Dispersal polymorphism and species diversity patterns

F. Laroche

PDE summer school – CIRM, Marseille – July 4th, 2016

Diversity in fragmented habitats & associated processes

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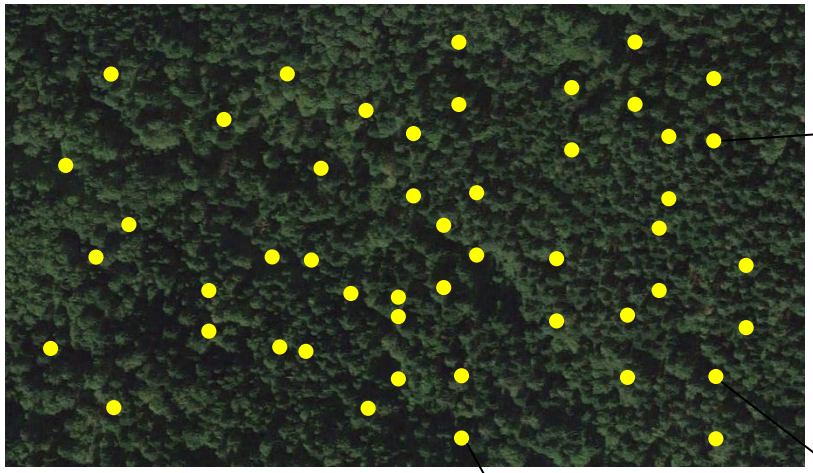
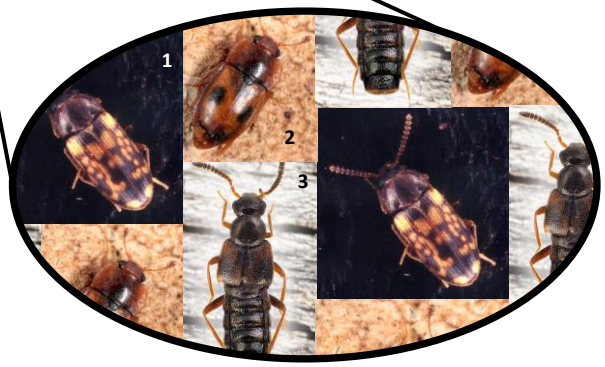
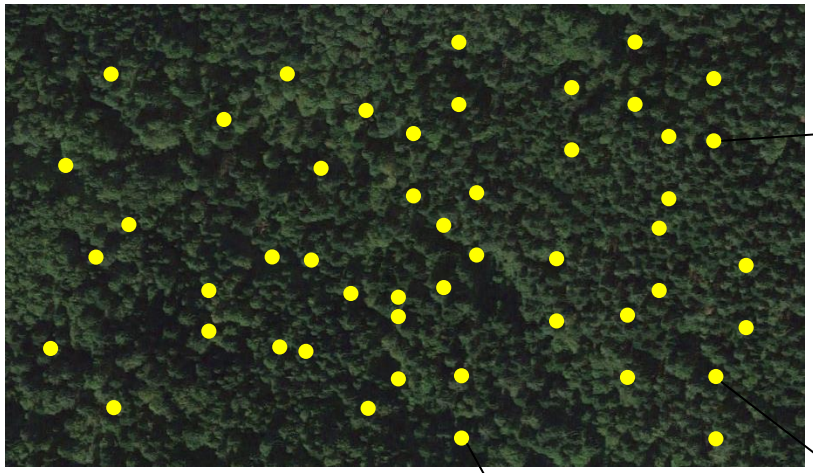




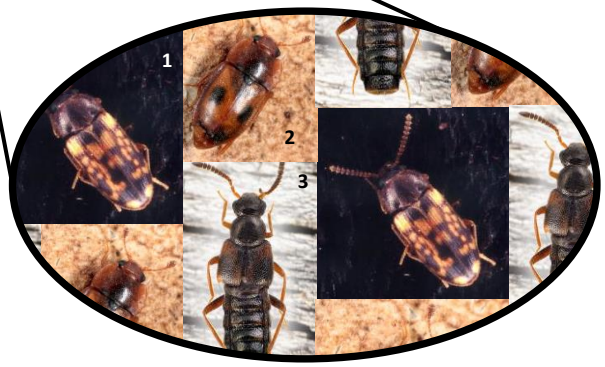
Pictures authorship: 1 - Lacon; 2 – M. Ehrhardt; 3 - F. Chevaillot , adapted from galerie-insecte.com. 4 – J.L. Fasciotto

Diversity in fragmented habitats & associated processes



β

α



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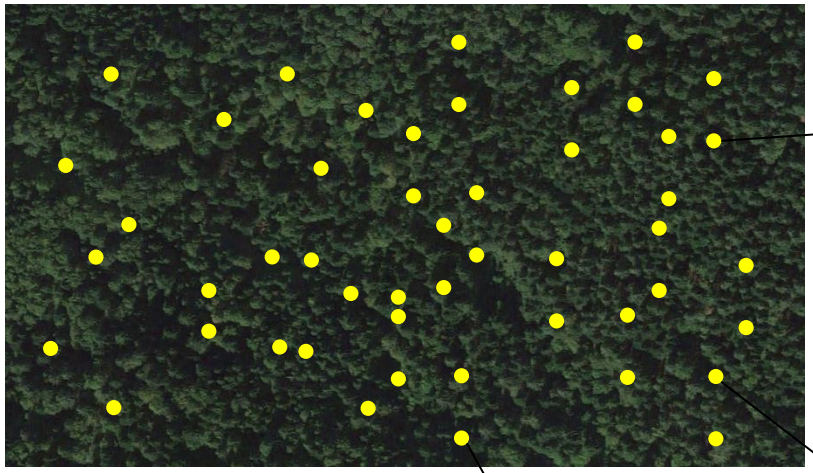


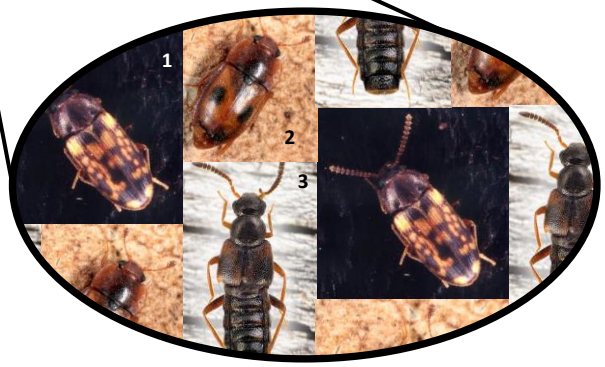
β

α

Performance

Interactions

Dispersal



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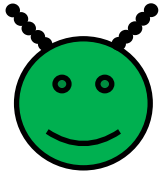
Why does dispersal matter in fragmented habitat?



Tracking habitat
Overcoming local disturbances
Limiting kin competition

Costs (risks and metabolism)
Trade-offs

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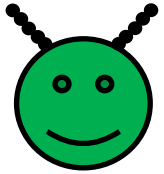

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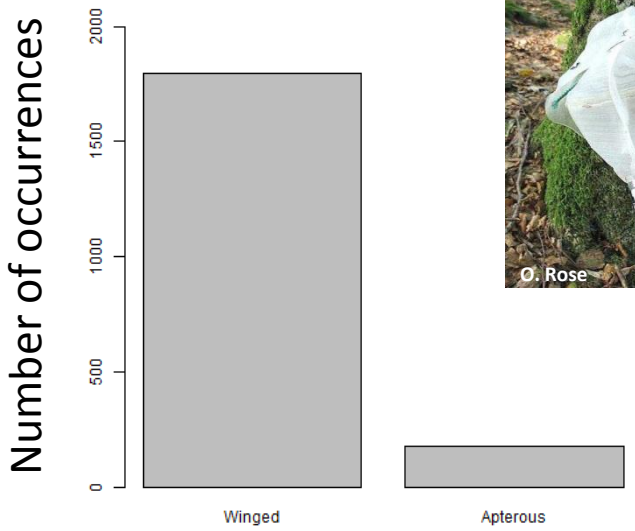
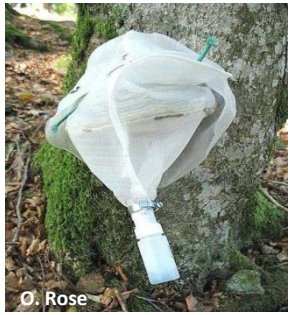
Heterogeneous among species

→ Why is it so ?





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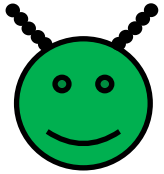


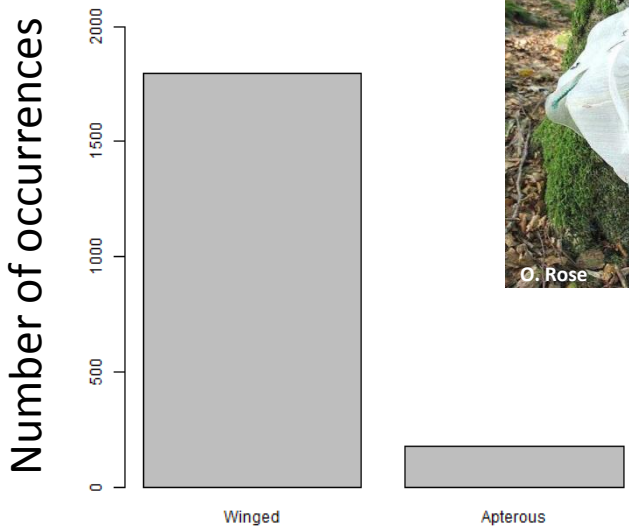
Tracking habitat
Overcoming local disturbances
Limiting kin competition

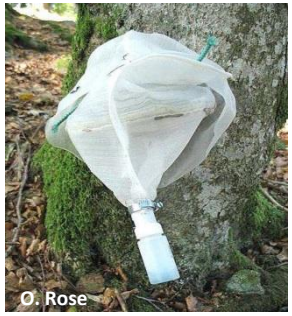
Costs (risks and metabolism)
Trade-offs

Heterogeneous among species

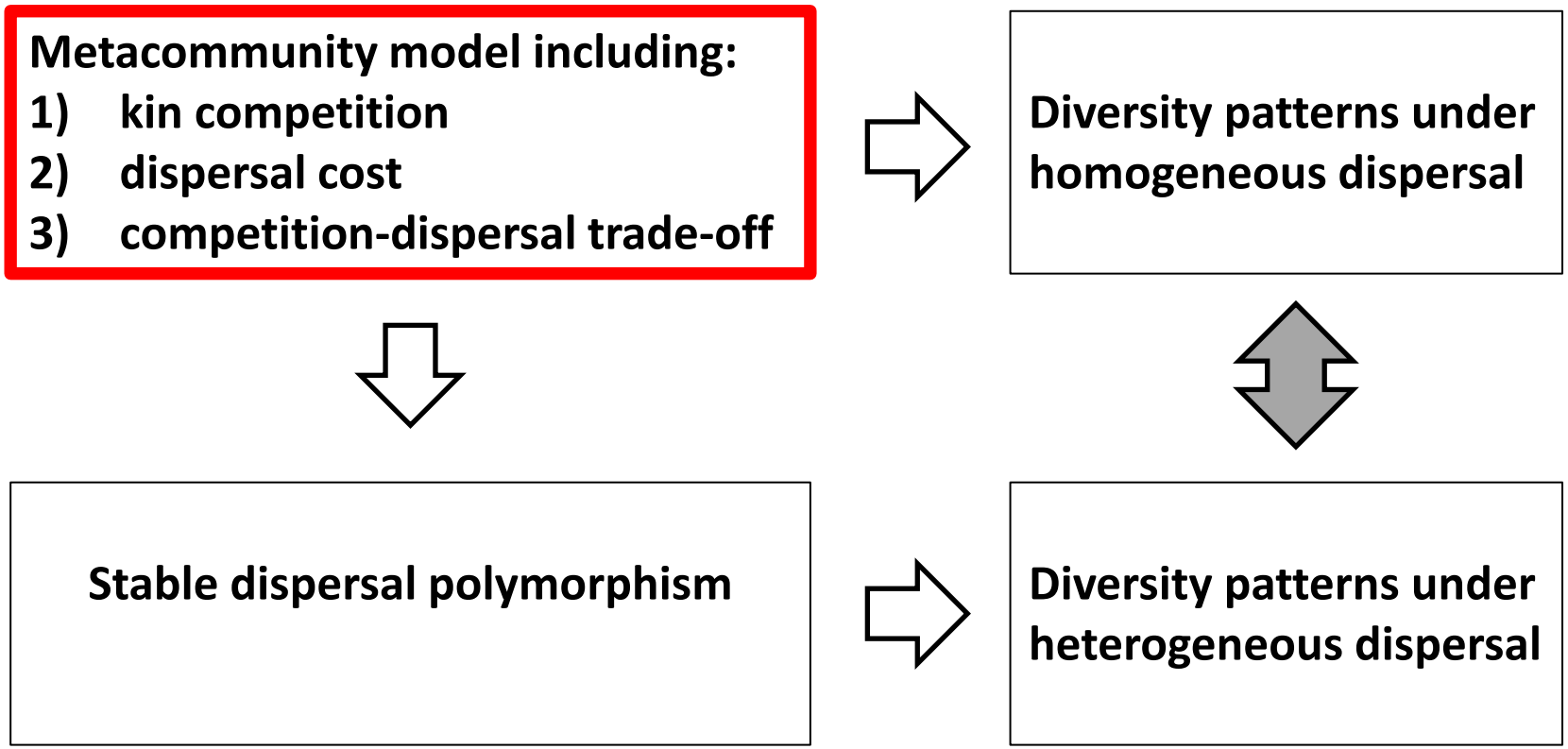
→ Why is it so ?

→ **How does it affect diversity patterns (α,β)?**





Outline


Metacommunity model including:
1) kin competition
2) dispersal cost
3) competition-dispersal trade-off
Diversity patterns under homogeneous dispersal
Stable dispersal polymorphism
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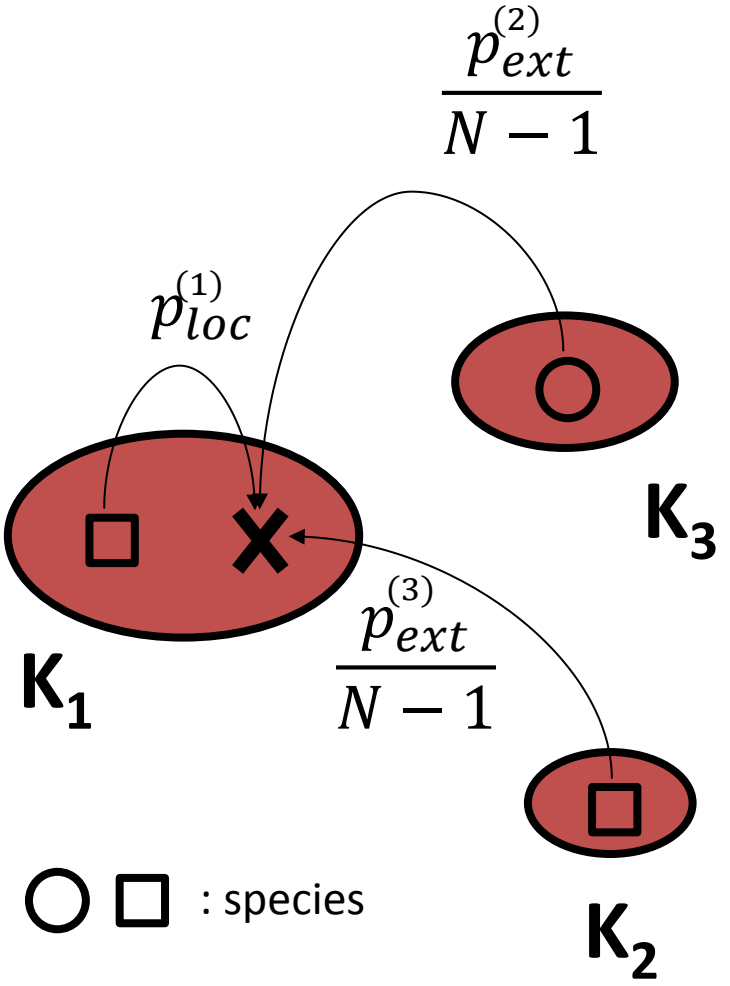
A structured Moran model of metacommunity

- **Island model & zero-sum game**
- Point speciation
- Dispersal trait (p_{loc}, p_{ext})
- Considering $N \to +\infty$



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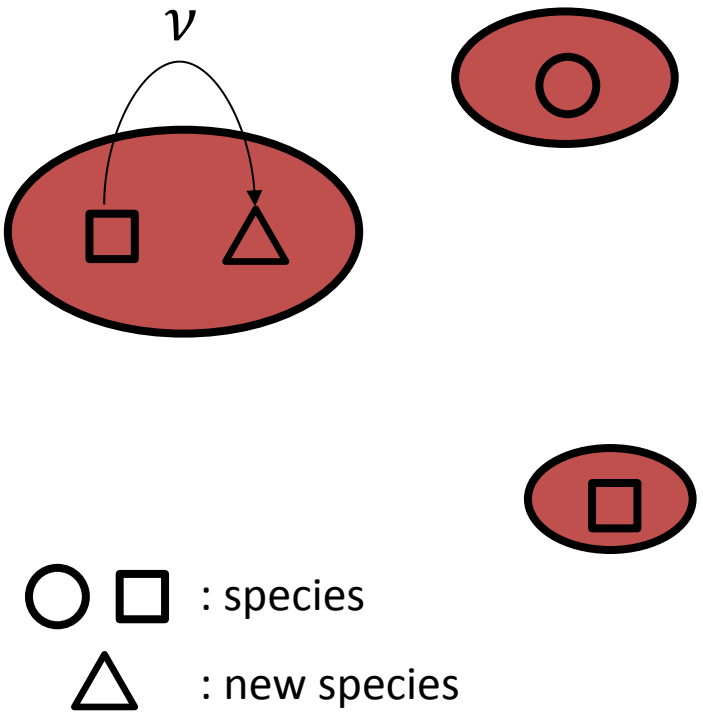

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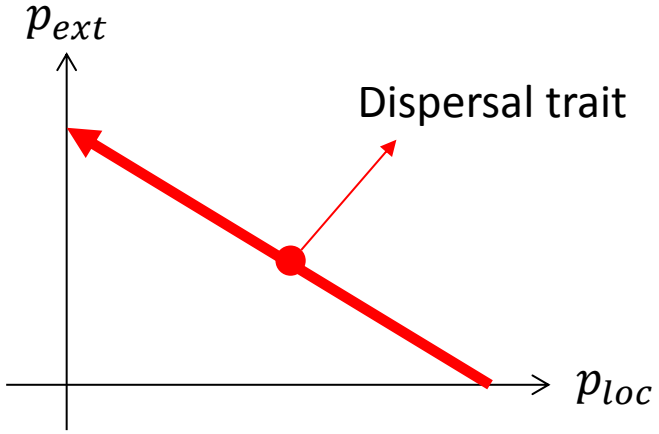
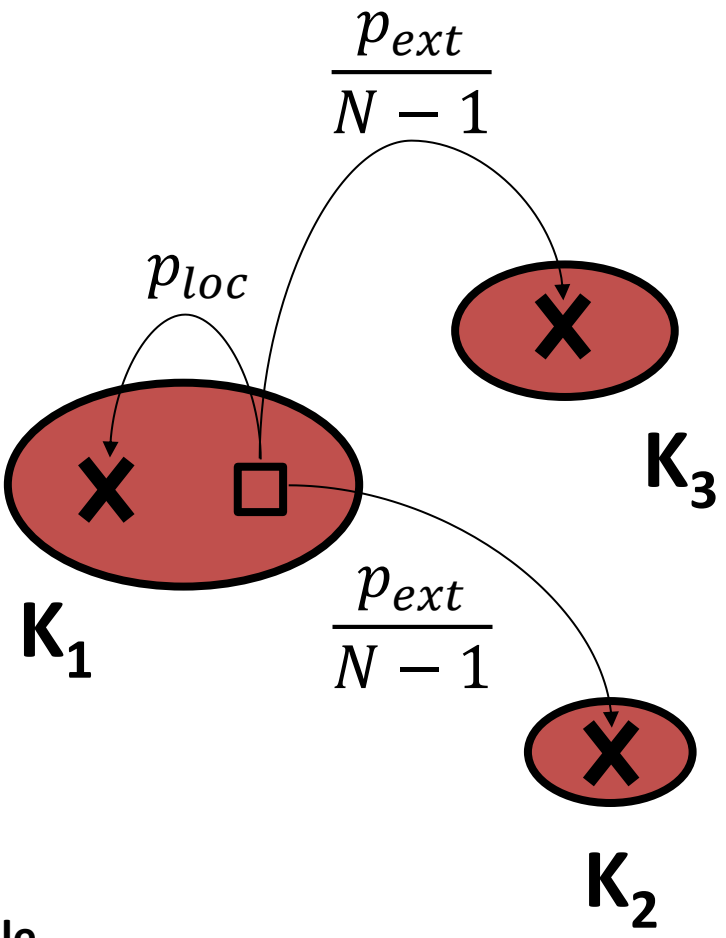
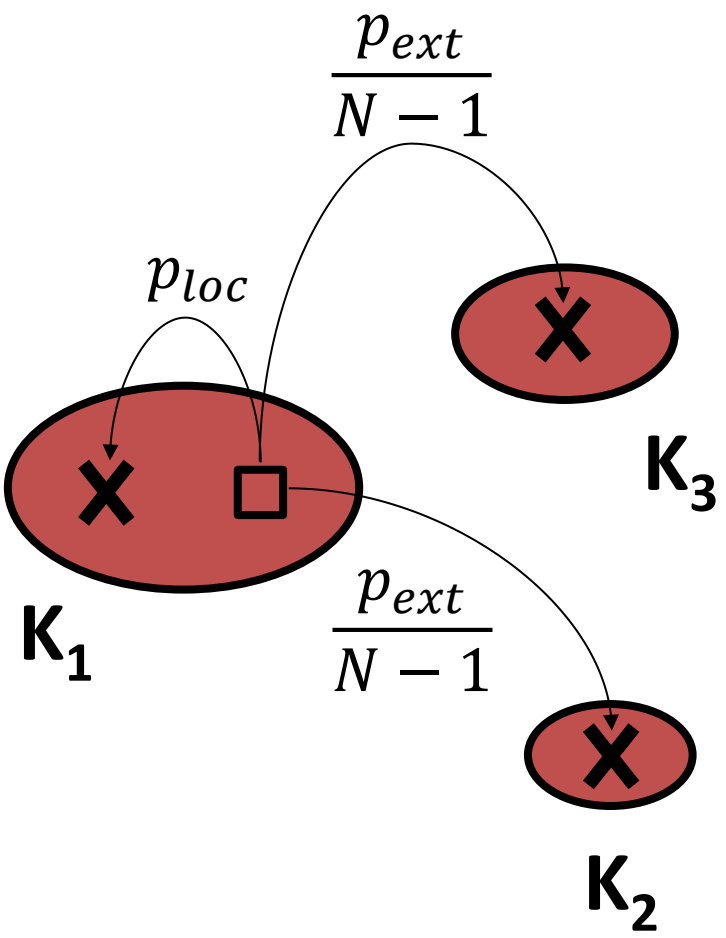




Heritable

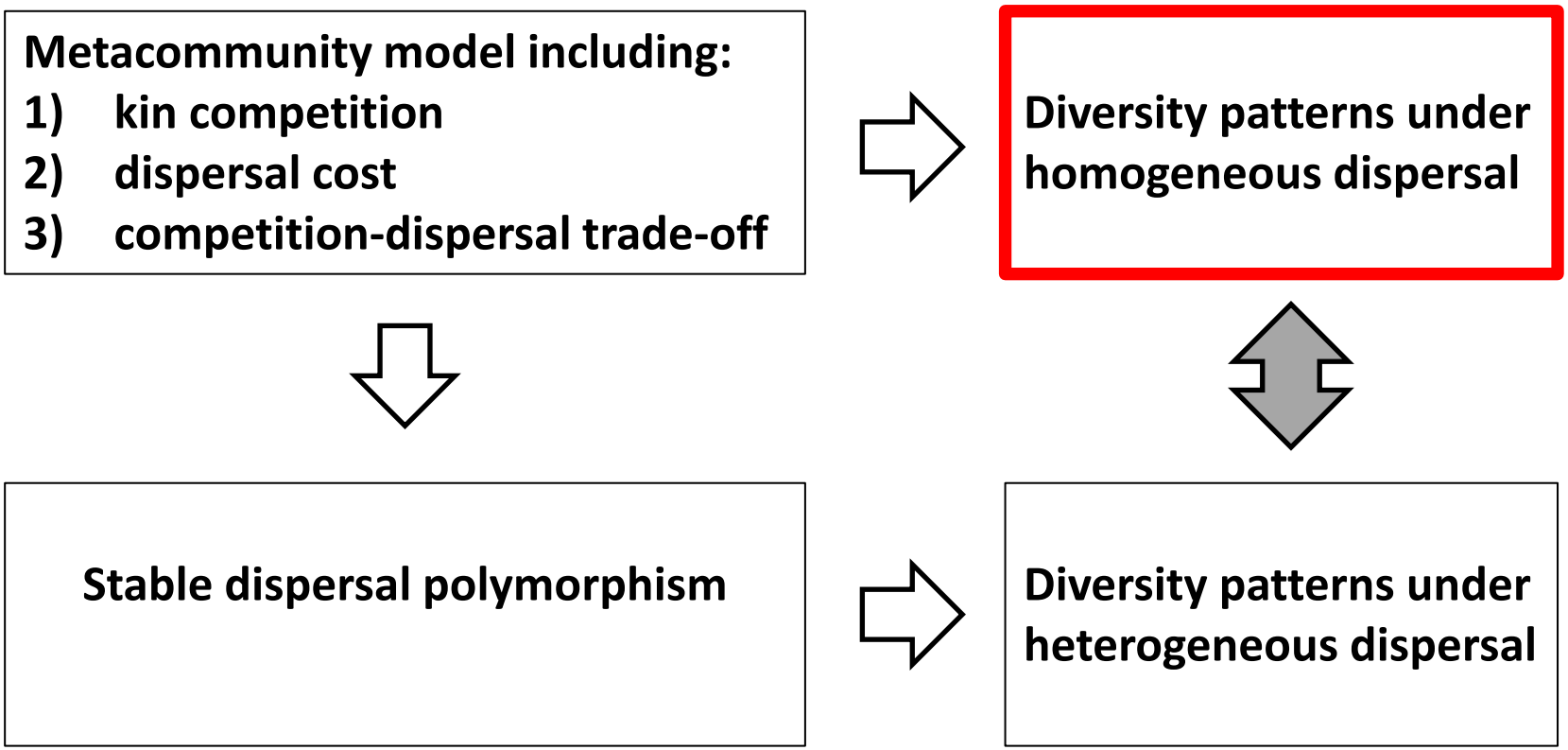
A structured Moran model of metacommunity

- Island model & zero-sum game
- Point speciation **(νN converges)**
- Dispersal trait (p_{loc}, p_{ext})
- **Considering** $N \to +\infty$



… summing up the life cycle …

Outline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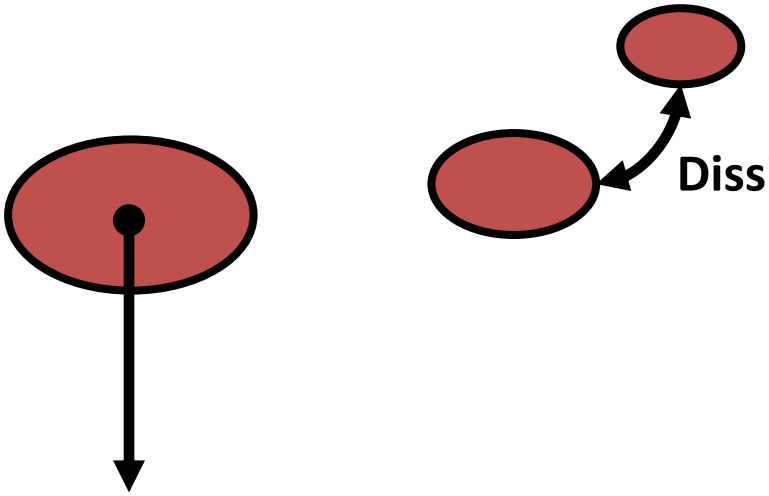
Choosing diversity indices under the neutral assumption

All the individuals have the same dispersal trait (p_{loc}, p_{ext}) → **neutral model**



Dissimilarity between two sites D_β

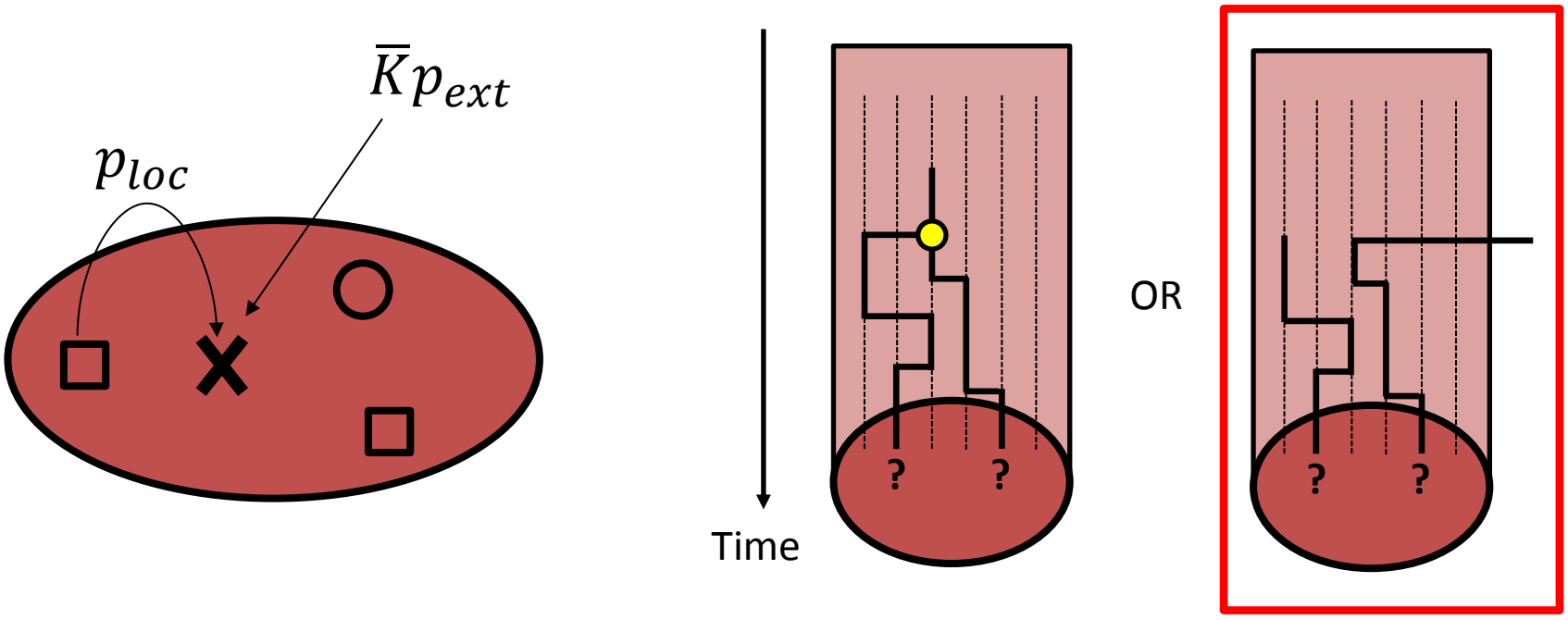
Probability that sampling one individual in each site yields two distinct species

Diversity within a site D_α

Probability that sampling two individual in the site yields two different species

Can be obtained using the **coalescent** point of view

Coalescent process for pairs of lineages



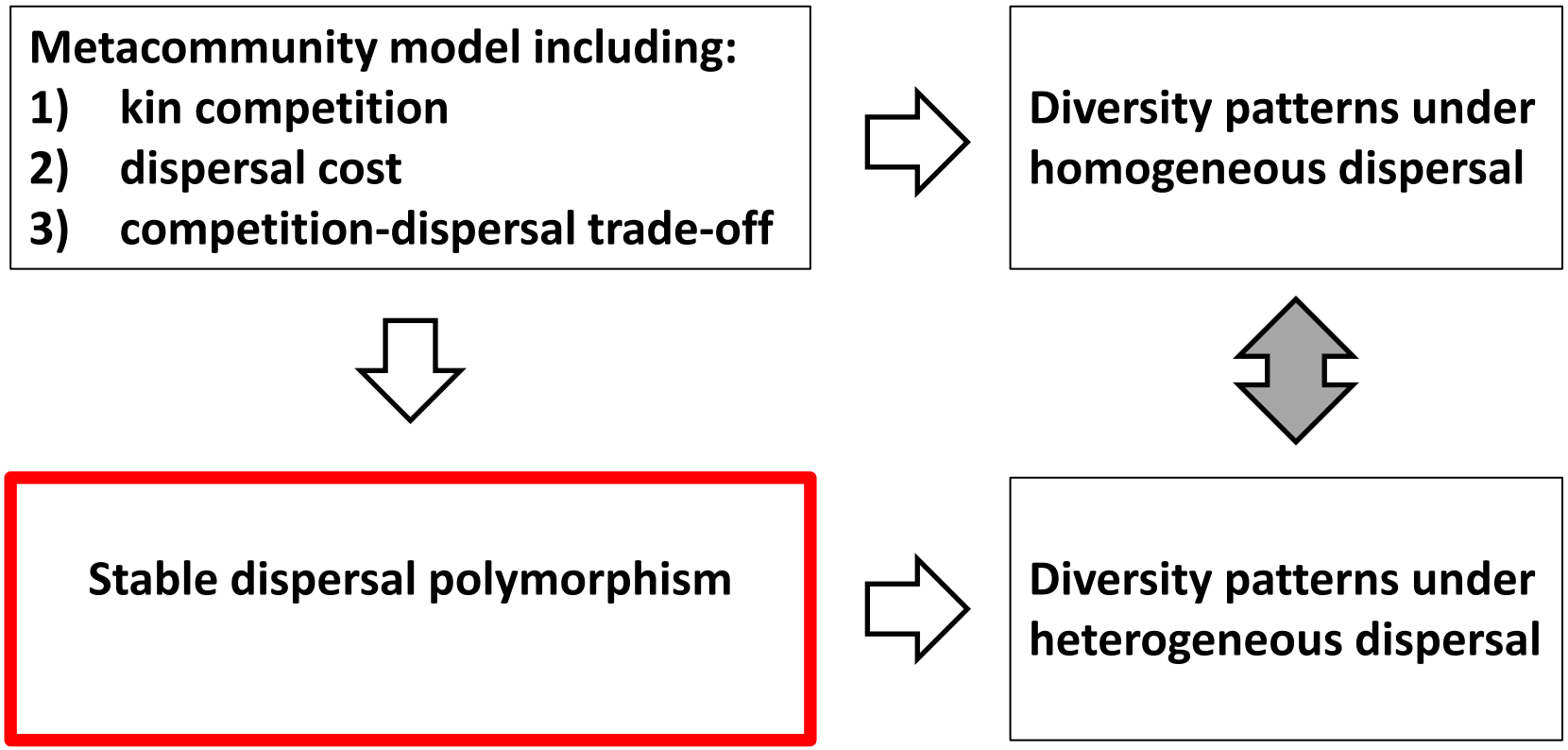
Slower phase
Speciation involved
« Delocalized »

Predicted patterns:
→All the pairs of site have the same D_β
→All the sites have the same D_α

In particular, carrying capacity of sites has no impact on considered diversity indices.

(Wakeley 2002)

Outline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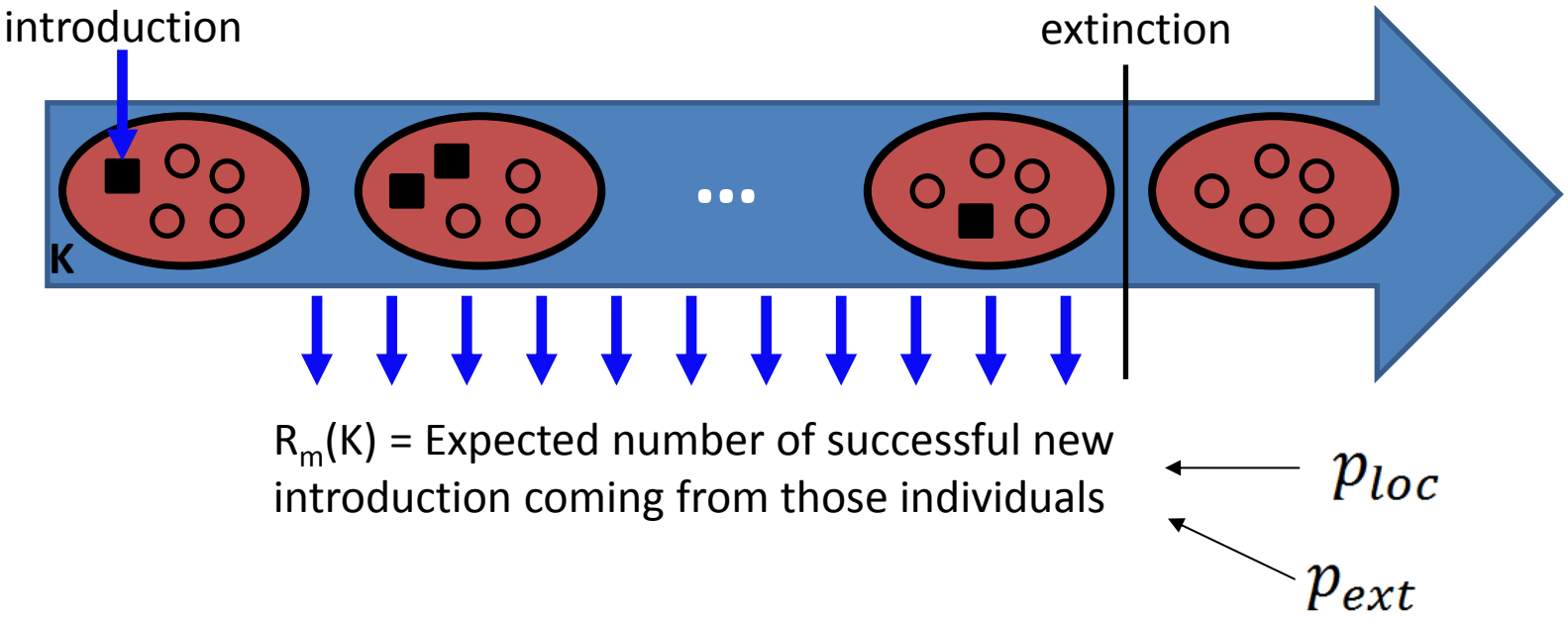
When is monomorphism unstable ?

When is monomorphism unstable ? **Metapopulation fitness criterion R_m**



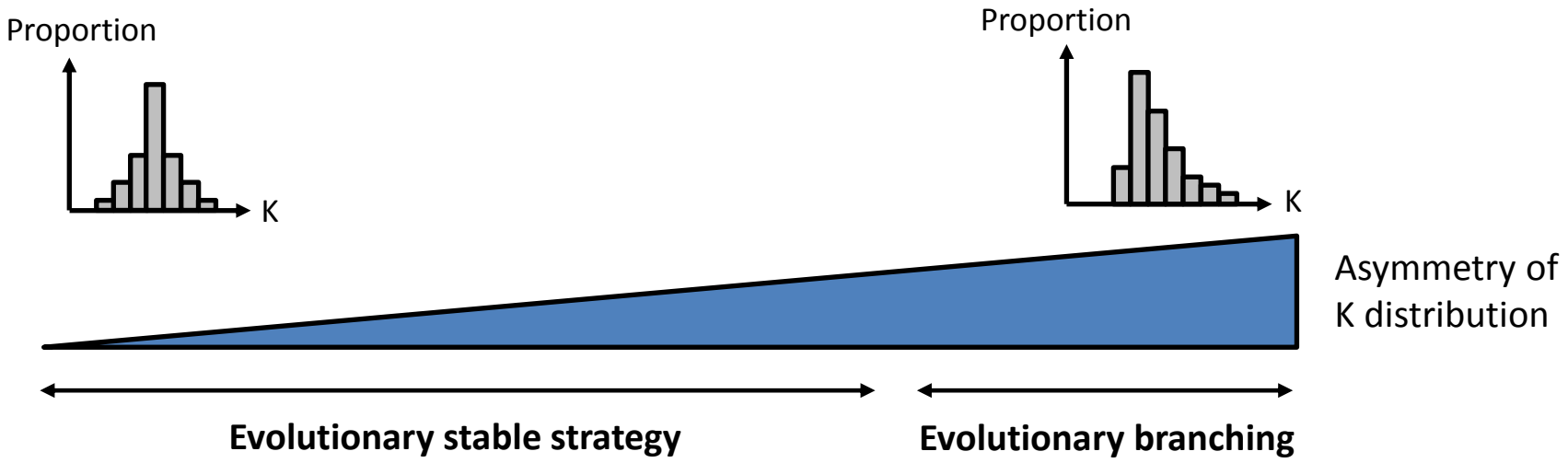
Initial dynamics may be seen as a branching process

R_m= expectation of $R_m(K)$ over K

If $R_m > 1$, the descendent of the individual will rise in frequency from rare within the meta-community .

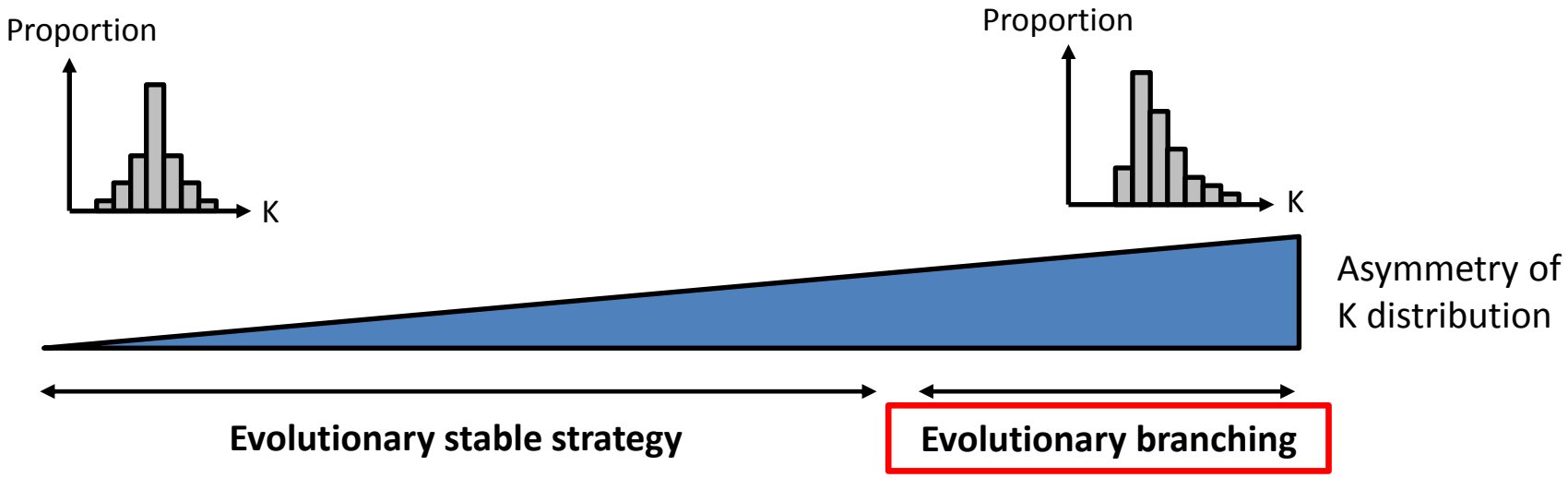
(Chesson 1984, Metz&Gyllenberg 2003)

Polymorphism and adaptive dynamics of dispersal traits

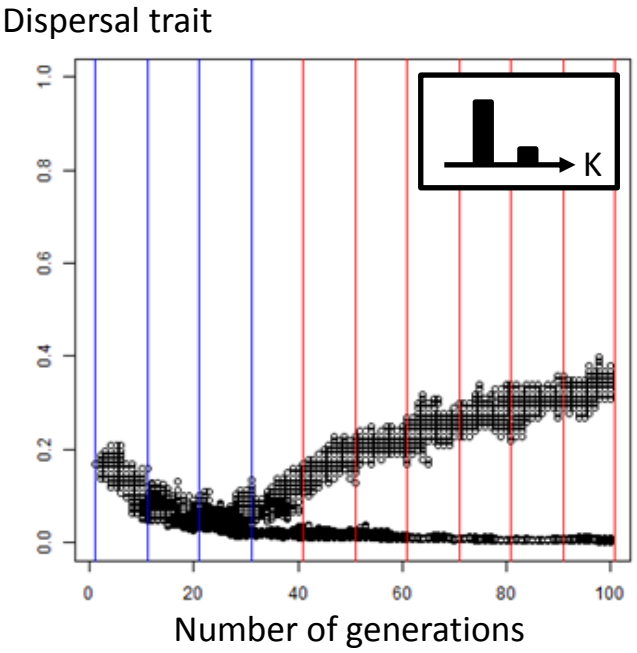


(Massol *et al.,* 2011)

Polymorphism and adaptive dynamics of dispersal traits



Simulations with two patch sizes



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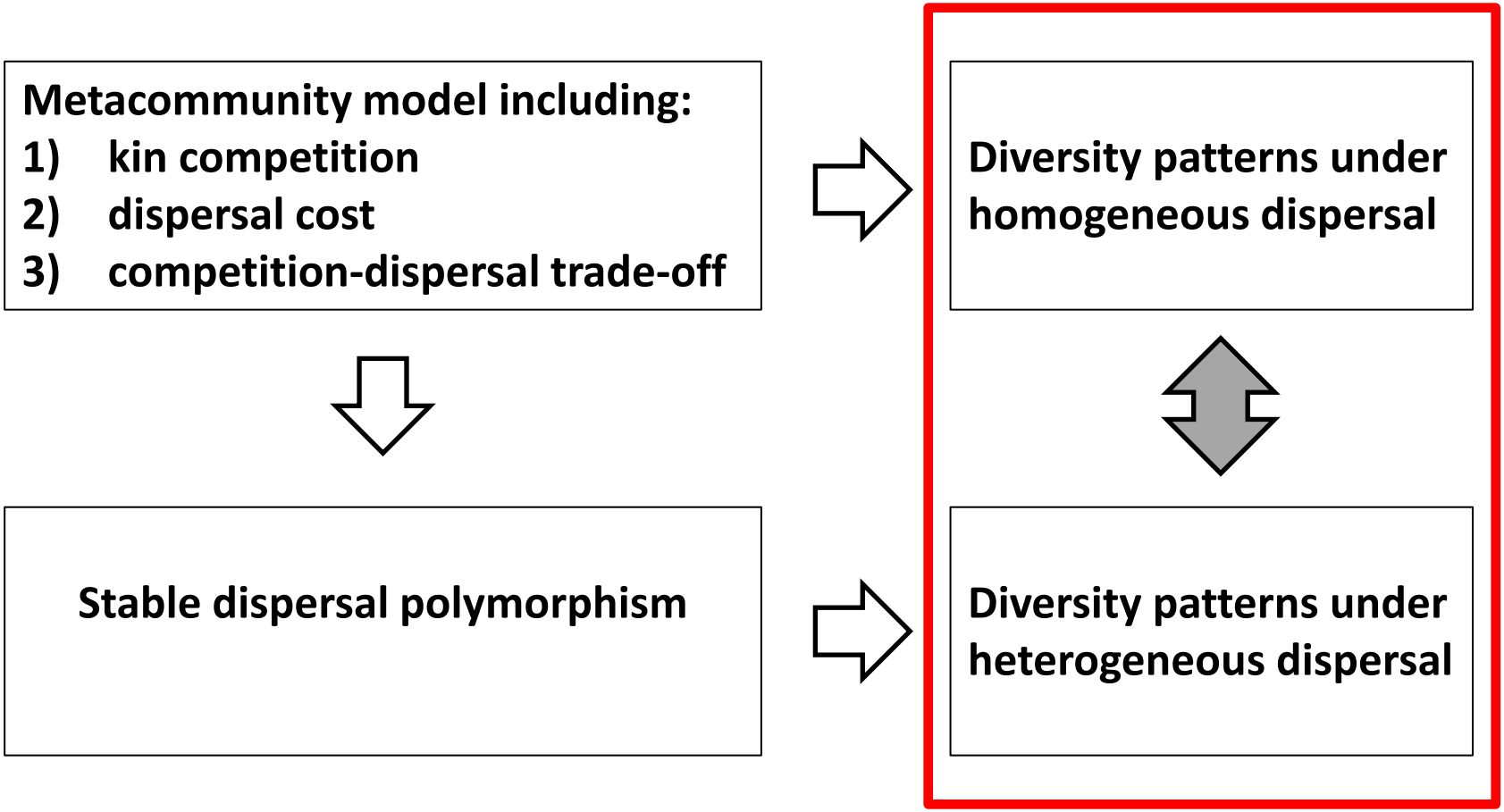
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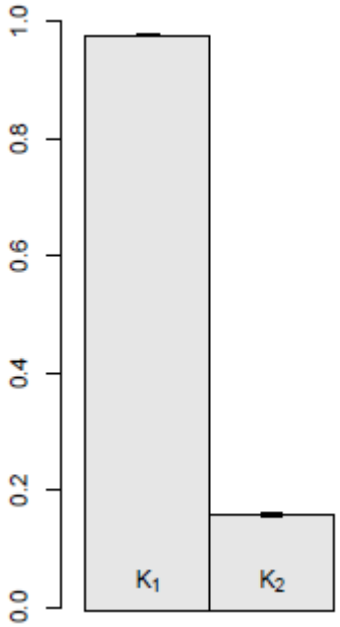
Spatial structure of dispersal traits

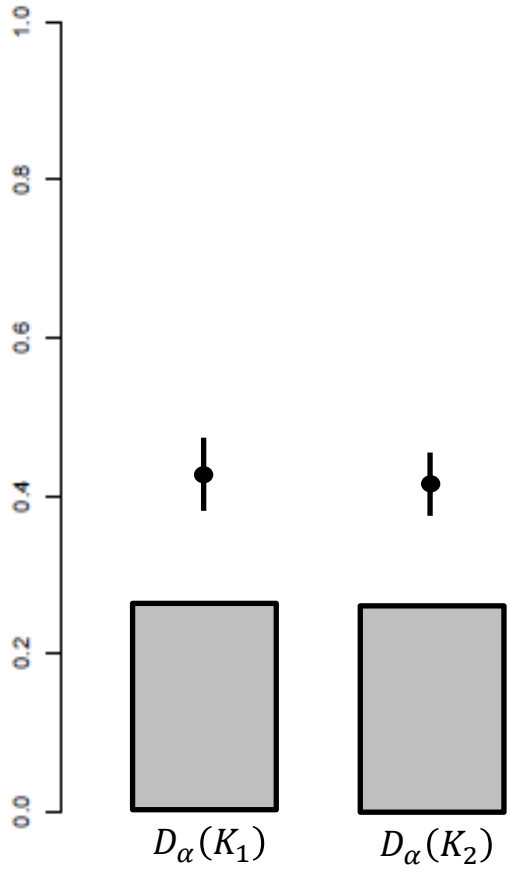
Larger sites harbors organisms that are more competitive and disperse less on average.

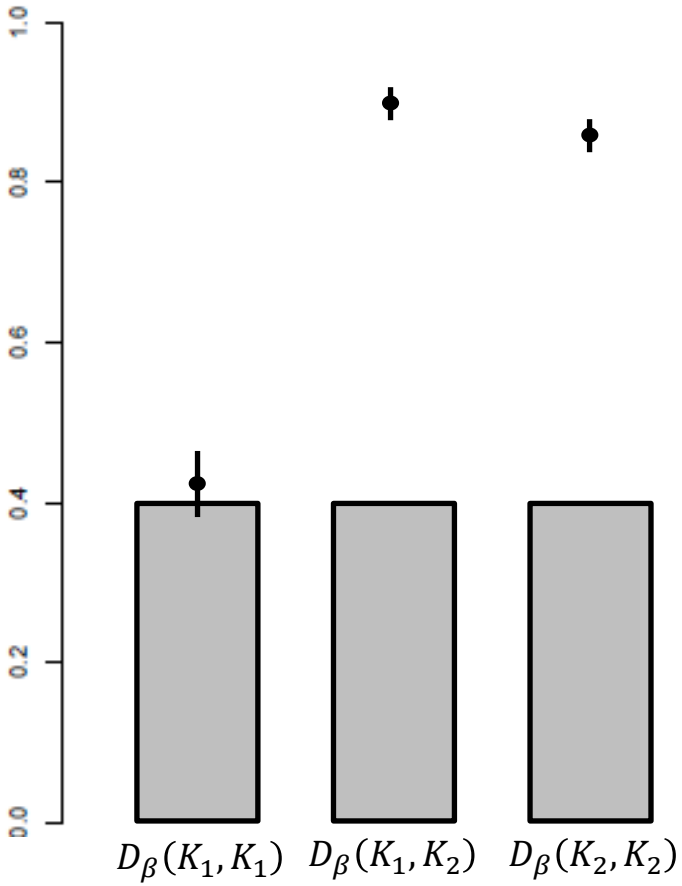
(Effect is smaller under the ESS)

Mean dispersal trait
(all the species together)



Impact of polymorphism on communities dissimilarity





Summary

1. **Neutral model** predicts that expected α and β diversity measures should not depend on carrying capacities.

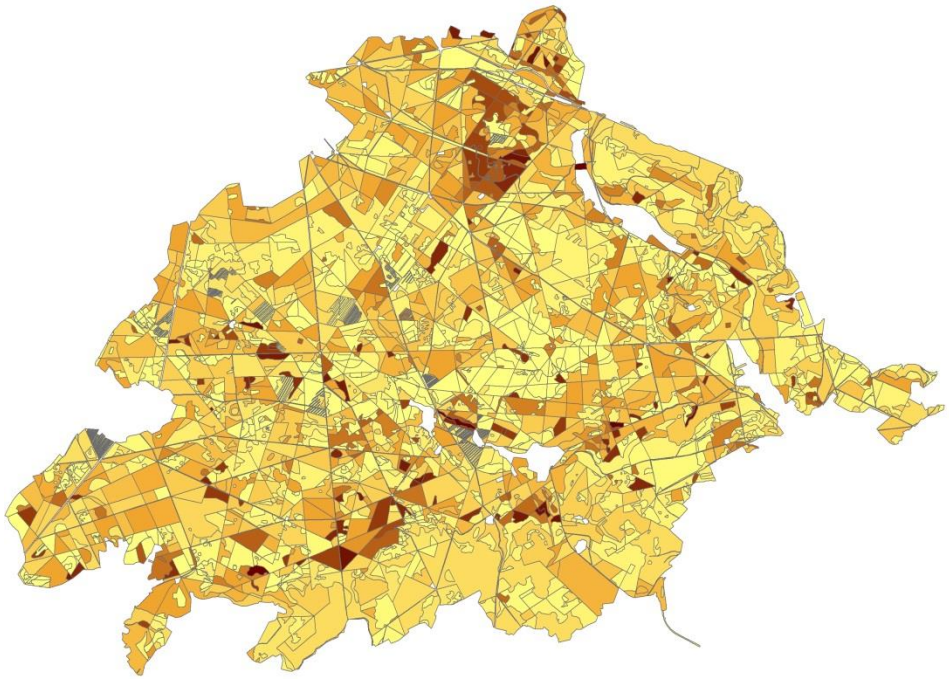
2. **Interspecific polymorphism** of dispersal traits can emerge through evolutionary dynamics when carrying capacities are **assymetrically distributed** in the metacommunity.

3. Species with heterogeneous dispersal traits are segregated along the community carrying capacity range.

Perspective

→ Introducing isolation by distance

→ Considering more continuous landscapes?



Acknowledgements

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- Thomas Perrot

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- Christophe Bouget
- Gwendoline Percel

Laroche, F., P. Jarne, T. Perrot, et F. Massol. 2016.
« The evolution of the competition–dispersal trade-off affects α- and β-diversity in a heterogeneous metacommunity ». *Proceedings of the Royal Society of London B: Biological Sciences* 283 (1829).

and thank you for your attention !