Functional distinctiveness in ecological communities

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FREE working group: Functional Rarity in Ecology and Evolution
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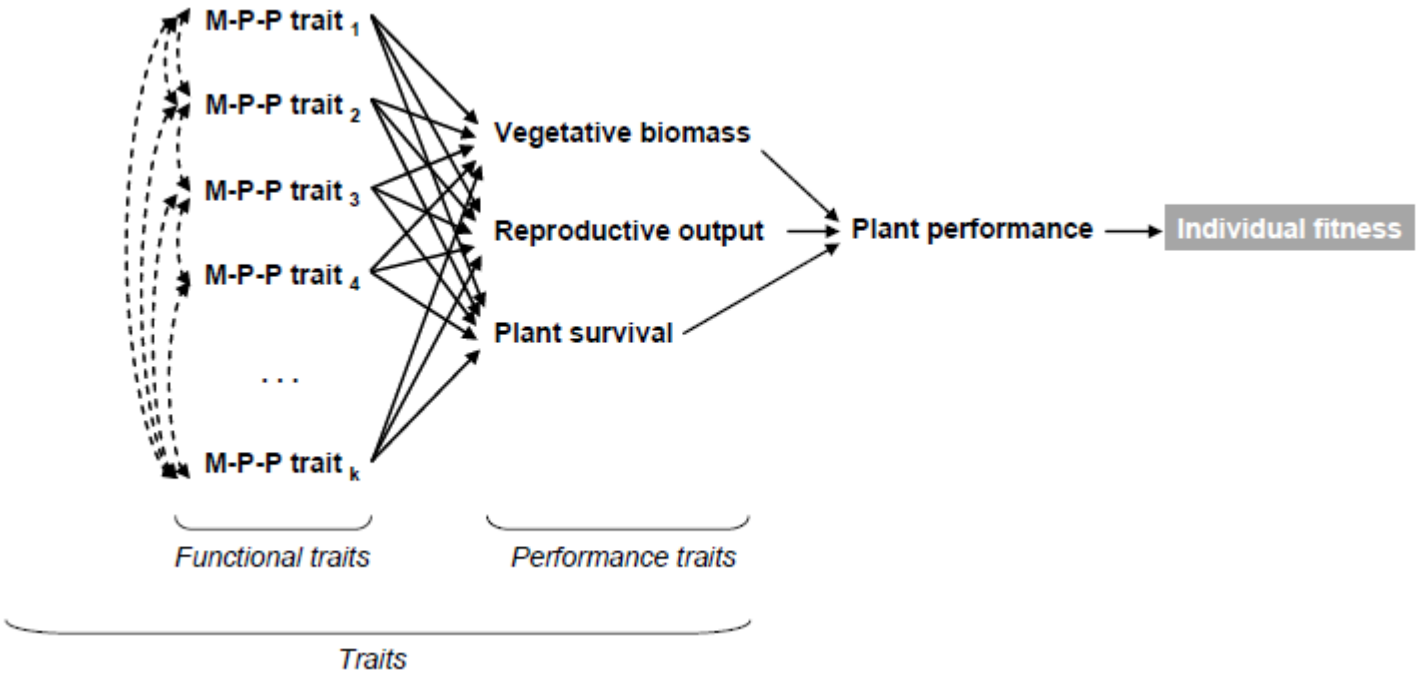
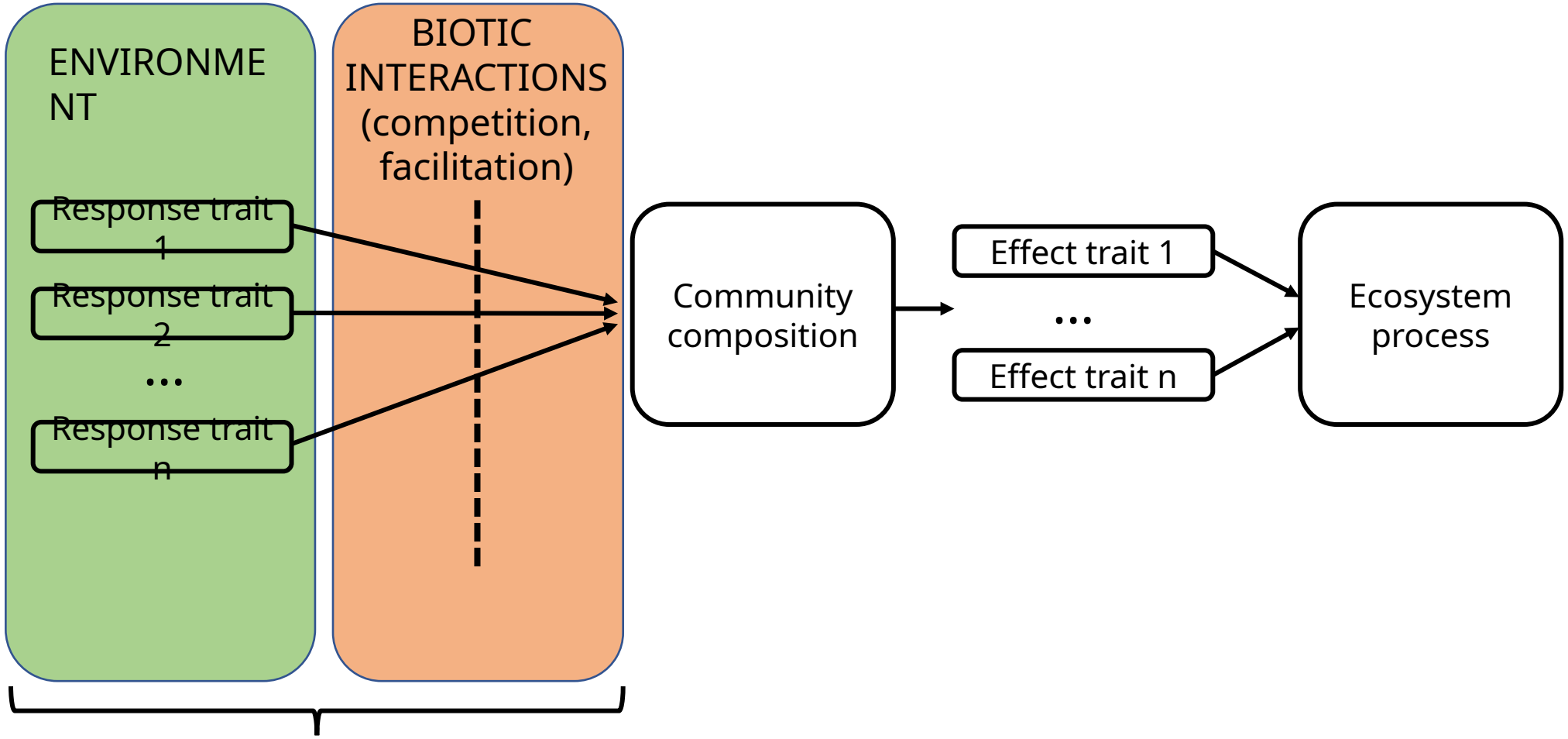
FRB FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ
CESAB CENTRE DE SYNTHÈSE ET D'ANALYSE SUR LA BIODIVERSITÉ
CENTRE D'ECOLOGIE FONCTIONNELLE & EVOLUTIVE
UNIVERSITÉ DE MONTPELLIER
ENS DE LYON

Functional traits



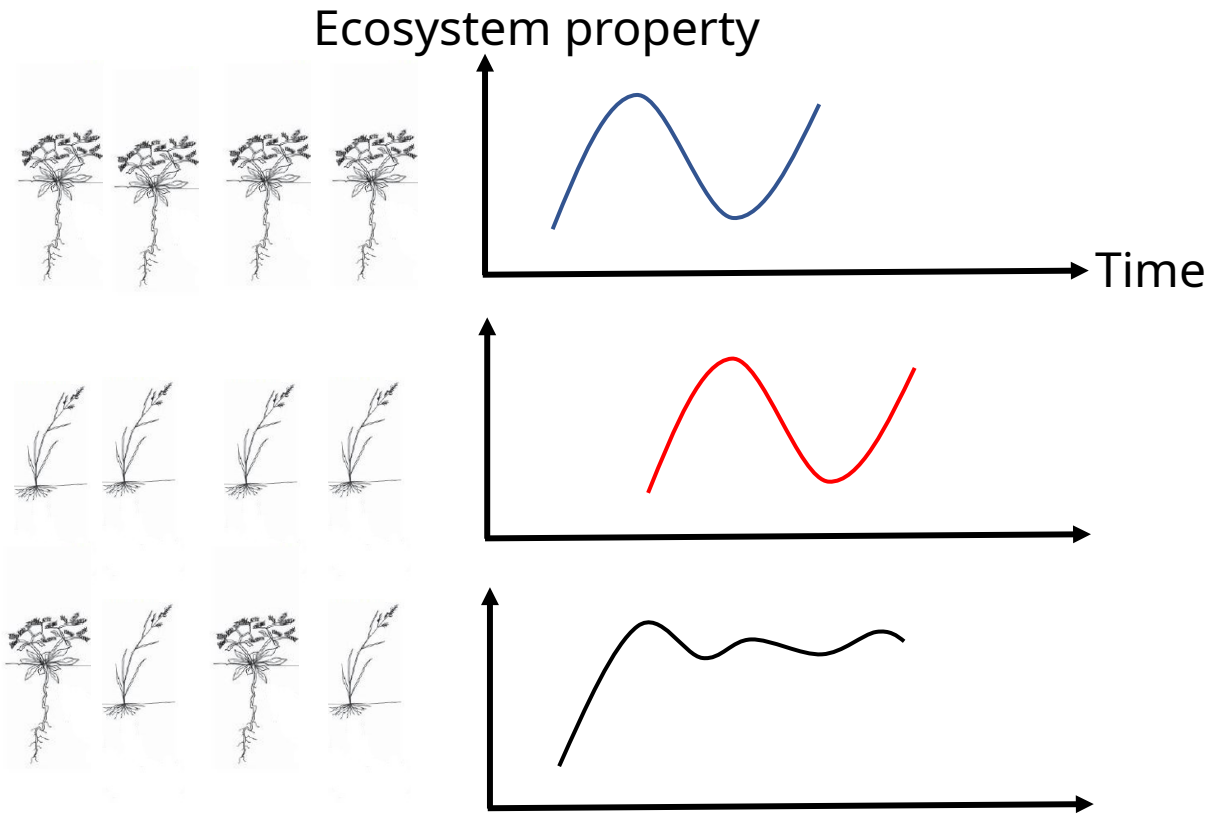
Violle et al., Oikos (2007)

Response and effect framework



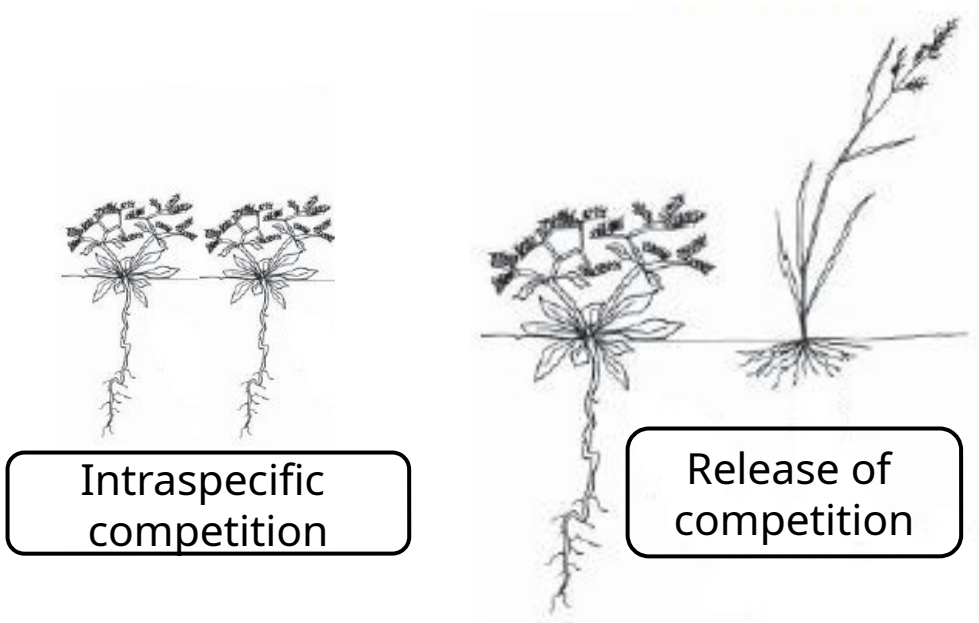
The roles of functional diversity in ecosystem functioning

Species diversity can buffer environmental changes



Yachi and Loreau, PNAS (1999)

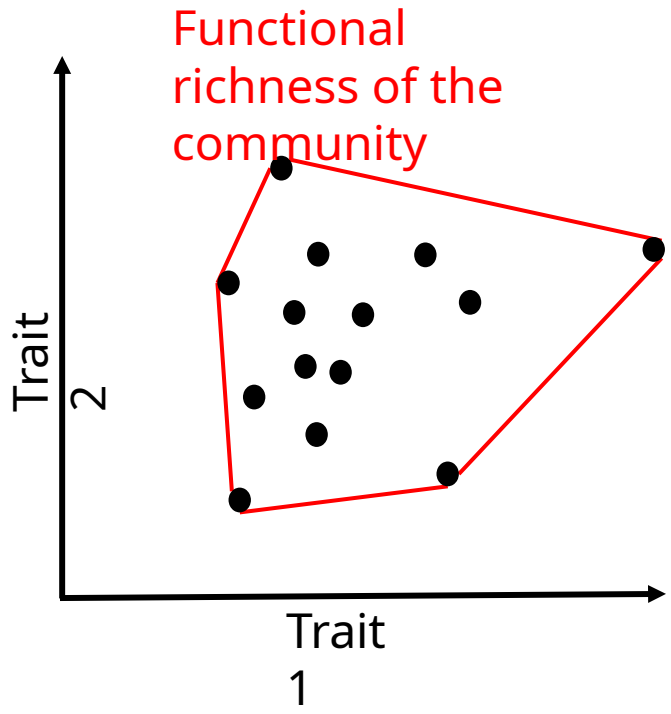
Niche differences can reduce competition



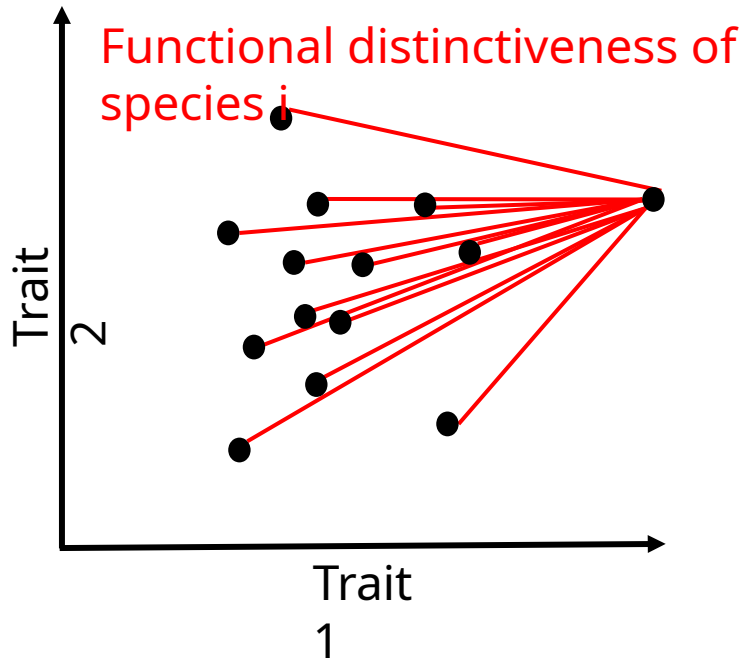
Levine and HilleRisLambers, Nature (2009)

From community to particular species

Focusing on the community



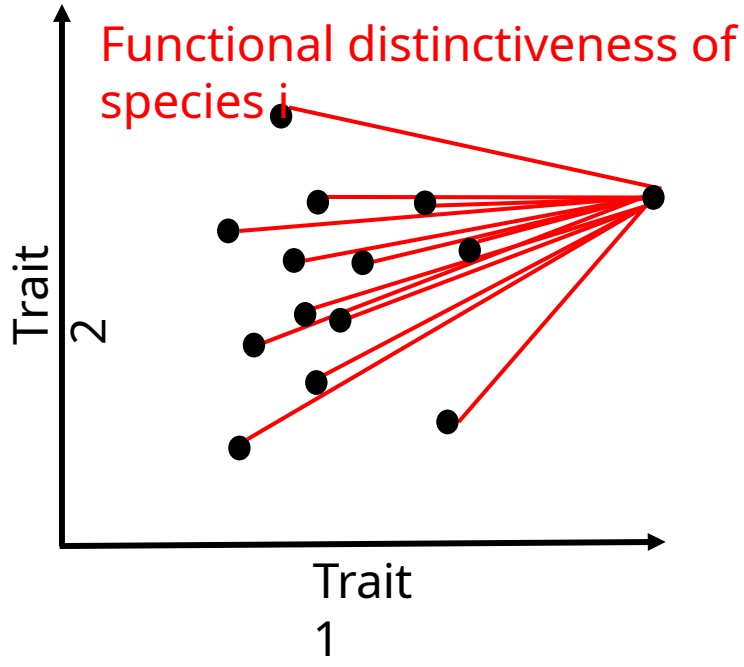
Focusing on particular species



Grenié et al., Diversity and Distributions (2017)

From community to particular species

Do functionally distinct species influence ecosystem functioning ?

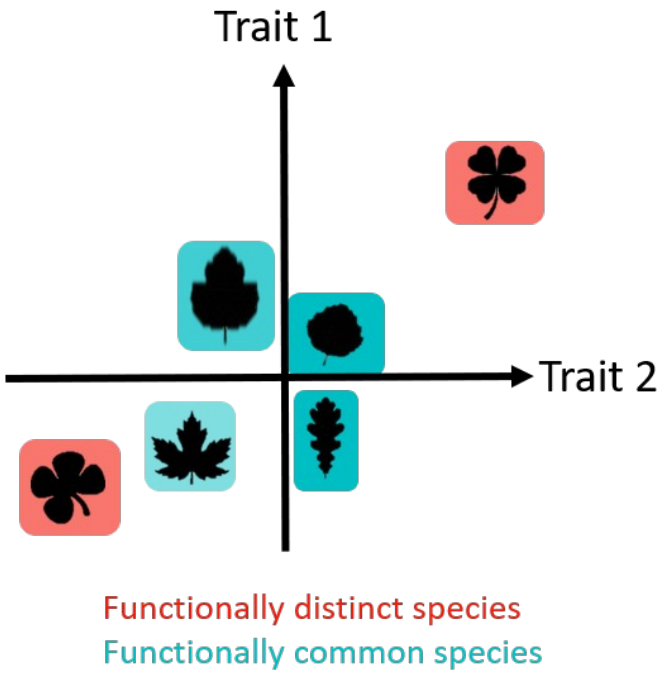


Functional distinctiveness and ecosystem functioning

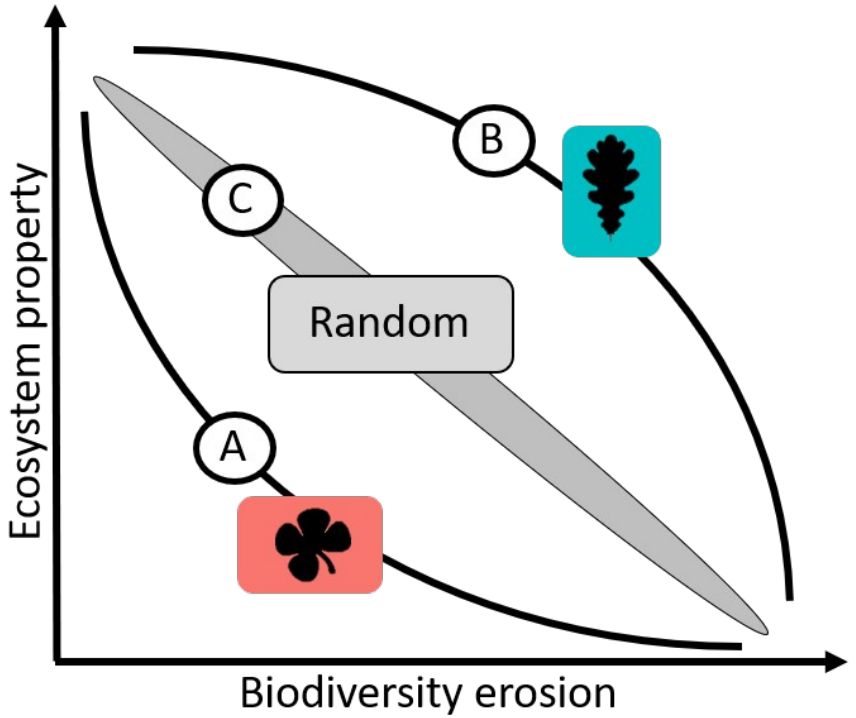
Delalandre, L., Gaüzère, P., Thuiller, W., Cadotte, M., Mouquet, N., Mouillot, D., Munoz, F., Denelle, P., Loiseau, N., Morin, X., & Violle, C. (2022). Functionally distinct tree species support long-term productivity in extreme environments. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1967), 20211694. https://doi.org/10.1098/rspb.2021.1694

Functional distinctiveness and ecosystem functioning: hypotheses

A. Functional distinctiveness



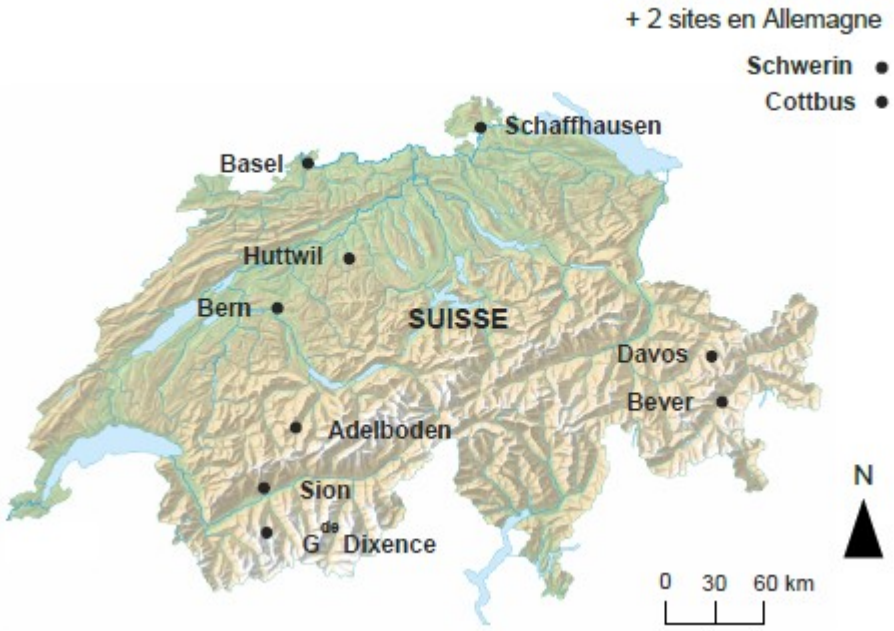
B. Predictions for ecosystem functioning



Ecological context

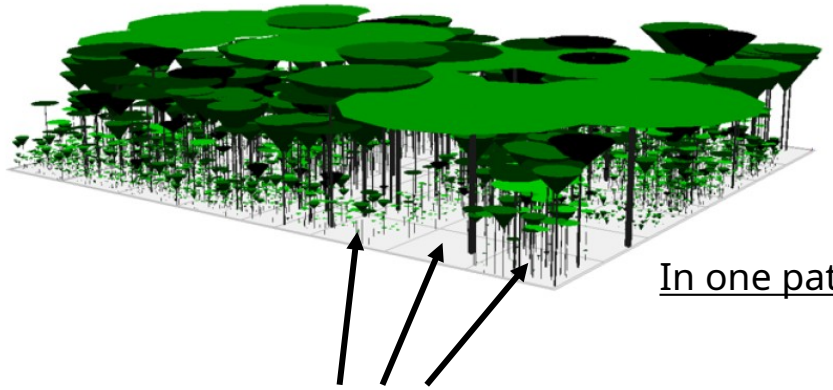
30 main tree species in Europe

11 sites on a gradient



The ForCEEPS model

Forest Community Ecology and Ecosystem ProcesseS



Independent patches

Homogeneous environment:
Temperature
Drought stress
Nitrogen availability

2-D competition for **light** within a patch

In one patch:

Species pool

Main tree species in Europe

1) Establishment

2) Growth

3) Mortality

Year 1

Species pool

Main tree species in Europe

1) Establishment (plus previous individuals)

2) Growth

3) Mortality

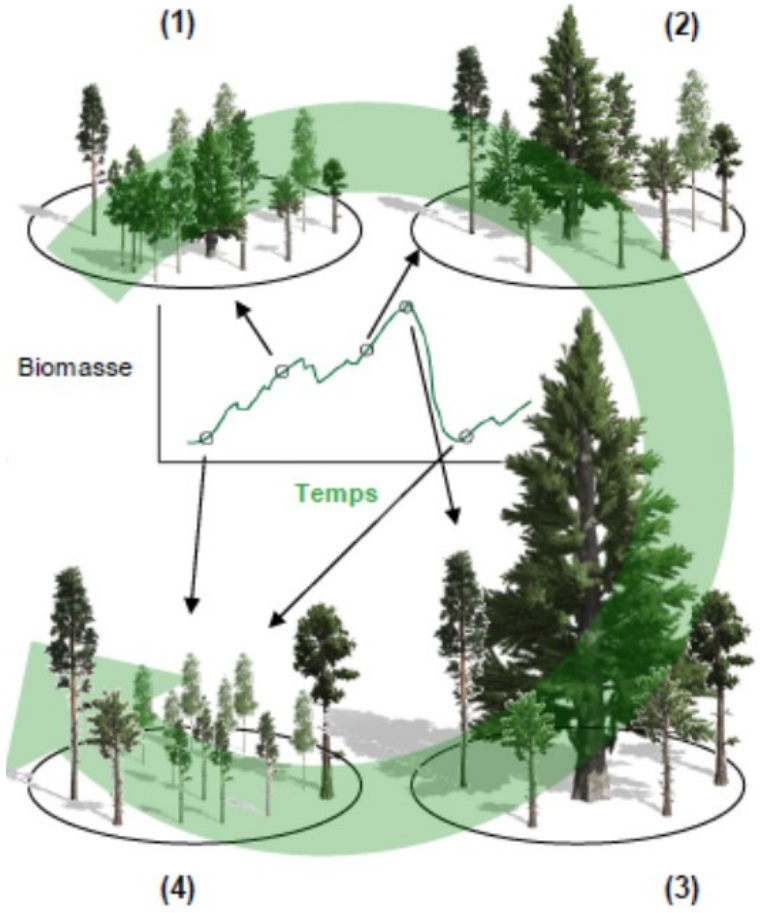
Year 2

Succession
Output at time t:
richness, composition, biomass, productivity

Original figures from Xavier Morin et Mickaël Chauvet

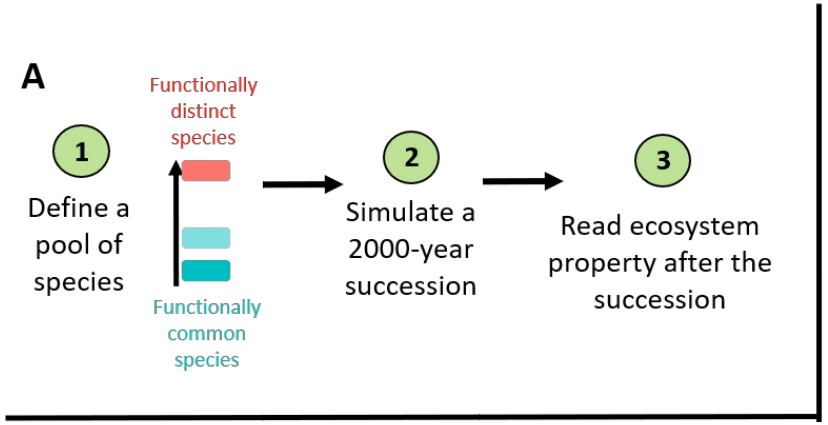
The ForCEEPS model

Forest Community Ecology and Ecosystem ProcesseS

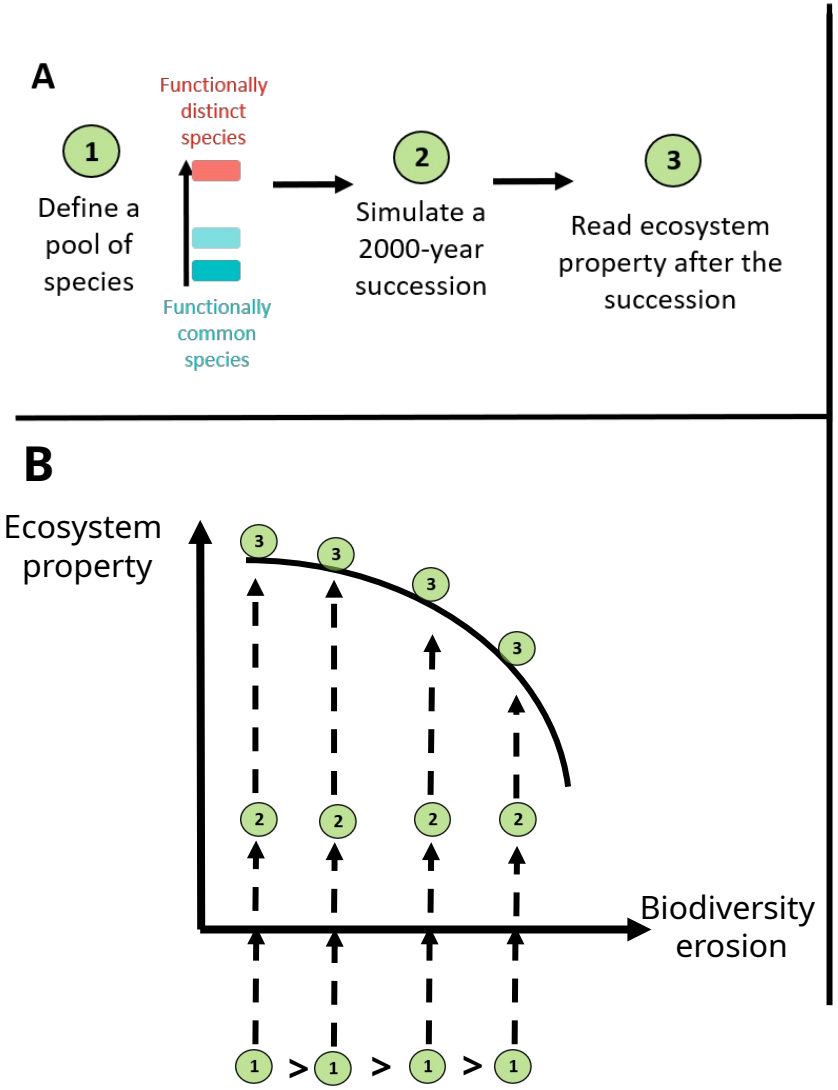


Original figures from Xavier Morin et Mickaël Chauvet

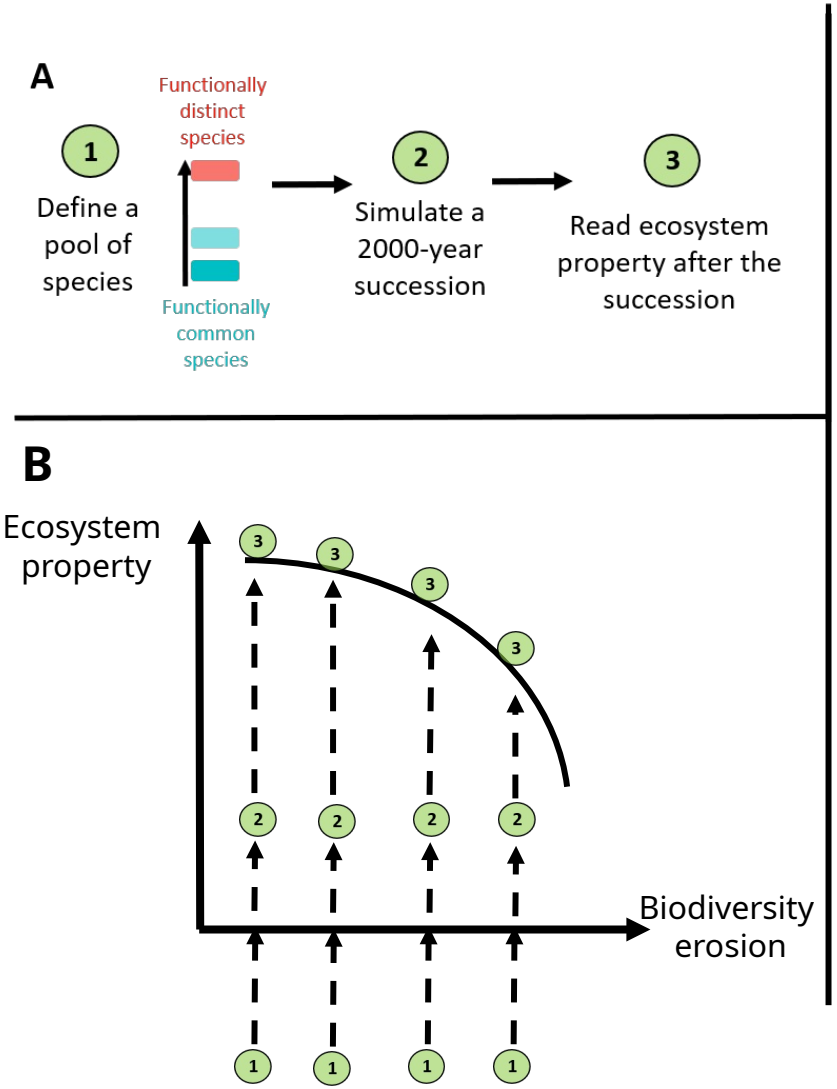
Simulate forest successions with varying pools of species



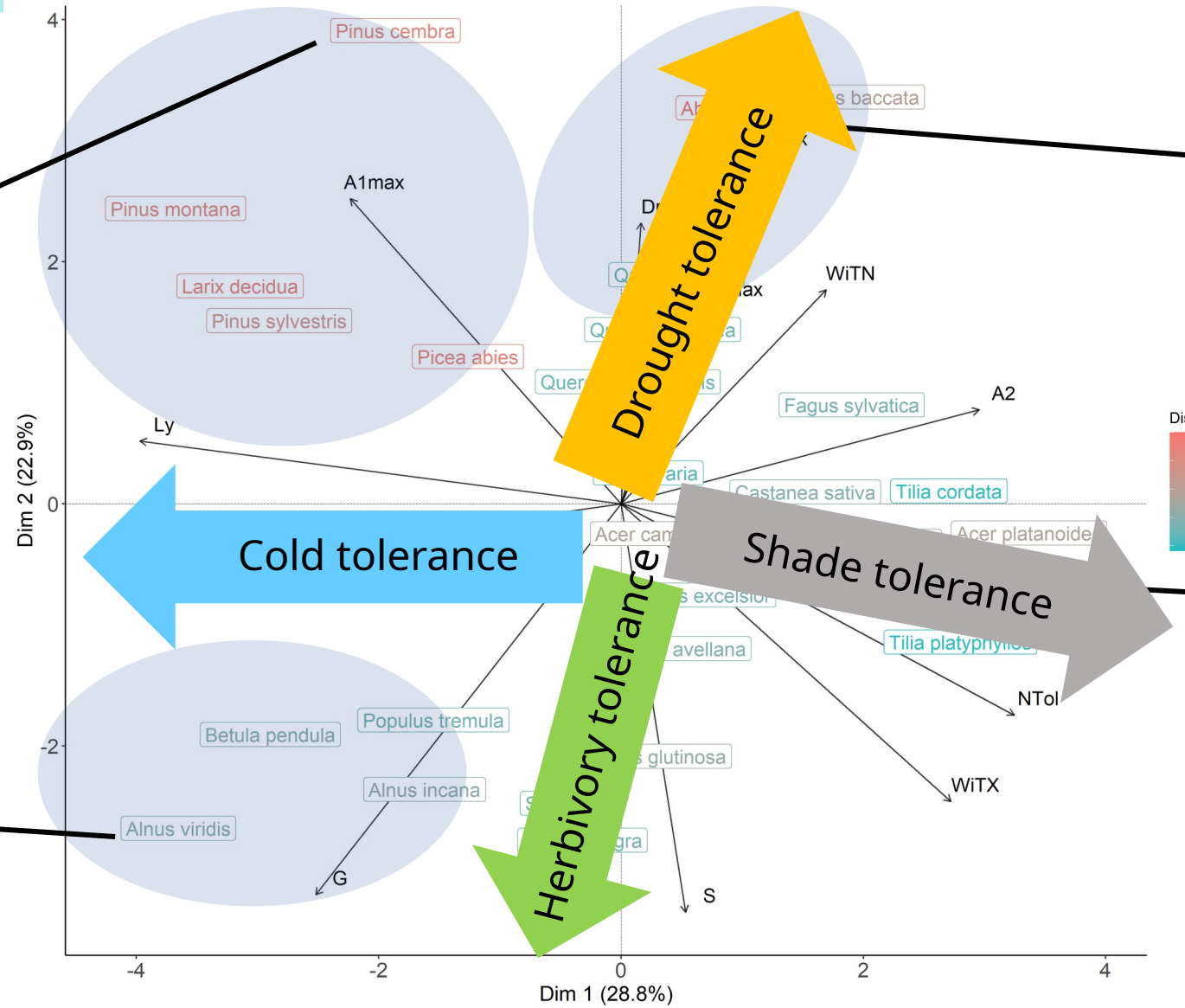
Simulate forest successions with varying pools of species



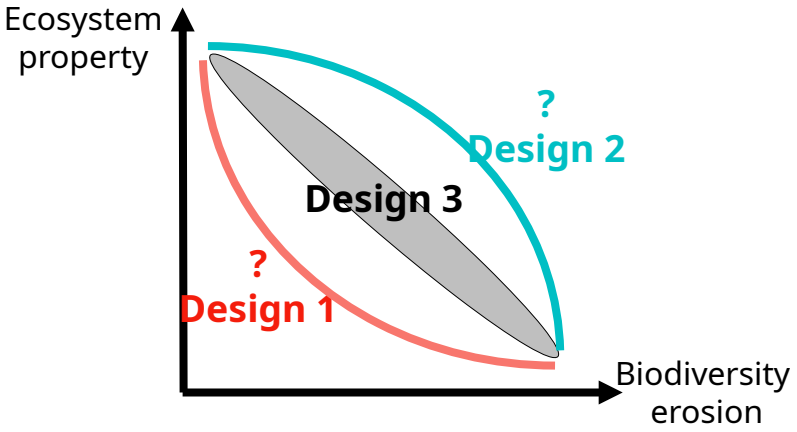
Simulate forest successions with varying pools of species

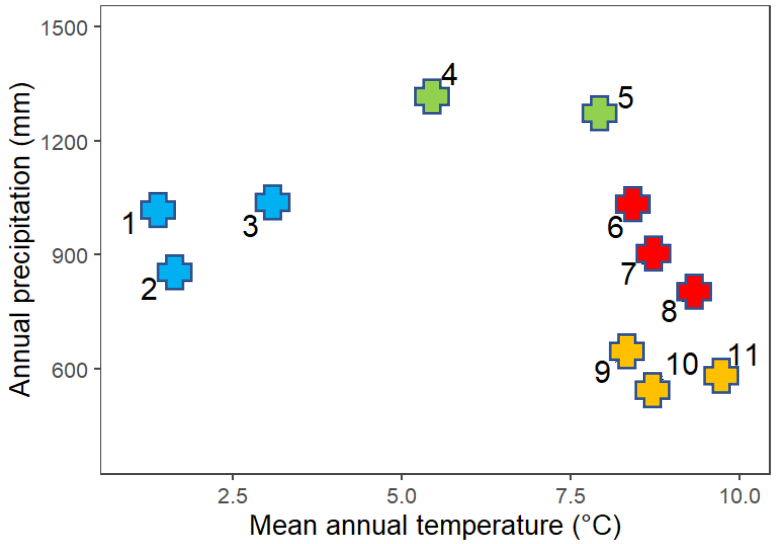


Functional distinctiveness of tree species of central Europe



Effect of functionally distinct species in different environmental conditions



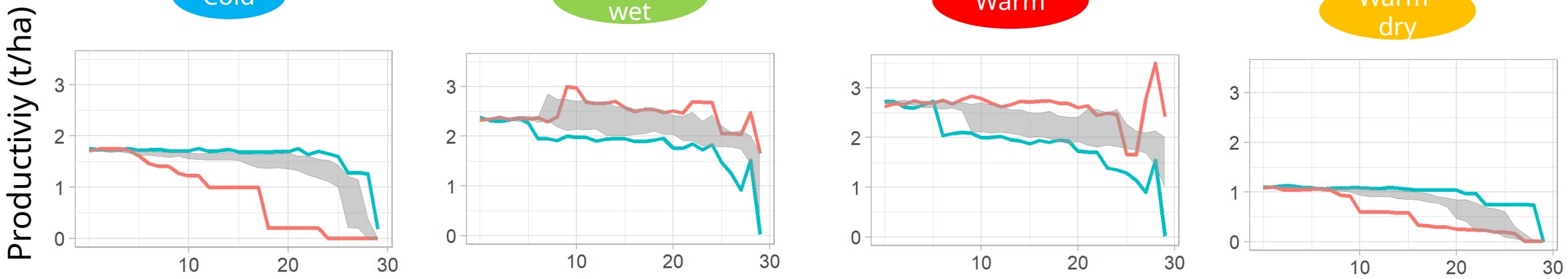


Cold

Warm-wet

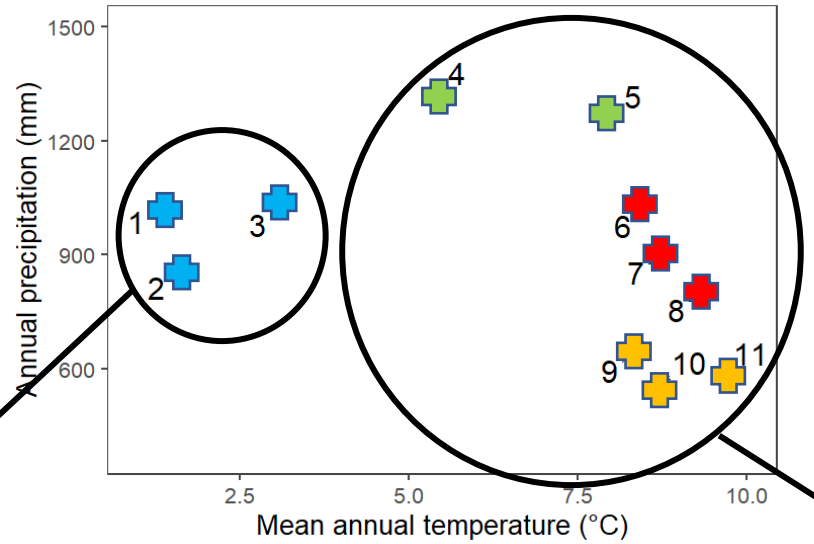
Warm

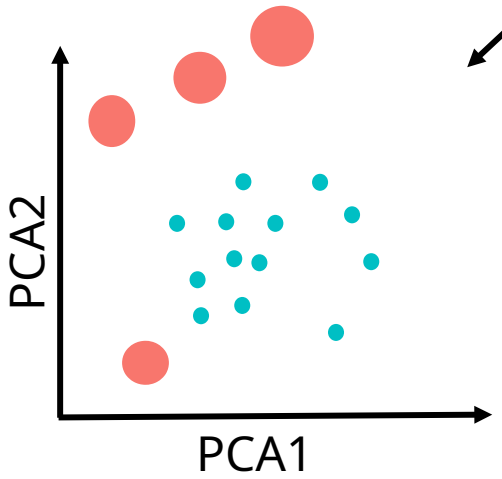
Warm-dry

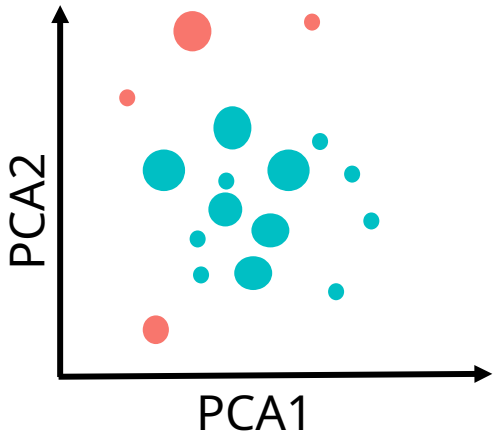


Abundance and distictiveness

Species abundance







Partitioning biodiversity effects

Monocultures

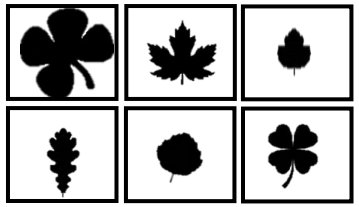
Mixtures

H0:
No biodiversity effect

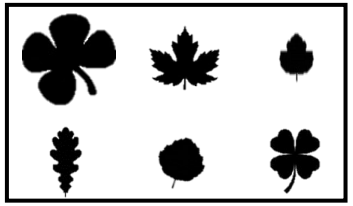
H1:
Biodiversity effect

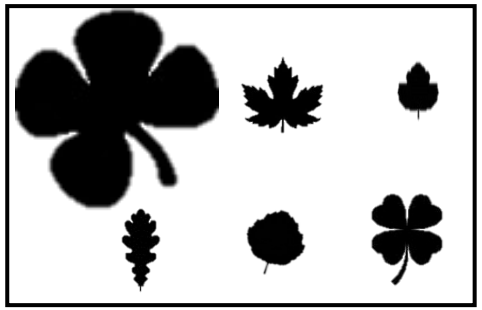
Selection

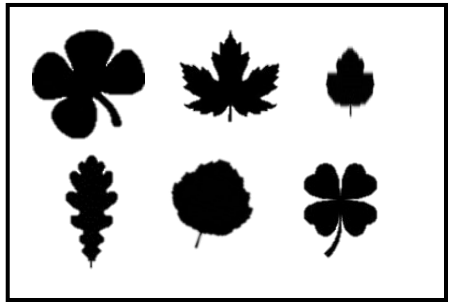
Complementarity



NB: species who passed the abiotic filter







Loreau and Hector, Nature (2001)

Identify key species

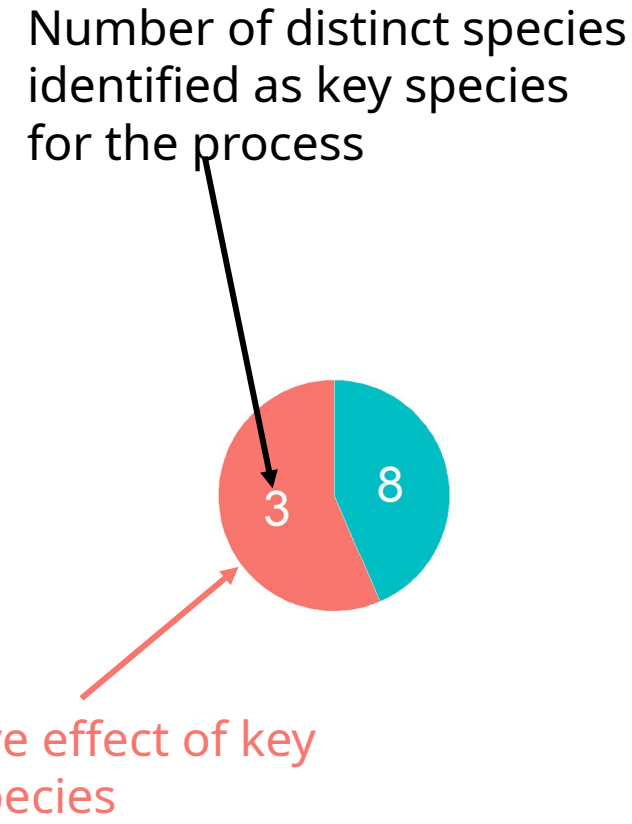
Community-Wide Scans (similar to Genome-Wide Scans):

M0: Ecosytem Process ~ Species Richness

$M1_i$: Ecosystem Process ~ Species Richness + Sp_i

Compare the two models: $\Delta AIC = AIC(M0) - AIC(M1_i)$

Species i is considered **key species** if **$\Delta AIC > 4$**



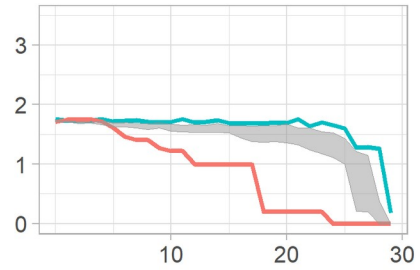
Maire et al., Proc B (2018)

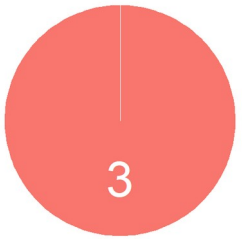
Key species for biodiversity effects

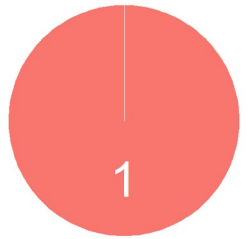
Selection

Complementarity

Cold

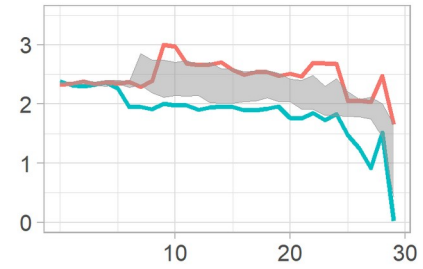


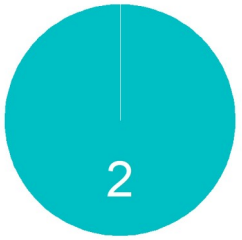


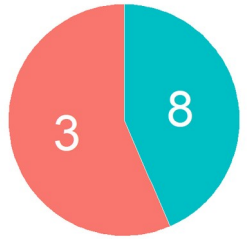


Warm-wet

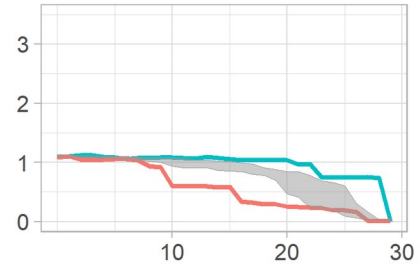
Warm

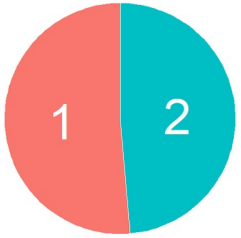


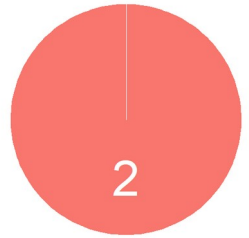




Warm-dry







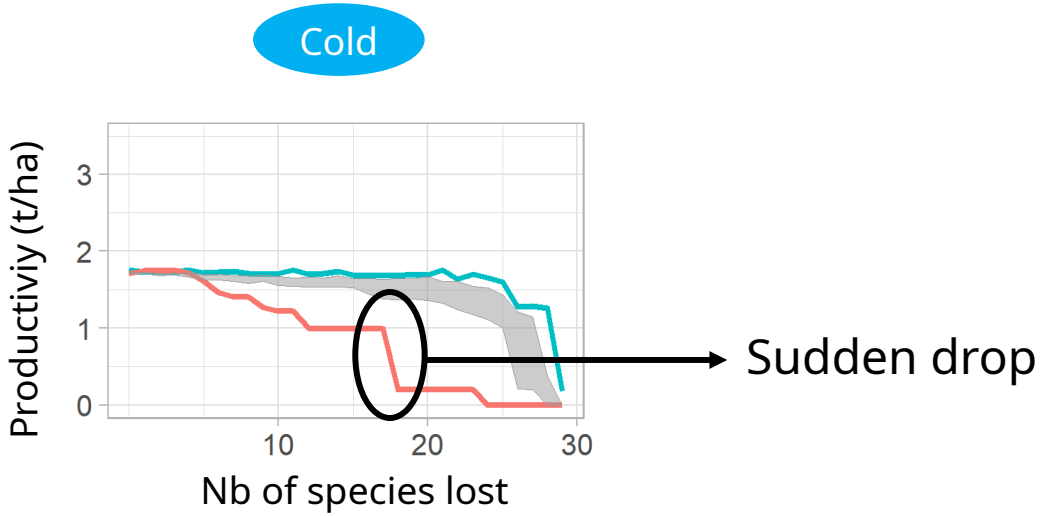
Conclusion and perspectives

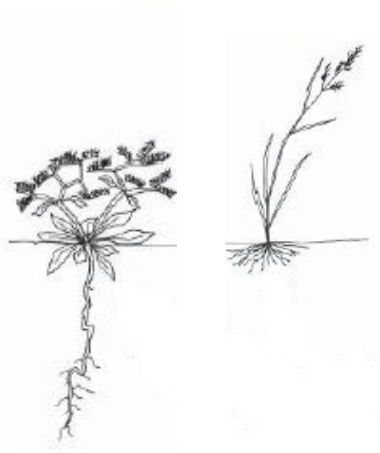
ENVIRONMENT

→ Distinct species had response traits enabling them to grow in the extremes of the environmental gradient

BIOTIC INTERACTIONS

→ Distinct species were key for complementarity effect in extreme sites





Functional redundancy of response traits matters!

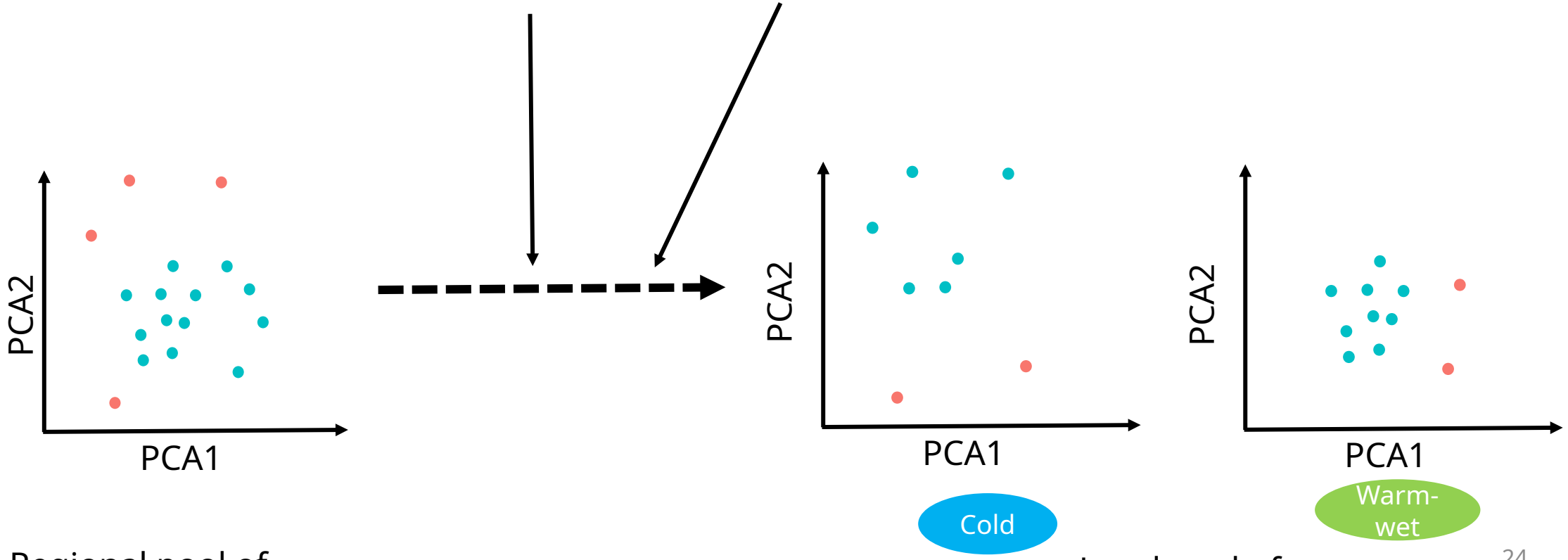
The issue of spatial scale

ENVIRONMENT

→ Distinct species had response traits enabling them to grow in the extremes of the environmental gradient

BIOTIC INTERACTIONS

→ Distinct species were key for complementarity effect in extreme sites



Regional pool of species

Local pool of species

The issue of spatial scale

ENVIRONMENT

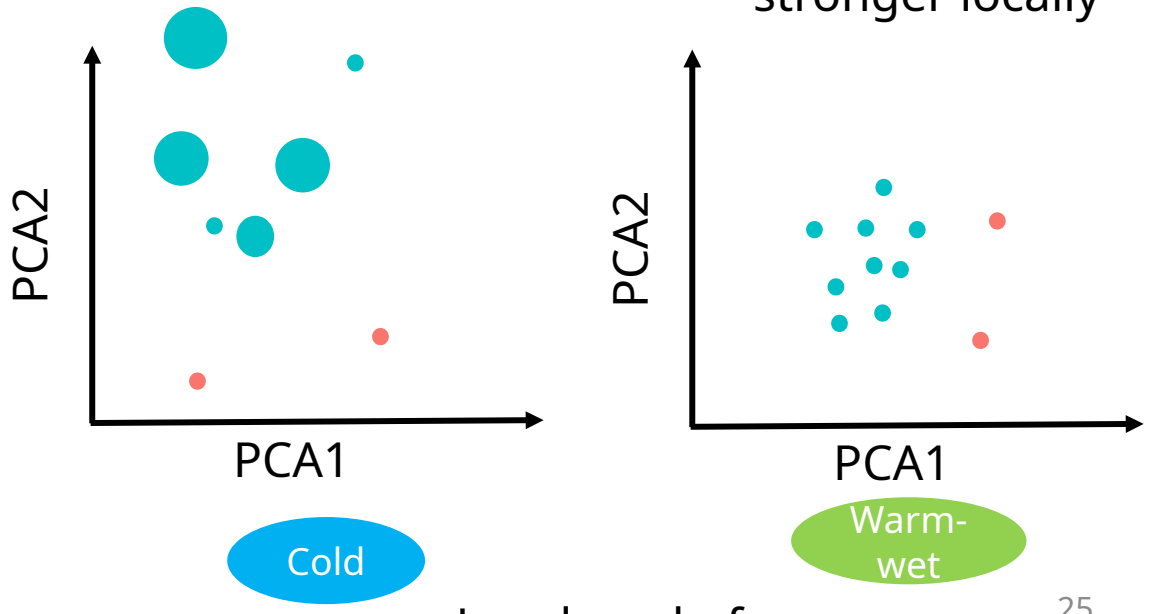
→ Distinct species had response traits enabling them to grow in the extremes of the environmental gradient

BIOTIC INTERACTIONS

→ Distinct species were key for complementarity effect in extreme sites

1) Abundant species may not be the most distinct locally

Complementarity effect of distinct species may be stronger locally

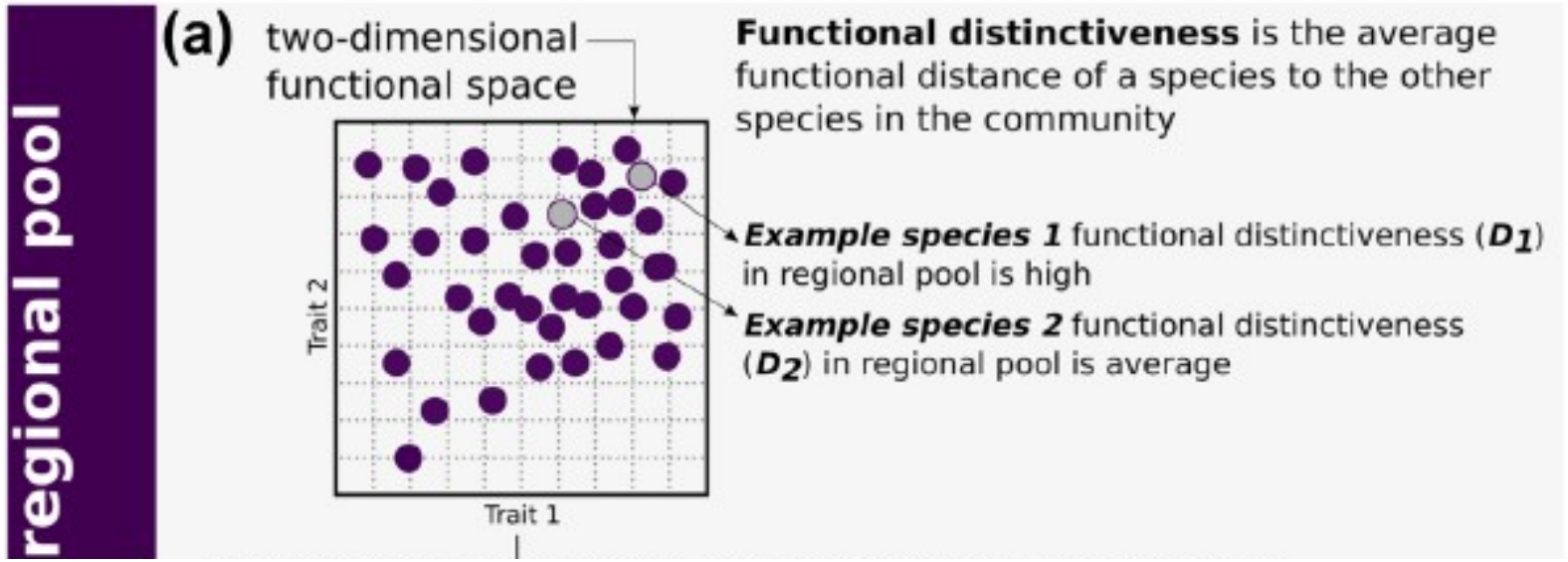


Local pool of

Scale dependence

Gaüzère, P., Blonder, B., Denelle, P., Fournier, B., Grenié, M., **Delalandre, L.,** Münkemüller, T., Munoz, F., Violle, C., & Thuiller, W. (2022). The functional trait distinctiveness of plant species is scale dependent. *Ecography*, *n/a*(n/a), e06504. https://doi.org/10.1111/ecog.06504

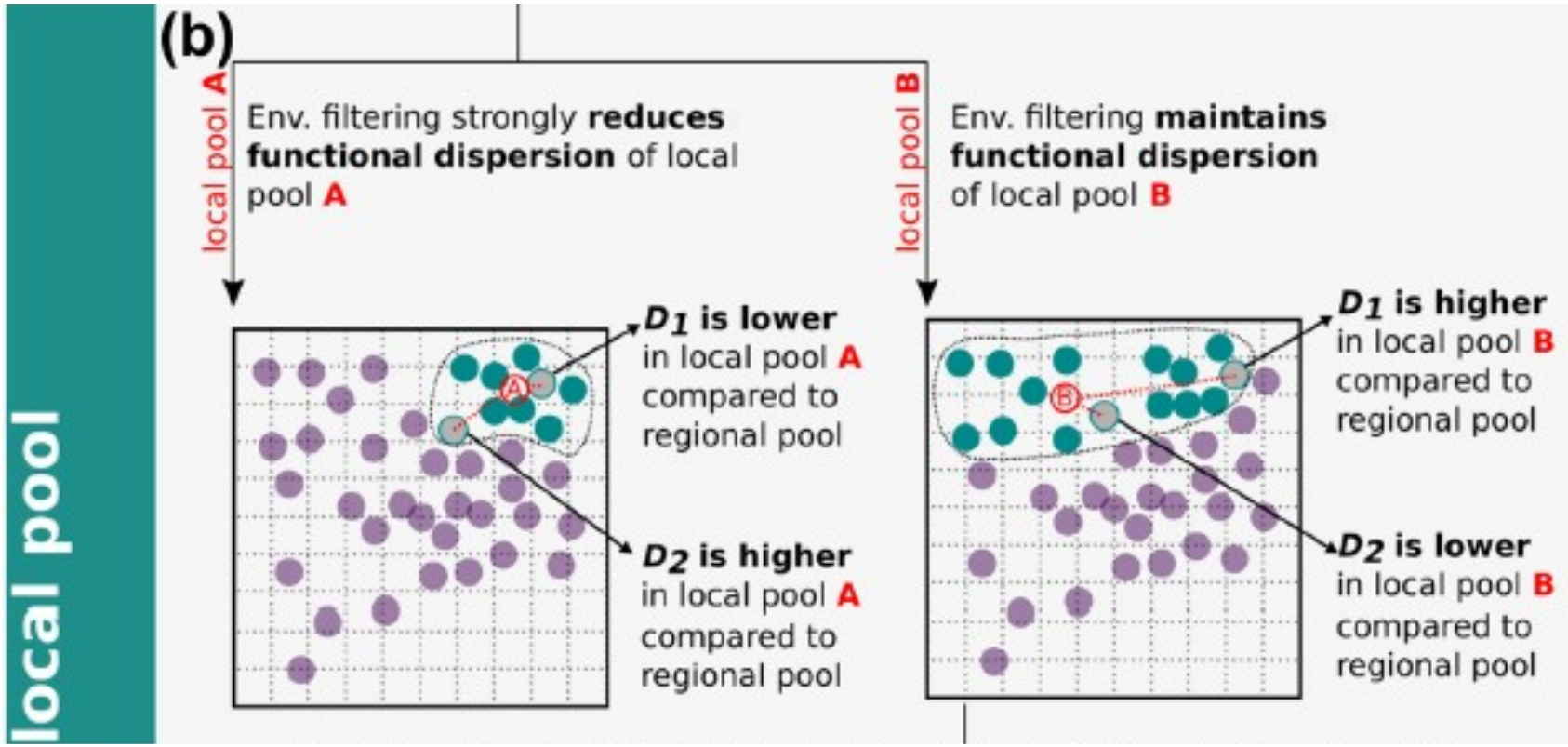
1) regional scale



Gaüzère et al., Ecography (2022)

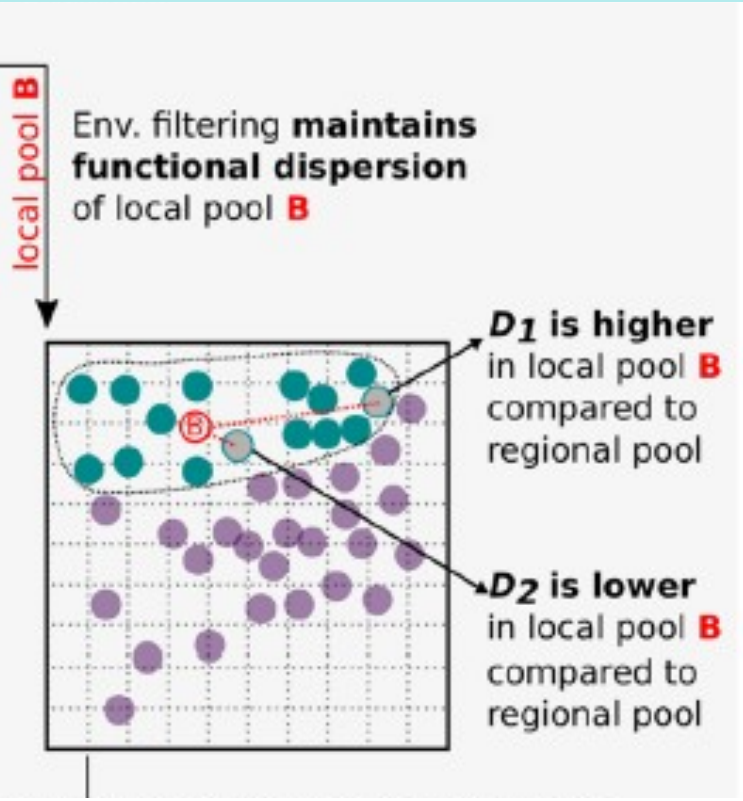
2) Local scale

Abiotic processes

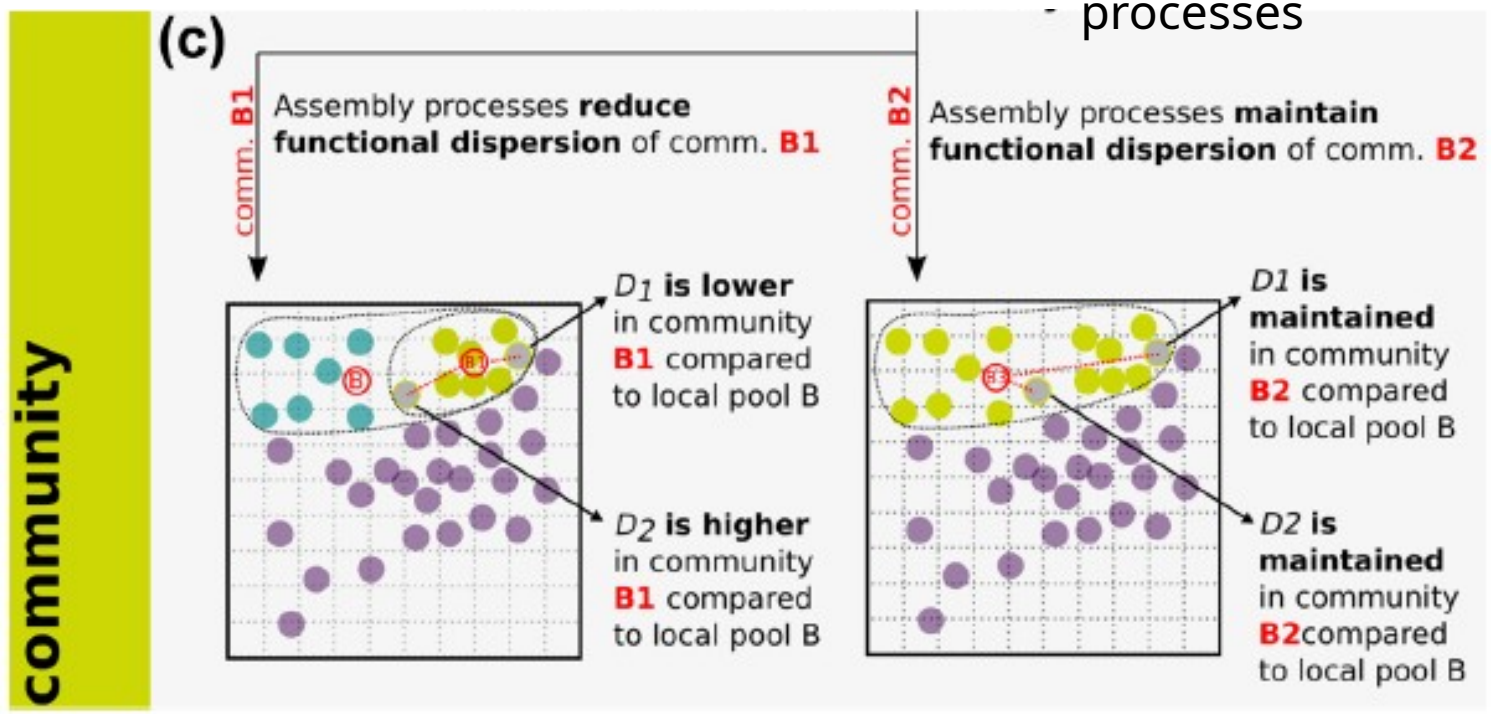


Gaüzère et al., Ecography (2022)

3) Community scale

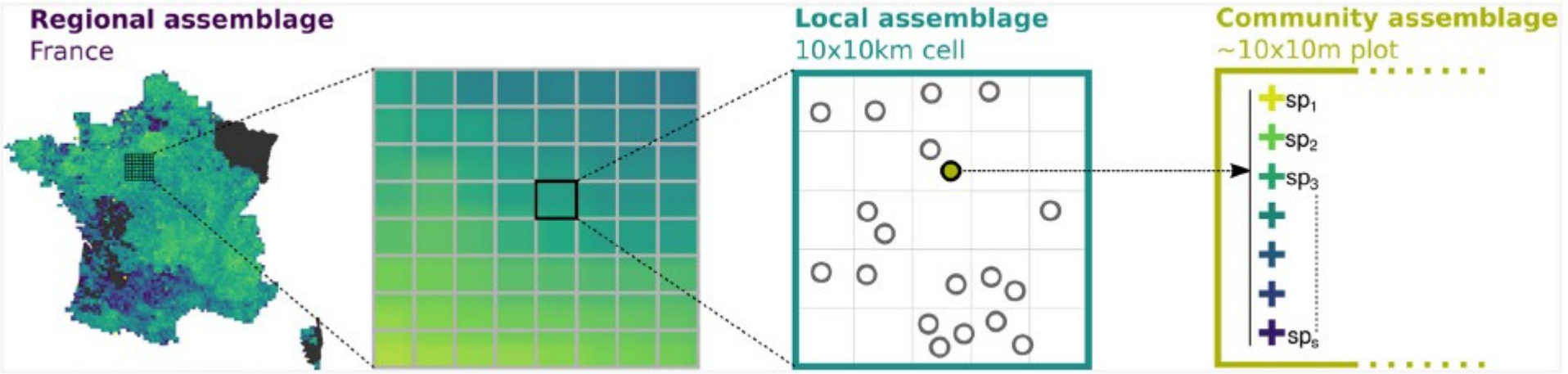


Abiotic processes and Biotic processes



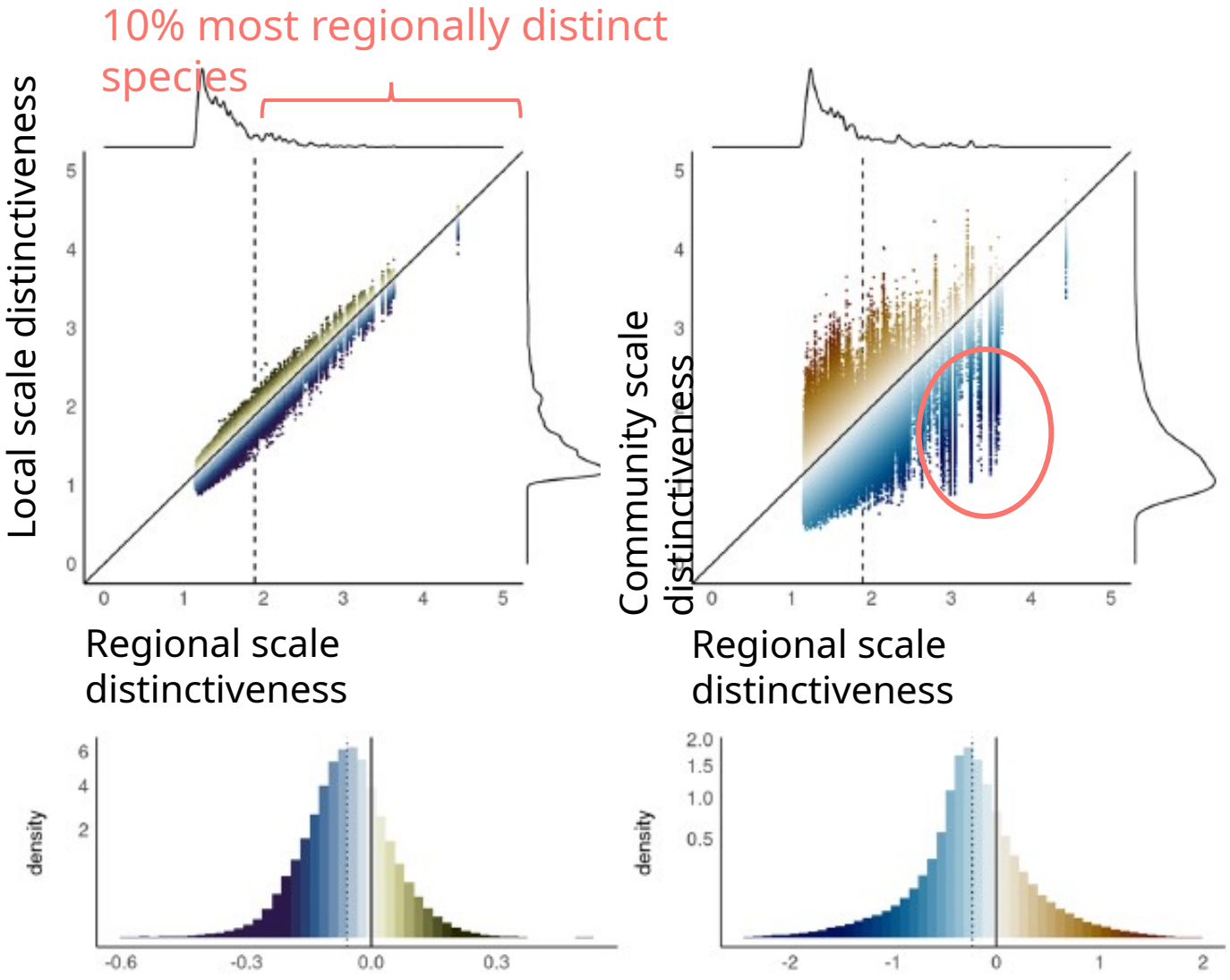
Gaüzère et al., Ecography (2022)

Grasslands in mainland France

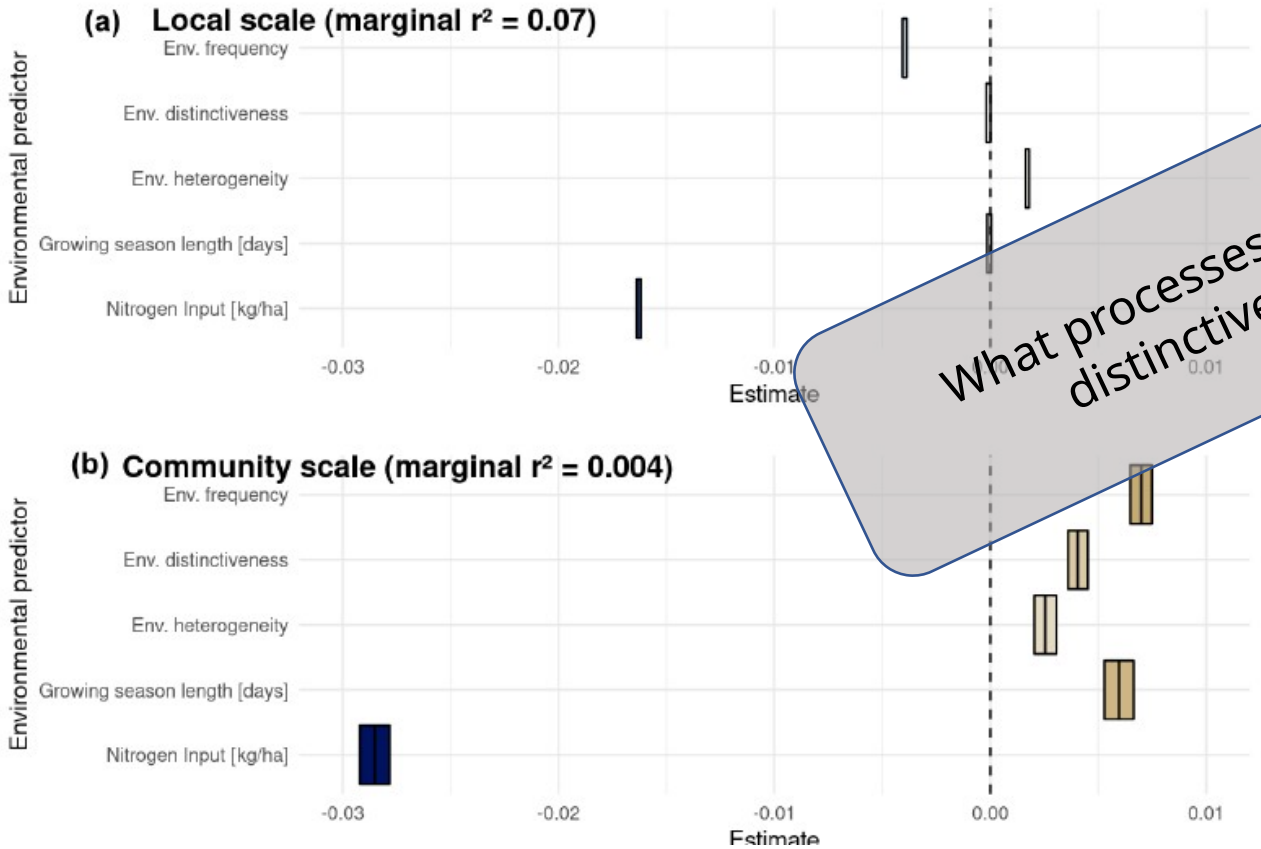


Siliflore DIVGRASS

Variation of distinctiveness between scales



Environmental effects



What processes generate distinctiveness?

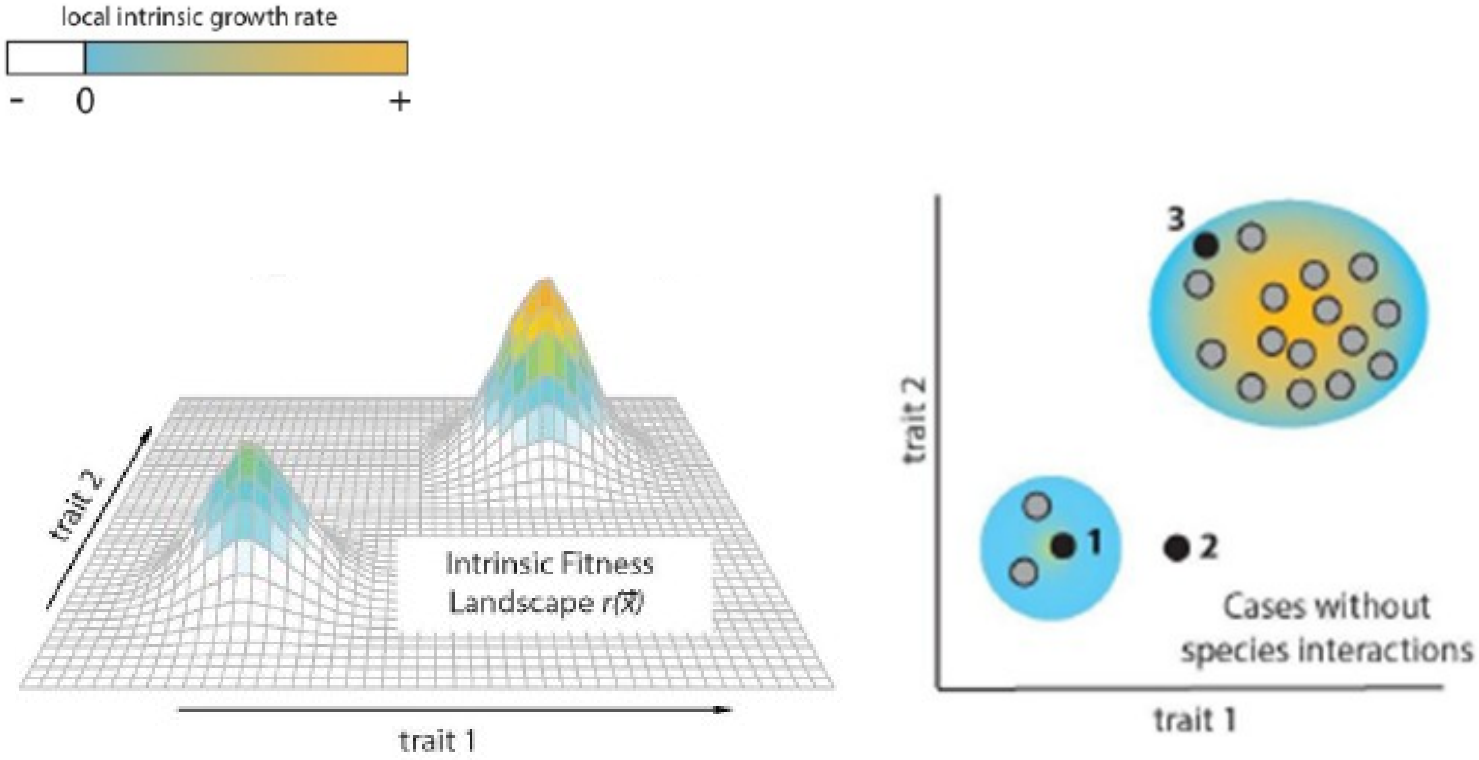
ENVIRONMENT

BIOTIC INTERACTIONS (competition, facilitation)

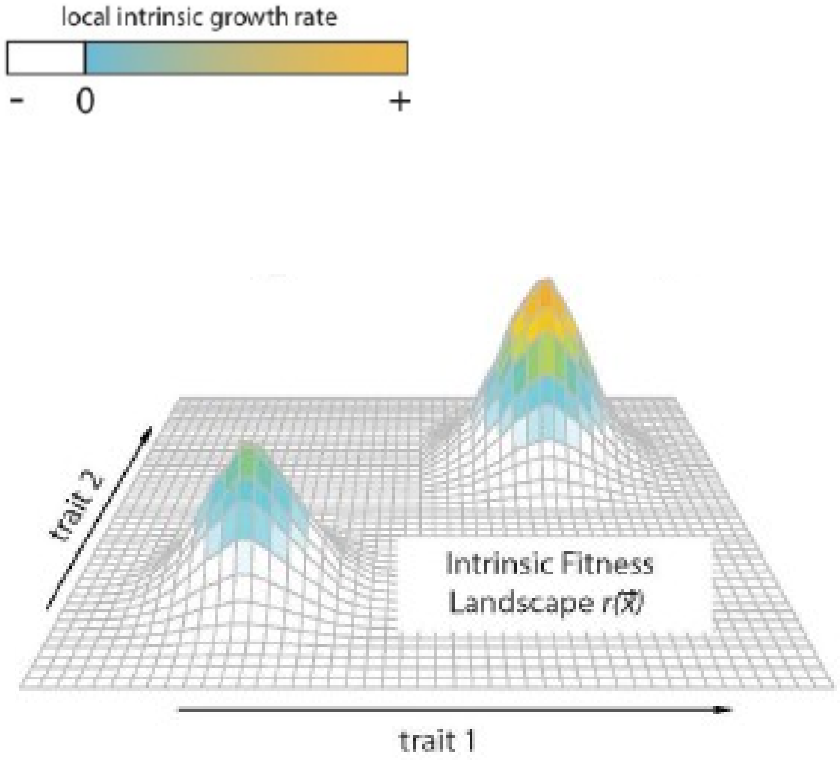
Causes of functional distinctiveness in communities

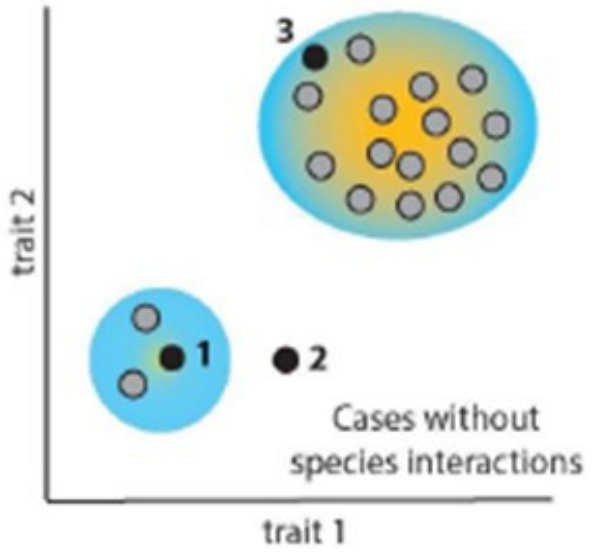
Munoz, F., Klausmeier, C., Gaüzère, P., Kandlikar, G., Litchman, E., Mouquet, N., Ostling, A., Thuiller, W., Algar, A., Auber, A., Cadotte, M., **Delalandre, L.,** Denelle, P., Enquist, B., Fortunel, C., Grenié, M., Loiseau, N., Mahaut, L., Maire, A., … Kraft, N. (2022). The ecological causes of functional distinctiveness in communities. *In revision for Ecology Letters*. https://doi.org/10.22541/au.166488862.28762630/v1

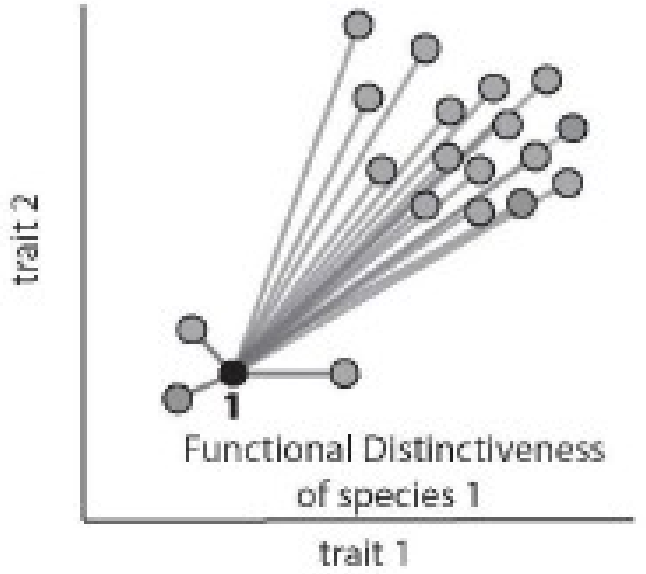
Heterogeneous fitness landscape



Case 1: Occupancy of a distinct peak in a heterogeneous fitness landscape

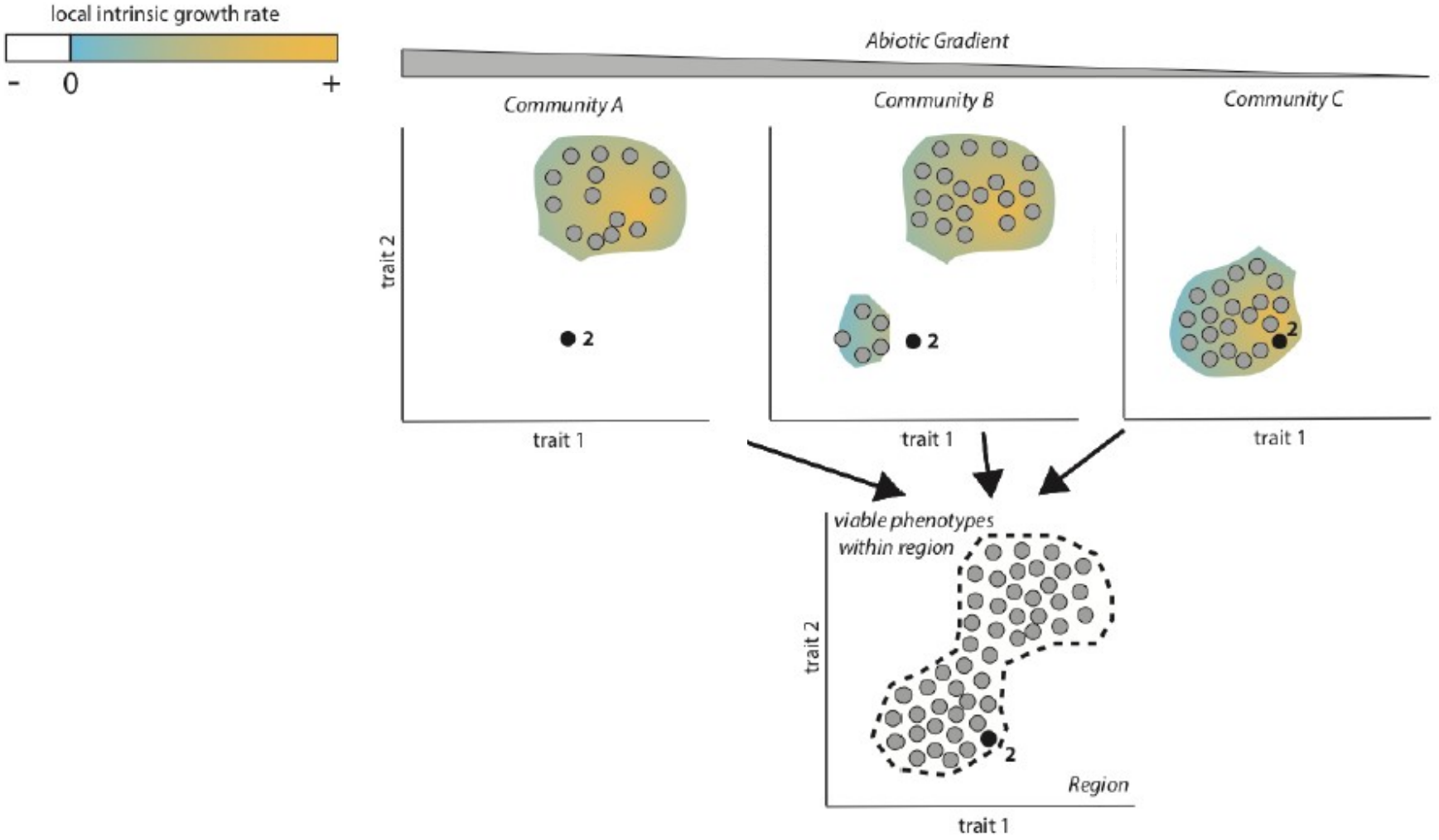




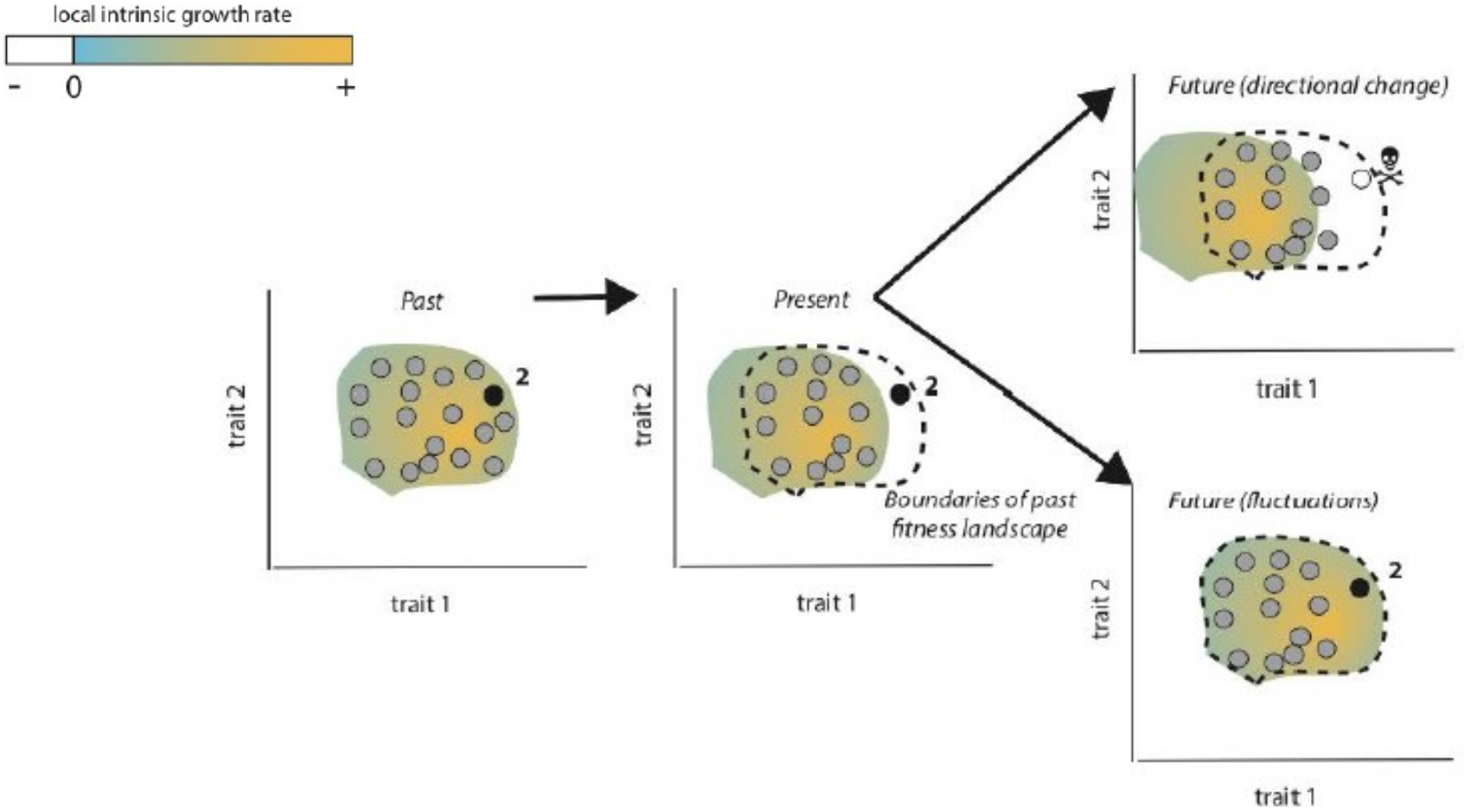


Case 1: Occupancy of a distinct peak in a heterogeneous fitness landscape

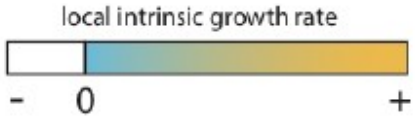
Case 2A: Spatial sink population

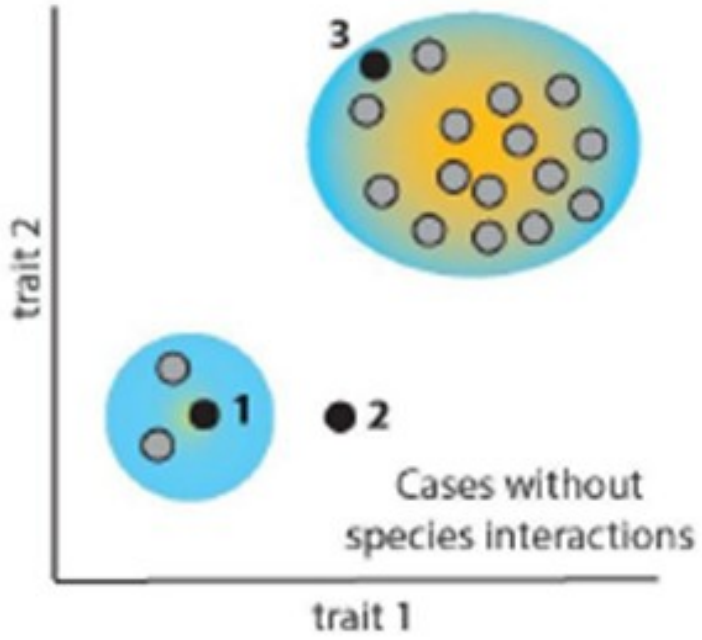


Case 2B: Temporal sink population

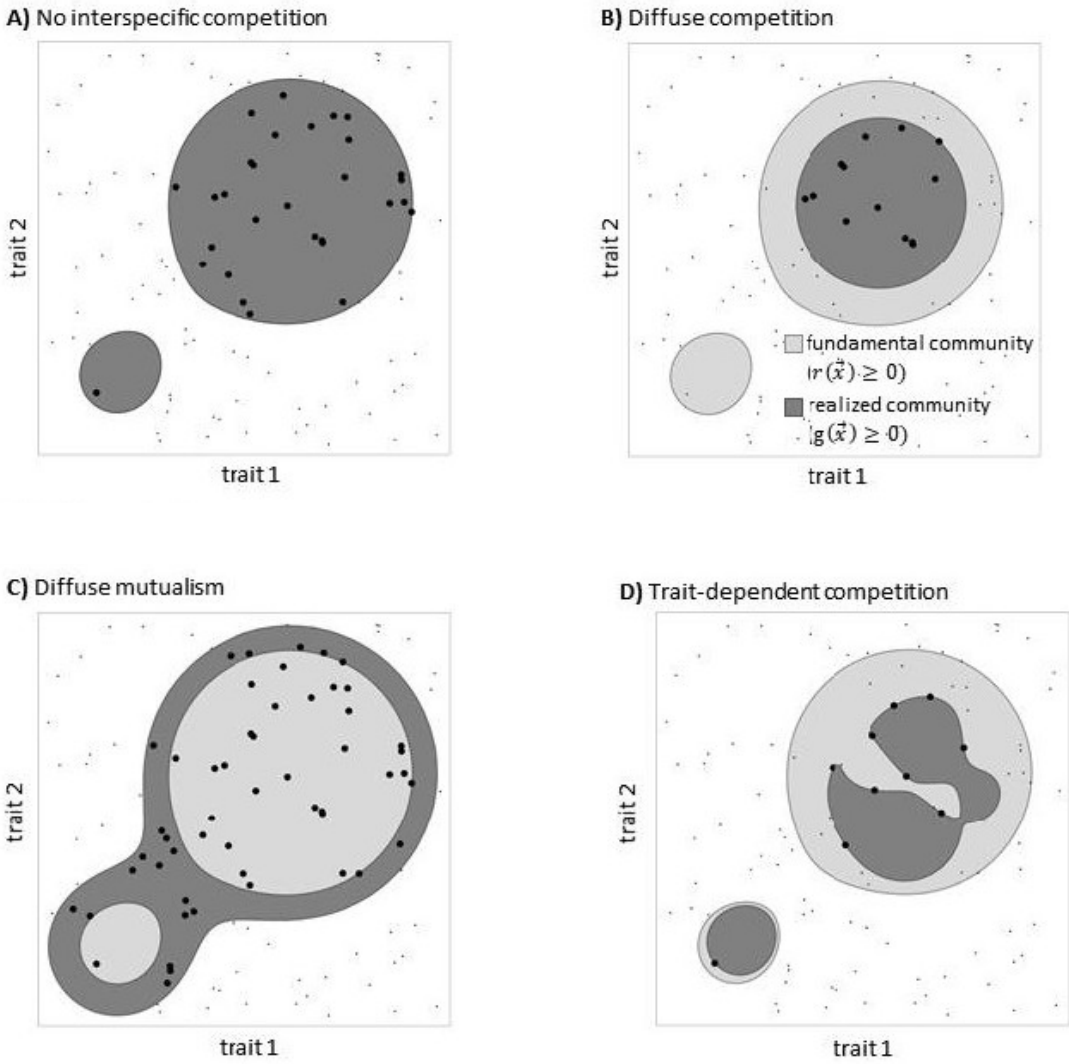


Case 3: Species at the margin of fitness surface



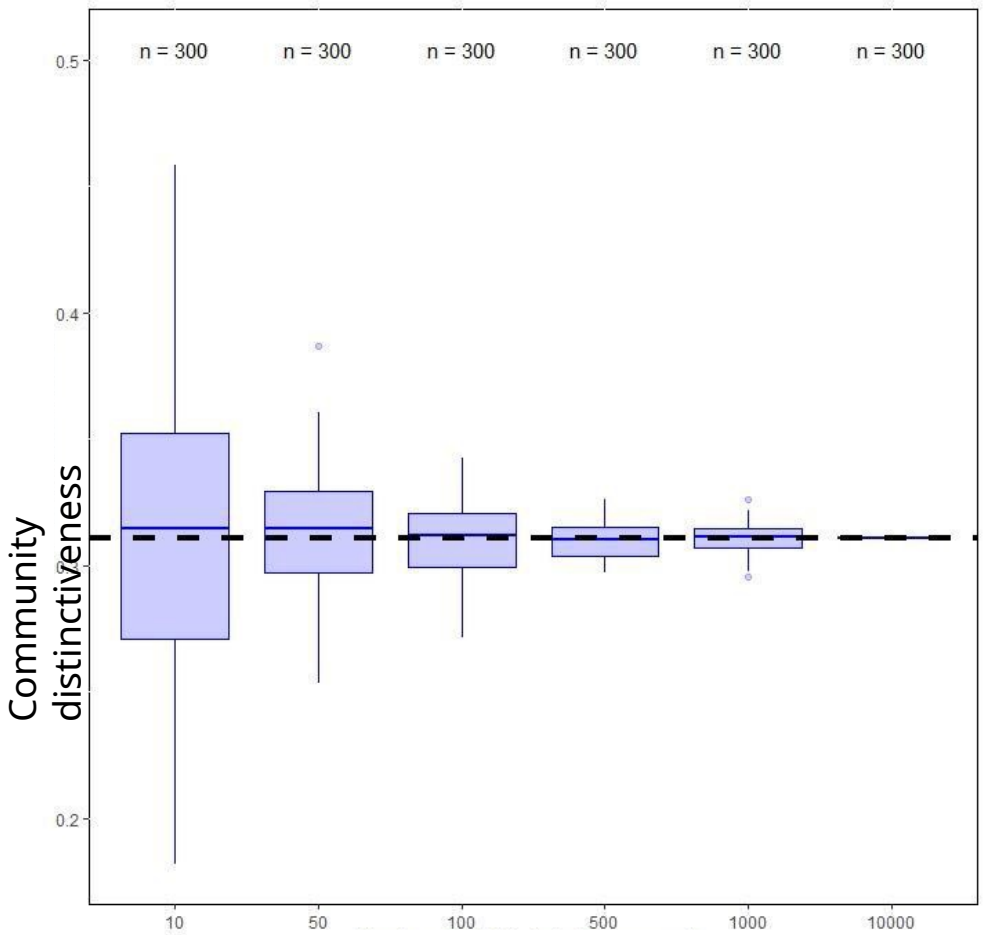


Case 4: Species interactions



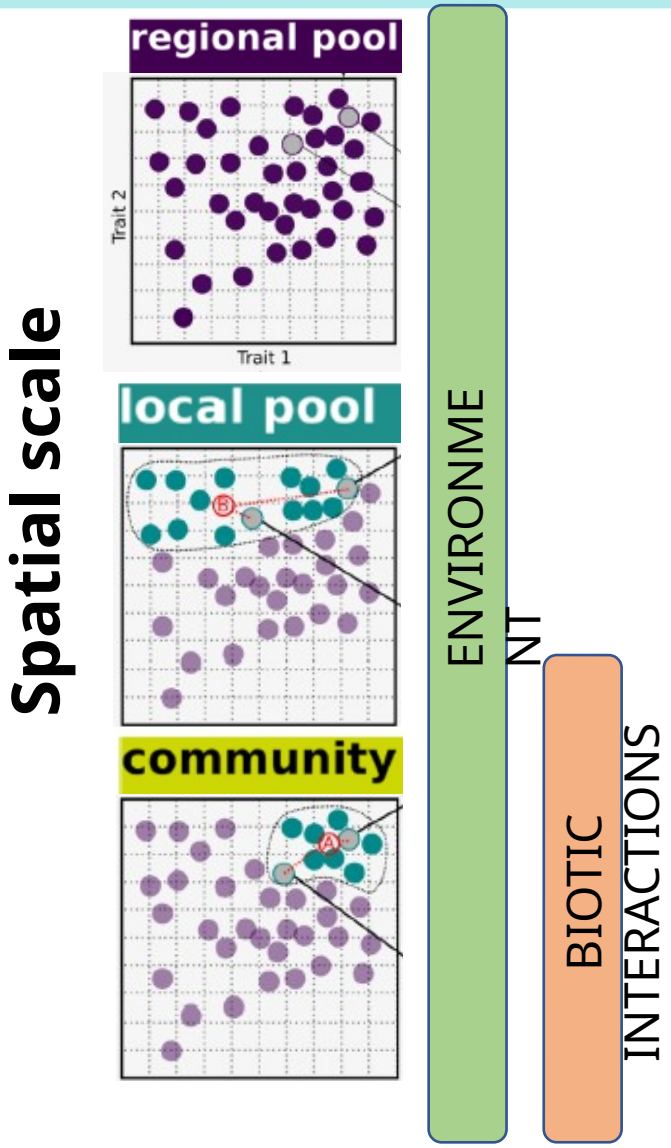
Limiting similarity

Case 5: Sampling



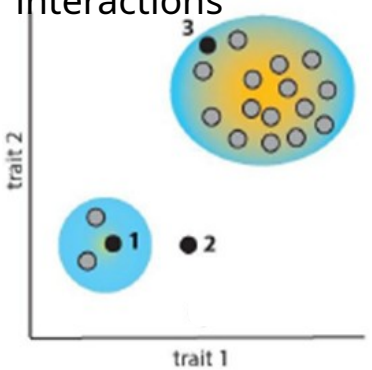
Conclusions

Conclusions

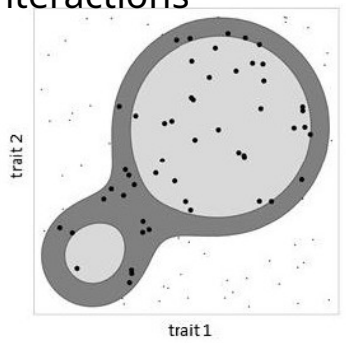


Determinants at local scales

Without species interactions

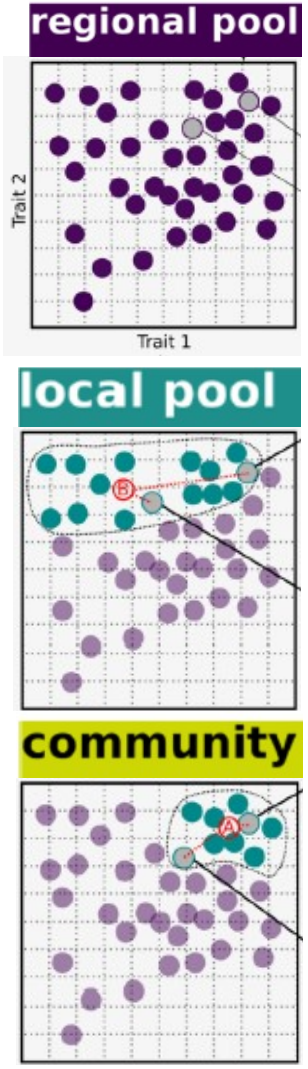


With species interactions



Conclusions

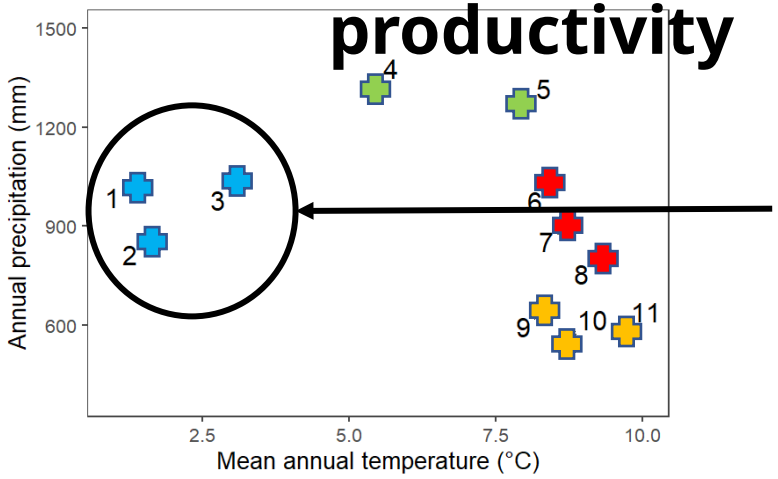
Spatial scale



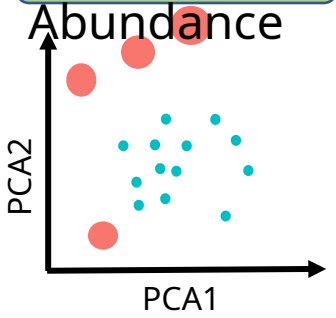
ENVIRONMENT

BIOTIC INTERACTIONS

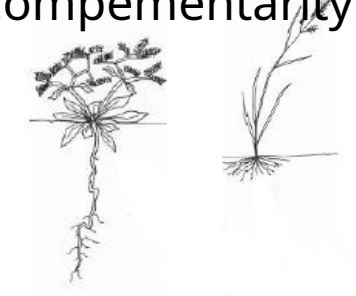
Effects on ecosystem productivity



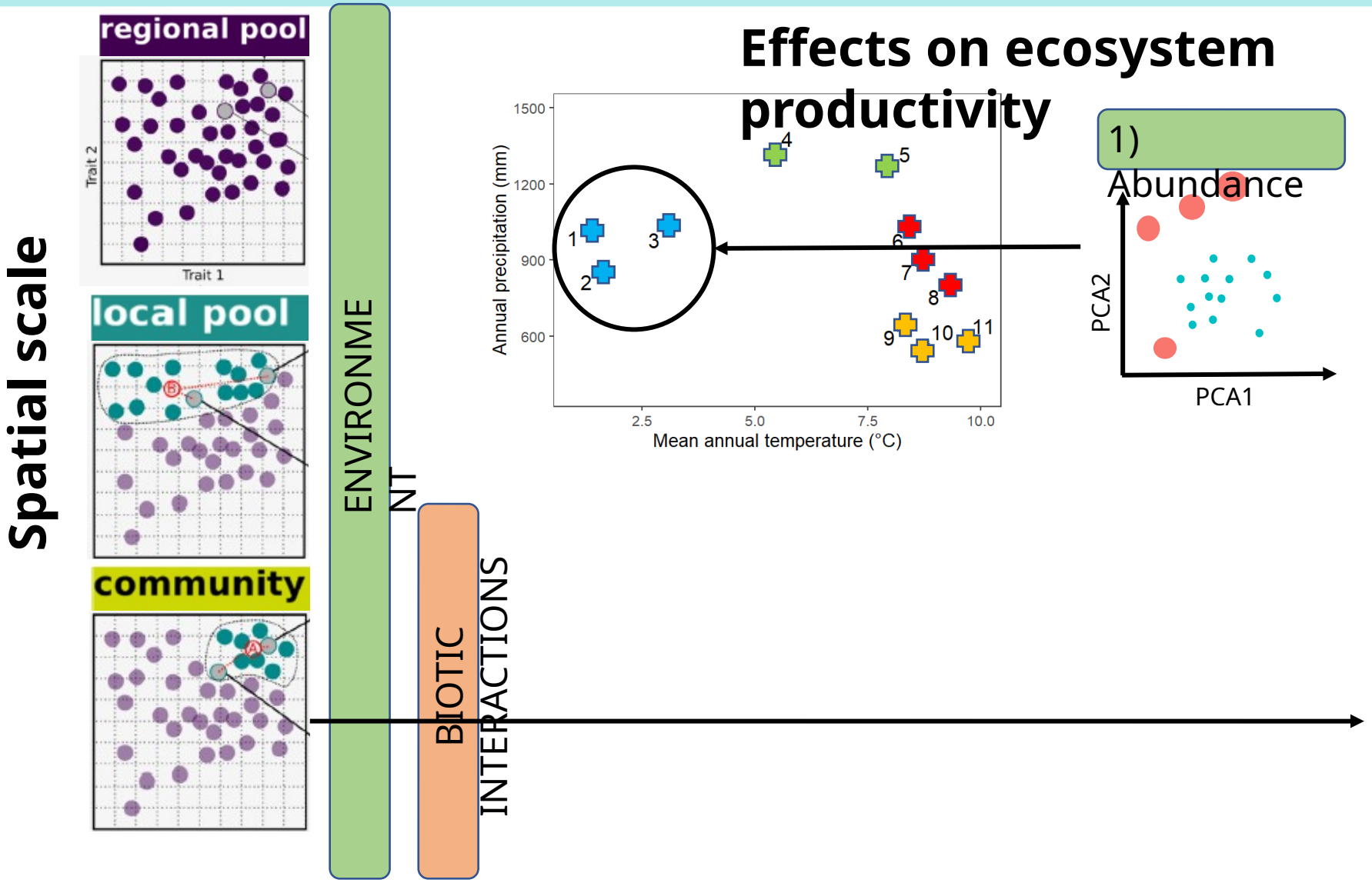
1) Abundance



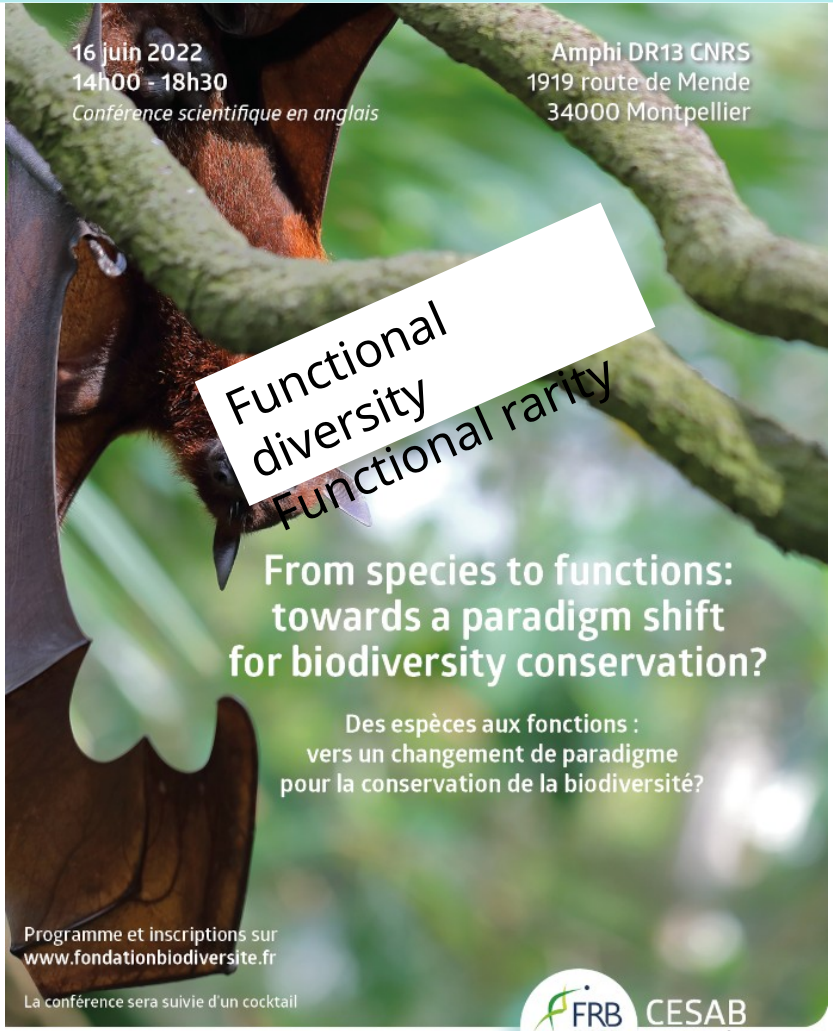
2) Compementarity?



Perspectives



Perspectives



Thank you for you attention

FREE working group (Functional Rarity in Ecology and Evolution), 2021, Montpellier