BRidging Information on tree Diversity in French Guiana and a test of Ecological theories

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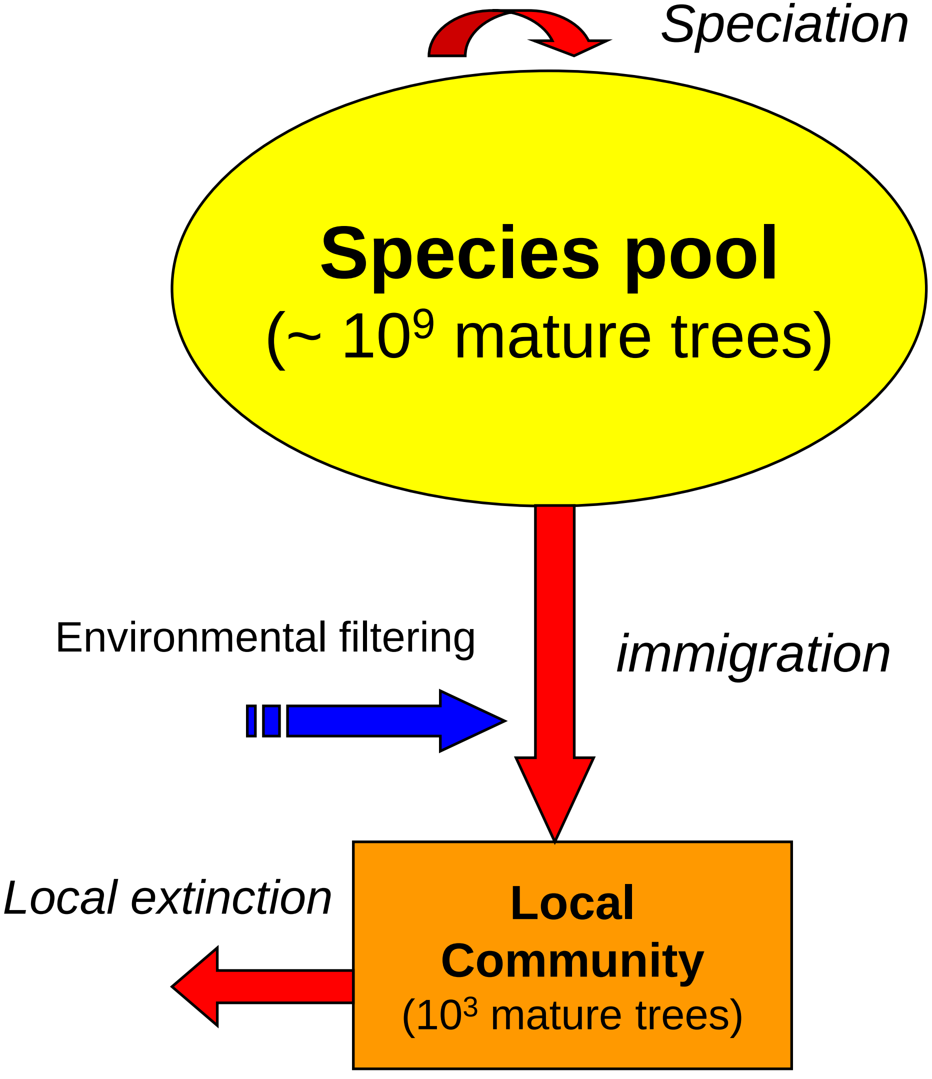
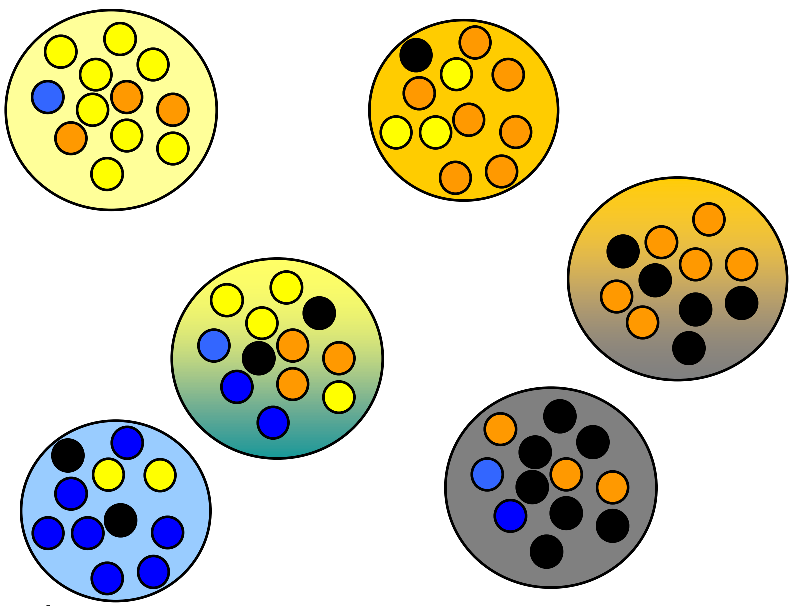
Community assembly rules



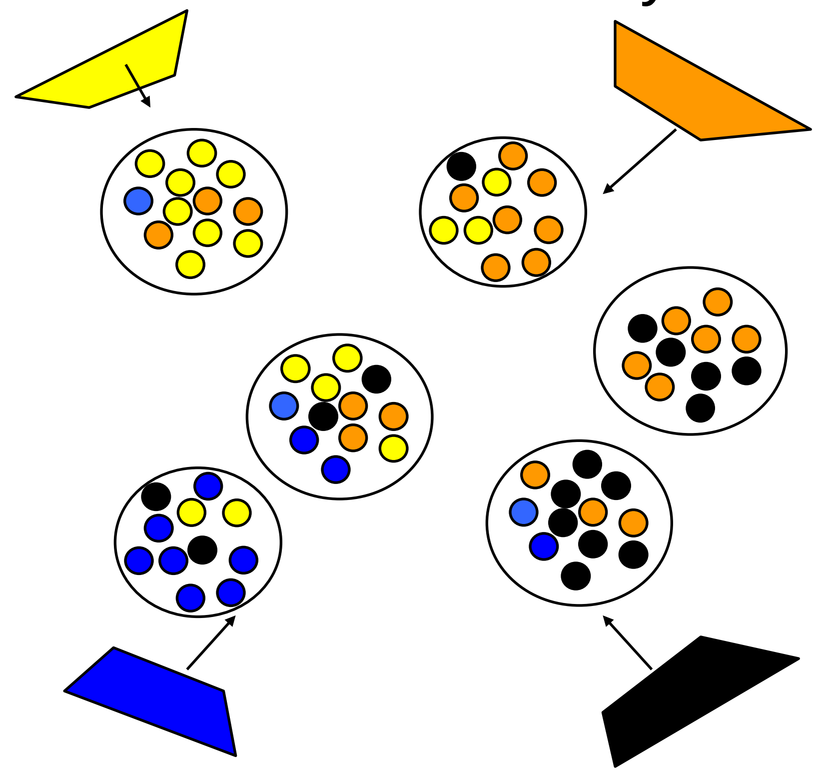
Niche and neutrality

Pure niche-assembly models



Premise:
Maintenance of species richness *mostly* due the action of ecological filters and to deterministic assembly rules

Pure dispersal-assembly models



Premise:
Maintenance of species richness *mostly* due to local demographic drift, dispersal limitation, immigration (and regional speciation)

Hubbell (2001)

NICHE THEORY?

No concept in ecology has been more variously defined or more universally confused than 'niche'

Leslie A Real, Simon A Levin 1991

I believe that community ecology will have to rethink completely the classical niche-assembly paradigm from first principles Stephen P Hubbell 2001

NICHE =
BIOLOGICAL EQUIPMENT OF A SPECIES IN RELATION TO COMPETITION

VOLUME XVII AUGUST, 1929 No. 2

THE BIOLOGICAL EQUIPMENT OF SPECIES IN RELATION TO COMPETITION[1]

BY E. J. SALISBURY.

(*With Plates* XIV–XVI *and six Figures in the Text.*)

DARWIN in *The Origin of Species* stated that "probably in no one case could we precisely say why one species has been victorious over another in the great battle of life," and Yapp (**48**) in his Address to this Society in 1925, after quoting this passage, added "we have not progressed very far even to-day."

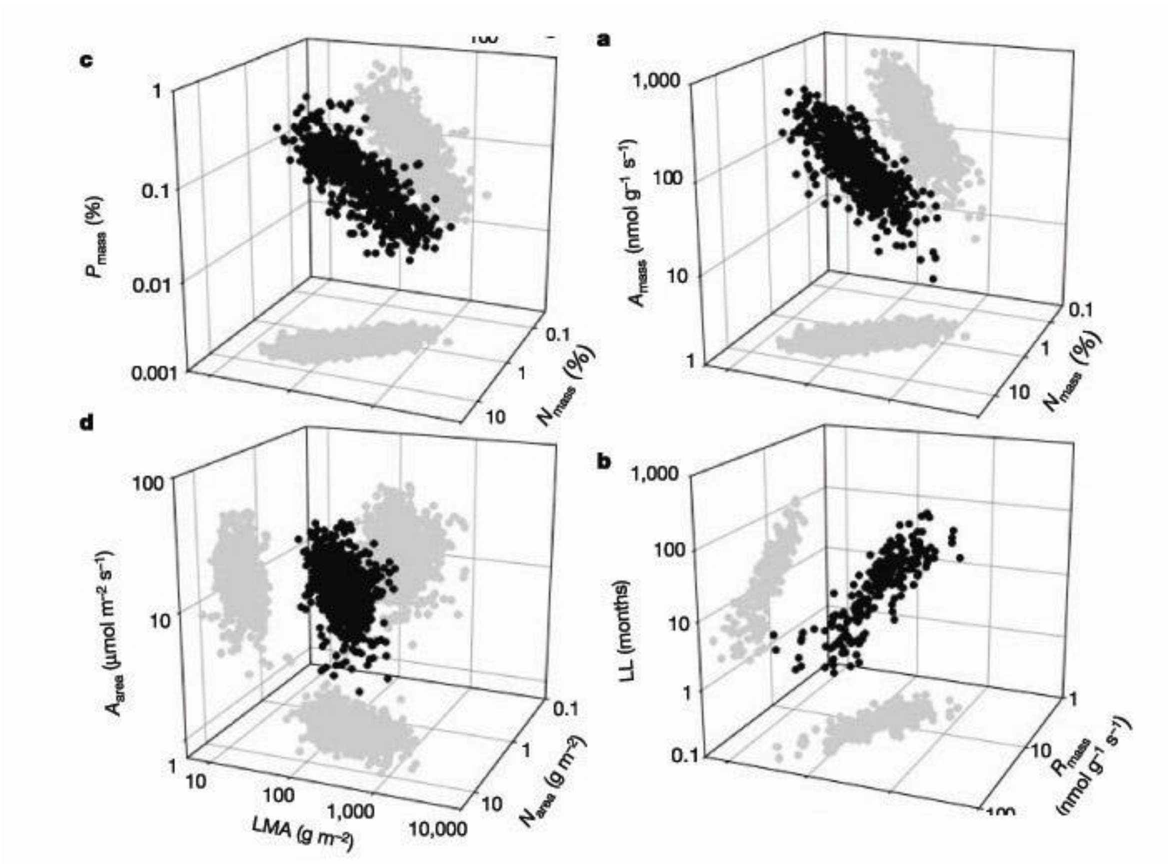
Whilst only too conscious of the risk attendant upon my task I make no apology for an attempt to consider how far it is possible to analyse some of the factors of competition and replace vague generalisations by observation and measurement.

No student of field ecology can doubt the paramount importance of the competition factor and the need for replacing qualitative by quantitative data. But the question at once arises as to how far the factors involved are capable of measurement with our present knowledge and technique. Although primarily concerned here with the higher plants a reference to the causes of dominance amongst Bacteria will be helpful in this connection.

H Evelyn Hutchinson

Niche dimensions for plants

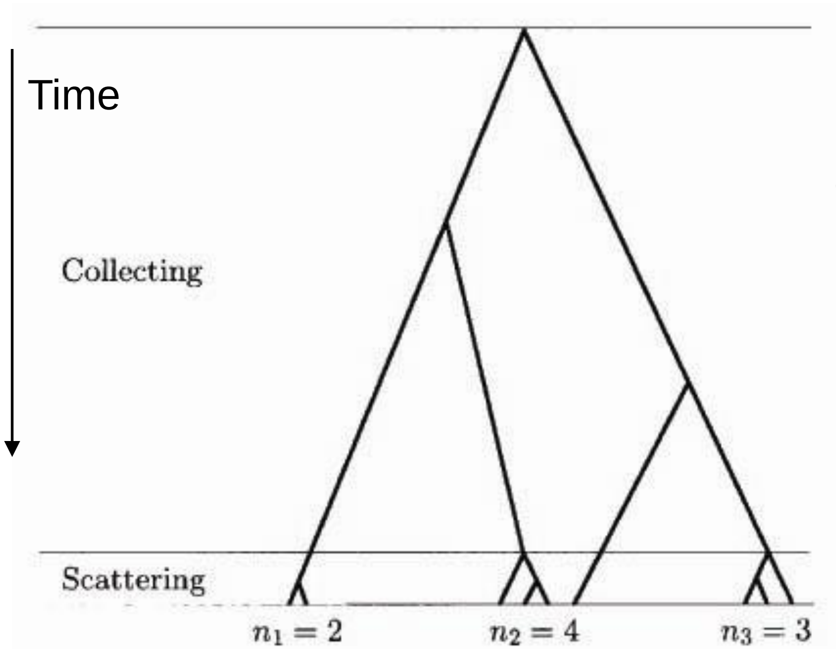
- Ressource use efficiency (photosynthetic, utilization of soil chemicals)
- Reproduction traits
- Defense traits (physical, chemical)



Wright et al. Nature 2003

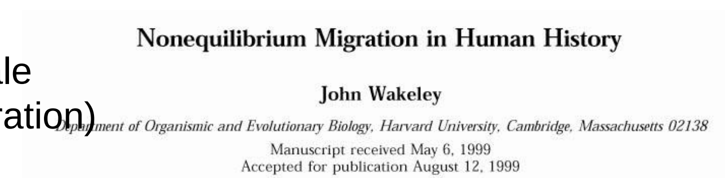
Evolutionary versus ecological niches

Separation of time-scales! Niche differences and ongoing competitive exclusion over **ecological** timescales ≠ Realized differences caused by the action of these processes over **evolutionary** timescales (the 'ghost of the competition past')



Evolutionary timescale
(speciation, trait evolution)

Ecological timescale
(demography, migration)



Nonequilibrium Migration in Human History

John Wakeley

Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts 02138

Manuscript received May 6, 1999
Accepted for publication August 12, 1999

An active area of research …

ECOLOGY

Untangling an Entangled Bank

David Storch, Pablo A. Marquet, Kevin J. Gaston

Dispersal, Environment, and Floristic Variation of Western Amazonian Forests

Hanna Tuomisto,[1*] Kalle Ruokolainen,[1] Markku Yli-Halla[2]

The distribution of plant species, the species compositions of different sites, and the factors that affect them in tropical rain forests are not well understood. The main hypotheses are that species composition is either (i) uniform over large areas, (ii) random but spatially autocorrelated because of dispersal limitation, or (iii) patchy and environmentally determined. Here we test these hypotheses, using a large data set from western Amazonia. The uniformity hypothesis gains no support, but the other hypotheses do. Environmental determinism explains a larger proportion of the variation in floristic differences between sites than does dispersal limitation; together, these processes explain 70 to 75% of the variation. Consequently, it is important that management planning for conservation and resource use take into account both habitat heterogeneity and biogeographic differences.

SCIENCE VOL 299 10 JANUARY 2003 241

OPEN ACCESS Freely available online PLoS BIOLOGY

Feature

Beyond Neutrality—Ecology Finds Its Niche

Virginia Gewin

From physics to ecology, one formidable goal of scientific exploration is determining the forces at work in nature and how these forces organize our world. In trying to uncover simple laws, scientists must balance the accuracy and complexity necessary to describe essential mechanisms. Sir

Box 1. Neutral Models in Biology Often Spark Controversy

Neutral models are not new in biology, nor is a subsequent debate about their interpretation. Stephen Hubbell, in fact,

Niche tradeoffs, neutrality, and community structure: A stochastic theory of resource competition, invasion, and community assembly

David Tilman†

10854–10861 | PNAS | July 27, 2004 | vol. 101 | no. 30 www.pnas.org/cgi/doi/10.1073/pnas.0403458101

SCIENCE'S COMPASS • REVIEW

REVIEW: ECOLOGY

Neutral Macroecology

Graham Bell

The central themes of community ecology—distribution, abundance, and diversity—display strongly marked and very general patterns. These include the log-normal distribution of abundance, the relation between range and abundance, the species-area law, and the turnover of species composition. Each pattern is the subject of a large literature that interprets it in terms of ecological processes, typically involving the sorting of differently specialized species onto heterogeneous landscapes. All of these patterns can be shown to arise, however, from neutral community models in which all individuals have identical properties, as the consequence of local dispersal alone. This implies, at the least, that functional interpretations of these patterns must be reevaluated. More fundamentally, neutral community models provide a general theory for biodiversity and conservation biology capable of predicting the fundamental processes and patterns of community ecology.

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A test of the unified neutral theory of biodiversity

Brian J. McGill

Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona 85721, USA

NATURE | VOL 422 | 24 APRIL 2003 | www.nature.com/nature

Field parameterization and experimental test of the neutral theory of biodiversity

J. Timothy Wootton

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Aim of the project

“To allow the development of field, laboratory, and analytical techniques to understand the processes that control the maintenance of species, functional, and phylogenetic diversity in neotropical rain forests, and to assess the resilience of this diversity to environmental fluctuations”

BRIDGE

Research plan

Plot censuses
5000 trees

DNA barcode database
1500 sequences RpoC1/matK

Mariwenn trait database (Kourou)

10 tree plots in FG
Environmental variables

Herbier de Cayenne

Functional trait database
18 traits for 5000 individual trees

Phylogeny reconstruction
380 genera with two genes (rbcL and matK)

Question 1 : What is the relationship between diversity and environment?

Question 2 : what is the conservatism of traits?

Question 3 : What is the relative role of ecological theories to predict biodiversity?

Partners

70 researchers, tecghnical staff or students, in four countries (France, UK, Belgium, Netherlands) and 9 research teams.

Participant 1: UMR Evolution et Diversité Biologique (EDB) Toulouse (Jérôme Chave)

Participant 2: UMR Ecologie des Forêts de Guyane (Ecofog), Kourou (Eric Marcon et Christopher Baraloto)

Participant 3 : Royal Botanic Gardens, Kew, Royaume Uni (Vincent Savolainen)

Participant 4: ONF Guyane (Stéphane Guitet)

Participant 5 : UMR AMAP, Montpellier (Grégoire Vincent)

Participant 6: Herbier de Guyane (IRD), Cayenne (Jean-Jacques de Granville)

Participant 7: CNRS/MNHN Brunoy (Bernard Riéra)

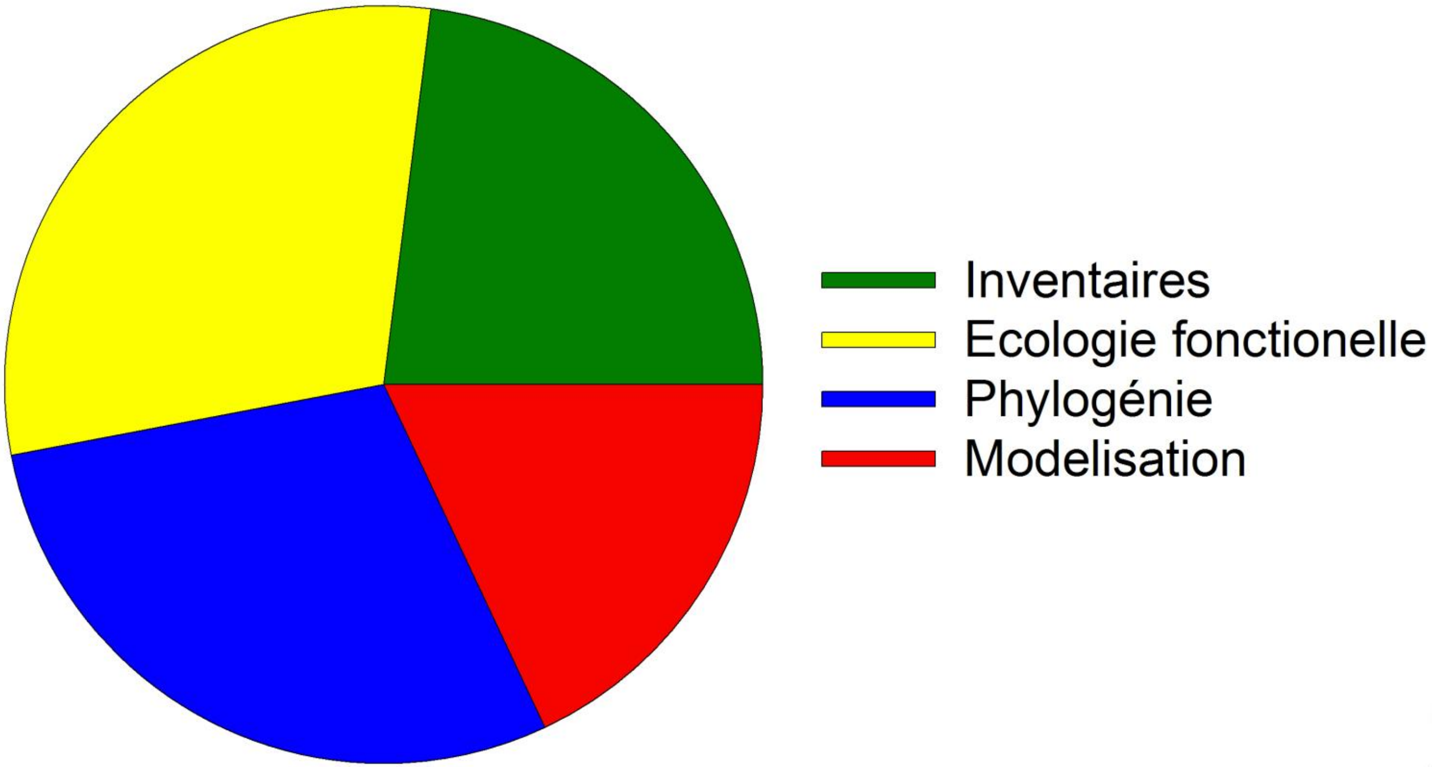
Participant 8 : Université Libre de Bruxelles, Belgique (Olivier Hardy)

Participant 9 : Wageningen University, Pays Bas (Frans Bongers)

Budget

	Equipement	Personnel	Missions	Prestations de Services	Autres dépenses de Fonctionnement	**Total**
Toulouse	**14560**	**159550**	**26960**	**87360**	**53040**	341471
Kourou	**18720**	**132188**	**33280**	**60320**	**78000**	322508
ONF	**0**	**0**	**3120**	**0**	**18512**	21632
AMAP	**5200**	**0**	**21840**	**0**	**6240**	33280
Herbier	**0**	**0**	**26000**	**0**	**13416**	39416
Brunoy	**0**	**0**	**12480**	**0**	**8320**	20800
Total	**38480**	**307338**	**123679**	**147680**	**161928**	**779107**

Budget by work-package



Project organisation : animation, databases, communication

- **Scientific Board, in charge of:**
  - **scientific coordination across teams**
  - **financial reporting**
  - **job interviews**

- **Project communication: mail-list (ecofog-bridge@listes.inra.fr), website (http://ecofog.cirad.fr/Bridge/), e-bulletin (to be taken care of by the project people and made available online), Project Administrator in French Guiana (Julien Engel)**

- **Databases access (phylogeny, taxonomy, functional traits) through the website and public-access storage databases (GeneBank, TreeBase, GBIF, Glopnet …)**

- **Public conferences in French Guiana and in France, media coverage.**

BRIDGE

The challenge of testing ecological theories based on spatially and phylogenetically structured datasets

Work-package ‘Integration’

Ecology, 87(7) Supplement, 2006, pp. S163–S165

PHYLOGENETIC ECOLOGY AT WORLD SCALE, A NEW FUSION BETWEEN ECOLOGY AND EVOLUTION

MARK WESTOBY[1]

Department of Biological Sciences, Macquarie University, Sydney, New South Wales 2109 Australia

Abstract. One fusion between ecology and evolution is well established, under the title of population biology. The years 2006–2020 will see a new fusion, likely to prove equally creative. Inputs from ecology to this second fusion will be worldwide data sets for ecological traits across many species. Inputs from evolution will be phylogenetic trees with well-resolved topology and with increasingly tight geological dates for each branch point. There will be unification of two aims: first to explain the spread of different ways of making a living, across the range of present-day species; and second, to narrate the evolutionary history that has led up to present-day ecology.

Key words: ecological traits of species; evolution; fusion; historical ecology; phylogeny; world data sets.

Classic tests of the niche: species diversity along a gradient

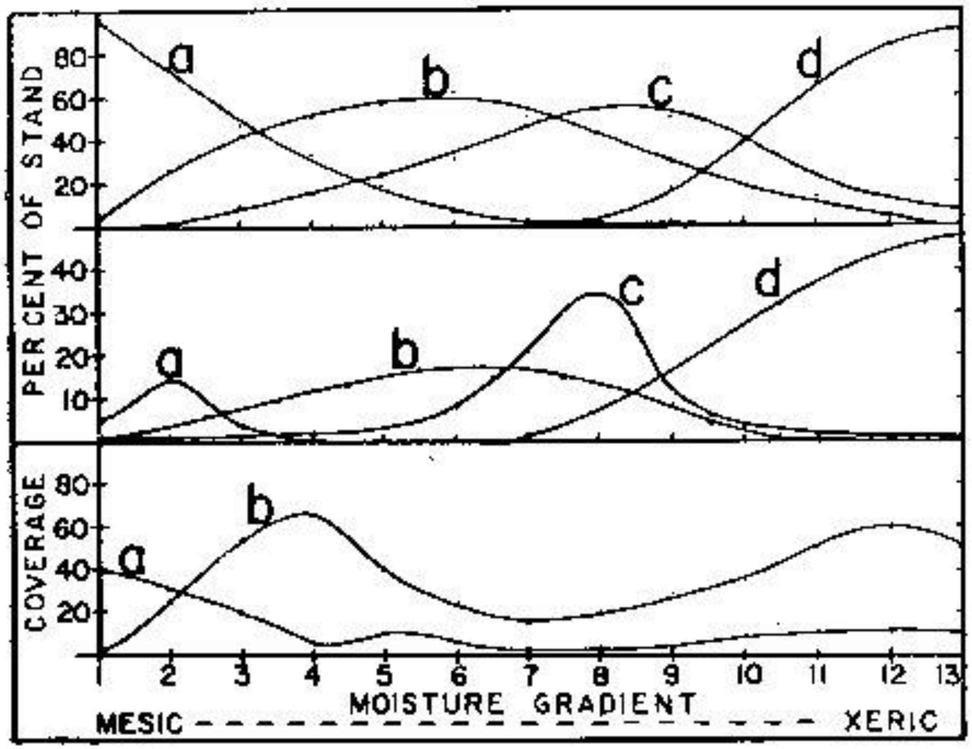


FIG. 2. Transect of the moisture gradient, 1500-2500 ft. Top—curves for tree classes: a, mesic; b, submesic; c, subxeric; d, xeric. Middle—curves for tree species: a, *Betula allegheniensis*; b, *Cornus florida*; c, *Quercus prinus*; d, *Pinus virginiana*. Bottom—curves for undergrowth coverages: a, herbs; b, shrubs.

R Whittaker

(1956)

Explaining spatial variation of species diversity based on environmental factors

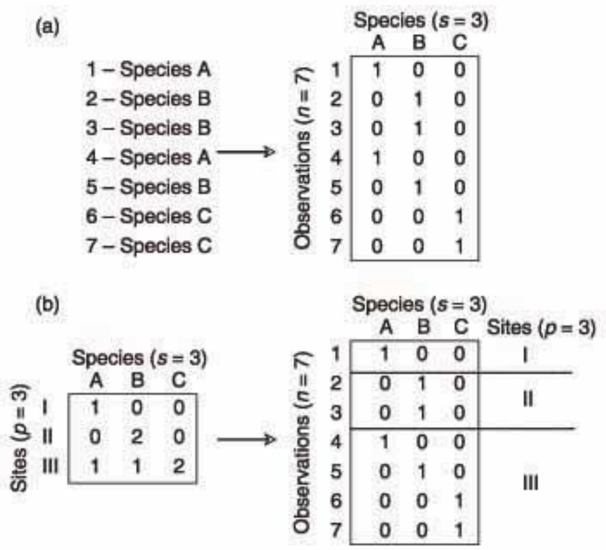


Fig. 1 (a) From a list of $n = 7$ individual observations of $s = 3$ species to a $n \times s$ table of species occurrences, **Y**. (b) From a table of species abundances of $s = 3$ species in $p = 3$ sites that sums to $n = 7$ observations, to a $n \times s$ table of species occurrences partitioned according to p sites.

If a community is statistically correlated with the environment, the neutral theory is falsified.

However, this does not explain which **process** drives the pattern

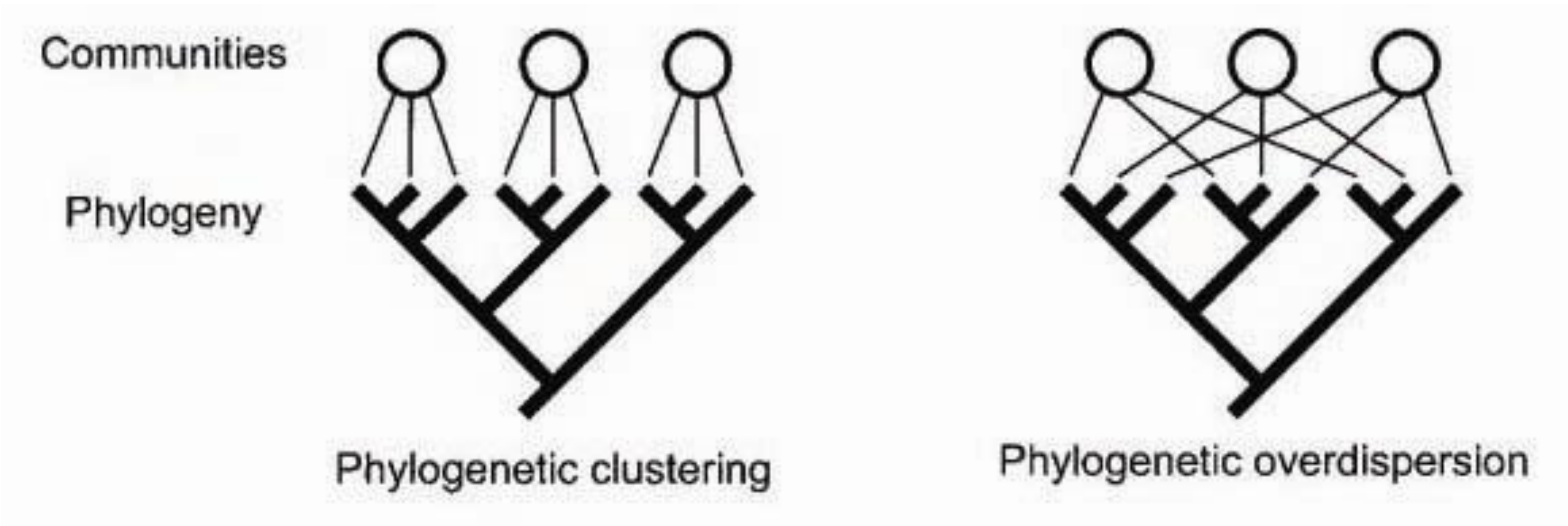
Journal of Ecology 2007
95, 294–300

FORUM

An operational, additive framework for species diversity partitioning and beta-diversity analysis

RAPHAËL PÉLISSIER and PIERRE COUTERON*
*IRD, UMR AMAP (Botanique et Bioinformatique de l'Architecture des Plantes), TA40/PS2, Bd. de la Lironde, 34398 Montpellier cedex 5, France, and *Institut Français de Pondichéry, Pondicherry, 605001 India*

One step beyond: phylogenetic structure in communities



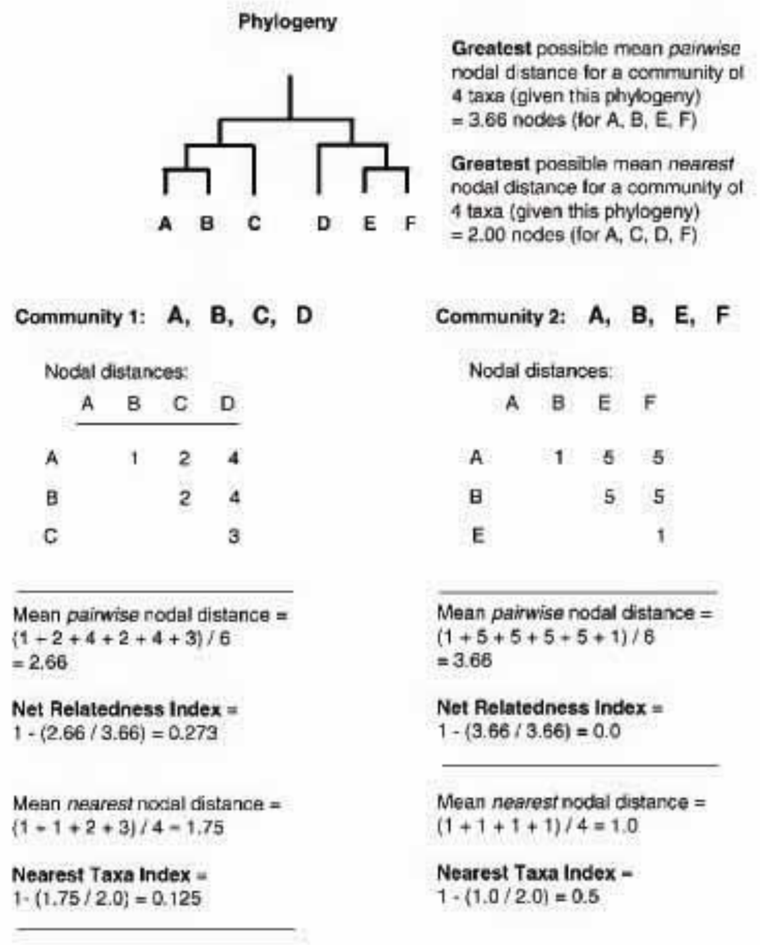
« In natural communities, both environmental filtering and competitive interactions are occurring. As characters evolve along phylogenetic lineages, some may confer increased environmental tolerance (filtering), while others may reduce competition among species. The combination of species traits and their evolutionary lability produces the phylogenetic structure that is observed within communities. »

Test of phylogenetic conservatism in communities

- Define a metrics that depends on the structure of the subtending phylogenetic tree (NRI, NTI)
- Compare this metrics in a real community (e.g. one plot) to a null model of a community randomly assembled from the species pool

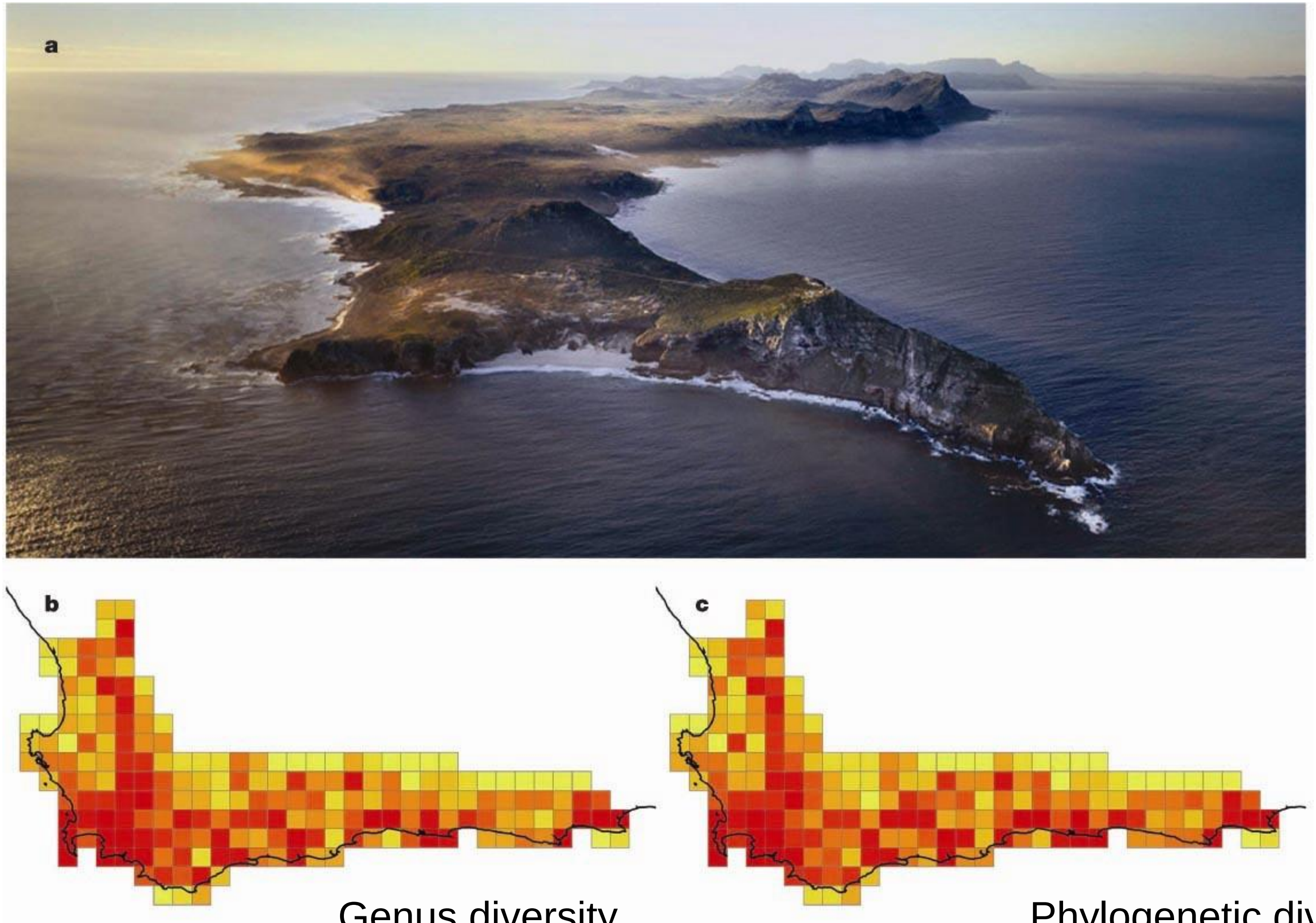
- « I found that the species in plots were more phylogenetically related than expected by chance, a result that was insensitive to various modifications to the basic methodology. I tentatively infer that variation in habitat among plots causes ecologically more similar species to co-occur within plots.» (Webb 2000)

This is not a trait-based approach



Webb Am Nat (2000)

The NRI & NTI metrics are related to phylogenetic diversity



Genus diversity

Phylogenetic diversity = total branch length of the subtending tree

Forest et al. Nature (2007)

Evolution of niche traits

- Phylogenetic structure in communities cannot be considered alone as a strong evidence for the presence of habitat filtering or of competitive displacement, as it might just reflect the amount of shared evolutionary history in coexisting species

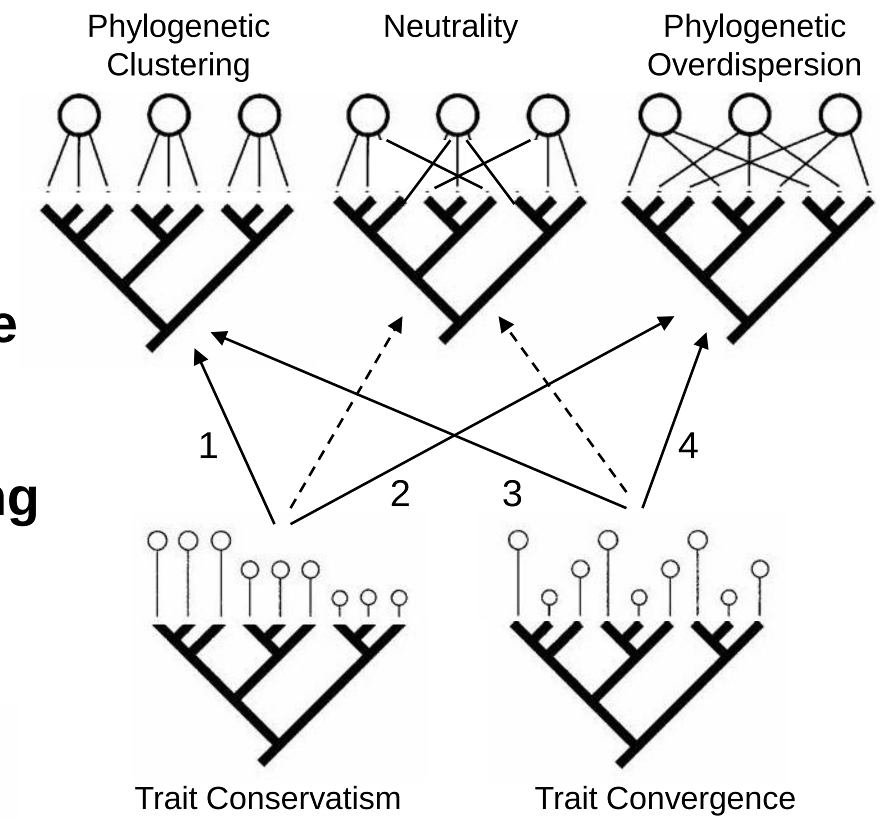


Figure 2. A conceptual illustration of relationships between trait evolution and community phylogenetic structure. The null model for species distributions is neutral or random dispersion of species regardless of trait clustering in the phylogeny. Scenarios 1 and 3 suggest the contribution of environmental filtering, whereas scenarios 2 and 4 suggest competitive displacement. Adapted from Cavender-Bares et al. 2004.

Trait similarity within communities

Trait evolution	Clustering of traits (driven by environmental filtering)	Overdispersion of traits (driven by competitive interactions)
Conserved	Phylogenetic clustering	Phylogenetic overdispersion
Convergent	Phylogenetic overdispersion	Phylogenetic clustering or random dispersion

Partitioning functional traits into within- and among-community variation

Mean species trait:
(t_{ij} is the trait for species i in plot j;
p_{ij} is the relative abundance of species i in plot j)

$$\bar{t}_i = \sum_{j=1}^{P} p_{ij} t_{ij}$$

Mean plot trait:

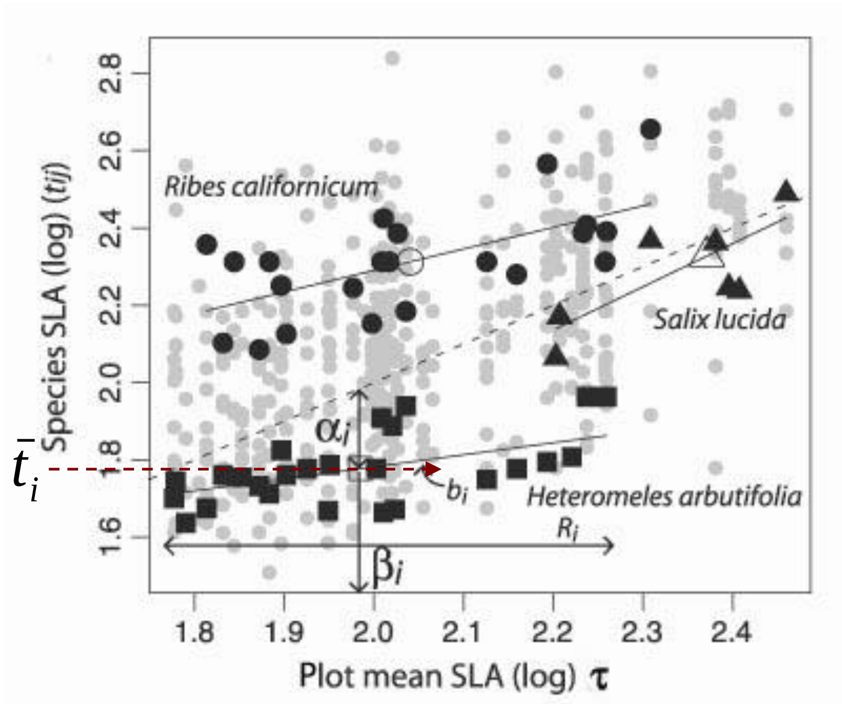
$$\bar{\tau}_j = \sum_{i=1}^{S} p_{ij} t_{ij}$$

Is a species trait changing more or less rapidly than the plot-mean trend?? *Salix* increases parallel to the plot-mean trend, but *Heteromeles* increases more slowly

$$\bar{t}_i = \alpha_i + \beta_i \qquad \beta_i = \sum_{j=1}^{P} p_{ij} \bar{\tau}_j$$

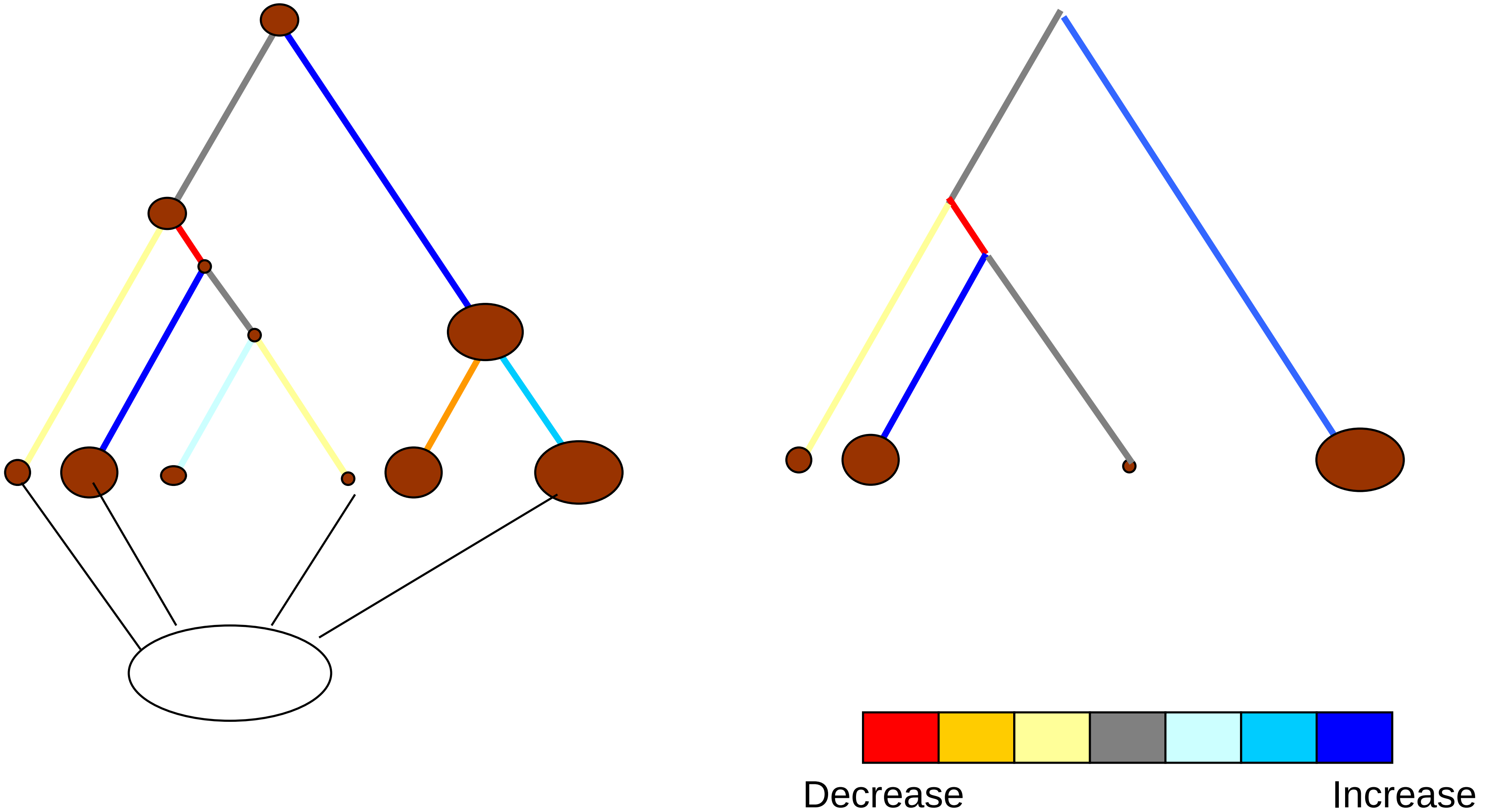
Within community

Among community

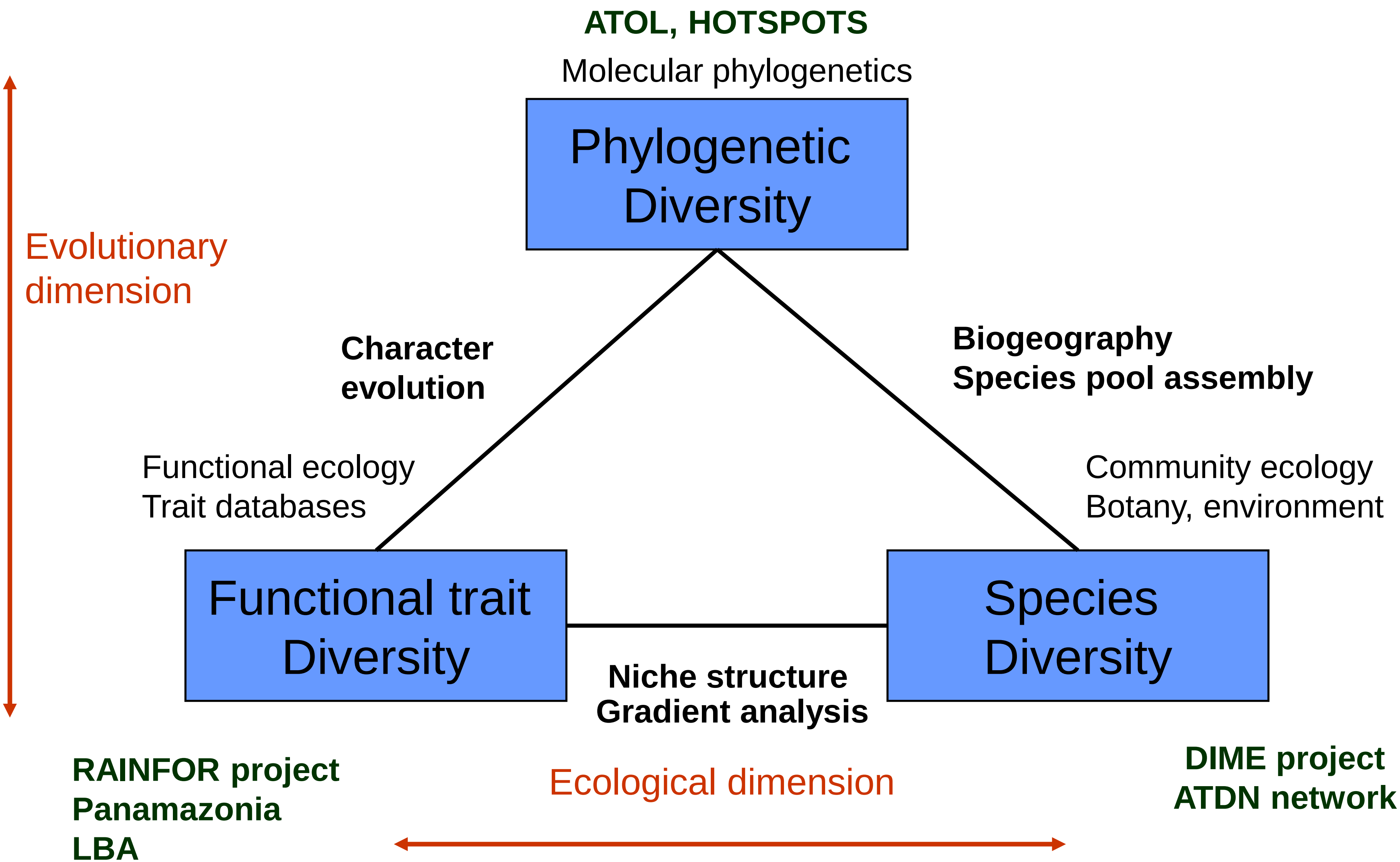


Ackerly & Cornwell Ecol Letts (2007)

Another possible test



Overall objective: towards a more mechanistic understanding of biodiversity



Some questions/tasks for the Kourou meeting

Are we happy with what we have committed to?

How can we make sure that everybody can access information related to the project and contribute to it? (Project Administrator)

Who will carry out field work, and when (WP1)?

Will taxonomic vouchers samples be managed in Cayenne or in Kourou (WP1)?

Which specialist will we invite to help determine these samples (WP1)?

How (and by which lab) will the leaf samples be analysed (WP2)?

What will be the time schedule of the wood trait sub-package (WP2)?

Which genera will we include in the phylogenetic reconstruction, and will we need fresh material (WP3)?