METACOMMUNITY ECOLOOGY

Figure 0.1. The Naeem Triptych. As an explanation of the images, Shahid included the following text:

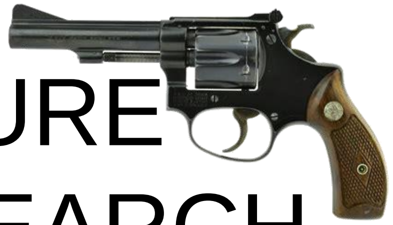
“The outer panels of a triptych open to reveal an inner scene of inspirational images, usually religious in nature. The outer panels differ in quality, either having less color than the inner panels or focused on only a few subjects for whom the triptych was commissioned or inspired by. The paintings are richly iconographic in nature, using animals, plants, objects and religious figures as symbols of the characters and their virtues found in the tales the triptych wishes to portray.

In this triptych, the outer panel represents both evolution and ecology, the processes that inspired the inner panels. People serve as the symbolic representations of these processes, to make the outer panels distinct from the inner. On the left is Wallace, represented by his placement behind Darwin. He is further symbolized by the mosquito on his hand that gave him the malaria that caused the fever that gave him the dream that inspired him to come up with natural selection and evolution as the process by which species originated from ancestors. Darwin is symbolized by the well known tale of his eagerness to collect beetles in which, having already a beetle in each hand, he placed one in his mouth to catch a third. The beetle in his mouth released a noxious chemical onto his tongue which caused him to spit it out. He is shadowed by Wallace since at least one historian believes that Darwin’s synthesis on evolution was not coincidentally simultaneous, but directly inspired by Wallace’s letter that Darwin had in his possession for longer than he confessed. On the right is ecology, symbolized by Hutchinson noting that two corixids have a size ratio of 1.30, shown by holding up one finger on hand and one and three on the other hand (much the way in Christian iconography the three upheld fingers symbolize the Trinity). This simple idea, blown out of proportion to its original intent, is one of the legendary beginnings of ecology’s first paradigm— competition- based community structure. As he was inspired by the corixids found in the pool named in honor of the patron saint Santa Rosalia, the saint appears behind Hutchinson. However, the bones of Santa Rosalia have been scientifically determined to be the bones of a goat, so Santa Rosalia is portrayed as a goat. The lemur on Hutchinson’s shoulder with “FSU” on its sweatshirt symbolizes Florida State University’s challenge to the paradigm that would arise many years later. In each panel the animals represent creatures that are often used as examples of ecology and evolution. The Galapagos finches appear to show Hutchinsonian ratios in bill dimensions and the giant tortoise of the Galapagos Islands demonstrate how creatures can become modified through selection and other evolutionary processes. The inner panels reveal the three special aspects of living systems that inspire biologists. The left panel portrays the remarkable shared history living things have, going back over three quarters of the earth’s history, as known from the fossil record. The central panel shows development, reproduction, and life history strategies symbolized by different developmental stages and birth in a clutch of salamander eggs. Surrounding this central figure are simply other creatures, big and small, that have in common ecologies driven by development, reproduction, and life history processes. The animals were each chosen in part from their iconographic symbolism in Christian art (such as the lion, giraffe, mouse, blackbird) or for connections to adjacent panels (e.g., the dragonfly). Their somewhat fanciful appearance stems from my own mixed perceptions of living things that live justifiably both in the hearts of population dynamic equations and stories, folk tales, and children’s literature. The right panel symbolizes the commonality of death among living things. Again, the creatures were chosen from old triptychs and Christian religious art. For example, the blackbird symbolizes the temptations that draw mortals into the underworld (hence their linkage of the right and central panels). The leopard and bear, as further examples, symbolize cruelty. In the left panel, the Austin Mini Cooper heading off to the castle in the background represents my leaving for Silwood Park, England (not till 24 February 1992) in yet another attempt to learn more about the things in life that inspire me (ecology in an academic setting and little cars).”

Community Ecology

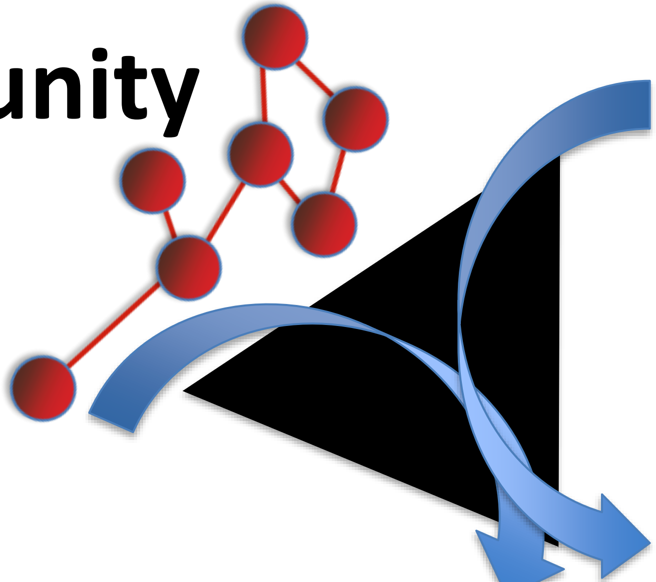
THE COMMUNITY ASSEMBLY WARS

“The null model wars”



FUTURE RESEARCH

The metacommunity concept



Metacommunity analysis

1. Distance Decay
2. Variance Partitioning
3. Metacommunity structure
4. Beta diversity components
   Local Contribution to Beta Diversity-LCBD
5. Null models
6. Multiscale codependence analysis – Joint Spatial Distributions
7. Permutational Simper (PER-SIMPER)
8. Fourth-corner relationships and Community Assembly by Traits Selection (CATS)
9. Univariate community assembly analysis
10. Patch-based graphs & Network analyses

Explaining local composition…

→ **NICHE PROCESSES**

→ **NEUTRAL PROCESSES**

THE COMMUNITY ASSEMBLY WARS

“The null model wars”

Explaining local composition…

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THE COMMUNITY ASSEMBLY WARS

"The null model wars"

Community Ecology

Ecology is '*The scientific study of the interactions that determine the distribution and abundance of organisms*' (Krebs 1994).

Naturalists constantly use information about spatial patterns in abundance. A birder seeking the scarce ocellated antbird *Phaenostictus mcleannani* does not head for random points within its range, but rather aims for **unbroken tracts of lowland rainforest with just the right kind of undergrowth and army ant swarms where this species is most abundant**.

A species' distribution reflects in part its ability to increase when rare – in other words, whether environmental conditions lie within its **niche**

Formally, the niche emerges from a function r(e) describing dependence of population intrinsic growth rates **r** on the environment, e, including abiotic and biotic factors.

r(e) < 0 – The growth of the population decrease (until nobody is left…)

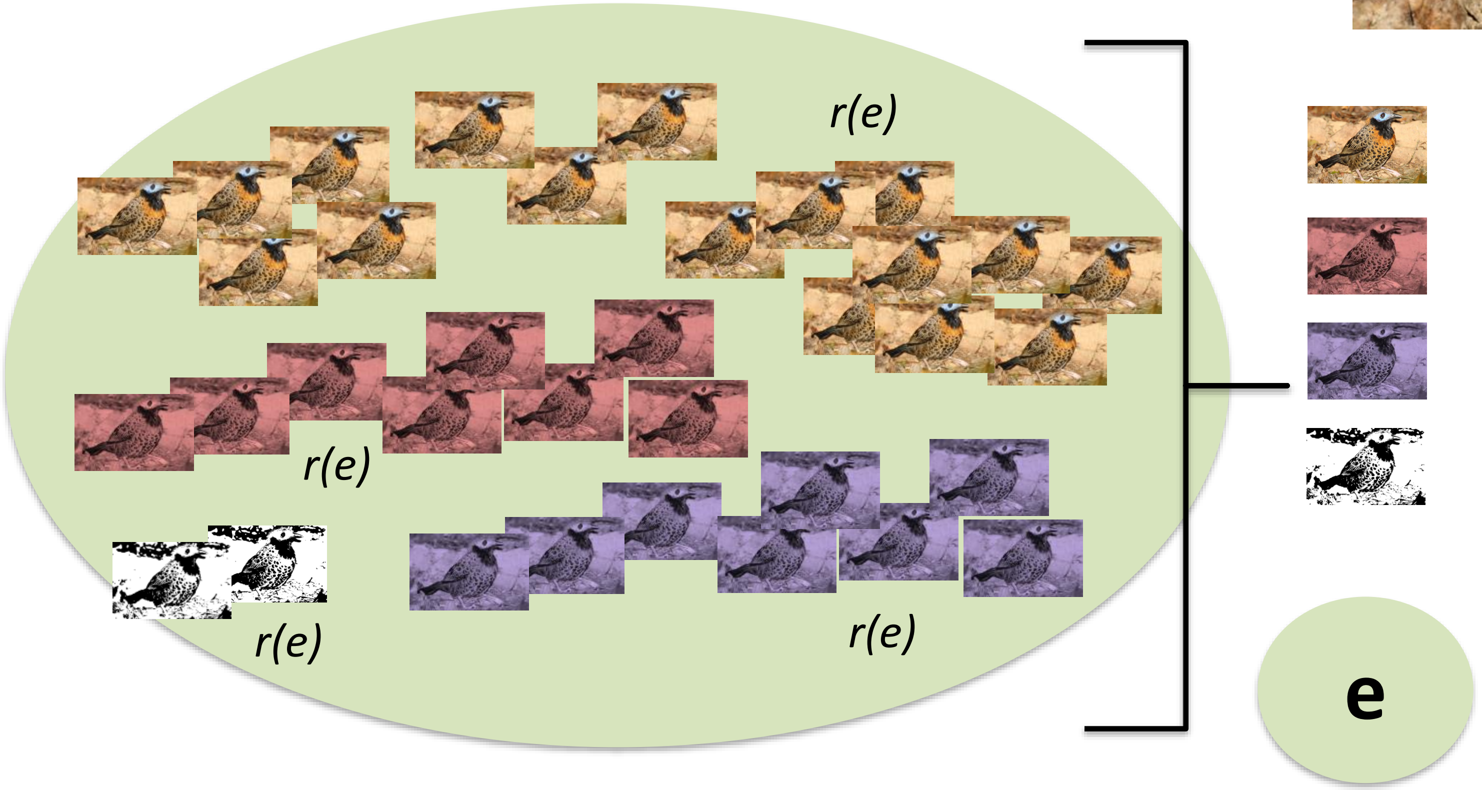
r(e) > 0 – The population abundances increase!

The niche is that set of environments where this inequality holds. (Hutchinson 1978)

Holt, R. D. 2020. Reflections on niches and numbers. Ecography 43:387–390.

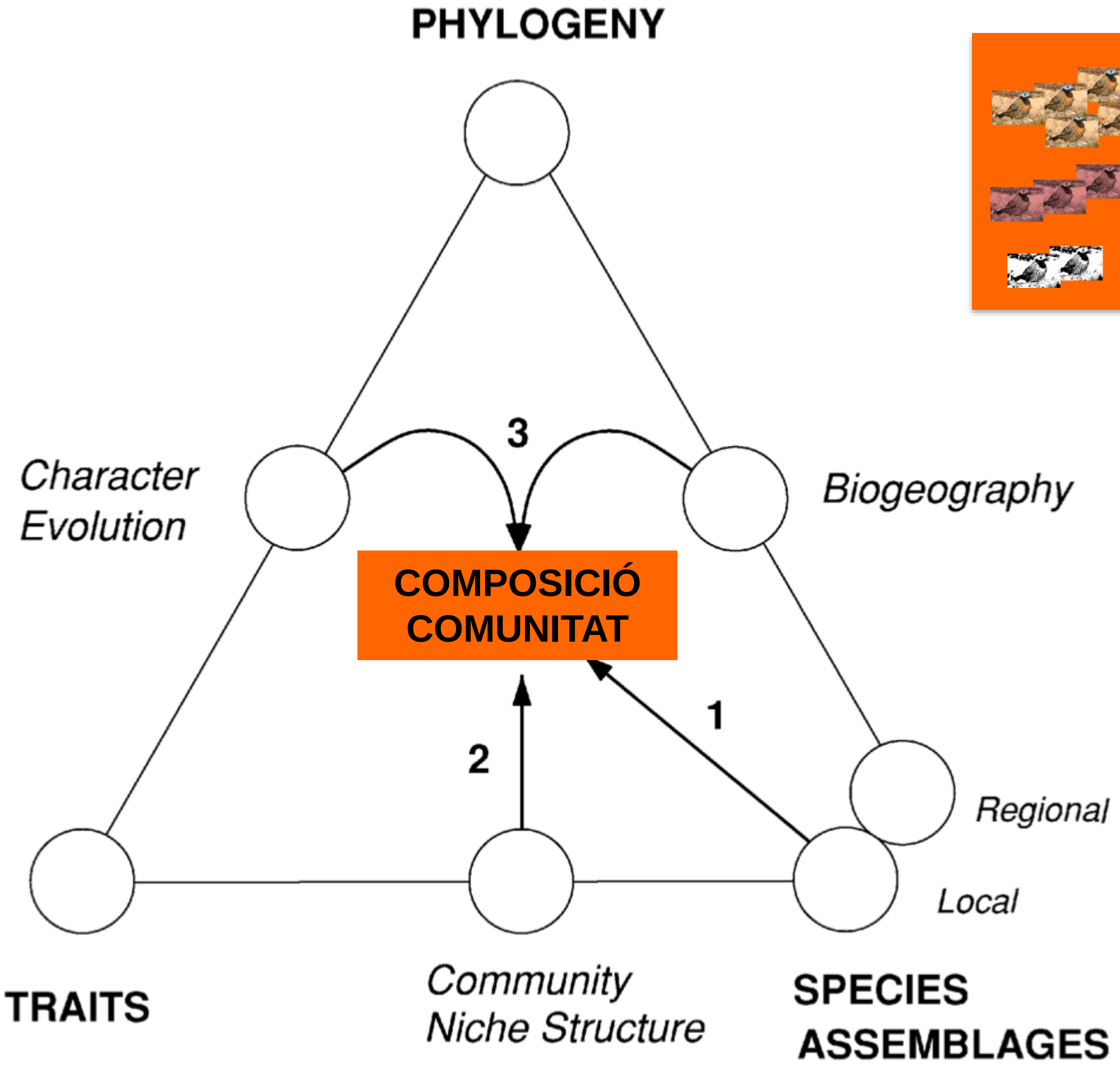
NICHE?

The niche is that set of environments (factors) where this inequality holds.



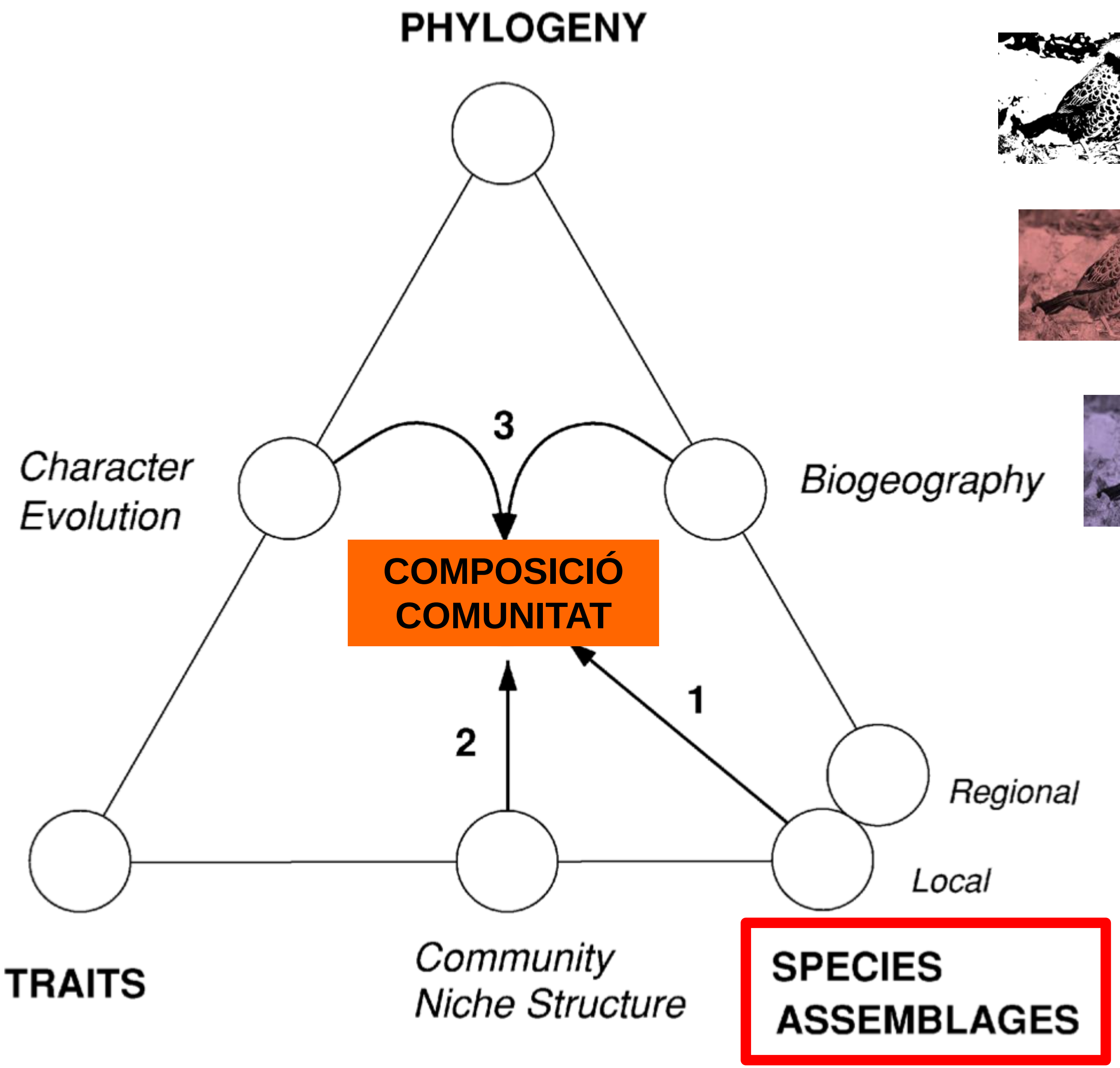
Holt, R. D. 2020. Reflections on niches and numbers. Ecography 43:387–390.

The triumvirate: Species, Traits and Phylogeny



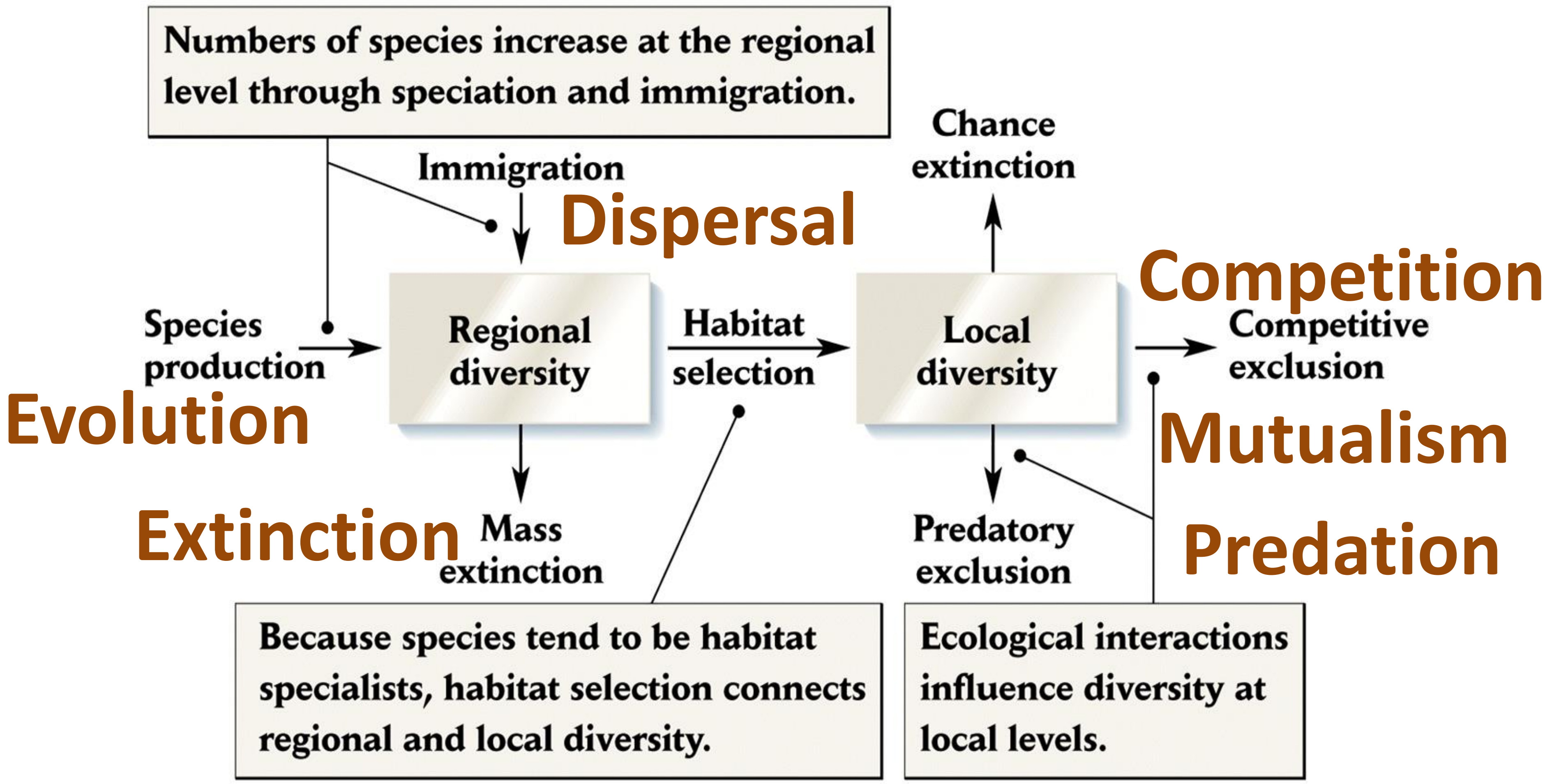
Webb et al. (2002)

Species

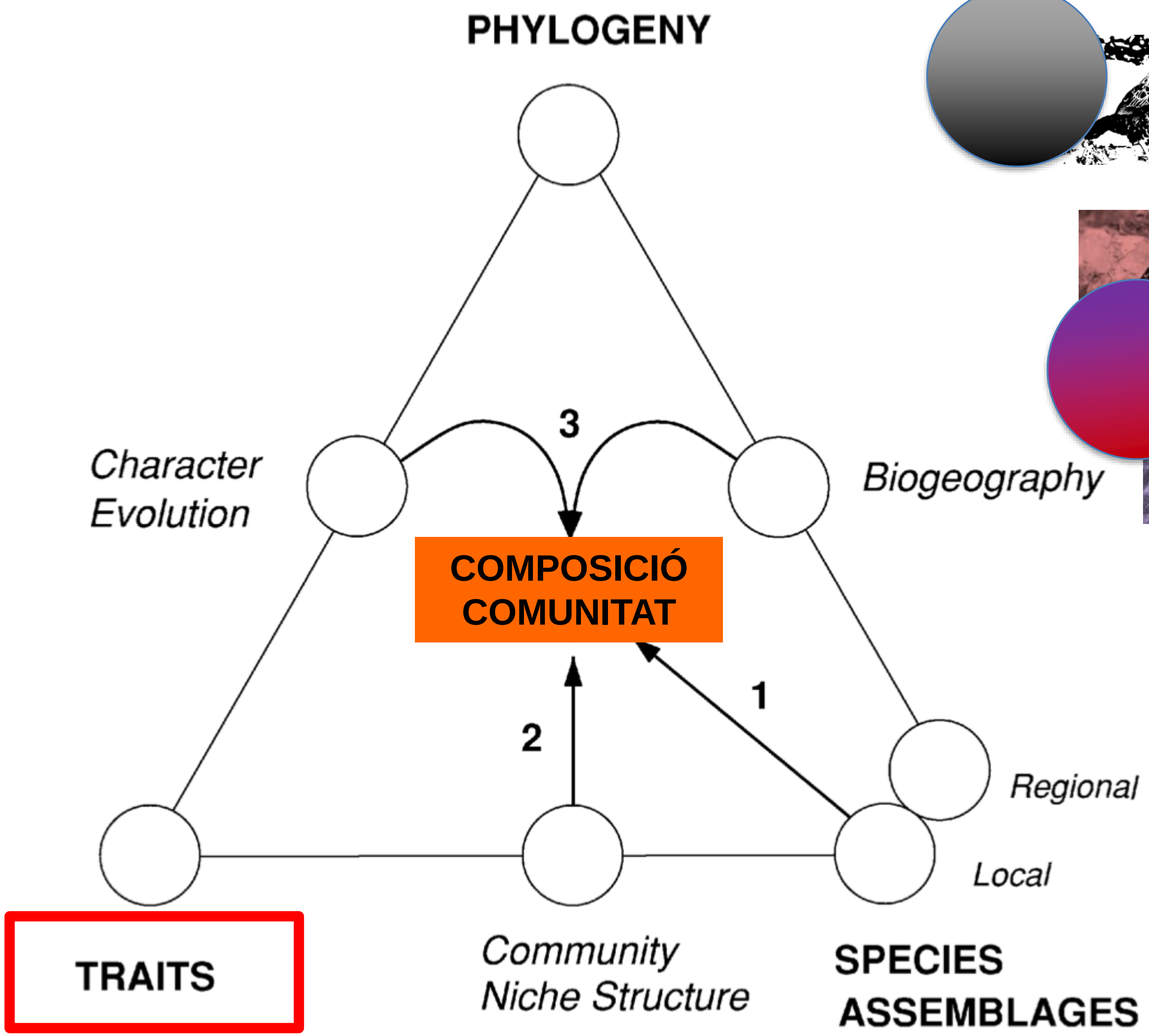


Webb et al. (2002)

Many factors shape regional and local diversity



Traits



Webb et al. (2002)

What is a biological trait?

→ Correspond to taxon-specific characteristics that summarise or represent its biological features (e.g., life cycle, reproduction, morphology, behavior), its mobility, its interaction with other species or the environment.

→ Independent from taxonomy

« Habitat Templet »

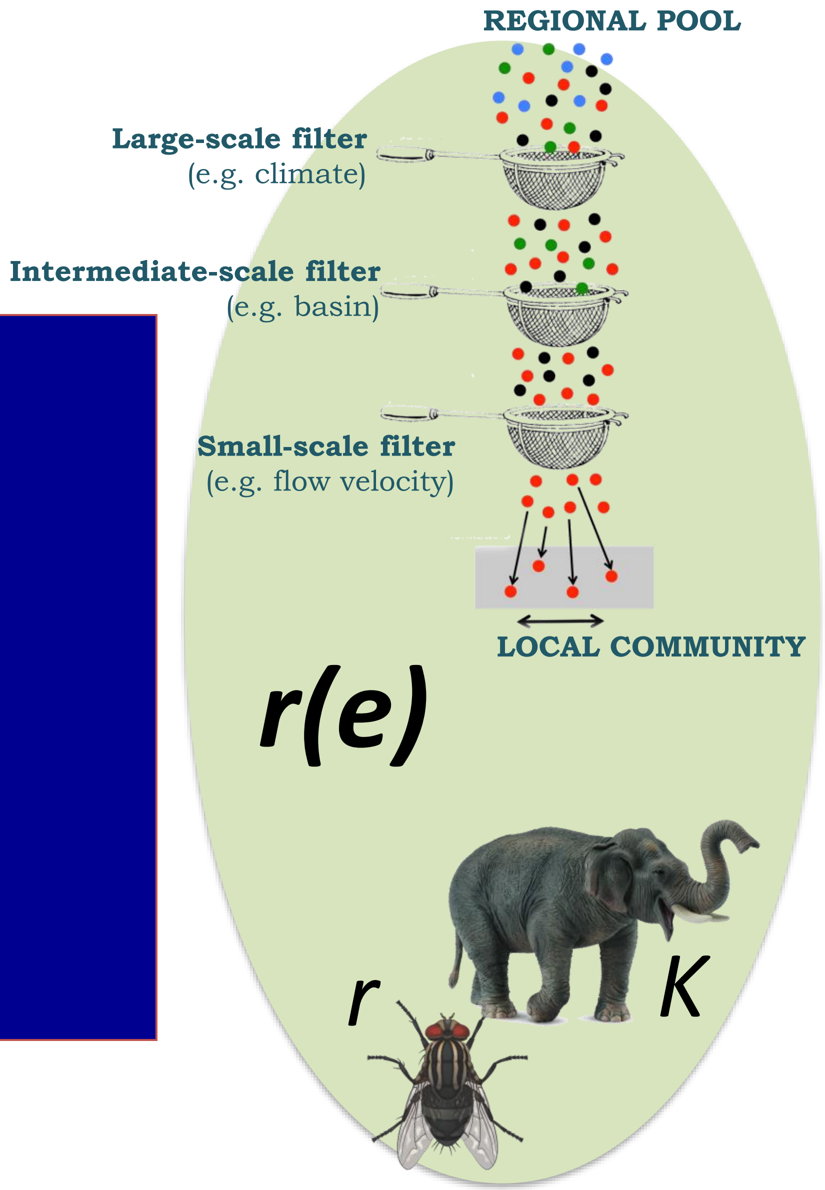
(Southwood 1977, 1988)

Large organisms and small organisms, long-lived and short-lived, those that produce a single young at a time and those whose progeny are counted in terms of thousands - is Nature simply a random assemblage of these traits or are they evolved adaptations to their environment: **adaptations that have increased fitness**.

« Habitat Templet »

(Southwood 1977, 1988)

Habitat filter concept
(Thienemann 1920)
+
Niche Concept
(Hutchinson 1957)
+
r-K concept
(McArthur & Wilson, 1967)



Traits

The habitat is defined by several environmental axes. Every species will fit within them according to their traits…

Body size

Life cycle

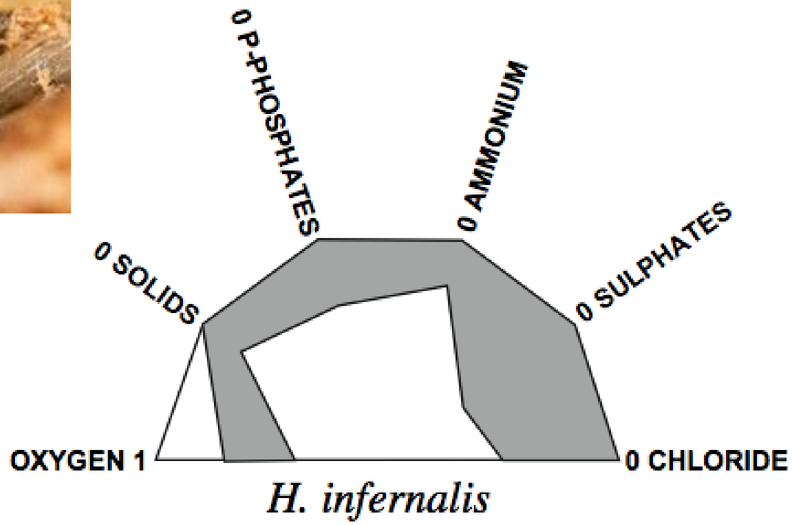
Reproduction type

Dispersal abilities

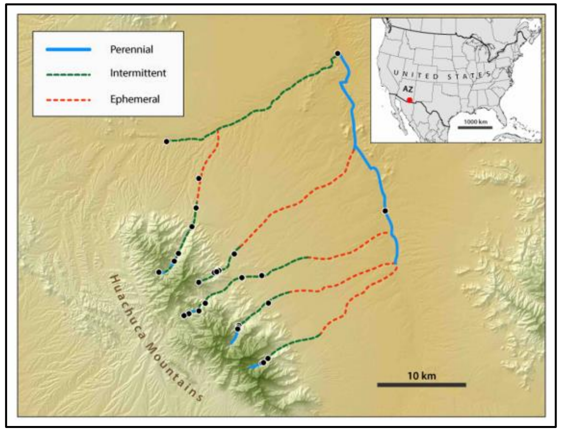
Feeding type

Behaviour

Bonada et al. (2004)



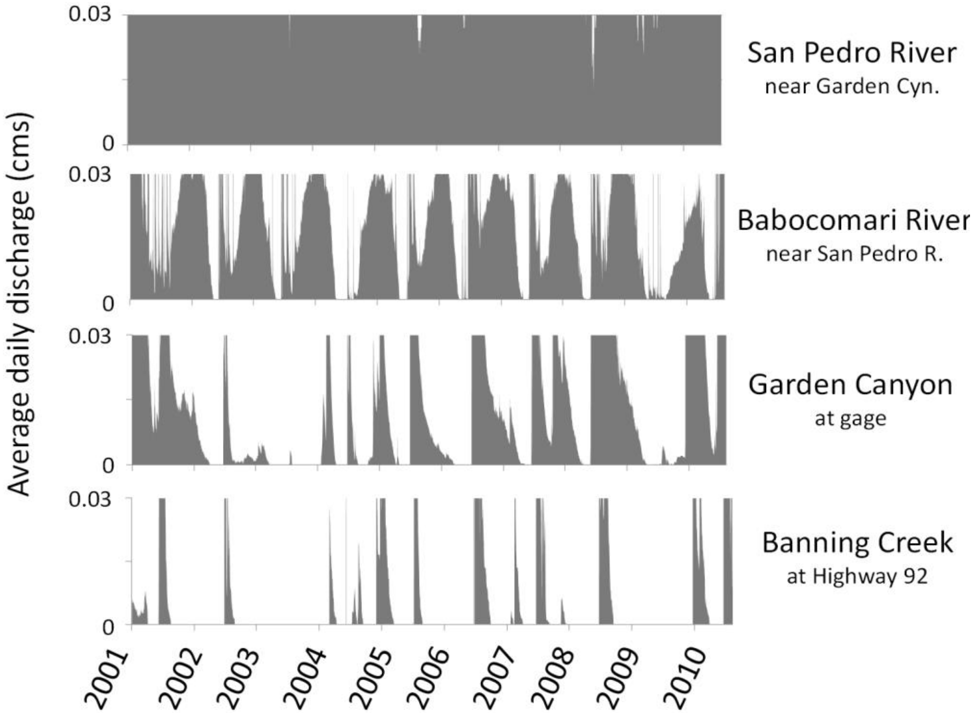
Traits



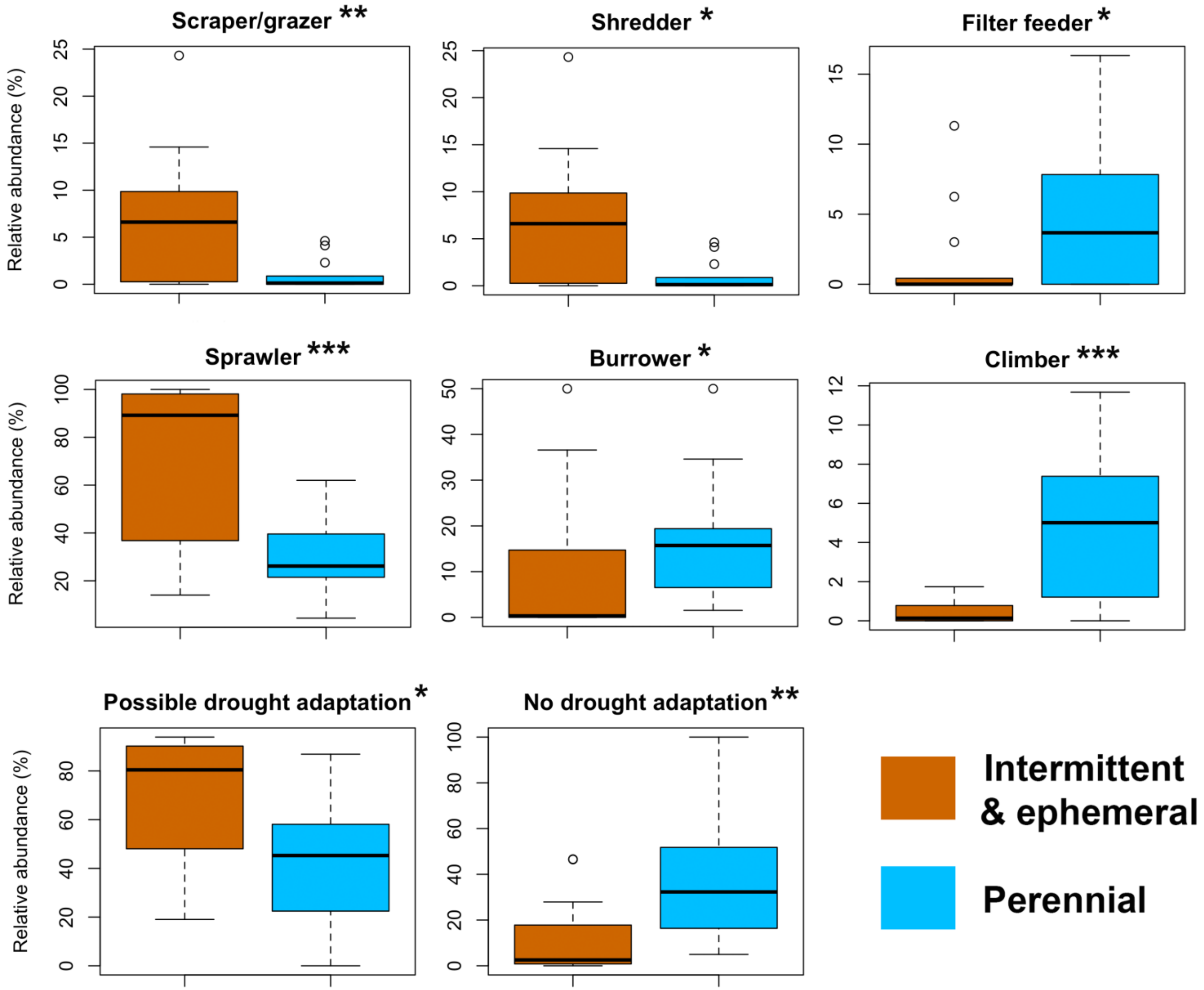
Perennial streams: never cease to flow.

Intermittent streams: dry seasonally.

Ephemeral streams: flow occasionally.

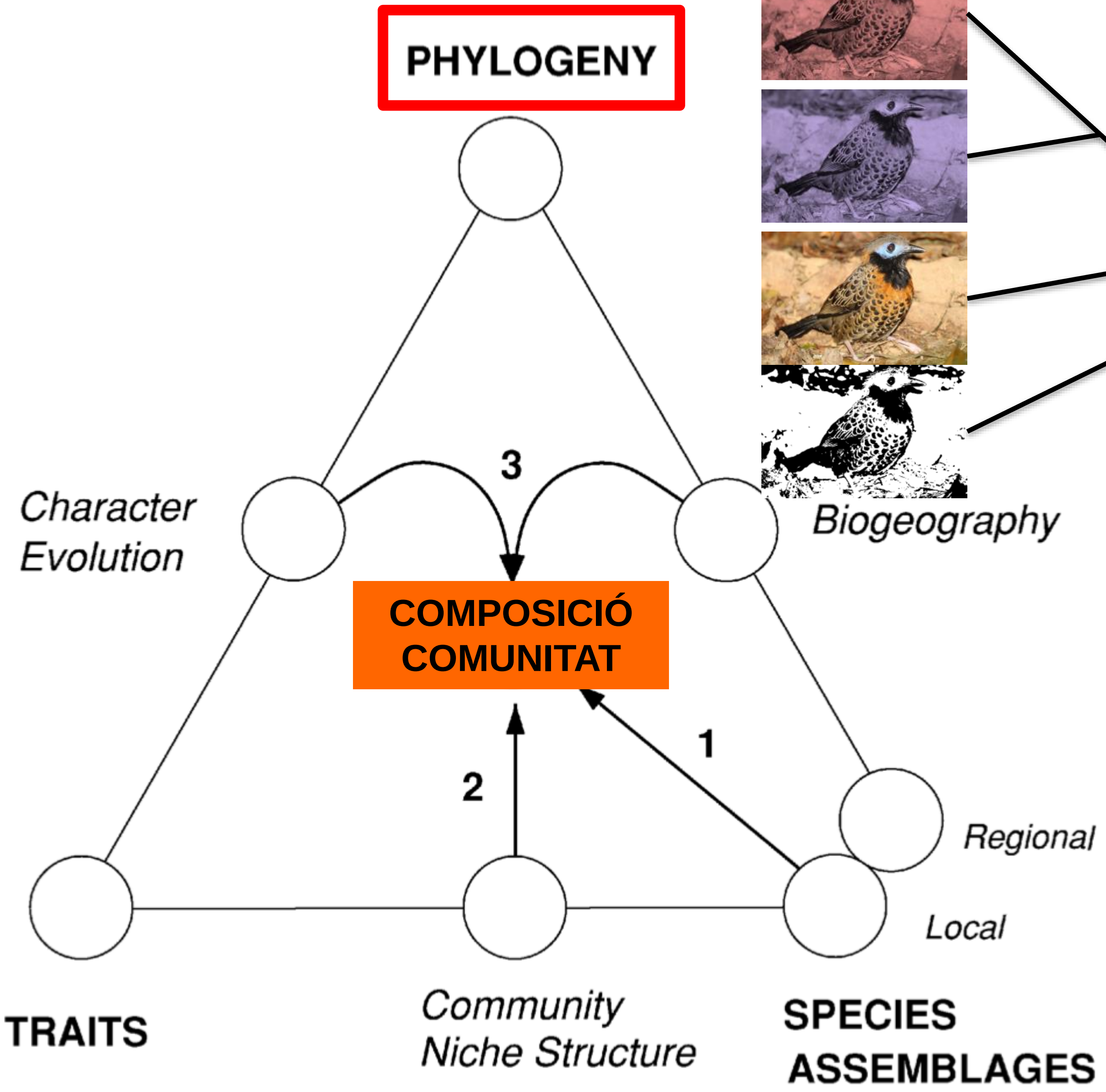


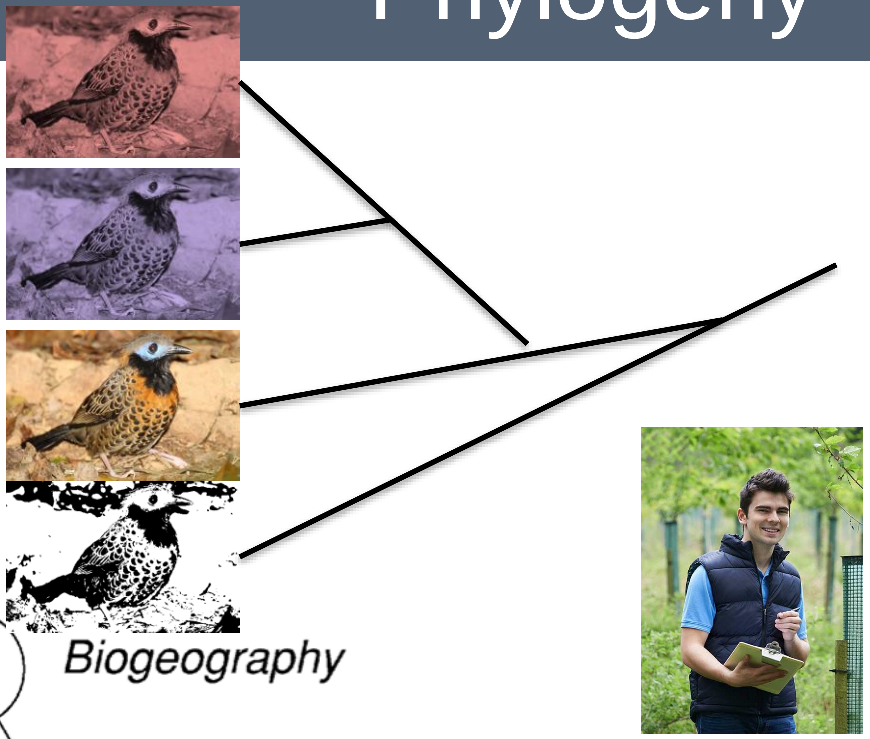
Traits



CAÑEDO-ARGÜELLES M. *et al.* (2016) Ecological indicators 71: 155-162.

Phylogeny





Webb et al. (2002)

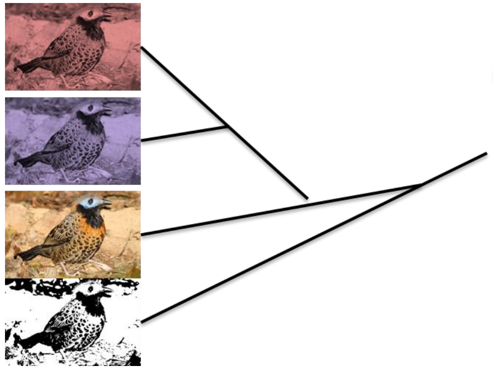
Species coexisting in the same community are the result of changes in a common ancestor…

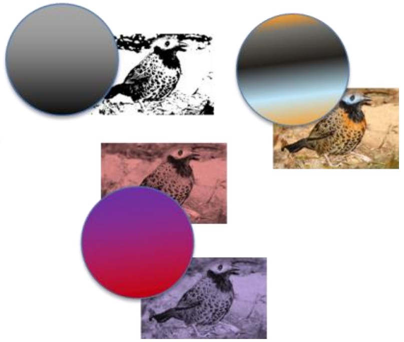
As species of the same genus have usually, though by no means invariably, some similarity in habits and constitution, and always in structure, the struggle will generally be more severe between species of the same genus, when they come into competition with each other, than between species of distinct genera (Darwin 1859).

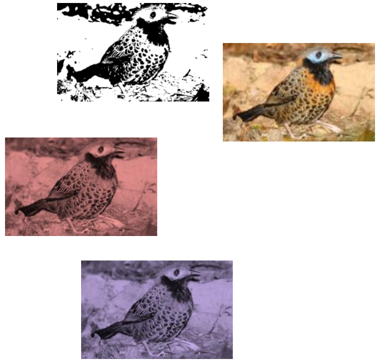
- → Les espècies interaccionen formant comunitats
- → Les espècies interaccionen en relació a les seves diferències i semblances fenotípiques
- → La variació fenotípica té una base evolutiva

Closing the triangle

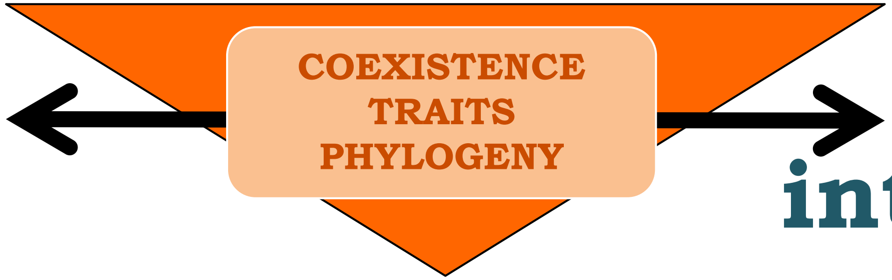
Joining the vertices of the triangle…



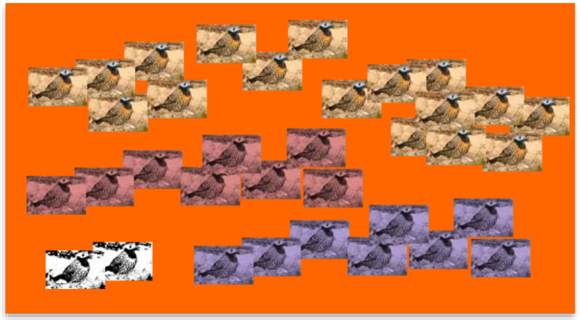




Abiotic “filters”



Biotic interactions



Explaining local composition…

→ **NICHE PROCESSES**

→ **NEUTRAL PROCESSES**

THE COMMUNITY ASSEMBLY WARS

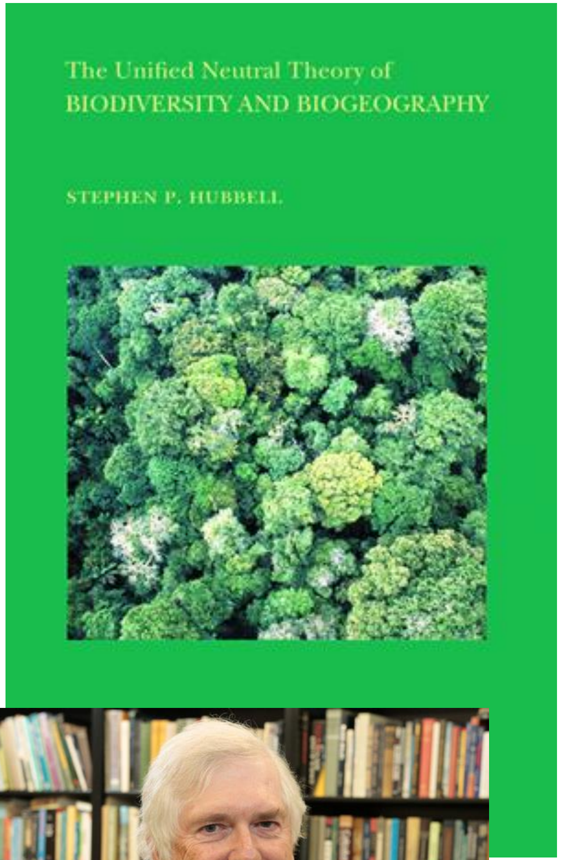
“The null model wars”

https://www.nature.com/scitable/knowledge/library/neutral-theory-of-species-diversity-13259703/

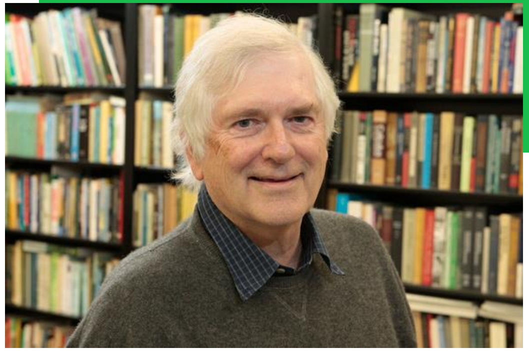
Neutral processes

Hubbell, 2001

All species are **ecologically identical**, and niche differences are not needed to explain community composition.

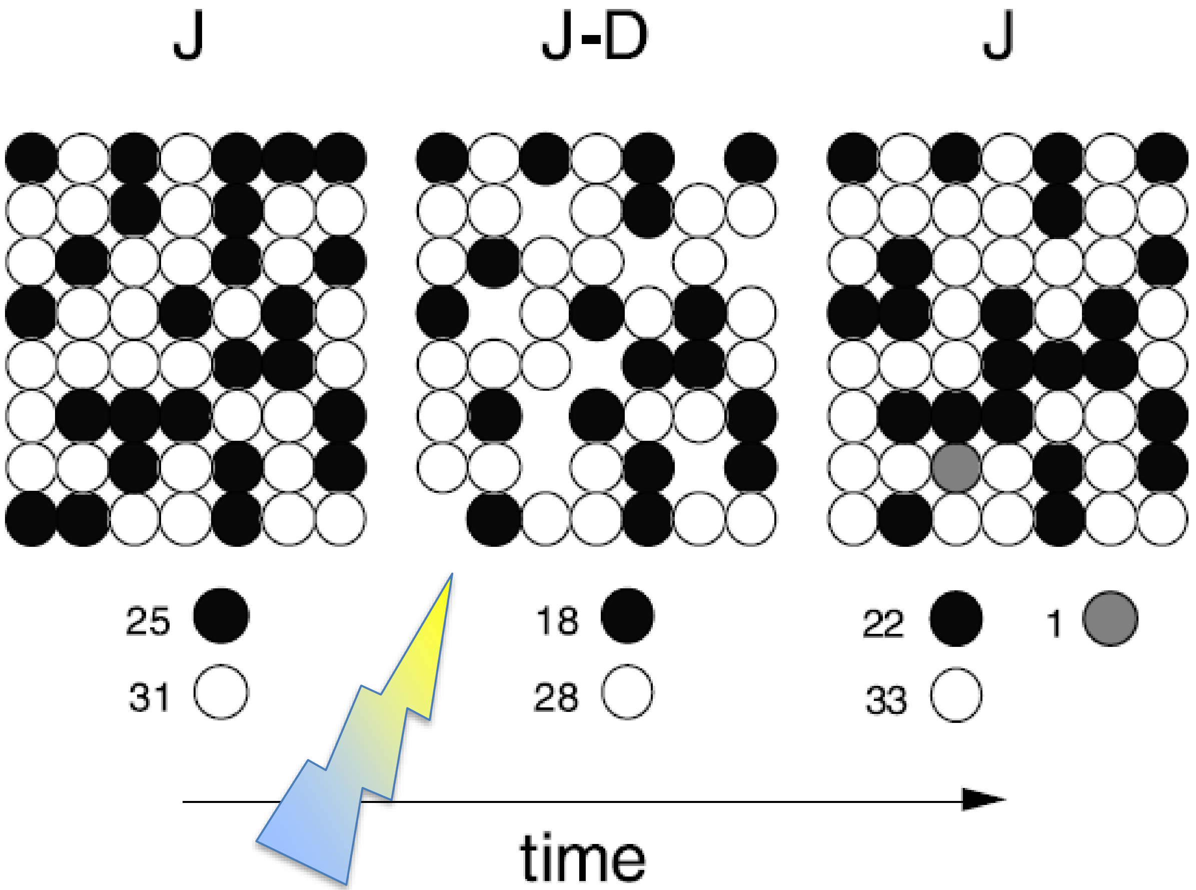


1. **Dispersal**
2. **Speciation**
3. **Extinction**

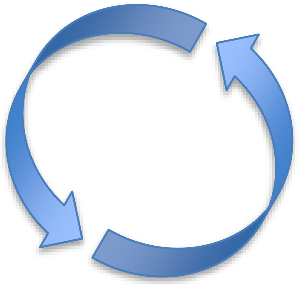


Random extinction, dispersal and speciation

The backbone of neutral theory



"One disturbance cycle"

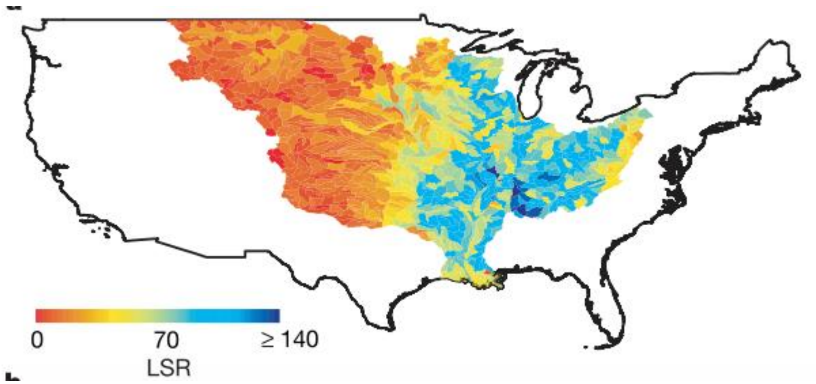


Hubbell, 2001

Neutral processes

Neutral metacommunity models predict fish diversity patterns in Mississippi–Missouri basin

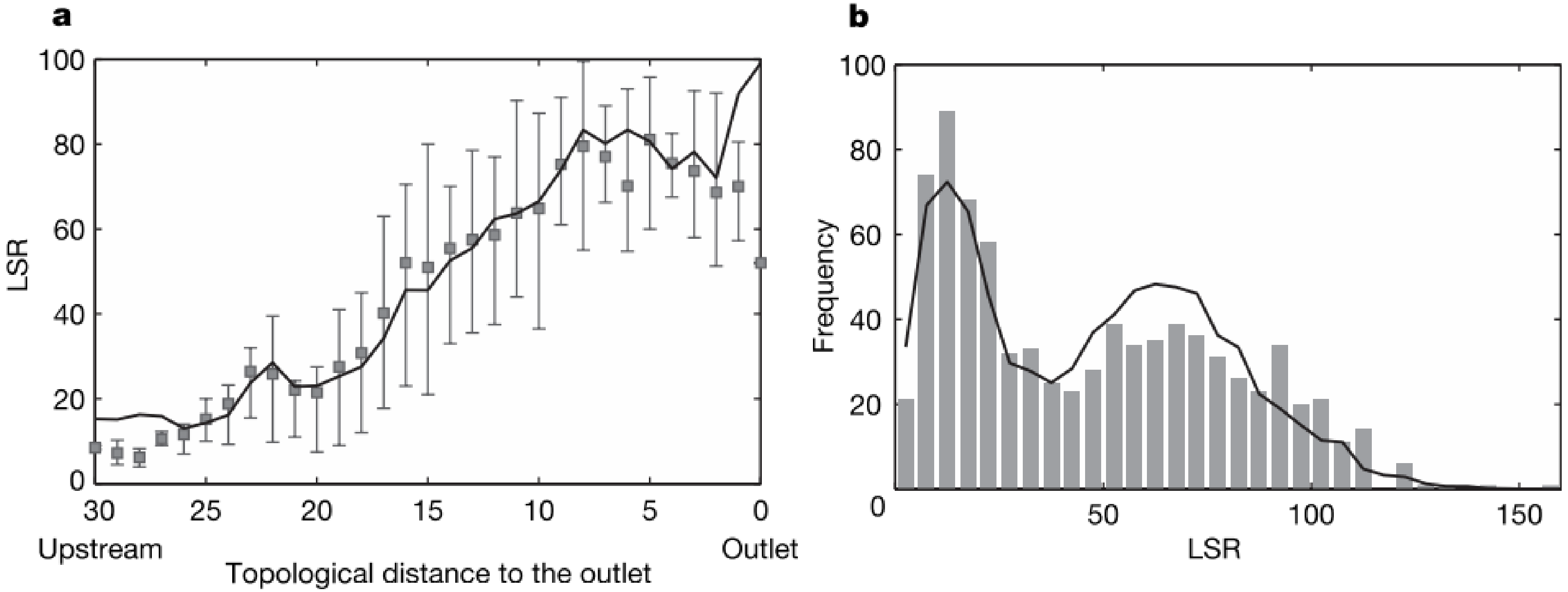
Rachata Muneepeerakul[1], Enrico Bertuzzo[1,2], Heather J. Lynch[3], William F. Fagan[3], Andrea Rinaldo[2,4] & Ignacio Rodriguez-Iturbe[1]

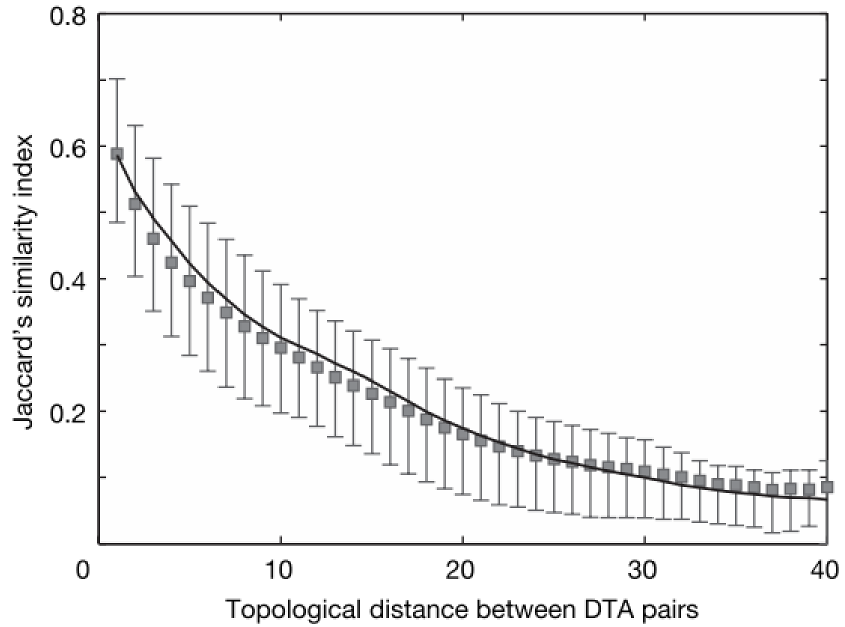


1. We use **river network** as the structure of the metacommunity.
2. Each **basin** is a **local community** in that metacommunity and has a different fish-habitat capacity, **“H”**, defined as the number of ‘fish units’ sustainable by resources in that particular basin (“**fish unit**” represents a **subpopulation of a fish species**)
3. “H” is proportional to the product of the **basin watershed area** and **average flow**.
4. The model uses the **topological distances** between basins because they are representative of how far fish can swim (dispersal kernel).
5. The model captures basic ecological processes: **birth, death, dispersal, colonization and diversification.**
6. The simulations are run until the system reaches a steady state; the biodiversity patterns of interest are then determined and **compared with the empirical patterns**.

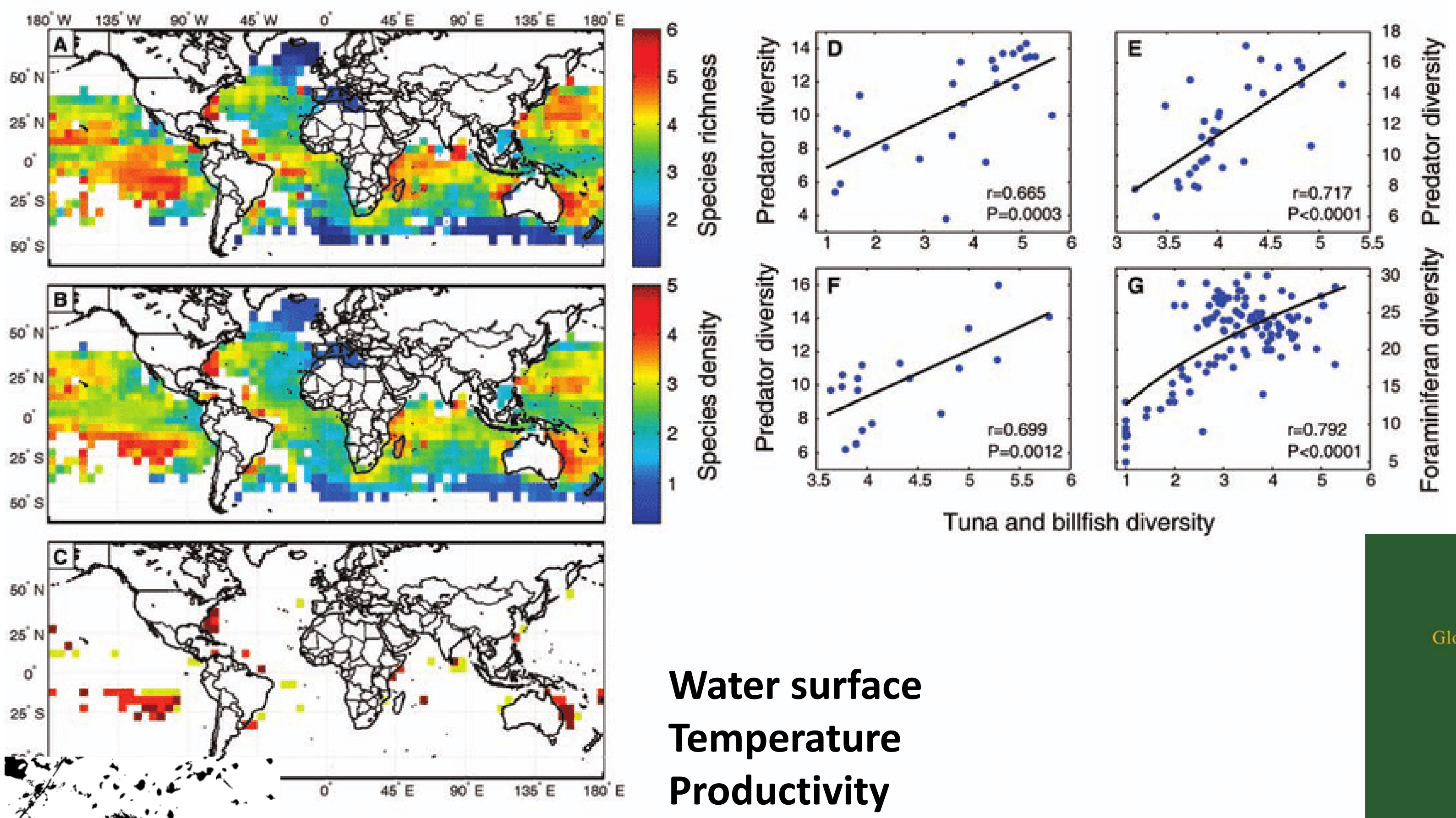
Muneepeerakul, R., E. Bertuzzo, H. J. Lynch, W. F. Fagan, A. Rinaldo, and I. Rodriguez-Iturbe. 2008. Neutral metacommunity models predict fish diversity patterns in Mississippi-Missouri basin. Nature 453:220–222.

Neutral processes

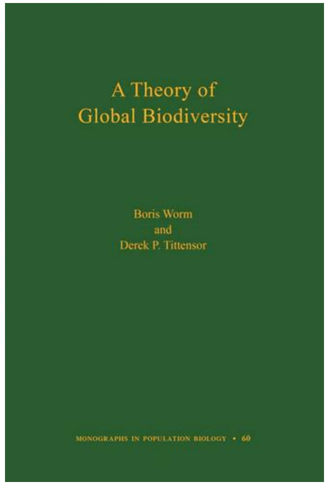




Neutral processes



Water surface
Temperature
Productivity

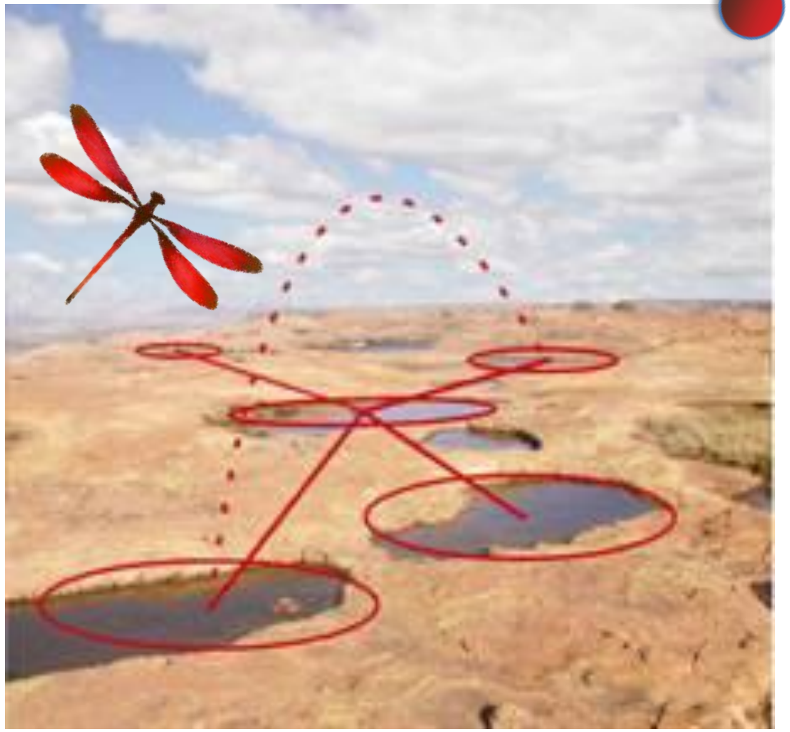


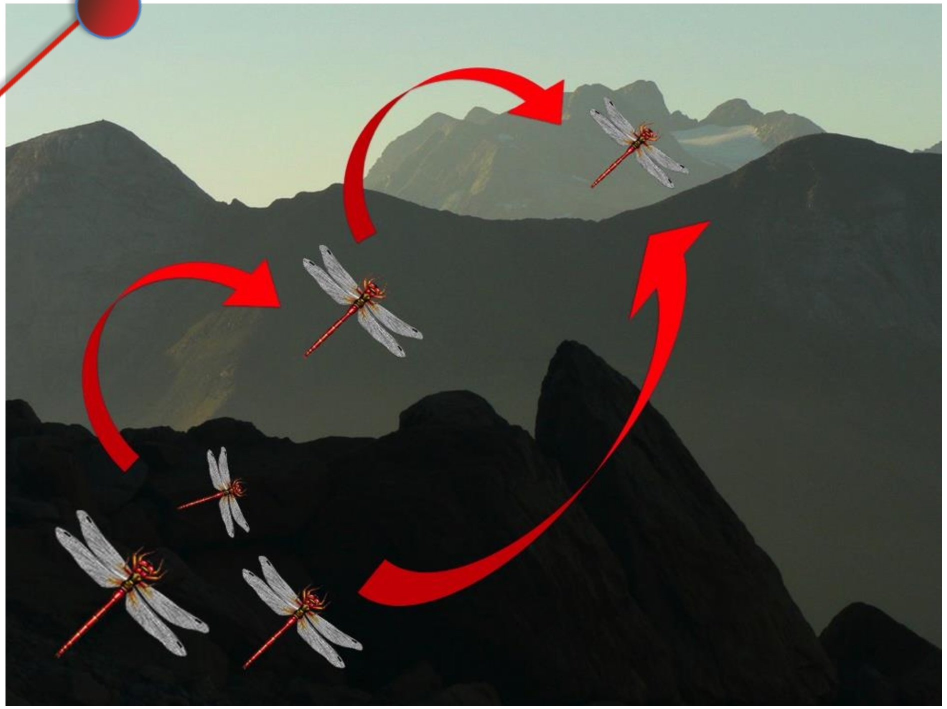
Worm, B., and D. P. Tittensor. 2018. A Theory of Global Biodiversity. Princeton University Press.

THE COMMUNITY ASSEMBLY WARS

Not mutually exclusive

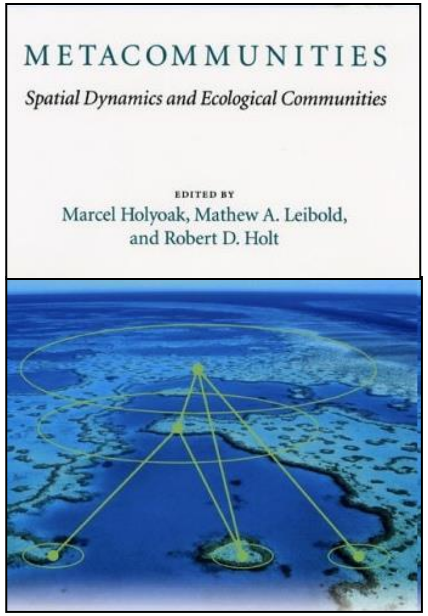
The metacommunity concept



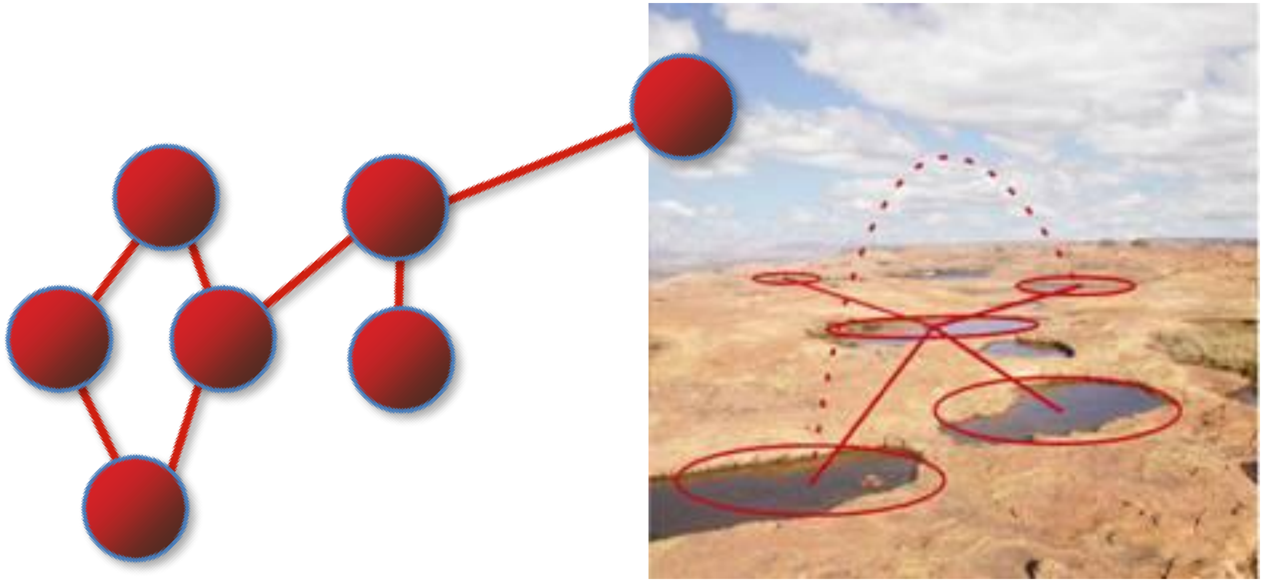


METACOMMUNITIES

It highlights the relevance of dispersal, speciation in COMMUNIT ASSEMBLY



Metacommunity = a set of local communities that are linked by dispersal of multiple **potentially interacting** species



Metacommunities

Table 1. Comparison of metapopulation and metacommunity concepts and their applications in empirical studies. These disciplines have separate histories and perspectives; greater integration of approaches is highly desirable

	Metapopulations	Metacommunities
Scale of ecological organization	Population (single species)	Community (multi-species)
Focus	Persistence	Species composition
Models	*Homogeneous patches:* Levins *Heterogeneous patches:* spatially realistic metapopulation theory, source-sink	*Homogeneous patches:* patch dynamics, neutral* *Heterogeneous:* mass effects, species sorting
Parameters	Focus on colonization and extinction rates	Focus on colonization, extinction and local growth rates as a function of dispersal rates and interspecific interactions
Measurements	Population size, occupancy	Alpha and beta diversity, variance in community composition
Heterogeneity	Focus on suitable vs. not suitable habitats	Focus on resource gradients
Challenges to empirical testing	Designating patches, defining suitable habitat Estimating colonization and extinction	Designating communities arbitrarily

*Neutrality focuses on equivalence of demographic performance among species and does not necessarily assume all sites are environmentally homogeneous.

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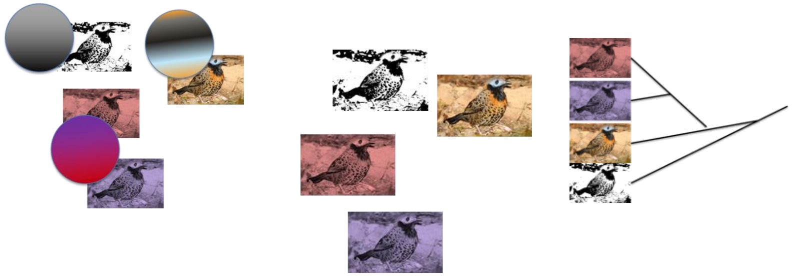
Metacommunities

*A metacommunity will be a **spatially coherent congregation** of local communities which, by virtue of their spatial proximity can potentially **sustain** species populations and in our study-cases, where **more than one species is considered, metacommunities**.*

Boothby, J. 1997. Pond conservation: towards a delineation of pondscape. Aquatic Conservation: Marine and Freshwater Ecosystems 7:127–132.

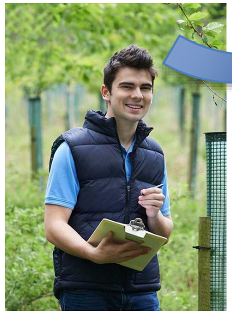


Stochasticity or Neutrality

“One disturbance cycle”

Neutral assembly

Niche assembly



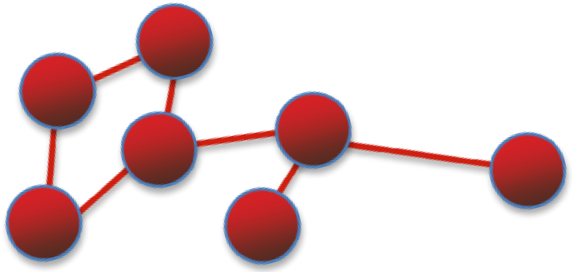
Abiotic “filters”

Biotic interactions

Metacommunities

A set of local communities that are linked by **DISPERSAL** of multiple **potentially interacting** species

Dispersal

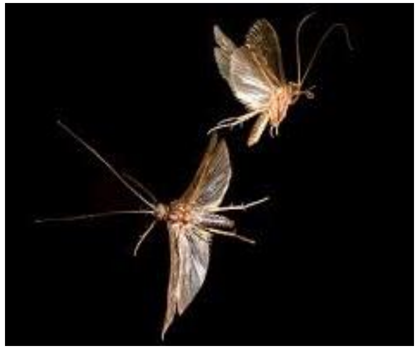


Stochasticity or Neutrality

Abiotic "filters"

Biotic interactions

FACTORS DE DISPERSIÓ ENDÒGENS



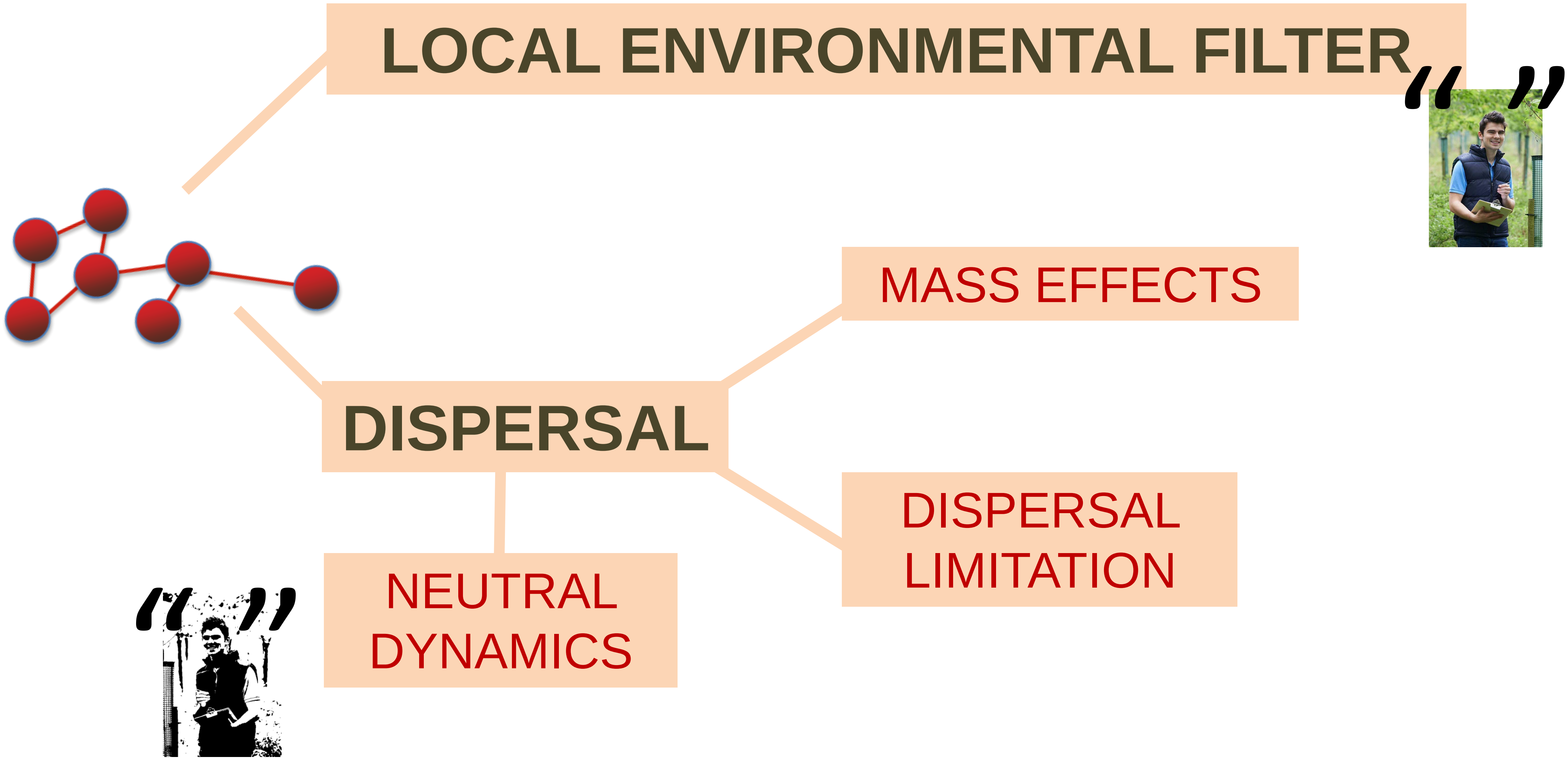

FACTORS DE DISPERSIÓ EXÒGENS



Community consequences of dispersal

- Dispersal brings new species
- Dispersal allows persistence in unsuitable habitat (“sinks”)
- If dispersal ability is negatively correlated with competitive ability (i.e., there is a tradeoff) across species, stable coexistence can be maintained
- Dispersal can counteract (or reinforce) local selection
- Dispersal can counteract drift

Metacommunity “models”



Metacommunity “models”

- **Environmental filtering**: based on the **ecological niche.** If we find an species in a determined place is because in that place there are specific environmental conditions that are favouring its presence. Relation between an species and its ecological niche.

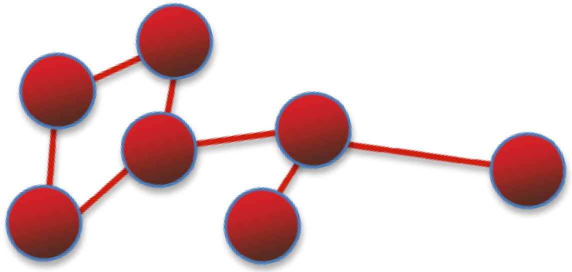
- **Dispersal limitation:** The absence of an species in a determined place is due to the fact that this species has not been able to reach that place (through dispersal) even though the the environmental conditions of the place would allow the species to live there.

- **Mass effects**: If that species is able to exist in that place is because there is so much dispersal (many individuals arriving either due to “wind”, “water flow” or any other major force) that even if the environment is negative (strong filter) for that species its population can remain in that place.

- **Neutral/Random**: There is no connection between environemtnal or spatial (dispersal) drivers and the presence of a determined species… its presence is therefore completely “random”.

Metacommunity “models”

Dispersal



Environmental filtering

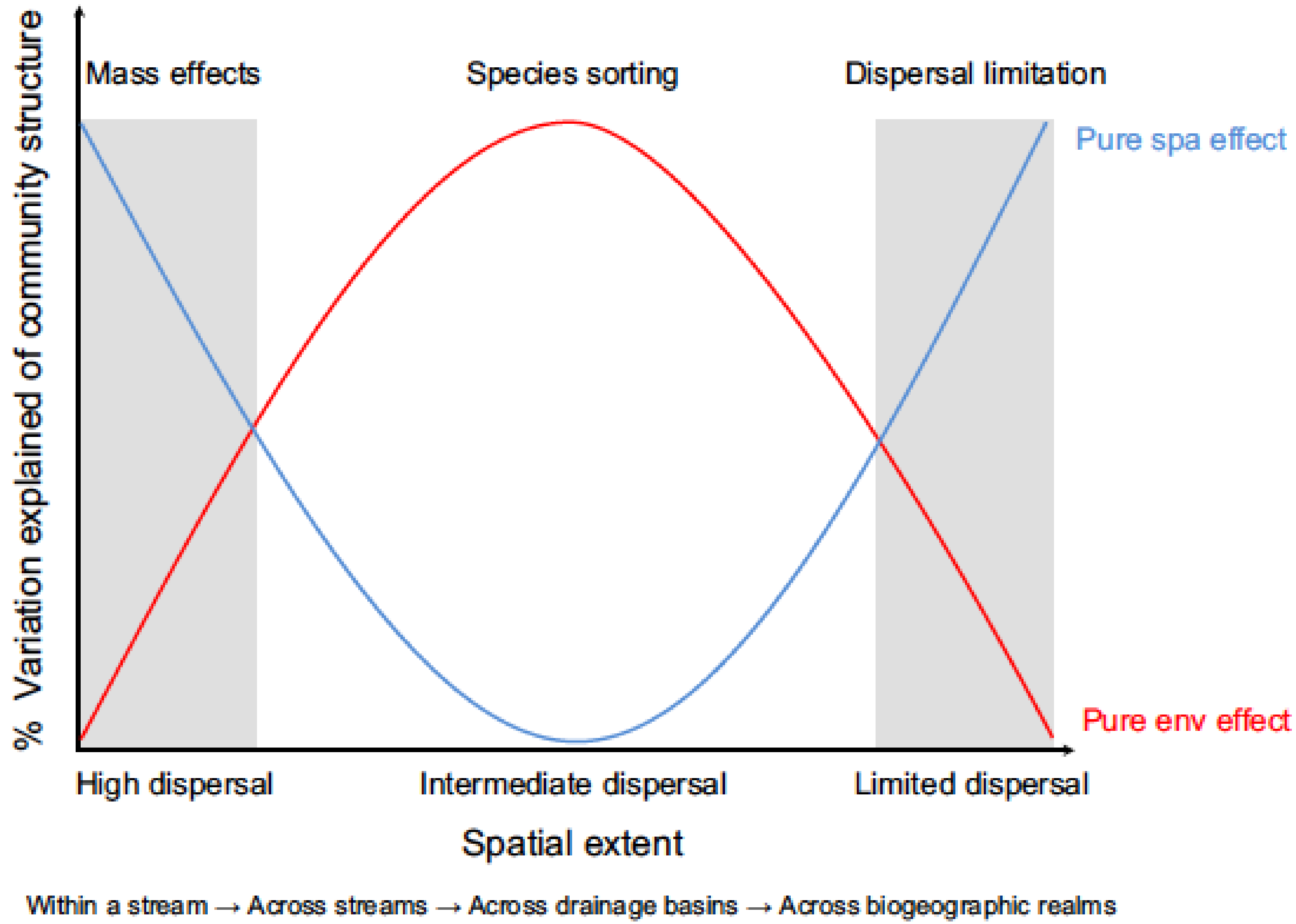
Dispersal limitation

Mass effects

Neutral/Random

METACOMMUNITIES

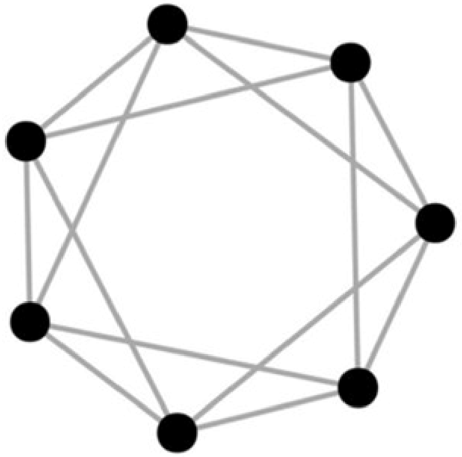
Metacommunity “models”



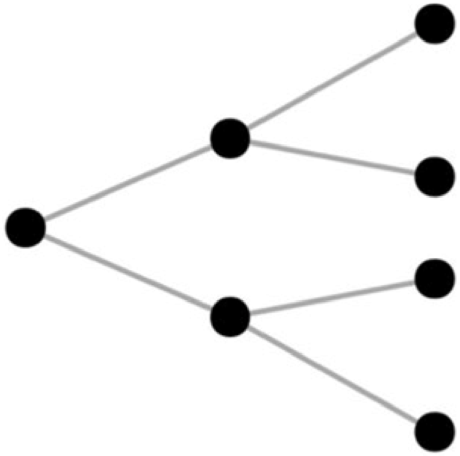
Heino, J., A. S. Melo, T. Siqueira, J. Soininen, S. Valanko, and L. M. Bini. 2015. Metacommunity organisation, spatial extent and dispersal in aquatic systems: patterns, processes and prospects. Freshwater Biology 60:845–869.

Dispersal structure (metacomm's skeleton)

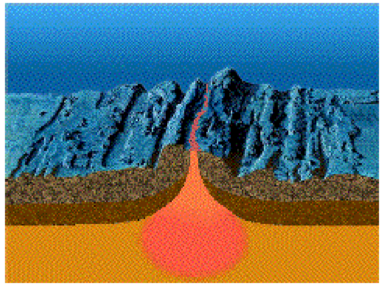
LATTICE

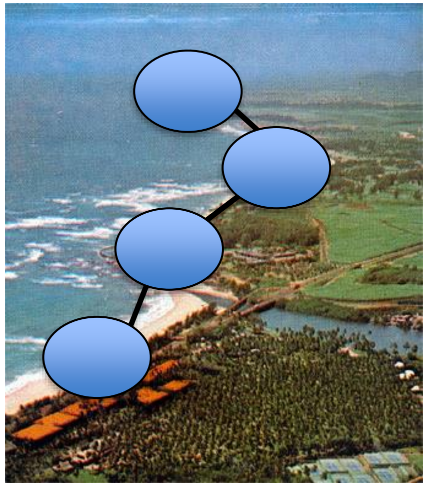


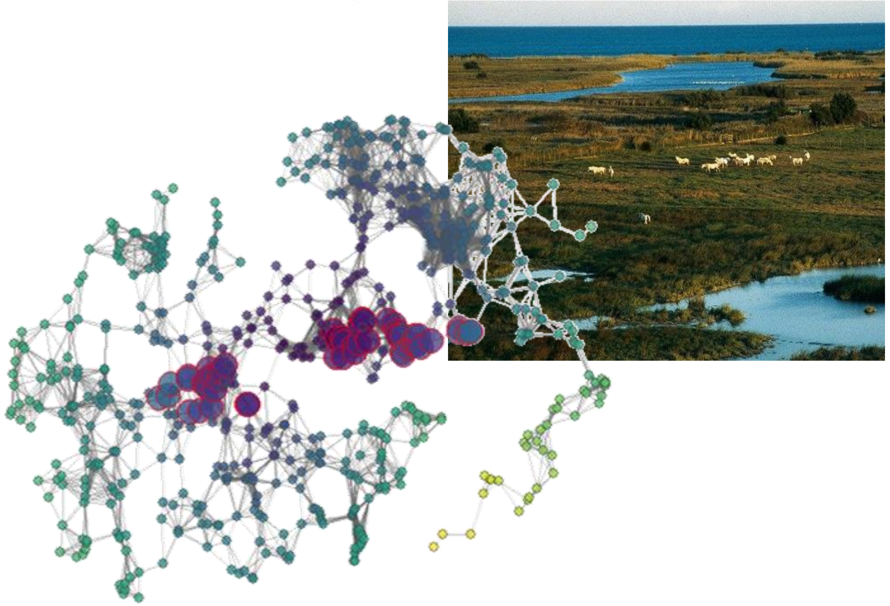
DENDRÍTIC

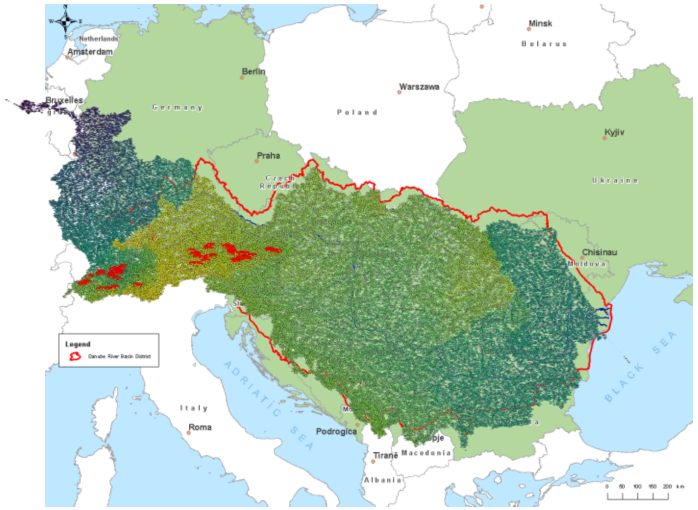


LINEAL



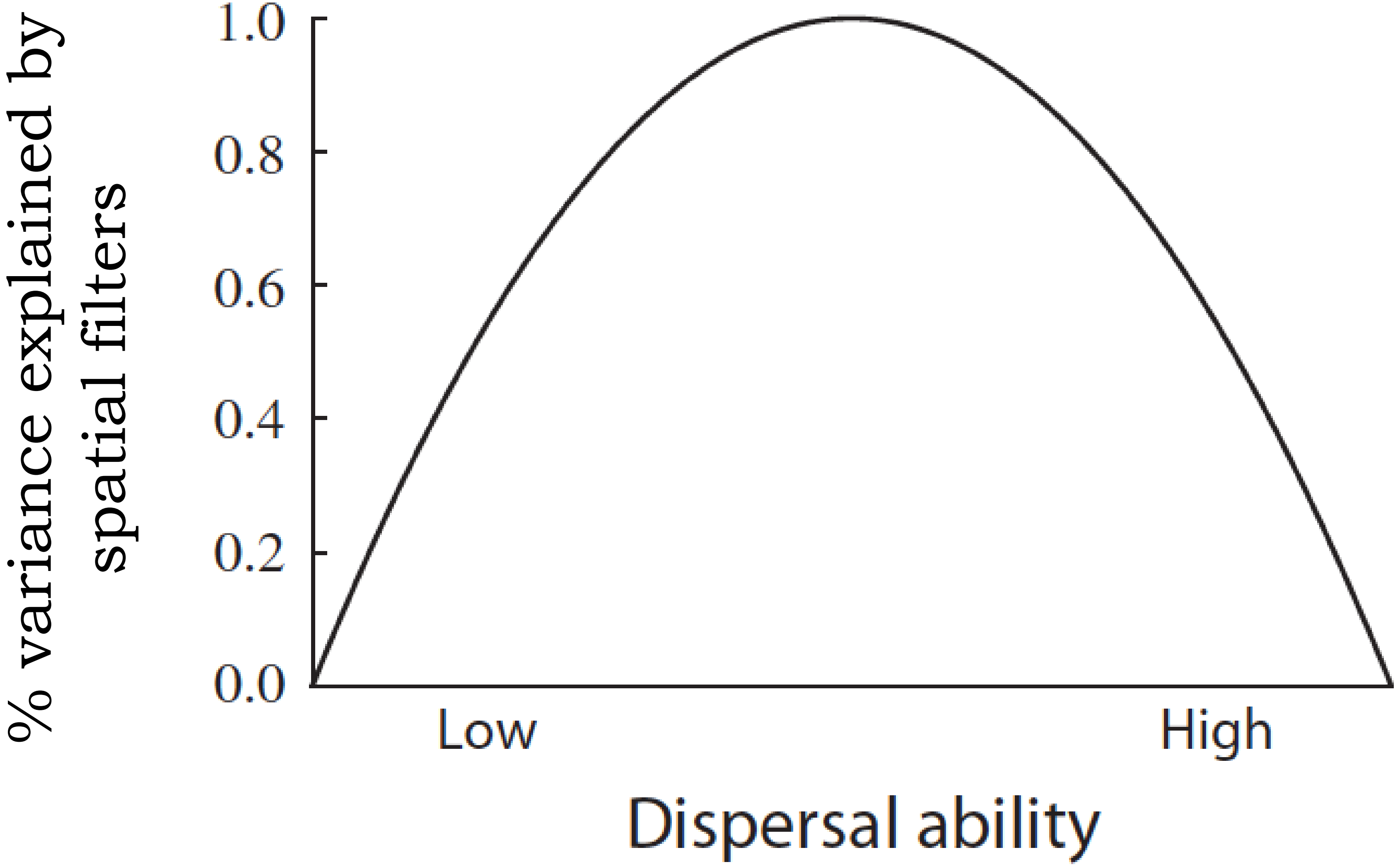






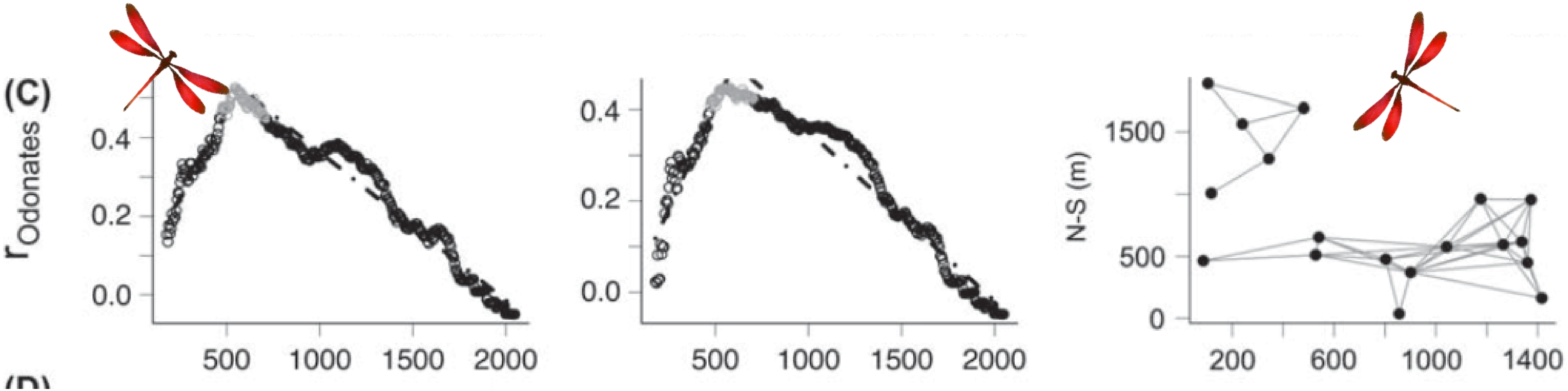
Dispersal structure (metacomm's skeleton)

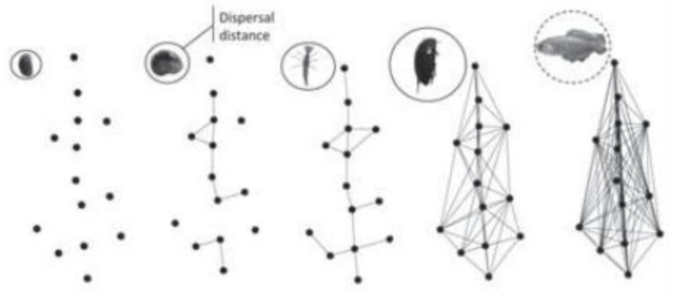
Phillipsen et al. , 2015



Dispersal structure (metacomm’s skeleton)

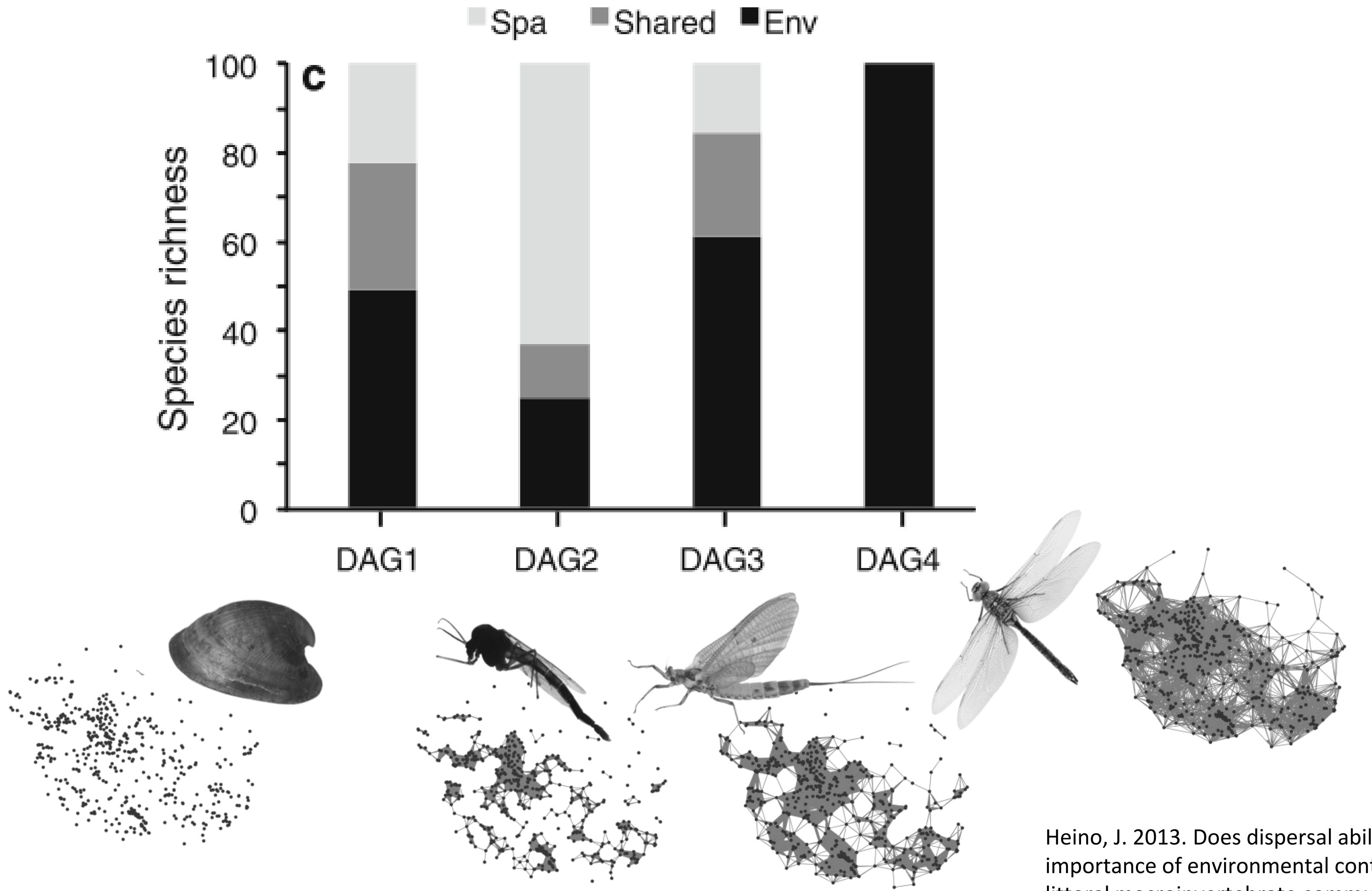
Disentangling the effects of local and regional processes on biodiversity patterns through taxon-contingent metacommunity network analysis





Borthagaray, A. I., M. Berazategui, and M. Arim. 2015. Disentangling the effects of local and regional processes on biodiversity patterns through taxon-contingent metacommunity network analysis. Oikos 124:1383–1390.

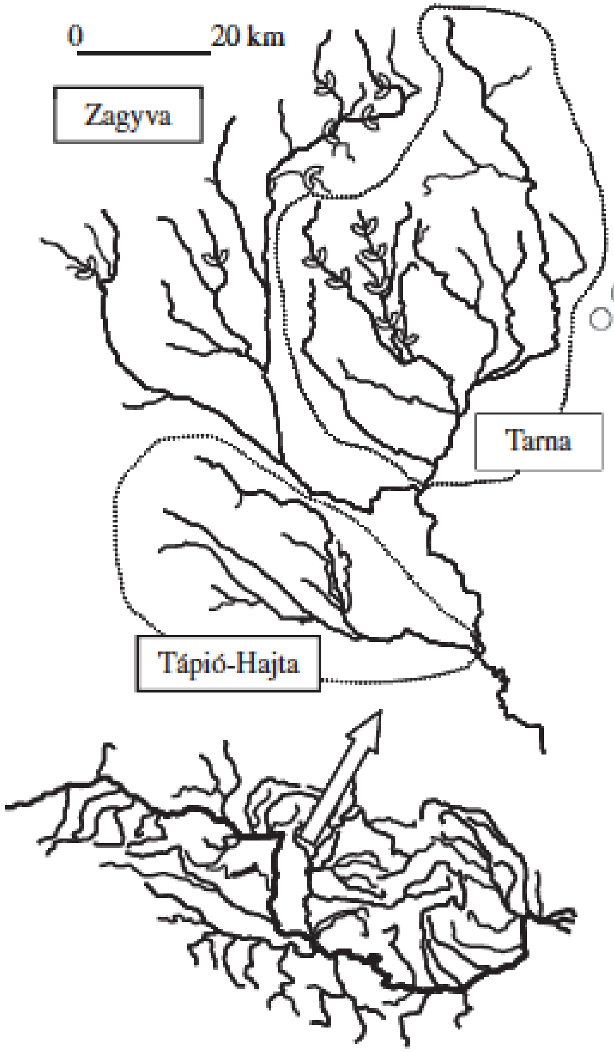
Dispersal structure (metacomm's skeleton)



Heino, J. 2013. Does dispersal ability affect the relative importance of environmental control and spatial structuring of littoral macroinvertebrate communities? Oecologia 171:971–980.

Dispersal structure (metacomm’s skeleton)

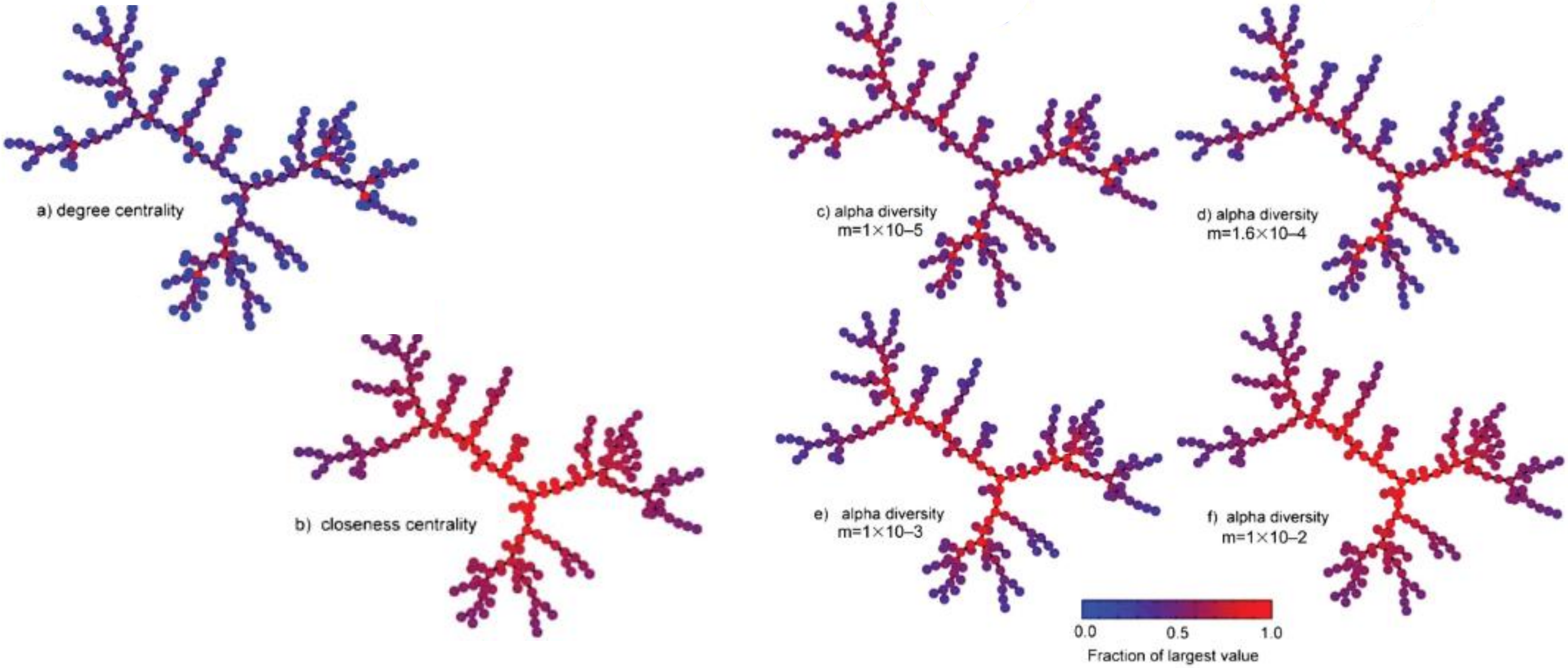
Spatial connectivity



Eros et al., 2011

Dispersal structure (metacomm's skeleton)

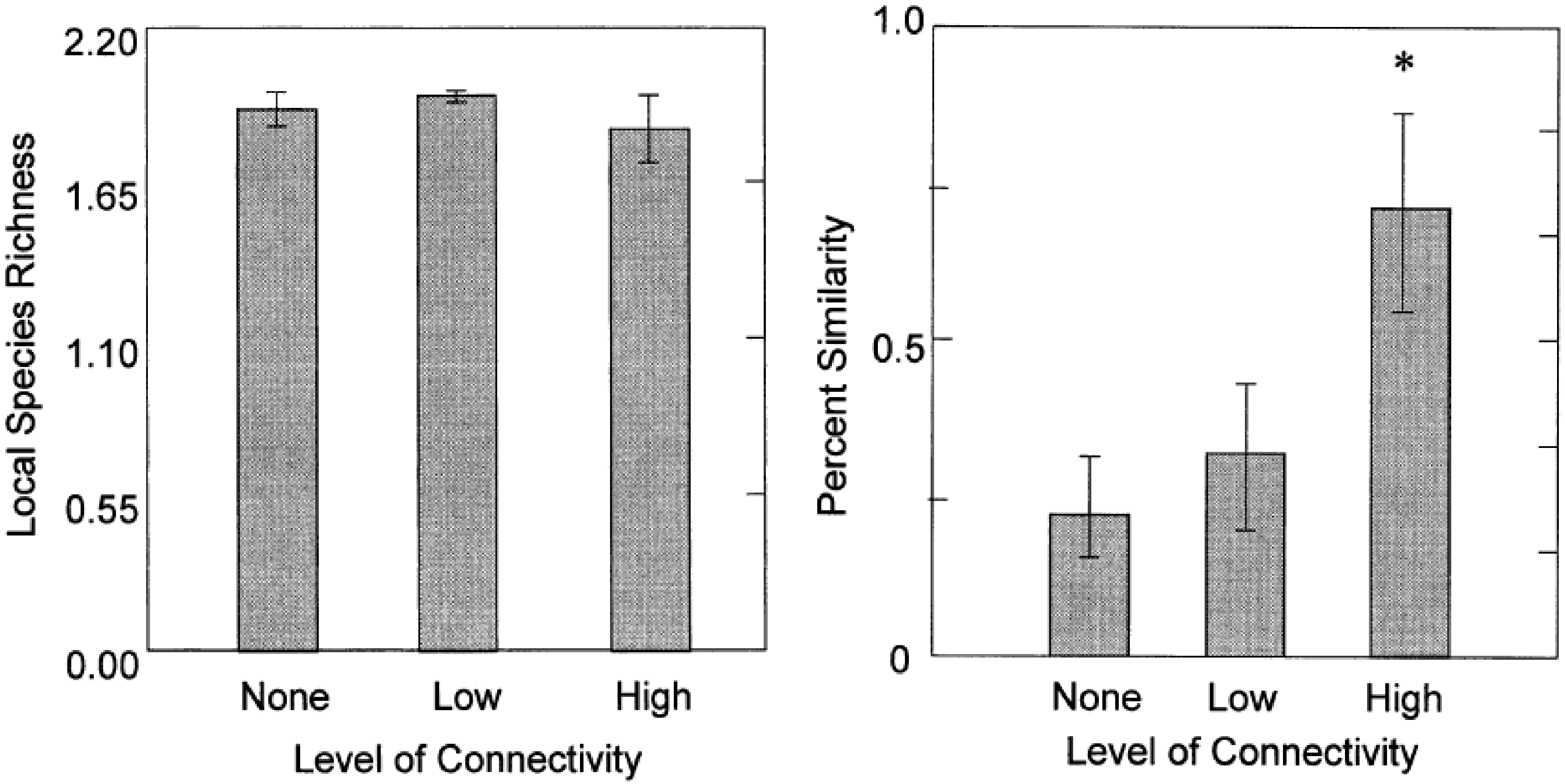
Spatial connectivity



Economo, E. P., and T. H. Keitt. 2010. Network isolation and local diversity in neutral metacommunities. Oikos 119:1355–1363.

Dispersal structure (metacomm's skeleton)

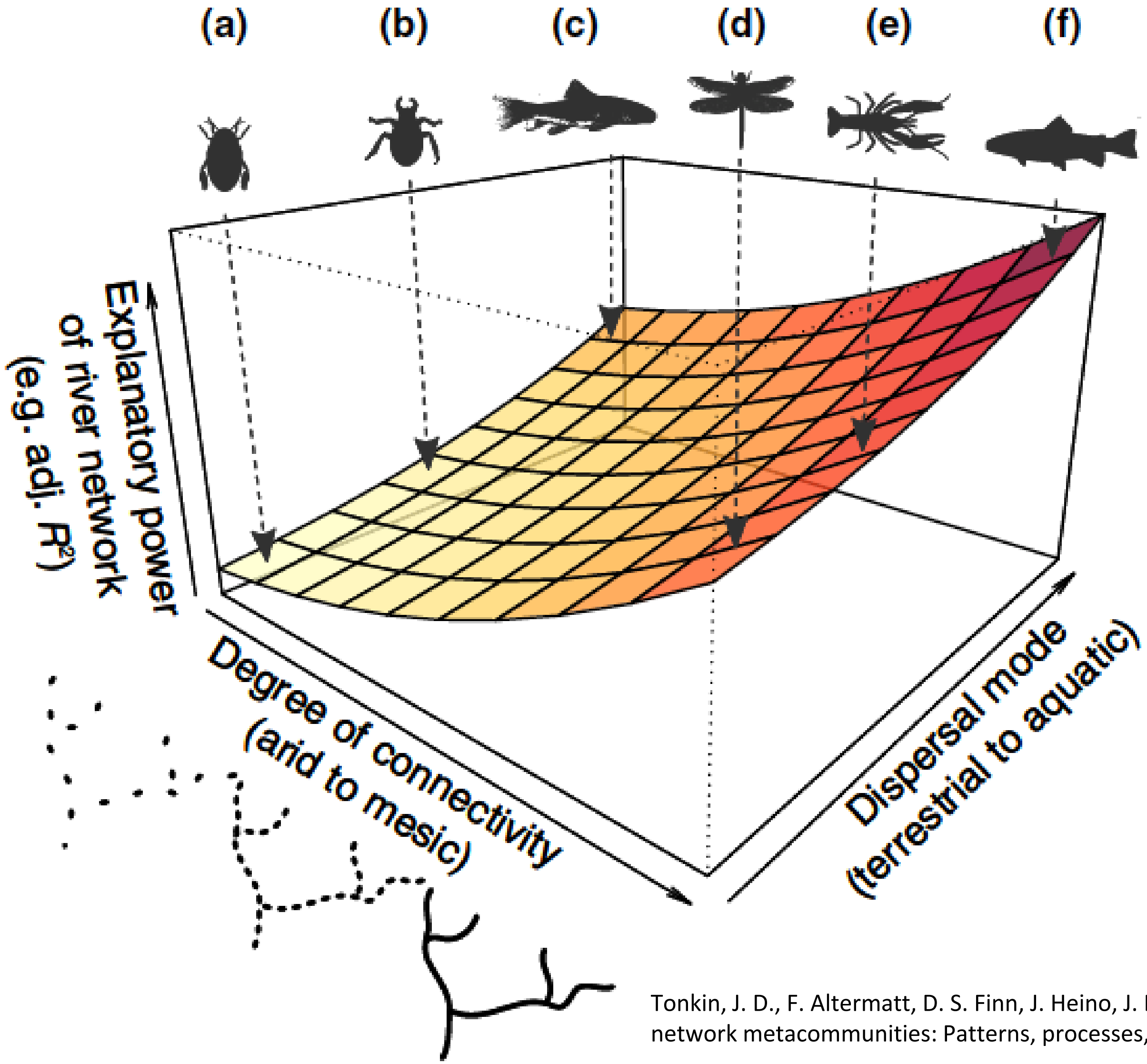
Spatial connectivity



Forbes & Chase, 2002

Dispersal structure (metacomm's skeleton)

Spatial connectivity

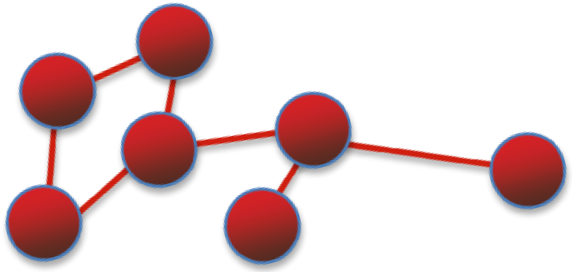


Tonkin, J. D., F. Altermatt, D. S. Finn, J. Heino, J. D. Olden, S. U. Pauls, and D. A. Lytle. 2018. The role of dispersal in river network metacommunities: Patterns, processes, and pathways. Freshwater Biology 63:141–163.

Metacommunities

A set of local communities that are linked by **DISPERSAL** of multiple **potentially interacting** species

Dispersal



Dispersal limitation

Mass effects

Stochasticity or Neutrality

Abiotic “filters”

Biotic interactions

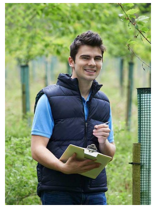
Environmental filtering

Neutral/Random

Metacommunities

NEUTRAL PROCESSES: All spp have no ecological or biological differences, so these parameters are not determining spatial structure.

NON-NEUTRAL PROCESSES: Niche-based. Spp are different in their ecological and biological characteristics.



Models or Cases or Structures (“big four”)

All patches are homogeneous.

PATCH DYNAMICS: Patterns of diversity are a product of colonization-competition trade-offs.

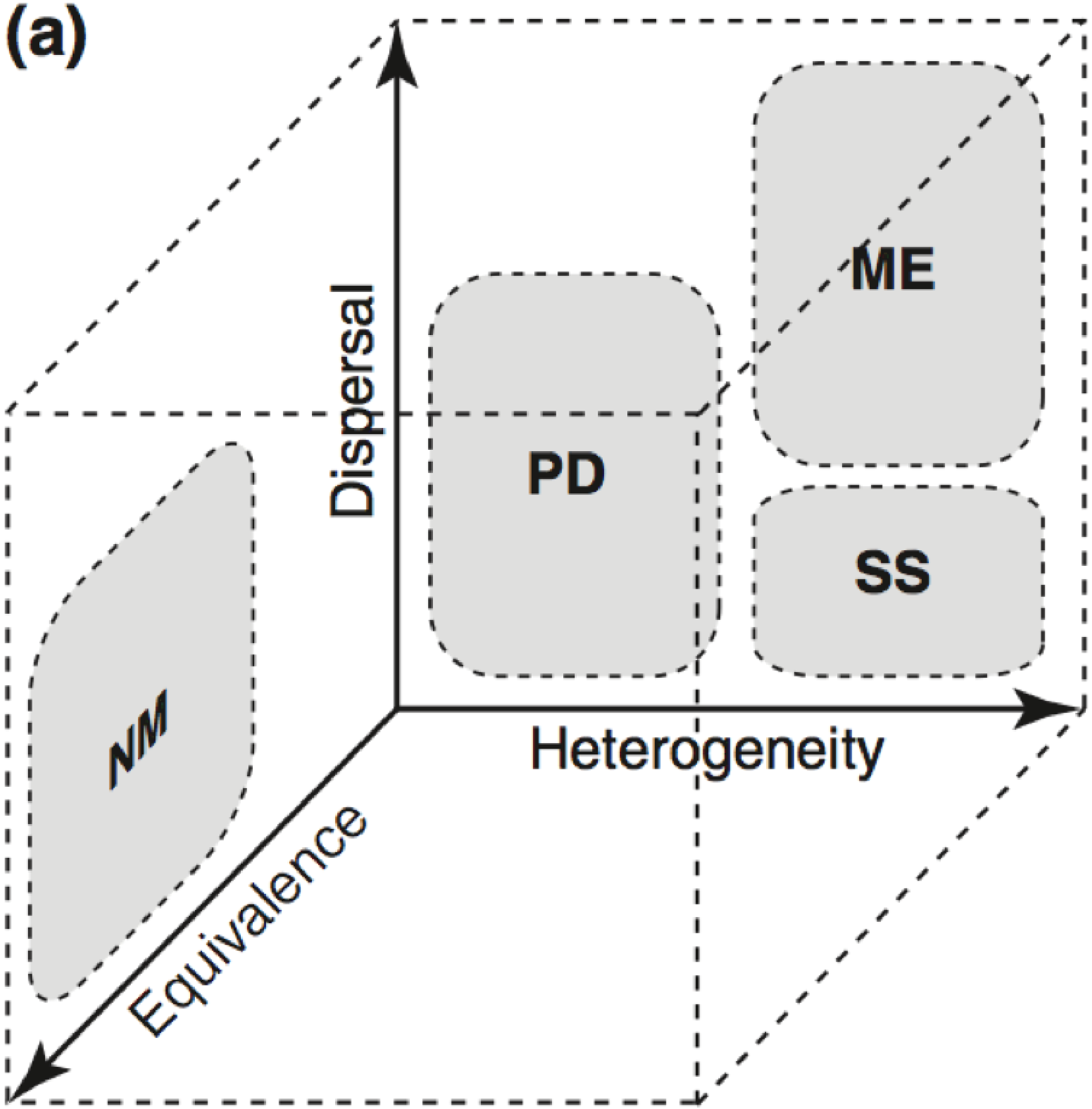
NEUTRAL DYNAMICS: Patterns of diversity are unrelated to species traits or characteristics and are related to stochasticity*

All patches are heterogeneous.

SPECIES SORTING: Local scale filtering processes are fast enough to avoid settlement of dispersers. Species are segregated in their respective niches. Suitability to local conditions is important.

MASS EFFECTS: Dispersal is faster than local filtering processes. Species exclusion is continuously replaced by new arrivals. Dispersion is important.

Metacommunities

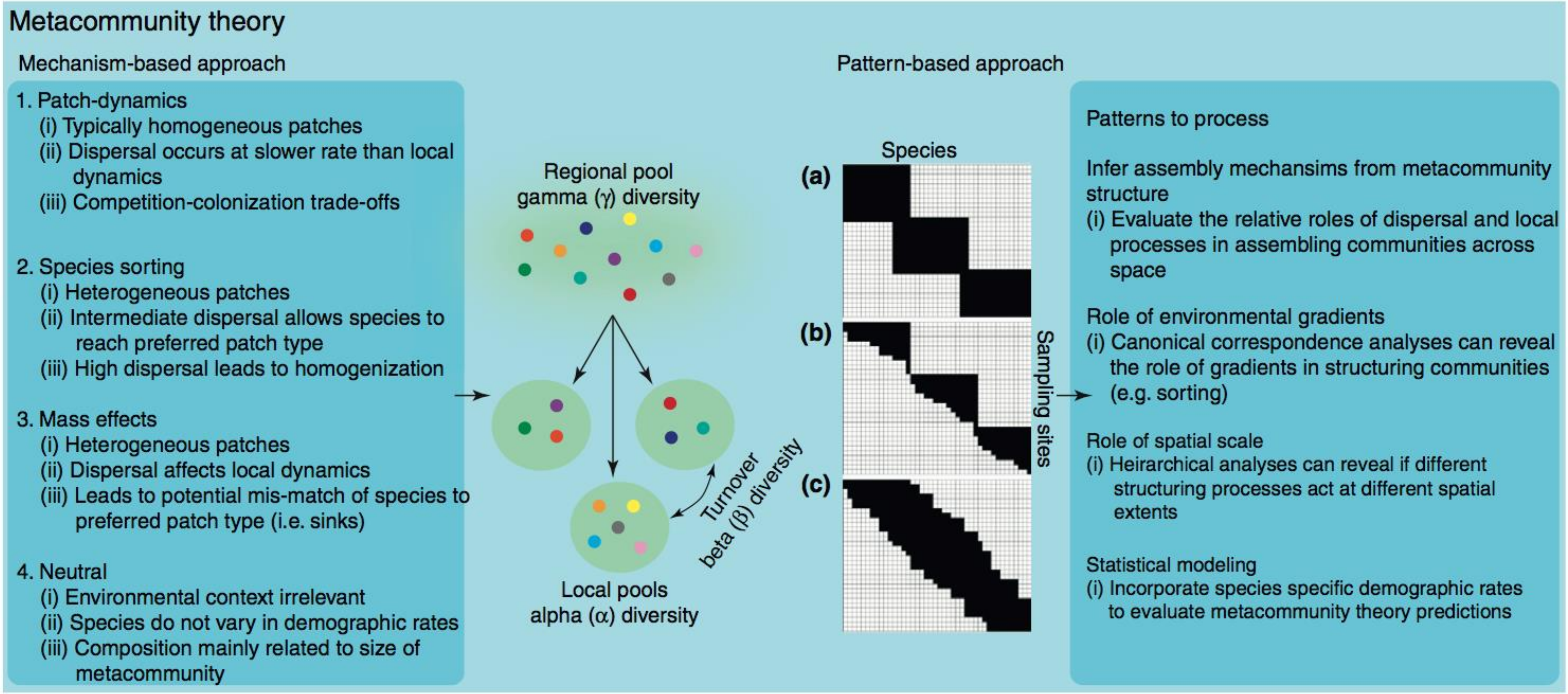


NM: Neutral Model
PD: Patch Dynamics
ME: Mass Effects
SS: Species Sorting

Logue, J. B., N. Mouquet, H. Peter, H. Hillebrand, and T. M. W. Group. 2011. Empirical approaches to metacommunities: A review and comparison with theory. Trends in Ecology and Evolution 26:482–491.

Metacommunities

Mechanism-based or Pattern-based “ways” to look at Metacomm.



Mihaljevic, 2012

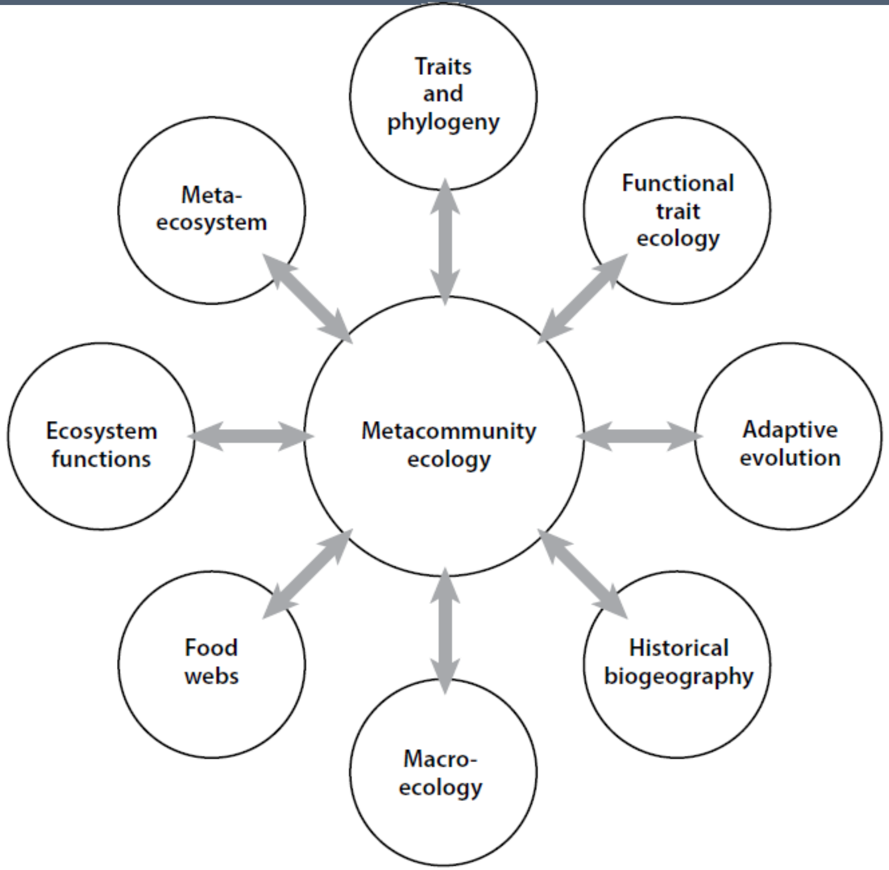
Metacommunities

Leibold, M. A., and J. M. Chase. 2018. Metacommunity Ecology. Princeton University Press.

CHAPTER ONE

Introduction

The Rise, Fall, and Rise Again of Metacommunity Ecology



Prospectus

1. Traditional perspectives of community ecology, including species interactions, coexistence, and biodiversity, have focused on **local- scale processes** and have met with a great deal of controversy and disagreement.

2. The recognition of the importance of **spatial (and temporal) processes has risen** dramatically in recent years, although threads of ideas (importance of **dispersal**) and controversies (**stochasticity vs. determinism**) are evident throughout the history of ecology.

3. **Metacommunity ecology, by explicitly incorporating scale as a critical feature** of the outcomes of coexistence and biodiversity, among other variables, has the potential to **unify** what seems like a largely unresolved field.

4. This unification will require explicitly **incorporating spatiotemporal heterogeneities, dispersal, the interactions between stochasiticity and determinism**, and a number of complicating variables (e.g., food webs,evolution).

The major weakness of traditional community ecology, and why it has so conspicuously failed to come up with many patterns, rules and workable contingent theory, is its overwhelming emphasis on localness.

Lawton (1999)

Metacommunity analysis

1. Distance Decay

2. Variance Partitioning

3. Metacommunity structure

4. Beta diversity components
Local Contribution to Beta Diversity-LCBD

5. Null models

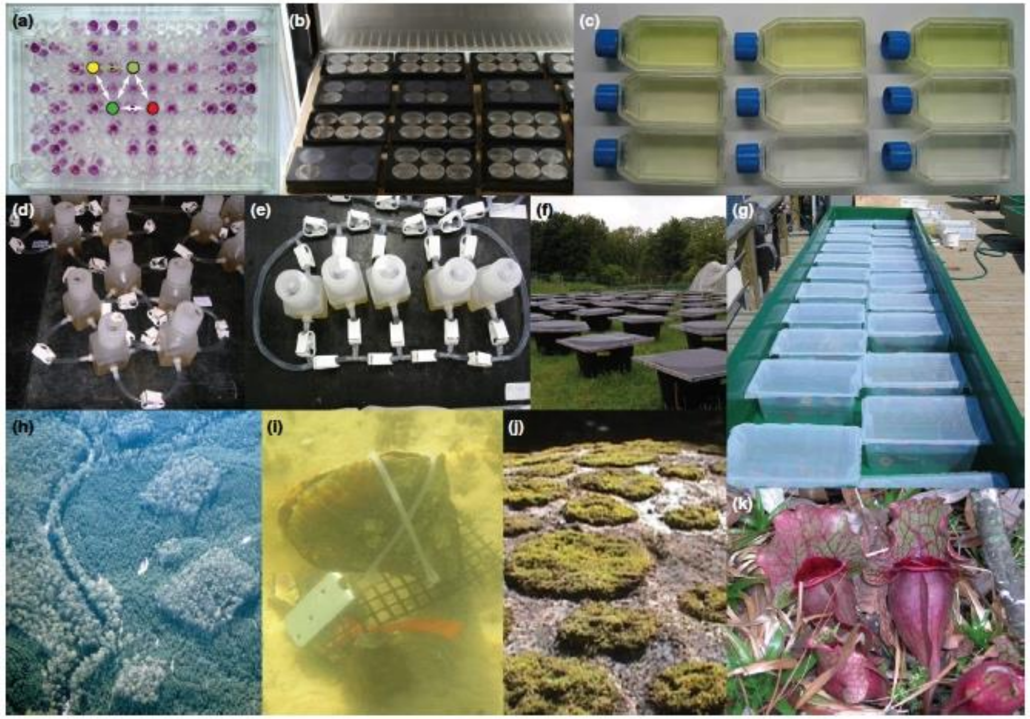
6. Multiscale codependence analysis –
Joint Spatial Distributions

7. Permutational Simper (PER-SIMPER)

8. Fourth-corner relationships and
Community Assembly by Traits Selection (CATS)

9. Univariate community assembly analysis

10. Patch-based graphs & Network analyses



Metacommunity analysis

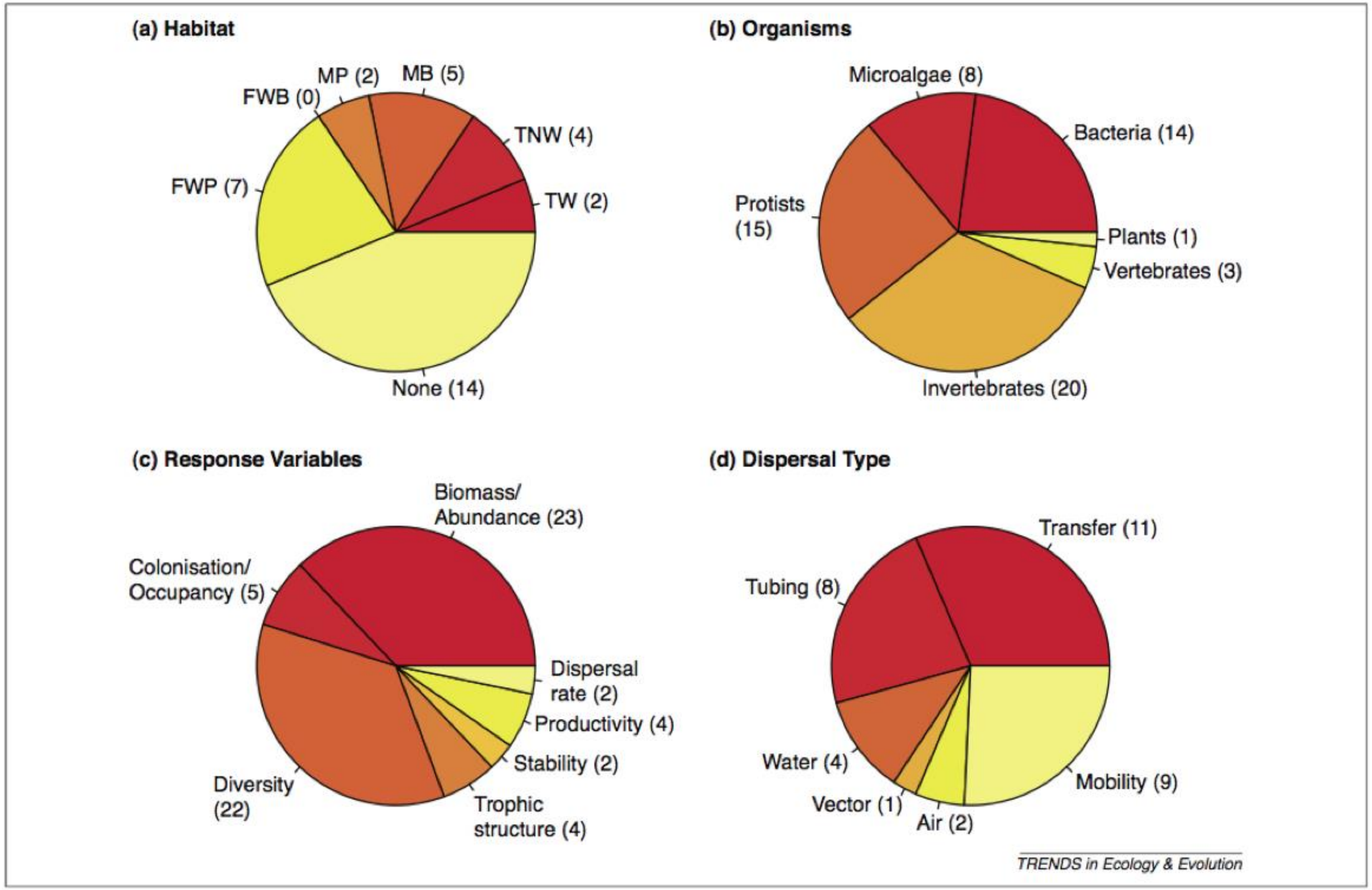
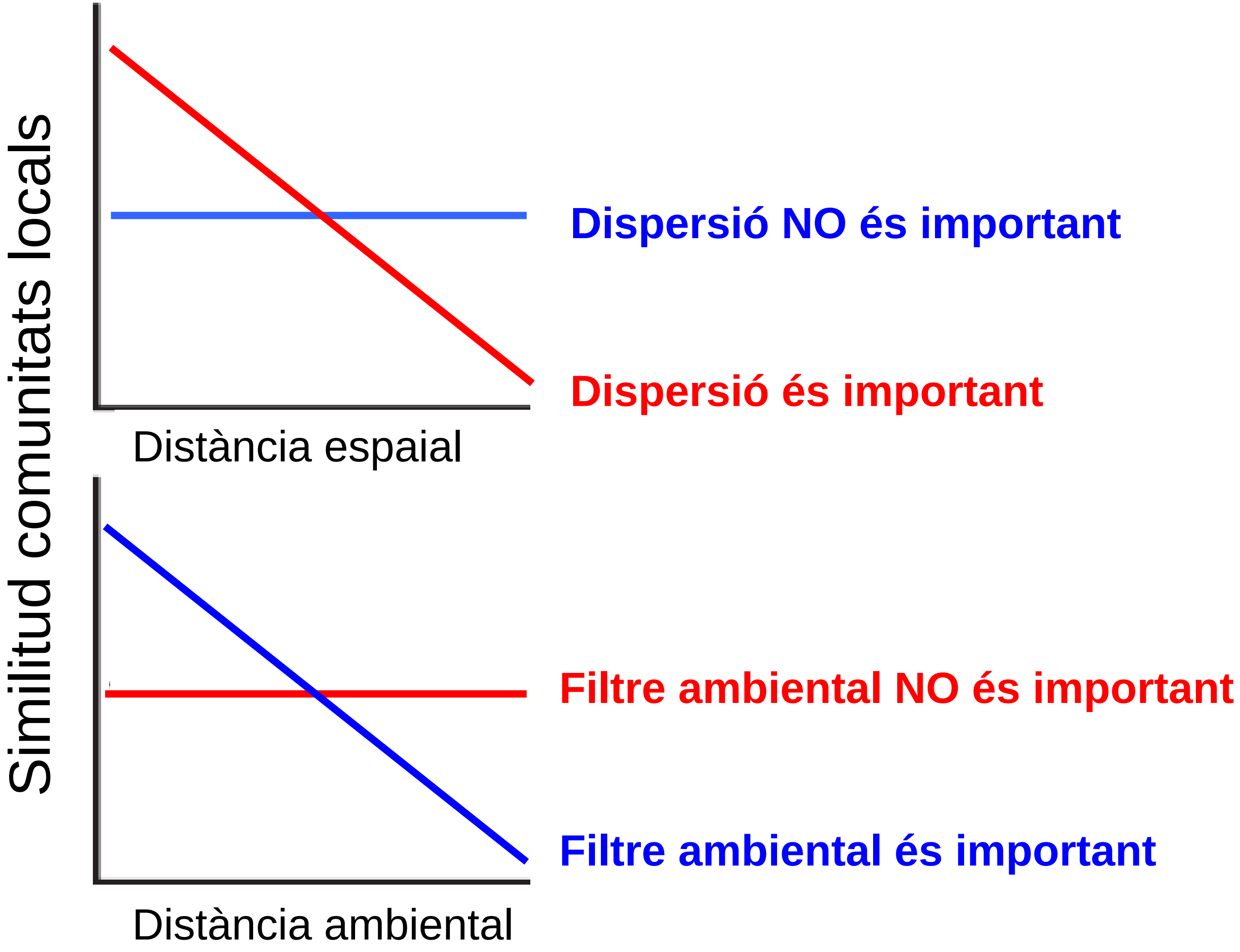


Figure 2. Summary of results for 34 experimental metacommunity studies. The diagrams show the proportion of studies falling into different categories with regard to **(a)** habitat type, **(b)** organism group, **(c)** response variable and **(d)** the dispersal type. Absolute numbers of studies are given in brackets with each text label. However, the sums can deviate from 34 as studies used multiple treatments or organisms, or because studies addressed various response variables or dispersal types. Abbreviations: FWB, freshwater benthic; FWP, freshwater pelagic; none, artificial microcosm that does not reflect any particular system; MB, marine benthic; MP, marine pelagic; TNW, terrestrial non-woody; TW, terrestrial woody. Tubing describes patches linked by tube-like connectors, which are often manipulated by altering the ratio of time closed to time open. Transfer includes all types of transport of water or individuals between habitat patches by the manipulator. Classically, this involves extracting a certain volume of each patch (e.g. via a pipette or a bucket) and transferring this between patches. Mobility identified those metacommunities that lacked any kind of direct connection

Logue, J. B., N. Mouquet, H. Peter, H. Hillebrand, and T. M. W. Group. 2011. Empirical approaches to metacommunities: A review and comparison with theory. Trends in Ecology and Evolution 26:482–491.

1. Distance Decay



Metacommunity analysis

1. Distance Decay

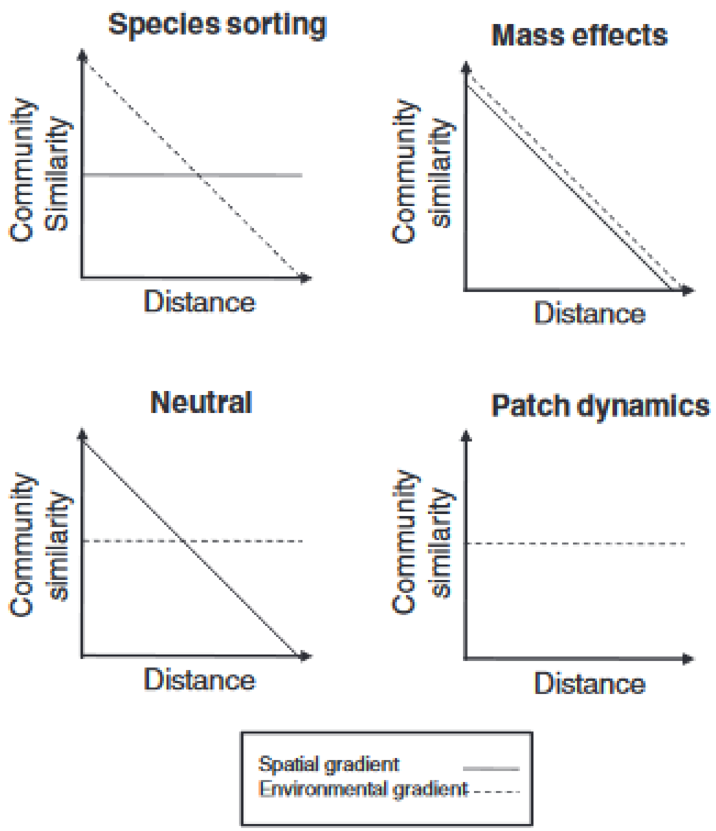
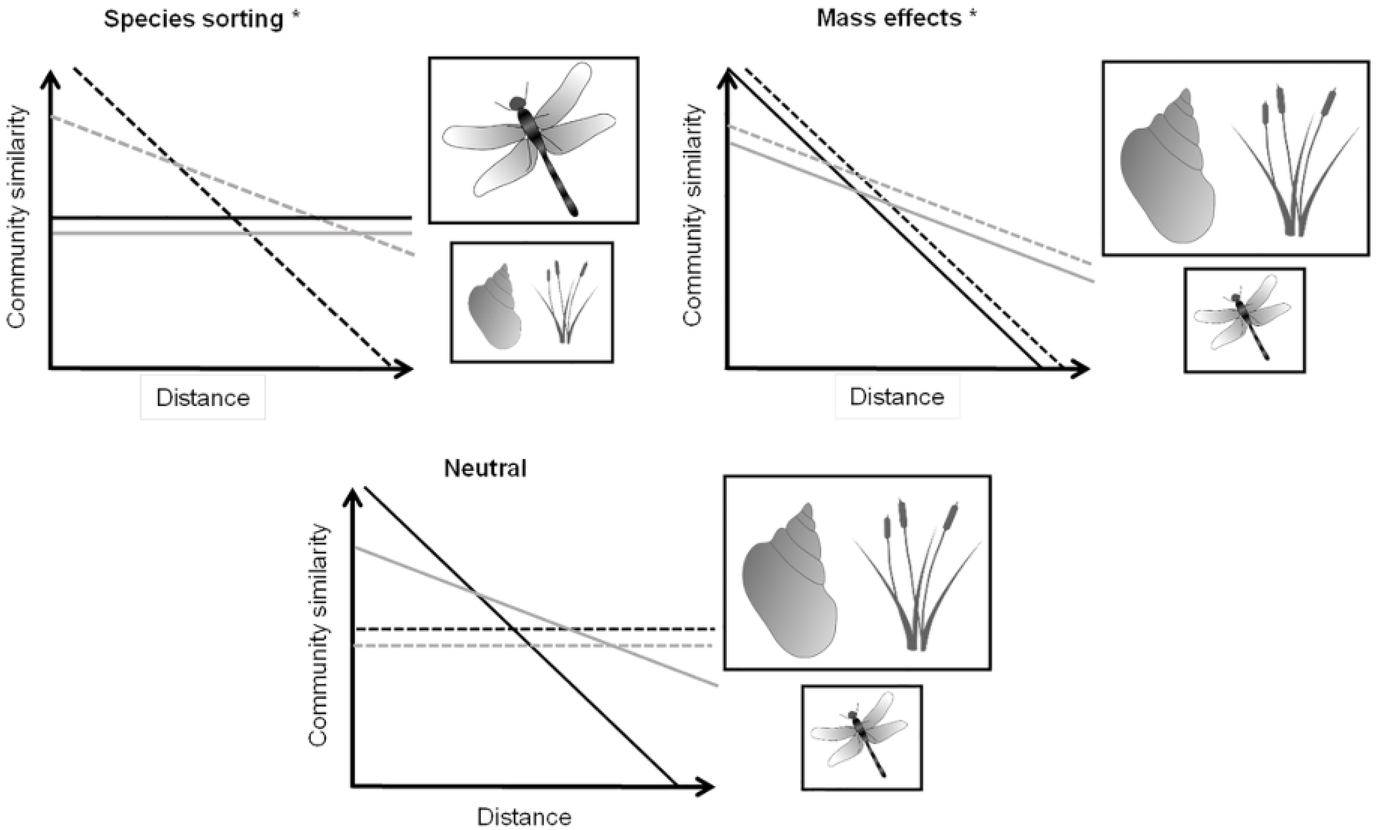


Fig. 1. Decrease of similarity in community structure along spatial and environmental gradients according to different types of metacommunity perspectives. The patch dynamics perspective is difficult to describe in this context, and is not dealt with directly herein. Figure redrawn based on Chase *et al.* (2005) and Logue & Lindström (2008).

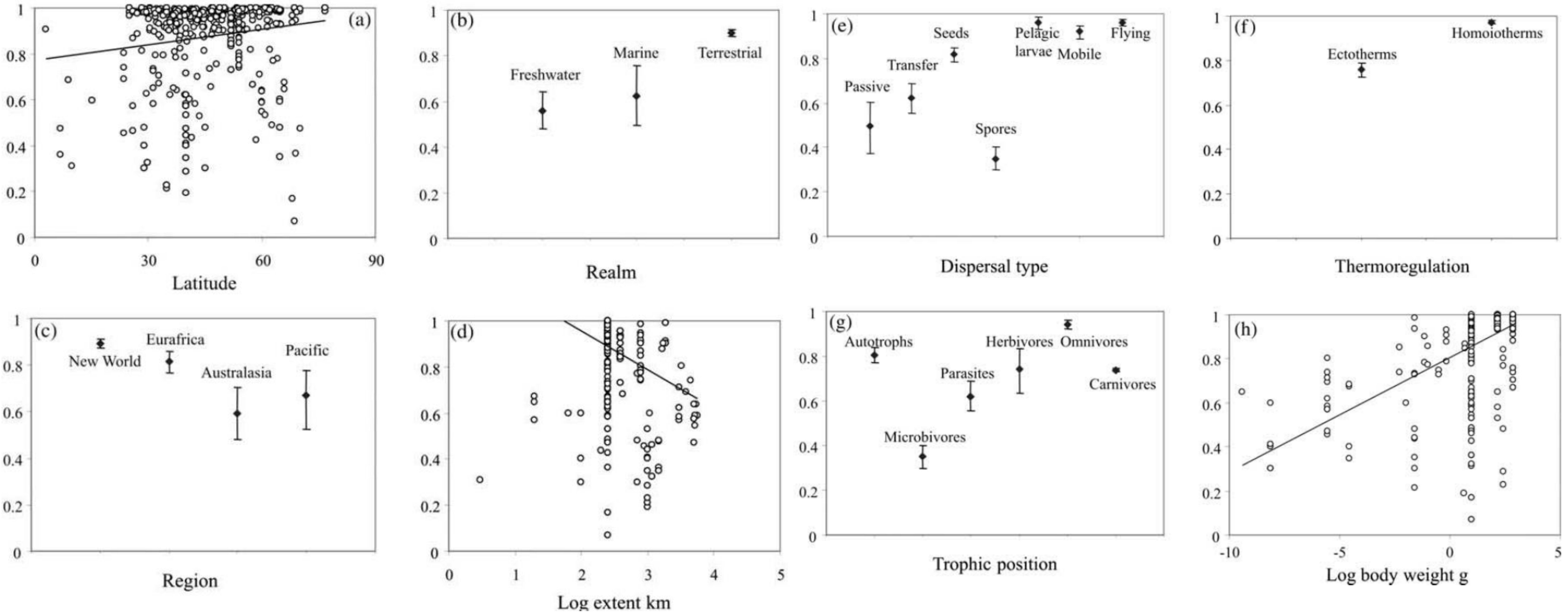


Tornero, I., D. Boix, S. Bagella, C. Pinto-cruz, M. C. Caria, A. Belo, A. Lumbreras, J. Sala, J. Compte, and S. Gascón. 2018. Dispersal mode and spatial extent influence distance-decay patterns in pond metacommunities. PloS one 13:e0203119.

Heino, J. 2013. The importance of metacommunity ecology for environmental assessment research in the freshwater realm. Biological Reviews 88:166–178.

Metacommunity analysis

1. Distance Decay

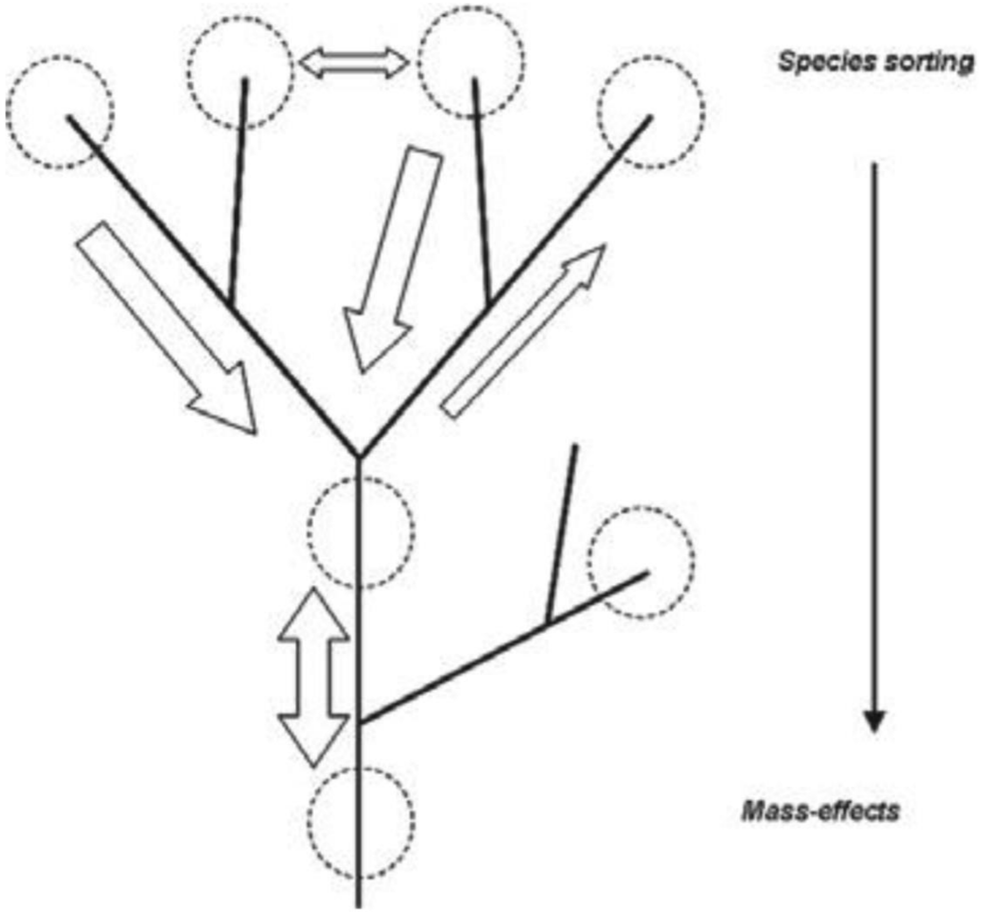


Mean effects (±95% confidence intervals) of a) latitude, b) realm, c) region, d) study extent, e) organism dispersal type, f) thermoregulation, g) trophic position and h) body weight on initial similarity (i.e. similarity at one km distance).

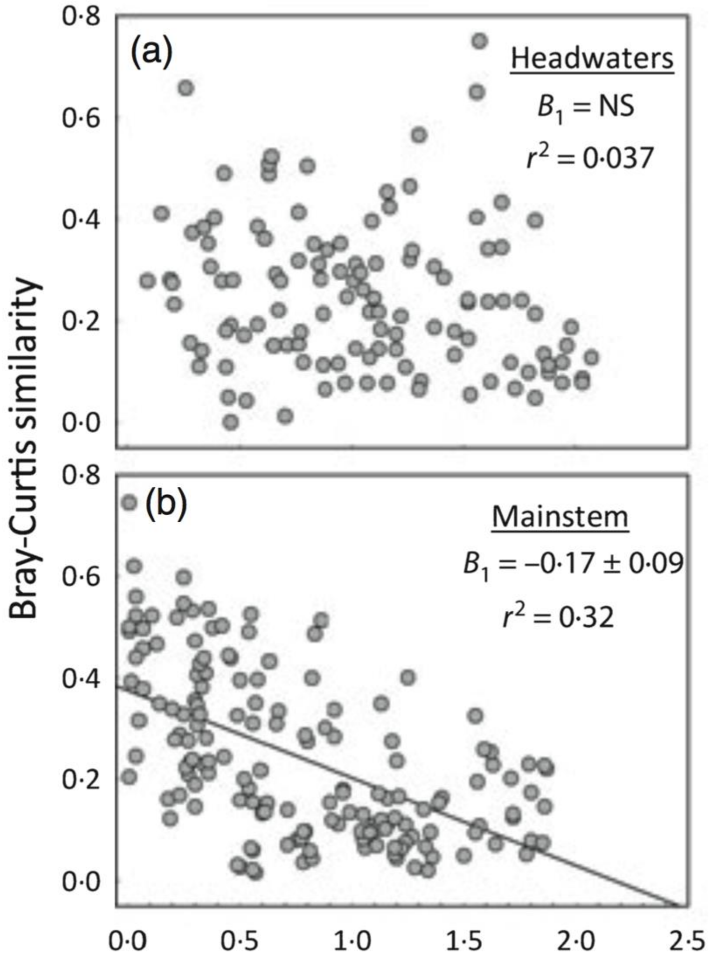
Soininen, J., R. McDonald, and H. Hillebrand. 2007. The distance decay of similarity in ecological communities. Ecography 30:3–12.

Metacommunity analysis

1. Distance Decay



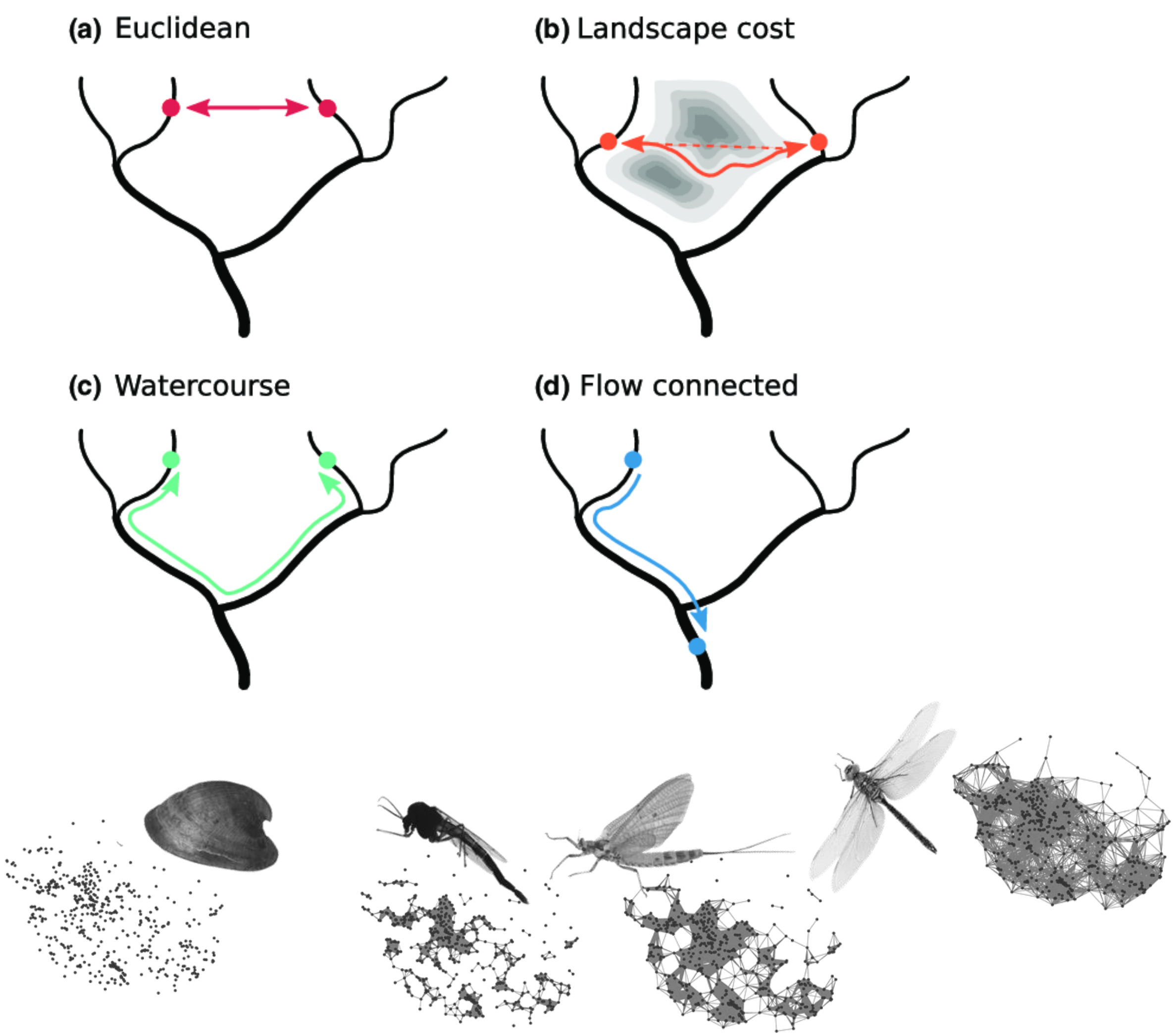
Brown & Swan, 2010

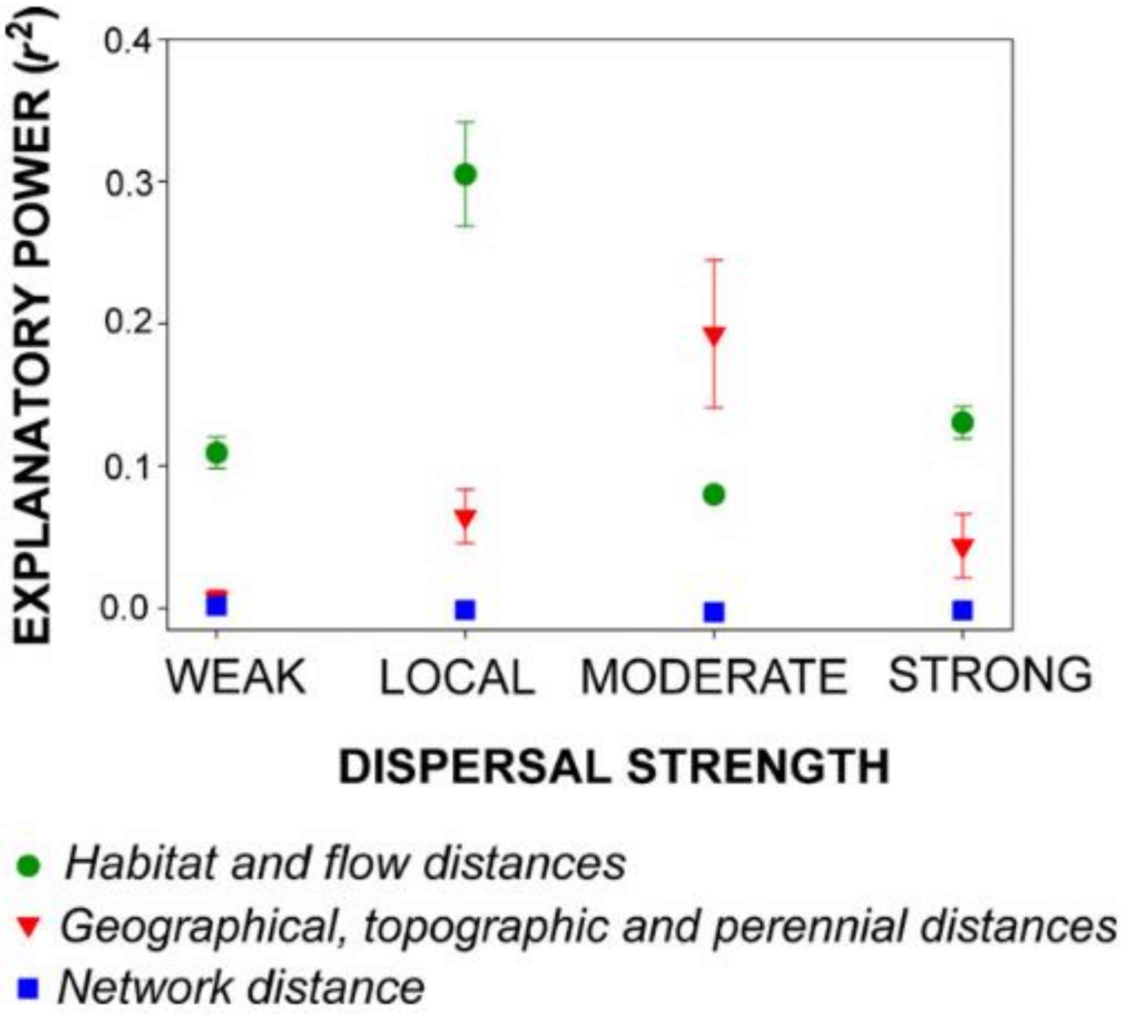


Distància espaial

Metacommunity analysis

1. Distance Decay





Cañedo-Argüelles, M., K. S. Boersma, M. T. Bogan, J. D. Olden, I. Phillipsen, T. A. Schriever, and D. A. Lytle. 2015. Dispersal strength determines meta-community structure in a dendritic riverine network. Journal of Biogeography 42:778–790.

2. Variance Partitioning

Macroinvertebrates in the Yarlung Zangbo Grand Canyon of Tibet (Tibetan Plateau).
Li *et al.* 2019

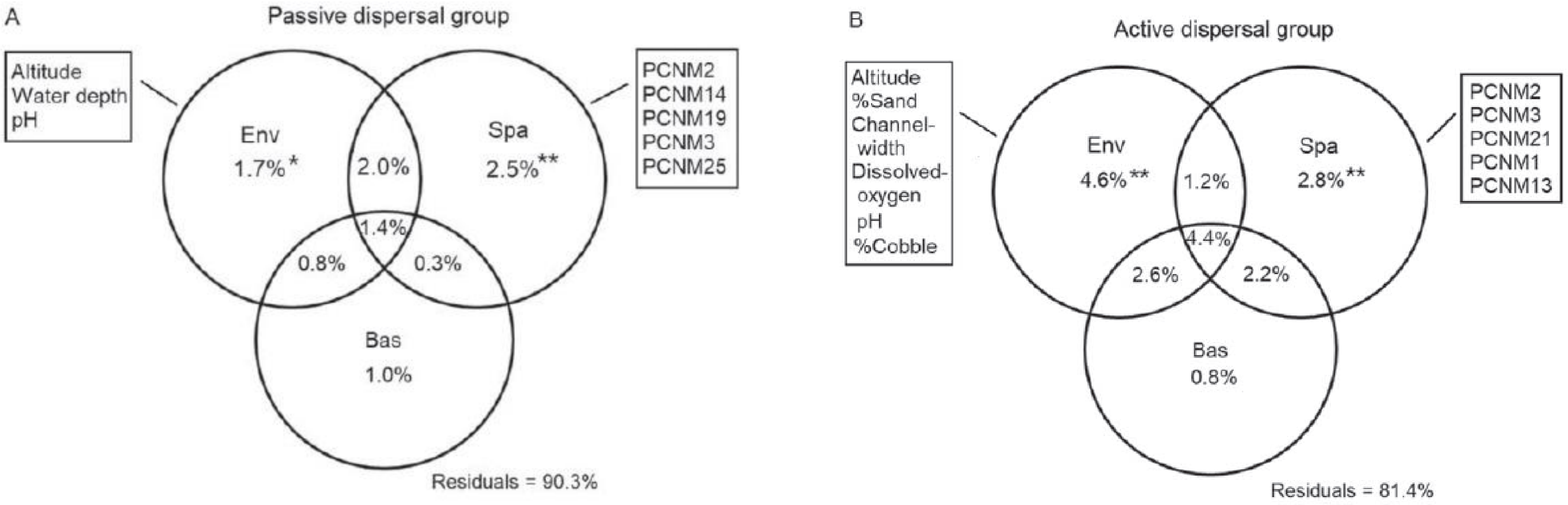
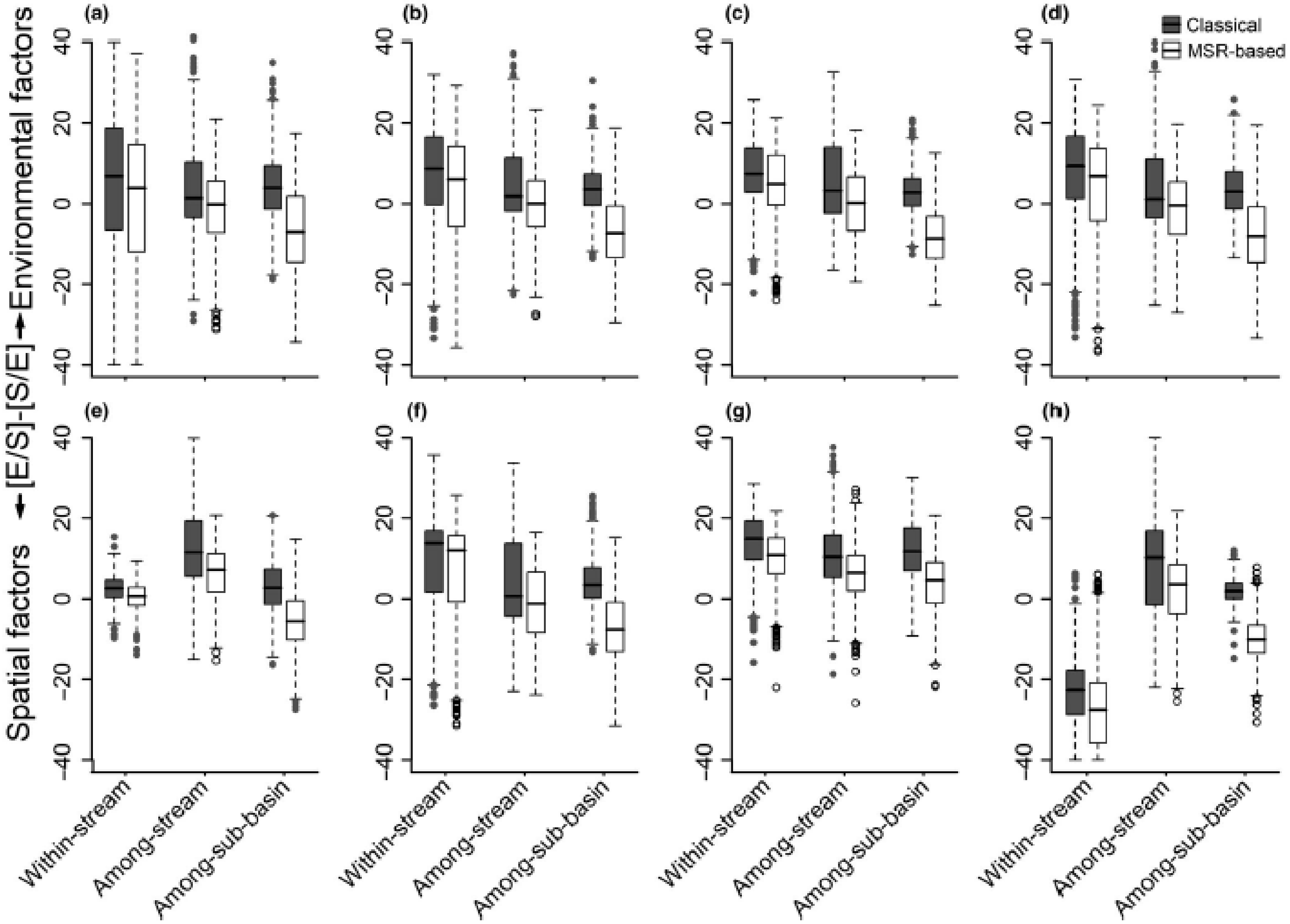


Figure 3. Venn diagrams showing the association between environmental variables (Env), spatial factors (Spa), and dummy basin variables (Bas) and assemblage structures of passive (A) and active (B) dispersal groups in the whole study area. Values represent adjusted R^2-values. ** = $p < 0.01$, * = $p < 0.05$.

Metacommunity analysis

2. Moran Spectral Randomization Variance Partitioning



He, S., J. Soininen, G. Deng, and B. Wang. 2020. Metacommunity Structure of Stream Insects across Three Hierarchical Spatial scales. Ecology and Evolution:2874–2884.

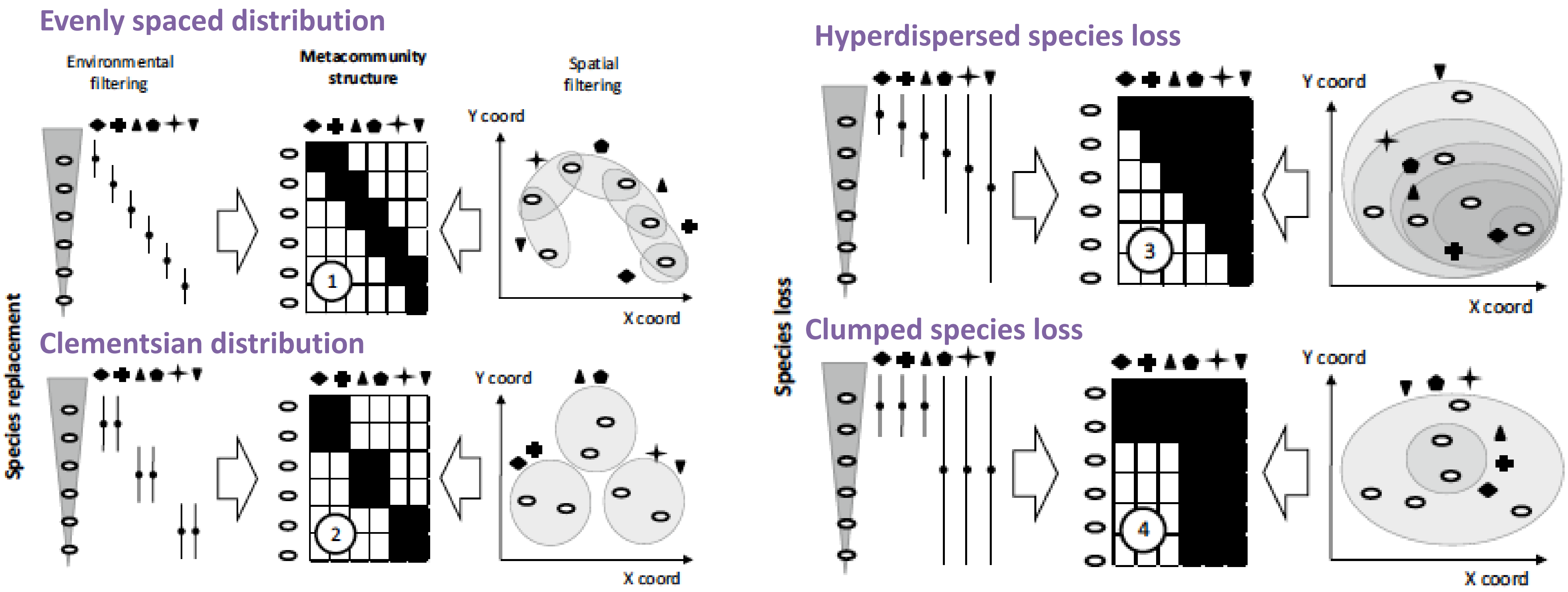
MEM's

Moran eigenvector maps

Borcard, D. & Legendre, P. (2002) All-scale spatial analysis of ecological data bymeans of principal coordinates of neighbour matrices.Ecological Modelling,153,51–68

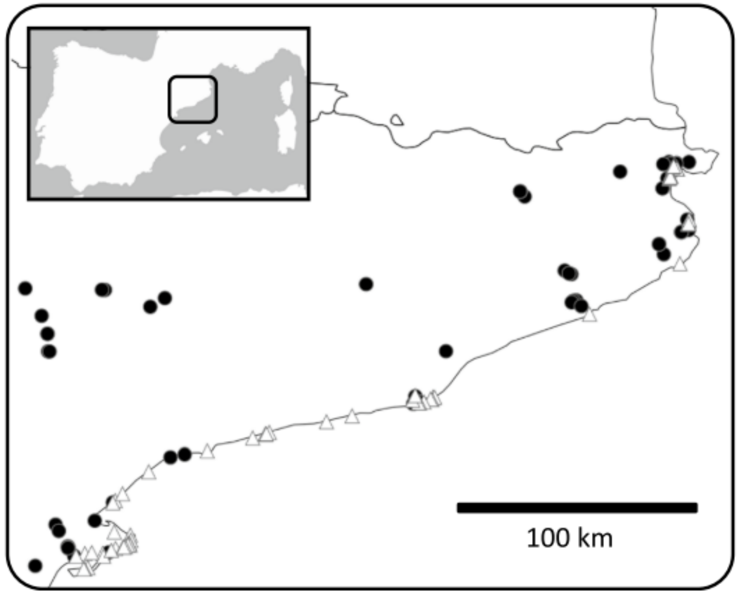
Metacommunity analysis

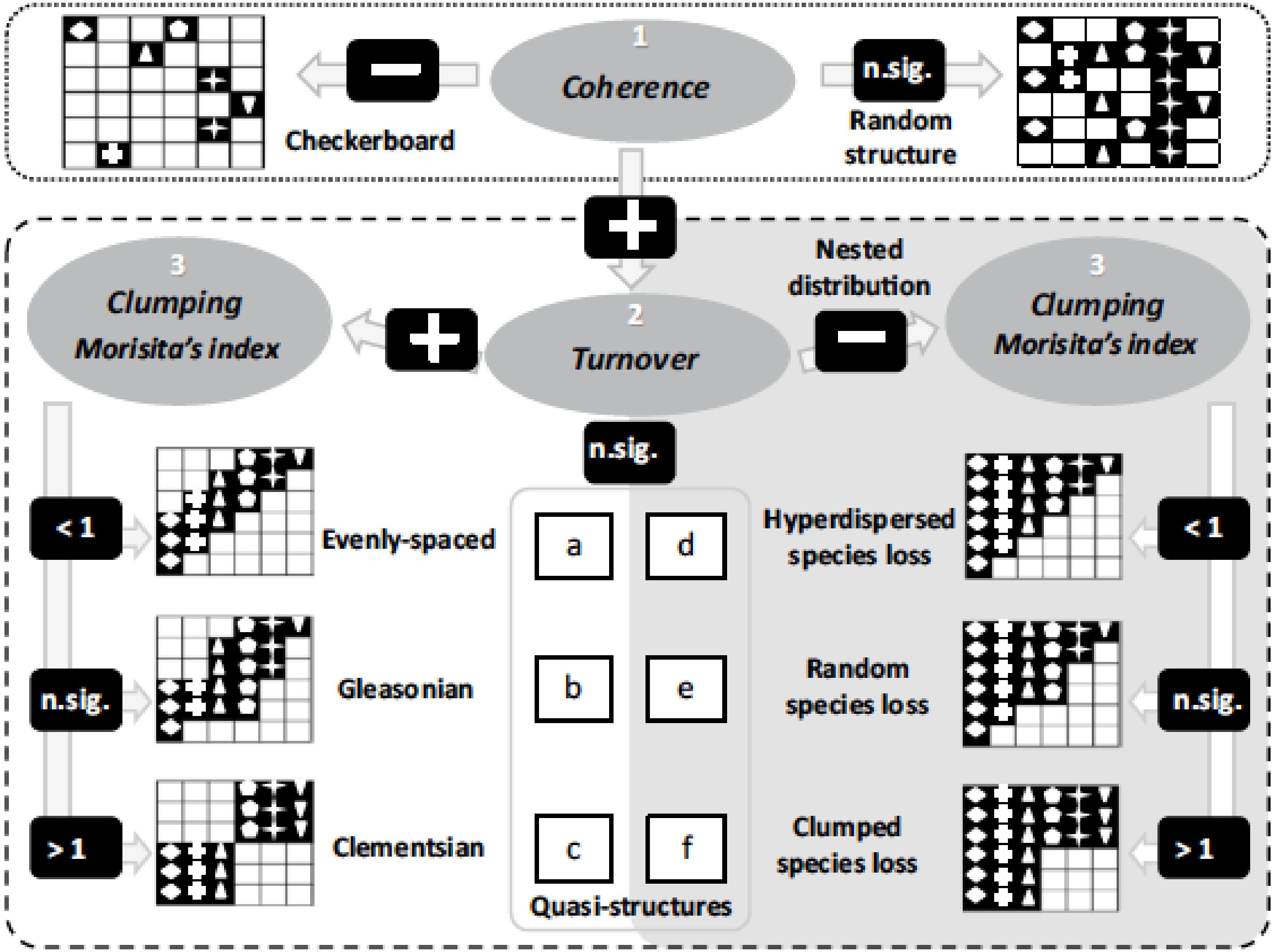
3. Metacommunity structure



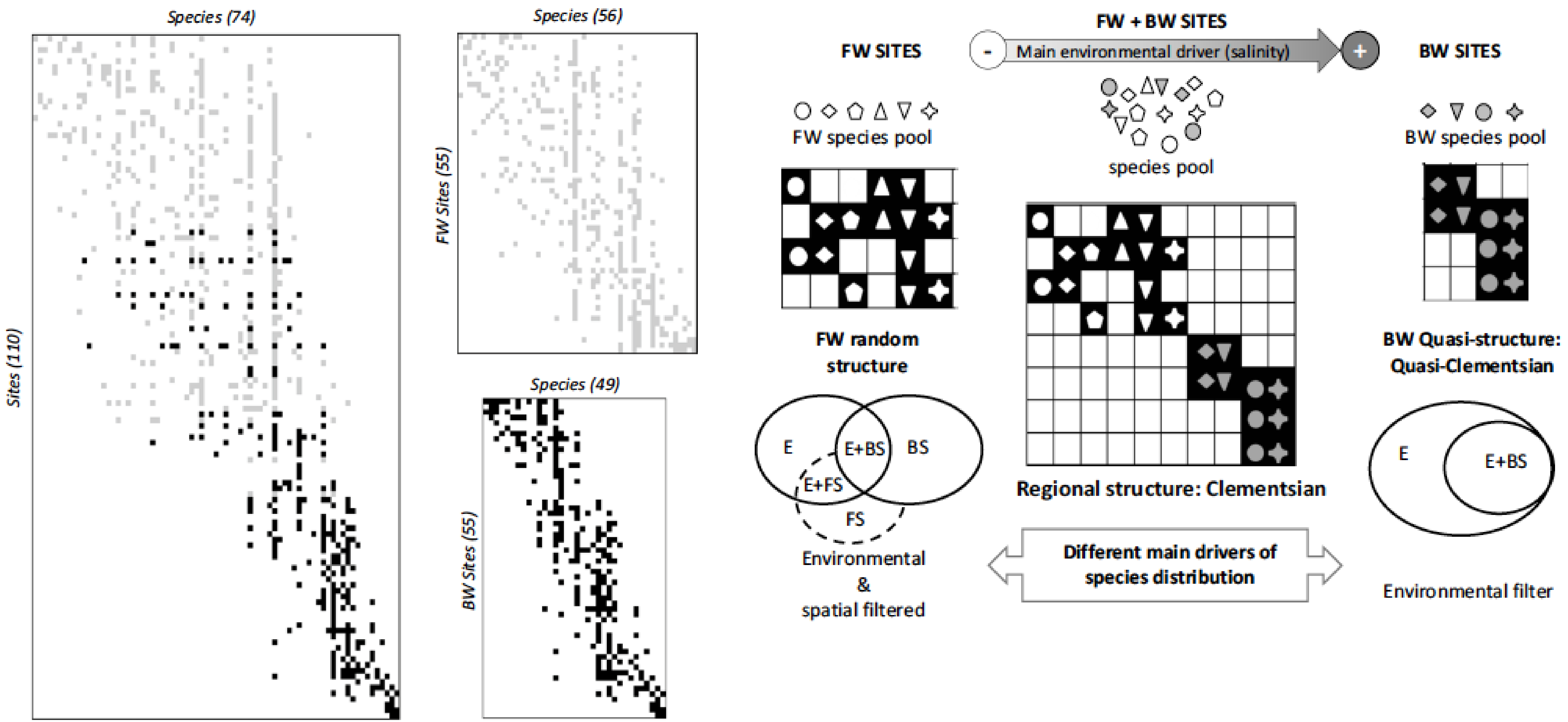
Gascón, S., I. Arranz, M. Cañedo-Argüelles, A. Nebra, A. Ruhí, M. Rieradevall, N. Caiola, J. Sala, C. Ibàñez, X. D. Quintana, and D. Boix. 2016. Environmental filtering determines metacommunity structure in wetland microcrustaceans. Oecologia:1–13.

3. Metacommunity structure

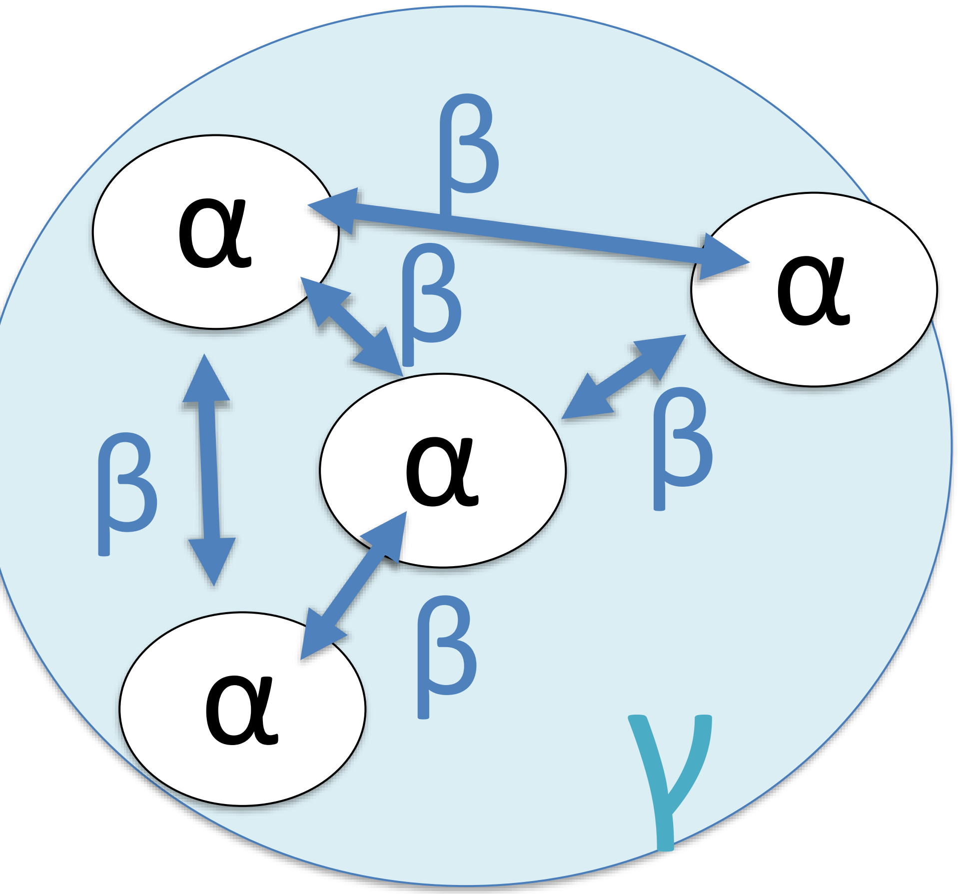




3. Metacommunity structure



4. Beta diversity components



β ????

Direct relation (alpha/gamma=Beta)

Pairwise dissimilarities (Jaccard index, Bray-Curtis index)

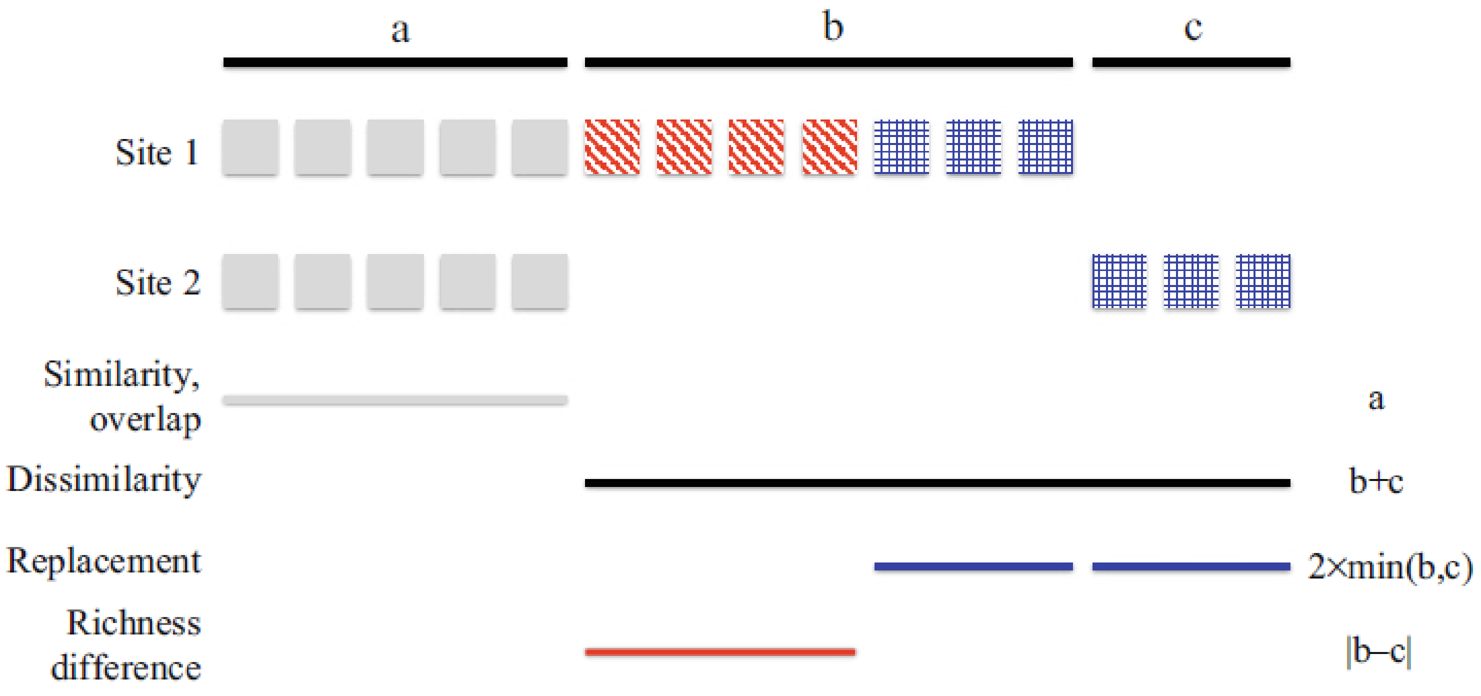
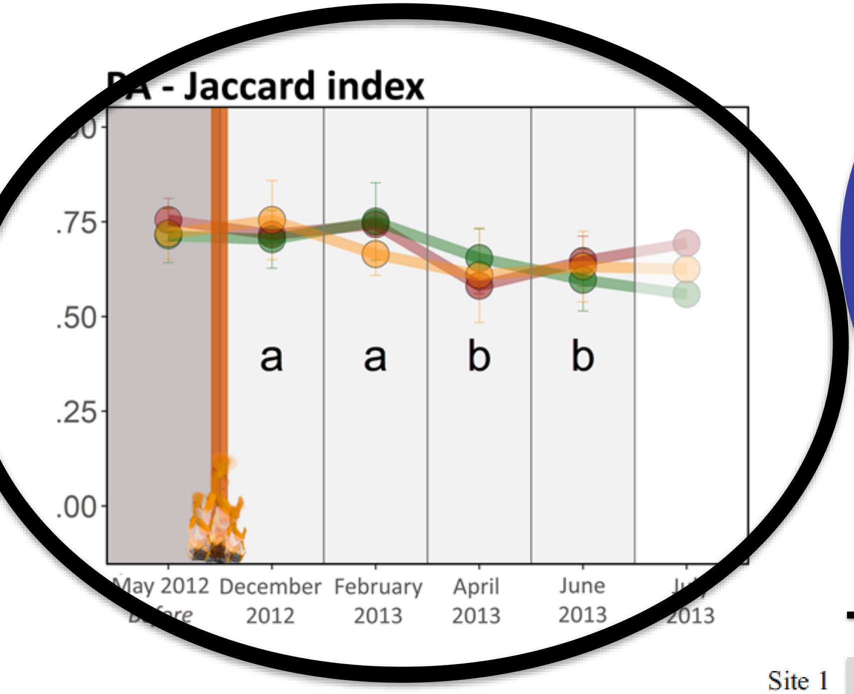
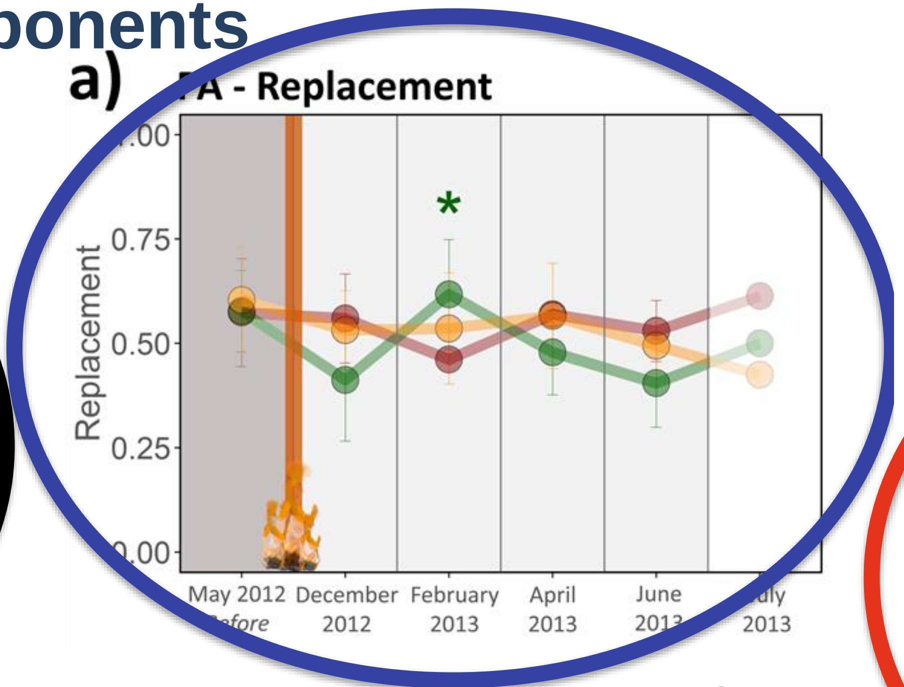
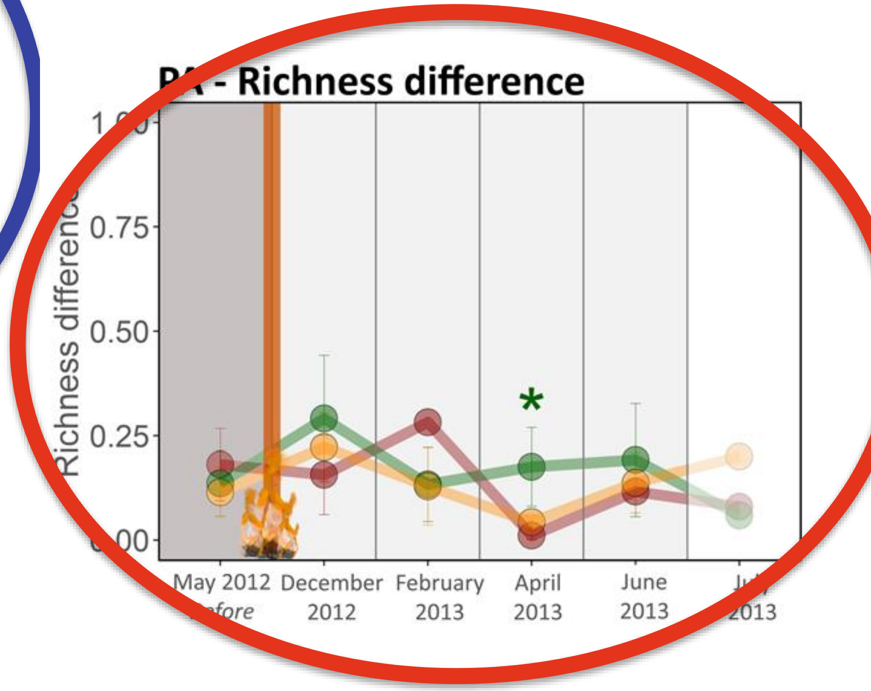


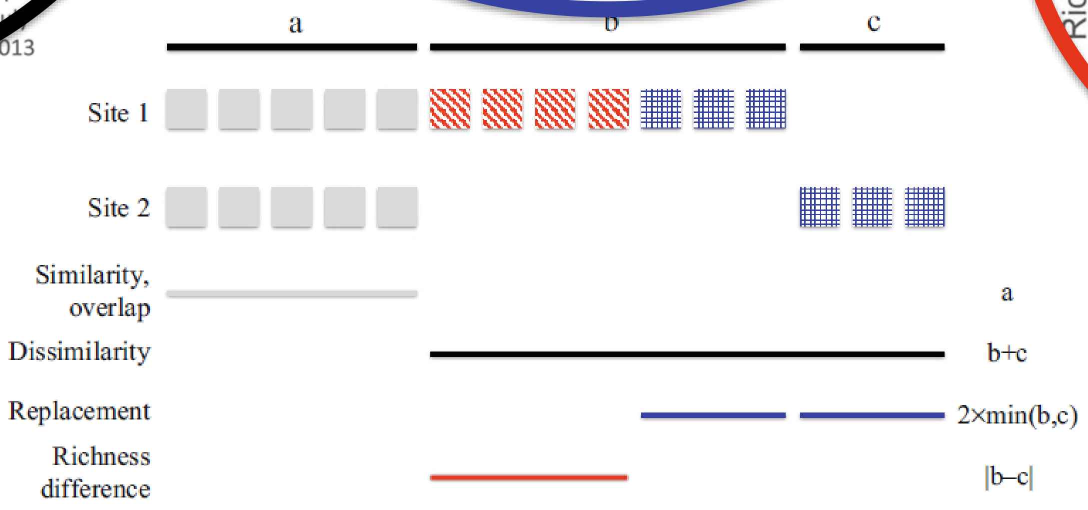
Fig. 8.5 Two fictitious sites with 12 (site 1) and 8 (site 2) species, with the quantities *a*, *b* and *c* used to construct indices of dissimilarity, replacement, richness difference and nestedness for presence-absence data. After Legendre (2014)

4. Beta diversity components



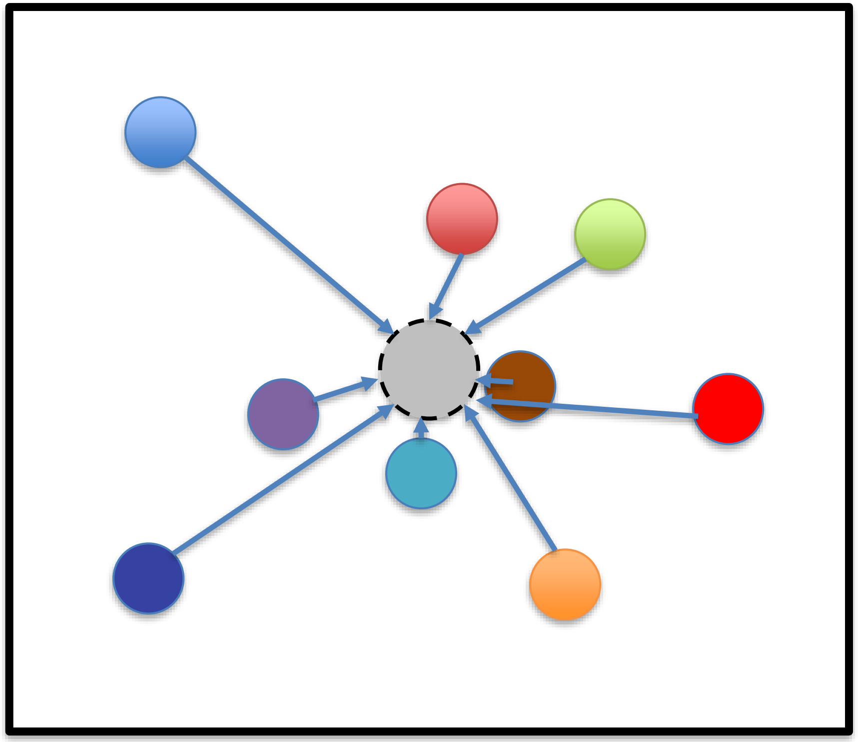




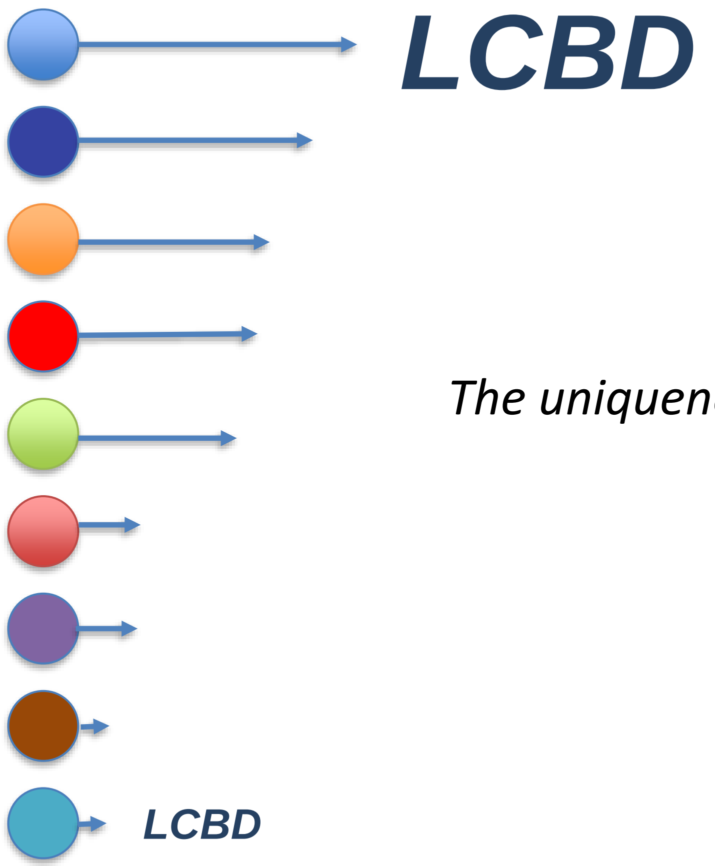


Cunillera-Montcusí, D., D. Boix, I. Tornero, X. D. Quintana, J. Sala, and S. Gascón. 2021. Recovery of temporary pond alpha and beta diversity after wildfire disturbance: the role of dispersal and recolonization processes. Inland Waters.

4. Beta diversity components
Local Contribution to Beta Diversity-LCBD



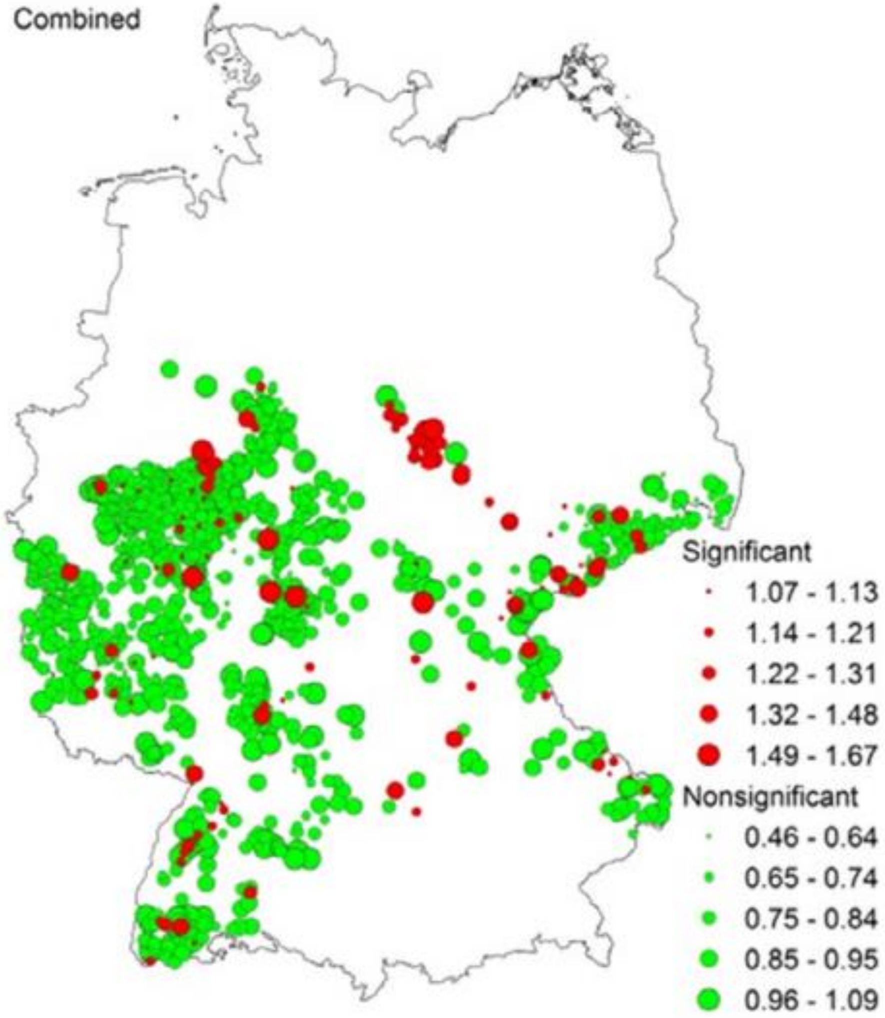
Jaccard index



The uniqueness of each community

Borcard, D., F. Gillet, and P. Legendre. 2011. Numerical Ecology with R. Springer-Verlag New York.

4. Beta diversity components
Local Contribution to Beta Diversity-LCBD



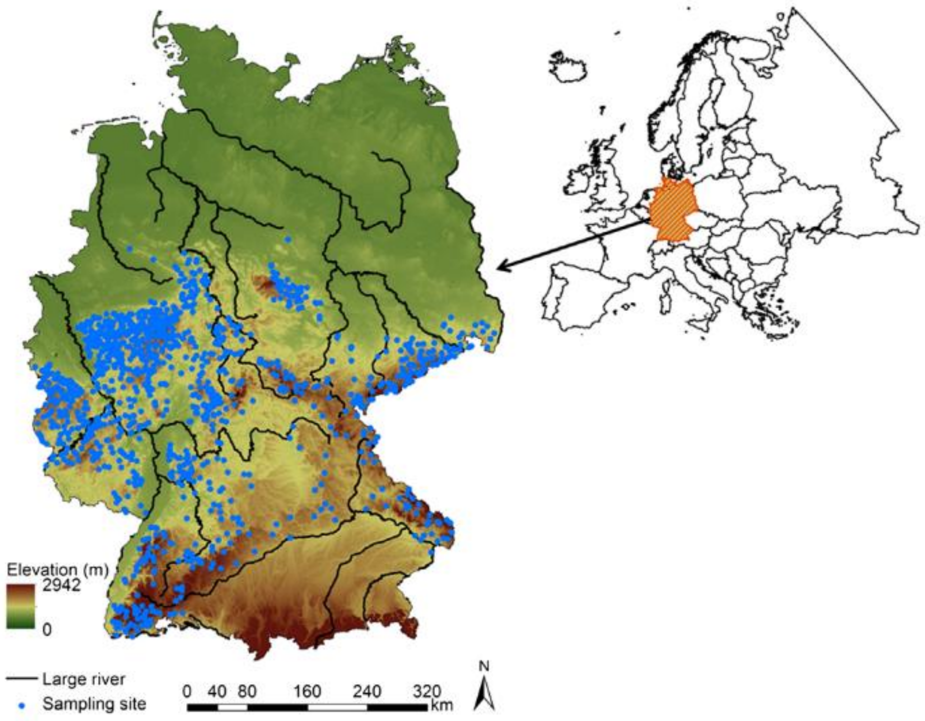
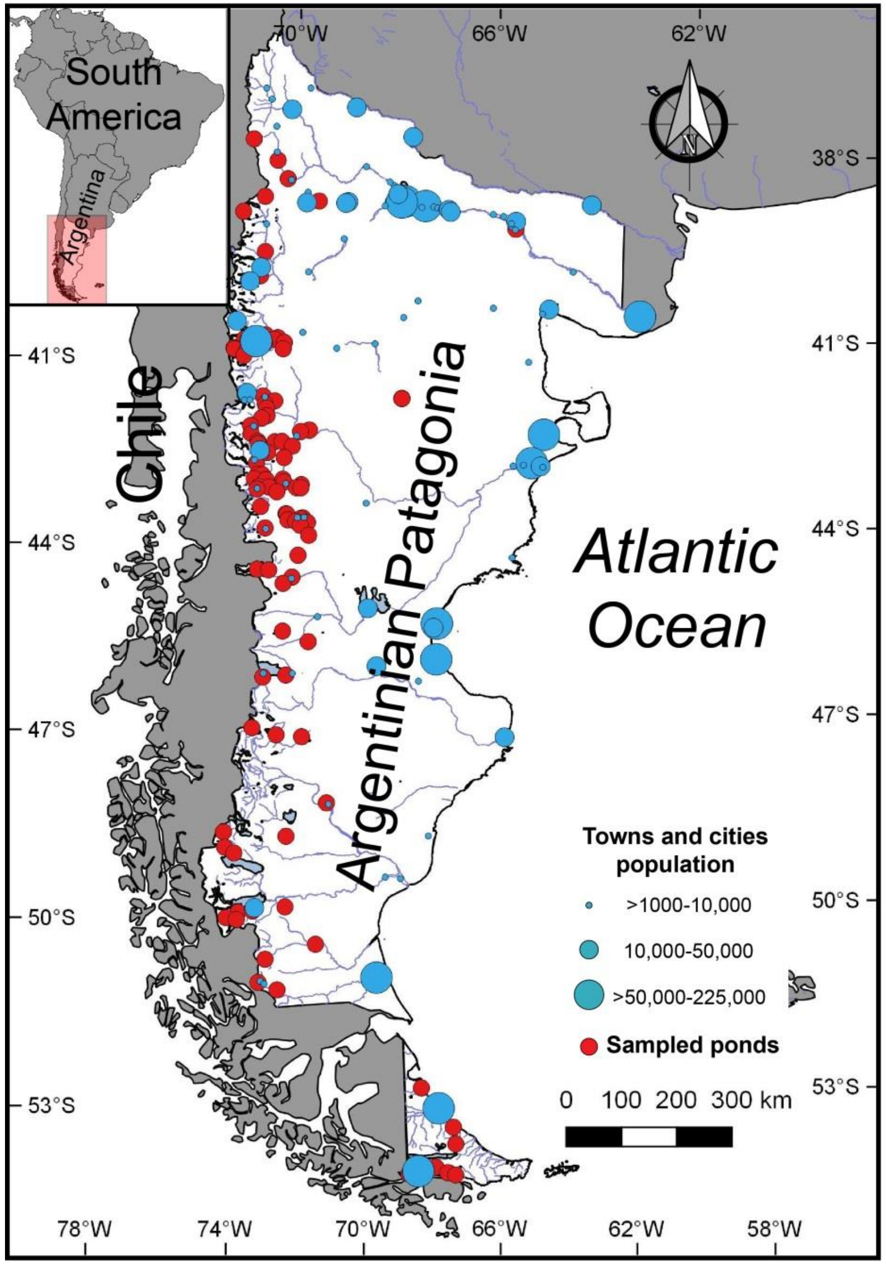


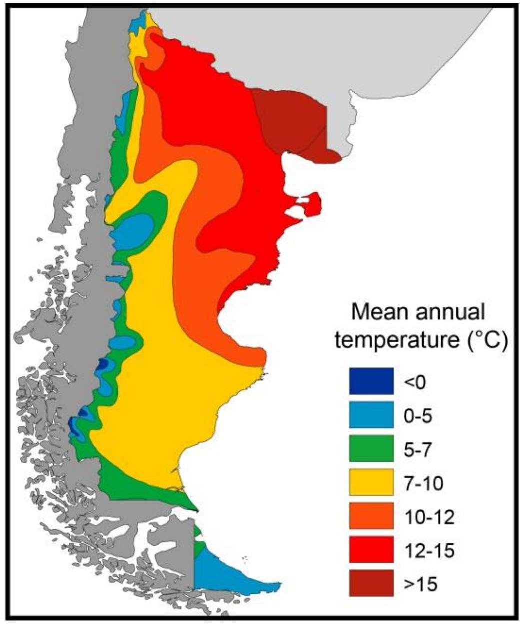
Fig. 1. Distribution of sampling sites in Germany.

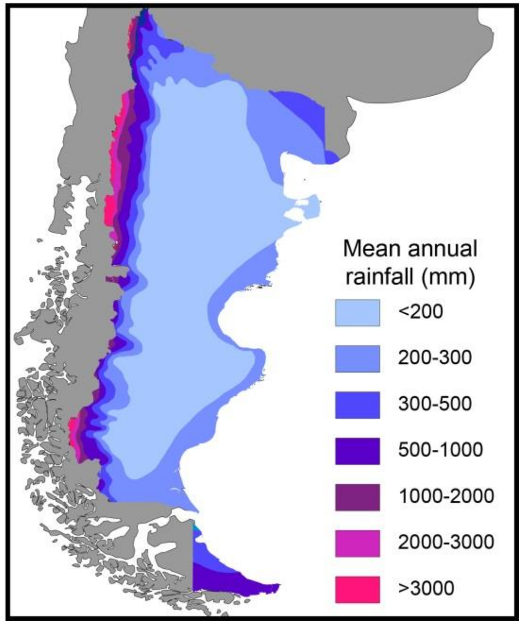
Li, F., J. D. Tonkin, and P. Haase. 2020. Local contribution to beta diversity is negatively linked with community-wide dispersal capacity in stream invertebrate communities. Ecological Indicators 108:105715.

Metacommunity analysis

5. Null models







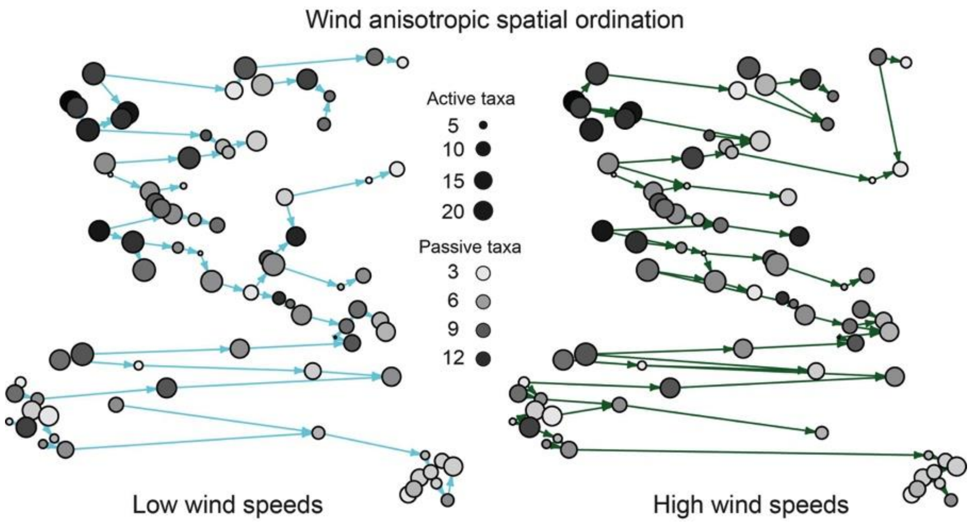
Epele, L. B., D. A. Dos Santos, R. Sarremejane, M. G. Grech, P. A. Macchi, L. M. Manzo, M. L. Miserendino, N. Bonada, and M. Cañedo-Argüelles. 2021. Blowin’ in the wind: Wind directionality affects wetland invertebrate metacommunities in Patagonia. Global Ecology and Biogeography:1–13.

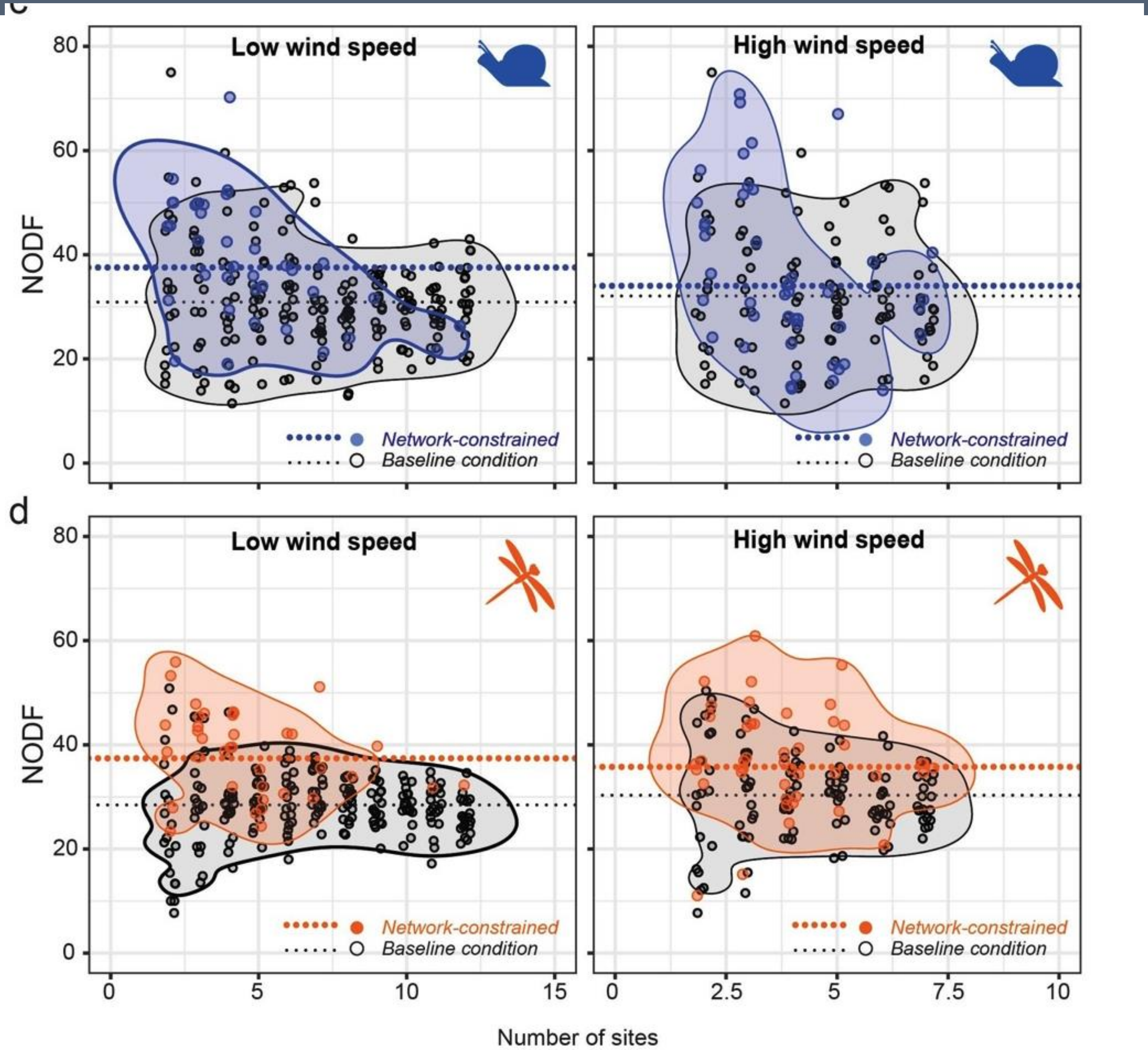
Metacommunity analysis

5. Null models

Random pond selection and calculation of the "NODF"

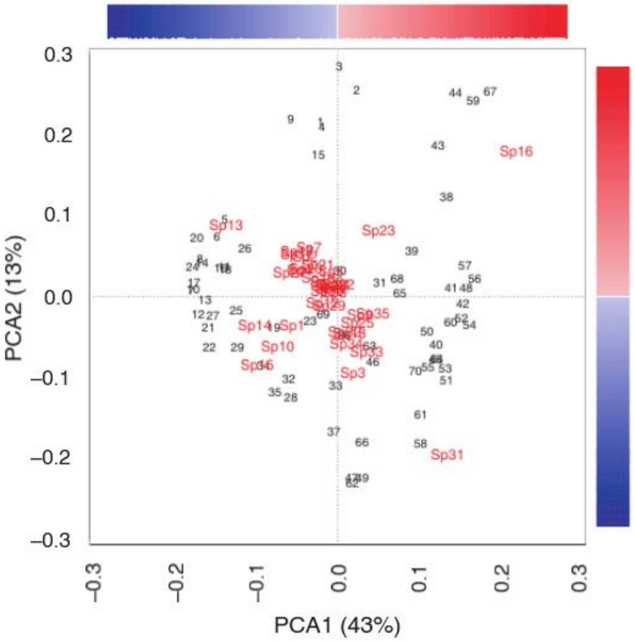
VS





6. Multiscale codependence analysis – Joint Spatial Distributions

Oribatid mite community in Lac Geai (in Québec, Canada).



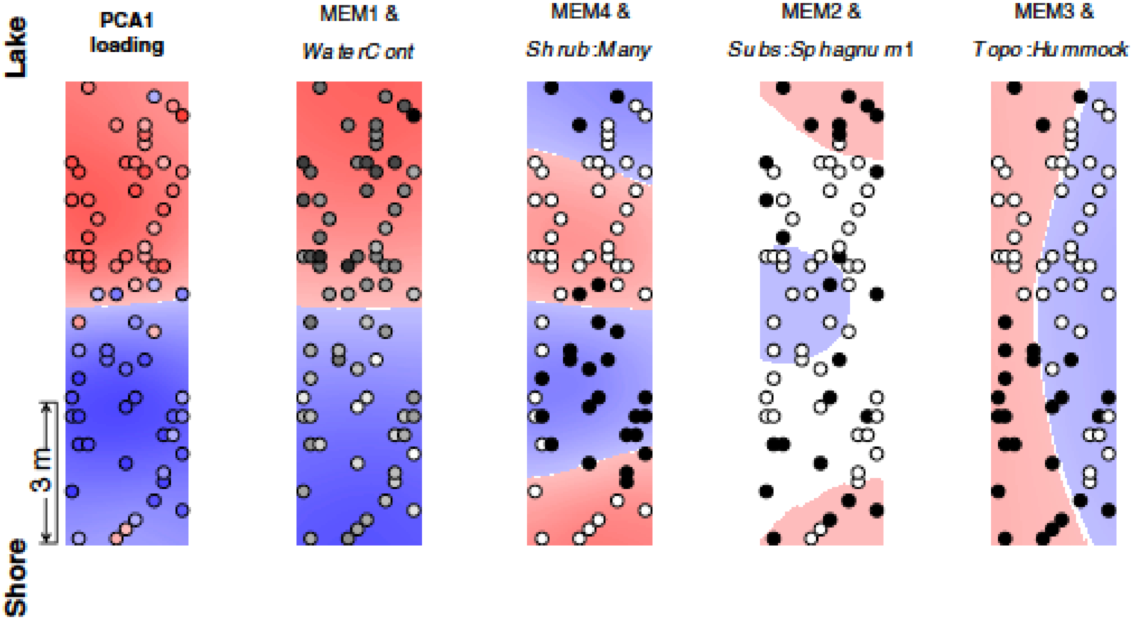


FIGURE 8 Geographic map of the mite data showing the statistically significant spatial components of the codependence between the mite community structure and the environmental variables to which it is associated at certain spatial scales, as found by the analysis. The left panel shows the 70 sites with colours corresponding to their positions along PCA1 (Figure 7). The following panels show the 70 sites again with symbols shaded according to the value of the environmental variable shown at the top of the map, and background colours corresponding to the MEM component (positive and negative values in red and blue, respectively) associated with the scale of the mite-environment codependence. Values between the sampling locations were calculated from the prediction scores of the MEM for single species, which were then projected on the PCA

Metacommunity analysis

7. Permutational Simper (PER-SIMPER)

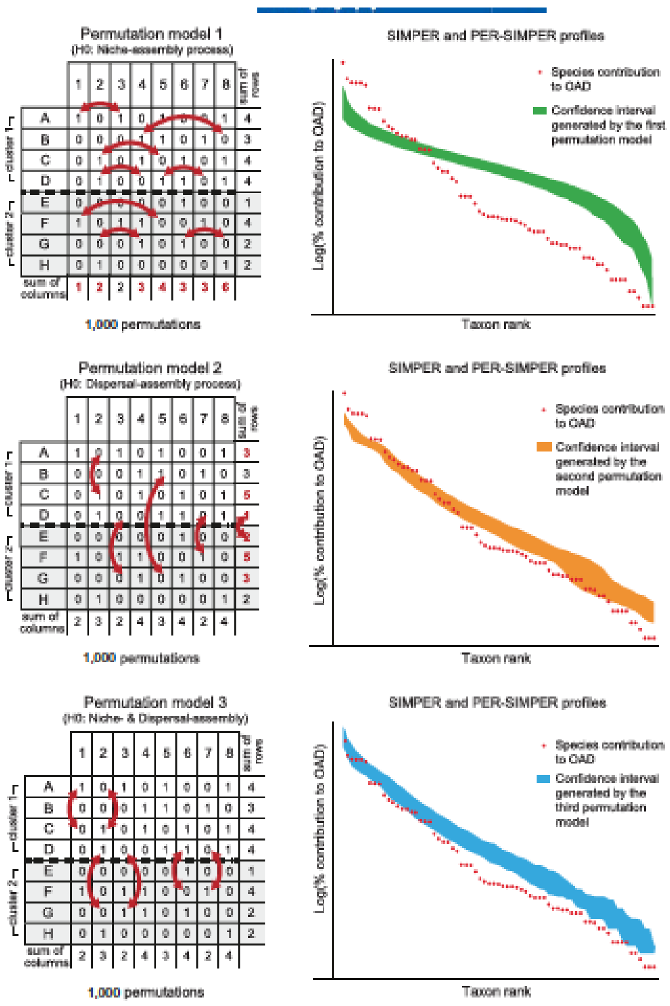
OAD = Overall average dissimilarity

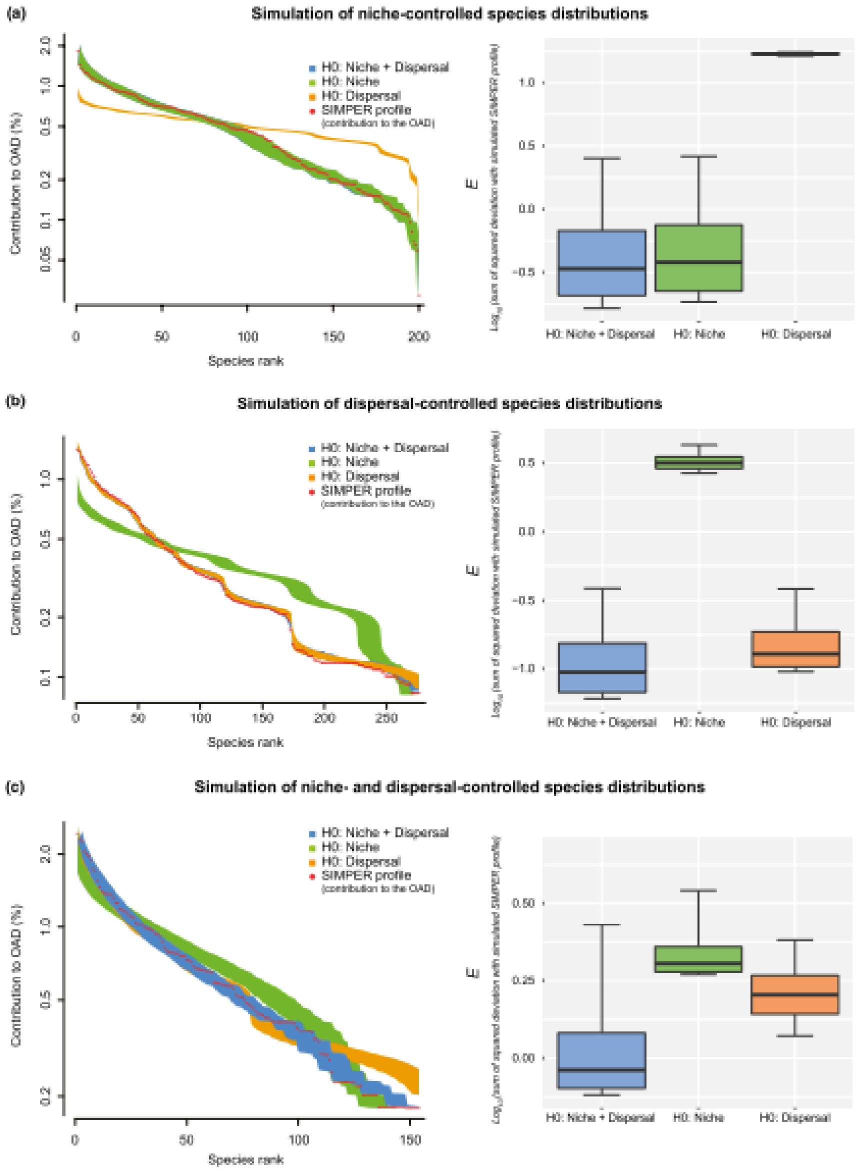
(a)

Taxa

Localities		1	2	3	4	5	6	7	8	sum of rows
cluster 1	A	1	0	1	0	1	0	0	1	4
cluster 1	B	0	0	0	1	1	0	1	0	3
cluster 1	C	0	1	0	1	0	1	0	1	4
cluster 1	D	0	1	0	0	1	1	0	1	4
cluster 2	E	0	0	0	0	0	1	0	0	1
cluster 2	F	1	0	1	1	0	0	1	0	4
cluster 2	G	0	0	0	1	0	1	0	0	2
cluster 2	H	0	1	0	0	0	0	0	1	2
	sum of columns	2	3	2	4	3	4	2	4	

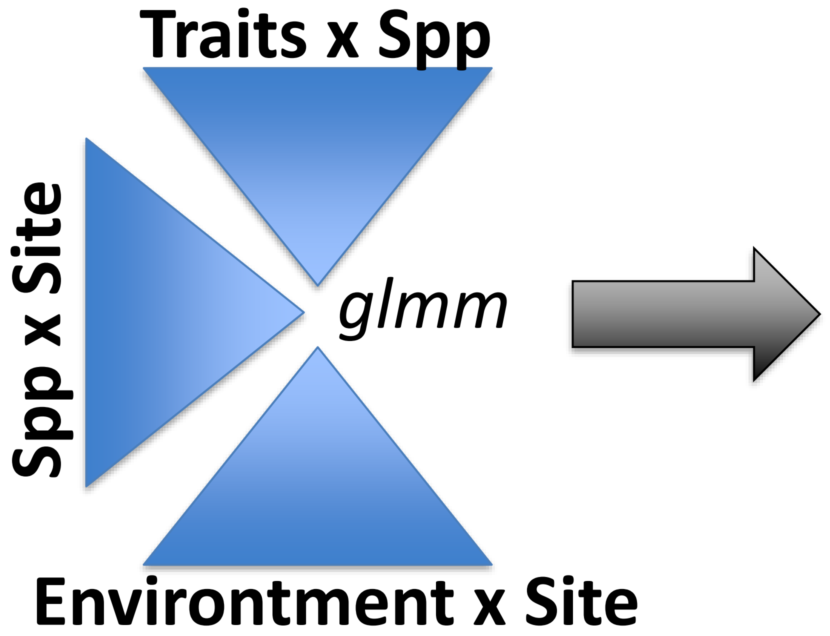
Original data table of occurence

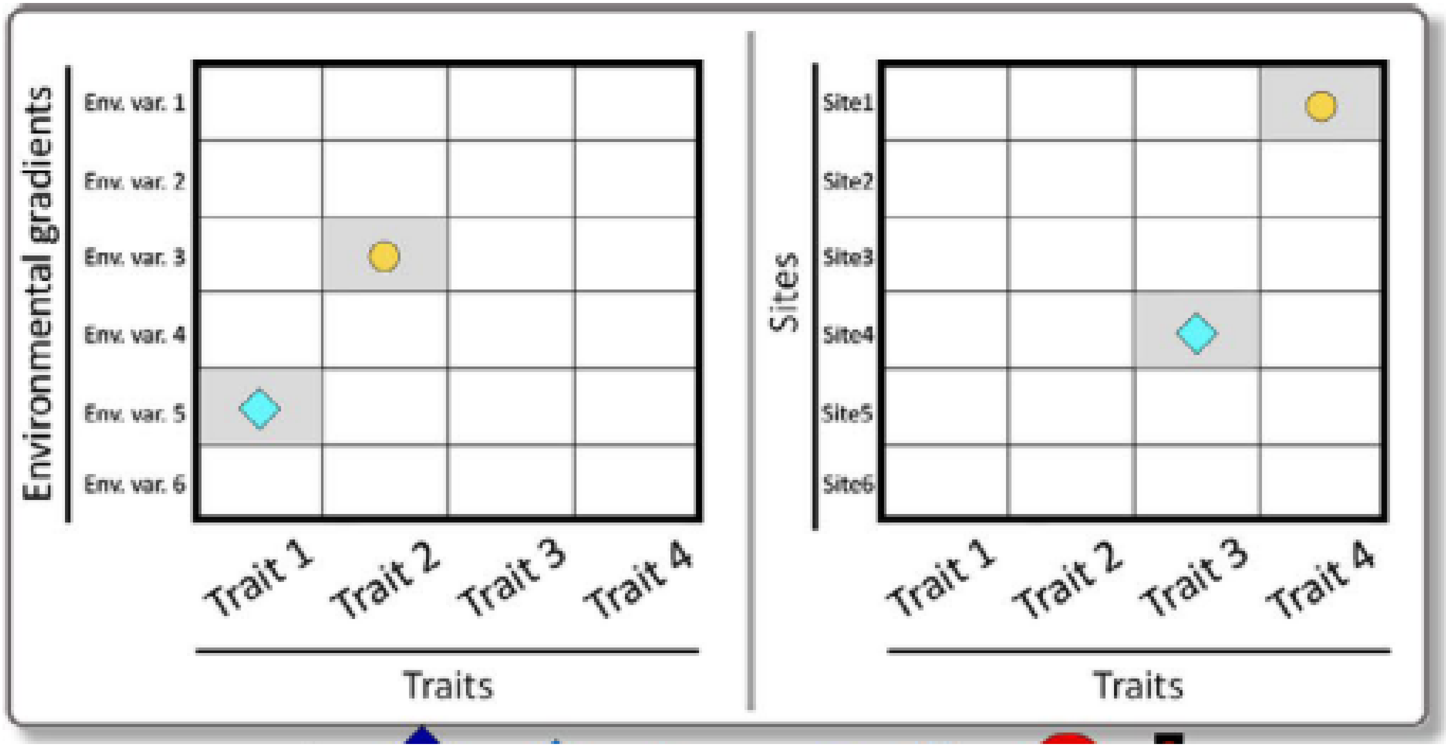




Gibert, C., and G. Escarguel. 2019. PER-SIMPER—A new tool for inferring community assembly processes from taxon occurrences. Global Ecology and Biogeography 28:374–385.

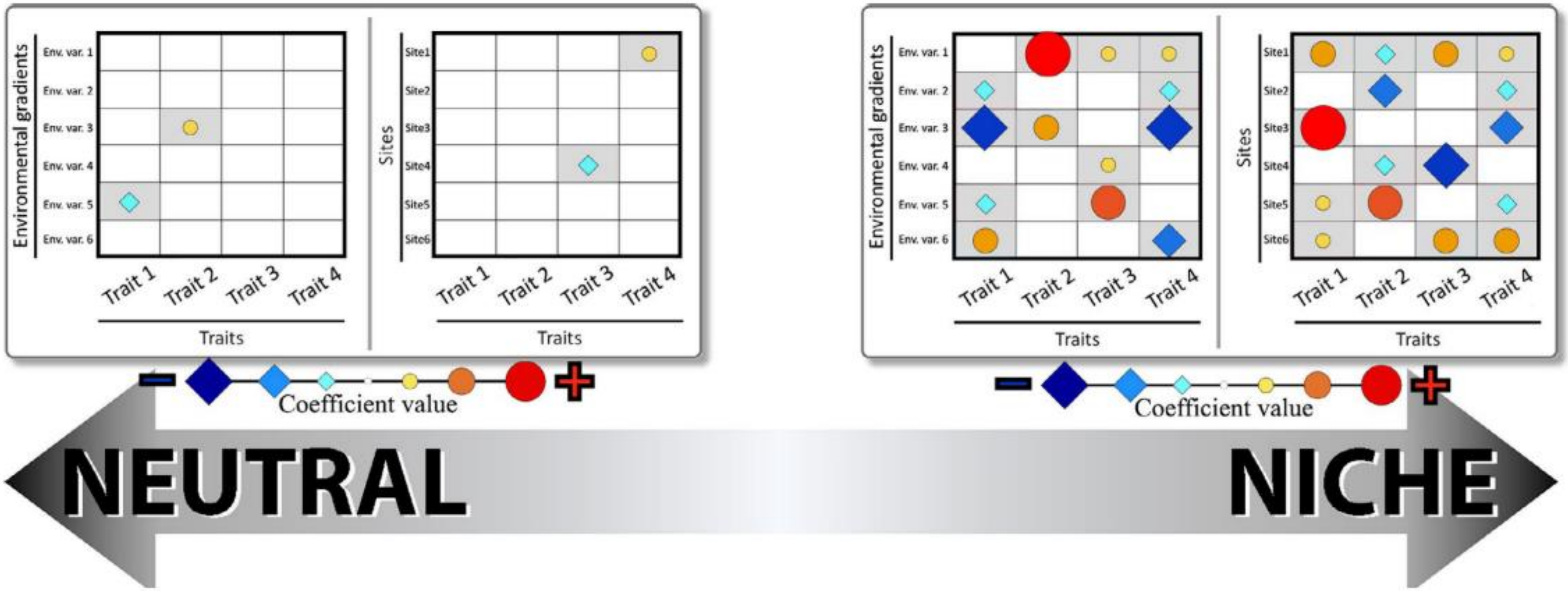
8. Fourth-corner relationships and Community Assembly by Traits Selection (CATS)





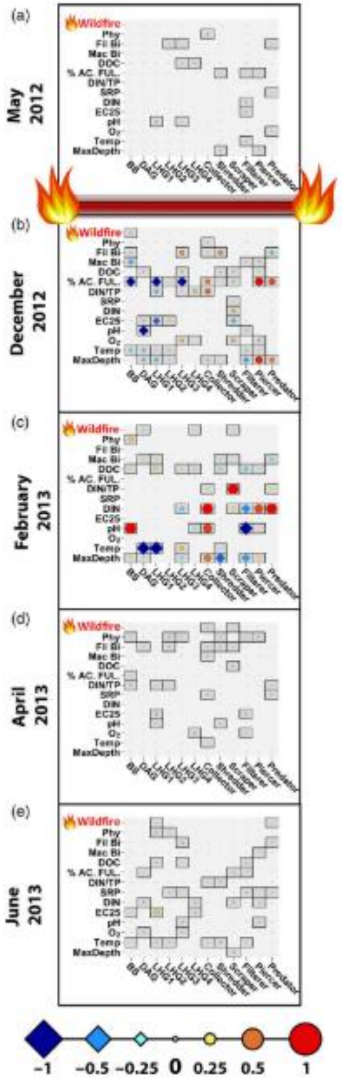
Cunillera-Montcusí, D., M. Arim, S. Gascón, I. Tornero, J. Sala, D. Boix, and A. I. Borthagaray. 2020. Addressing trait selection patterns in temporary ponds in response to wildfire disturbance and seasonal succession. Journal of Animal Ecology 89:2134–2144.

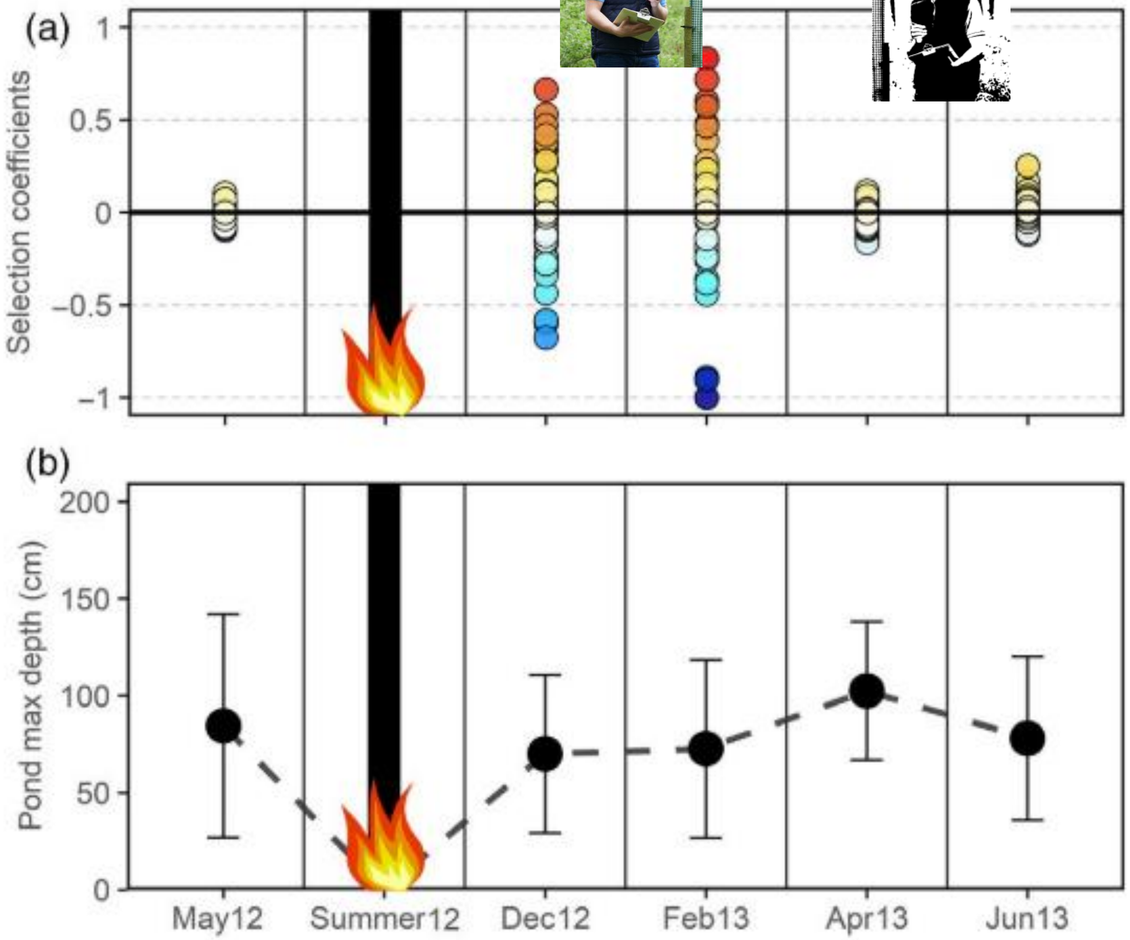
8. Fourth-corner relationships and Community Assembly by Traits Selection (CATS)



Metacommunity analysis

8. Fourth-corner relationships and Community Assembly by Traits Selection (CATS)



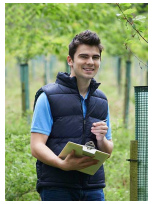


9. Univariate community assembly analysis

UniCAA uses Generalized Linear Mixed Models (GLMMs) with the **probability of species occurring within communities** as a response variable.

Incorporates the **distance to source habitat**, which for all species-by-site combinations specifies the geographic distance to the nearest site where the species is found.

The influence of environmental filters is tested by including Traits+ Environmental conditions terms, that is, **interactions between the environmental conditions and functional traits.**



The **influence of stochasticity** is tested by including the interaction term size × Commonness, that is, between the total number of individuals sampled within a given site (Community size) and the proportionate contribution of a species to the of individuals found outside a given community (Commonness).

Sydenham et al. 2018

9. Univariate community assembly analysis

To assess whether the observed relationship between species occurrences and Distance to source habitat, Species traits × Environmental conditions, and Community size × Commonness differ from that expected under stochastic community assembly, the regression coefficients from the fixed effect terms in the final model are compared to those obtained from a null model. In the **null model**, species are ecologically equivalent, immigration rates are high and species are free to disperse across the entire landscape—that is, species distributions are purely stochastic—resulting in a neutral metacommunity. The null model is constructed by reshuffling the original speciesby-site data frame while keeping the row and column sums constant.

Statistically significant **deviations from the null model** suggest that the observed (empirical) community compositions differ from that expected species were ecologically equivalent and free to disperse across the entire region.

9. Univariate community assembly analysis

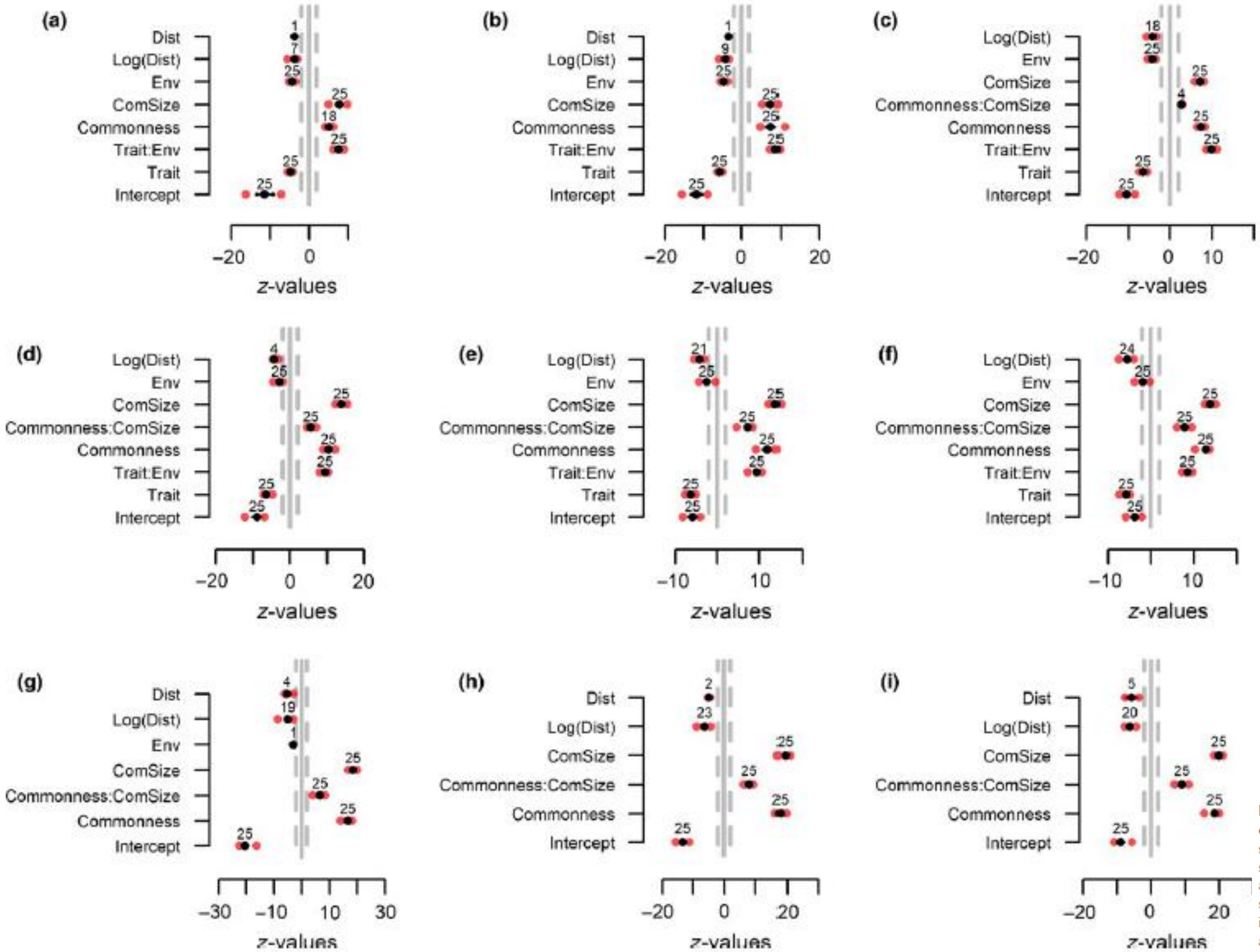
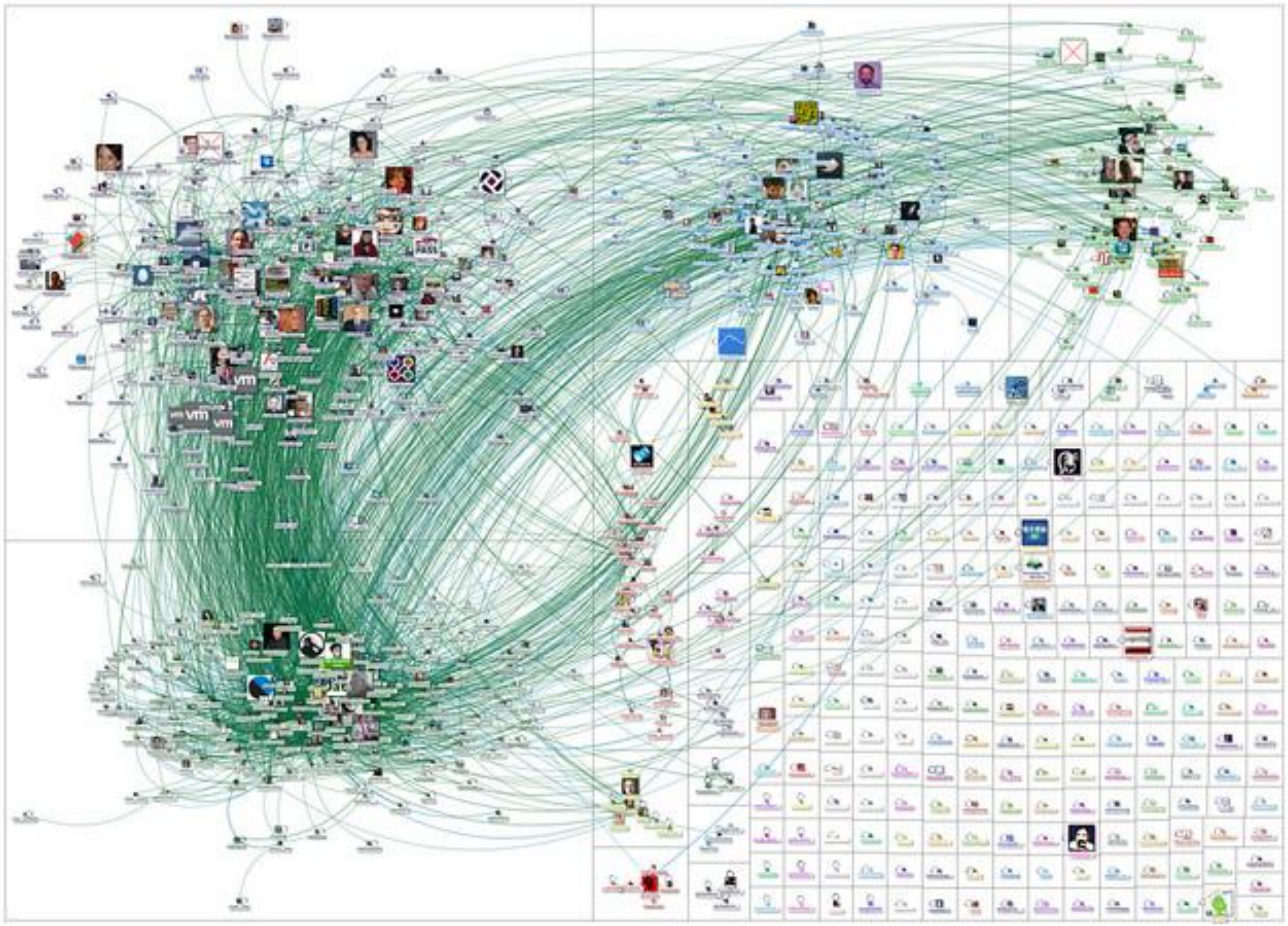


FIGURE 3 Step 1—with spatially restricted dispersal. Metacommunities were simulated with strong (a–c), intermediate (d–f) or without environmental filtering (g–i) and with low (left panels), intermediate (middle panels) or high (right panels) immigration rates. Black points show the mean and red points show the minimum and maximum effect size for each term. Gray dashed lines mark the cutoff value for statistical significance (i.e., an absolute value of two). Numbers above the mean z-values show the number of models (out of 25) in which a parameter was included. Positive and negative effect sizes indicate if community assembly processes led to an increase or decrease in species occurrence, respectively. For the community size × commonness interaction, a positive effect size indicates that the rate of increase in occurrence with community size depends on the commonness of species. For the environmental conditions × functional traits interaction, a positive effect size indicates that species occurrences along the environmental gradient (filter) depend on the functional traits of species

Metacommunity analysis

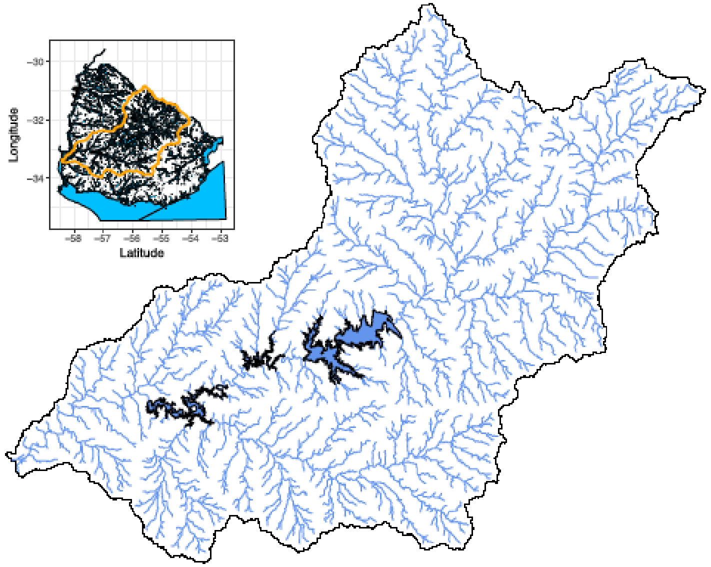
10. Patch-based graphs & Network analyses

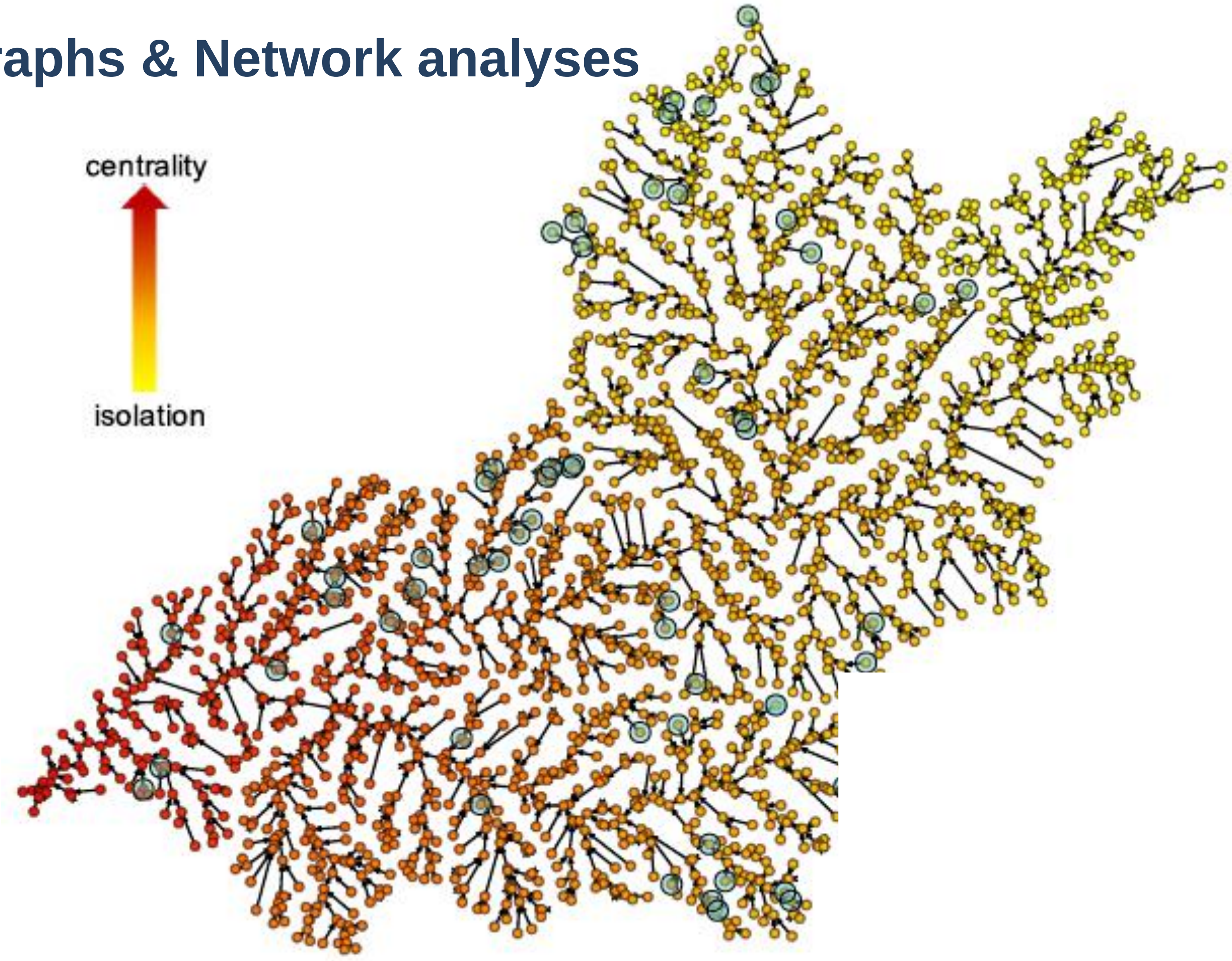
Social media network connections among Twitter users



Created with NodeXL (http://nodexl.codeplex.com) from the Social Media Research Foundation (http://www.smrfoundation.org)

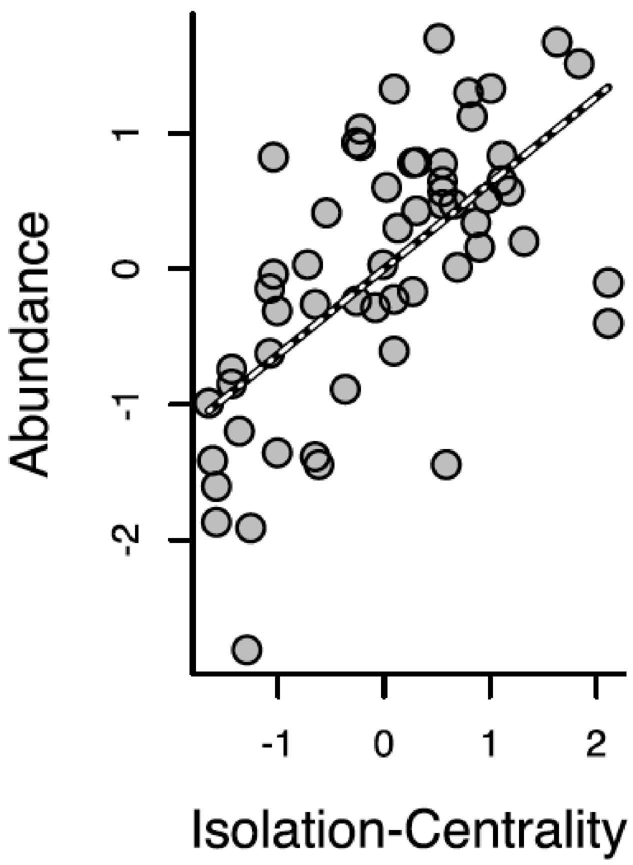
10. Patch-based graphs & Network analyses

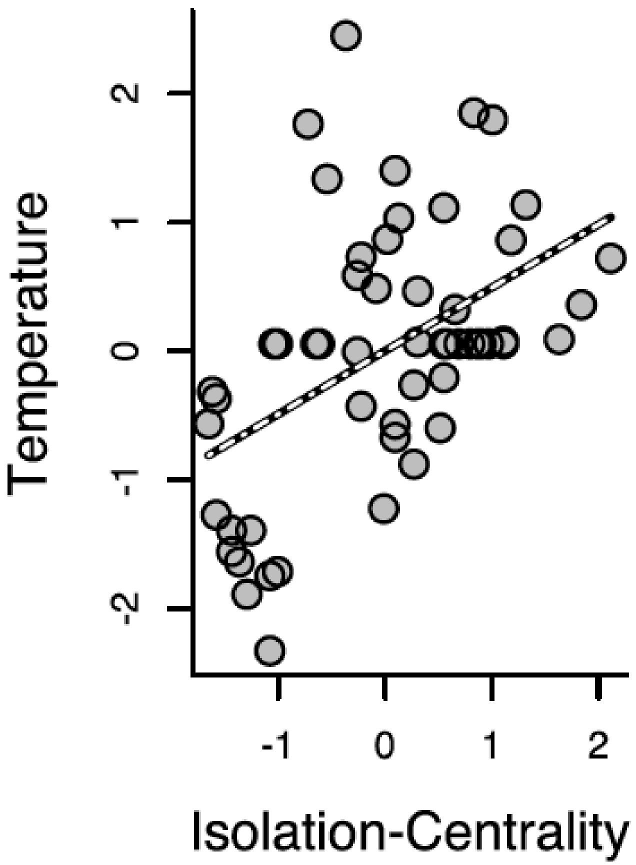




Borthagaray, A. I., F. Teixeira-de Mello, G. Tesitore, E. Ortiz, M. Illarze, V. Pinelli, L. Urtado, P. Raftopulos, I. González-Bergonzoni, S. Abades, M. Loureiro, and M. Arim. 2020. Community isolation drives lower fish biomass and species richness, but higher functional evenness, in a river metacommunity. Freshwater Biology:1–15.

10. Patch-based graphs & Network analyses

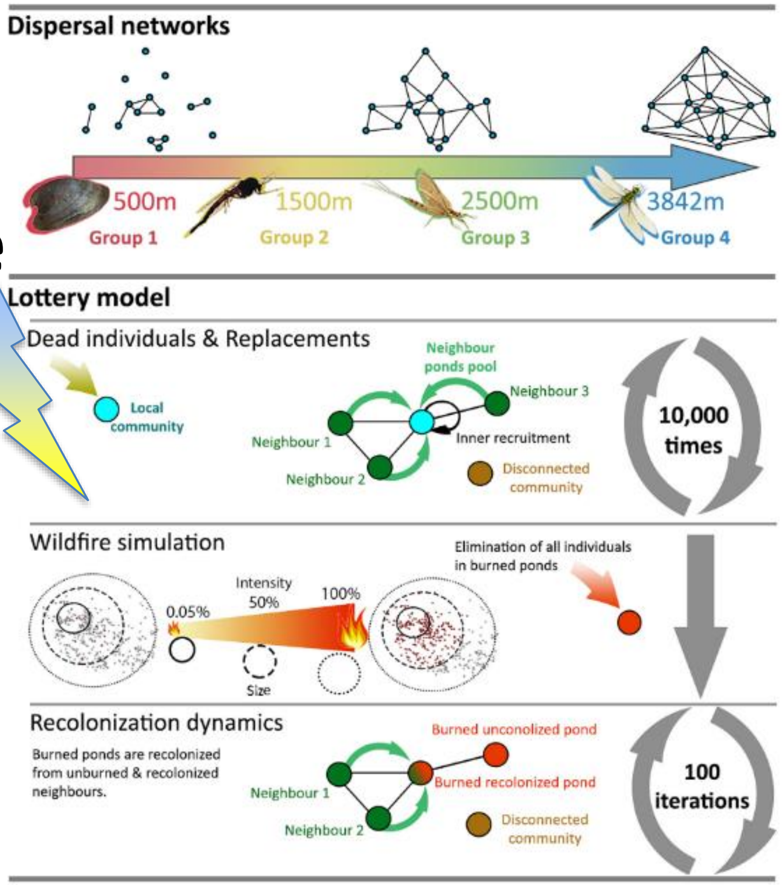


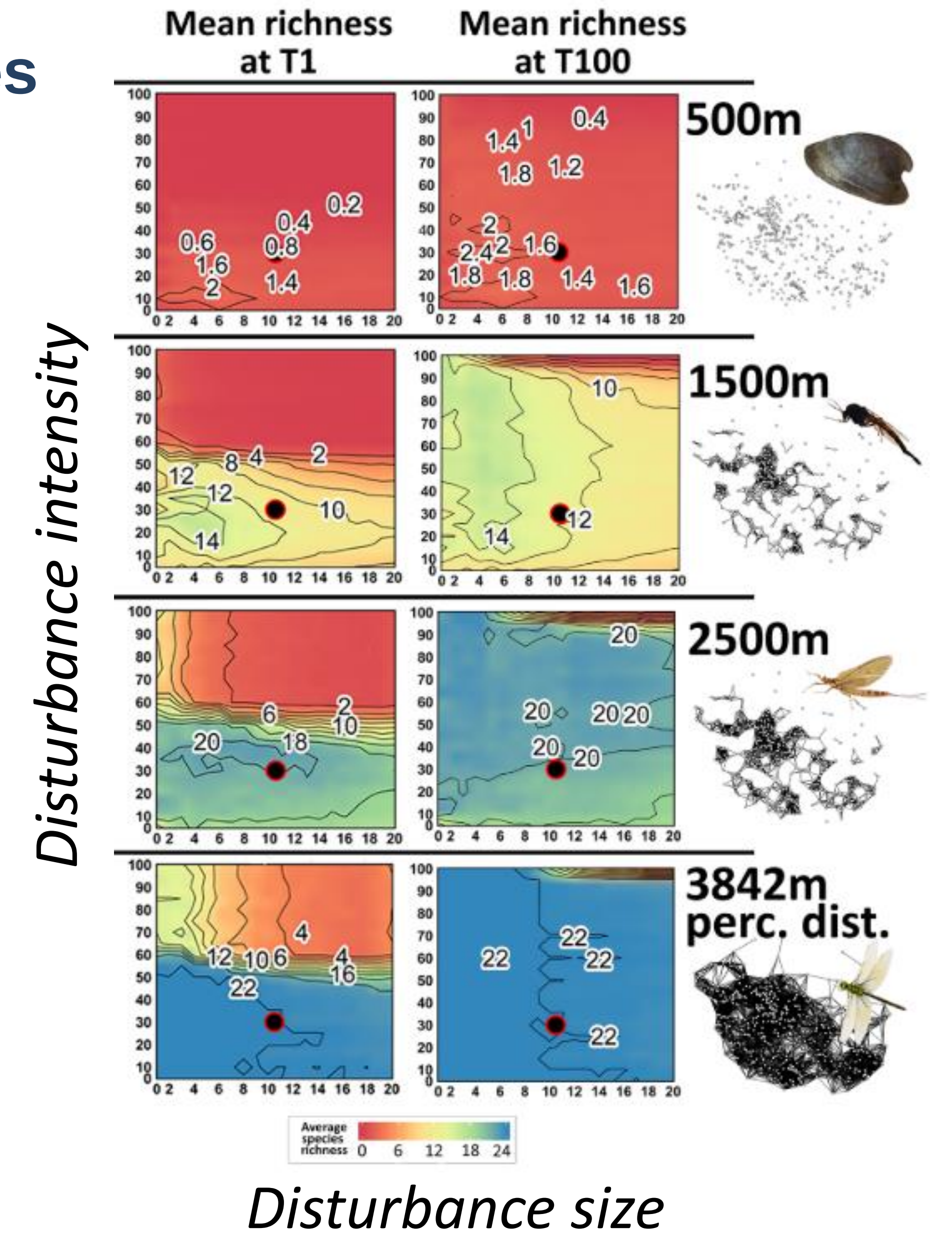


10. Patch-based graphs & Network analyses

“Disturbance cycles”

Hubbell, 2001





Cunillera-Montcusí, D., A. I. Borthagaray, D. Boix, S. Gascón, J. Sala, I. Tornero, X. D. Quintana, and M. Arim. 2021. Metacommunity resilience against simulated gradients of wildfire: disturbance intensity and species dispersal ability determine landscape recover capacity. Ecography 44:1022–1034.

FUTURE RESEARCH

1. Distance Decay
2. Variance Partitioning
3. Metacommunity structure
4. Beta diversity components
   Local Contribution to Beta Diversity-LCBD
5. Null models
6. Multiscale codependence analysis –
   Joint Spatial Distributions
7. Permutational Simper (PER-SIMPER)
8. Fourth-corner relationships and
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PATCH DYNAMICS
NEUTRAL DYNAMICS
SPECIES SORTING
MASS EFFECTS

WHAT DO YOU THINK?

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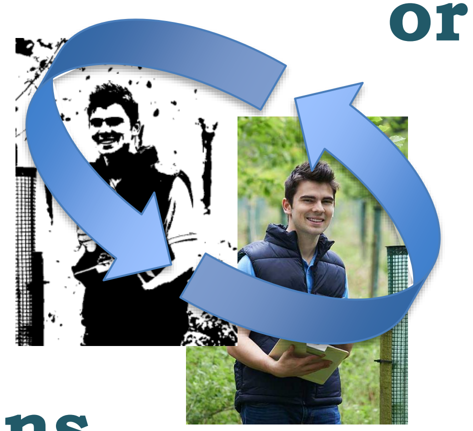
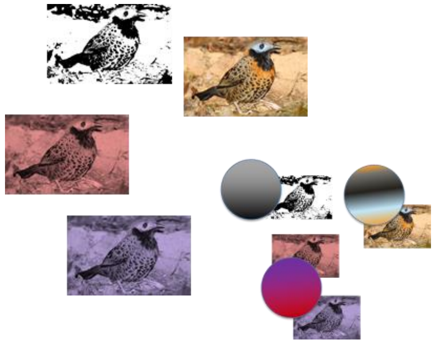
MEM's

Dispersal

Stochasticity or Neutrality

Abiotic filters





Biotic interactions

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NEUTRAL DYNAMICS
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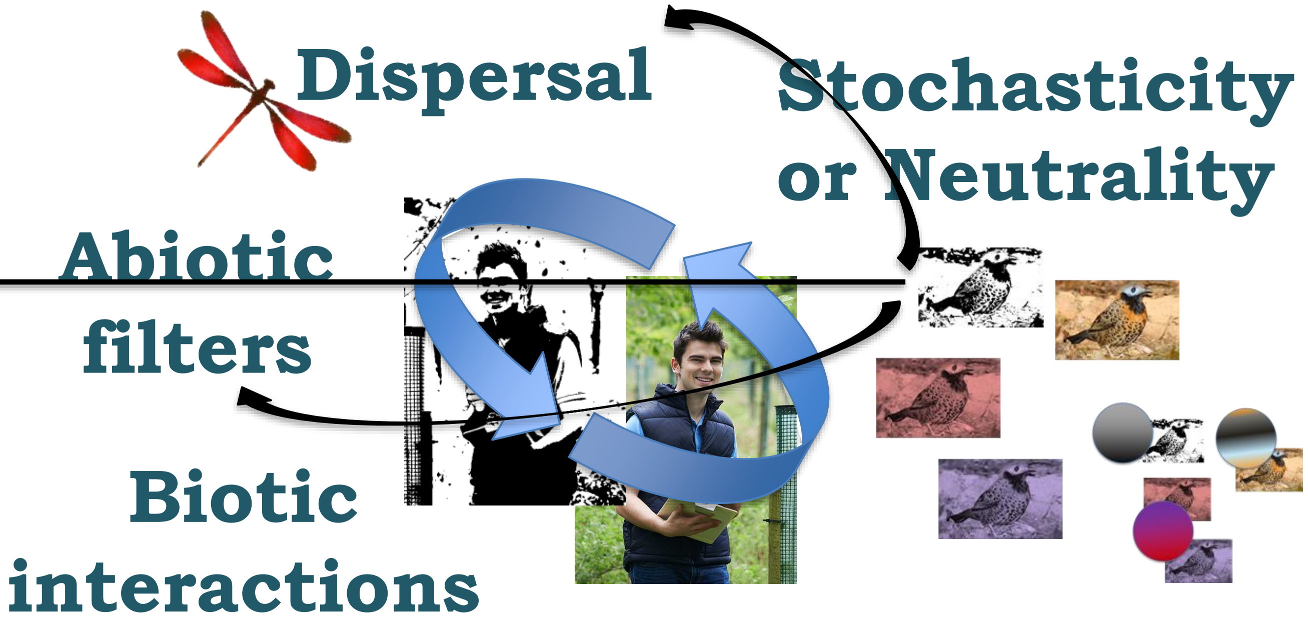

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FUTURE RESEARCH

6. Progress in metacommunity ecology is hampered by continuing to think of the original four archetypes as alternative hypotheses rather than as interacting components. Future progress will require us to find ways to understand how multiple processes work jointly and interactively to affect diversity and composition of biotas across spatial scales.

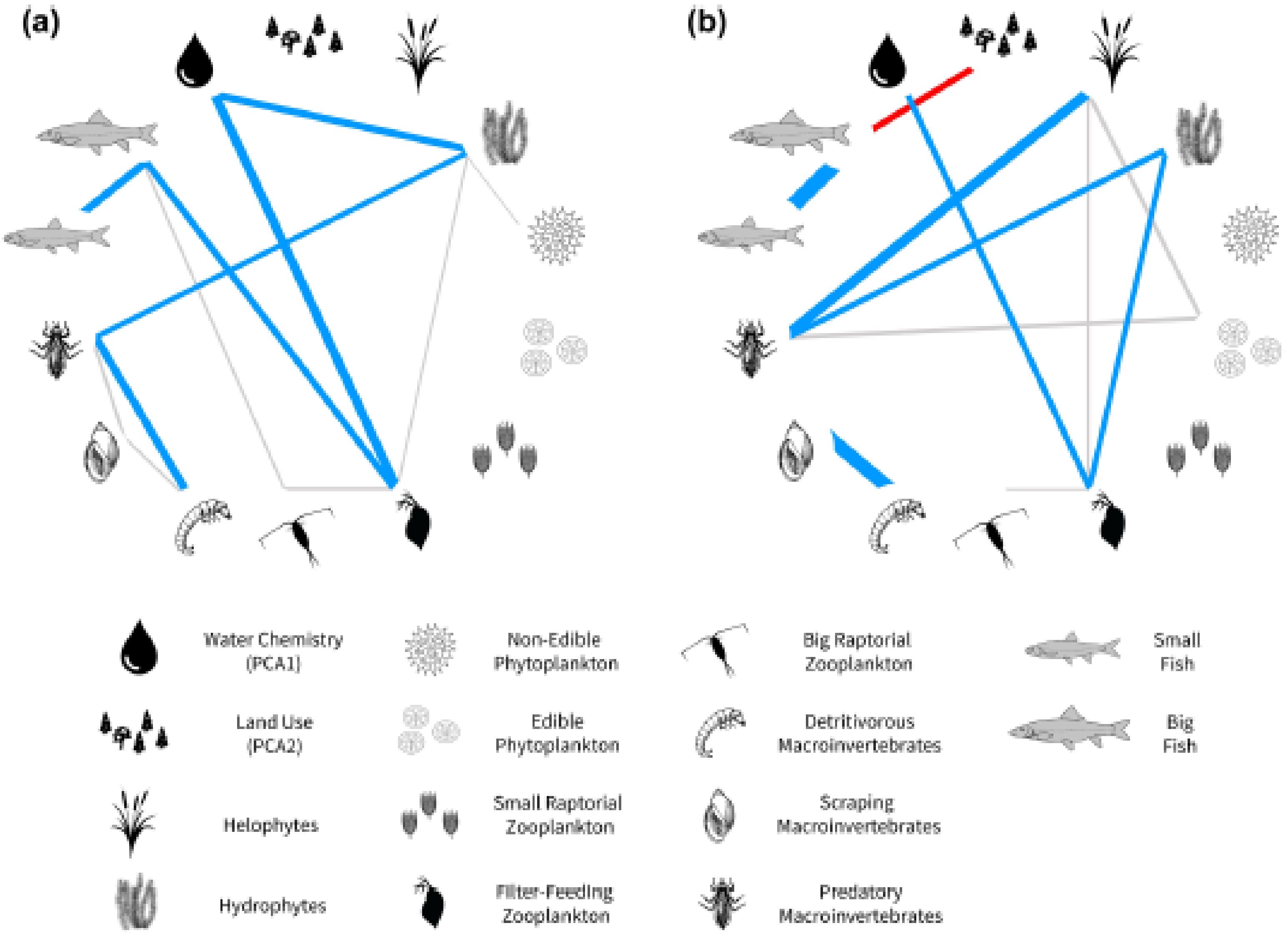
Models or Cases or Structures ("big four")

PATCH DYNAMICS
NEUTRAL DYNAMICS
SPECIES SORTING
MASS EFFECTS

"Archetypes"

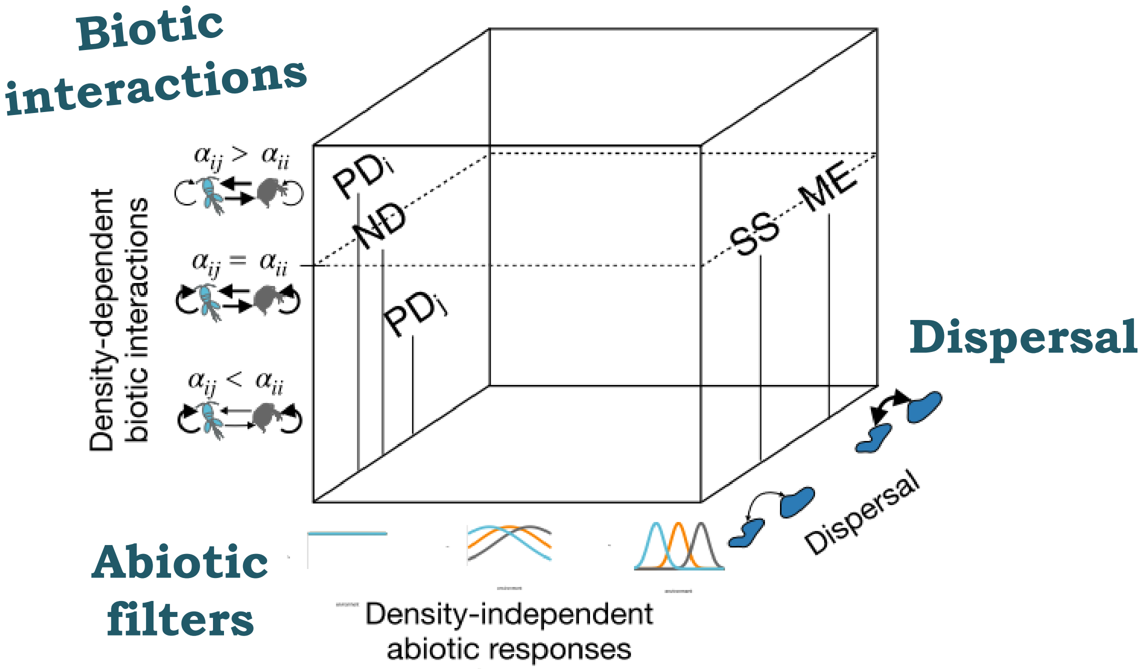
Leibold, M. A., and J. M. Chase. 2018. Metacommunity Ecology. Princeton University Press.

Biotic interactions



García-Girón, J., J. Heino, F. García-Criado, C. Fernández-Aláez, and J. Alahuhta. 2020. Biotic interactions hold the key to understanding metacommunity organisation. Ecography 43:1–11.

FUTURE RESEARCH



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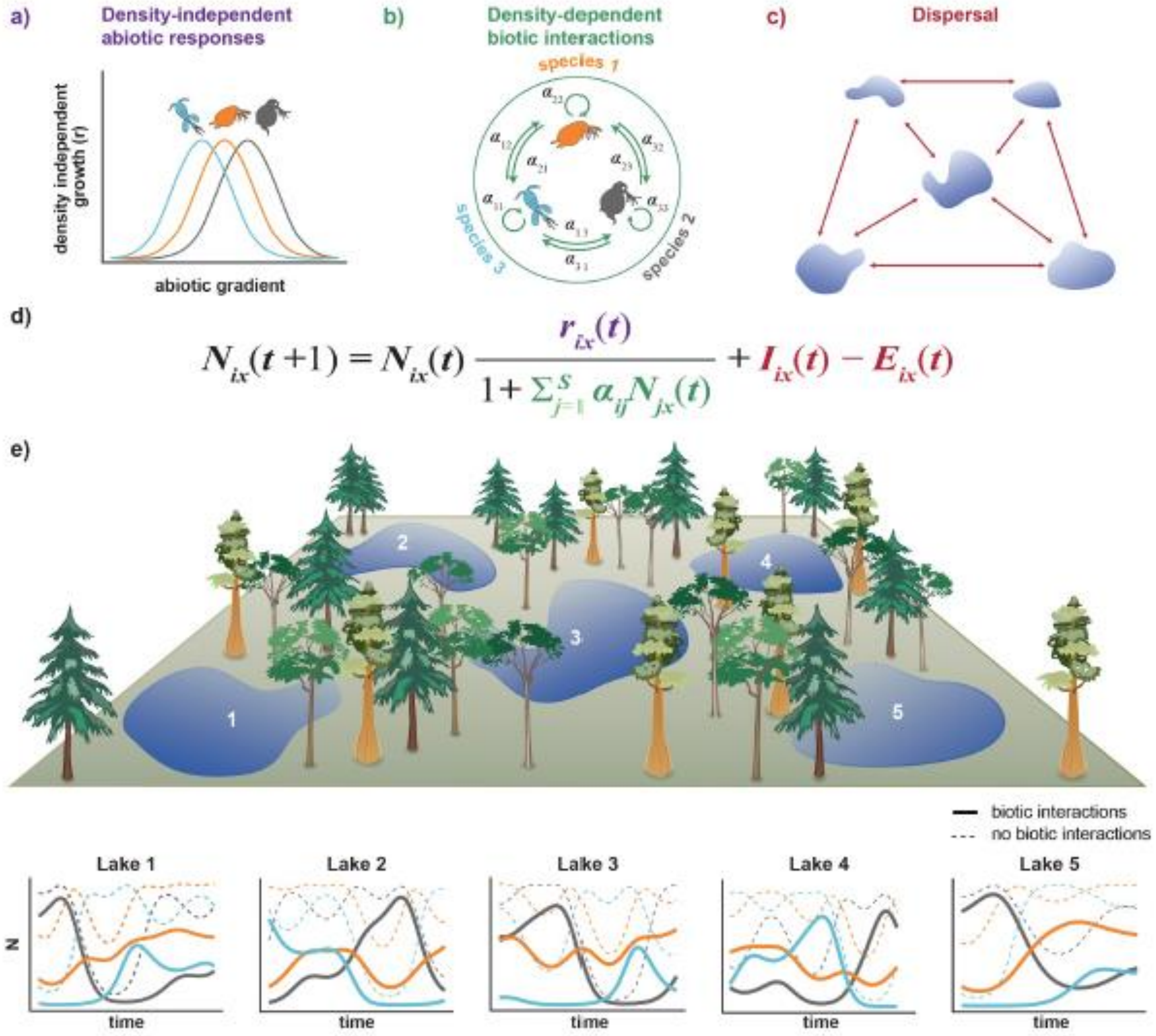
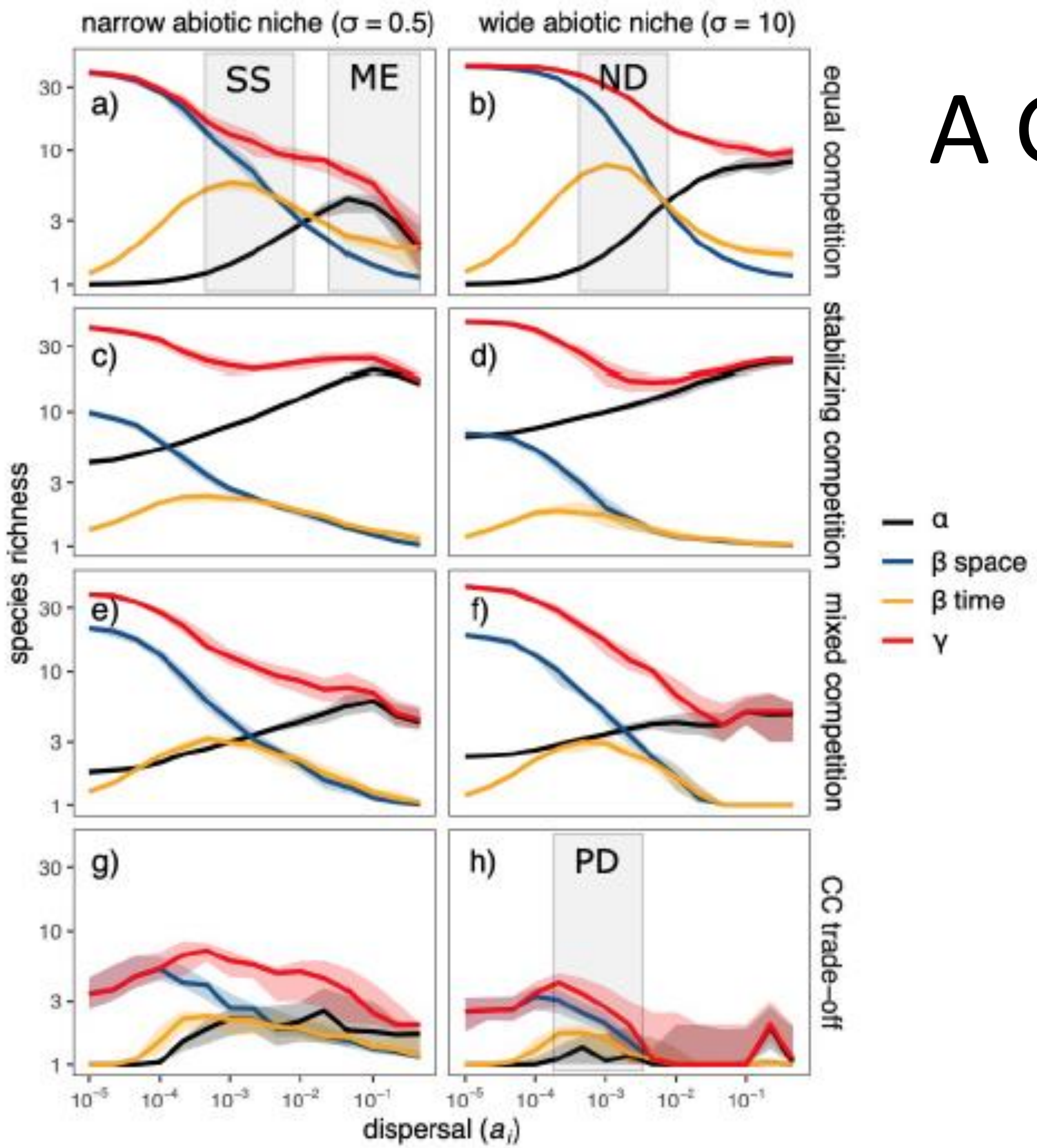


Thompson, P. L., L. M. Guzman, L. De Meester, Z. Horváth, R. Ptacnik, B. Vanschoenwinkel, D. S. Viana, and J. M. Chase. 2020. A process-based metacommunity framework linking local and regional scale community ecology. Ecology Letters 23:1314–1329.

FUTURE RESEARCH



A GRADIENT!

PATCH DYNAMICS
NEUTRAL DYNAMICS
SPECIES SORTING
MASS EFFECTS

THEY CONSTITUTE DIFFERENT ARCHETYPES OF POSSIBLE METACOMMUNITY STRUCTURE

Making sense of metacommunities: dispelling the mythology of a metacommunity typology

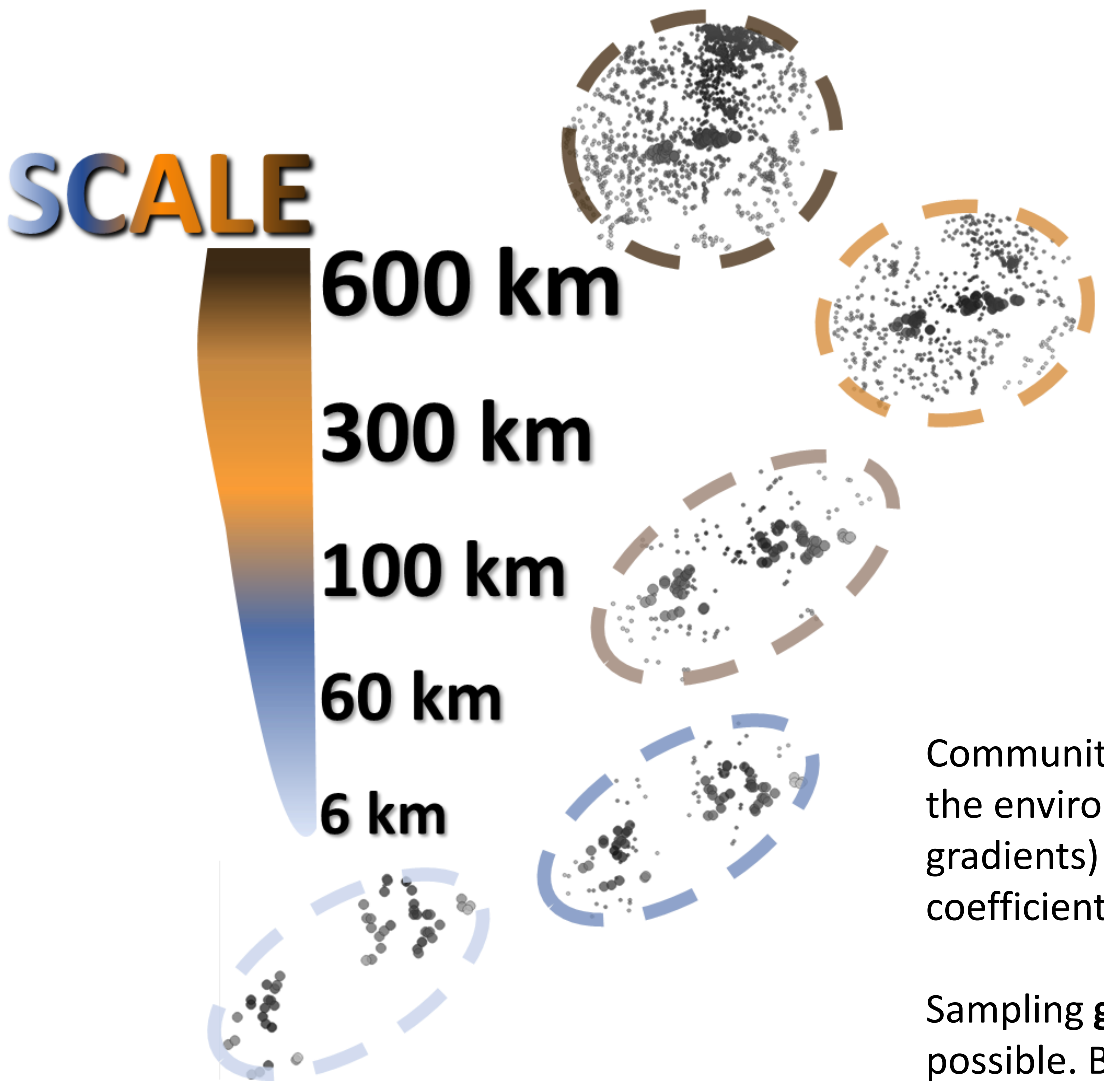
Bryan L. Brown[1] · Eric R. Sokol[2] · James Skelton[3] · Brett Tornwall[1]

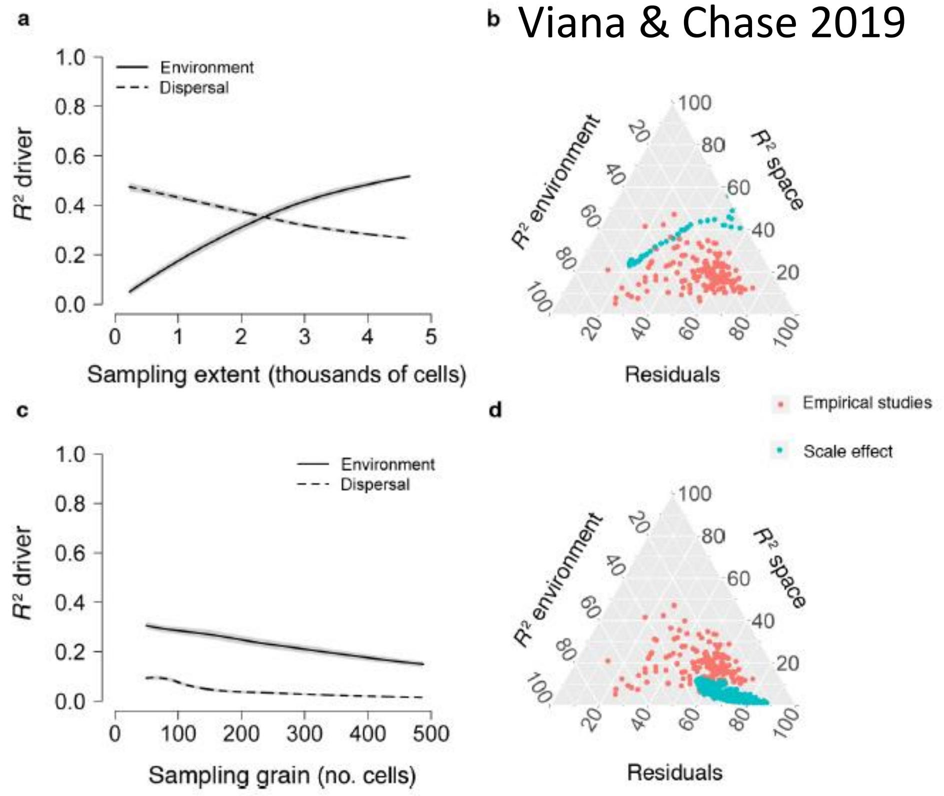
….many studies expressly define their goal as **identifying which of the Big 4** are responsible for structuring a system of interest. Unfortunately, these studies are in **many ways nonsensical** because they begin with the false premise that a community of interest can always, and exclusively, be classified as one of the Big 4. As a result, many studies ignore the swath of inference space that lies outside of the Big 4 paradigms and fail to recognize metacommunity inference space as continuous and multidimensional.

Brown, B. L., E. R. Sokol, J. Skelton, and B. Tornwall. 2017. Making sense of metacommunities: dispelling the mythology of a metacommunity typology. Oecologia 183:643–652.

FUTURE RESEARCH

SPATIAL SCALES





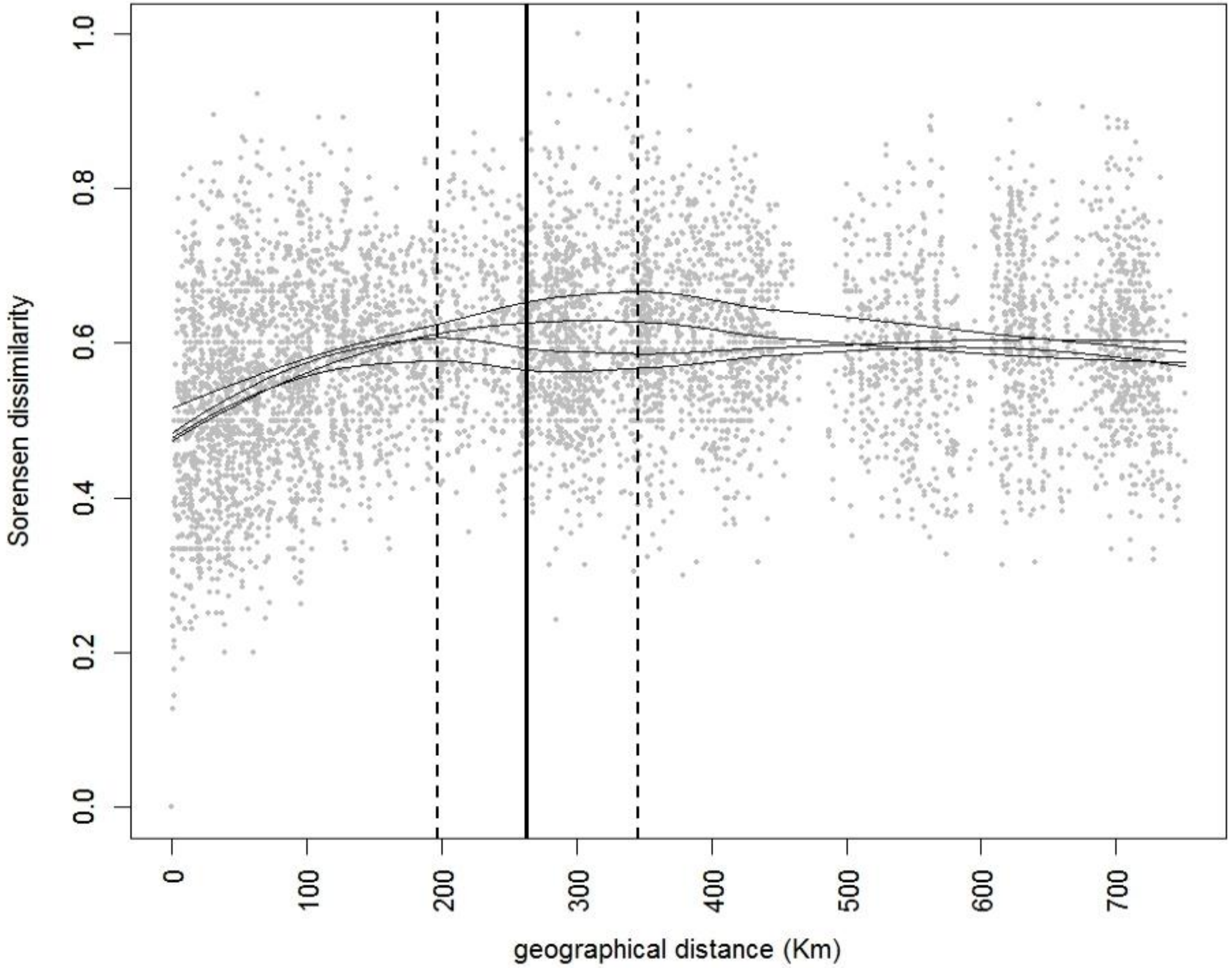
Communities should be sampled over multiple **spatial extents** to progressively increase the environmental heterogeneity (i.e., increase the coverage of relevant environmental gradients) and respective species responses. This will allow an estimate of a scaling coefficient that is a quantitative measure of the relative importance of processes.

Sampling **grain size** should be optimized to match environmental grain as closely as possible. Because environmental grain is multivariate, optimization requires choosing a grain size that maximizes environmental heterogeneity.

FUTURE RESEARCH

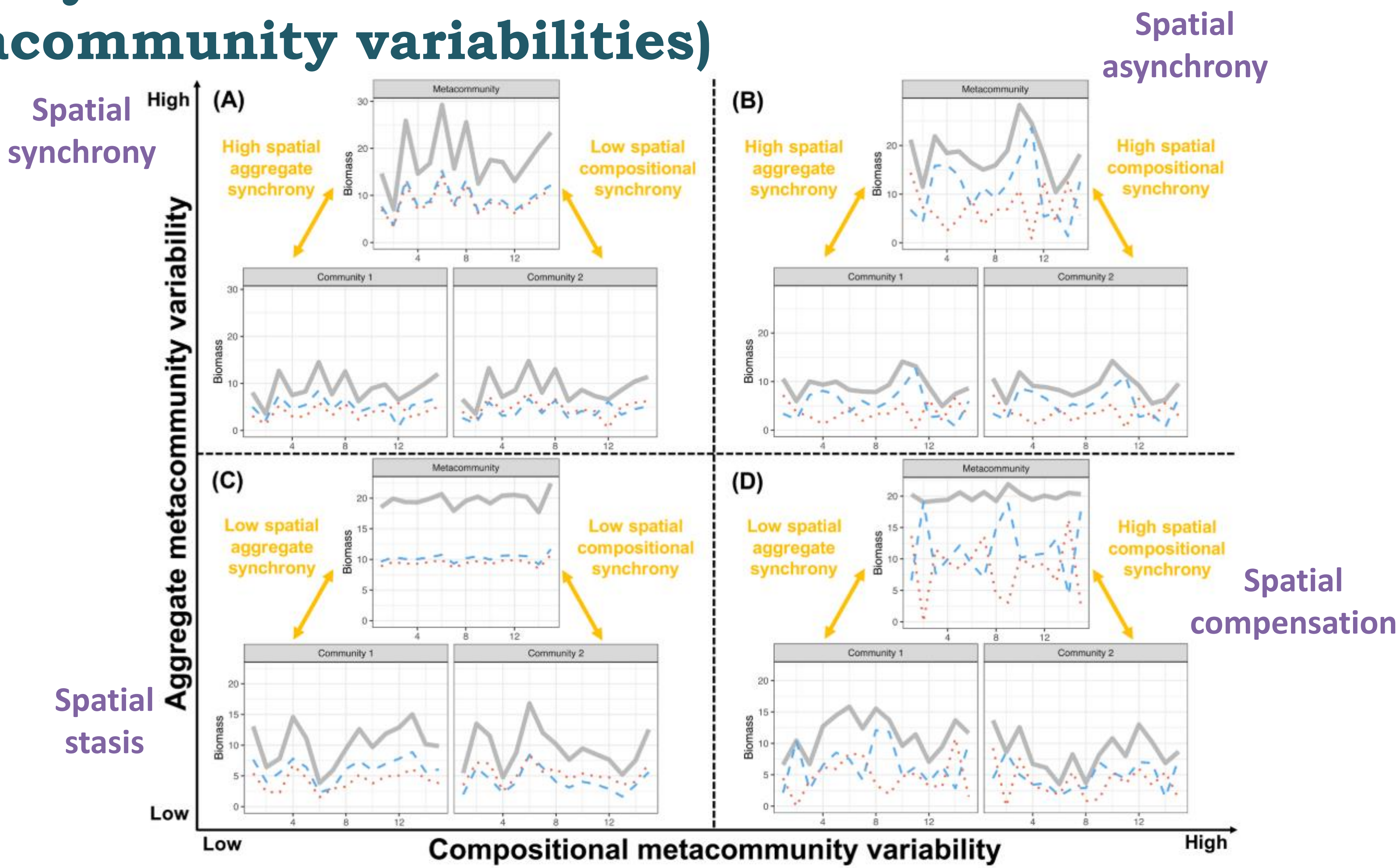
SPATIAL SCALES

Sarremejane et al. 2017



FUTURE RESEARCH

TIME – Synchrony
(local and metacommunity variabilities)

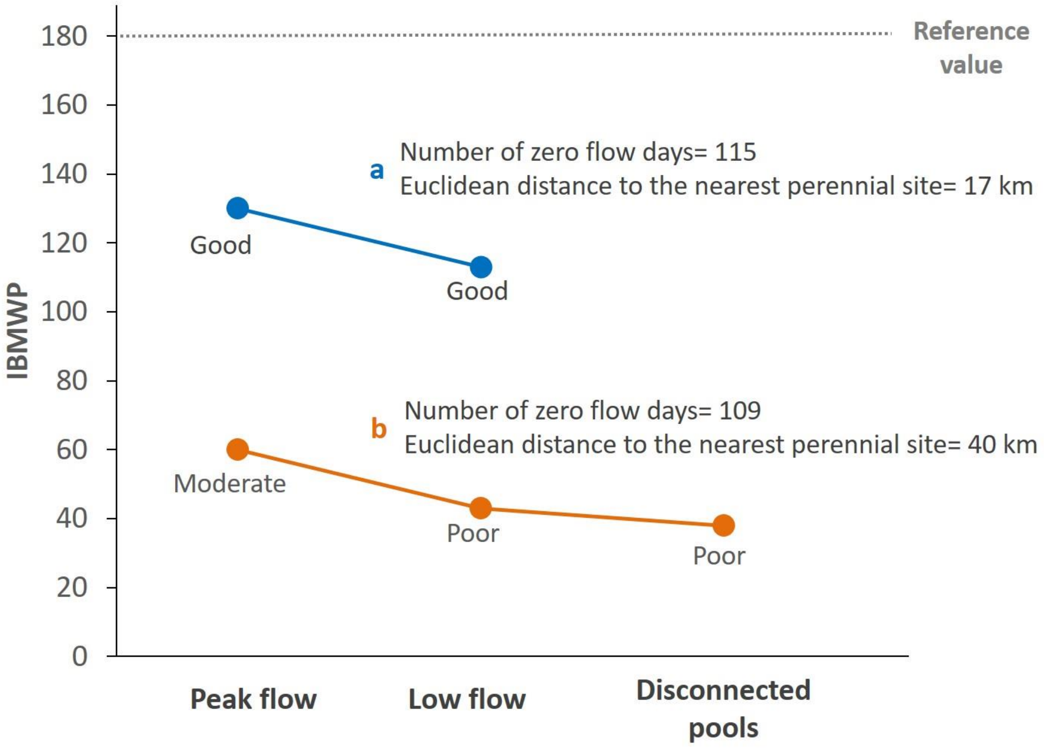


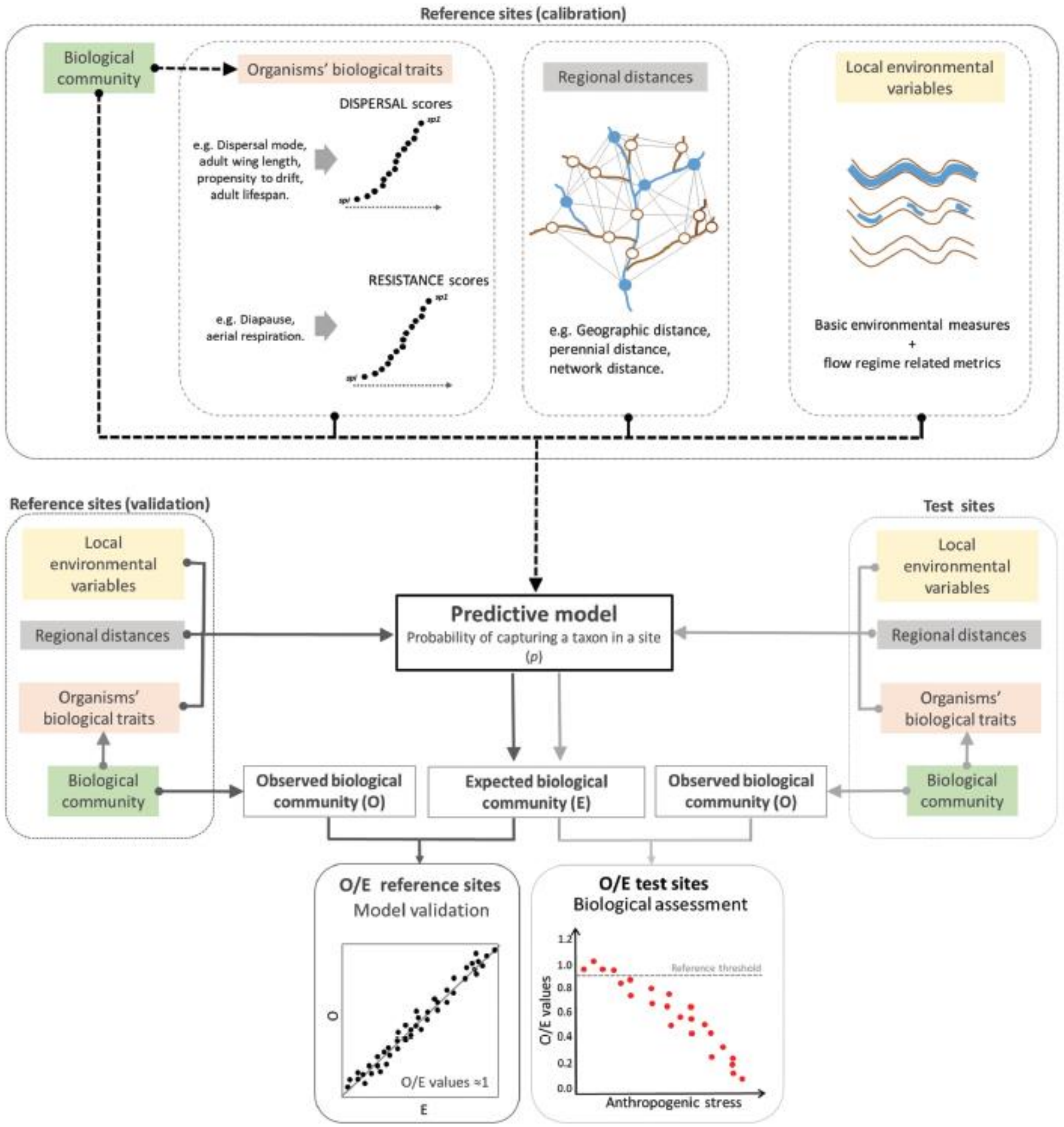
Lamy, T., N. I. Wisnoski, R. Andrade, M. C. N. Castorani, A. Compagnoni, N. Lany, L. Marazzi, S. Record, C. M. Swan, J. D. Tonkin, N. Voelker, S. Wang, P. L. Zarnetske, and E. R. Sokol. 2021. The dual nature of metacommunity variability. Oikos:1–15.

FUTURE RESEARCH

Monitoring

Cid et al. 2020





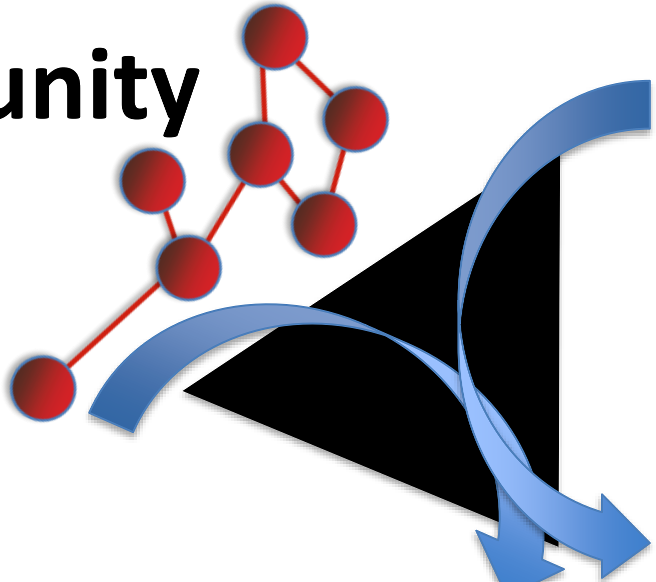
Community ecology

THE COMMUNITY ASSEMBLY WARS

"The null model wars"

FUTURE RESEARCH

The metacommunity concept



Metacommunity analysis

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