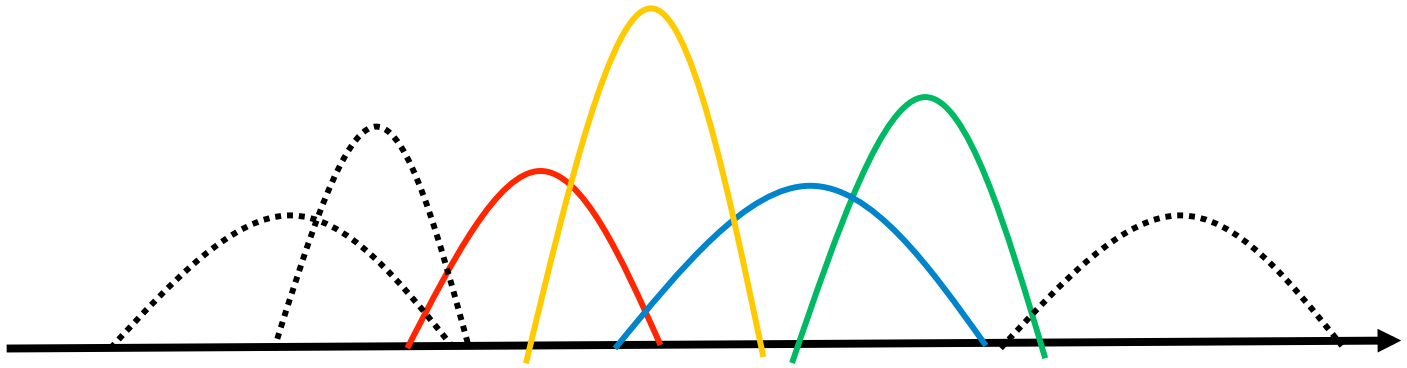
CENTRE DE LA SCIENCE DE LA BIODIVERSITÉ DU QUÉBEC
QUEBEC CENTRE FOR BIODIVERSITY SCIENCE

Cascading extinctions, functional complementarity, and selection in two-trophic-level model communities: A trait-based mechanistic approach



Sapijanskas, Jurgis & Loreau, Michel *Journal of Theoretical Biology* 267:375–387 (2010)

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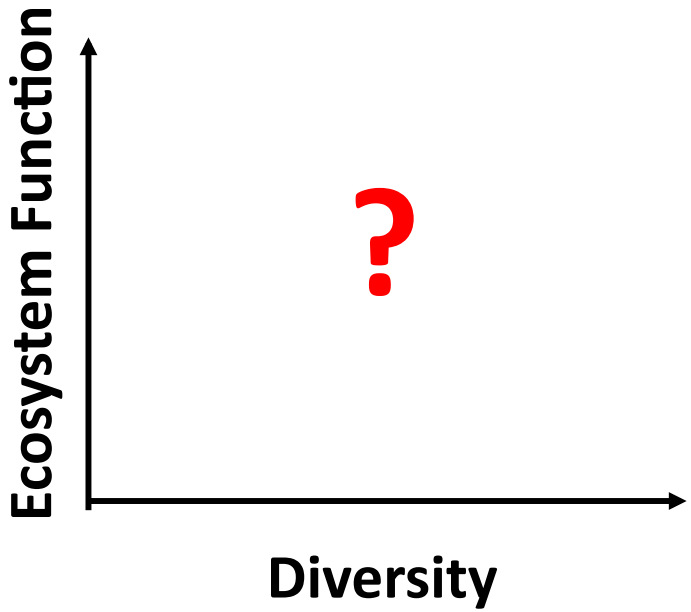
Introduction: Trait-based Biodiversity and Ecosystem Functioning Research



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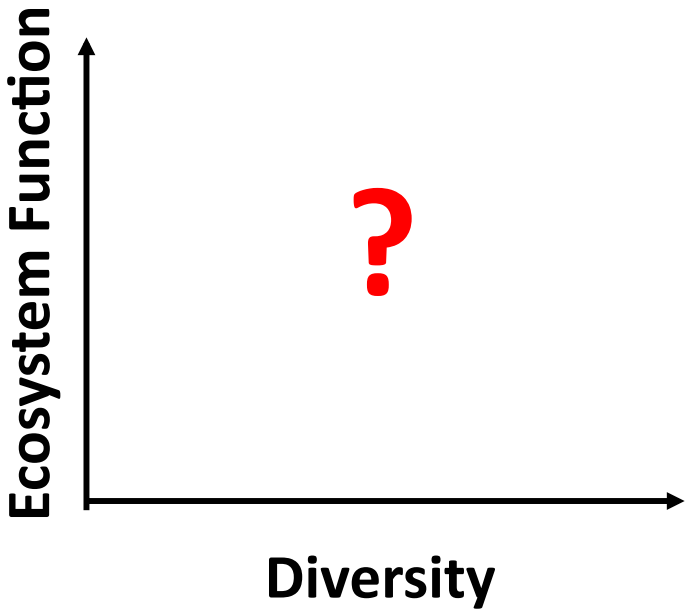

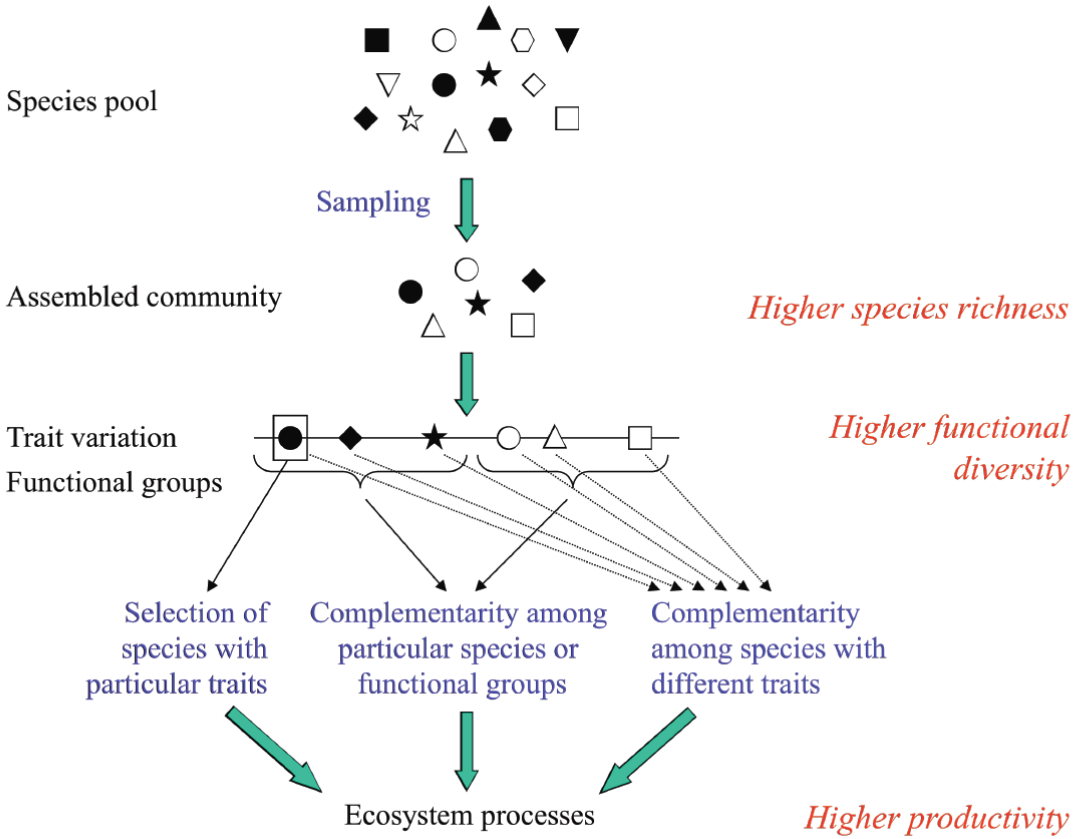

Loreau et al., *Science* 294:804-808 (2001)

Introduction: Trait-based Biodiversity and Ecosystem Functioning research

Trait-based theoretical work remains scarce *(Norberg et al. 2001, Pachepsky et al. 2001, Savage et al. 2007)*

Most trait-based studies are **static**, restricted to **single-trophic-level** communities and/or do not deal with **ecological interactions** in a satisfying way *(Naeem & Wright 2003, Suding et al. 2008, Reiss et al. 2009)*

Fail to link **functional redundancy** with trait-based coexistence and potential **extinction cascades**

Goals:

- **Is there a simple link between functional redundancy and the consequences of species deletion?**
- **Predict consumer diversity effects based on species traits in two-trophic-level systems**

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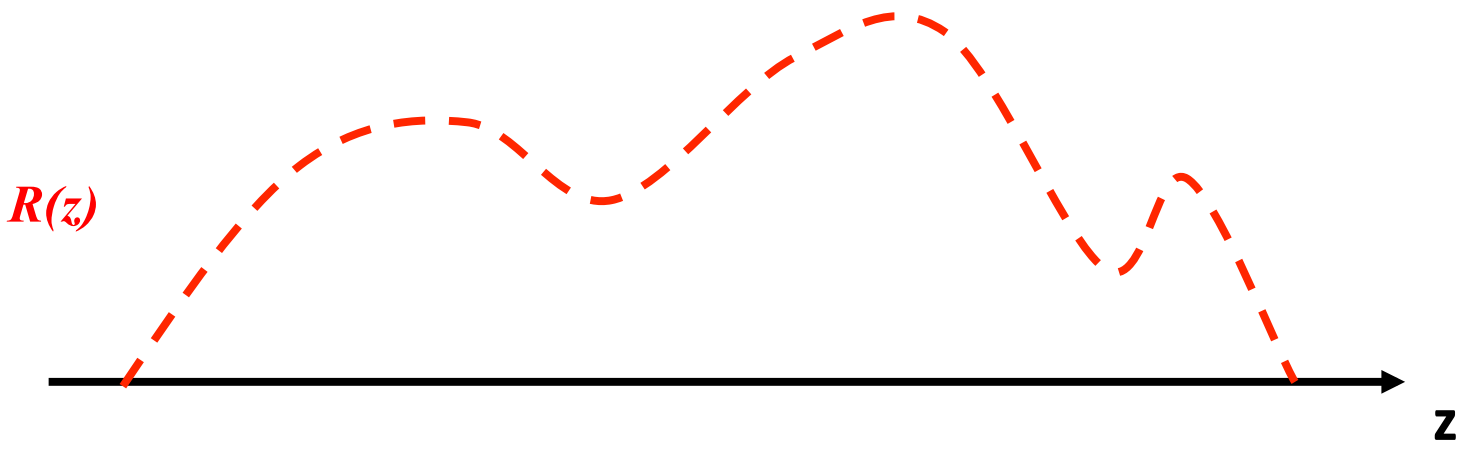
Fail to link **functional redundancy** with trait-based coexistence and potential **extinction cascades**

Goals:

- **Is there a simple link between functional redundancy and the consequences of species deletion?** ➡ **No!**
- **Predict consumer diversity effects based on species traits in two-trophic-level systems**

MacArthur's Consumer Resource Model

$$\frac{dR(z)}{dt} = \rho(z)R(z)\left(1 - \frac{R(z)}{\kappa_R(z)}\right)$$

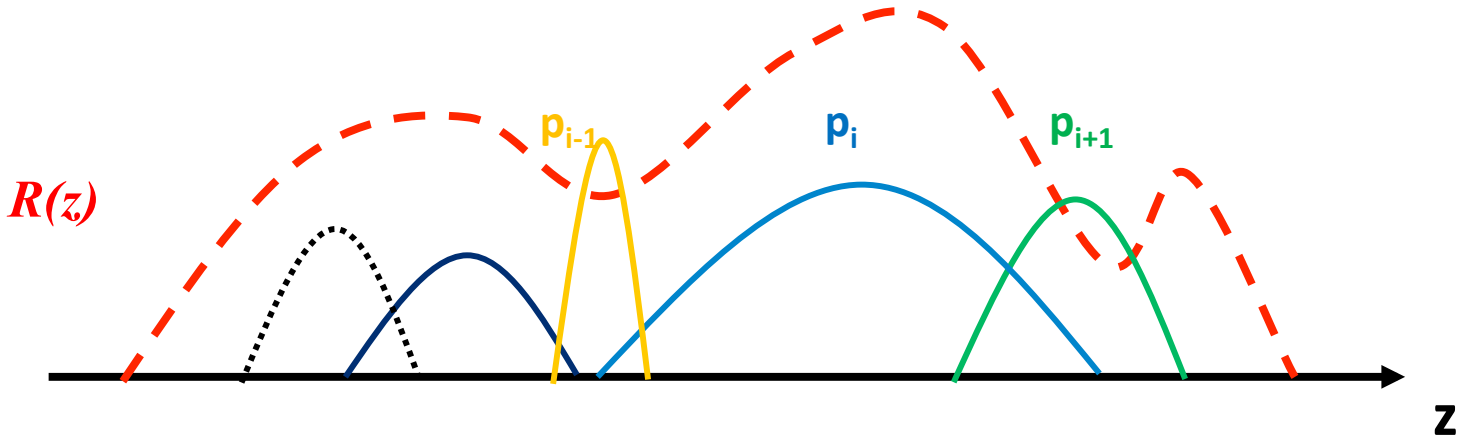


MacArthur & Levins 1967; MacArthur 1969,1970,1972.

MacArthur's Consumer Resource Model

$$\frac{dR(z)}{dt} = \rho(z)R(z)\left(1 - \frac{R(z)}{\kappa_R(z)}\right) - \sum_{i=1}^{S} p_i(z)N_i R(z)$$

$$\frac{dN_i}{dt} = N_i e_i \left(\int \varepsilon_i p_i(z)R(z)dz - d_i\right)$$



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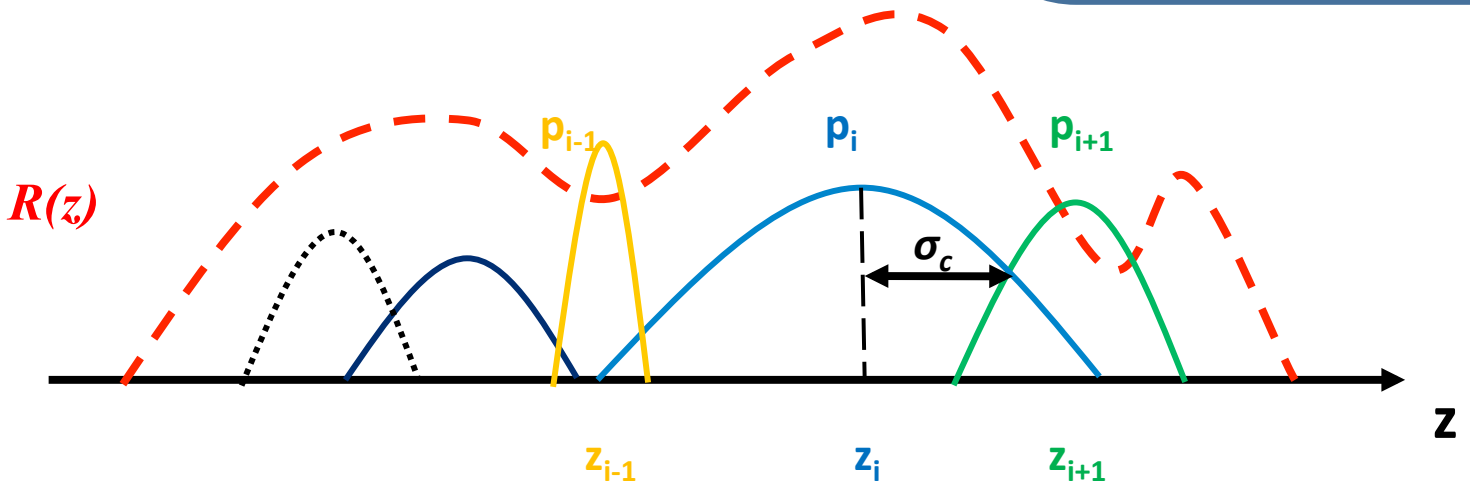
$$p_i(z) = \frac{A_i}{\sqrt{2\pi}\sigma_{c_i}} \exp\left(-\frac{(z - z_i)^2}{2\sigma_{c_i}^2}\right)$$

6 traits model :

Maintenance requirements	***d***
Conversion efficiency *from resource to energy*	***ε***
Conversion efficiency *from energy to offspring*	***e***
Total attack rate	***A***
Niche center	z_i
Niche width	σ_c



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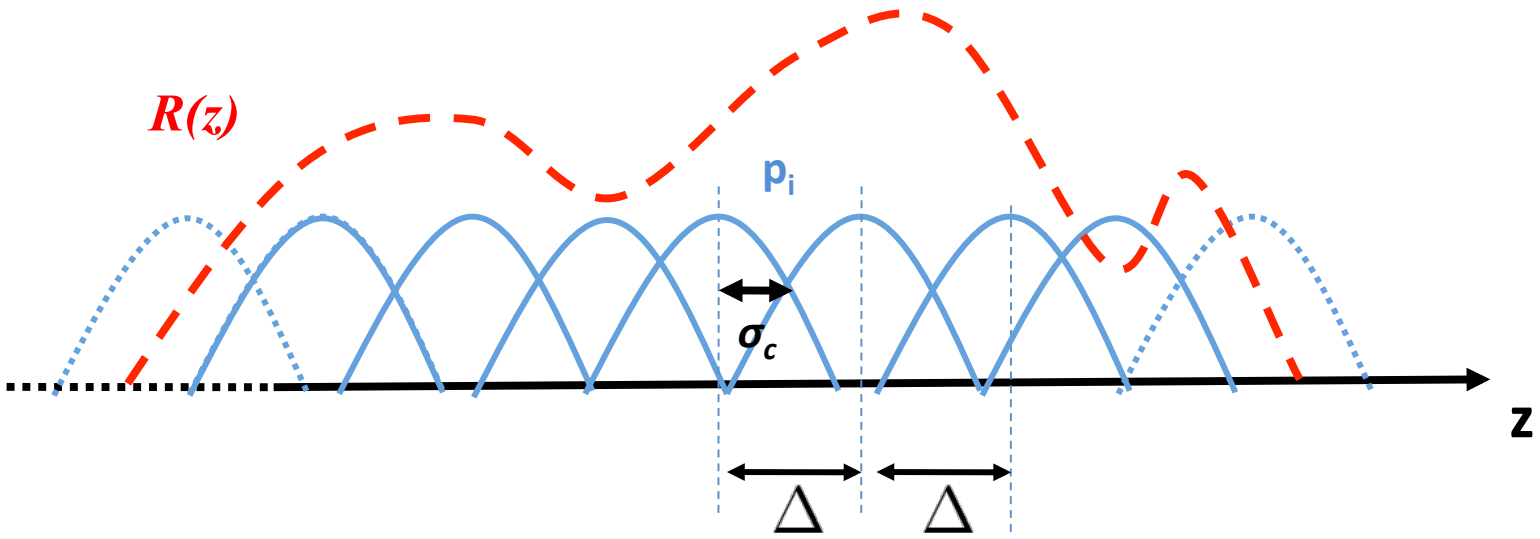
Complementarity Effect



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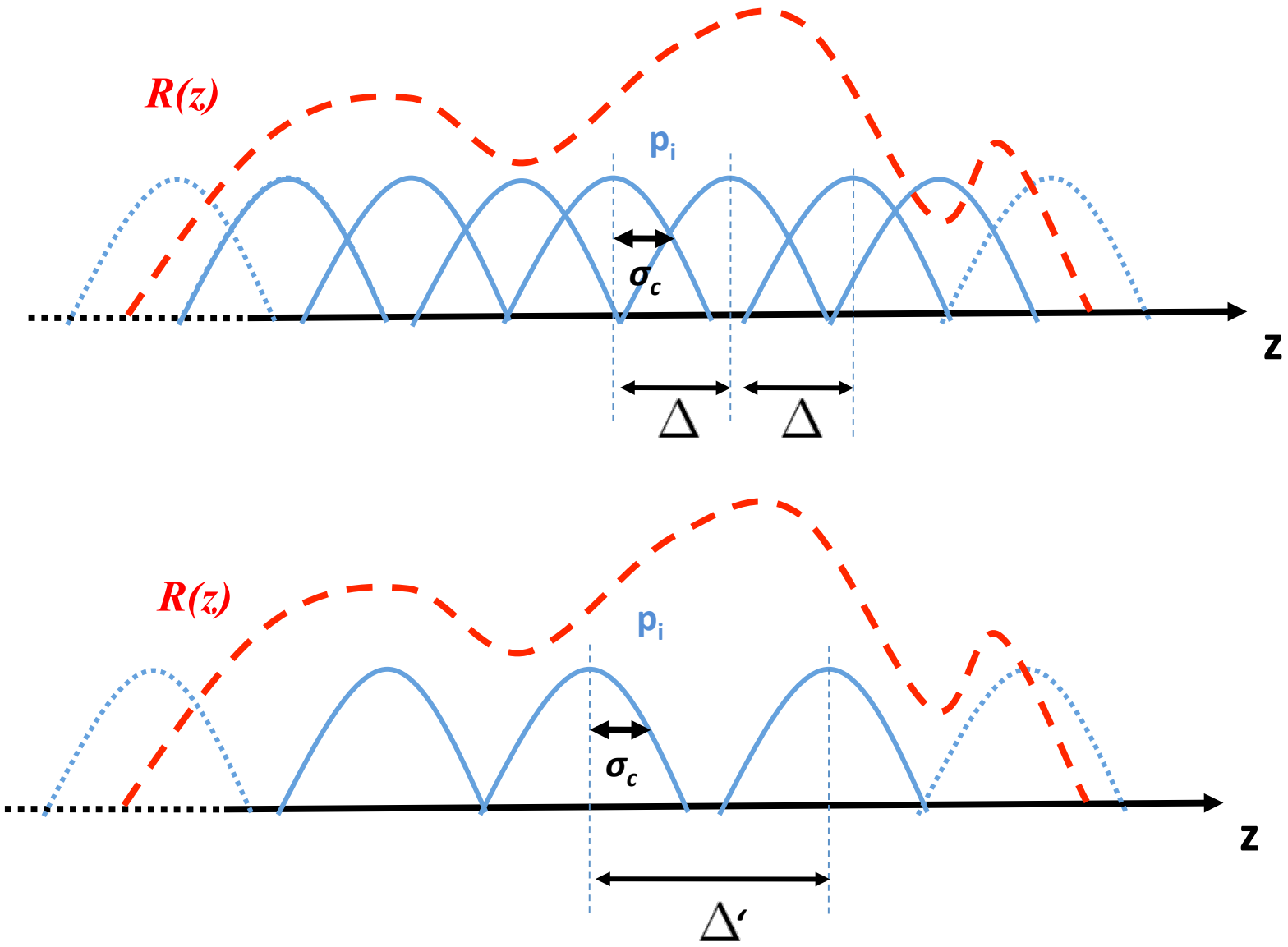

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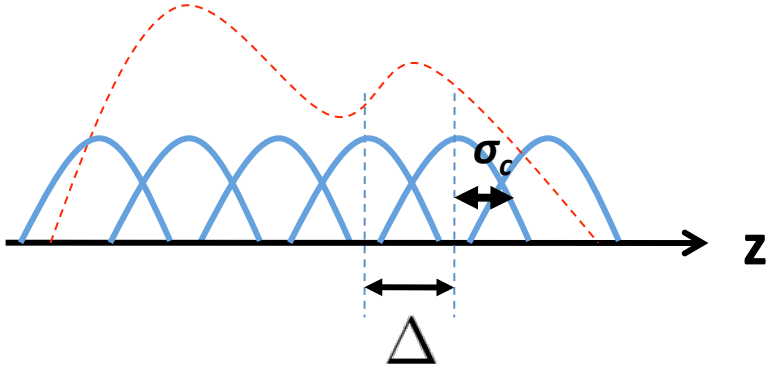
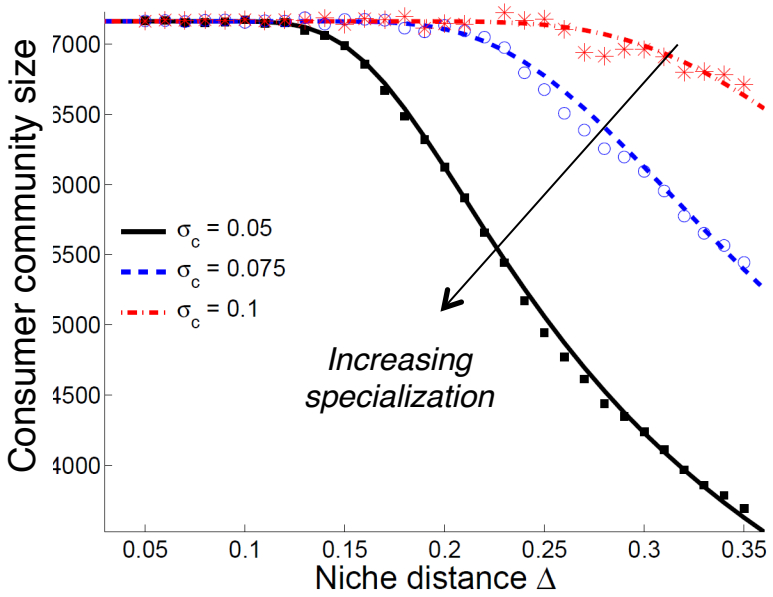
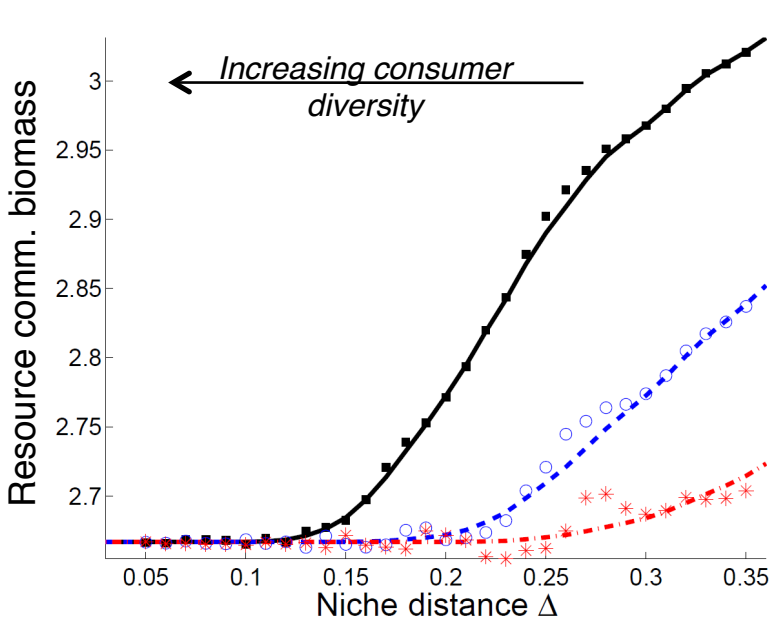
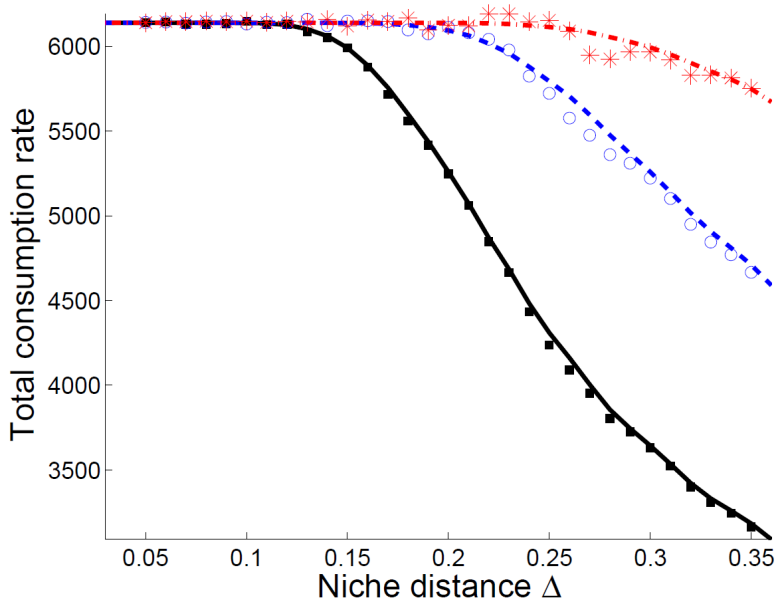
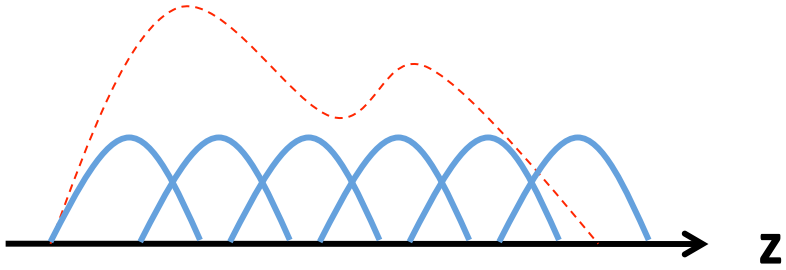


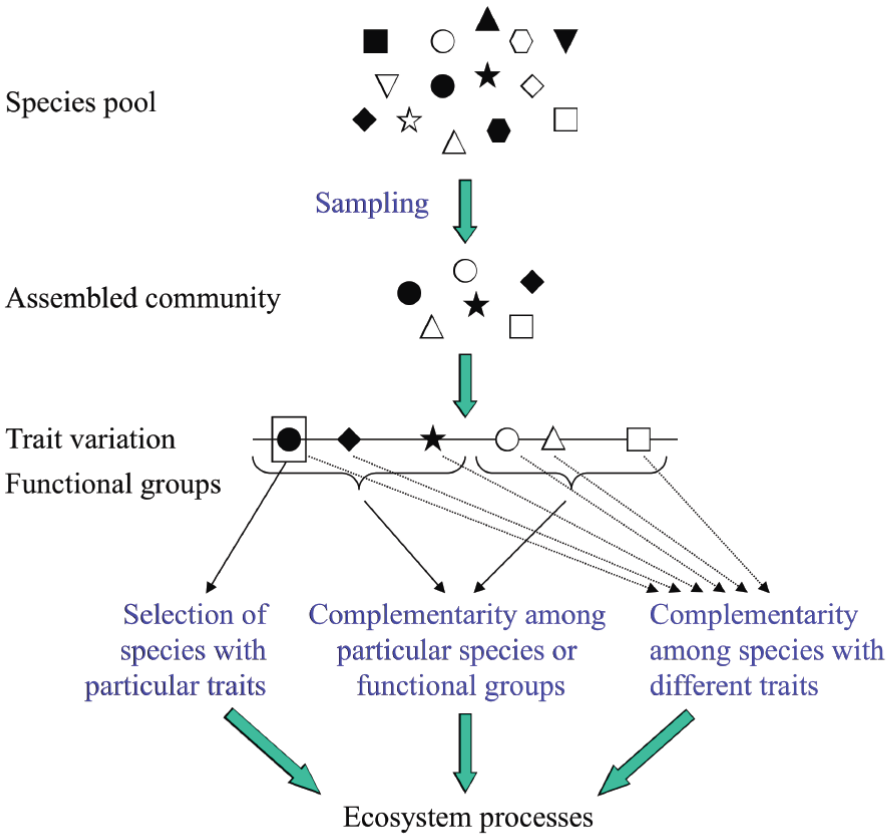






Selection Effect





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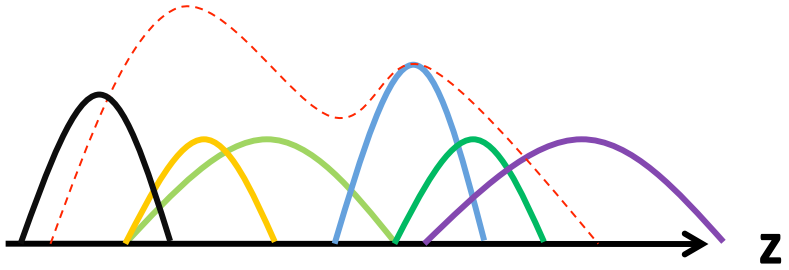
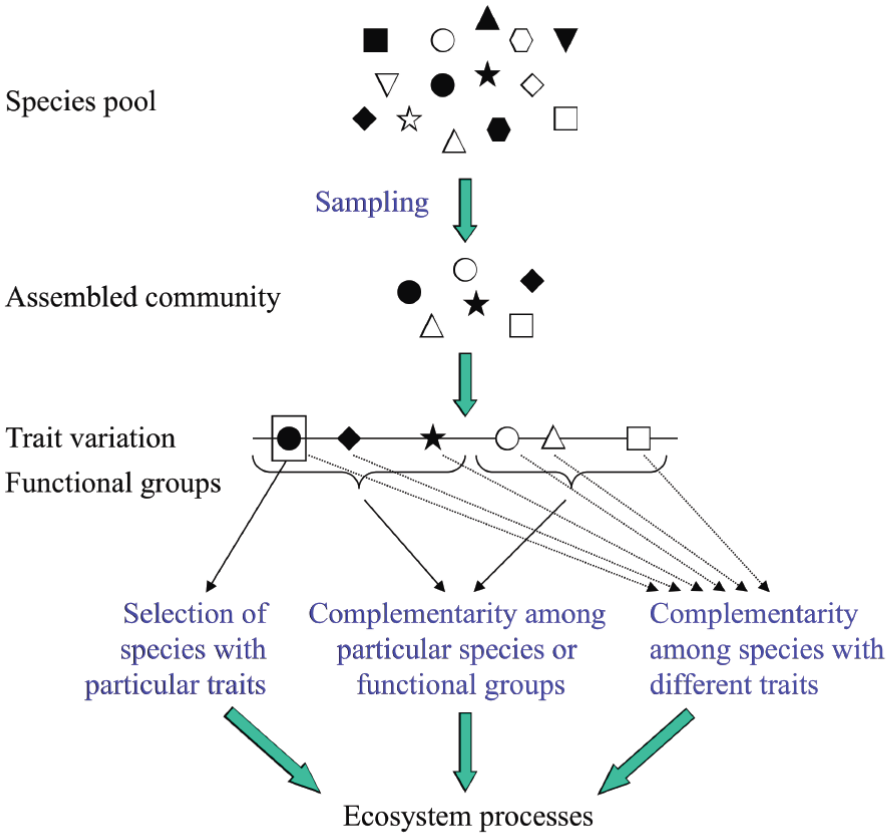
Diversity Effects



All 6 traits have a Normal distribution with a 5% CV in the regional species pool



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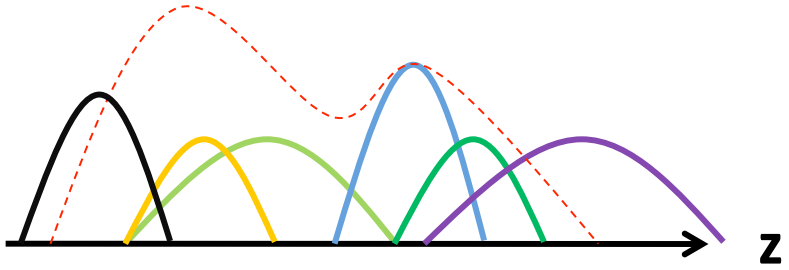
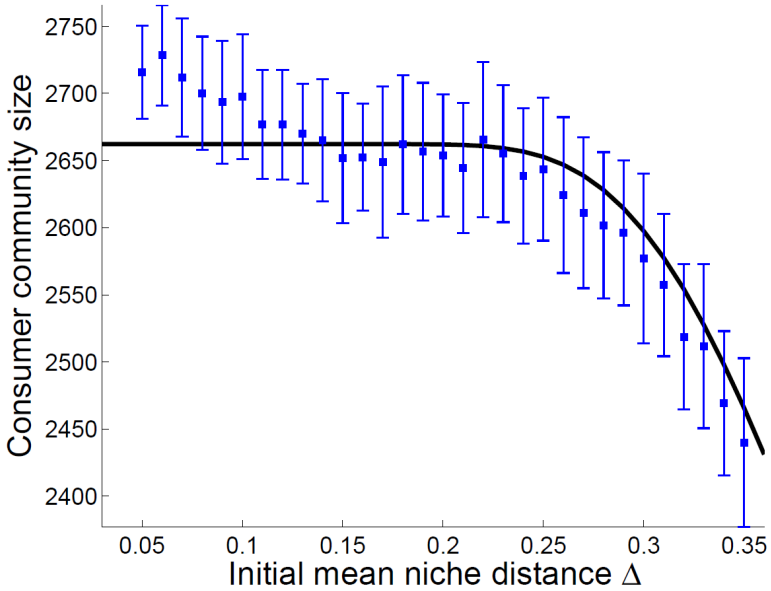
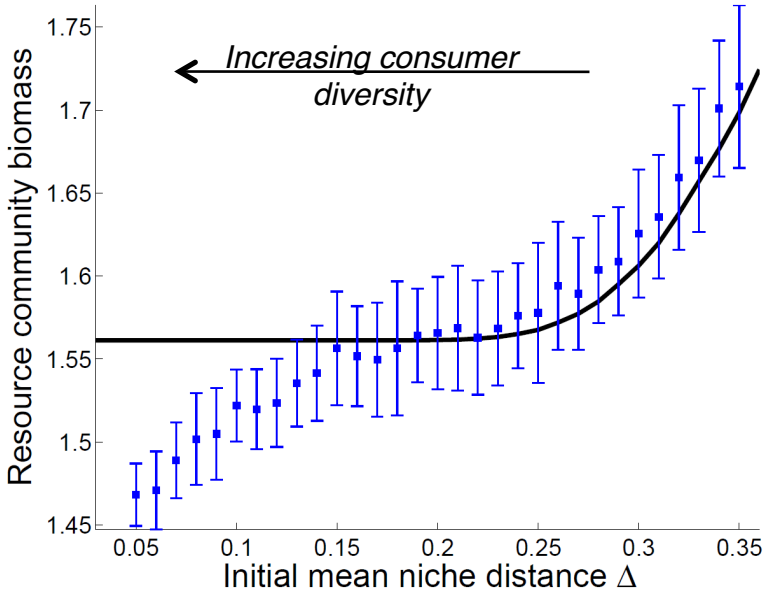
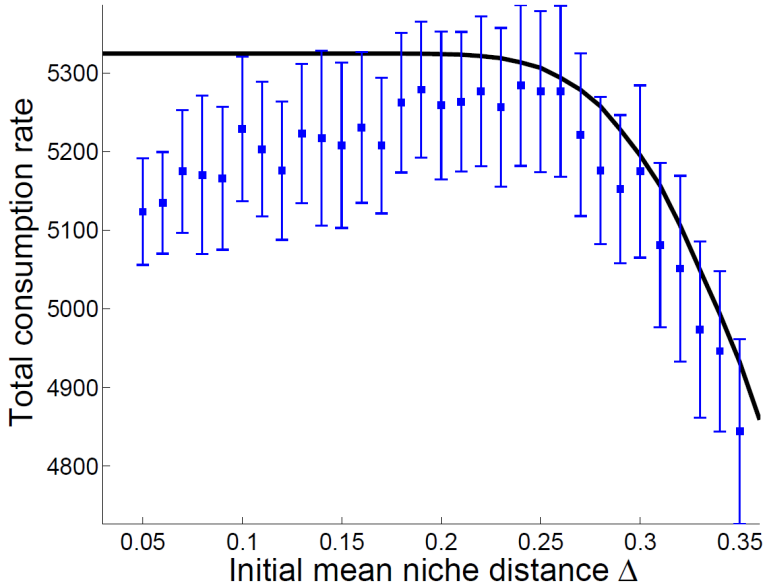


All 6 traits have a Normal distribution with a 5% CV in the regional species pool Symbols (■) and Error bars show mean and sd over 50 replicate communities







Selection Effect

Qualitative effects on community level processes at equilibrium of infinitesimal shifts in common trait values.

		if d ↘	if ε ↗	if A ↗
Consumer community size	if $\frac{d}{\varepsilon A \kappa_R} > \frac{1}{2}$	↗	↗	↗
	if $\frac{d}{\varepsilon A \kappa_R} < \frac{1}{2}$			↘
Resource community biomass		↘	↘	↘
Total consumption rate	if $\frac{d}{\varepsilon A \kappa_R} > \frac{1}{2}$	↗	↗	↗
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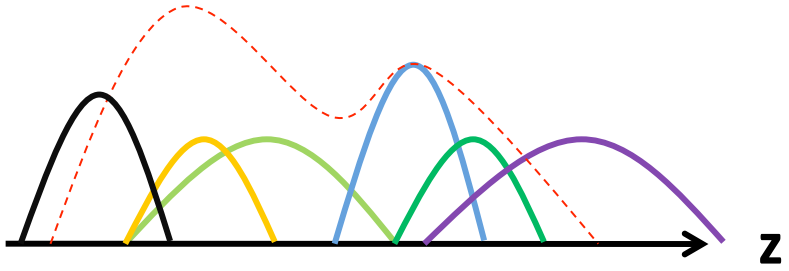

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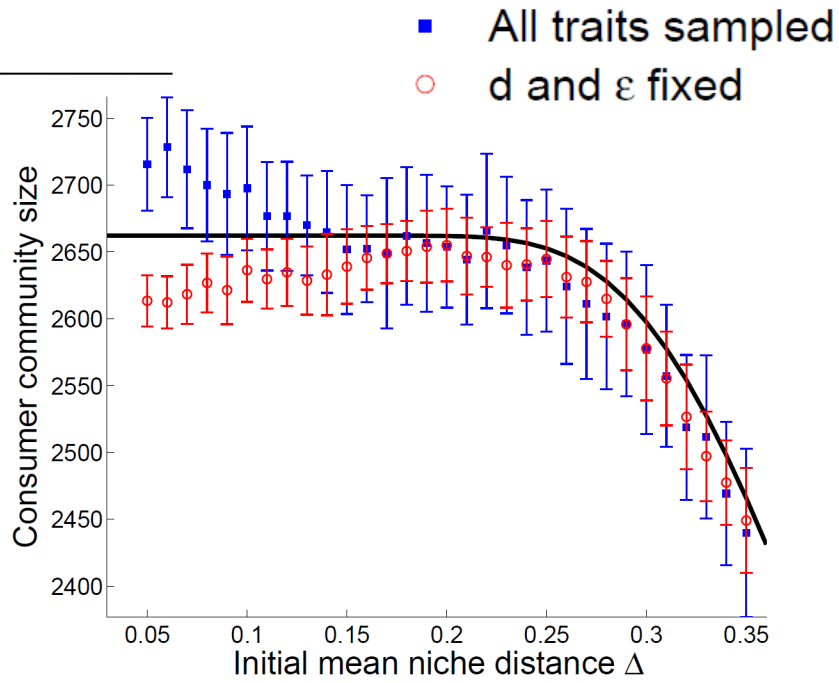

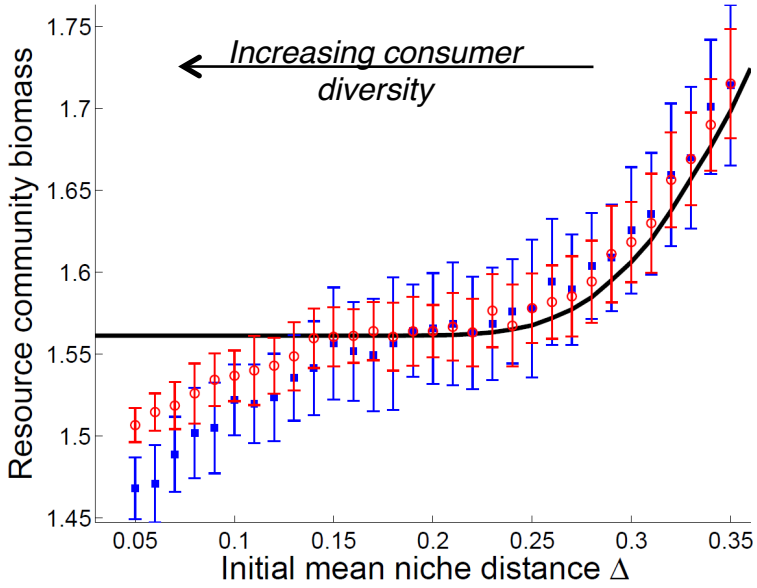

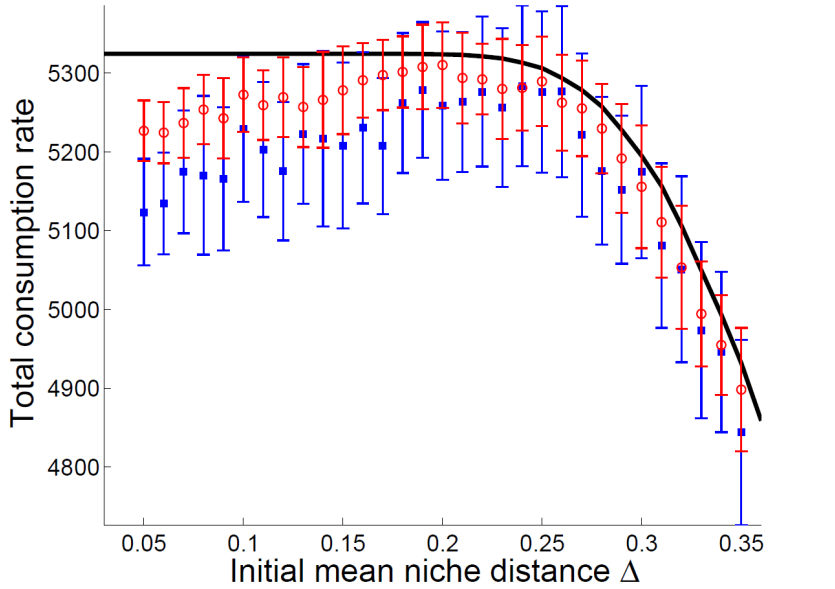

Conclusions

- **Complementarity effects produce saturating relationships, the shapes of which are entirely controlled by ecological interactions**
- **Selection effects can be positive, negative or neutral depending on the function of interest, abiotic factors and relative trait values and variability at the regional scale**
- **Resulting BEF relationship can be monotonic, hump-shaped or saturating but higher consumer diversity always leads to more complete resource depletion**
- **Static approaches could lead to the erroneous prediction that consumers with high niche overlap are redundant and that their extinction has no effect**
- **Competition among resources :**
  - **previous results hold**
  - **weakens the magnitude of complementarity effects**
  - **global coexistence requires an increase in niche breadth with trophic level**
- **The relative magnitude of selection effects compared to complementarity effects may increase with trophic level**

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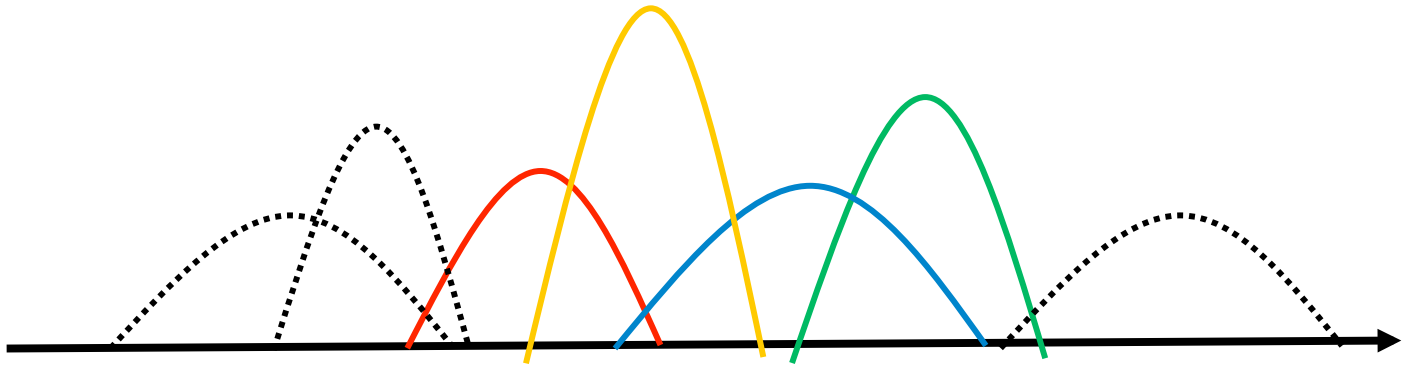
Thank you!



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