

Supplementary Material

Appendix 1

Individual-based simulation model

Simulations were run with an individual-based model on a landscape grid where individuals competed for space (building on the lottery model by Gravel et al., 2006). A lattice of 300 x 300 cells represented the spatially heterogeneous landscape. Each cell x was characterized by its environmental condition E_x , ranging between 0 and 100, and could host a single sessile individual. Lattice boundary conditions were of torus shape. We considered equal dispersal kernels for all species in the species pool. However, each species, i , was characterized by a specific offspring production rate, f_i , and a specific response curve of relative competitive performance along a gradient of environmental conditions (cf. below for details).

Simulations were initialized by randomly distributing individuals from a pool of 50 species (different species pools for different scenarios) across a landscape grid (different distributions of environmental conditions for different scenarios, Fig. 3 upper row). Each time-step comprised 90 000 successive updates of randomly selected cells to approximate continuous time dynamics (asynchronous updating). Each update of a cell started with mortality that randomly removed the resident individual (when the cell was

occupied) with a rate of 0.1 and was followed by competition-colonization dynamics of recruitment. Recruitment either into empty space or by competitive replacement could occur following a lottery among candidate offspring (Chesson and Warner, 1981, Hubbell, 2001). Offspring of a focal species could be part of the lottery for a cell if (1) 'offspring rain' of the focal species was greater than zero, (2) there was no superior competitor already established (competitive performance depended on the match between environment and the species' niches), (3) the local environment was suitable enough for establishment and (4) the overall amount of 'offspring rain' from all species was sufficient.

These four points are explained in more detail in the following. (1) The size of offspring rain of species i for cell x was given by:

$$O_{ix} = \sum f_i w(d_{xy}) n_{iy} + I$$

with $w(d_{xy}) = \exp(-0.5 d_{xy})$

Where the dispersal kernel $w(d_{xy})$ is a function of the Euclidean distance, d_{xy} , between cells x and y , and n_{iy} is abundance of species i in cell y (0 for absence, 1 for presence). We allow immigration from outside the lattice at rate $I=0.001$ (Loreau and Mouquet, 1999). We simulated dispersal dynamics with a radius of 5 cells and used a negative exponential dispersal kernel, $w(d_{xy})$. (2) When a species successfully reached a cell, competitive interactions occurred between the resident

individual (when the cell was occupied) and the offspring reaching the cell. An offspring could establish and replace the resident if its local competitive performance was larger than the one of the resident, mimicking resource competition as in earlier models of competition-colonization dynamics (Tilman, 1994). An individual's competitive performance was determined by the local environmental condition, E_x . We used a Gaussian survival function to describe the local competitive performance:

$$\lambda_{ix} = h_i \exp(-(E_x - \mu_i)^2 / (2\sigma_i^2))$$

Where h_i is the species maximal performance at optimal environmental conditions corresponding to the niche optimum μ_i . The parameter σ_i is niche breadth and described species as generalists or specialists. (3) For empty patches, we set a boundary minimal performance for an offspring to establish. This avoided occupation of unsuitable empty cells (λ_{ix} must be larger than the threshold value 0.1). (4) Additionally, cells could stay empty if the overall amount of 'offspring rain' from all species was too small. This was simulated via a probability equal to the total number of offspring from all neighbors divided by the expected number of offspring from all neighbors (calculated by assuming a fully occupied grid and an average offspring production rate). This ratio was set to one if it was greater than one.

Finally, there was lottery competition among the offspring that successfully entered the cell. Chances of each species to establish were proportional to the relative amount of offspring rain. Thus, after each

update, cells could stay empty, switch to an empty state due to mortality, keep their original individual in case no colonizer could establish or change to another species when there was a successful colonizer (Fig. 2). We run preliminary analyses and found that 5.000 time-steps were sufficient to create equilibrium dynamics. The model was programmed in C++ and built under gcc-4.4.0-mingw32 (<http://www.mingw.org/>).

Appendix 2

Landscape structure

Three different algorithms were used to generate 90 landscapes with three distinct structures of environmental heterogeneities (with values ranging from 0 to 100). The 'random landscape' (cf. Fig. 3c in the main text) was generated by randomly drawing environmental conditions for each cell from a uniform distribution of environmental conditions. The 'gradient landscape' (cf. Fig. 3b in the main text) was simulated using a smooth and deterministic gradient from 0 to 100 to which we added noise using a Gaussian distribution with mean of zero and standard deviation of 10. Finally, the 'auto-correlated landscape' (cf. Fig. 3a in the main text) was generated using spatio-temporal Gaussian random fields (package RandomFields, software R with mean of 50, variance of 200, scale of 10, i.e. spatial extend of autocorrelation, and alpha of 2, i.e. covariance of autocorrelation, R Development Core Team, 2011).

Appendix 3

Table A1: Examples of conflicting results of empirical community assembly studies. Studies differ greatly and few general patterns can be identified among similar ecological systems.

Reference	Facet ¹	Scale ²	Type of system	Method used to test for assembly processes	Identified community assembly processes
Cottenie 2005	t	α	Fish, birds, plants, invertebrates, zooplankton, phytoplankton, butterflies	Spatial and environmental correlations	Species-sorting, and combined species-sorting and mass- effects
Gilbert and Lechowicz 2004	t within f groups	α	Trees in temperate forest	Spatial and environmental correlations	Species-sorting
Meynard & Quinn 2008	t	α and β	Birds in temperate forest	Spatial and environmental correlations	Species-sorting
Tuomisto <i>et al.</i> 2003	t	α and β	Trees in tropical forests	Spatial and environmental correlations	Neutral dynamics and species-sorting
Davidar <i>et al.</i> 2007	t	β	Trees in tropical forests	Environmental correlations	Species-sorting
Condit <i>et al.</i> 2002	t	β	Trees in tropical forests	Distance decay	Dispersal limitations
Hardy and Senterre 2007	p	α and β	Trees in tropical forests	Phylogenetic clustering vs. over-dispersion	Species-sorting
Keppel <i>et al.</i> 2010	t	β	Trees in tropical islands.	Distance decay	Neutral dynamics
Thompson <i>et al.</i> 2010	f	α	Plants on temperate roadsides	Trait diversity compared to null expectation	Neutral dynamics
Fukami <i>et al.</i> 2005	f	α	Plants in experimental temperate communities	Trait divergence and convergence	Species-sorting and priority effects
Cornwell <i>et al.</i> 2006	f	α	Plants in Mediterranean communities	Trait diversity compared to null expectation	Species-sorting
Stubbs & Wilson, 2004	f	α	Plants in temperate communities	Trait diversity compared to null expectation	Competition (limiting similarity)
Storkey <i>et al.</i> 2010	t and f	α	Wetland plants in temperate communities	Community nestedness and trait dissimilarity	Competition (limiting similarity) and species-sorting
Petchey <i>et al.</i> 2007	f	α	Bird communities in temperate region	Functional diversity compared to null expectation	Species-sorting
Ellis & Ellis 2009	f	α	Moss communities in arctic environment	Trait diversity compared to null expectation	Species-sorting and stochastic events
Ingram & Shurin 2009	p and f	α	Fish communities	Community structure with respect to null model	Species-sorting for functional traits; non consistent patterns for phylogenetic structure
Swenson & Enquist 2009	p and f	α	Trees in tropical forests	Community structure with respect to null model	Species-sorting for functional traits; non consistent patterns for phylogenetic structure
Silva & Batalha 2009	p	α	Plants in tropical savanna	Community structure with respect to null model	Competition and evolutionary processes
Moen <i>et al.</i> 2009	p and f	α and β	Treefrogs in temperate systems	Spatial and environmental correlations	Species-sorting

¹ t: taxonomic, p: phylogenetic and f: functional diversity; ² α : alpha and β : beta diversity

Table A2: Phylogenetic signal for different scenarios (Blomberg's K)

<i>Species pool</i>	<i>Landscape</i>	<i>mean</i>	<i>sd</i>
Species-sorting	auto-correlated	0.99	0.34
	gradient	1.05	0.38
	random - Mass effect	0.90	0.45
Trade-off	auto-correlated	1.09	0.40
	gradient	1.12	0.50
	random	1.00	0.23
Neutral	auto-correlated	0.13	0.09
	gradient	0.07	0.06
	random	0.10	0.04

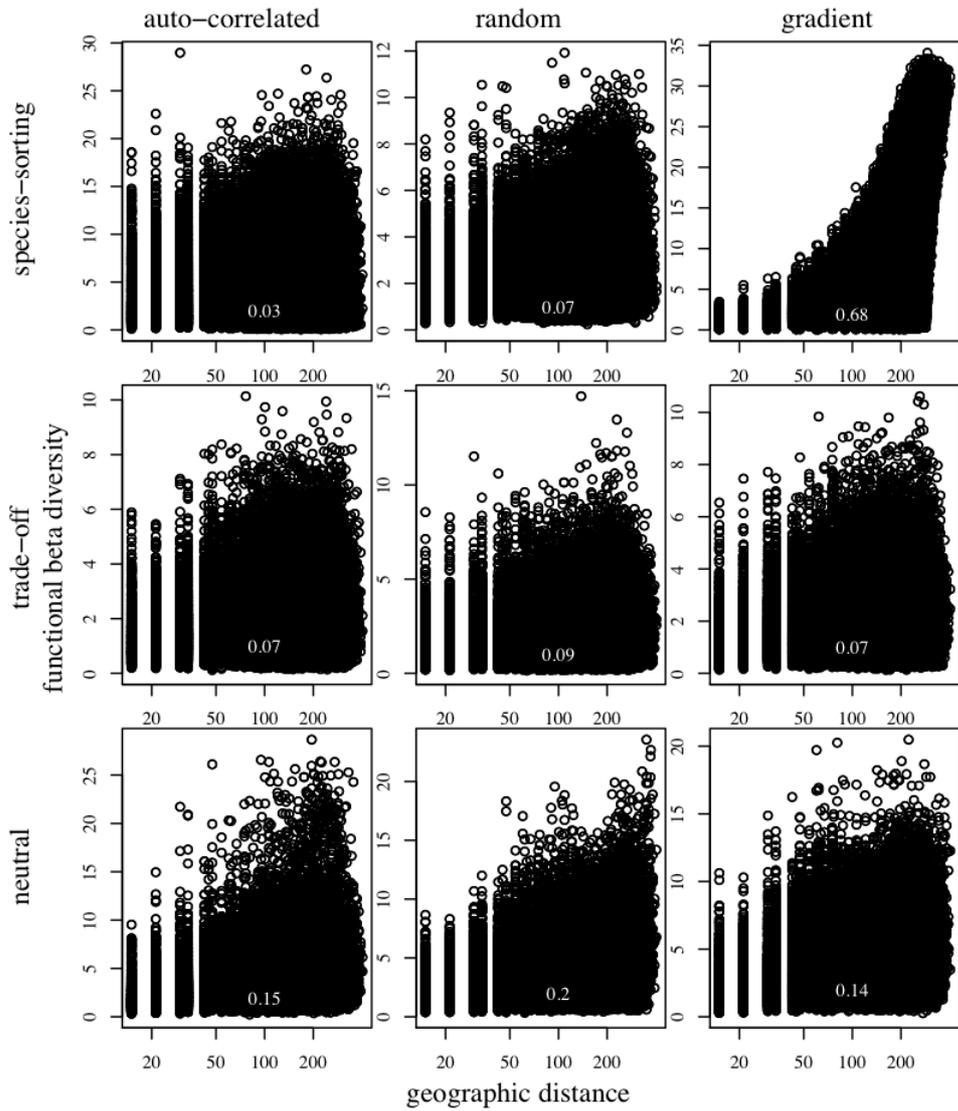


Figure A1: Distance decay of functional diversity for the different community assembly processes. Plotted are pairwise comparisons of geographical distances between communities (in units of grid cells) and functional proportional beta diversity for one simulation run of each of the nine different simulation scenarios with different species pools (species-sorting, trade-off, neutral) and different landscapes (auto-correlated, random, gradient).

Additional references

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