

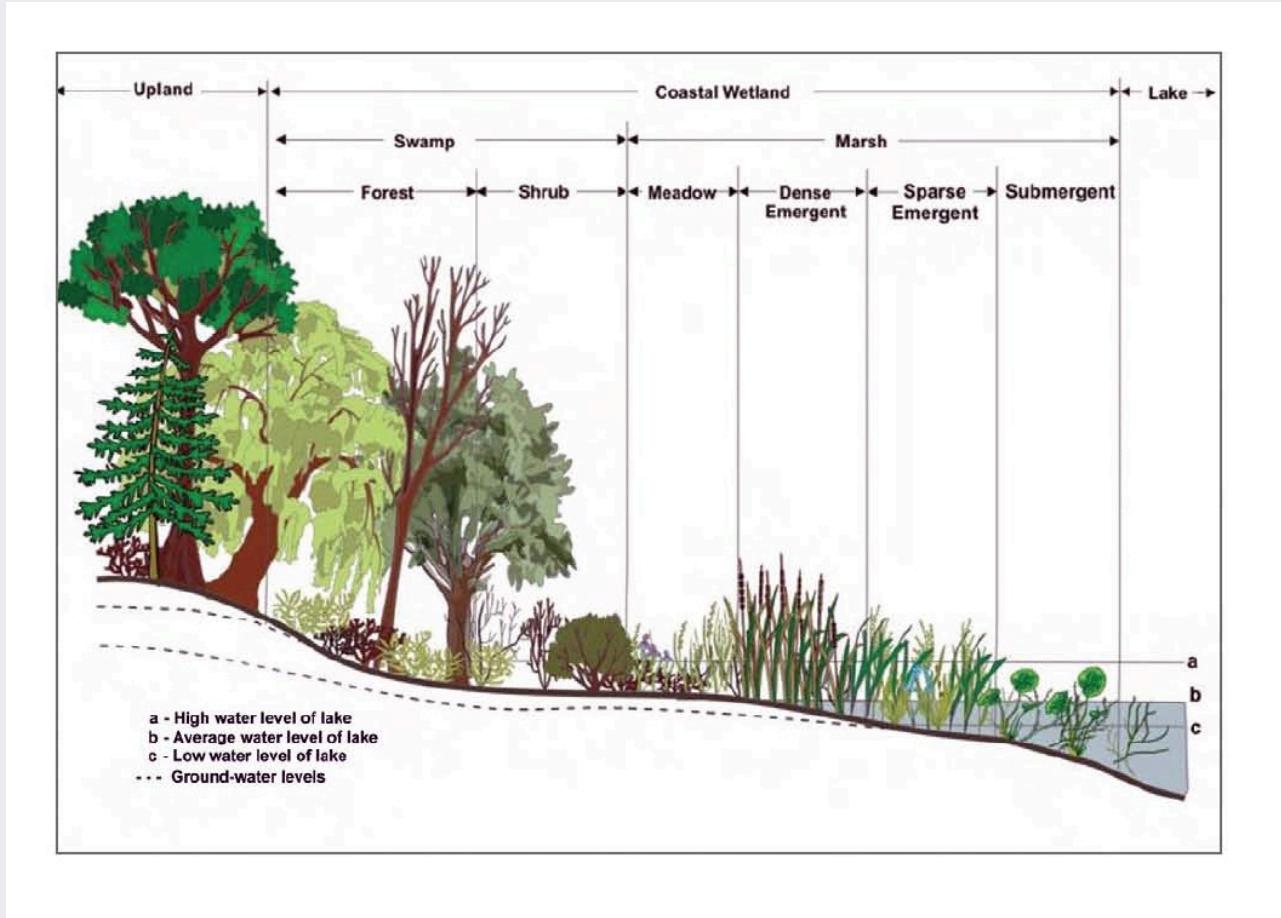
5. Traits, Trade-offs and Phylogeny

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2025-01-30

Why are traits (functional) and evolutionary history (phylogenetic) important dimensions of biodiversity to measure?

There's a lot of variation in species' traits



Traits typically relate to life-history strategies



e.g. the fast - slow continuum

There are often trade-offs among traits

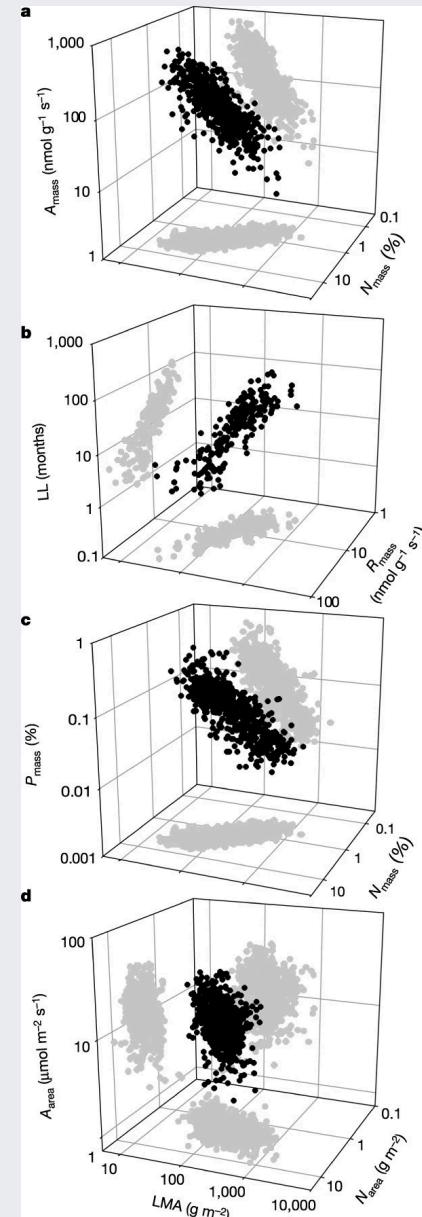
Leaf dry mass per unit area (LMA) predicts

- Nitrogen content
- photosynthetic capacity
- relative growth rate

But

- Trades off against leaf longevity

The leaf economics spectrum (LES) - Wright et al. 2004

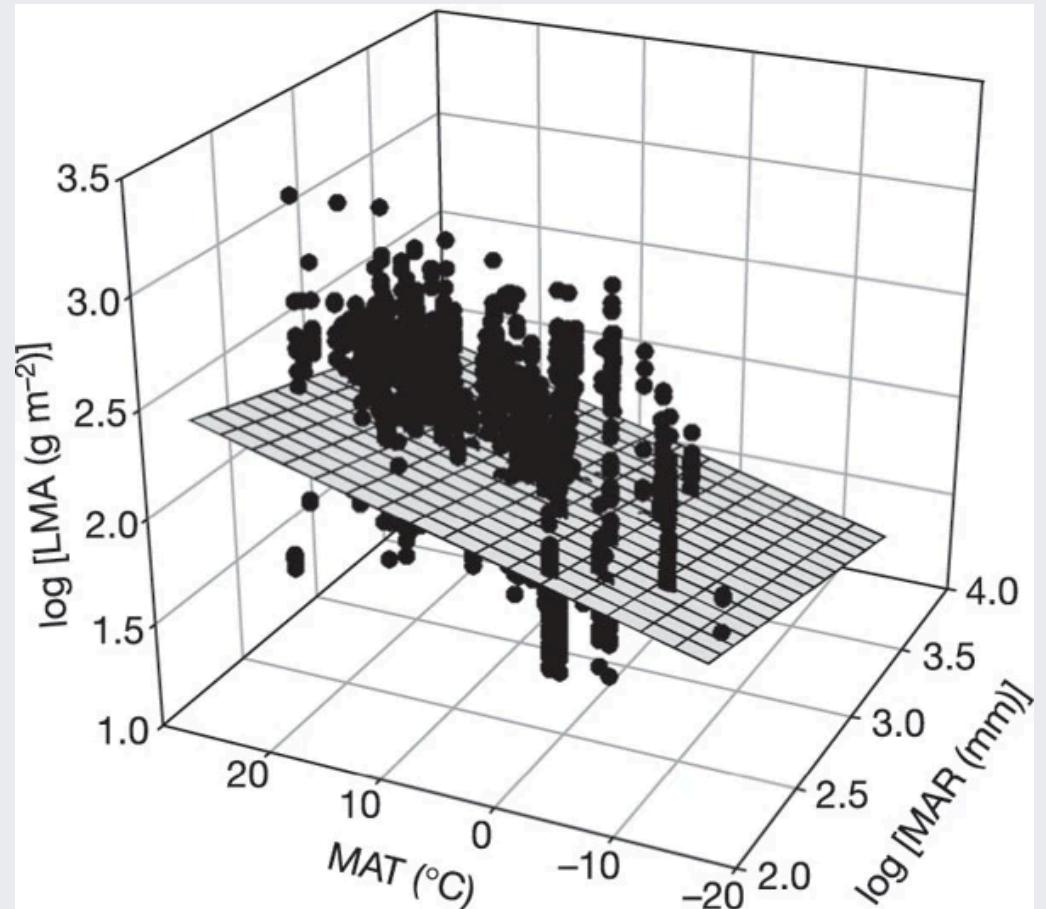


There are often trade-offs among traits

LMA correlates with environment (temp and rainfall)

- Higher LMA in hot, dry places

This also represents a trade-off in that specific traits can limit species to specific resource/habitat requirements (water, light, nutrients).

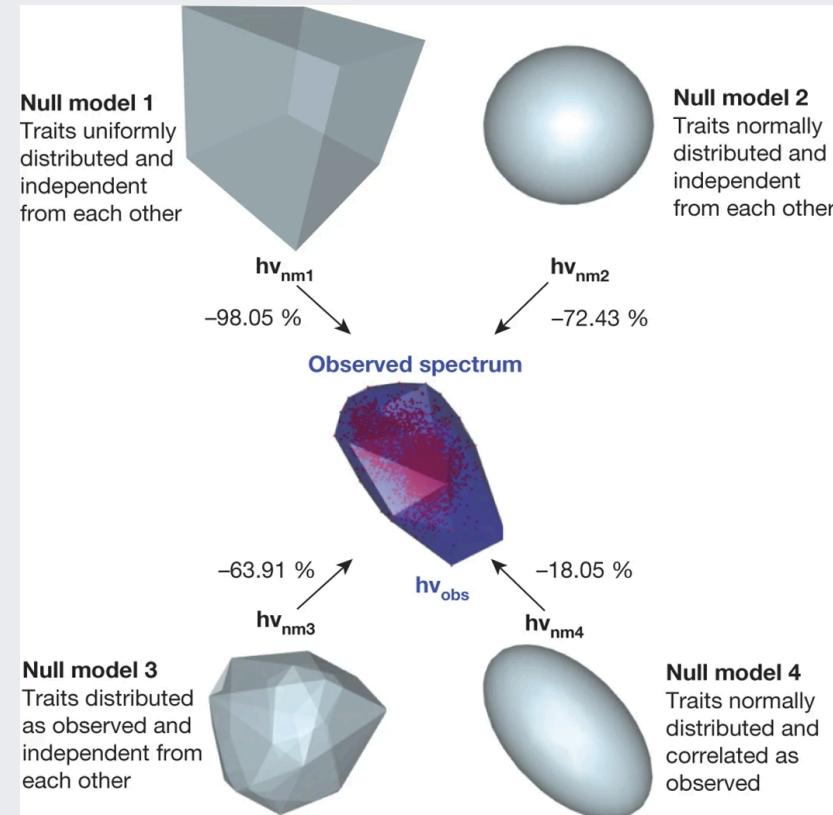


The leaf economics spectrum (LES) - Wright et al. 2004

Trade-offs constrain trait combinations

Trade-offs dictate that some traits and trait combinations (and thus life-history strategies) are impossible...

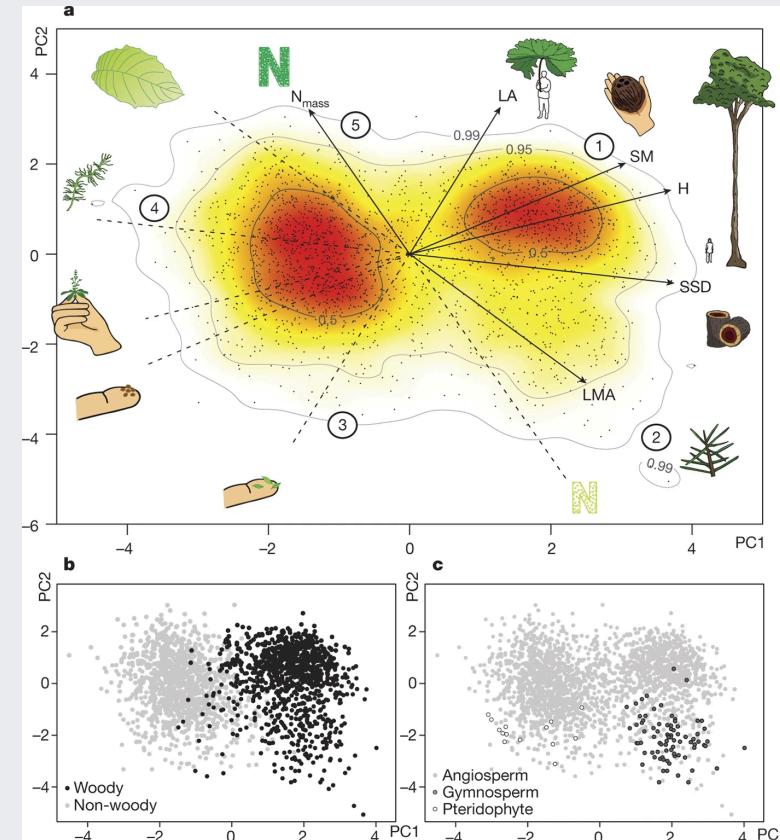
If each trait is a dimension, trade-offs dictate that the "volume" of the trait space is constrained (cannot be filled).



Trade-offs constrain trait combinations

But trait values, combinations and trade-offs are further constrained by phylogeny.

Traits and trade-offs often vary among taxonomic lineages, revealing a signal of their evolutionary history (phylogeny).

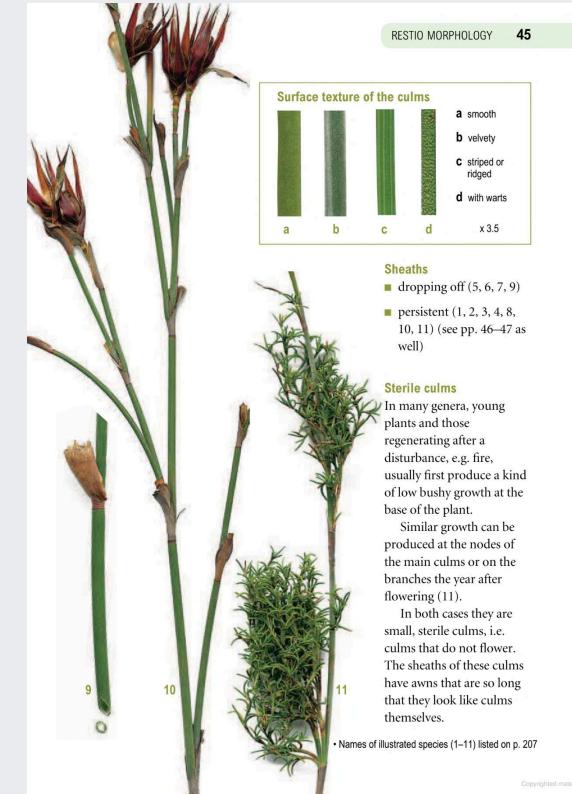
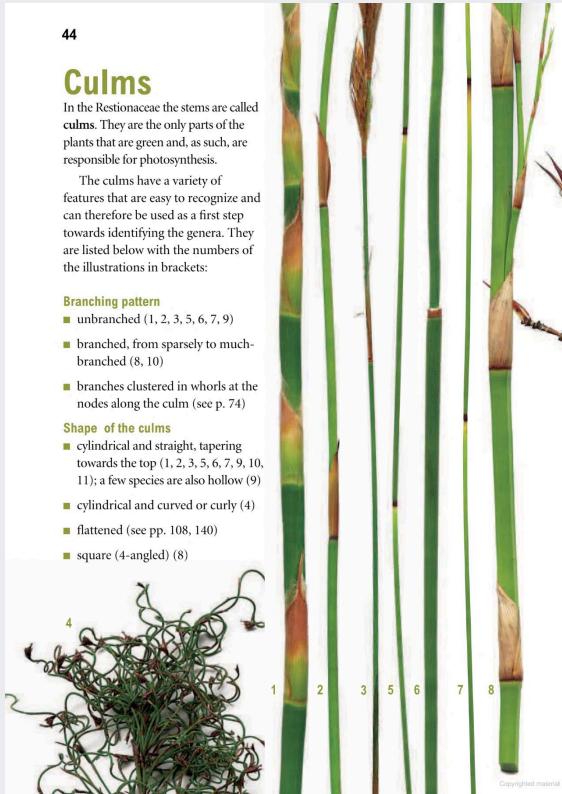


Diaz et al. 2016

Traits are often similar among closely related species...

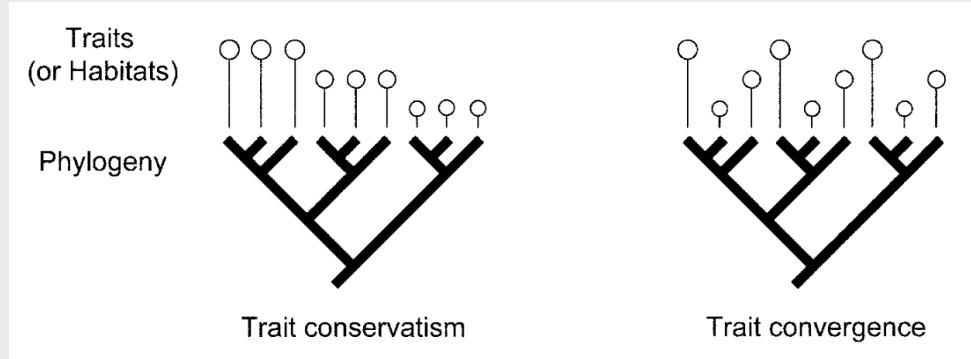


Traits are often similar among closely related species...



e.g. the loss of leaves in an ancestral restio means they are all culm (stem) photosynthetic...

...but not always...



Trait conservatism has a profound influence on ecology!

Especially if there is dispersal limitation, as is usually the case for islands... e.g. Darwin's finches

The finches have diversified to fill many niches on the Galapagos islands that are usually filled by other bird lineages elsewhere.

While there has been convergence/divergence in some traits like beak morphology, they all evolved from the same common ancestor and other traits that affect their ecology may be constrained (e.g. climatic tolerance, metabolism, etc).



Trait conservatism has a profound influence on ecology!

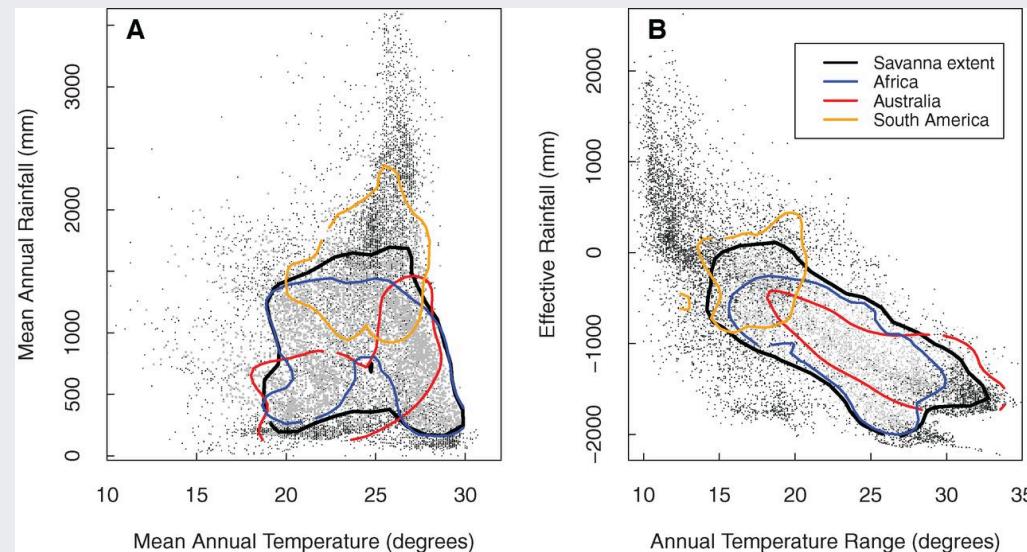
The Cape Flora is much like an island flora, with many species made up from a few lineages (30 clades account for >50% of the ~9500 species).

Large (diverse) clades like the Proteaceae (~300 spp), Restionaceae (~300 spp) and *Erica* (~700 species) are ecologically dominant, and have a big influence on ecological processes like fire, hydrology, nutrient cycling, etc.



Trait conservatism has a profound influence on ecology!

Savannas inhabit different climatic niches on different continents...



Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014) 23, 1235–1244



Contrasting architecture of key African and Australian savanna tree taxa drives intercontinental structural divergence

Glenn R. Moncrieff^{1*}, Caroline E. R. Lehmann^{2,3}, Jan Schnitzler^{4,5}, James Gambiza⁶, Pierre Hiernaux⁷, Casey M. Ryan³, Charlie M. Shackleton⁶, Richard J. Williams⁸ and Steven I. Higgins⁹

This is likely because of differences in the traits of the dominant lineages and their affects on ecosystem feedbacks, e.g. *Vachellia* and *Senegalia* in Africa versus *Eucalyptus* and *Corymbia* in Australia.

Lehman et al. 2014 *Science*

Moncrieff et al. 2014 *GEB*

Trait conservatism has a profound influence on ecology!

In fact, the same applies to most major biomes!

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015) 24, 324–334

A Journal of Macroecology



RESEARCH PAPER

Intercontinental divergence in the climate envelope of major plant biomes

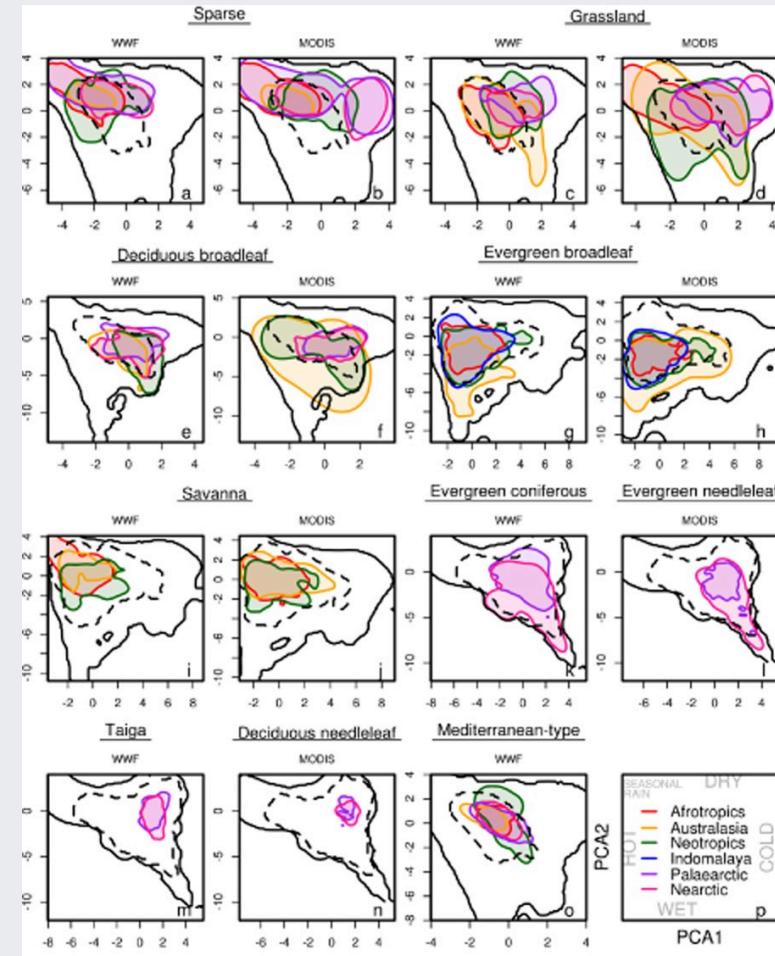
Glenn R. Moncrieff^{1*}, Thomas Hickler^{2,3} and Steven I. Higgins⁴

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ABSTRACT

Aim Convergent evolution and environmental filtering are assumed to often result in deterministic patterns of vegetation structure and function in relation to prevailing environmental conditions regardless of differences in evolutionary history among regions. We systematically evaluate the degree to which biomes located in different biogeographic realms converge in environmental space; identifying globally uniform entities and those diverging systematically among realms.

Moncrieff et al. 2015 *GEB*



Trait conservatism influence on biogeography!

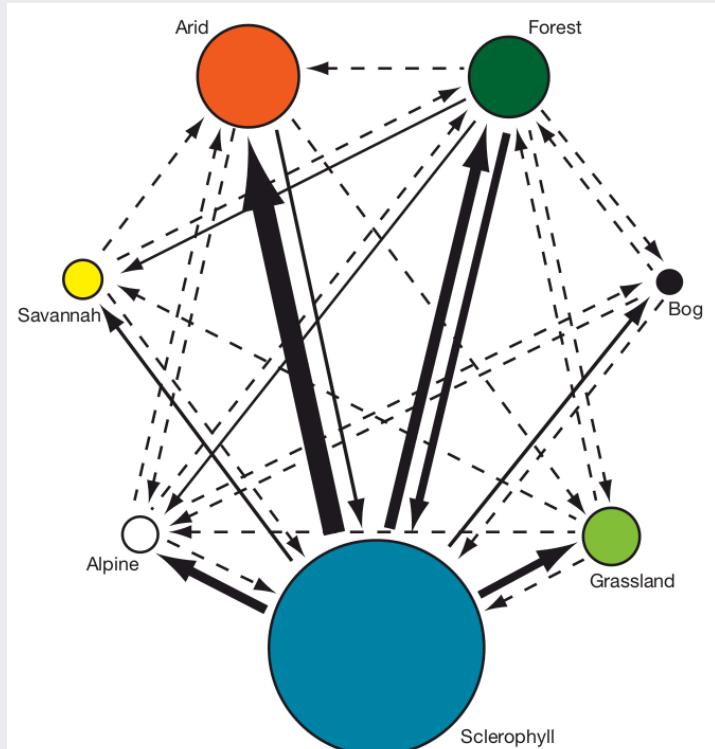


Figure 1 | Biome shifts within landmasses. Shifts occurred with only 356 of 10,800 speciation events within landmasses. Number of species sampled within each biome is proportional to the area of each circle: sclerophyll, 7,250; arid, 1,683; wet forest, 1,005; temperate grassland, 504; savannah, 242; montane, 186; bog, 84. Arrow thickness is proportional to the number of transitions in each direction, ranging from 6 to 95 events; dashed lines indicate 1–5 events and lack of an arrow indicates that there was no event.

Table 1 | Biome transitions coincident with transoceanic colonizations

Destination	Source							
	Arid	Bog	Forest	Grassland	Sclerophyll	Alpine	Savannah	Total
Arid	2							3.3
Bog		13.3						3.3
Forest			50.8					10
Grassland				21.7				6.3
Sclerophyll	1	0.3	3.5	2.7	87			8.5
Alpine			1	2	7	12		10
Savannah			1		0.5			1.5
Total	1	0.3	5.5	4.7	26.1	1	1	39.6

The number of biome transitions is shown for each biome in terms of source (columns) and sink (rows). Bold numbers along the diagonal show colonizations with no change of biome. Totals are for transitions only, that is, excluding values along the diagonal. Non-integer values result from fractional weighting of ambiguous reconstructions. For clarity, zeroes are left blank.

Speciation is more likely to occur via dispersal to a similar biome on a different continent than to a different biome right next door!

Crisp et al. 2009, Nature

Take-home

The evolutionary history of species leaves a strong imprint on current ecology, especially through trait and niche conservatism.

We can explore this influence by exploring speciation, trait evolution and biogeography in focal lineages.

We can also explore this influence by looking at and contrasting measures of functional and phylogenetic diversity of whole assemblages (previous lecture), revealing insights into the ecology, evolution and function of assemblages.

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.

Thanks!

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