

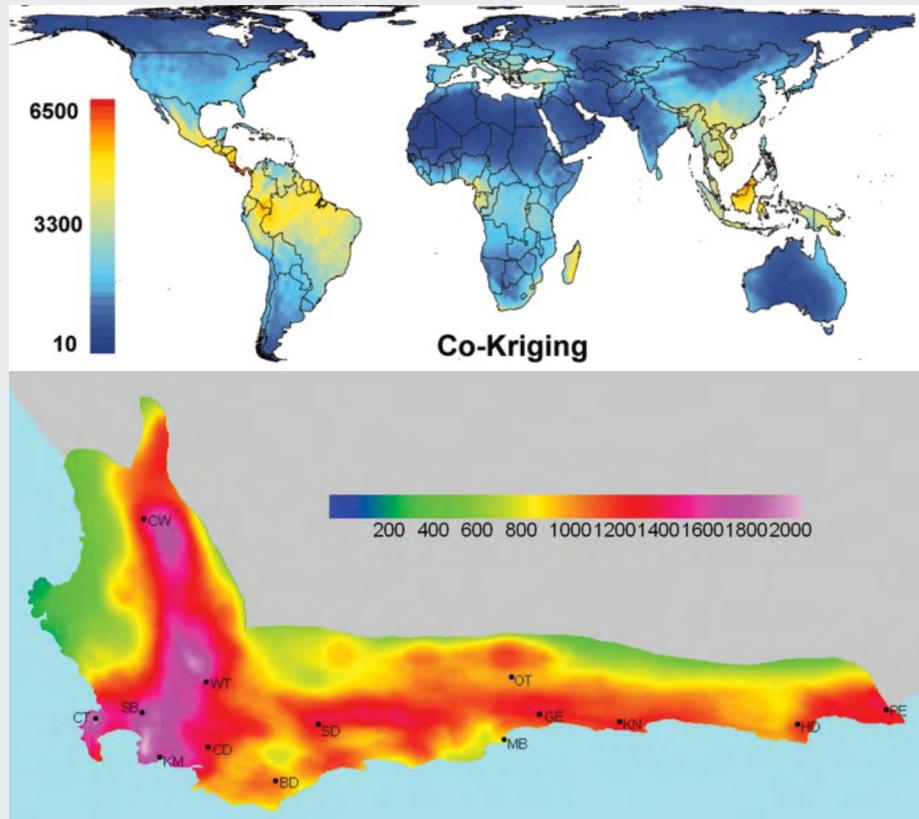
5. The Assembly of Diversity

Local Processes

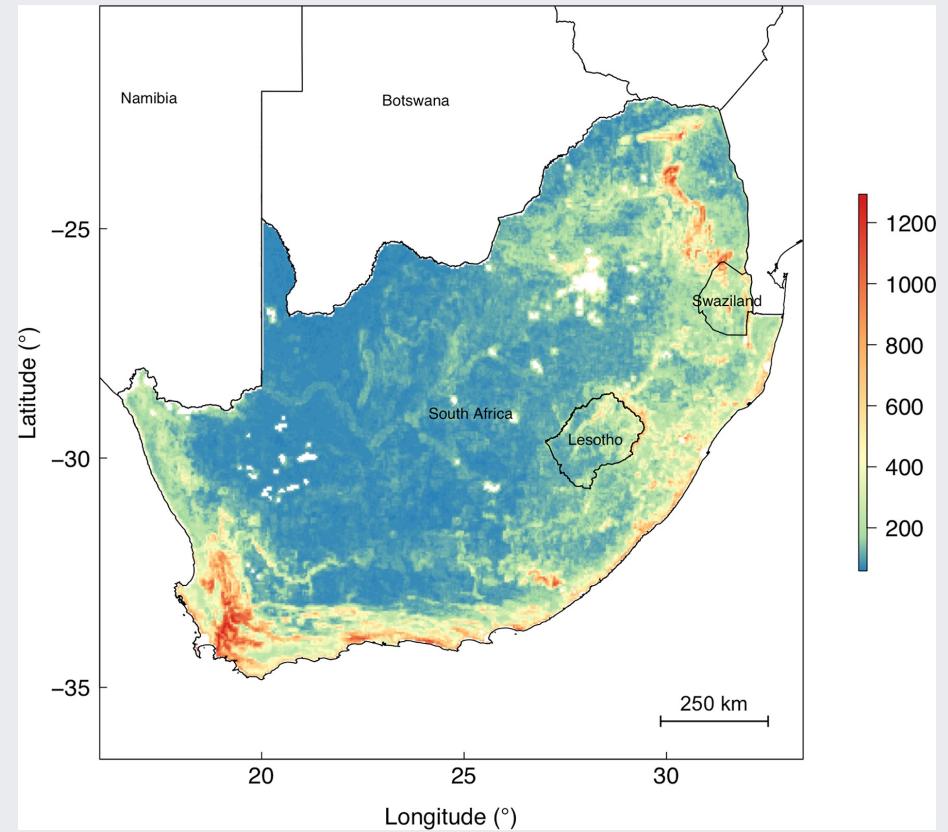
Jasper Slingsby, BIO3018F

2022-02-03

Diversity is not distributed evenly...



Kreft and Jetz 2007; Freiberg and Manning 2013

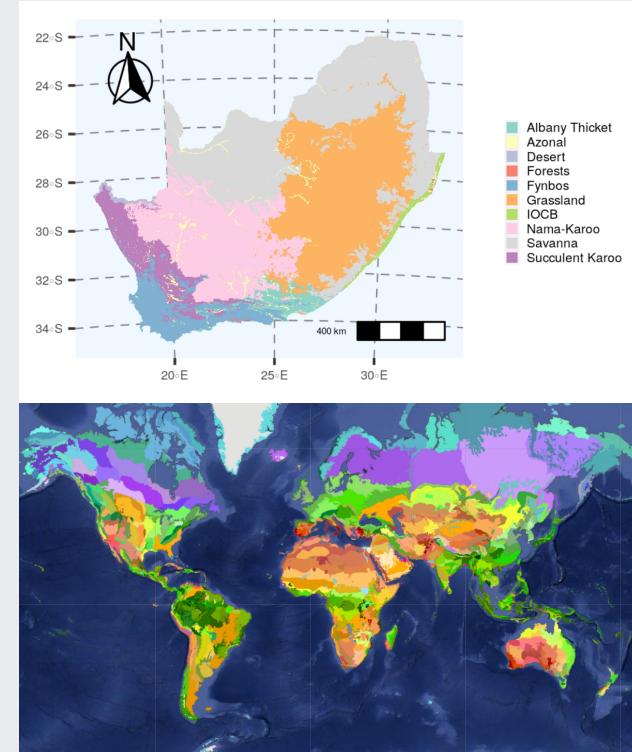


Cramer and Verboom 2017

What determines the distribution and abundance of biodiversity?



And how do these processes vary with spatial scale?



Niche theory

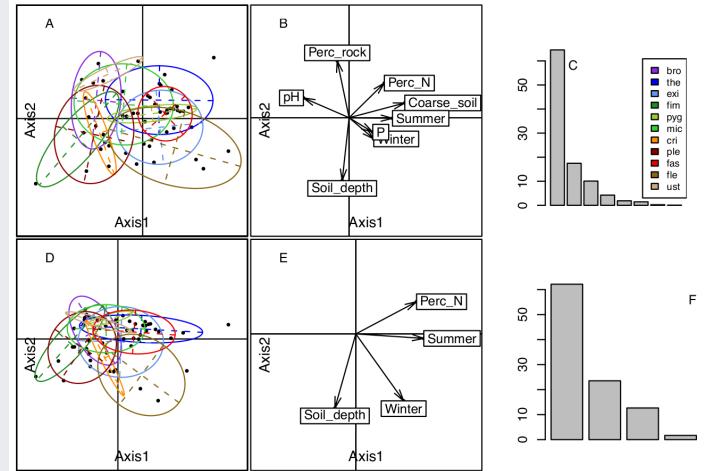
The niche is a multidimensional description of a species resource needs, habitat requirements and environmental tolerances¹

- i.e. a particular set of abiotic (light, water, nutrient, shelter, etc) and biotic conditions (predators, prey, pathogens, mutualists (e.g. mycorrhizae, pollinators), competitors, etc)
- often explored by looking at species traits, assuming they reflect resource use strategies

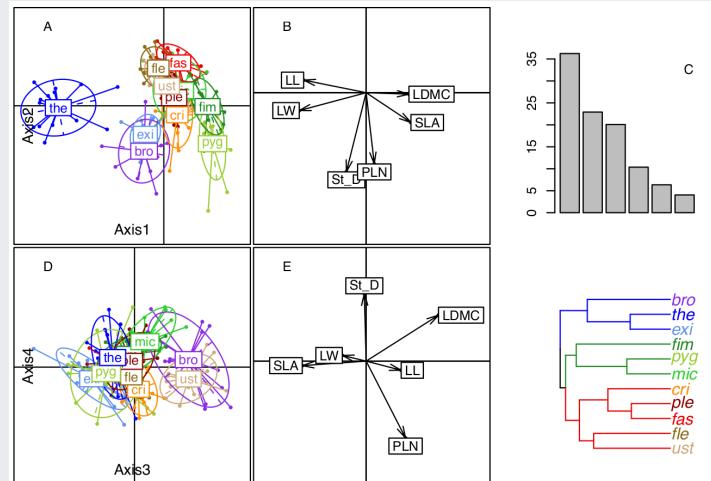
Niche theory predicts local deterministic processes like habitat filtering, competition, facilitation, etc.

- These processes influence co-occurrence (limiting diversity), trait distributions and relatedness

¹In simplified terms (there are a few definitions)



Environmental space



Trait space

Community assembly processes: local scale

Habitat filtering (or ecological sorting)

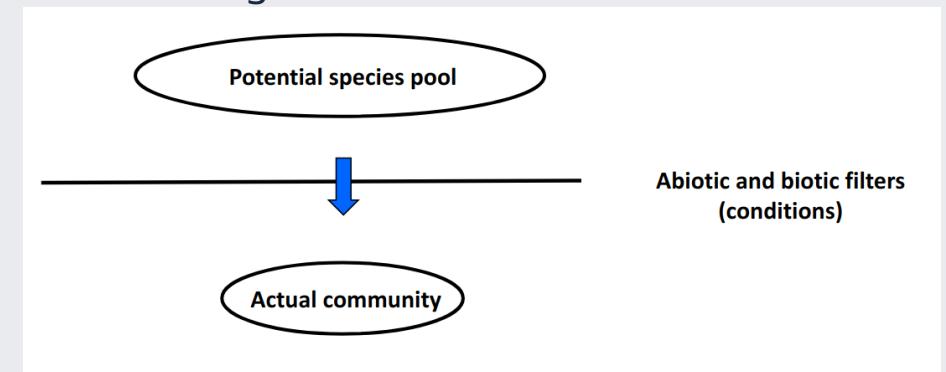
Hypothesis:

- species with similar resource requirements (or stress tolerance) will be sorted into the same environments

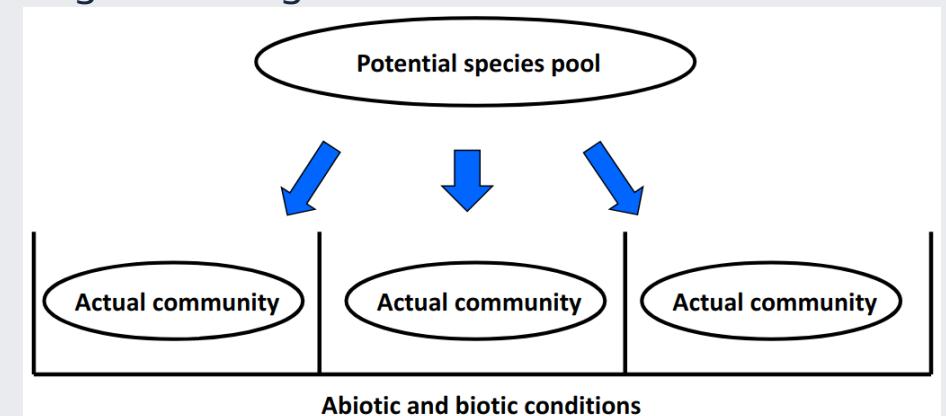
Predictions:

- co-occurring species should be more functionally ***similar*** than you'd expect by chance
- functionally similar species should co-occur ***more*** often than you'd expect by chance

Habitat filtering



Ecological sorting



Community assembly processes: local scale

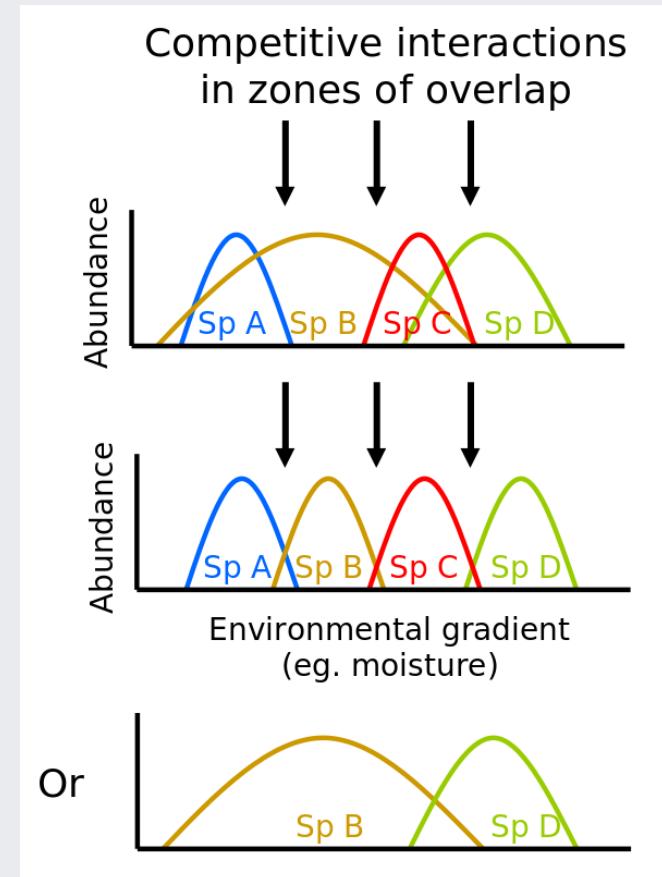
Limiting similarity and Competitive exclusion

Hypothesis:

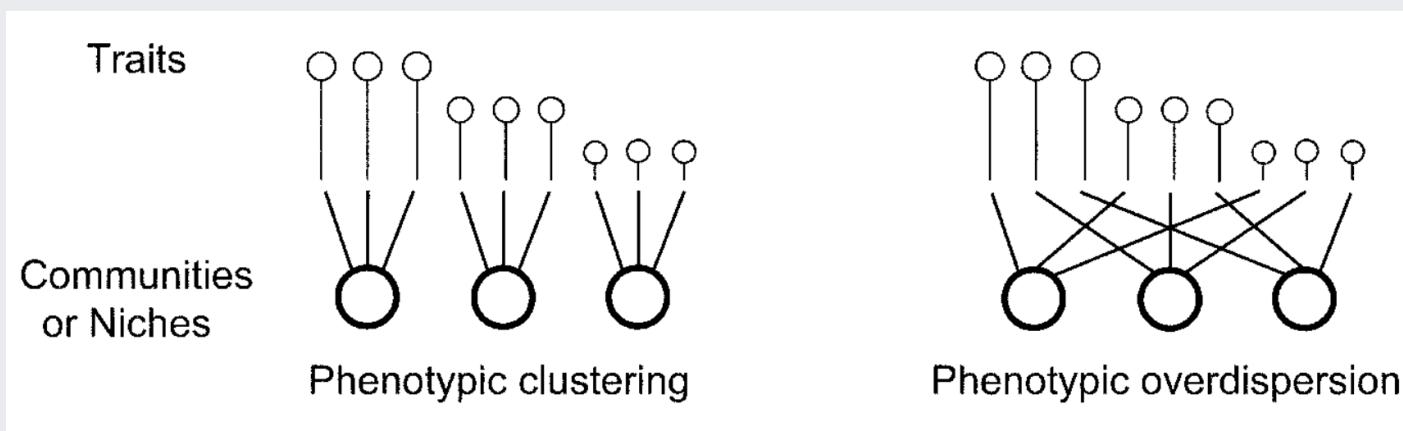
- species competing for the same resources cannot stably coexist, because the stronger competitors will exclude the others

Predictions:

- co-occurring species should be more functionally **different** than you'd expect by chance
- functionally similar species should co-occur **less** often than you'd expect by chance



We now have contrasting predictions!



Functional clustering (low Functional Diversity) = habitat filtering

Functional evenness/overdispersion (high Functional Diversity) = competition

Let's test them with null models...?

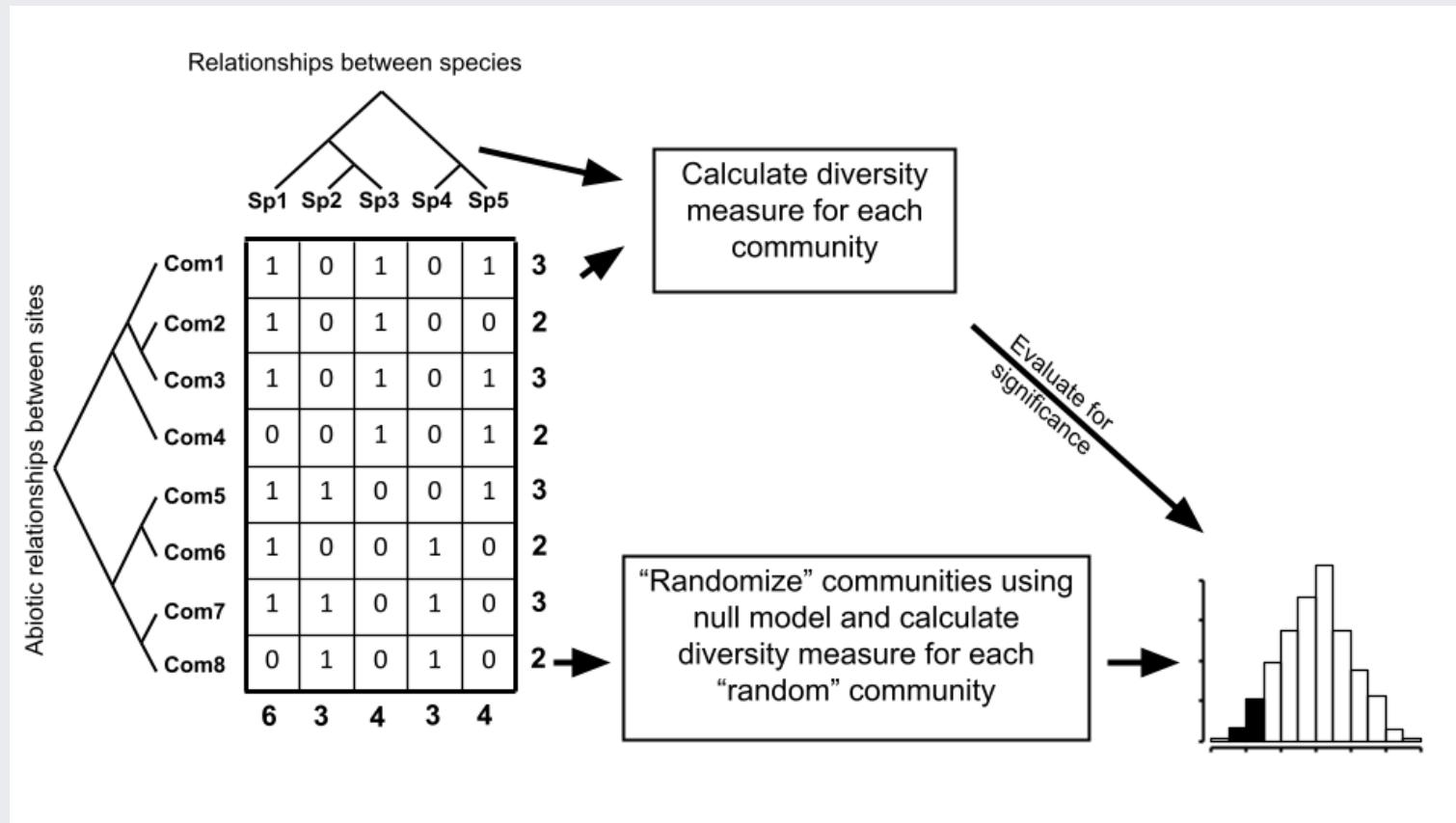


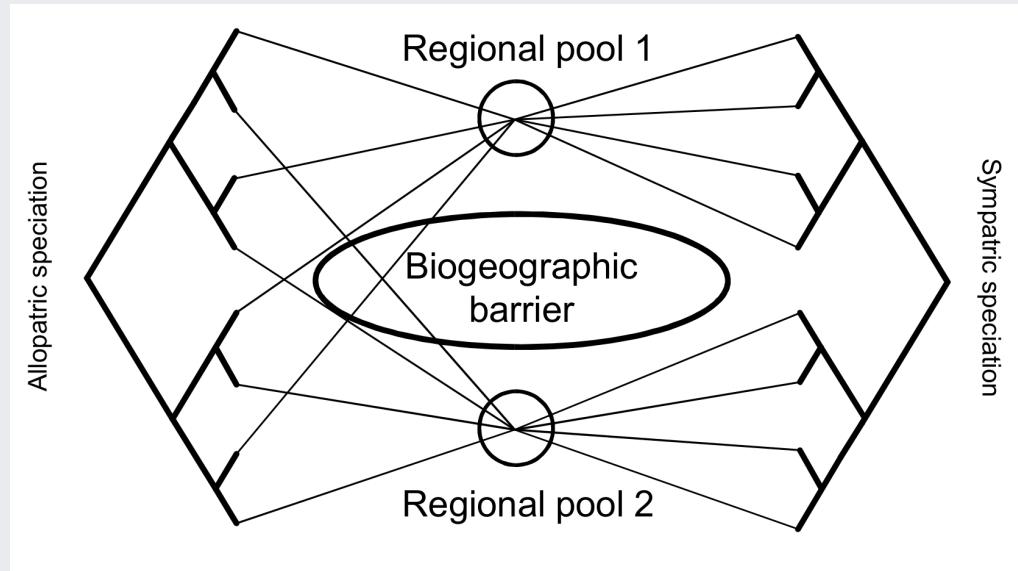
figure from Slingsby 2011, PhD

But wait!

There are other processes at play that can affect the outcomes...

Especially when we expand the spatial and temporal scale...

Mode of speciation



Closely-related species tend to be similar,
because they share a common ancestor
(phylogenetic signal and niche conservatism)

Where functional similarity reflects phylogeny:

- **Sympatric speciation** (in situ speciation) = phylogenetic and functional clustering
- **Allopatric speciation** (speciation via dispersal, isolation and drift) = phylogenetic and functional evenness/overdispersion

i.e. the mode of speciation can create the same pattern as competition or habitat filtering...

Community assembly processes

Vary with spatial scale

- competition or facilitation operates between neighbouring plants
- environmental filtering operates at a range of scales (climate > soils > microsite, etc)
- biogeographic processes (speciation, extinction, vicariance, dispersal) operate across large extents

Vary with temporal scale

- pollination, seed dispersal or herbivory can be near-instantaneous
- speciation or trait evolution occur over long periods of time

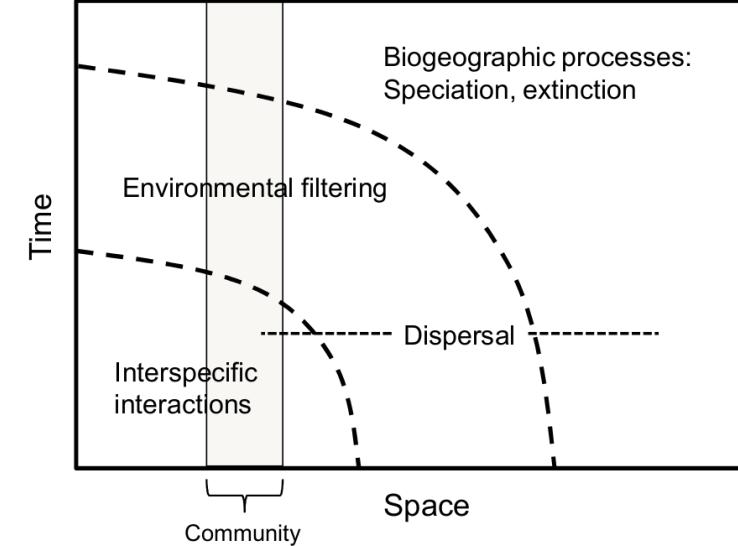
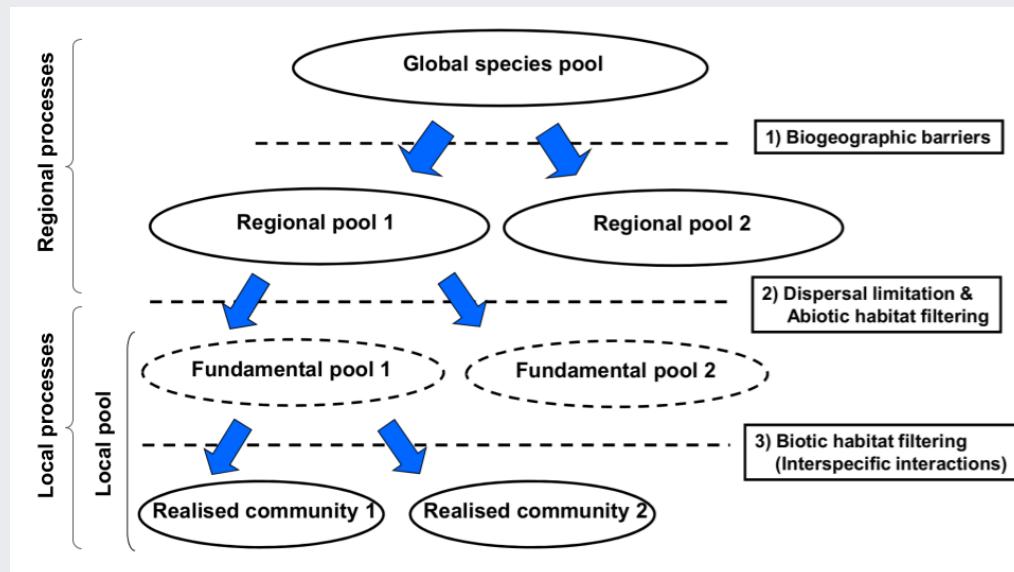


Figure 1.1: Processes that affect the assembly of communities at different spatial and temporal scales. Finer-scale processes are nested within broader scale processes. Adapted from Weiher & Keddy (1999), Cavender-Bares *et al.* (2009).

Assembly of species pools across scales

Community assembly can be thought of as the successive filtering of species pools descending in spatial (and temporal) scale from global to local



We often split it into **regional** versus **local** processes

Global species pool = all species on the planet (or in the defined study domain, e.g. Cape Floral Region)

Regional species pools = the species that are present in each region (e.g. a biogeographic region or mountain), limited by barriers to dispersal

Fundamental species pool = species with the potential to occur in a particular location (i.e. have the ability to disperse there and survive the abiotic conditions)

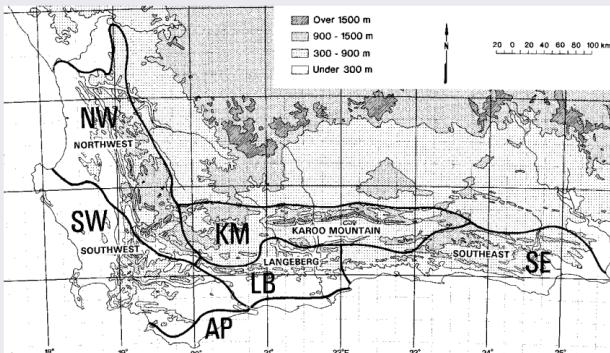
Realised community = the actual observed local community (i.e. a subset of the fundamental species pool that managed to get there and to coexist, either stably or unstably)

Functional or phylogenetic structure can be created or altered at any step...

Local vs Regional scale processes

The diversity of local biological communities is a balance of regional and local processes - Ricklefs 1987

Regional scale



Local scale

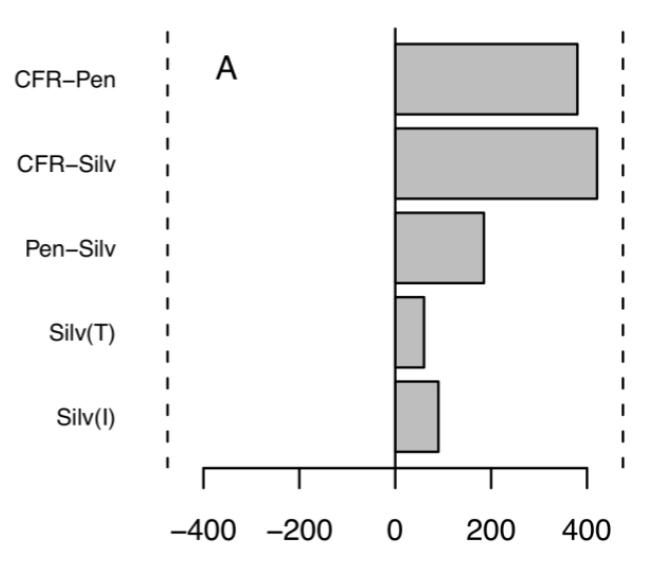


- speciation
- extinction
- dispersal

The phytogeographic centres of the CFR (Manning and Goldblatt 2012)

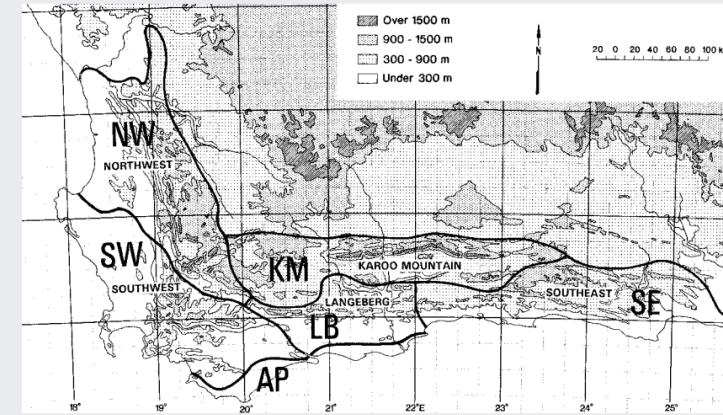
- environmental filtering
- interspecific interactions (competition, predation, pathogens, mutualisms)
- adaptation
- stochastic variation

An example of inferring community assembly from the Cape...



Three scales (pools):

- Global = Cape Floristic Region (CFR)
- Regional = Cape Peninsula (Pen)
- Local = plots within Silvermine (Silv)



The set of species on the Peninsula and in Silvermine are more dissimilar than expected relative to the CFR - **suggests allopatric speciation**

Species at Silvermine more dissimilar than expected relative to the Peninsula - **suggests competition**

Species within plots are more dissimilar than expected relative to all plots - **suggests competition**

Take-home

Patterns of diversity are determined by assembly processes that operate from local to regional scales

While the distinction between local and regional processes is somewhat arbitrary (or even artificial), local scale processes are typically ecological, operating over the near term, while regional processes are typically evolutionary, operating over longer periods of time

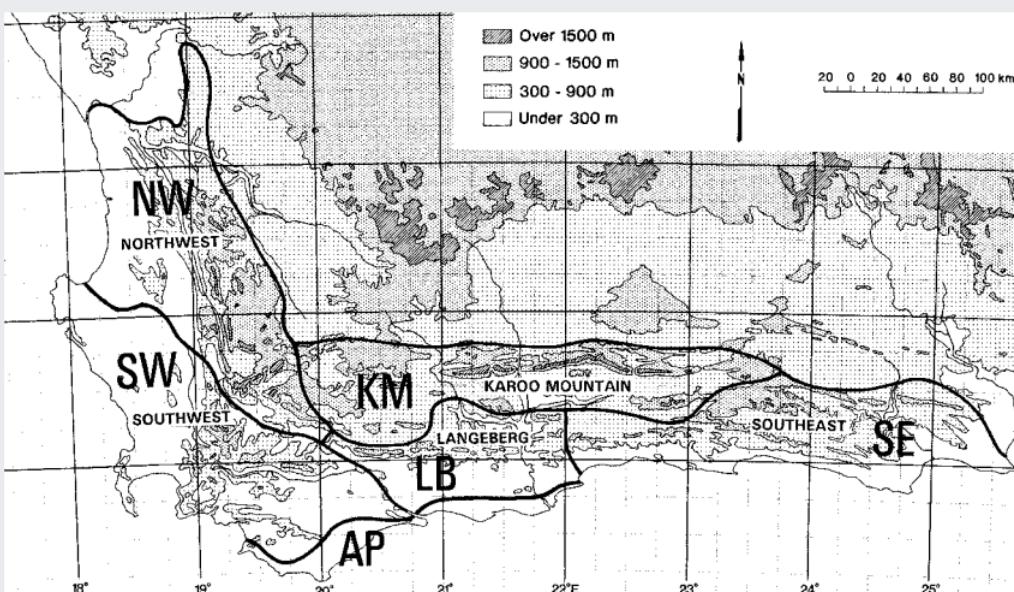
One method for investigating these processes by exploring functional and phylogenetic diversity at different scales (species pools), often in combination with null models

References

- Gotelli, N. J. and R. K. Colwell (2001). "Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness". In: *Ecology letters* 4.4, pp. 379-391. ISSN: 1461-023X, 1461-0248. DOI: 10.1046/j.1461-0248.2001.00230.x.
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- Whittaker, R. H. (1972). "Evolution and measurement of species diversity". En. In: *Taxon* 21.2-3, pp. 213-251. ISSN: 0040-0262, 1996-8175. DOI: 10.2307/1218190.

An example of regional species pools from the Cape...

The phytogeographic centres of the CFR



Data and figure from Manning and Goldblatt 2012

Region	Area (1000 km ²)	Number of species	Endemism (%)
Cape Floristic Region	90.8	9381	68,3
NW	23.1	4259	25,5
SW	21.3	4864	30,5
AP	4.2	1530	13,6
KM	16.8	2336	15,3
LB	8.1	2457	11,3
SE	17.3	2938	9,4
Cape Peninsula	4.7	2250	7,5

The Cape phytochoria make good *Regional species pools*, but the regional pools used can be defined differently depending on the purposes of the study and if it can be justified, e.g. the Cape Peninsula is a relatively isolated biogeographic unit

CFR effectively = *Global species pool*, because of such high endemism

Thanks!

Slides created via the R packages:

xaringan
gadenbuie/xaringanthemer

The chakra comes from remark.js, **knitr**, and R Markdown.