5. Traits, Trade-offs and Phylogeny

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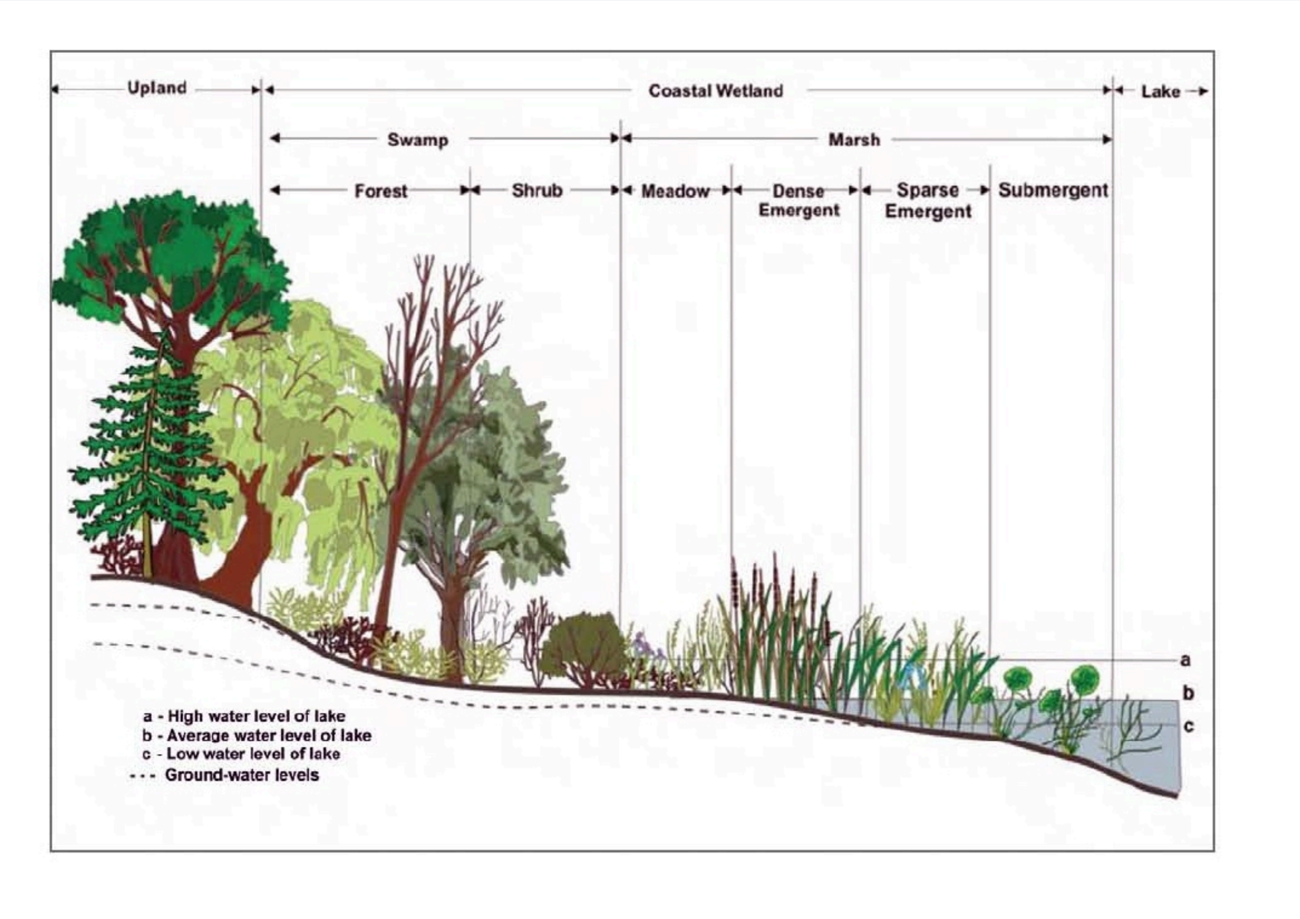
Why are traits (functional) and evolutionary history (phylogenetic) important dimensions of biodiversity to measure?

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

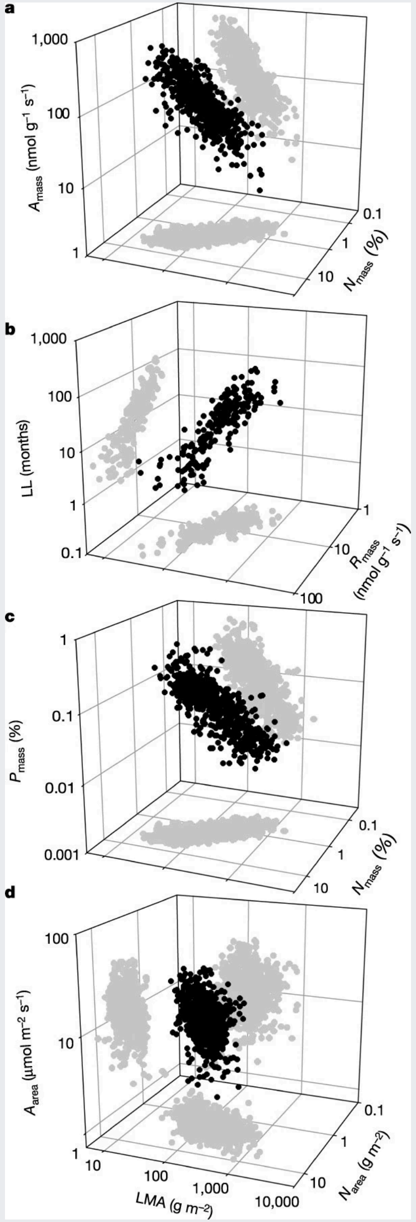
Leaf dry mass per unit area (LMA) predicts

- Nitrogen content
- photosynthetic capacity
- relative growth rate

But

- Trades off against leaf longevity

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

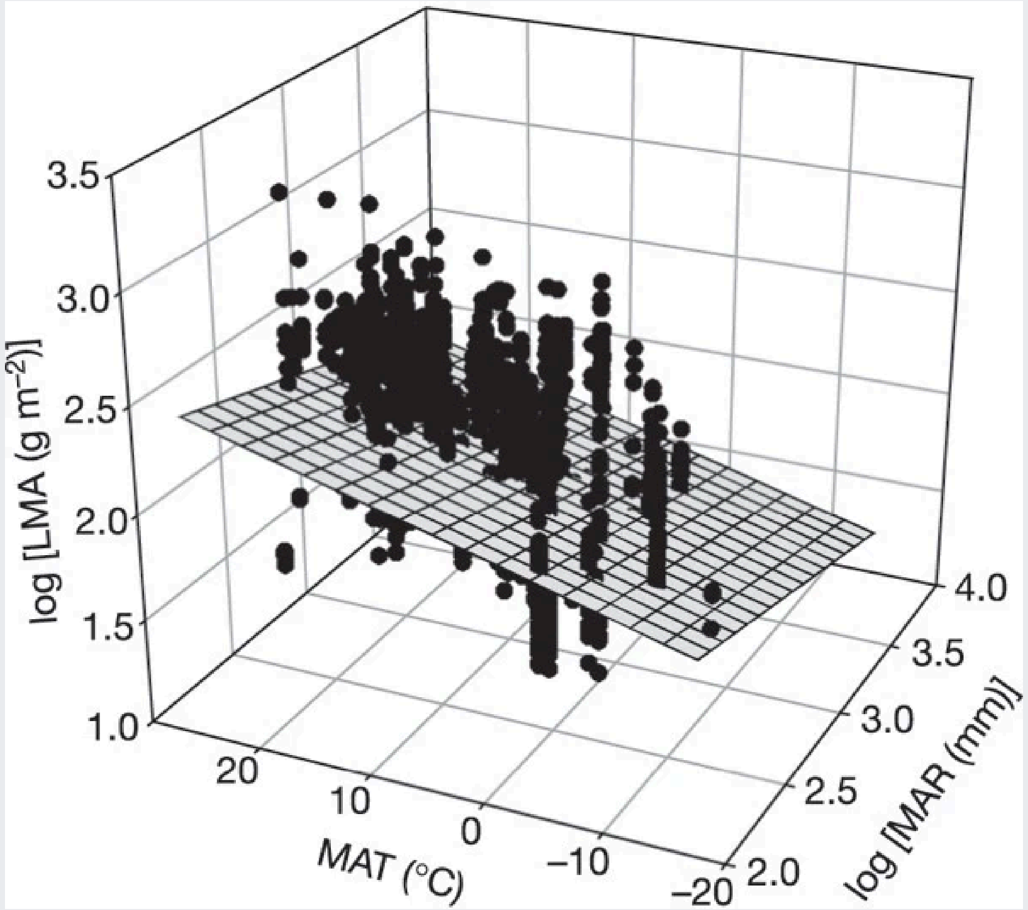


There are often trade-offs among traits

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).

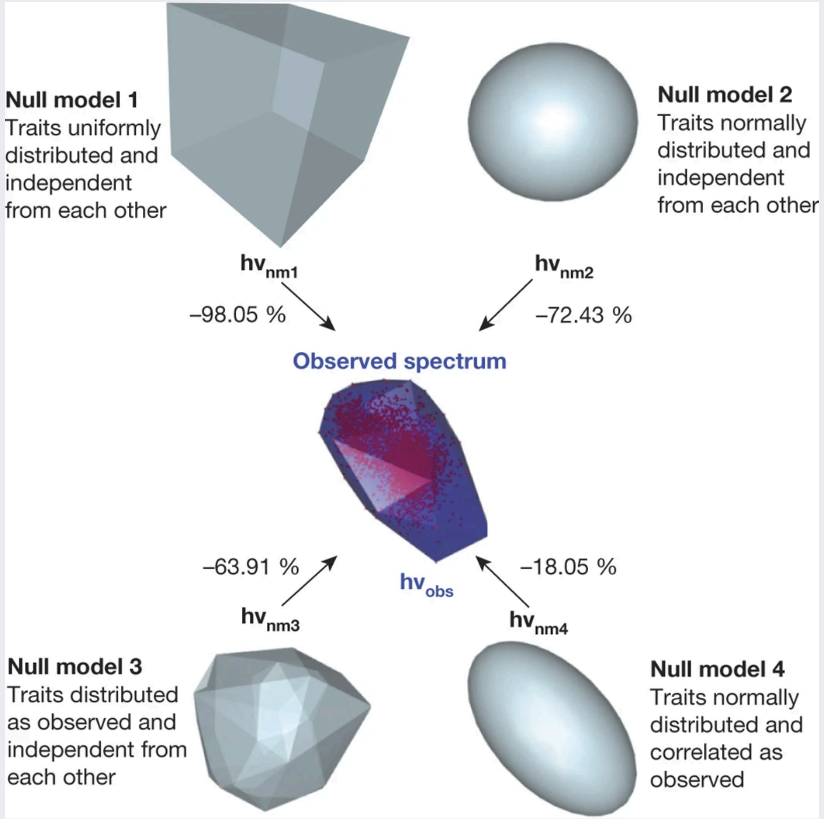


The leaf economics spectrum (LES) - Wright et al. 2004

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).

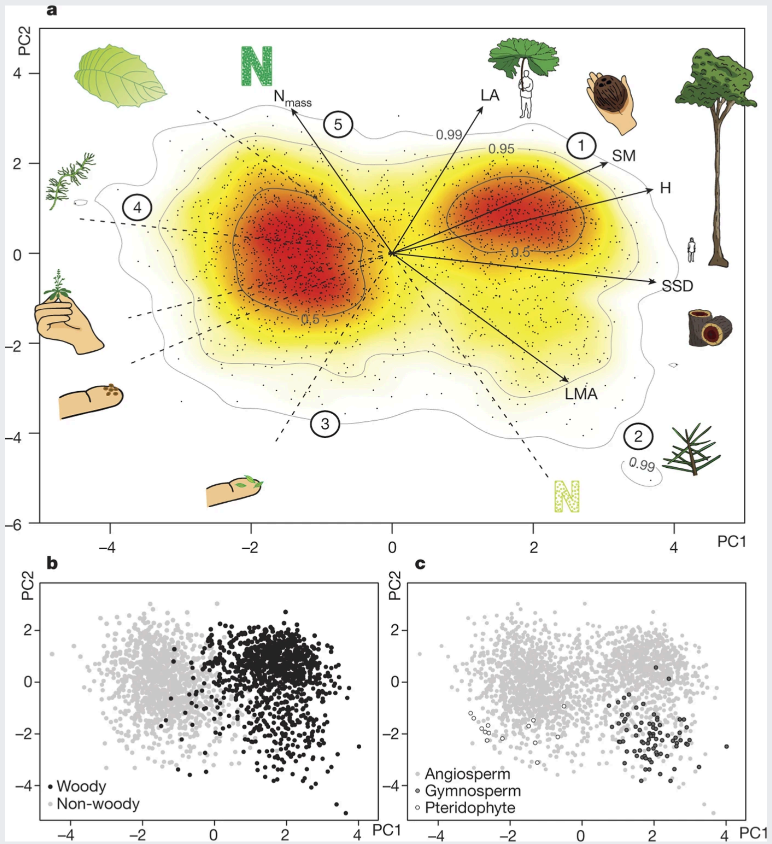


Diaz et al. 2016

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...

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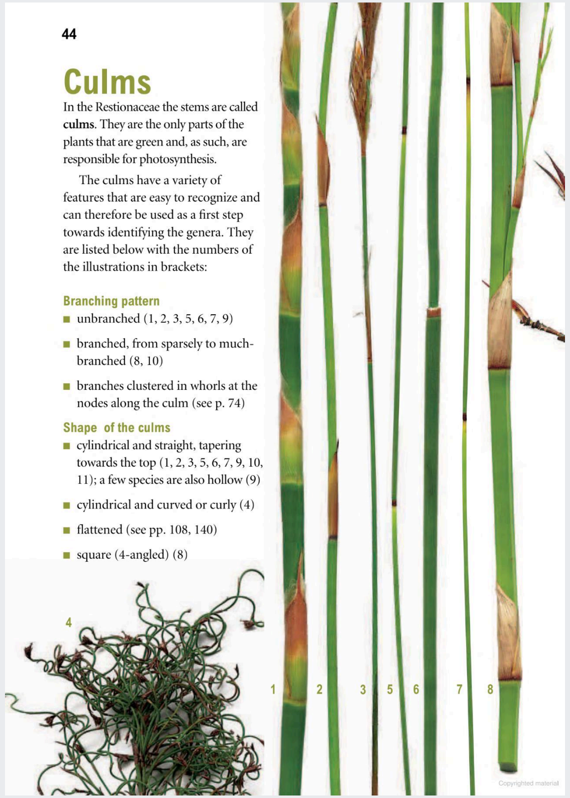

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Culms

In the Restionaceae the stems are called **culms**. They are the only parts of the plants that are green and, as such, are responsible for photosynthesis.

The culms have a variety of features that are easy to recognize and can therefore be used as a first step towards identifying the genera. They are listed below with the numbers of the illustrations in brackets:

Branching pattern

- unbranched (1, 2, 3, 5, 6, 7, 9)
- branched, from sparsely to much-branched (8, 10)
- branches clustered in whorls at the nodes along the culm (see p. 74)

Shape of the culms

- cylindrical and straight, tapering towards the top (1, 2, 3, 5, 6, 7, 9, 10, 11); a few species are also hollow (9)
- cylindrical and curved or curly (4)
- flattened (see pp. 108, 140)
- square (4-angled) (8)

4 1 2 3 5 6 7 8

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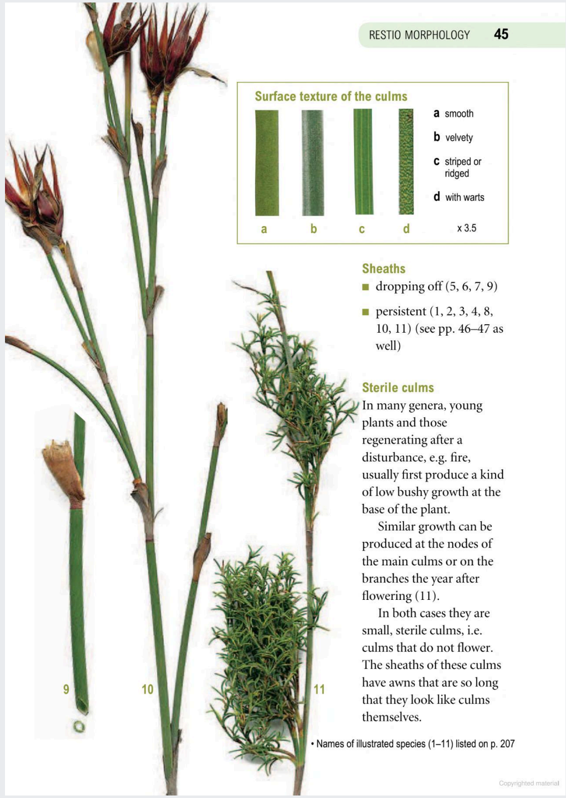

RESTIO MORPHOLOGY 45

Surface texture of the culms

a smooth
b velvety
c striped or ridged
d with warts

a b c d x 3.5

Sheaths

- dropping off (5, 6, 7, 9)
- persistent (1, 2, 3, 4, 8, 10, 11) (see pp. 46–47 as well)

Sterile culms

In many genera, young plants and those regenerating after a disturbance, e.g. fire, usually first produce a kind of low bushy growth at the base of the plant.

Similar growth can be produced at the nodes of the main culms or on the branches the year after flowering (11).

In both cases they are small, sterile culms, i.e. culms that do not flower. The sheaths of these culms have awns that are so long that they look like culms themselves.

9 10 11

• Names of illustrated species (1–11) listed on p. 207

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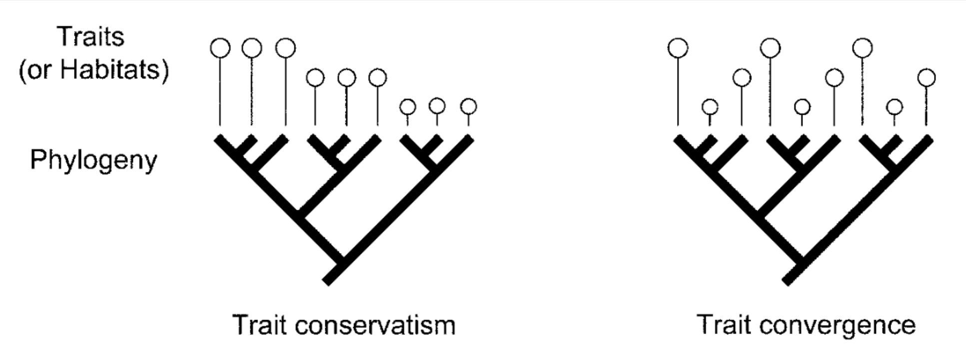
e.g. the loss of leaves in an ancestral restio means they are all culm (stem) photosynthetic…

...but not always...

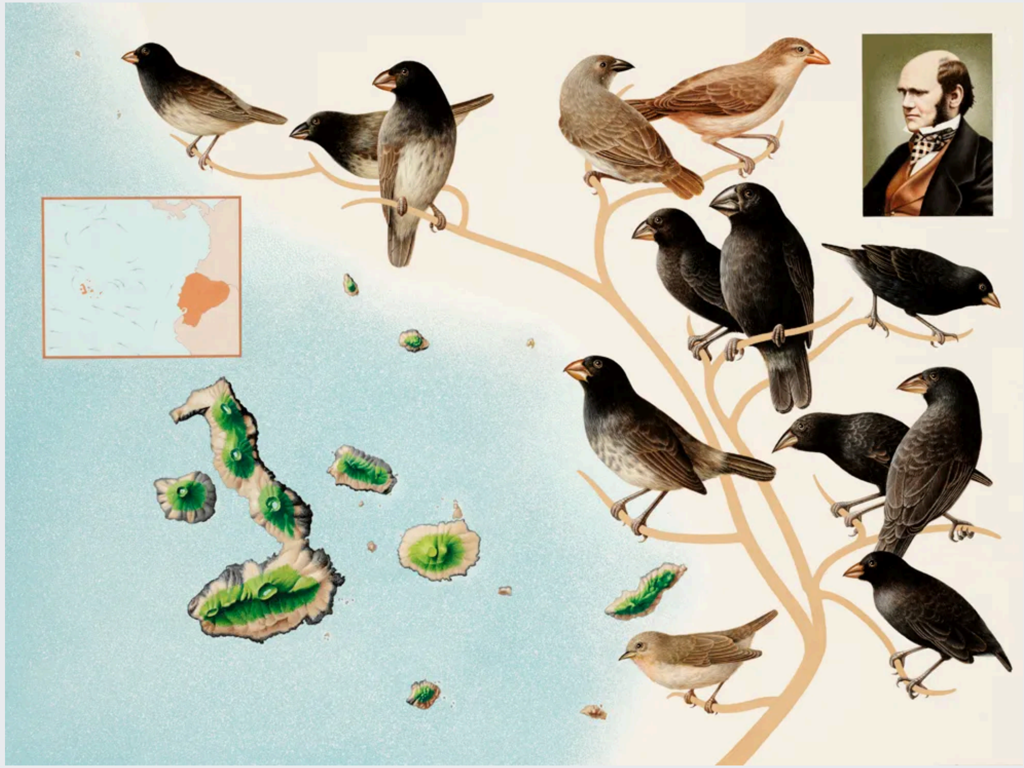


Trait conservatism has a profound influence on ecology!

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).



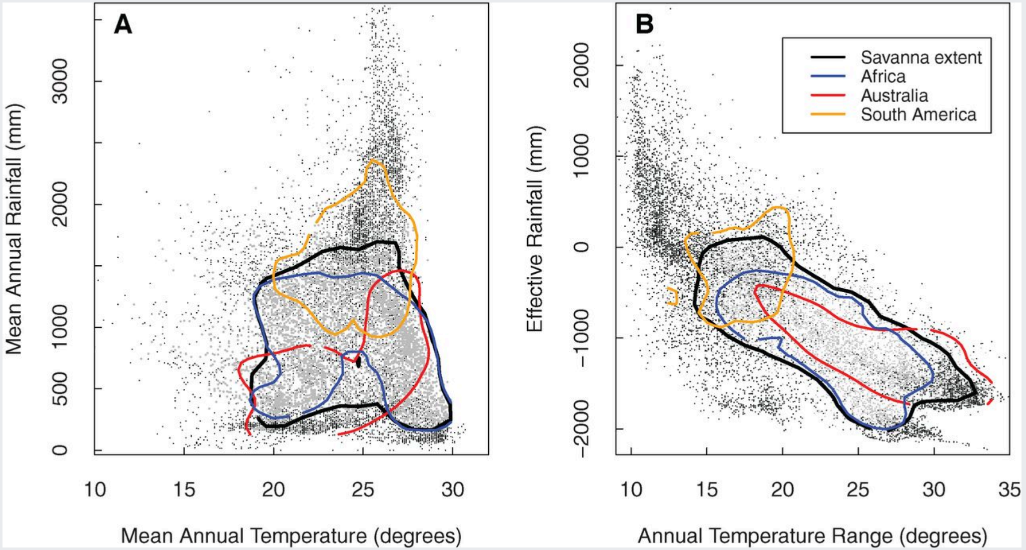
Trait conservatism has a profound influence on ecology!

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...



Lehman et al. 2014 *Science*

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

RESEARCH PAPER

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

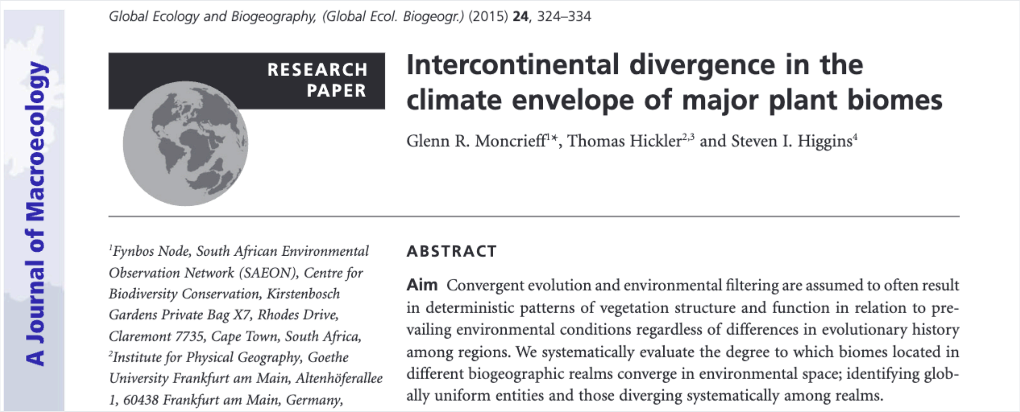
Glenn R. Moncrieff[1]*, Caroline E. R. Lehmann[2,3], Jan Schnitzler[4,5], James Gambiza[6], Pierre Hiernaux[7], Casey M. Ryan[3], Charlie M. Shackleton[6], Richard J. Williams[8] and Steven I. Higgins[9]

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.

Moncrieff et al. 2014 *GEB*

Trait conservatism has a profound influence on ecology!

In fact, the same applies to most major biomes!



A Journal of Macroecology

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

RESEARCH PAPER

Intercontinental divergence in the climate envelope of major plant biomes

Glenn R. Moncrieff[1]*, Thomas Hickler[2,3] and Steven I. Higgins[4]

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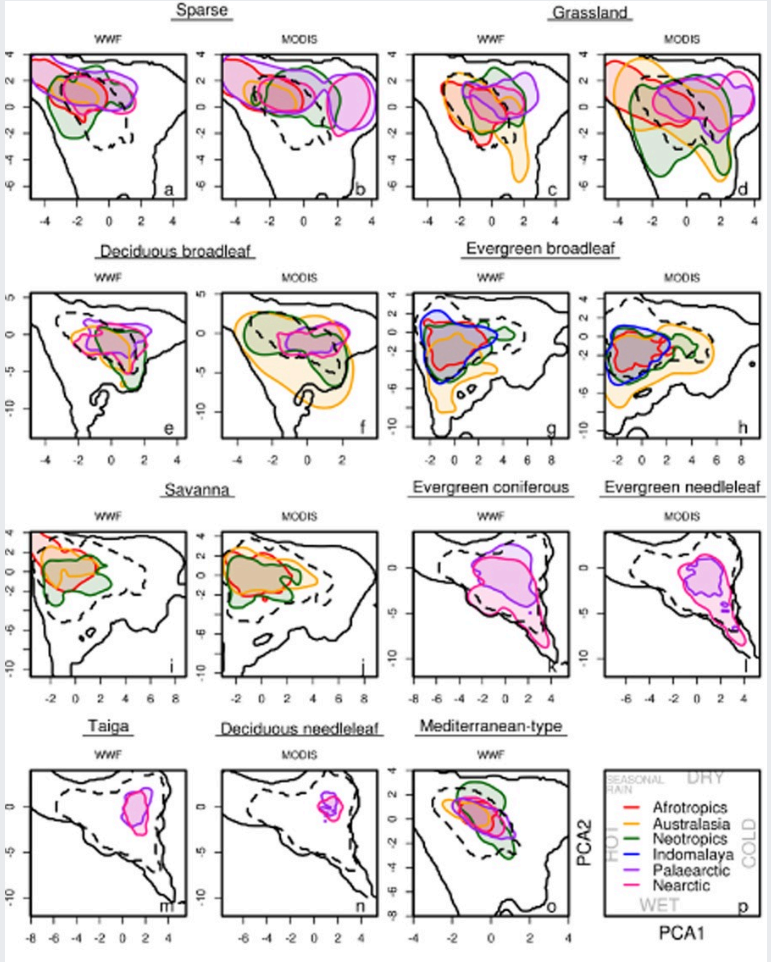
ABSTRACT

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!

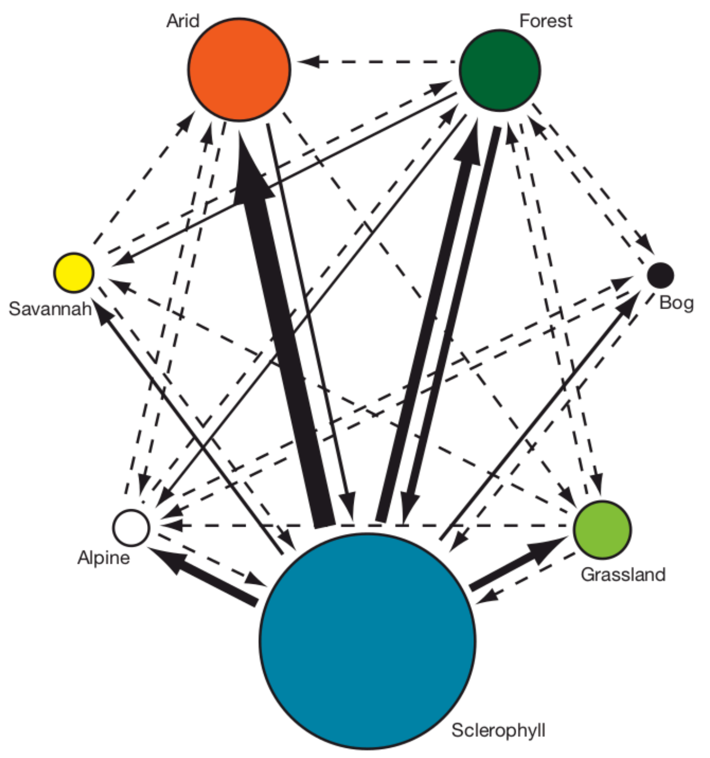


Figure 1 | Biome shifts within landmasses. Shifts occurred with only 356 of 10,800 speciation events within landmasses. Number of species sampled within each biome is proportional to the area of each circle: sclerophyll, 7,250; arid, 1,683; wet forest, 1,005; temperate grassland, 504; savannah, 242; 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**							
Bog		**13.3**			3.3			3.3
Forest			**50.8**		10			10
Grassland				**21.7**	5.3	1		6.3
Sclerophyll	1	0.3	3.5	2.7	**87**		1	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.

Slingsby, J. A., C. Merow, M. Aiello-Lammens, et al. (2017). "Intensifying postfire weather and biological invasion drive species loss in a Mediterranean-type biodiversity hotspot". En. In: *Proceedings of the National Academy of Sciences of the United States of America* 114.18, pp. 4697-4702. ISSN: 0027-8424, 1091-6490. DOI: 10.1073/pnas.1619014114.

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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