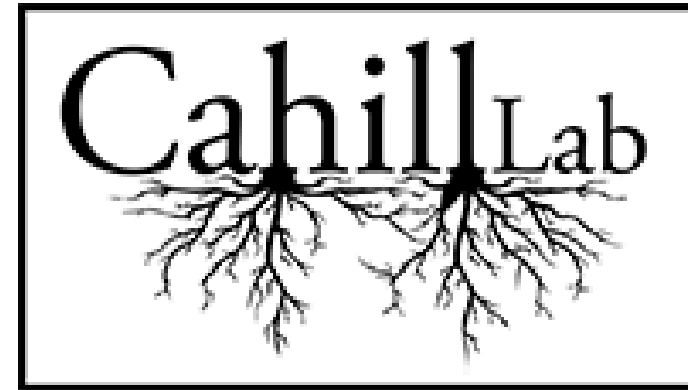
The ABMI respectfully acknowledges that our work takes place on the territories of Treaties 4, 6, 7, 8, 10, the Blackfoot Confederacy, and the Métis homeland, traditional and ancestral lands of First Nations and Métis Peoples, whose histories, languages, and cultures are directly linked to the biodiversity that we monitor. We acknowledge the traditional teachings of the lands that we work on, and that reciprocal, meaningful, and respectful relationships with Indigenous peoples make our work possible. We are deeply grateful for their stewardship of these lands, and we are committed to supporting Indigenous-led monitoring programs, while learning Indigenous ways of knowing, being, and doing.



COMMUNITY BASED
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Video credit: Tianna Barber-Cross



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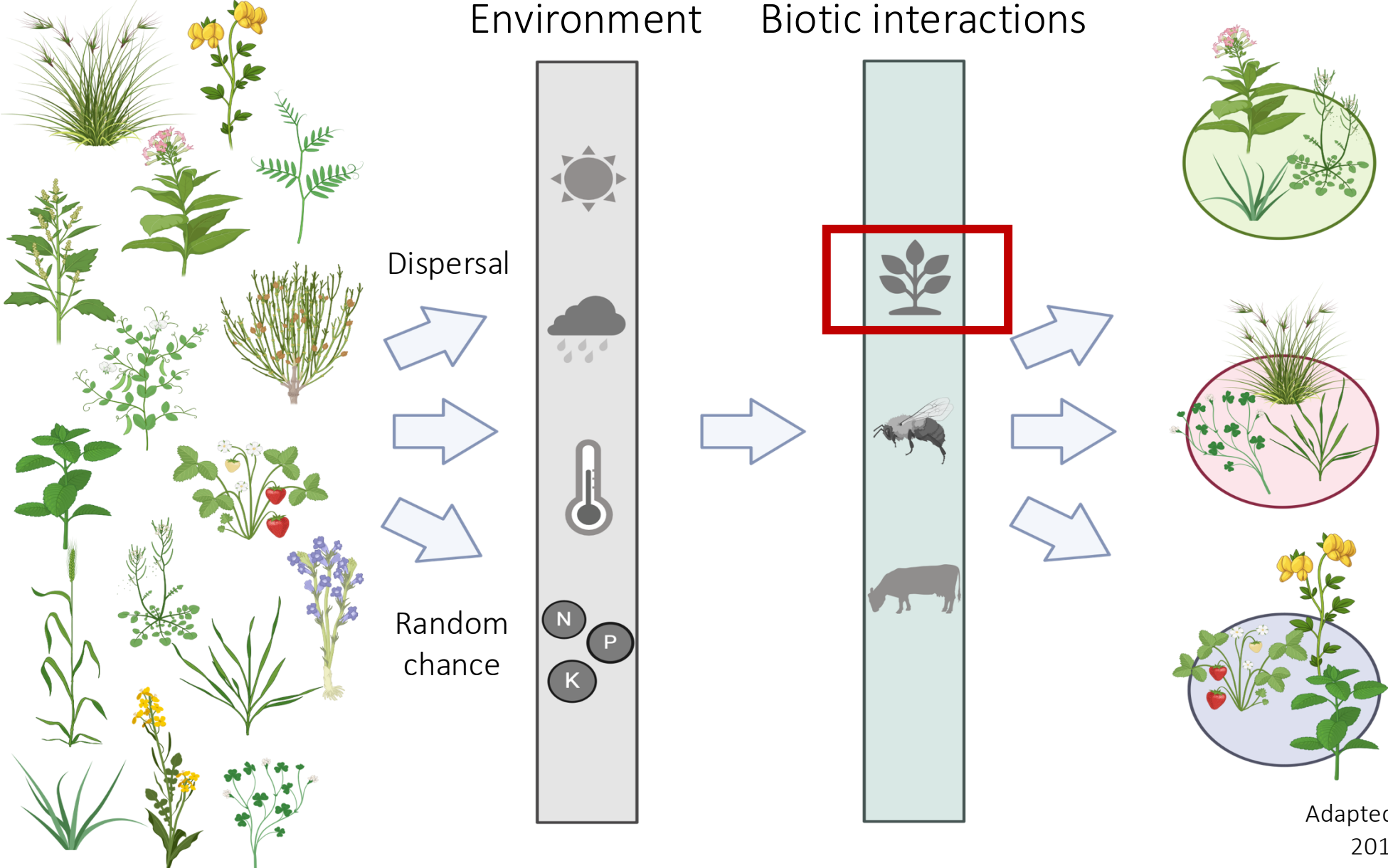
Credit: Chris Helzer





- Plants are foundational!
- Diversity is beneficial

What makes diverse plant communities?



Adapted from HilleRisLambers et al.
2012 *Annu. Rev. Ecol. Evol. Syst.*

A wide, open grassland field with a dense line of trees in the background under a bright blue sky with scattered white clouds. The foreground is filled with tall, green grasses and some small purple flowers. The trees in the background are a mix of deciduous and coniferous species, creating a dark green wall. The sky is a vibrant blue with several large, fluffy white clouds and some smaller, wispy ones. The overall scene is bright and clear, suggesting a sunny day.

How do plant interactions function in the community dynamics of a native grassland?

A landscape photograph showing a wide, green grassy field in the foreground. In the middle ground, there is a dense line of trees, likely a forest. The sky is bright blue with scattered white, fluffy clouds. The overall scene is bright and clear, suggesting a sunny day.

Plant interactions contribute to community diversity and stability, and should be considered in restoration planning.

Plant interactions

- Plant-plant interactions = impacts of plants on their neighbours



Plant interactions



- Historically, competition is emphasized
- Competition: loss of growth due to neighbours

Plant interactions



- Facilitation: increases in growth due to neighbours
 - Facilitation takes multiple forms (e.g. nurse plants)
 - Today, I'll focus on resource-based interactions

Plant interactions



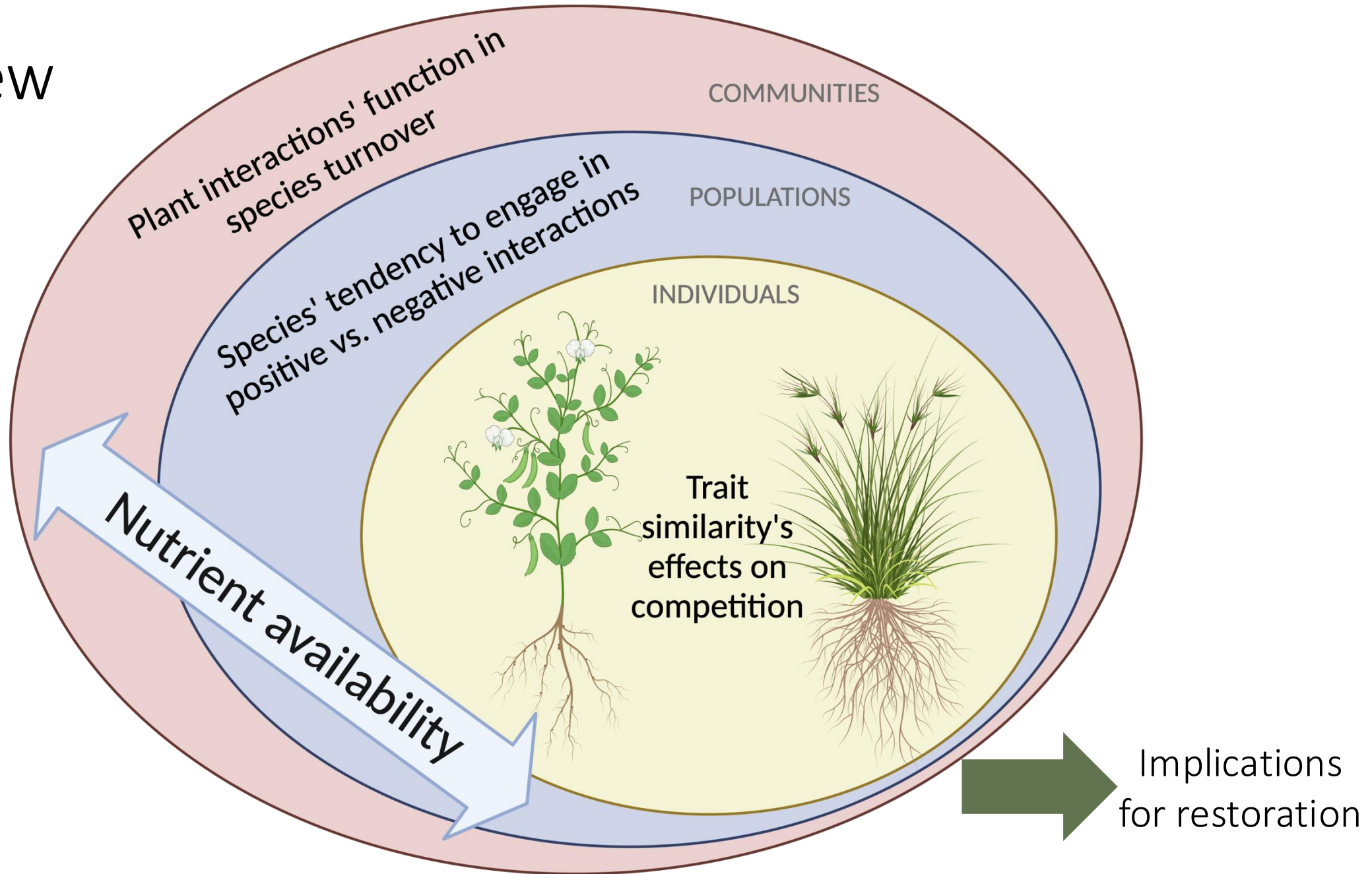
- Strength of interactions vary along nutrient gradients
- Foundational studies conducted in old fields with legacies of fertilizer addition
 - Trends may not apply in natural, low-nutrient settings

Plant interactions

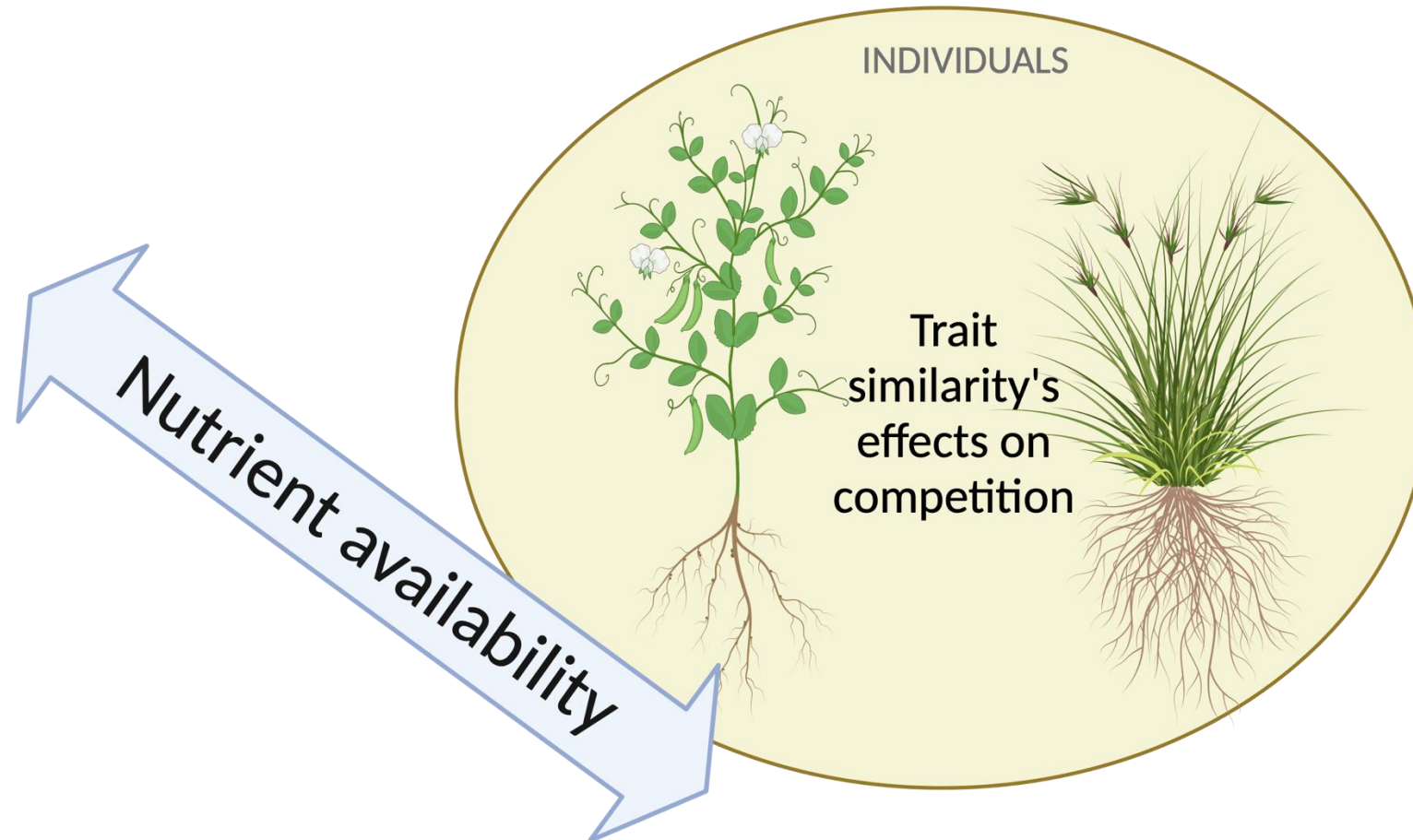


- Ultimately, the function of plant interactions remains poorly resolved
- There are opportunities to test these influential ideas with data!

Overview



Trait dissimilarity increases competitive interactions among co-occurring plants



Trait similarity



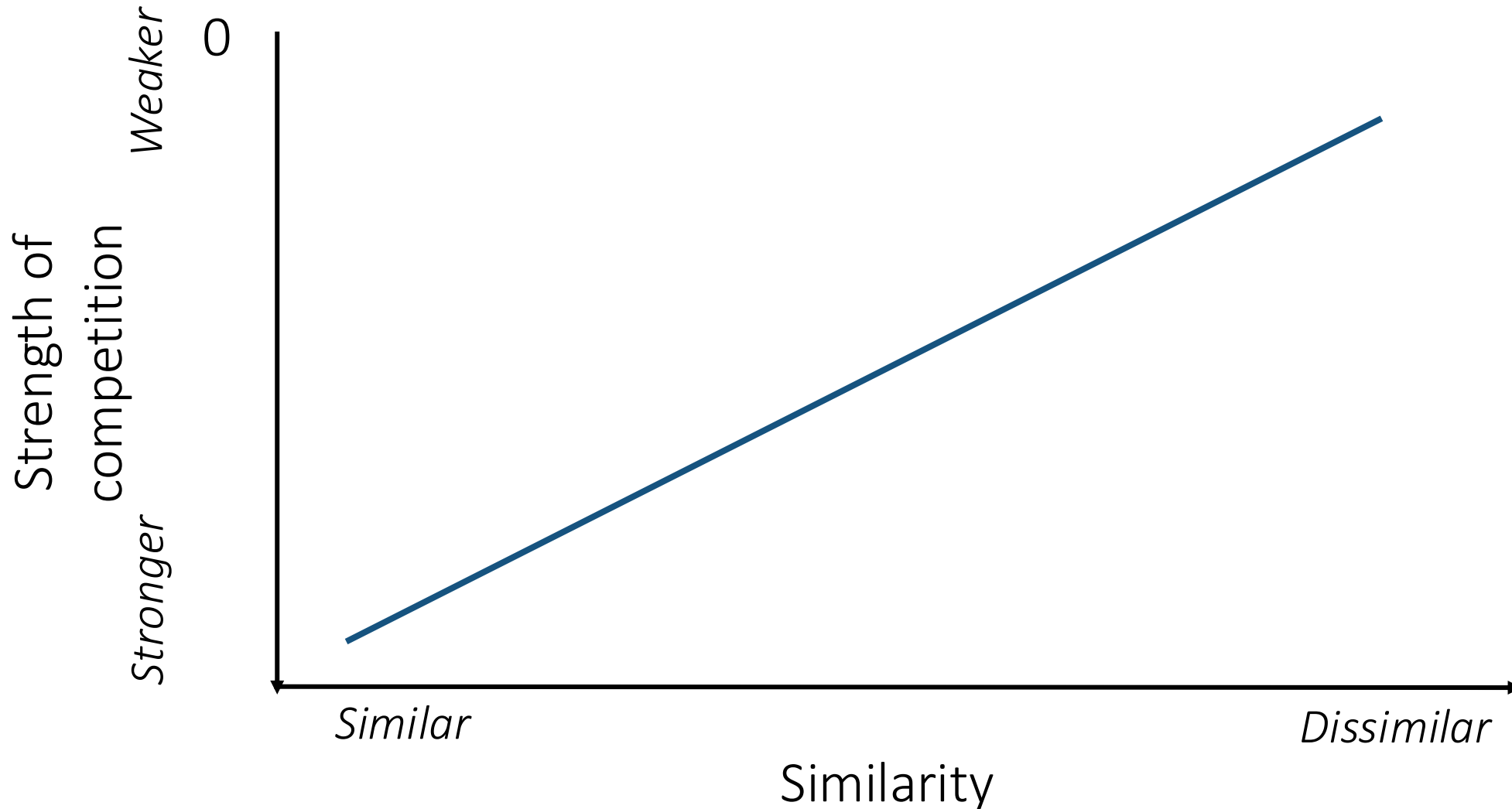
Trait similarity



Theory suggests limiting similarity minimizes competition



Theory suggests limiting similarity minimizes competition

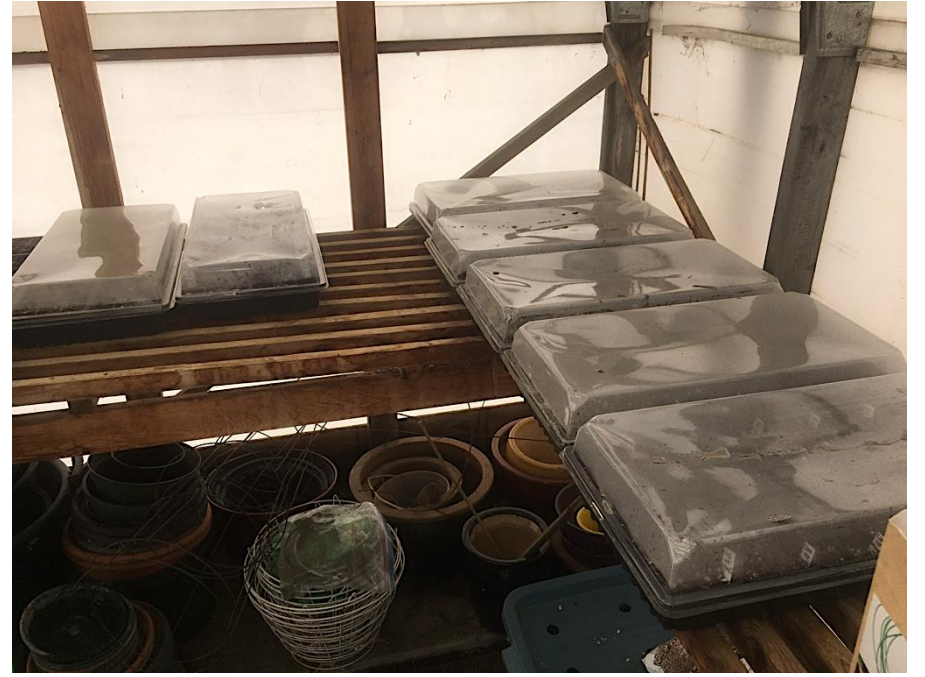


How does trait similarity with neighbours affect the competition experienced by an individual?





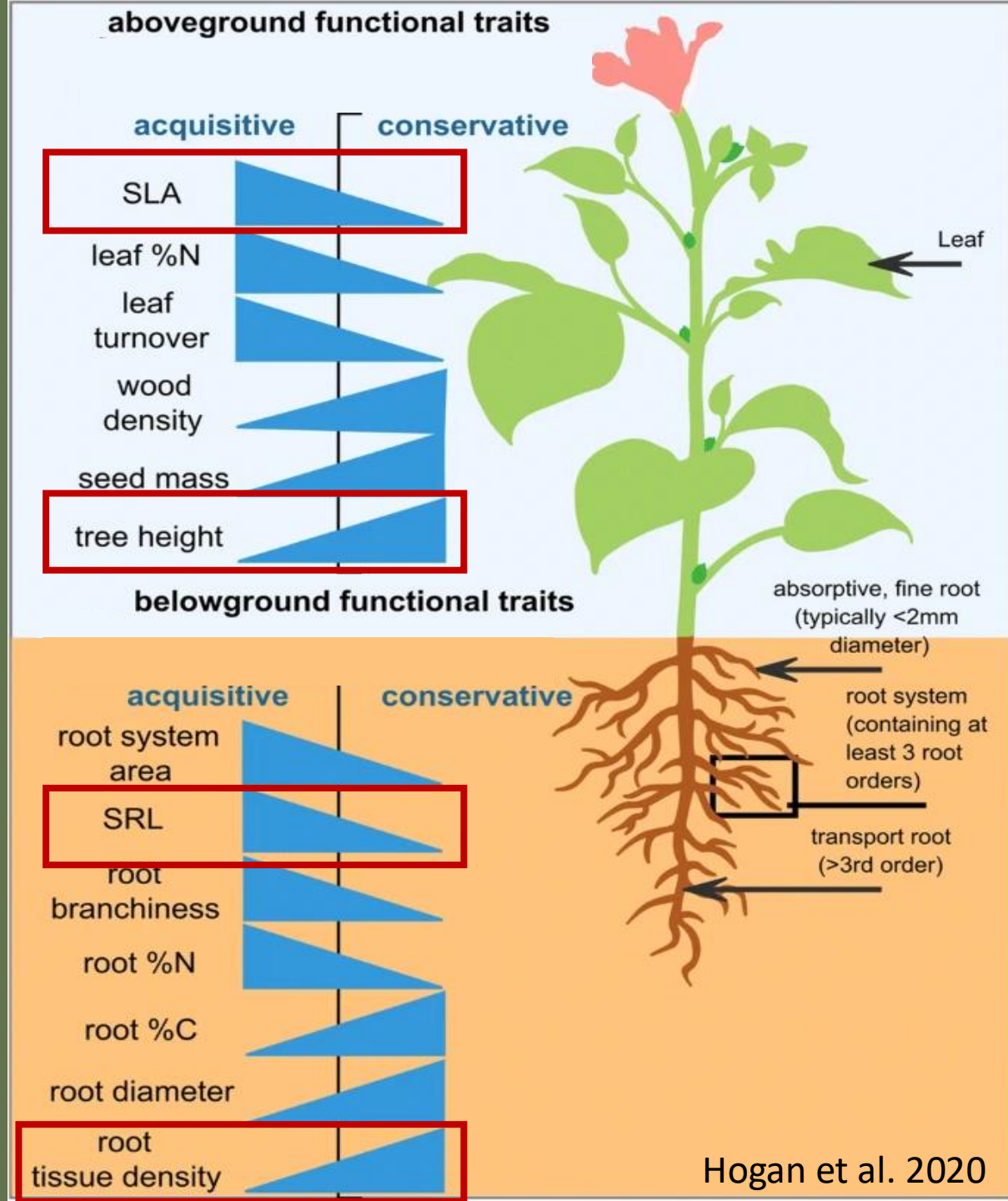
Experimental design



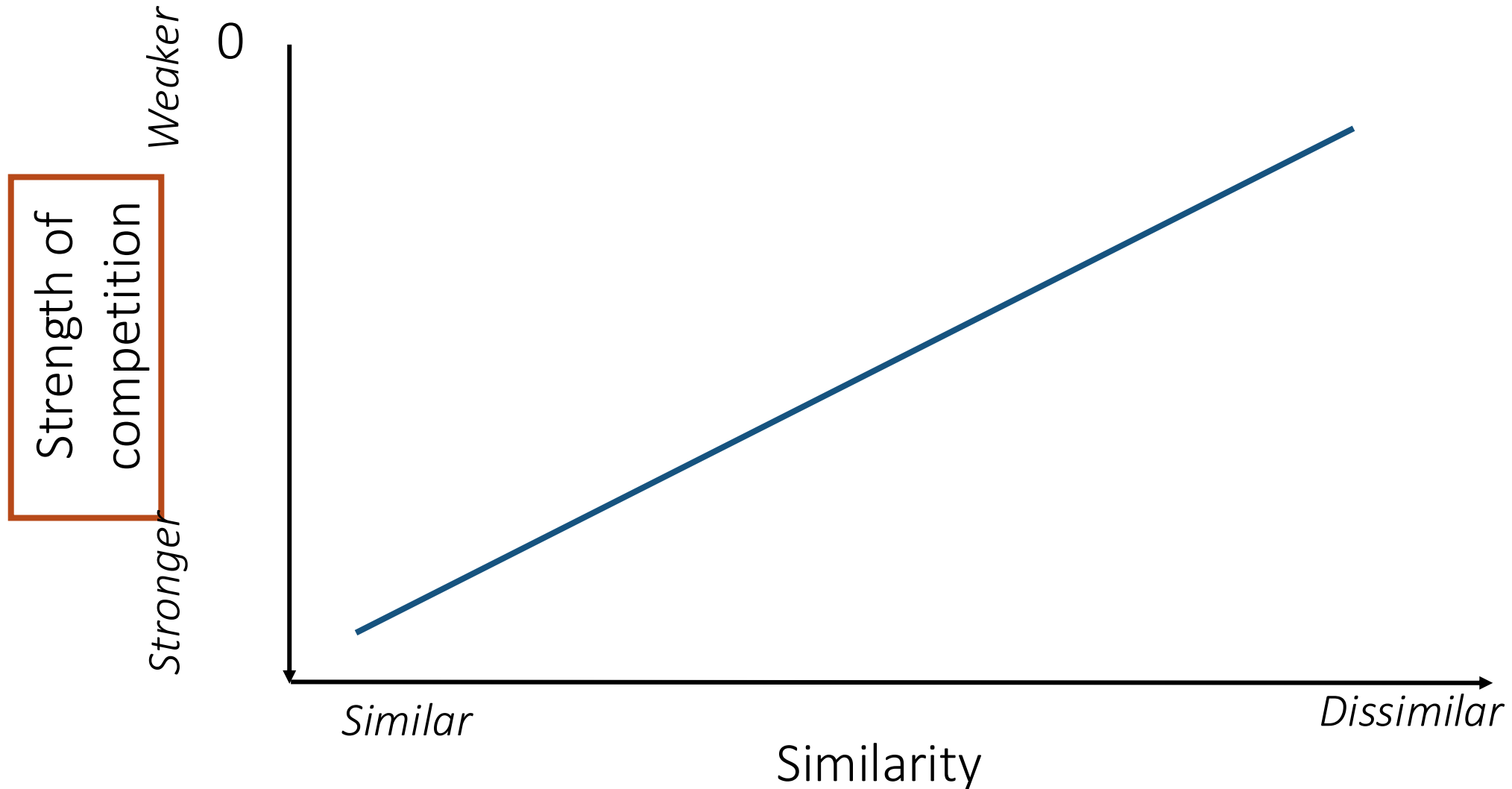


- Applied fertilizer to half of the pots
- Pots grew outdoors at the University of Alberta's South Campus

Examining competition through functional traits



Theory suggests limiting similarity minimizes competition



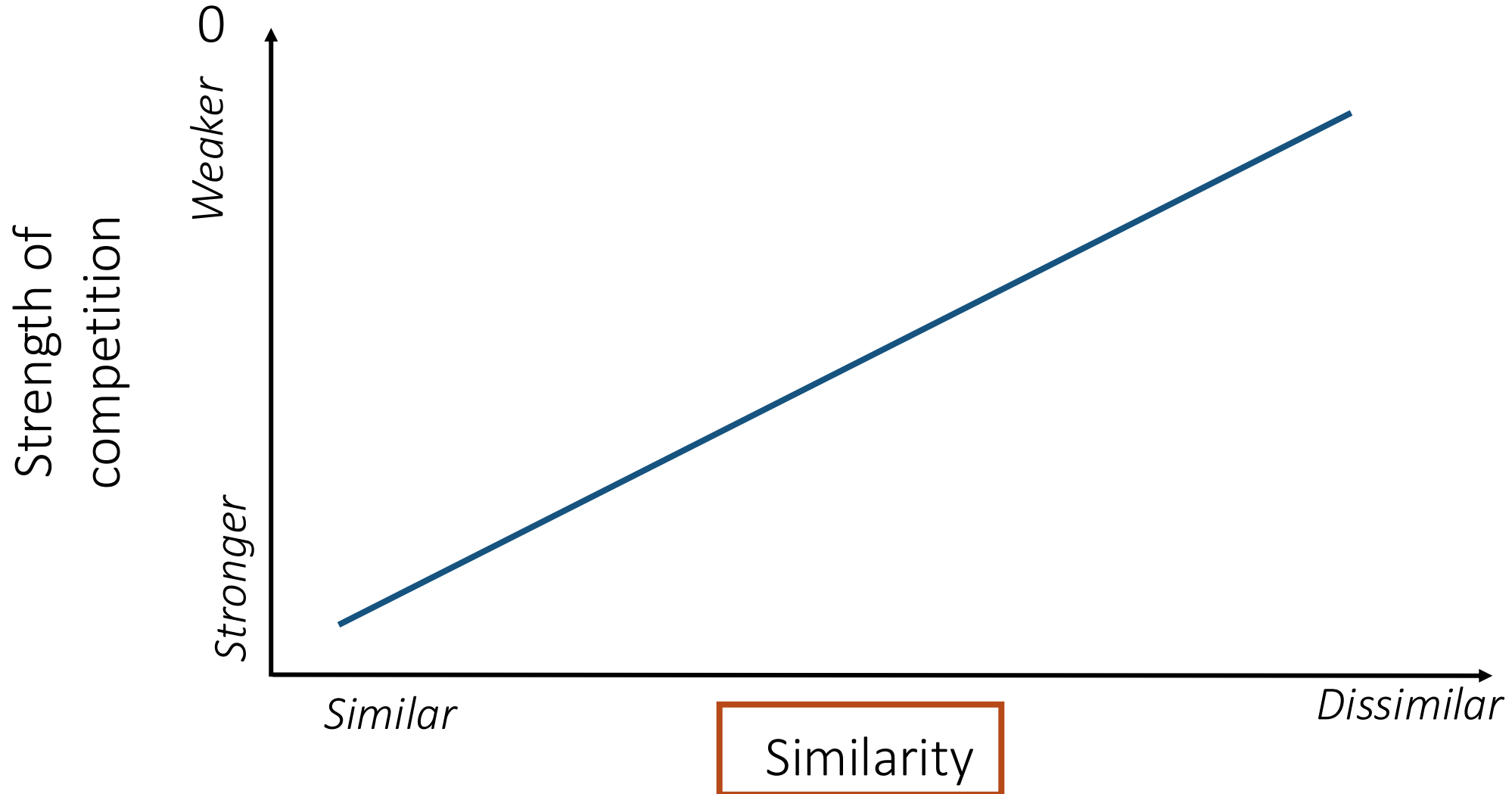
Quantifying competition

Focal plants:

- Strength of competition = net neighbour effects



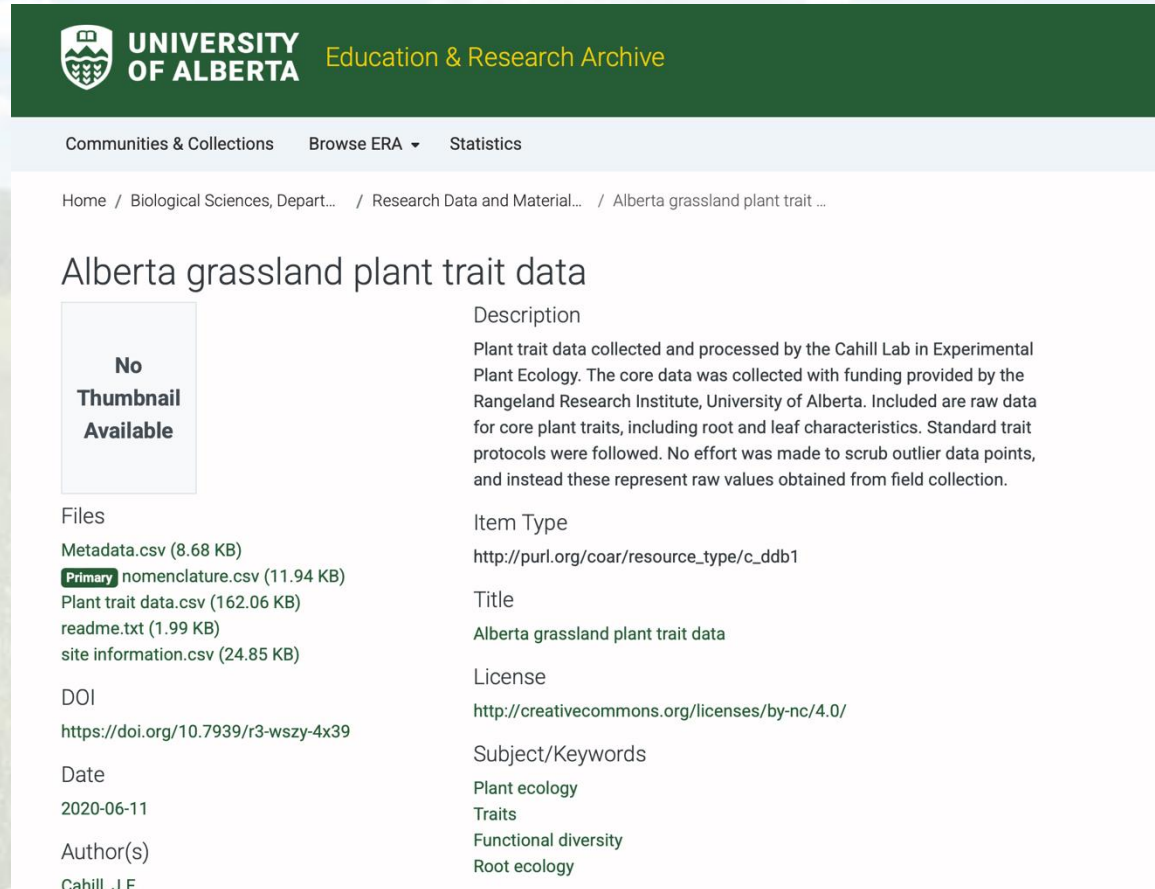
Theory suggests limiting similarity minimizes competition



Quantifying similarity

Communities:

- Neighbour abundance = biomass
- Community weighted means (CWMs) for traits



The screenshot shows the University of Alberta Education & Research Archive interface. The header includes the university logo and name, and the page title 'Education & Research Archive'. The main content area displays the title 'Alberta grassland plant trait data' and a 'No Thumbnail Available' message. Below this, there is a list of files: 'Metadata.csv (8.68 KB)', 'Primary nomenclature.csv (11.94 KB)', 'Plant trait data.csv (162.06 KB)', 'readme.txt (1.99 KB)', and 'site information.csv (24.85 KB)'. The page also includes a description of the data, item type, title, license, and subject keywords.

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Home / Biological Sciences, Depart... / Research Data and Material... / Alberta grassland plant trait ...

Alberta grassland plant trait data

No Thumbnail Available

Description
Plant trait data collected and processed by the Cahill Lab in Experimental Plant Ecology. The core data was collected with funding provided by the Rangeland Research Institute, University of Alberta. Included are raw data for core plant traits, including root and leaf characteristics. Standard trait protocols were followed. No effort was made to scrub outlier data points, and instead these represent raw values obtained from field collection.

Files
Metadata.csv (8.68 KB)
Primary nomenclature.csv (11.94 KB)
Plant trait data.csv (162.06 KB)
readme.txt (1.99 KB)
site information.csv (24.85 KB)

DOI
<https://doi.org/10.7939/r3-wszy-4x39>

Date
2020-06-11

Author(s)
Cahill, J.F.

Item Type
http://purl.org/coar/resource_type/c_ddb1

Title
Alberta grassland plant trait data

License
<http://creativecommons.org/licenses/by-nc/4.0/>

Subject/Keywords
Plant ecology
Traits
Functional diversity
Root ecology

Quantifying similarity

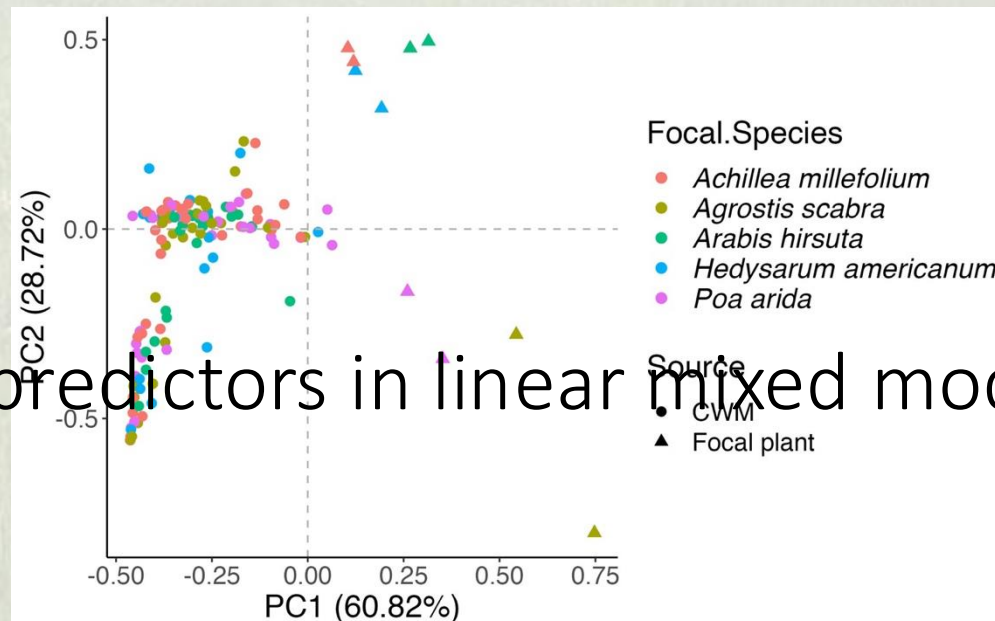
- Calculating single trait similarity:
| Individual trait value – CWM trait value |



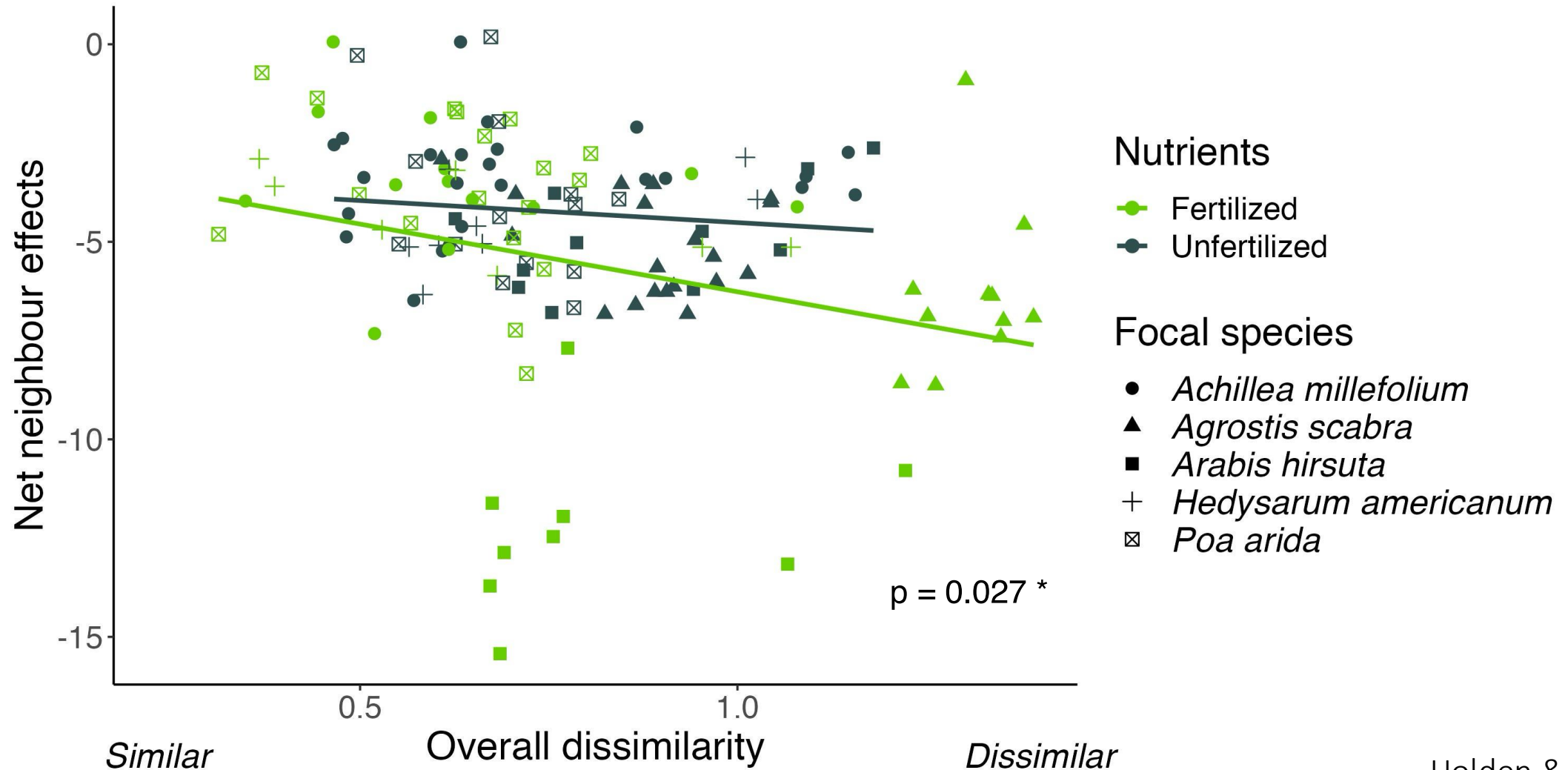
Quantifying similarity

- Calculating whole plant similarity:
 - Ordinated individual and CWM trait values together
 - Calculated Euclidean distance between individual and community for each replicate

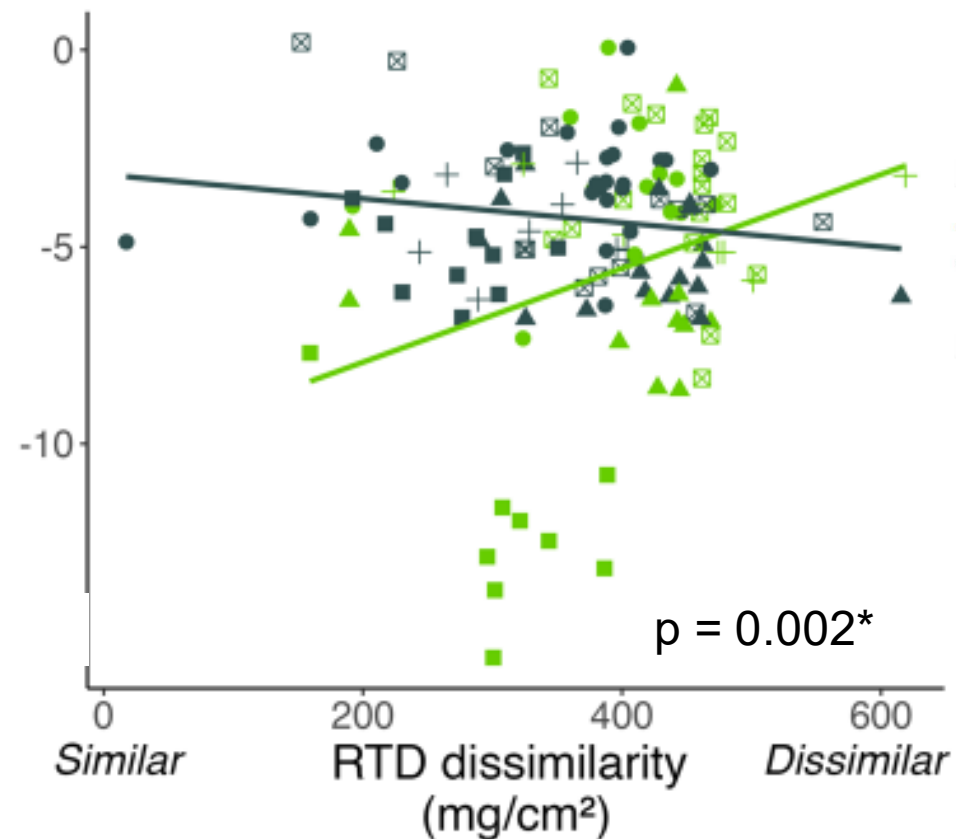
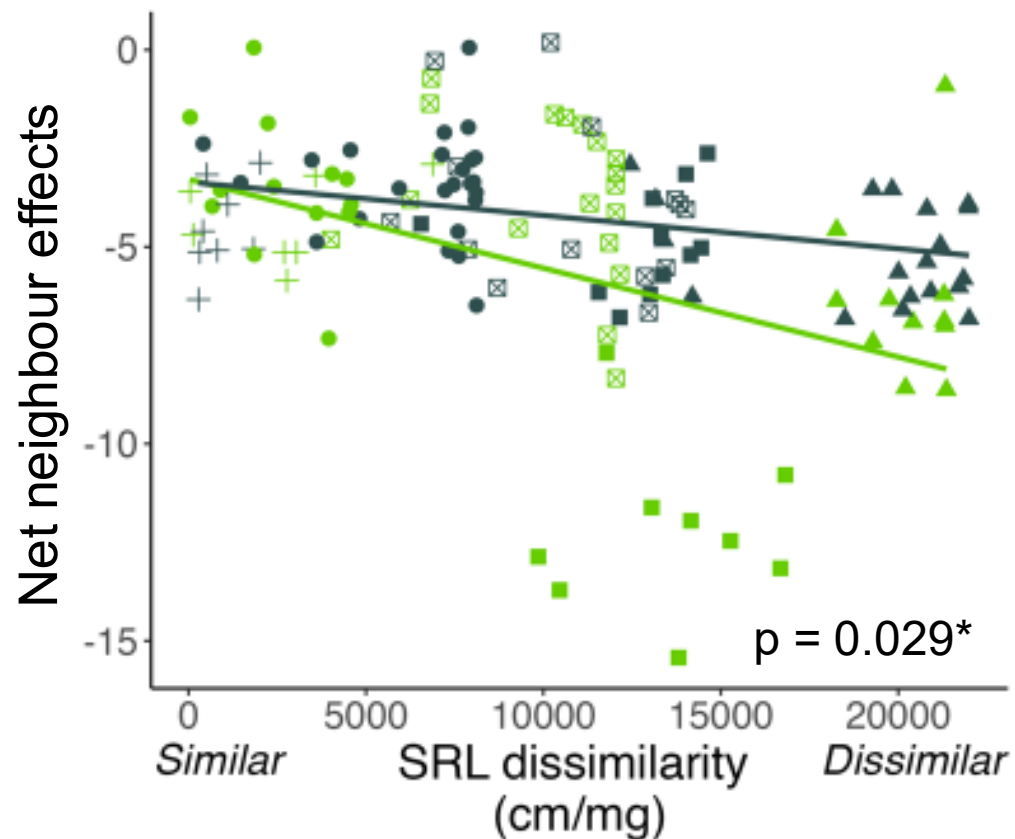
→ Used as predictors in linear mixed models (LMMs)



Competition increased with increased dissimilarity



Single traits: no consistent support for limiting similarity



Nutrients

- Fertilized
- Unfertilized

Focal species

- *Achillea millefolium*
- ▲ *Agrostis scabra*
- *Arabis hirsuta*
- + *Hedysarum americanum*
- ⊠ *Poa arida*

Conclusions

- Results opposed an influential theory
- Limiting similarity does not describe interactions among plants

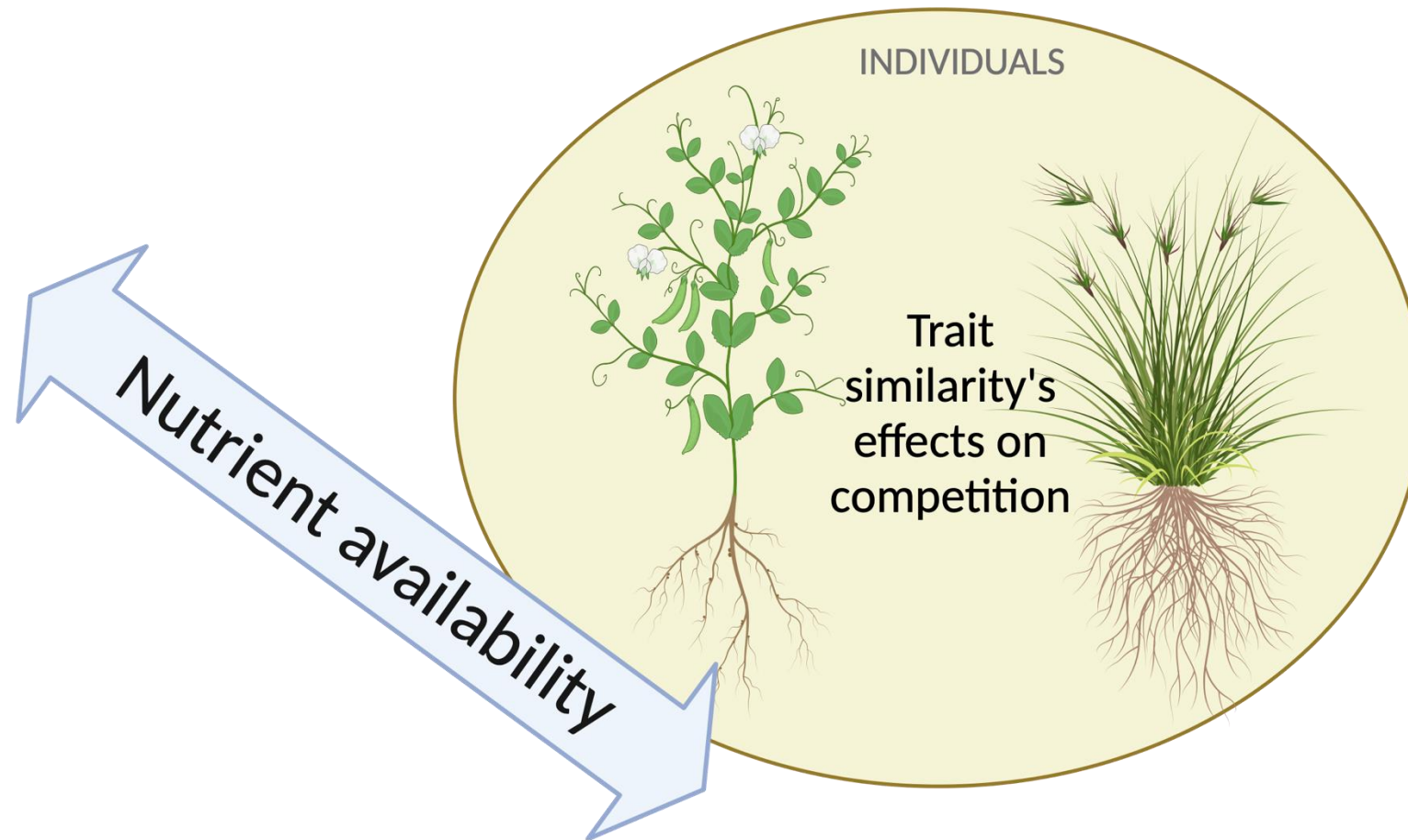


Conclusions

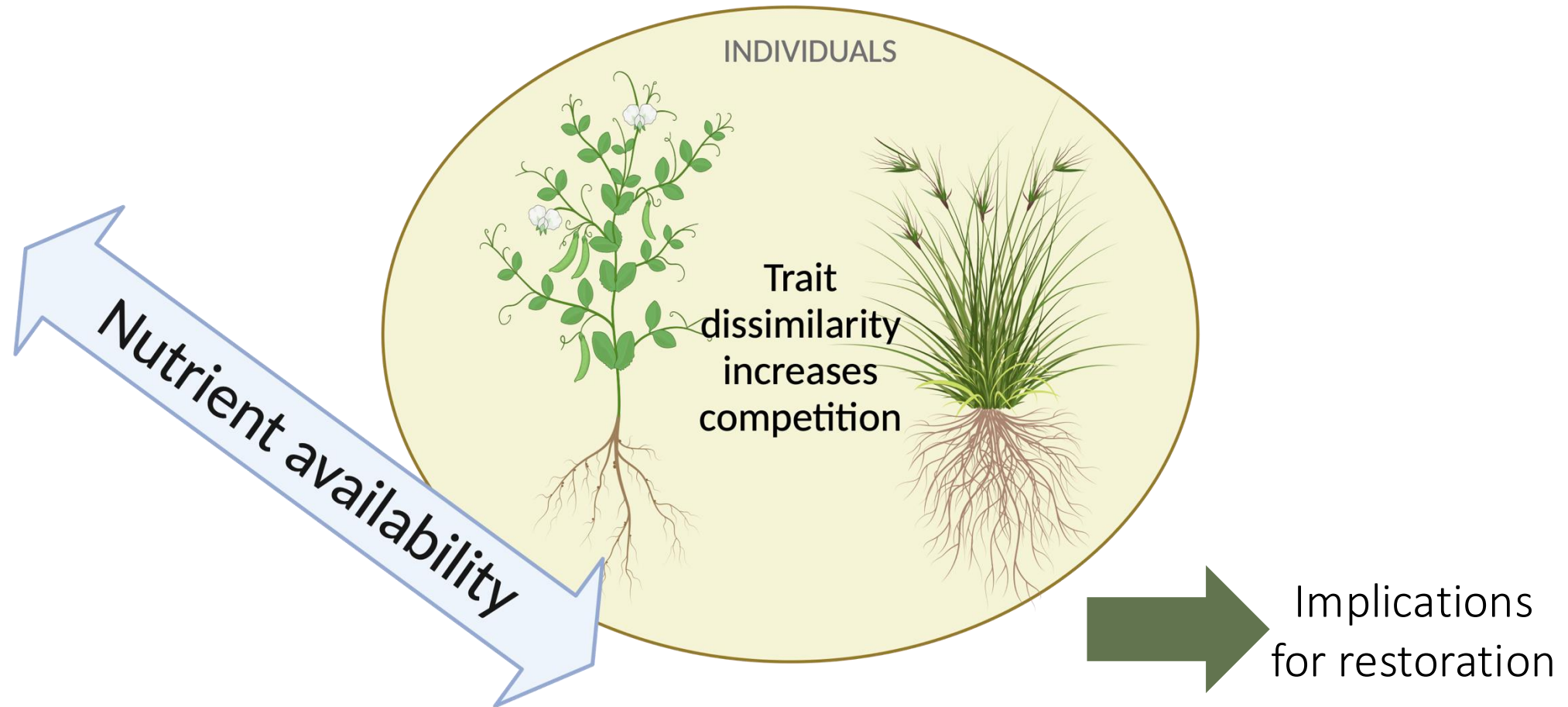
- We should not assume foundational theories are true without evidence!



Overview



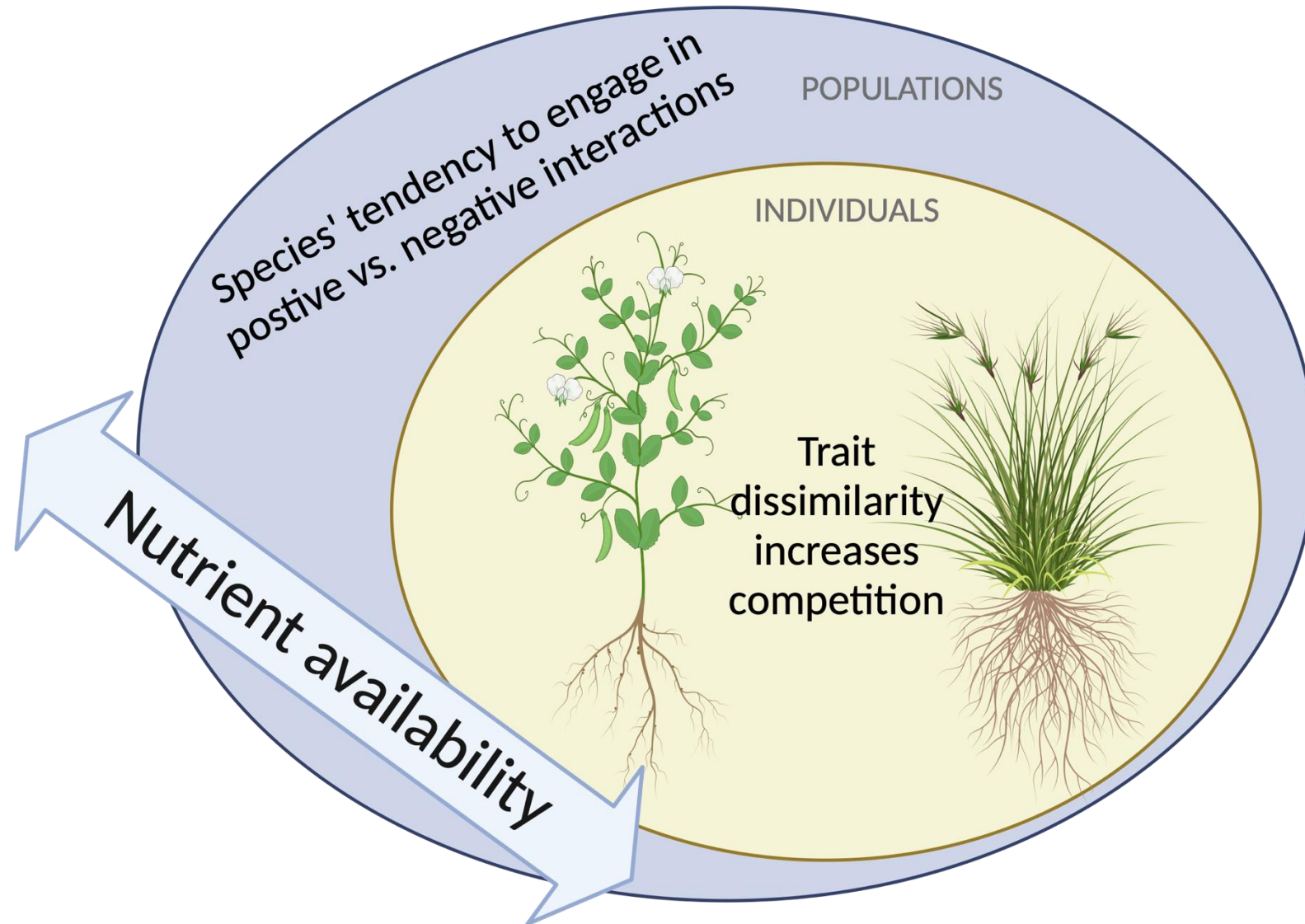
Overview



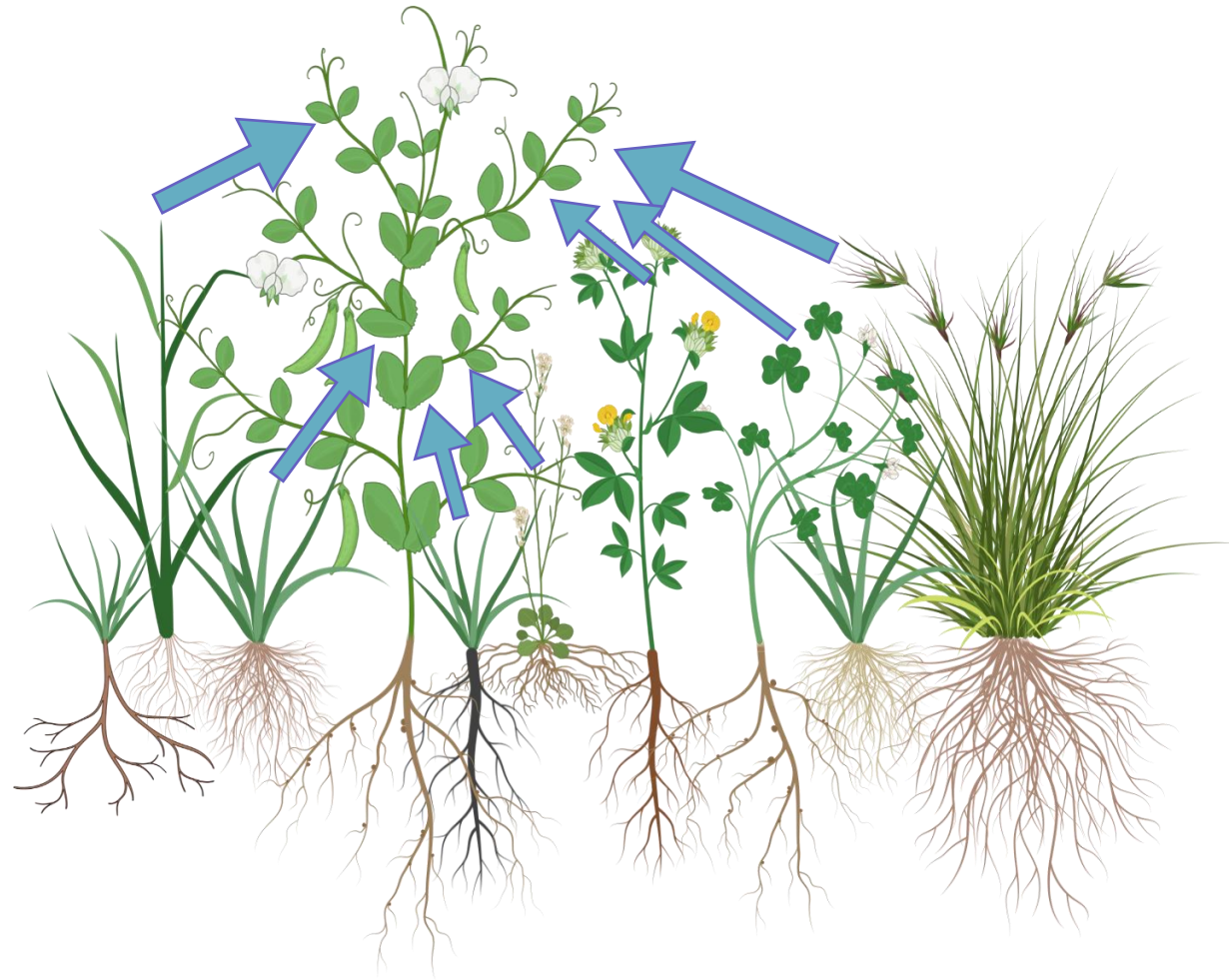
Implications for restoration

- Consider growing plants with similar traits together in communities
 - Choosing dissimilar plants for seed mixes and/or transplanting may create a more competitive environment and lead to performance reductions
- Look to existing plants to identify candidate species for reintroduction

Reframing plant strategies: Species engage in both competitive and facilitative interactions



Components of interactions: effect and response



Components of interactions: effect and response

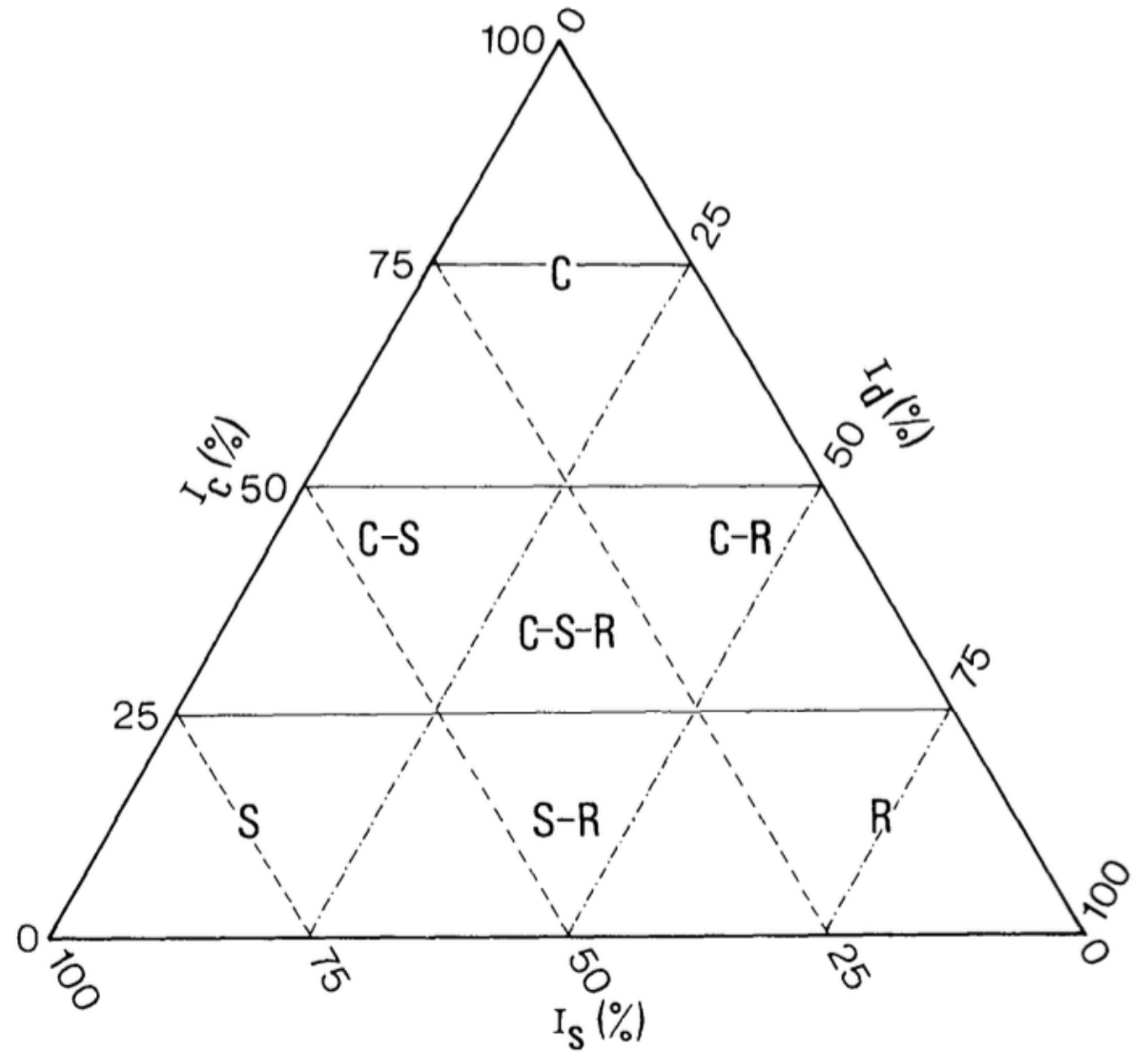


Plant interactions

- Typical investigations focus on average and negative effects



“Competitive” plants



Plant interactions

- Facilitation: growth enhancement due to neighbours



Expectation
that stronger
competitors
can't facilitate



Can competitors ever facilitate?





- Mesocosm experiment in which 13 co-occurring grassland species grew in all possible pairwise combinations (including with conspecifics) and alone

- 2 nutrient conditions*3 blocks
 - 332 treatments/1141 plants in total
- Measured final total (above- and belowground) biomass



Calculating neighbour effect and response

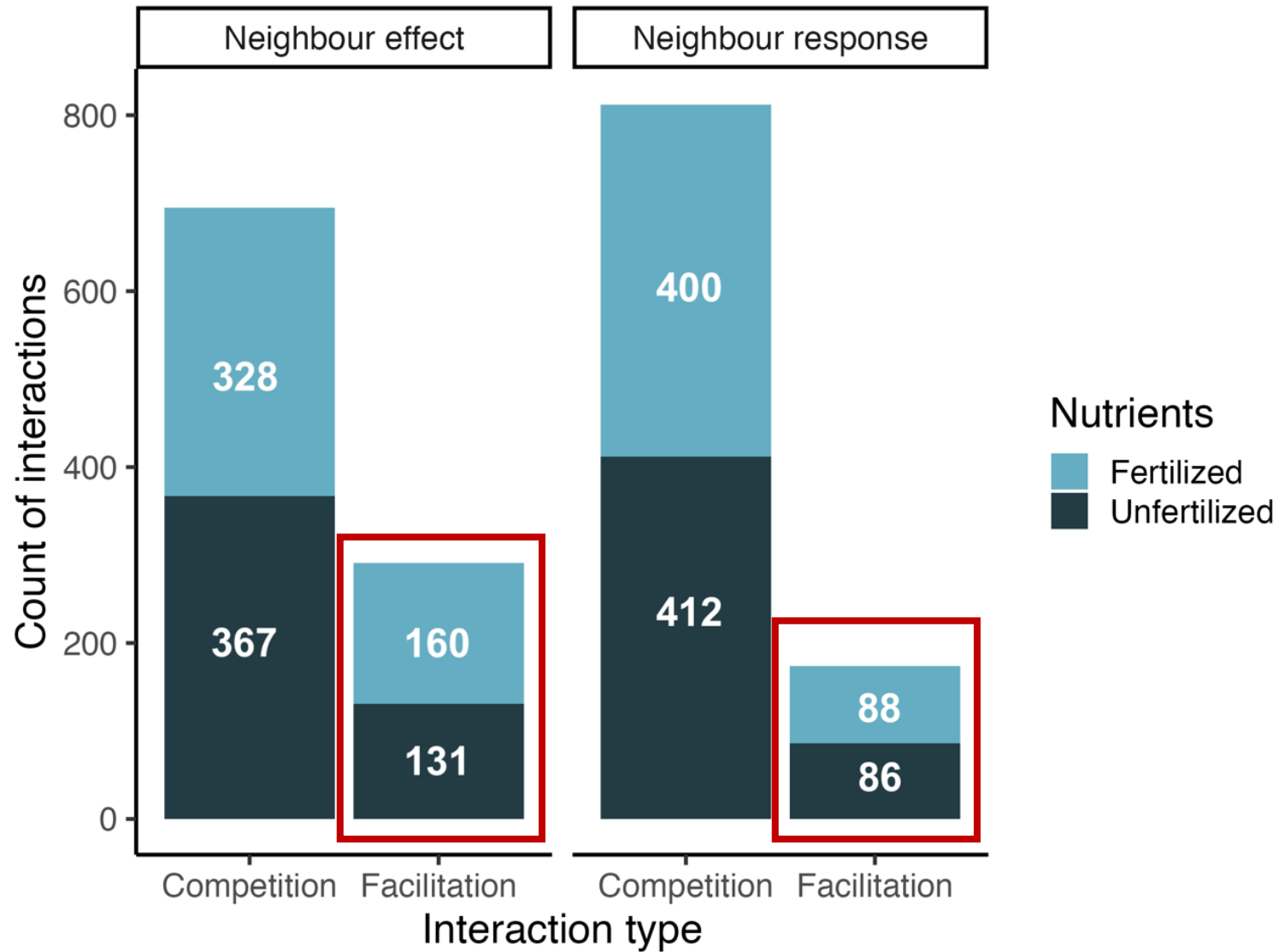


→ Repeated for all thirteen species and 168 combinations

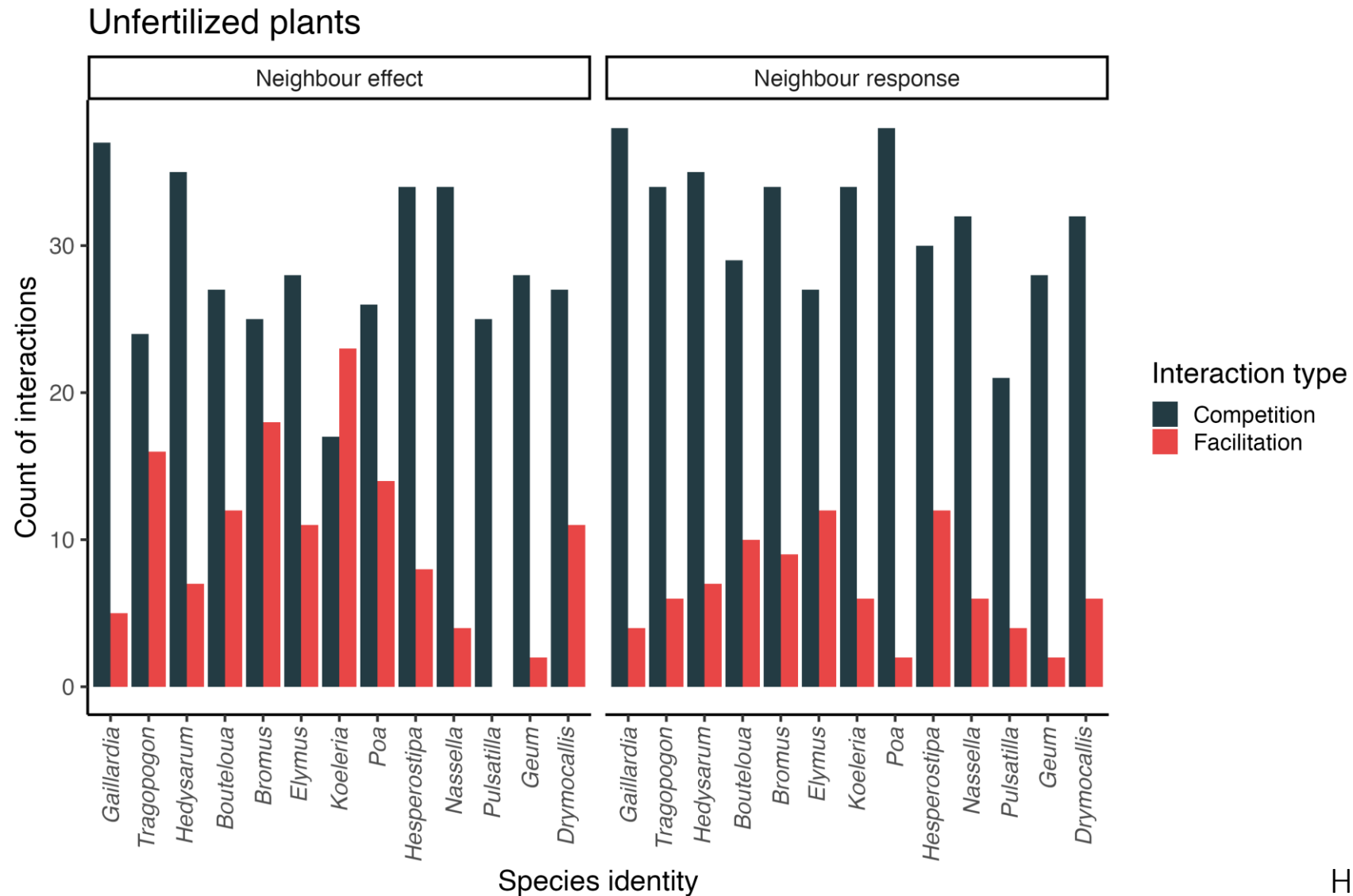


Counted instances of
competition and
facilitation per species
and nutrient treatment

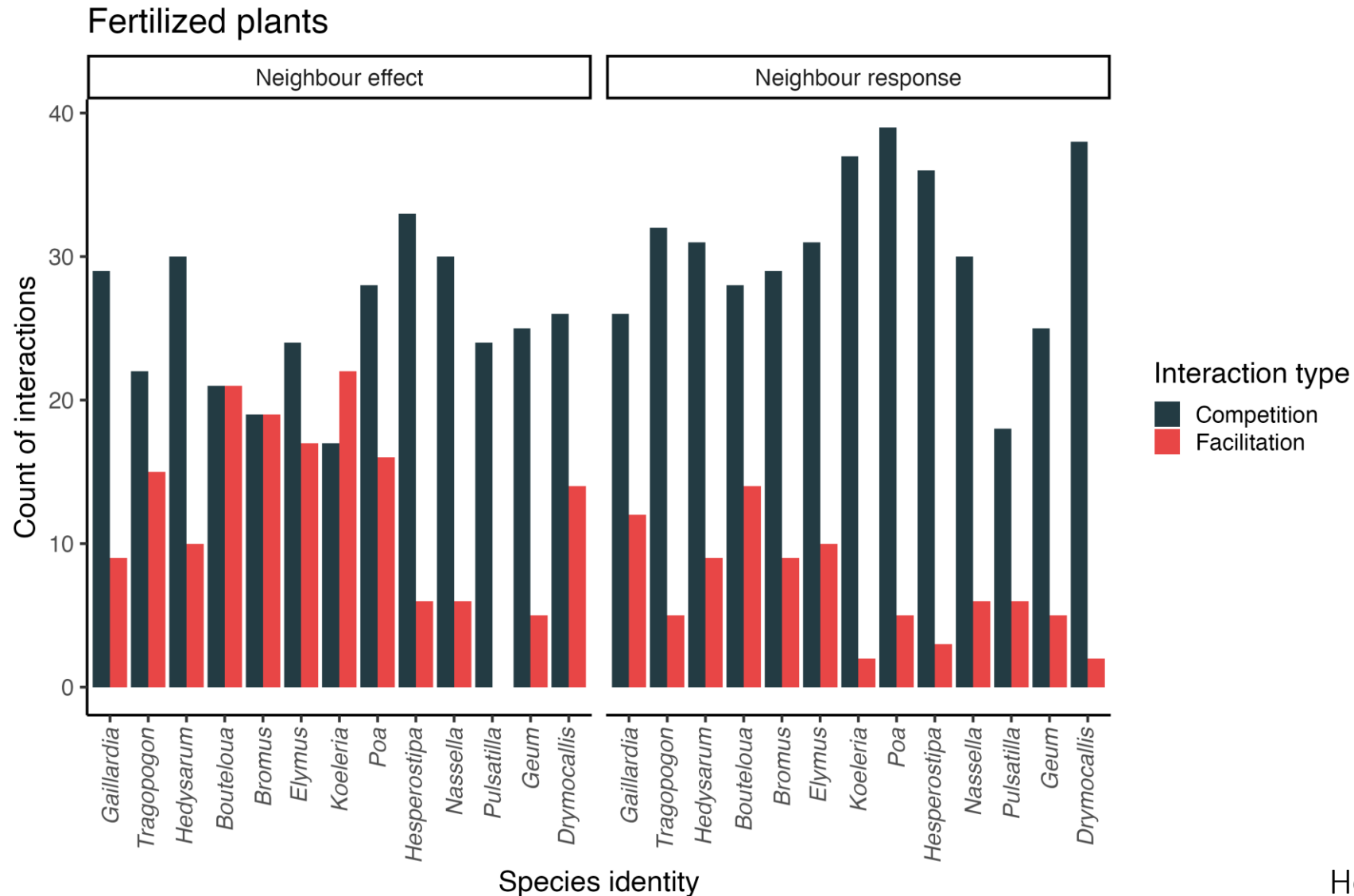
Facilitation was common



All species engaged in competition and facilitation

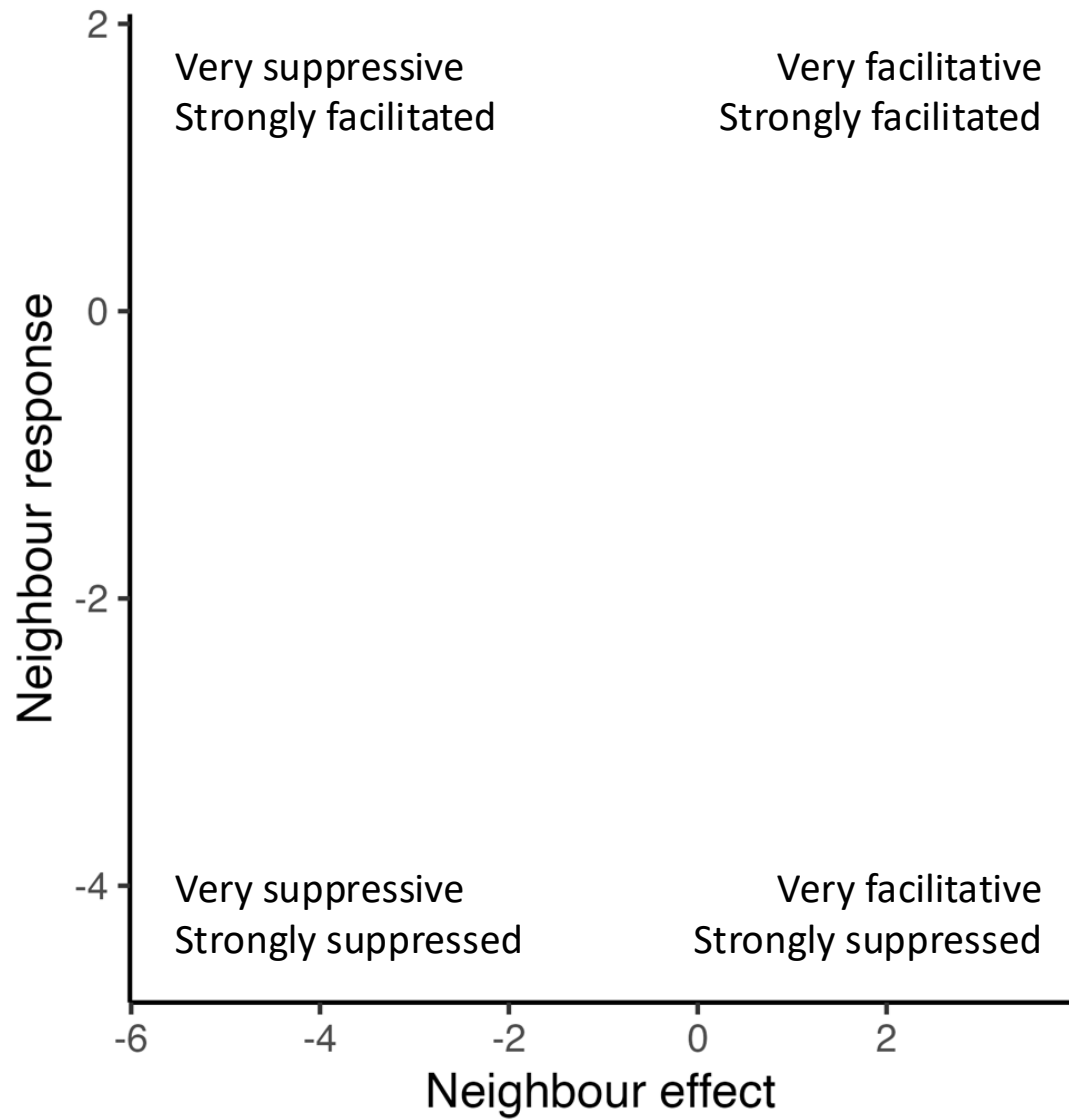


All species engaged in competition and facilitation

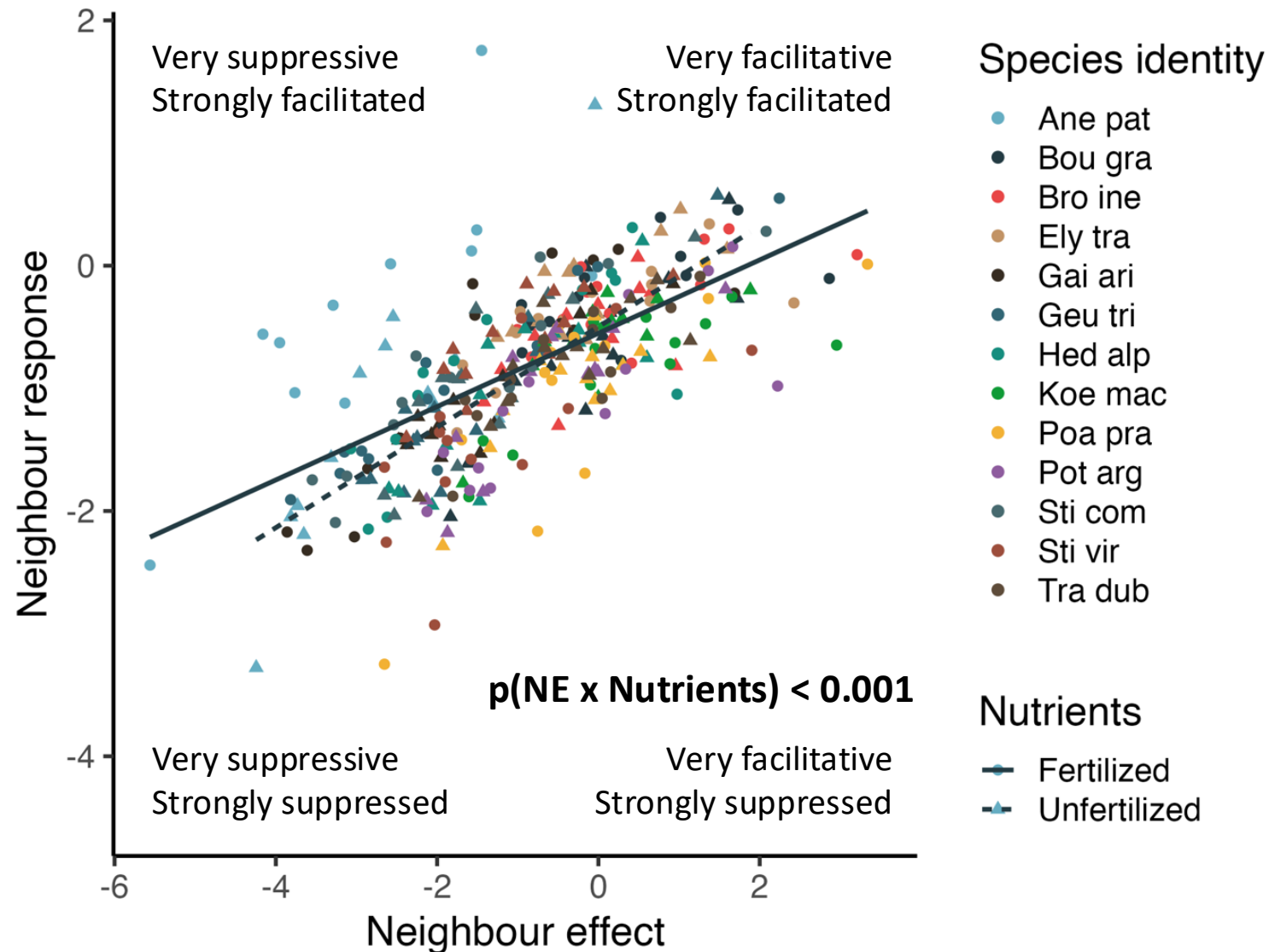


Do plants exhibit competitive strategies?





Evidence for competitive AND facilitative strategies



Conclusions



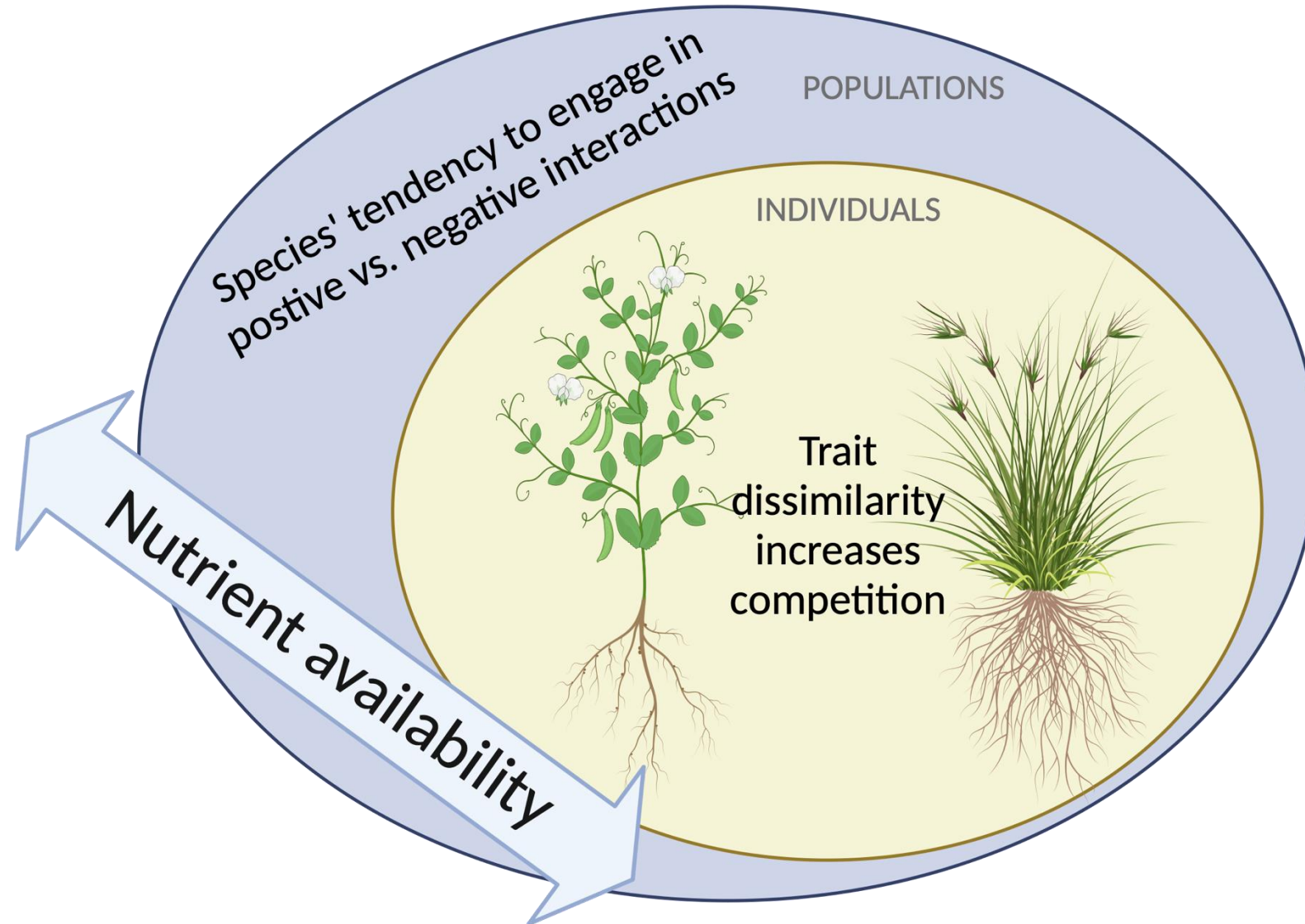
- Facilitation was common
- Competition is an outcome, not an intrinsic species quality
- Suggests facilitation is found even in competitive environments

Conclusions

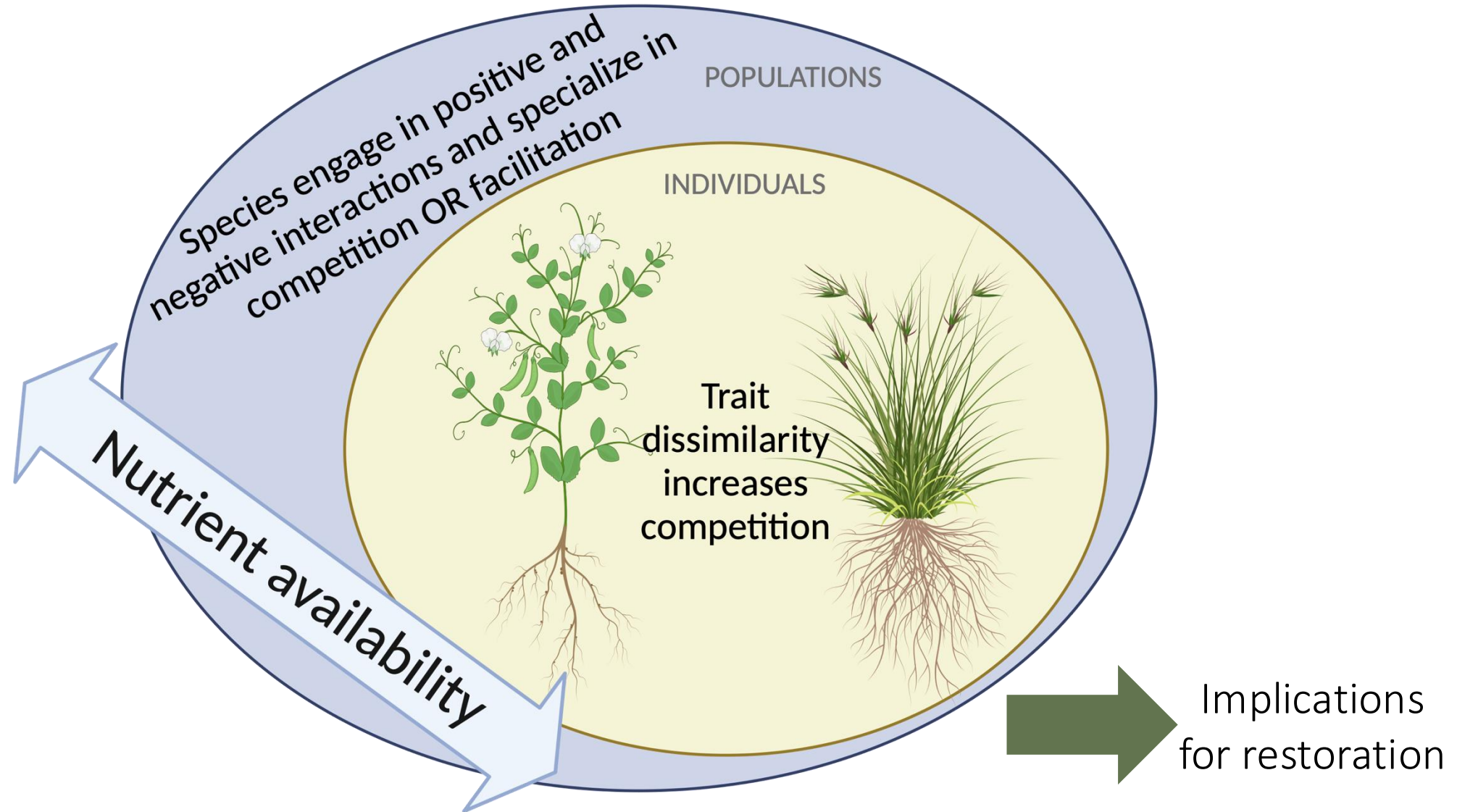


- Evidence for competitive AND facilitative strategies
 - We've ignored half of the spectrum of plant interactions!

Overview



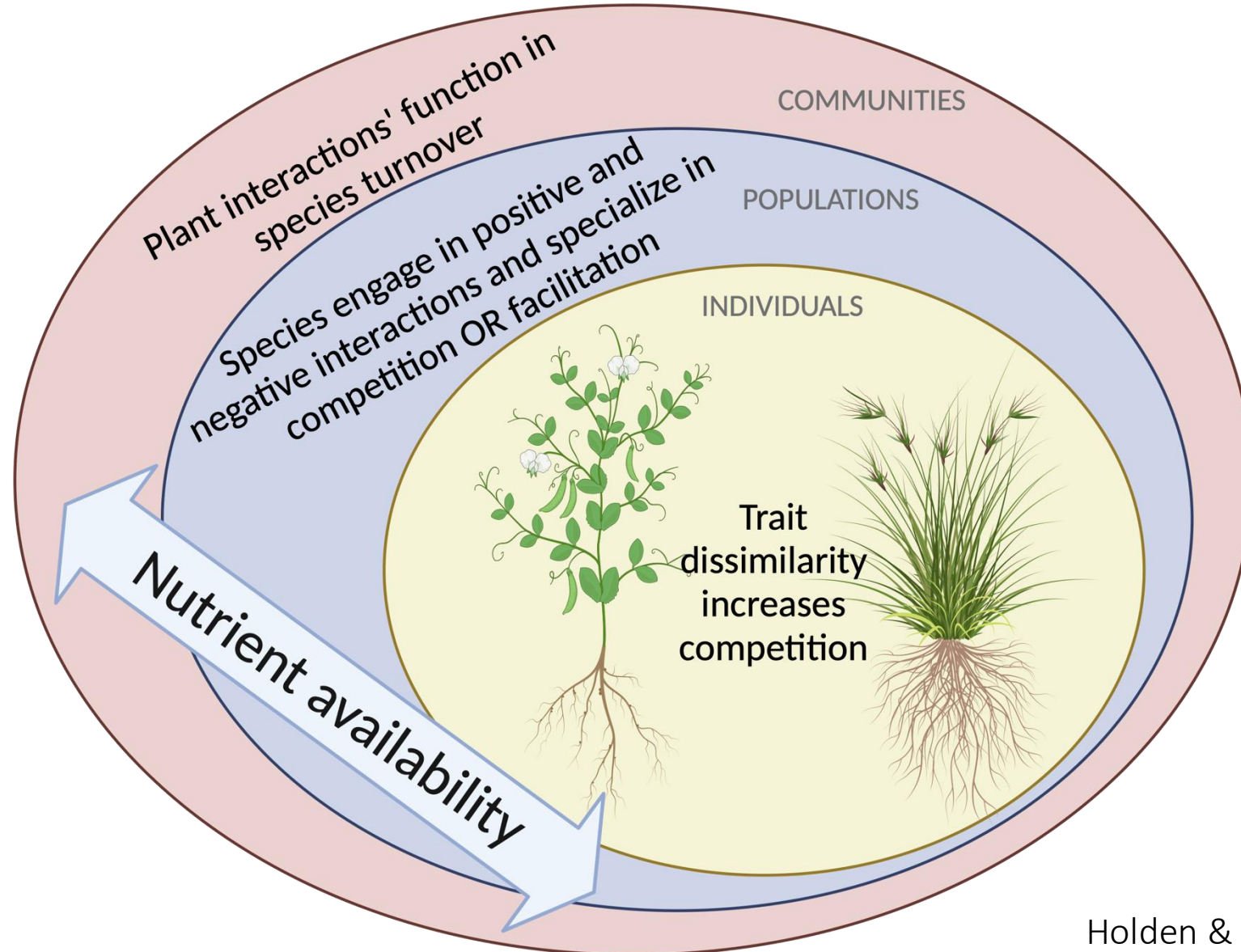
Overview



Implications for restoration

- Neighbours can improve plant performance
 - E.g. companion planting
 - Consider how species may help or hinder the performance of each other in seed mixes, transplants

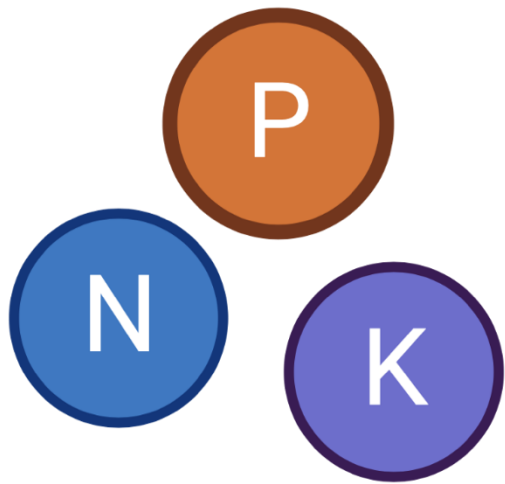
Social and structural traits influence species gains while resources influence species losses in a native grassland



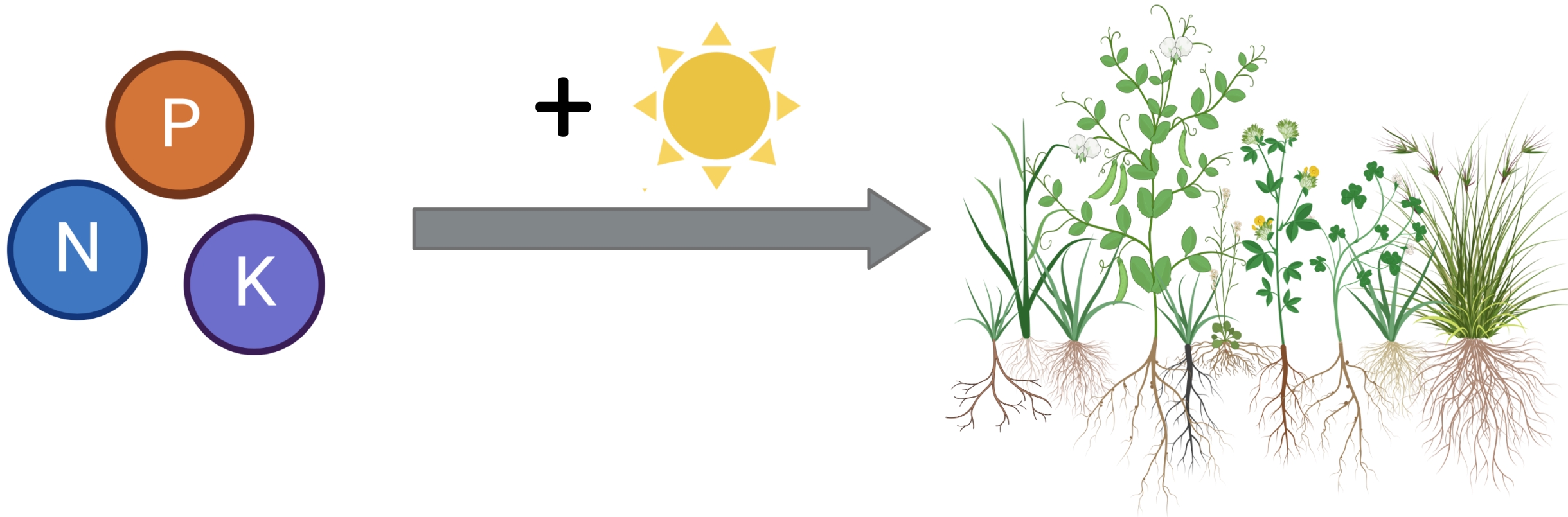
Diversity and stability



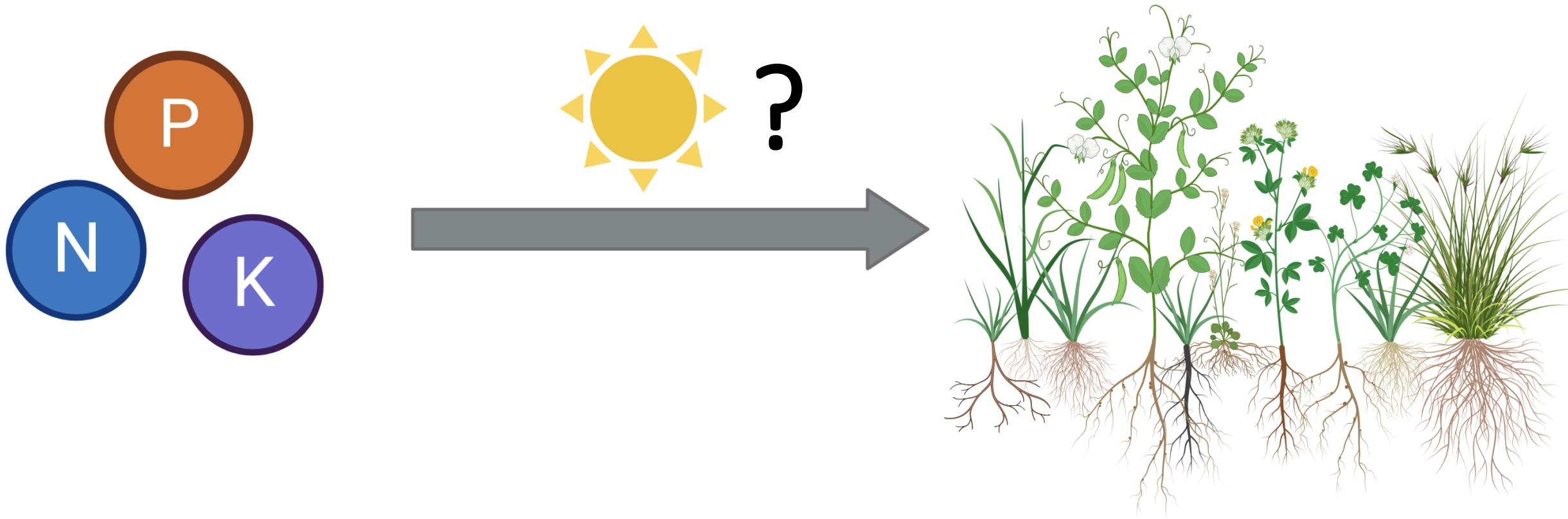
Nutrient addition leads to bigger plants and species loss



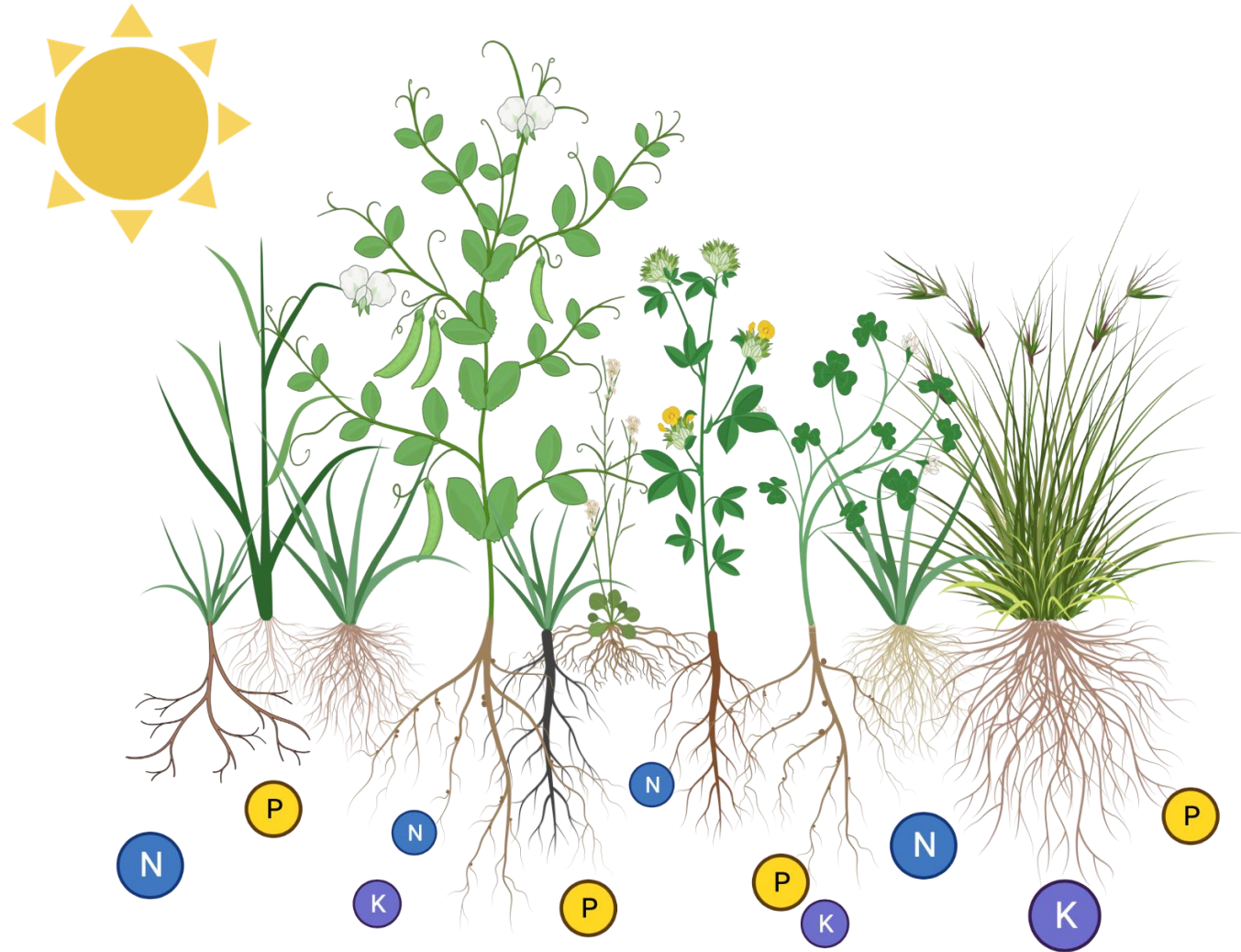
Understory light penetration rescues communities from species loss



Nutrient addition decreases species richness
regardless of light penetration



Do soil nutrient and light manipulations have similar effects on species gain and loss?



Light

- Ambient
- - (shaded)
- + (tie-backs)

Nutrients

- Ambient
- + NPK





Measuring
diversity

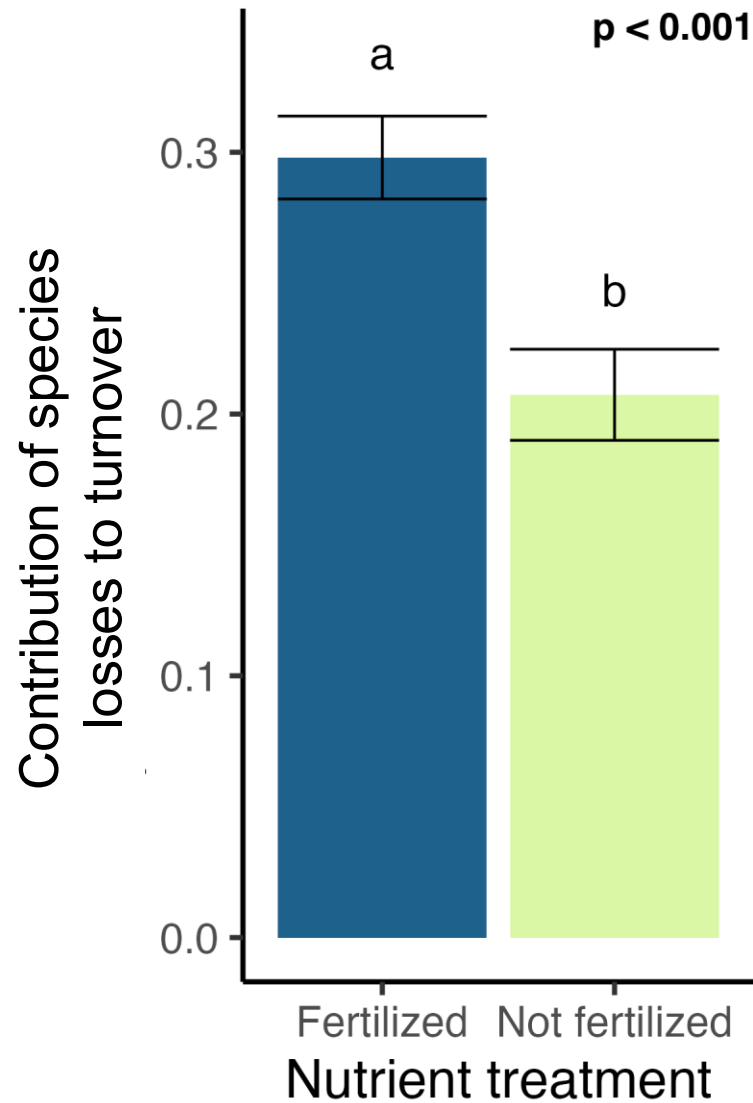
→ Species
presence, gain,
& loss

Measuring species turnover: temporal beta diversity

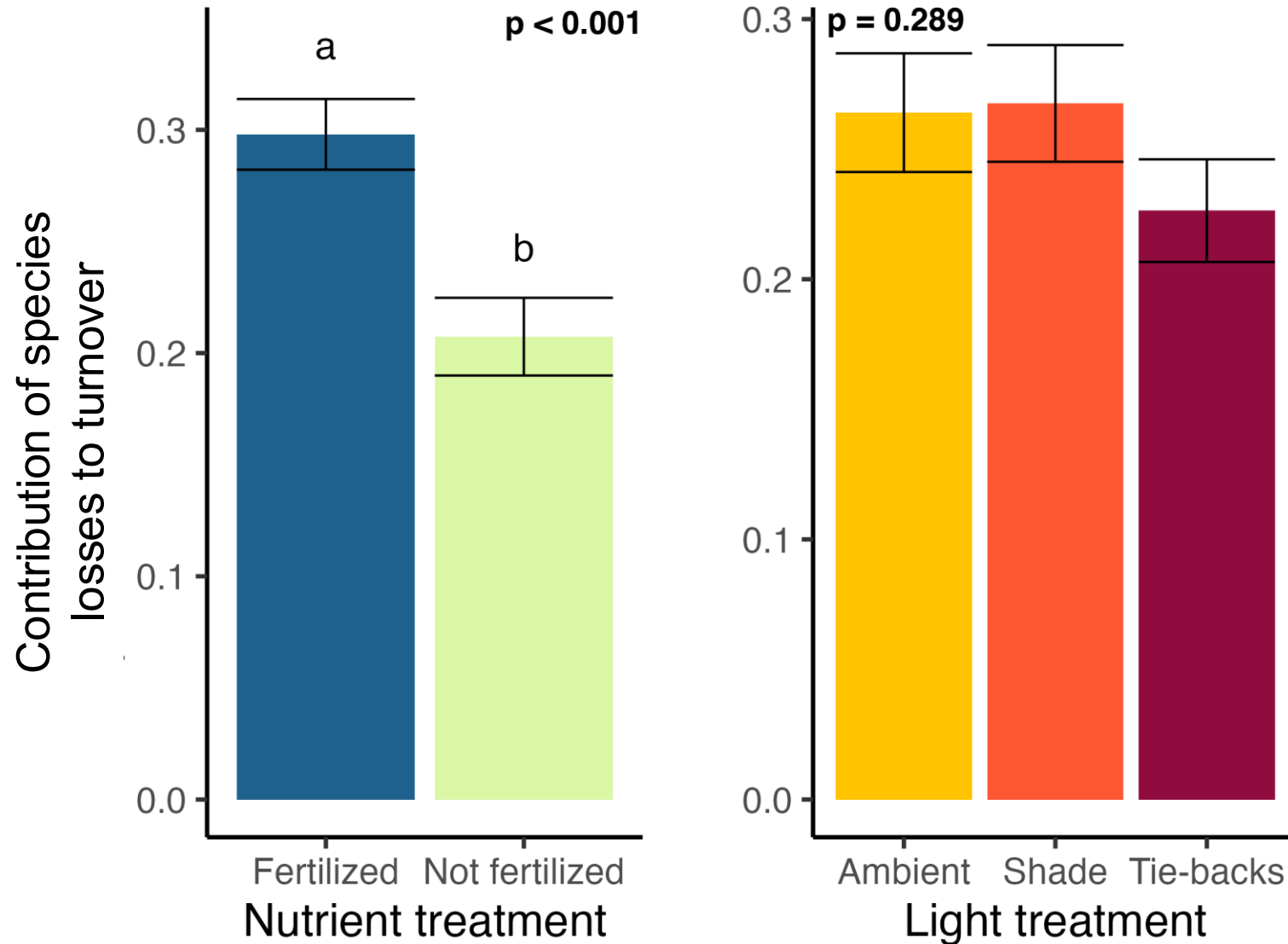


→ Became response variable in LMMs

Increased nutrients increased species losses



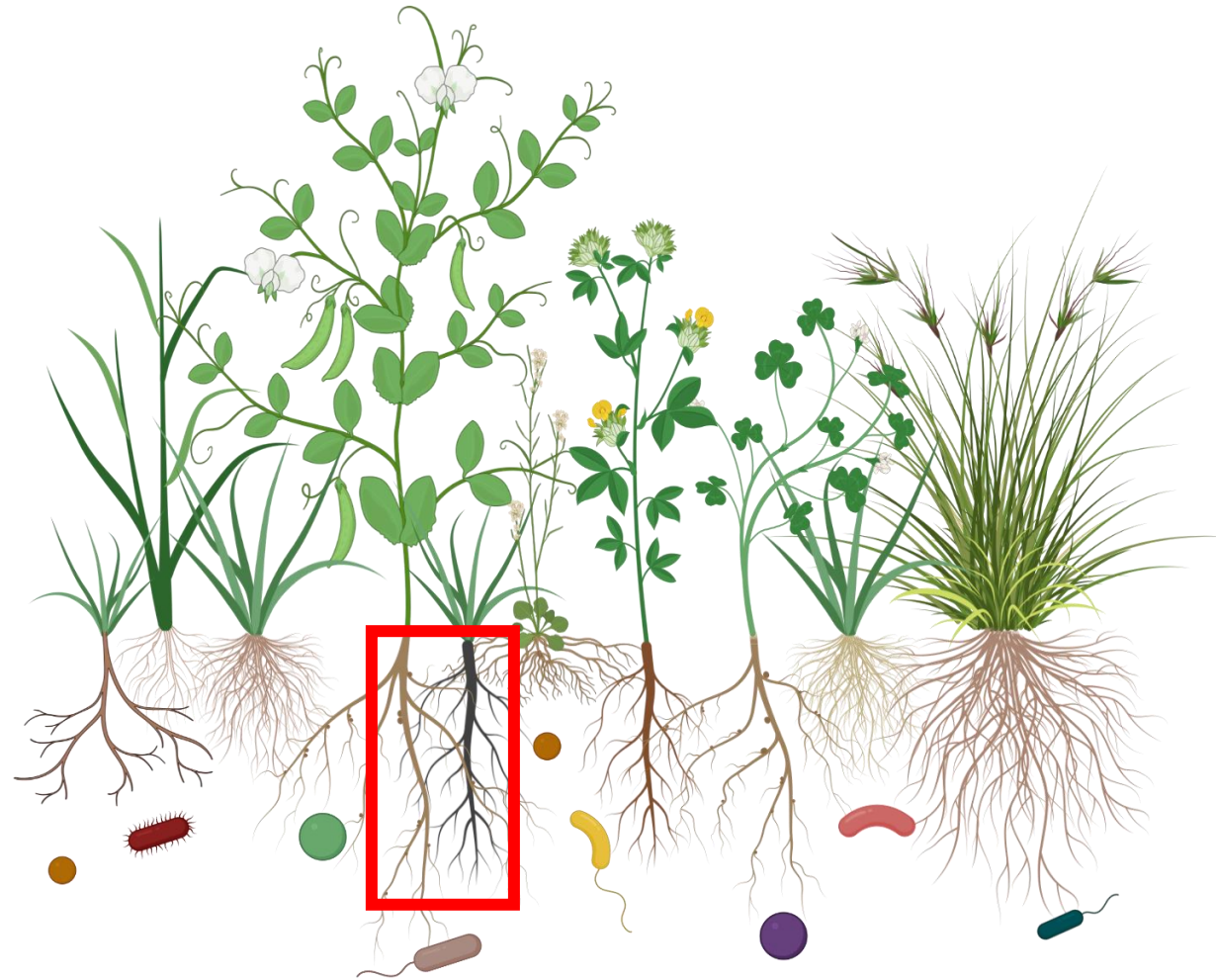
Increased nutrients but not decreased light increased species losses



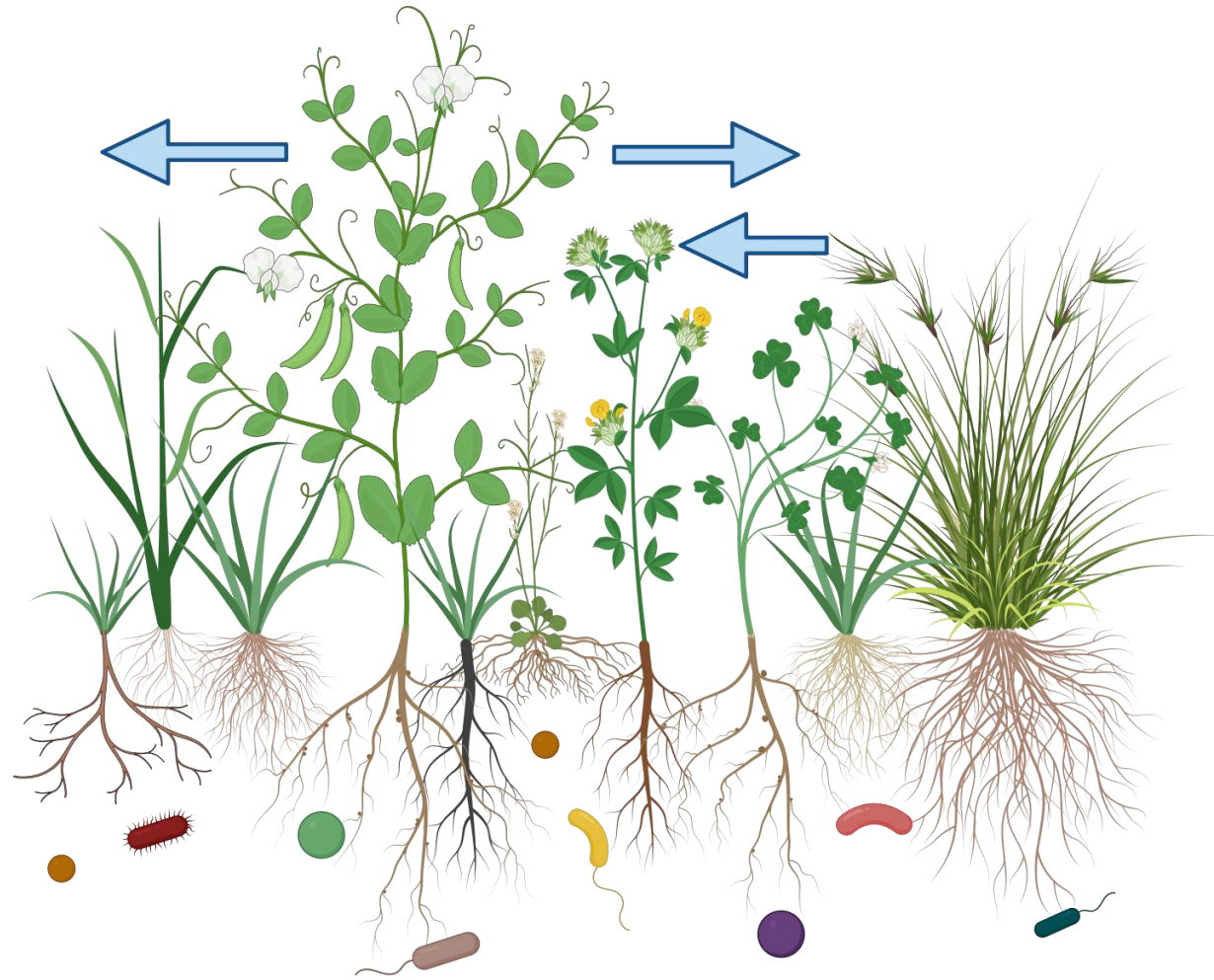
Neighbours can have non-resource effects



Neighbours can have non-resource effects



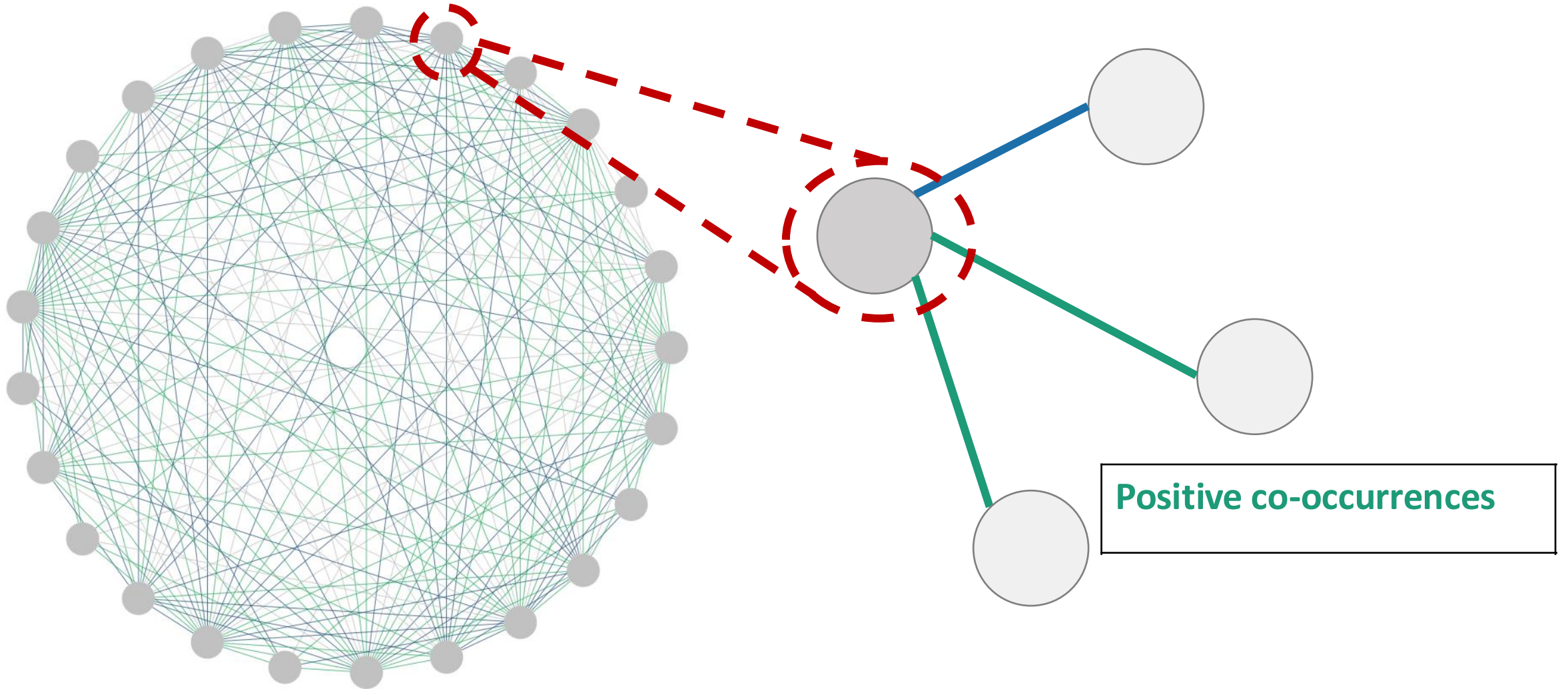
Does plant social context influence species gain and loss?



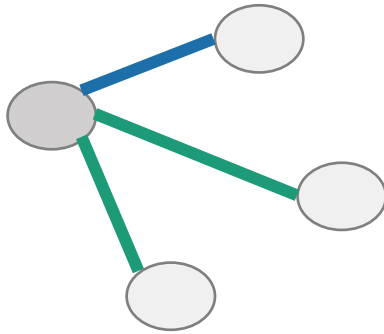


Characterizing
plant social
context

Using networks to understand plant social context



Creating social traits



Positive co-occurrences	2
Negative co-occurrences	1

×

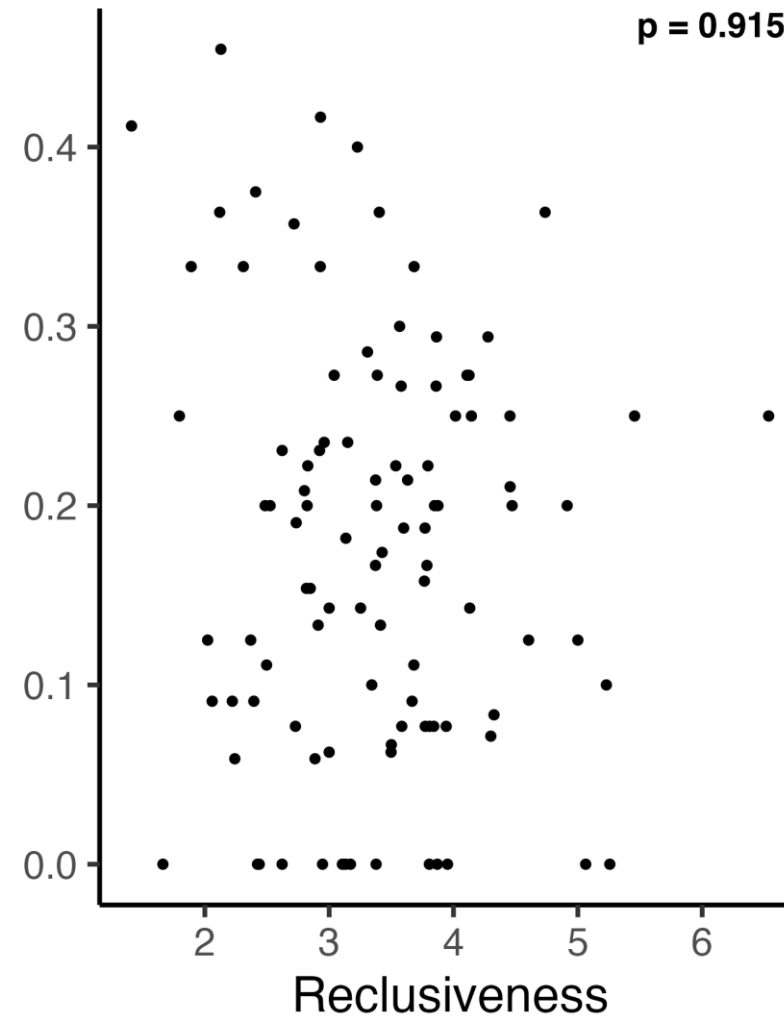
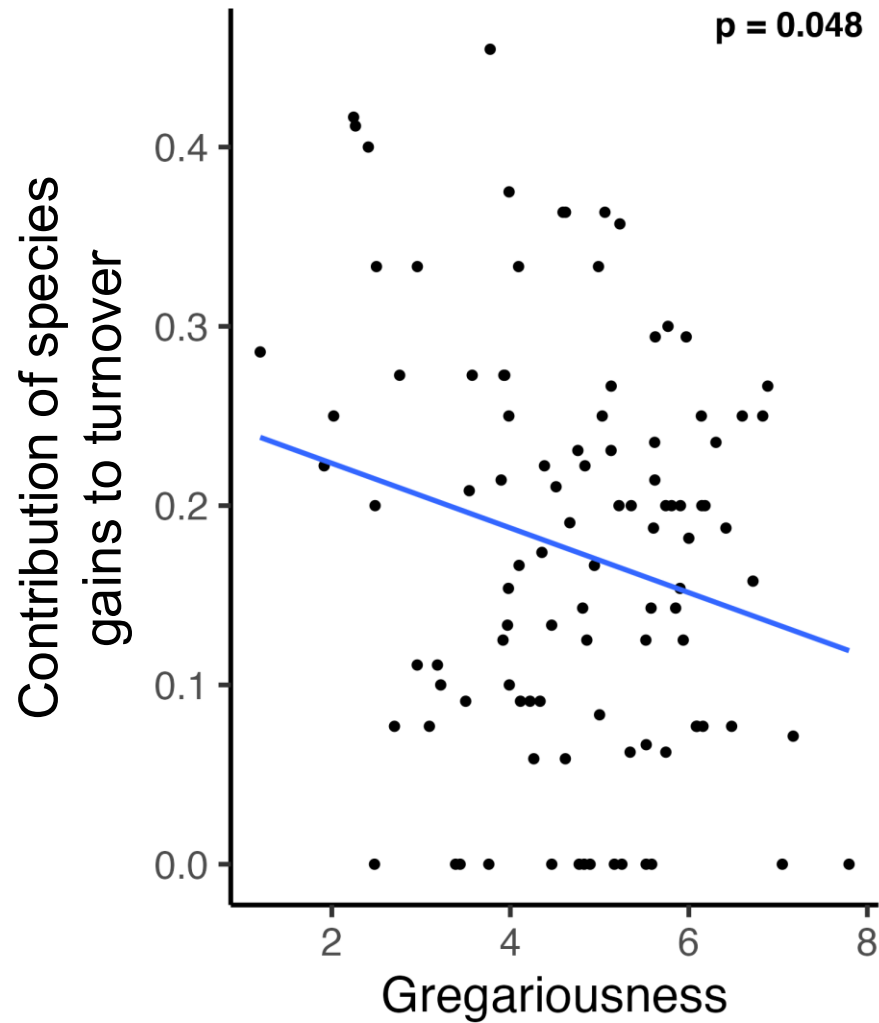


Social traits

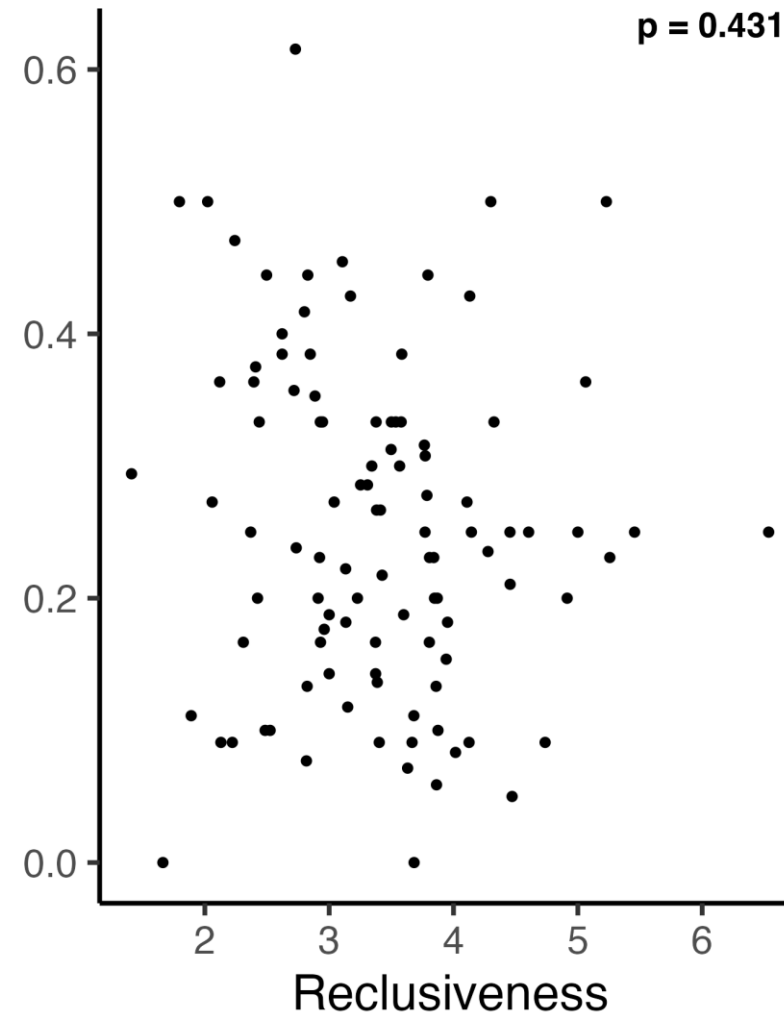
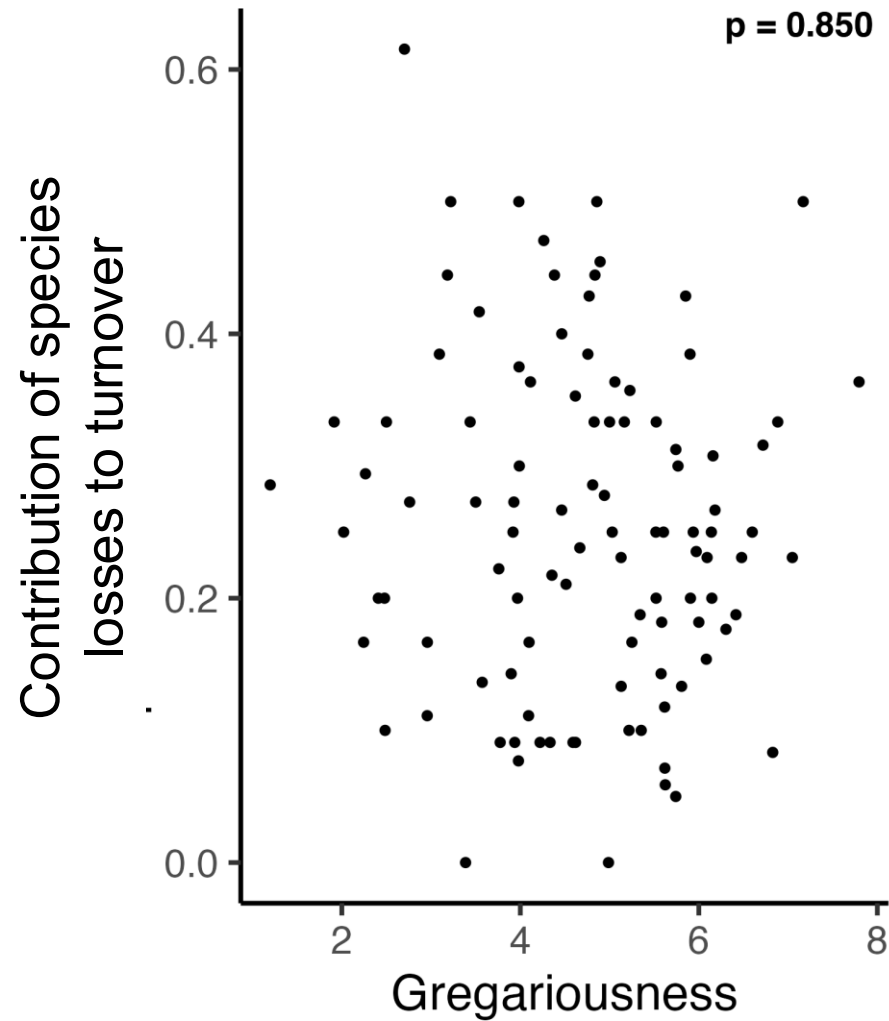
- “Gregariousness”: propensity of species in a community to engage in positive co-occurrences
- “Reclusiveness”: propensity of species in a community to engage in negative co-occurrences

→ Used as predictors in LMMs

Social traits influenced species gains but not losses



Social traits influenced species gains but not losses



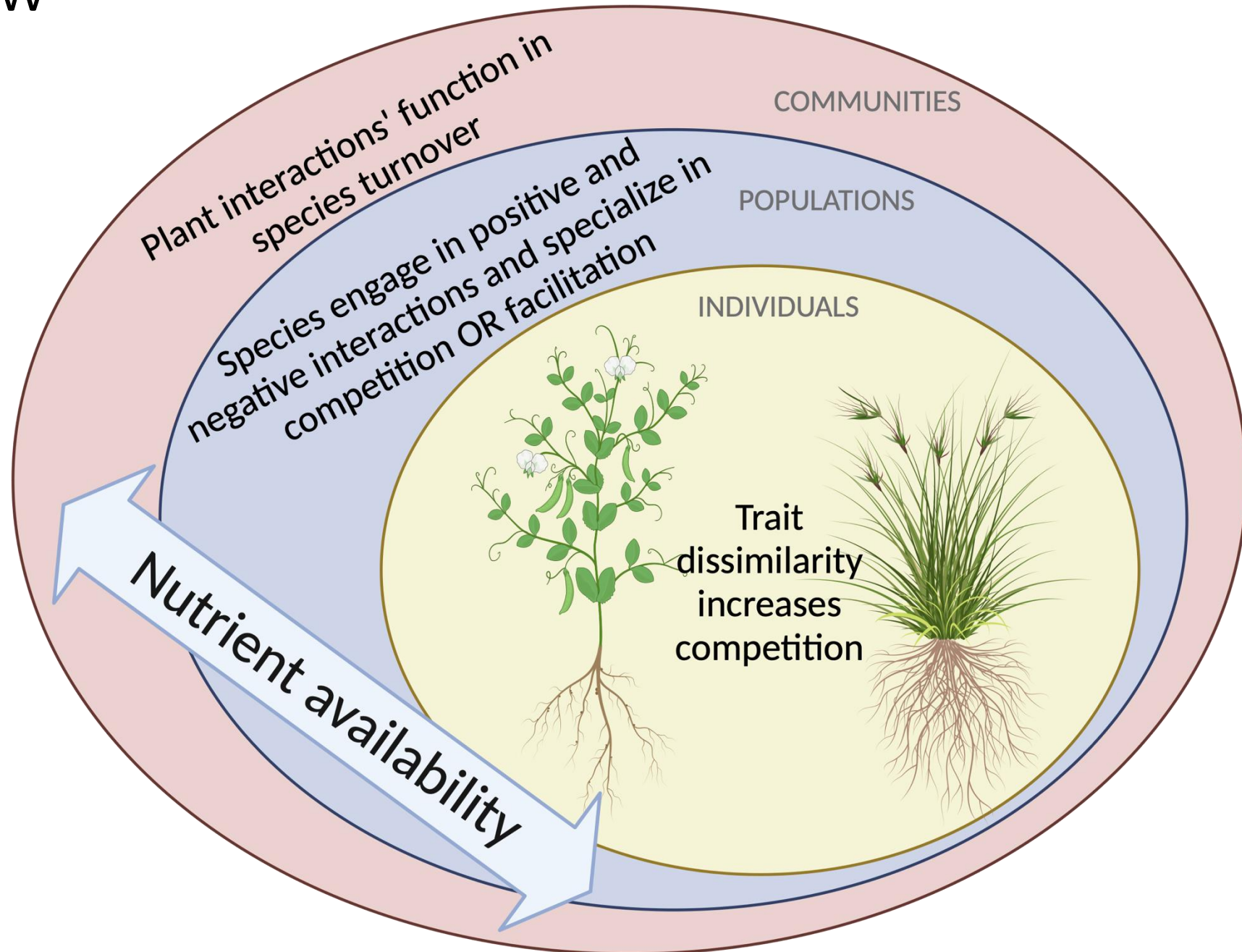
Conclusions

- Evidence for decoupling of nutrient and light effects on species losses
- This mechanism may not cause species loss in low-nutrient settings

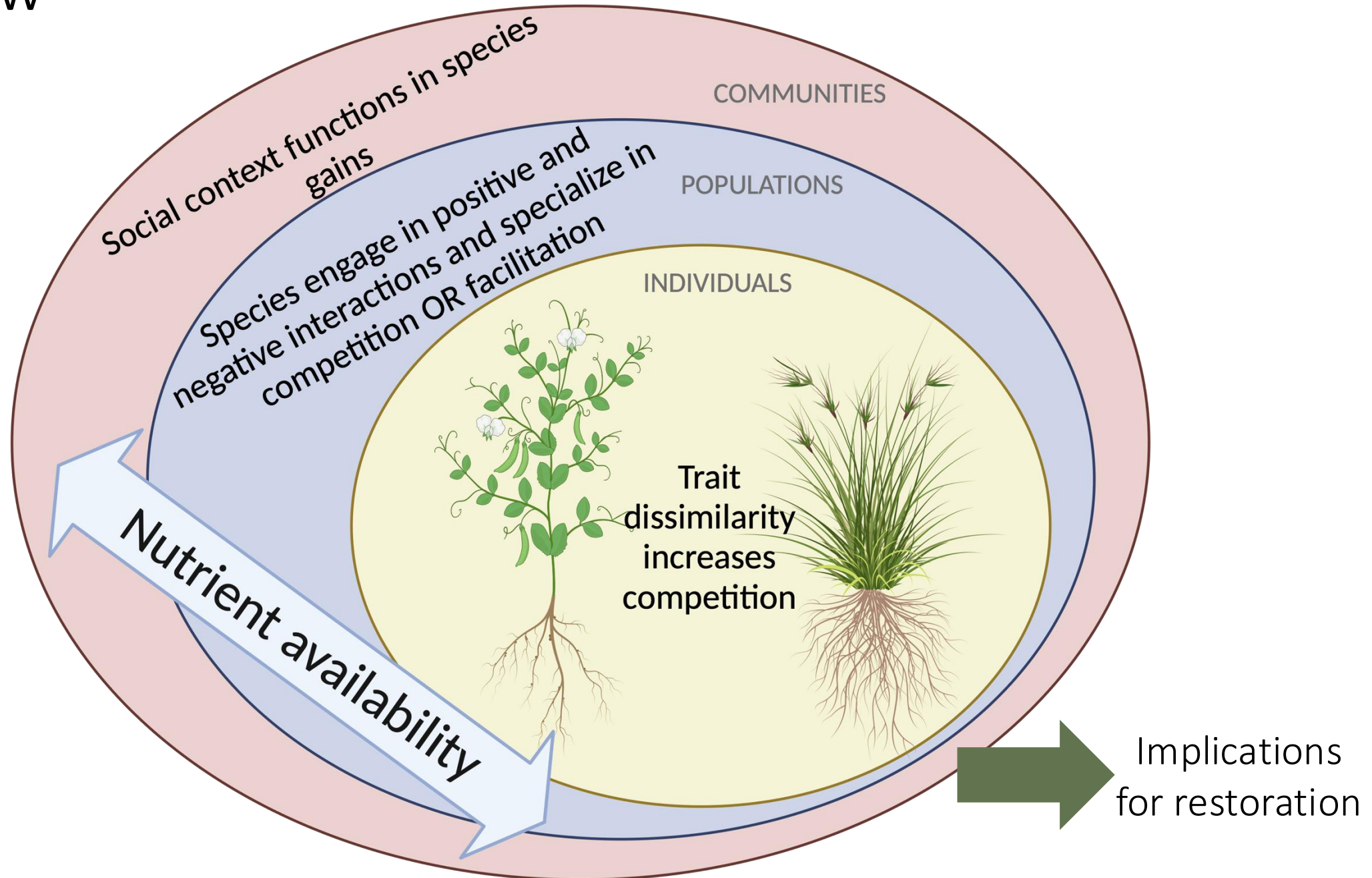
Conclusions

- Plant social context is functional in species gains!
- Considering social context can help us better understand community diversity and change

Overview

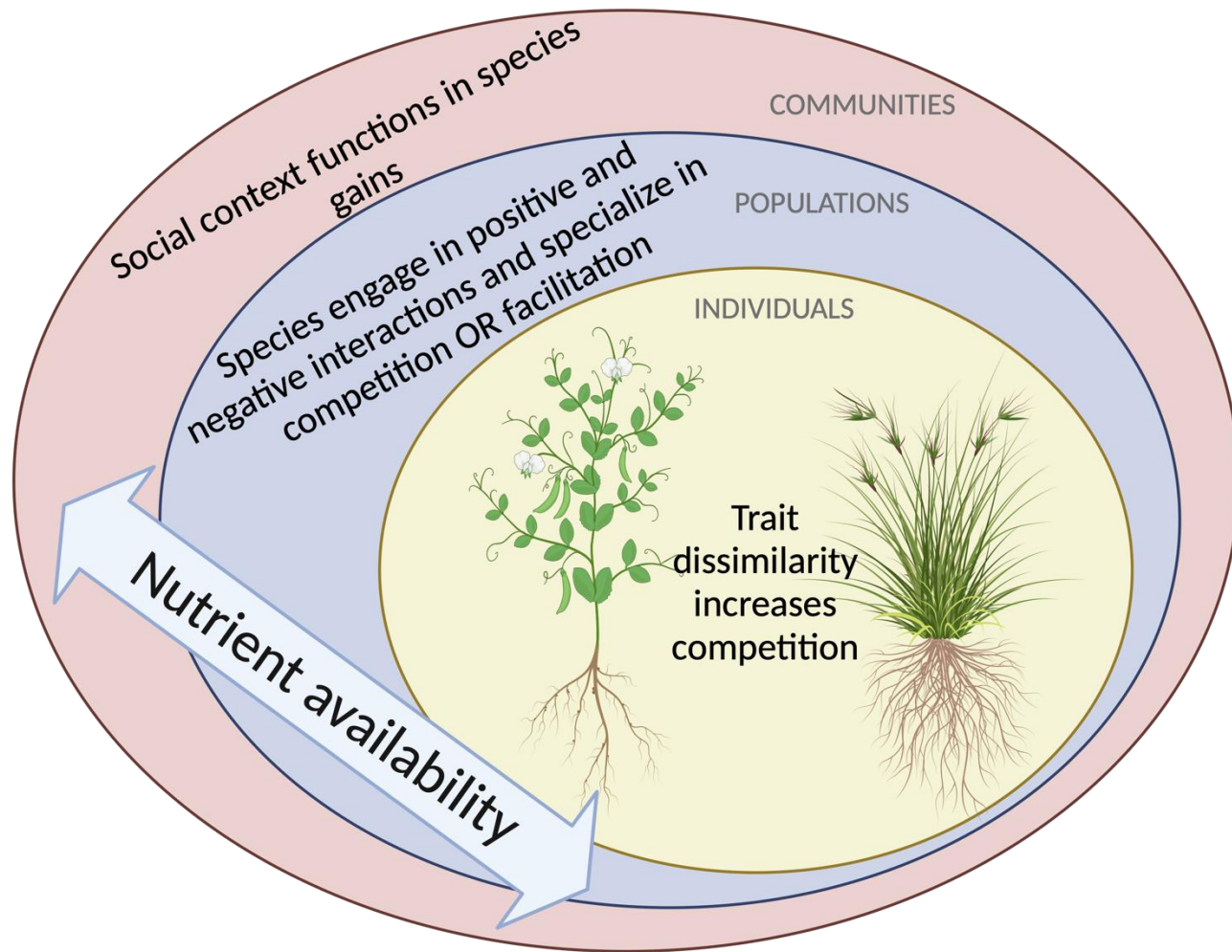


Overview



Implications for restoration

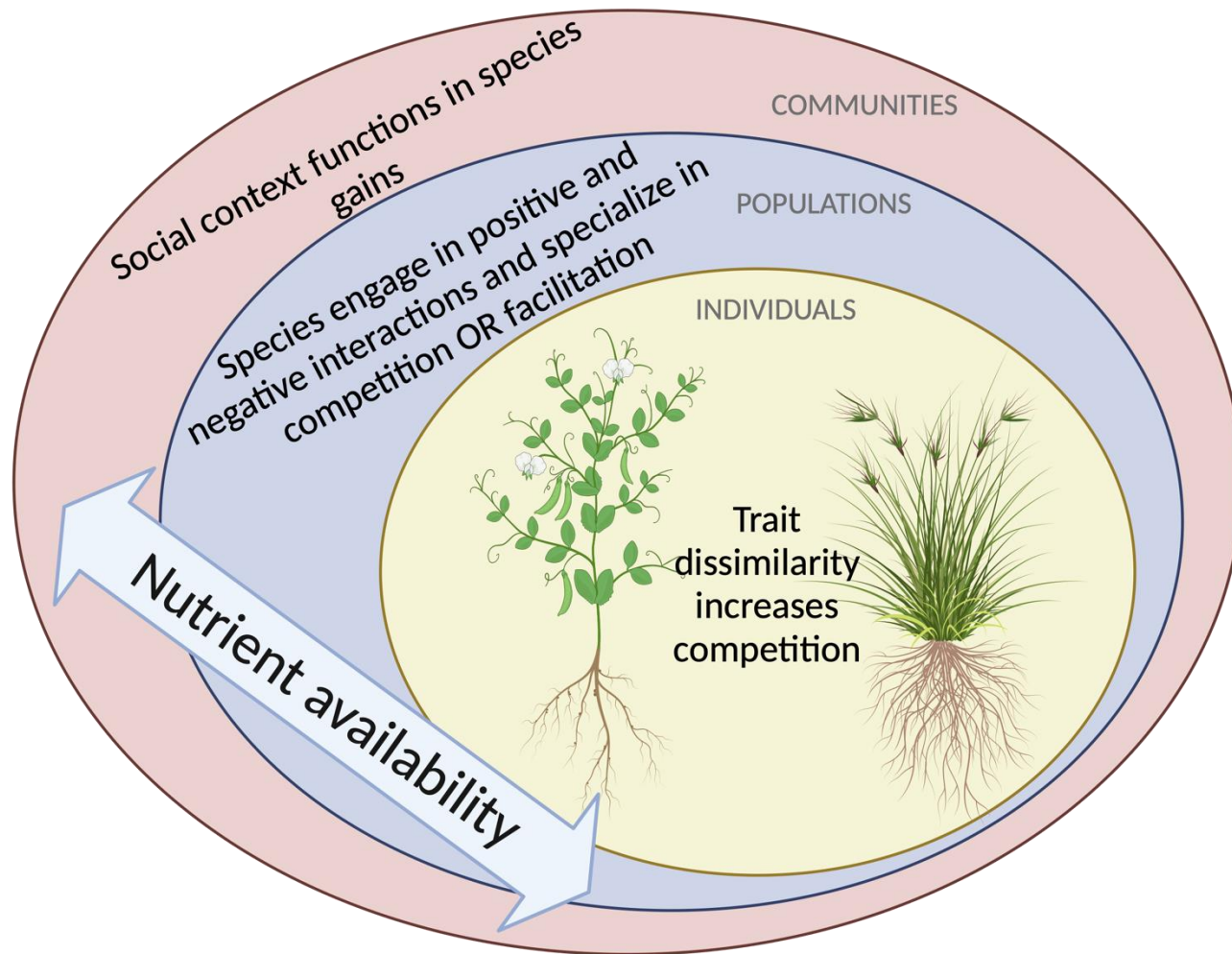
- Plant interactions can infer stability at the community level
 - This can be a good or bad thing (e.g. keep invasive species out or prevent desirable plants from re-establishing)
- Proof of concept: more work to do!



Overall conclusions

- Theory does not describe the actual dynamics of this system

Overall conclusions



- Plant interactions are functional!
 - Trait dissimilarity increases competition
 - Facilitation is common and plants exhibit facilitative strategies
 - Social context functions in species turnover



Plant interactions function in diversity

Where else could they function?



Thank You!
Questions?

emily.holden@ualberta.ca