Epiphytes

a critical review of concepts, facts and assumptions

Gerhard Zotz

Functional Ecology of Plants

University Oldenburg

What is an epiphyte?

Structurally dependent flora

Germination,Growth,Reproduction

Self-supporting Terrestrials
T,T,T

Structurally dependent flora

Holoepiphytes
P,P,P

Self-supporting Terrestrials
T,T,T

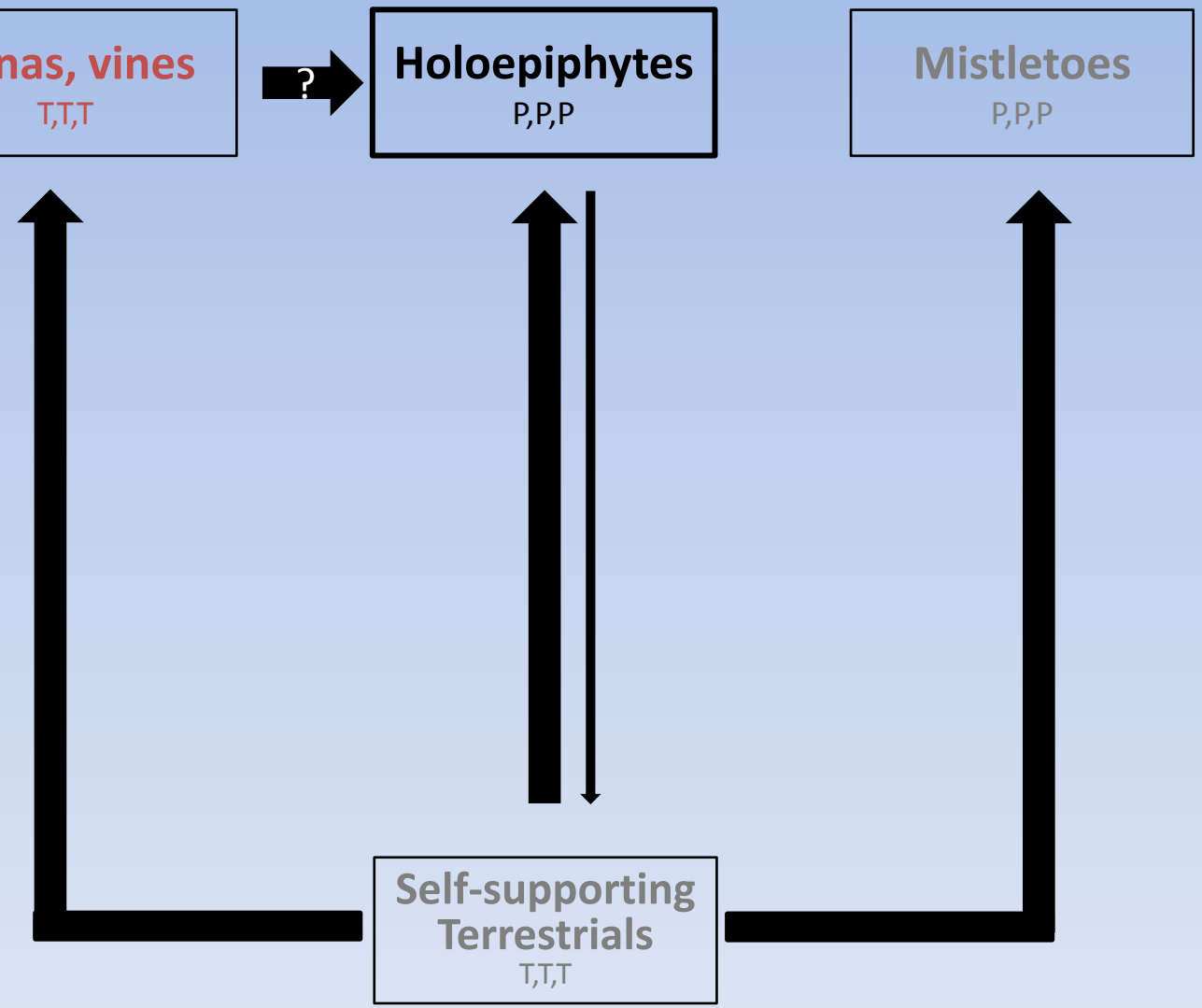
Structurally dependent flora

Holoepiphytes
P,P,P

Mistletoes
P,P,P

Self-supporting Terrestrials
T,T,T

Structurally dependent flora



Structurally dependent

Lianas, vines
T,T,T

?

Holoepiph
P,P,P

toes
P

Primary Hemiepiphytes
P,P/T,T

Self-supporting Terrestrials
T,T,T

Structurally dependent flora

Lianas, vines
T,T,T

?

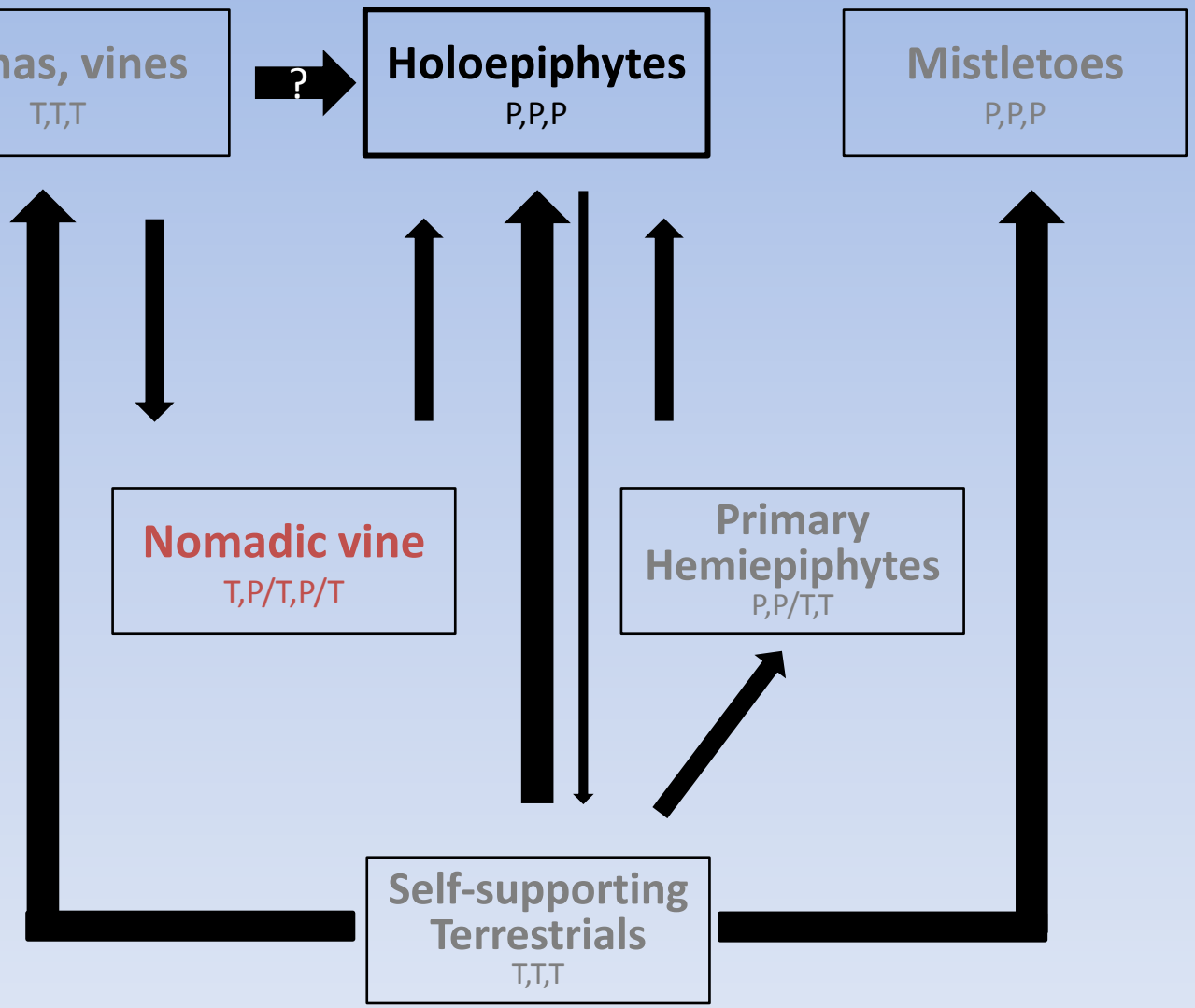
Holoepiphytes
P,P,P

Mistletoes
P,P,P

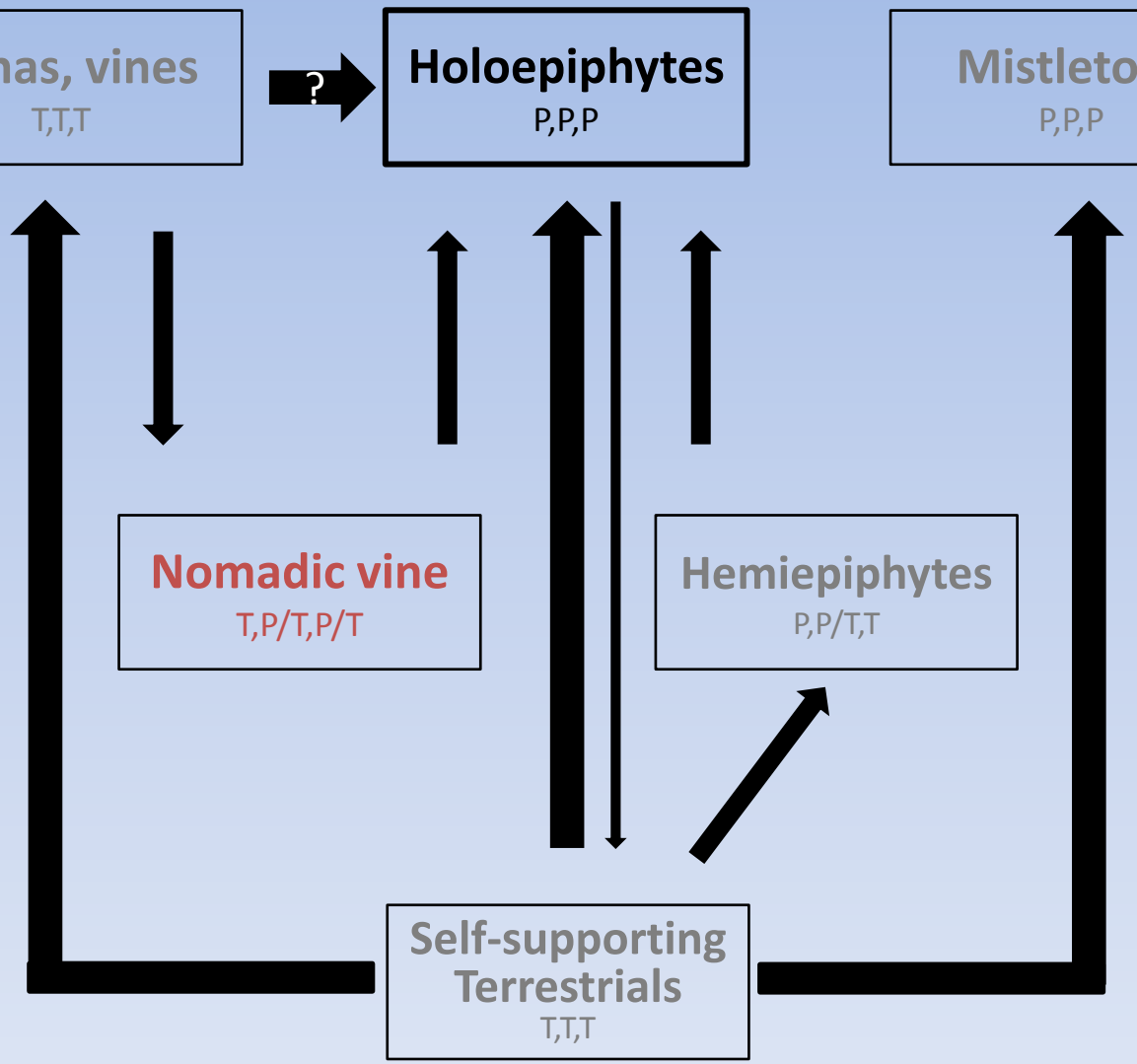
Primary Hemiepiphytes
P,P/T,T

supporting
rrestrials
T,T,T

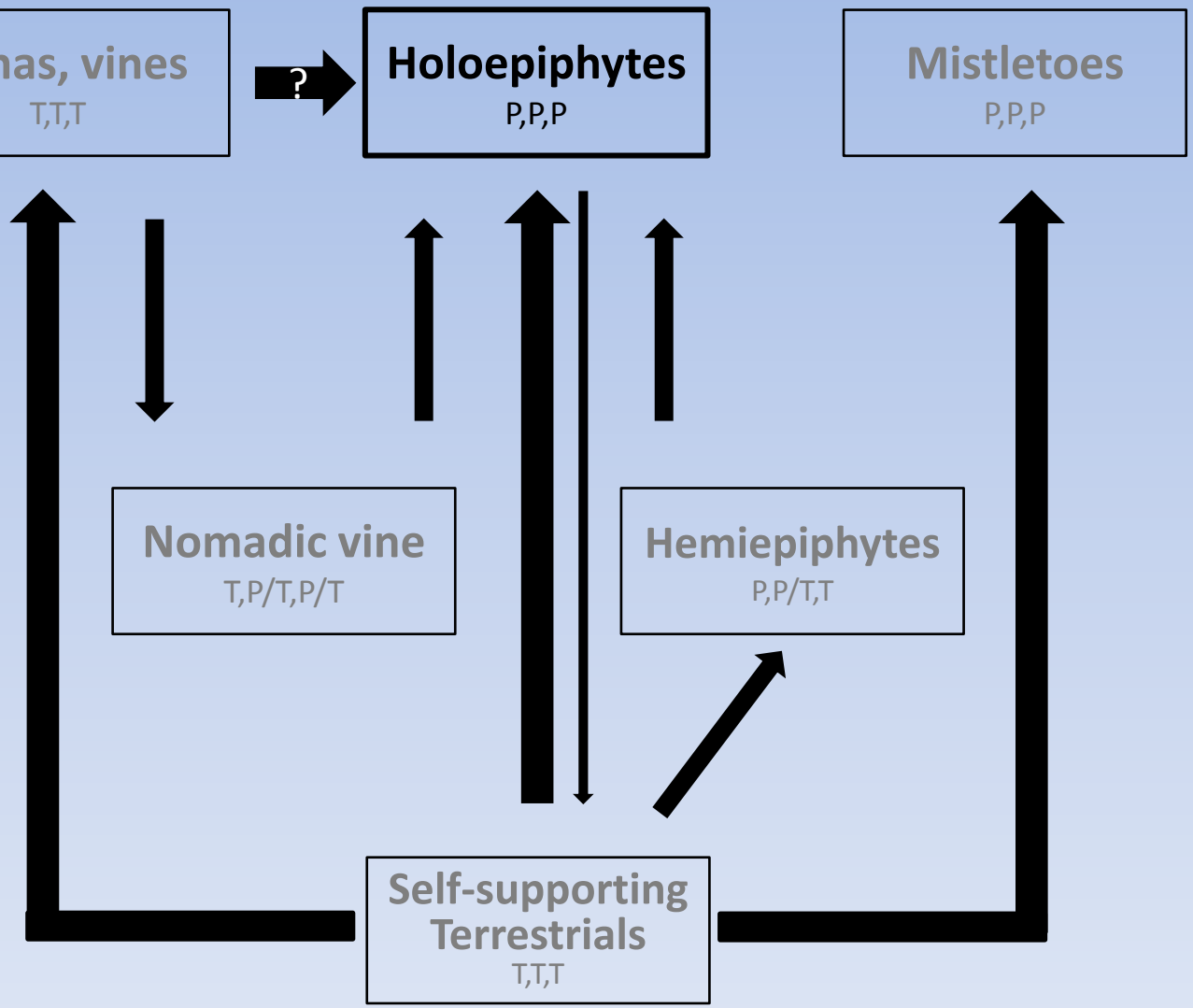
Structurally dependent flora



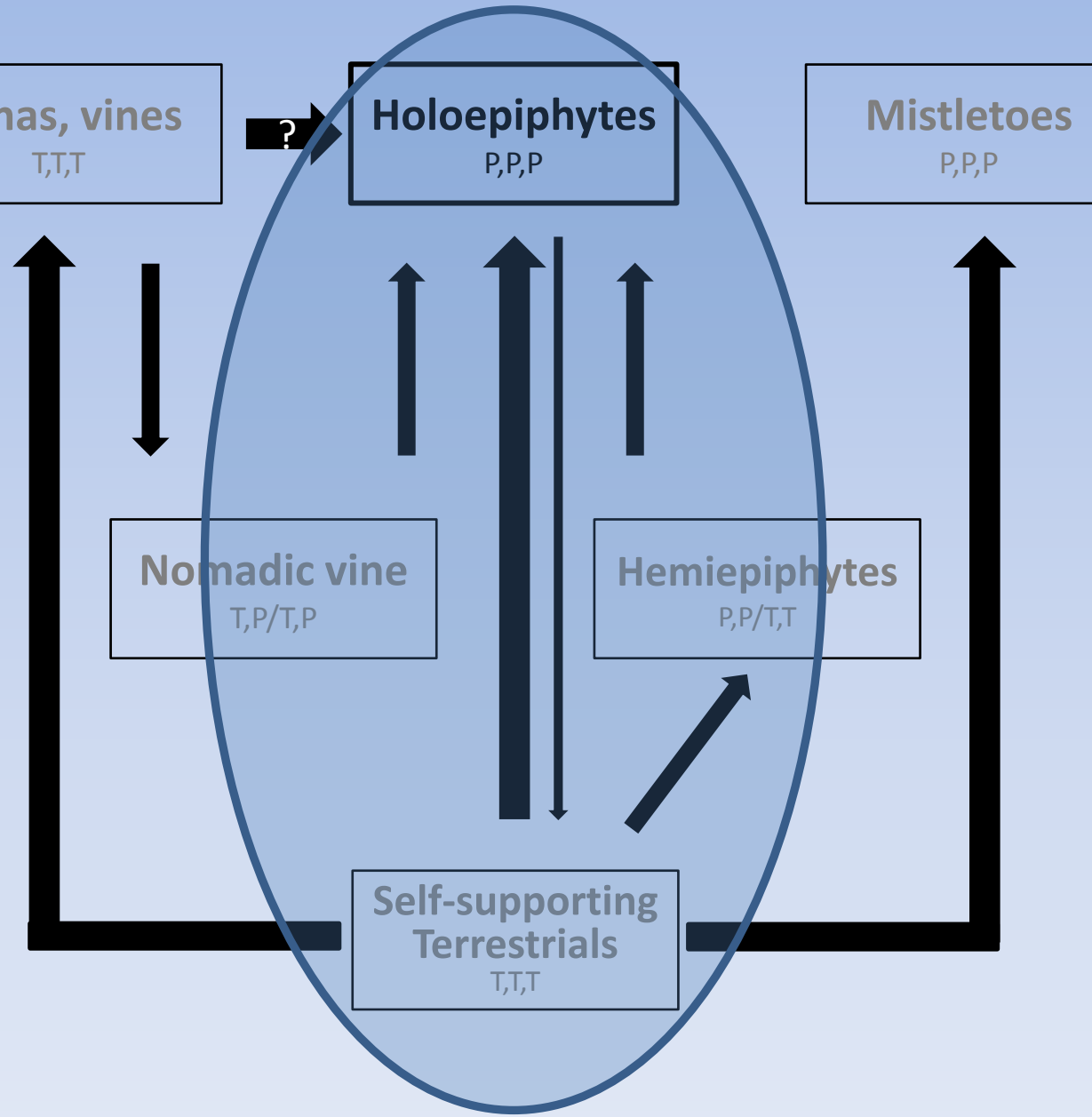
Structurally dependent flora



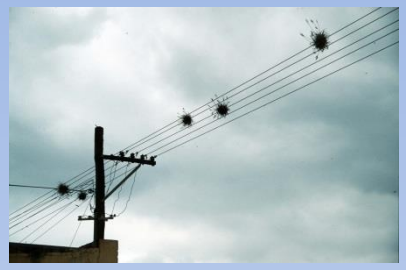
Structurally dependent flora



Structurally dependent flora



Structurally dependent flora



Lianas, vines
T,T,T

?

Holoepiphytes
P,P,P

Mistletoes
P,P,P

Nomadic
T,P/T,

epiphytes
P,P/T,T

Self-supporting Terrestrials
T,T,T

How many epiphytes?

Schimper 1888

Madison 1977

Kress 1986

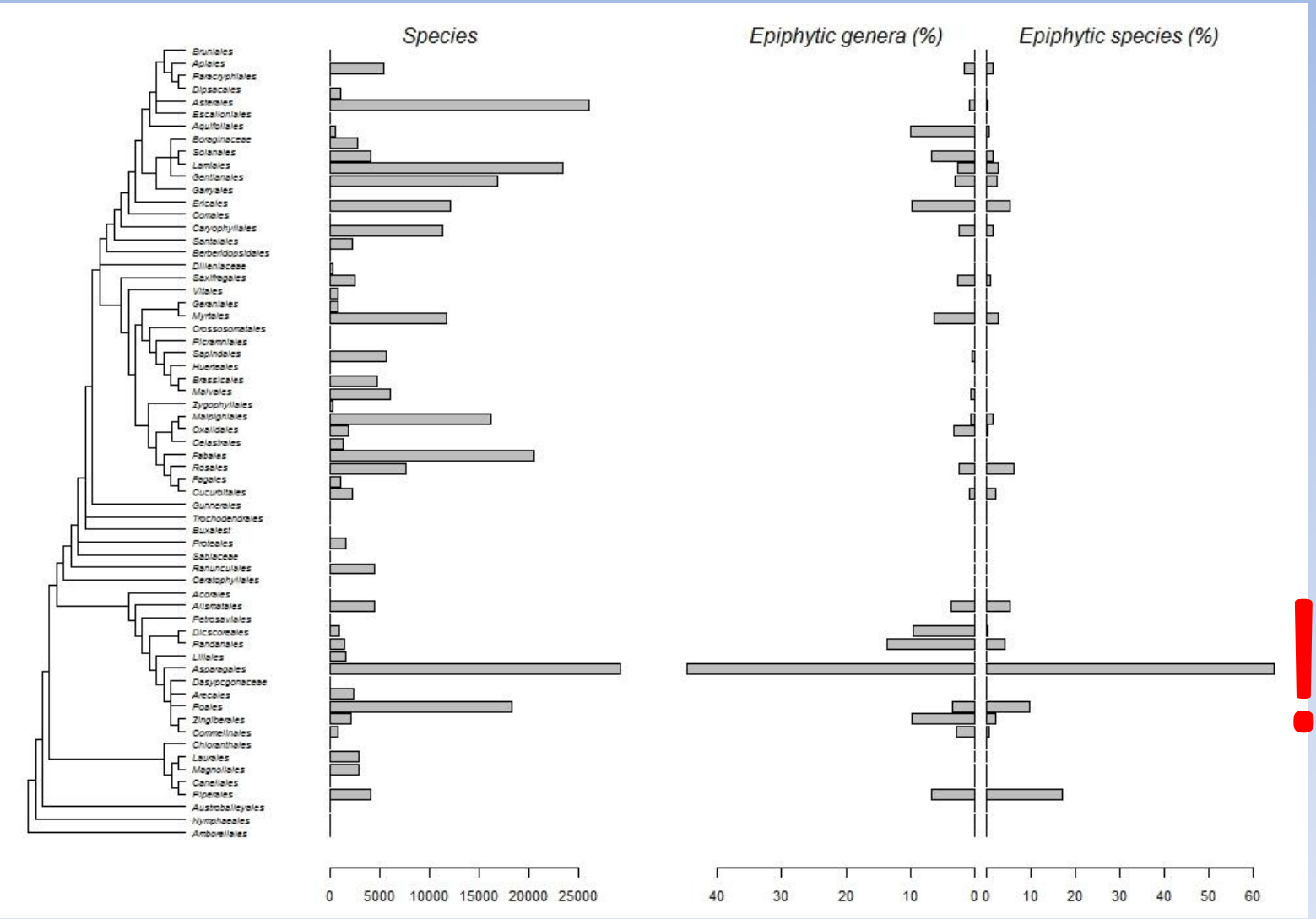
Gentry & Dodson 1986

Zotz 2013

The answer is 27614!

914 genera in 73 families…

Epiphytes and APG III



What´s different compared to Kress 1986? Additions

Asia: *Pedicularis dendrothauma*

Asia: many “new” Zingiberaceae (now 50 spp)

Americas: epiphytic *Cyathea*

Africa: many “new” *Impatiens* (5 → 15*)*

What´s different? Exclusions

Many clearly accidental taxa dropped
(Caryophyllaceae, Ranunculaceae)

“secondary hemiepiphytes”

Araceae

Marcgraviaceae

What´s different? Intrageneric variation

Kress: Epiphytic vs. terrestrial genera

Bulbophyllum, *Dendrobium*, etc etc all have a few terrestrial taxa

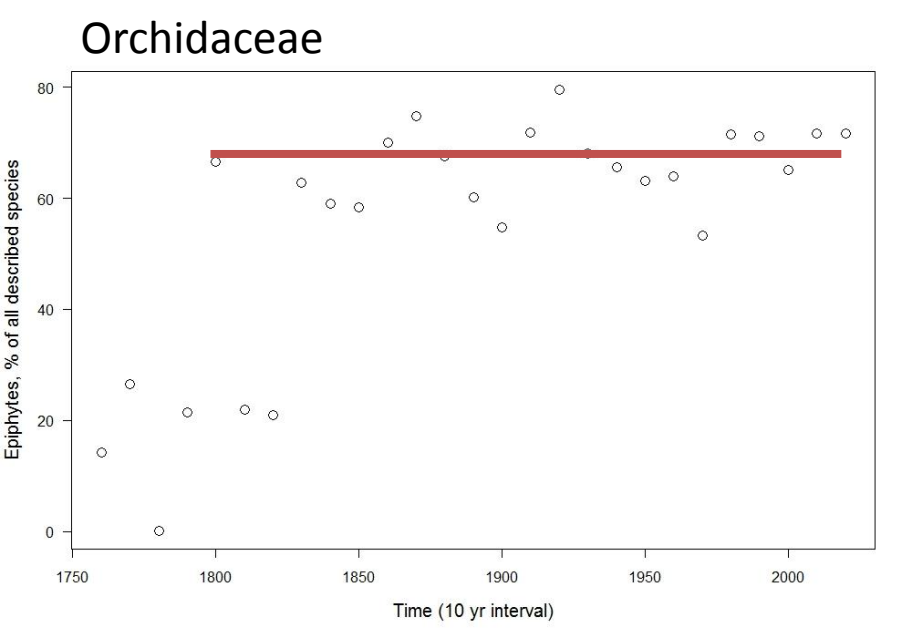
→ Evolution is not unidirectionally „up“ the tree!

Good example: Evolution in *Huperzia*

What´s different? Data base

I have a species-based list of some 28000 entries with synonyms, which can be updated in the future

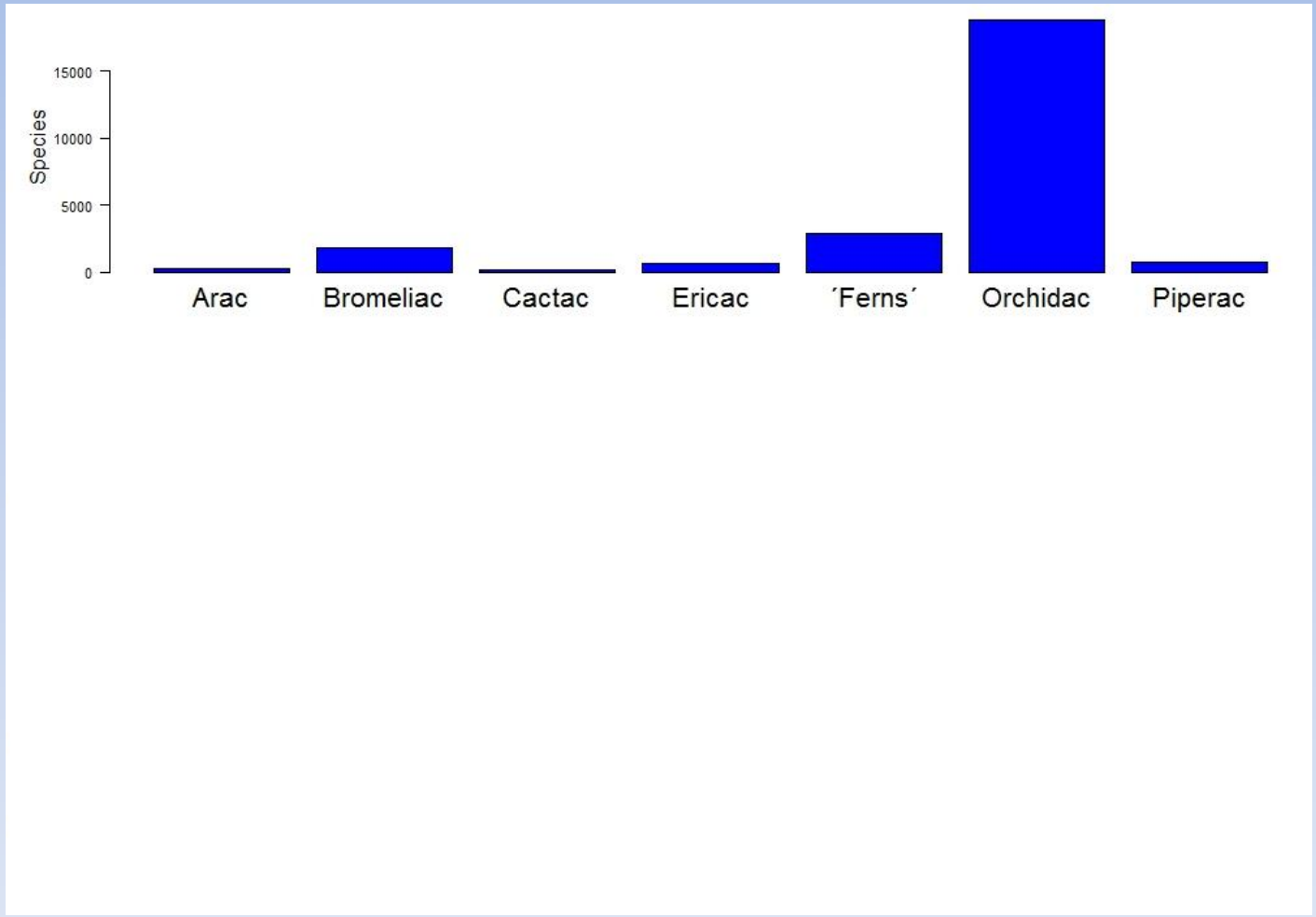
Future changes?



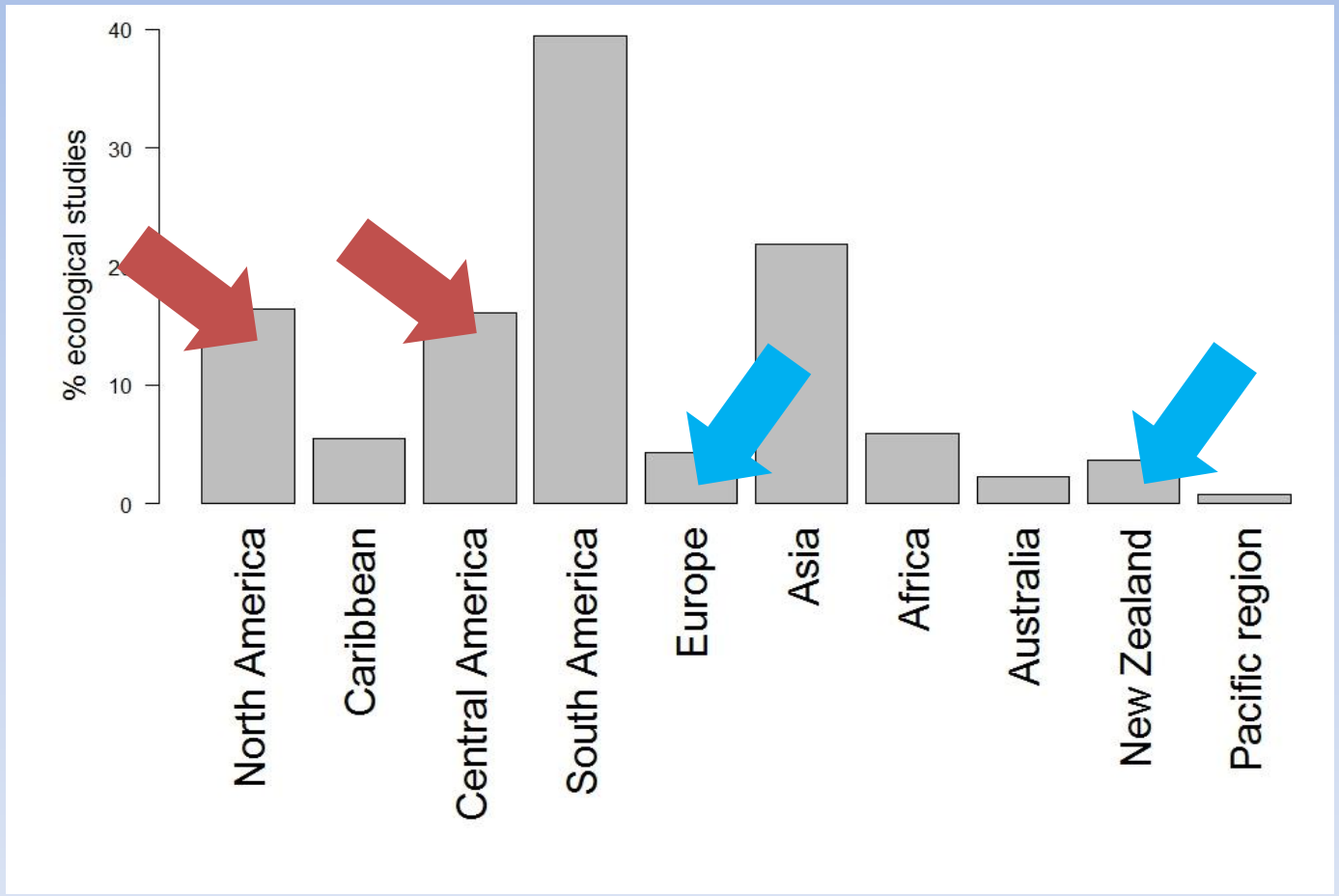
Proportion of epiphytes among newly described orchids has not changed in 200 years…

Epiphyte Ecology - a highly biased view!

Our current view is highly biased taxonomically!



… and geographically!



Conclusion

- The potential of multiple origins of epiphytism for generalisations has not been used

- Our view of epiphyte ecology is extremely biased

Epiphytes - anything special?

The ´Epiphyte syndrome´

Seeds	generally small (↔ Rockwood 1985)
Body size	generally small (never quantified in a phylogenetic context)
Growth	exceedingly and inherently slow (few taxa studied)
Life history	long-lived perennials, never annuals
	Water relations
CAM	frequent (not in all taxa, e.g. Ericaceae, Araceae, Gesneriaceae…)
Lightflecks	stomatal behaviour more conservative as in terrestrials
Cuticles	highly impermeable to water (Helbsing et al 2000)
Velamen radicum	typical for epiphytic orchids and many aroids (terrestrial taxa!)
Osmotic potential	less negative than in terrestrial in similarly dry habitats
…..	…..
…..	…..

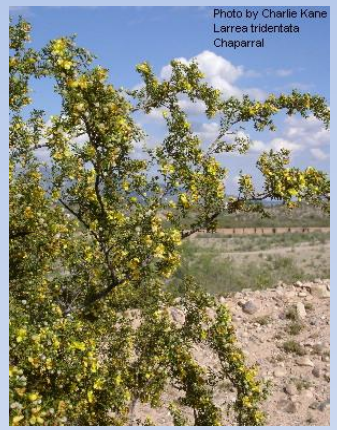
The ´Epiphyte syndrome´

What´s special?

From physiology to community …

Osmotic Potential

unusually high



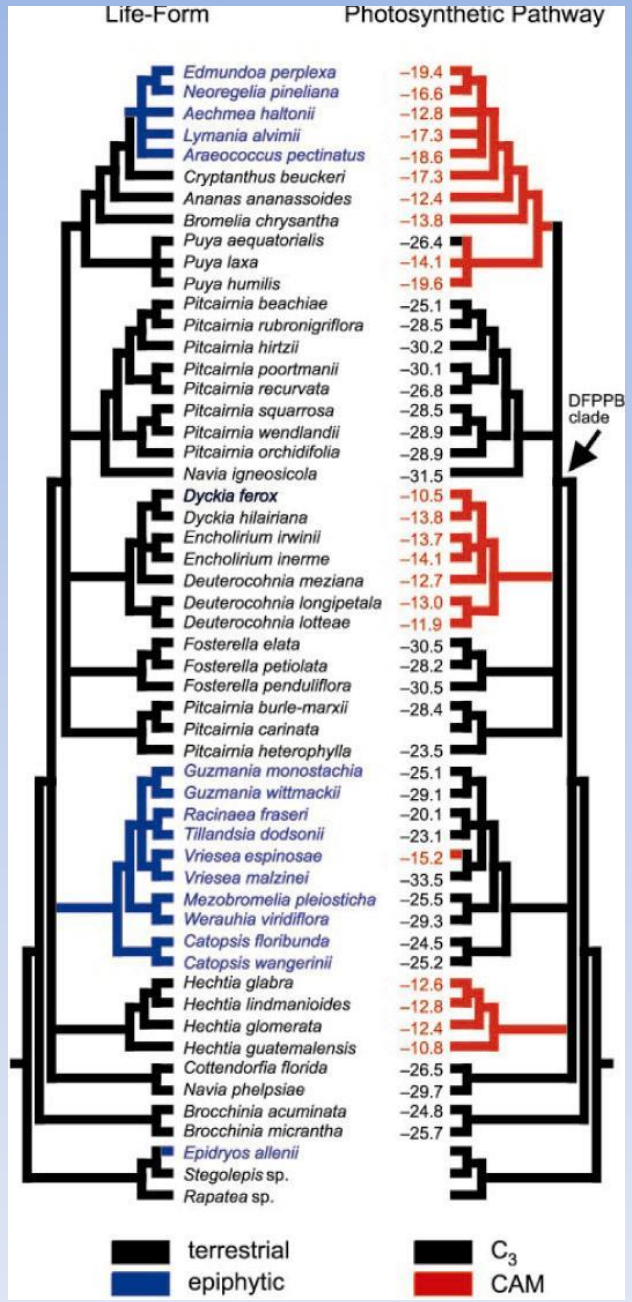
Compare, e.g., *Larrea* in the Southern US with osmotic potentials **< -10 MPa**

with

Trigonidium and other epiphytes, in which osmotic potentials are rarely **< –1 MPa** even after prolonged drought

CAM

useful, but not essential



Crayn et al 2004

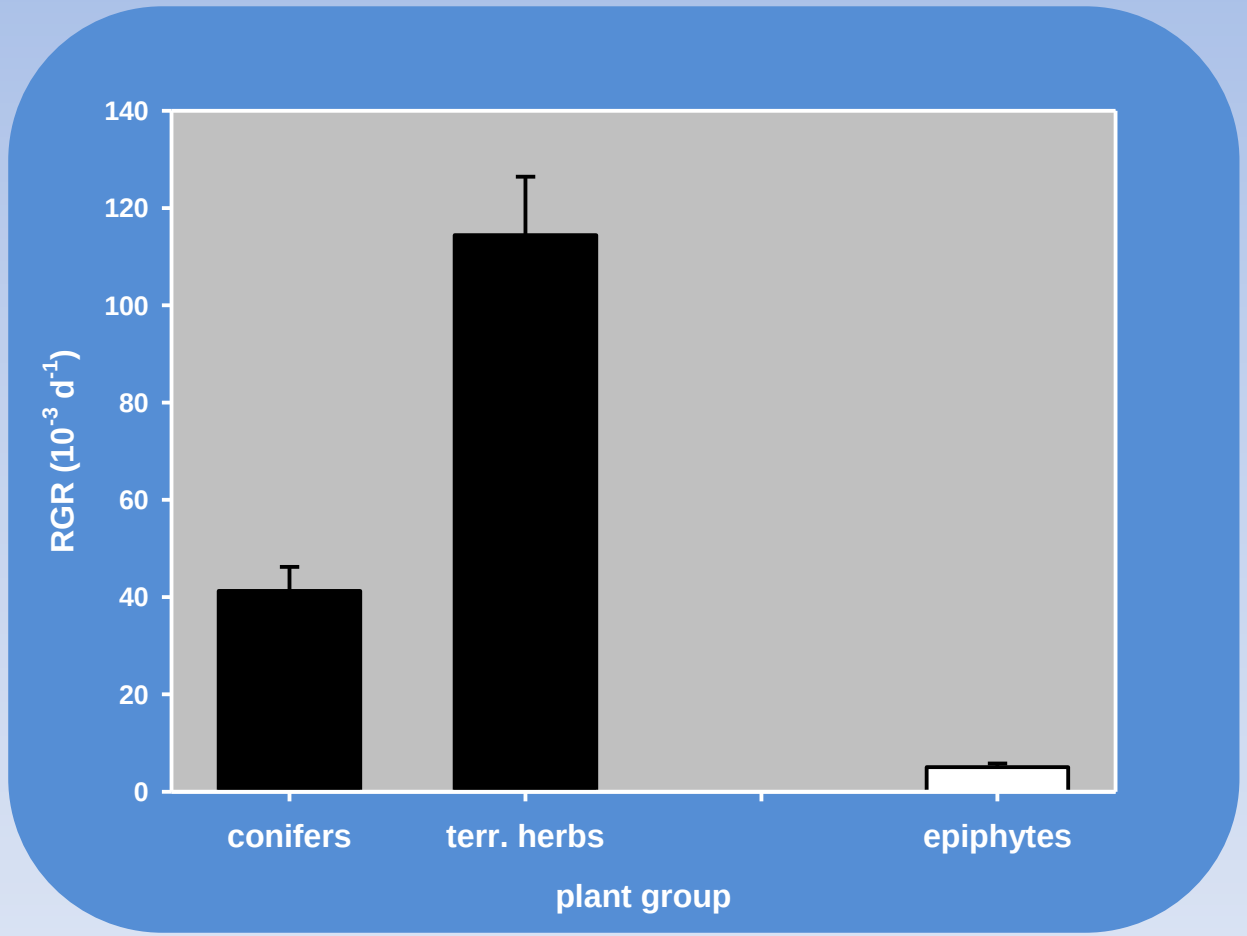
Growth

extremely slow

avg. juvenile period

Terrestrial herbs
3.5 ± 3.1 years (n = 53)

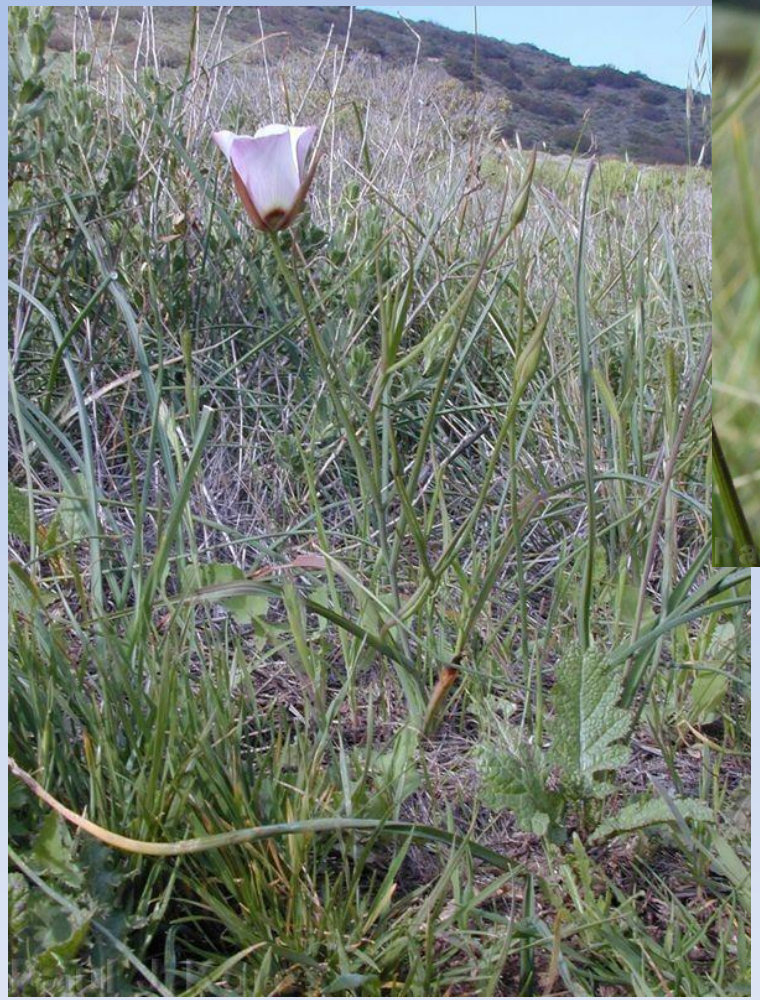
Epiphytic herbs
11 ± 3.5 years (n = 14)



Data from many sources

Growth

extremely slow



Even under cultivation, *Calochortus* needs about 5 years to reach maturity, about a decade under field conditions

Data from Moles et al 2004

Growth

extremely slow

Werauhia needs, on average, 5 years to reach 3-4 cm in size in the field, than another 10 years to reach maturity

Zotz et al 2005

Population biology

"tree-like"

		Stage at time t					
Stage at t+1	A1	A2	T1	T2	T3	T4	T5
A1 (atmospherics < 2cm)	51	1					19.4
A2 (atmospherics ≥ 2cm)	28	52					
T1 (tanks < 5cm)							
T2 (tanks 5 - 10cr							
T3 (tanks 10 - 20cm)			1	32	47	2	2
T4 (tanks 20 - 40cm)				1	30	60	1
T5 (tanks ≥ 40cm)					1	21	85
Mortality	20	27	26	19	20	18	11

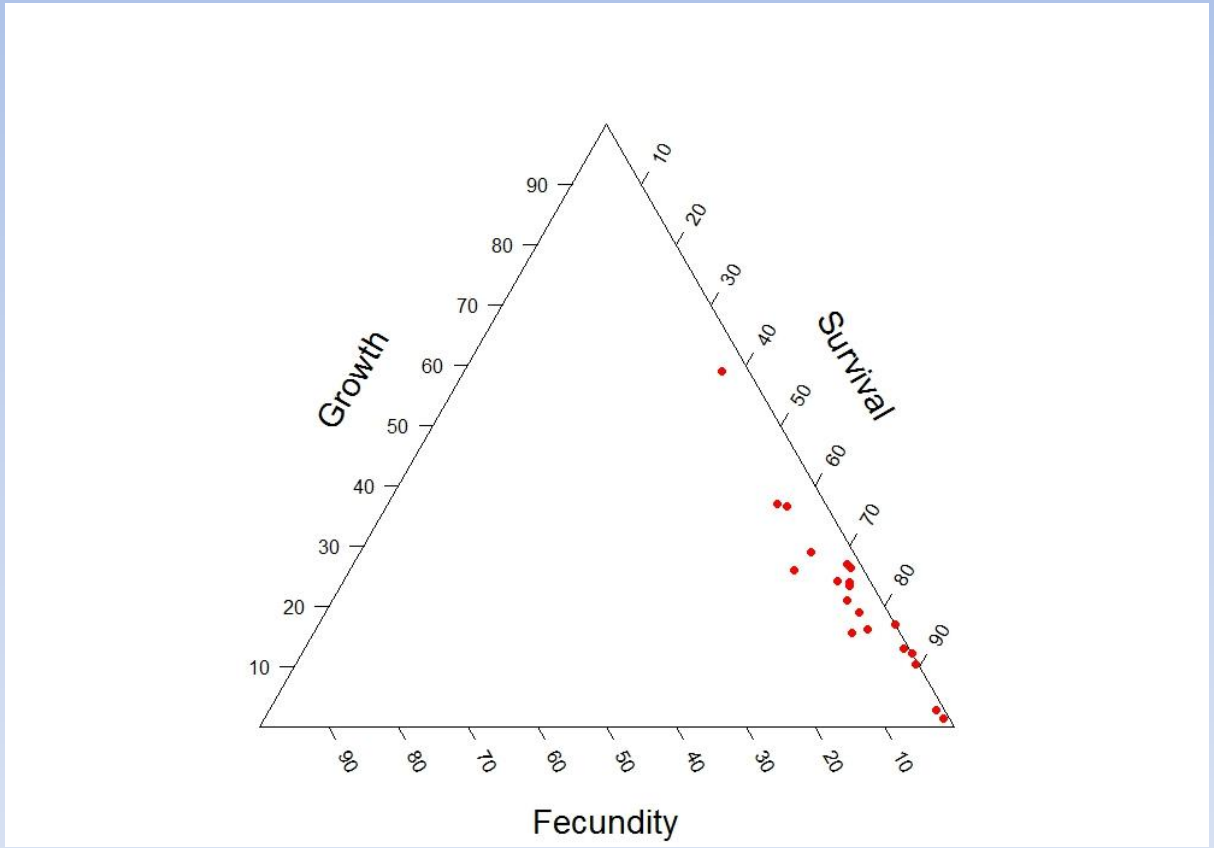
Elasticity Analysis

Growth + Survival + Fecundity = 1

Growth **Survival** **Fecundity**

Population biology

Comparison with other life forms

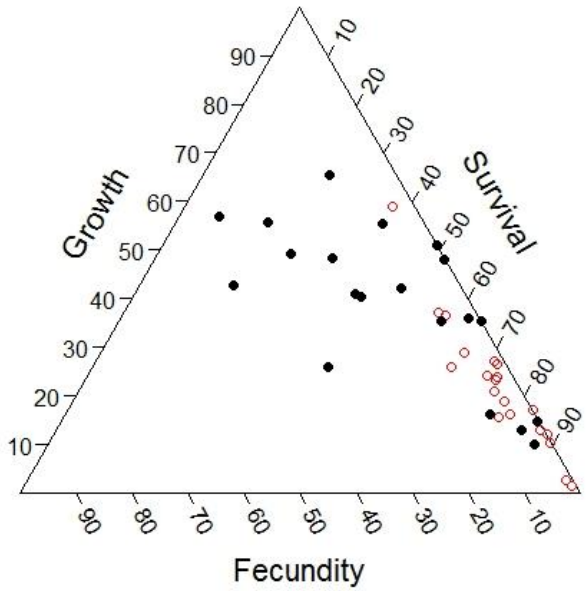


Multiple sources

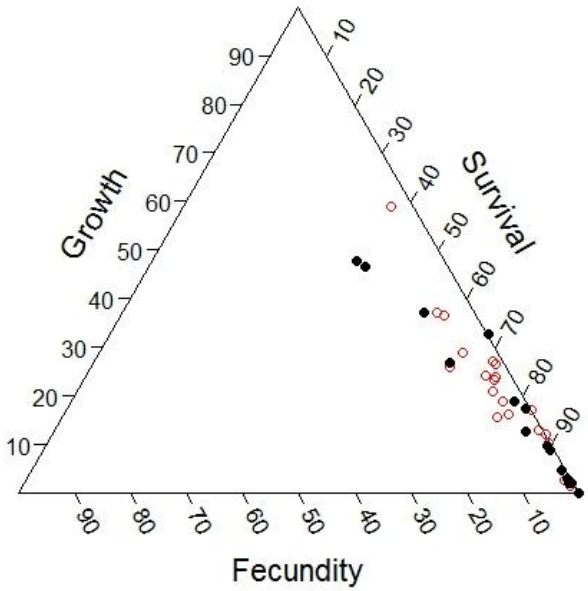
Population biology

“tree-like“

perennial herbs



trees



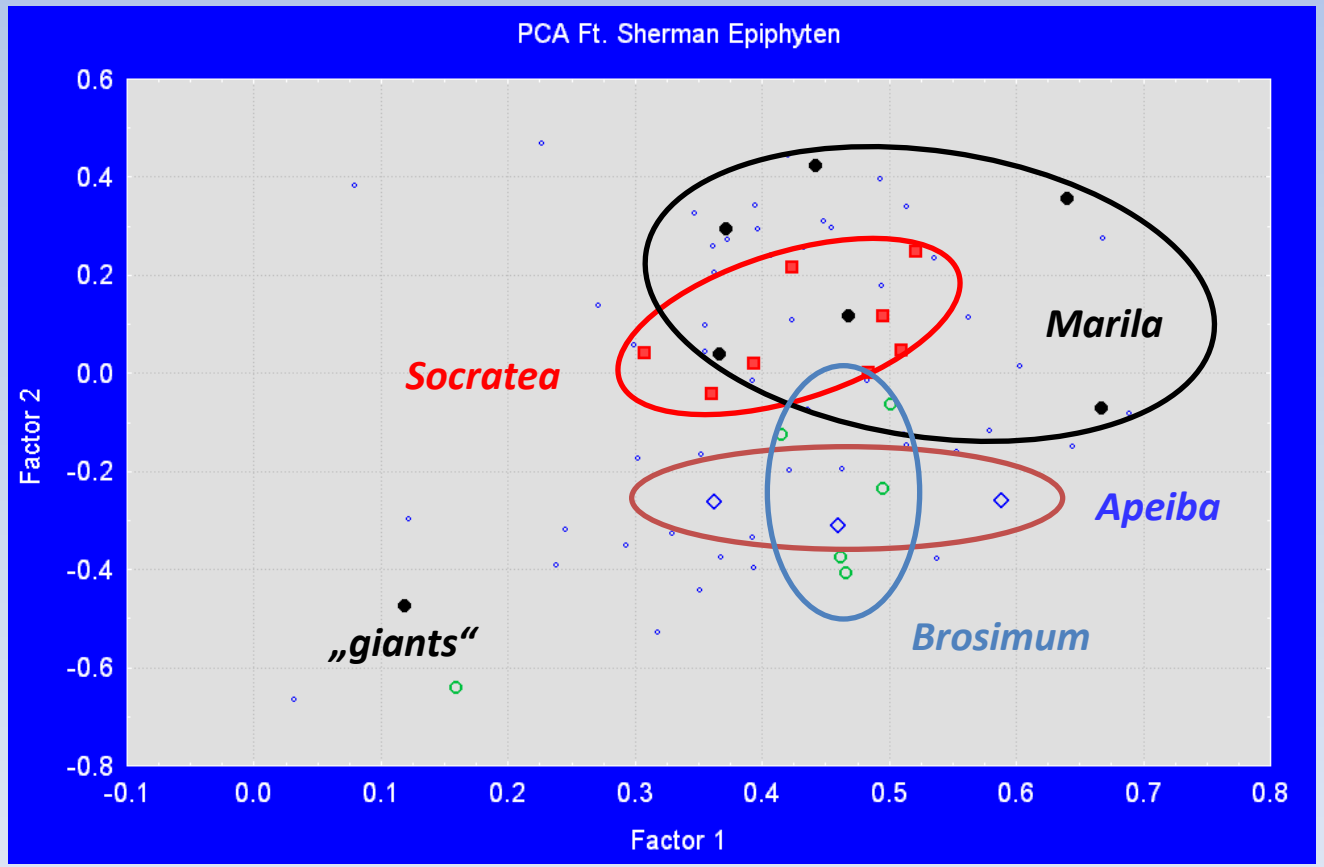
based on Silvertown et al 1993

Community assembly & dynamics

- Interaction with host tree
- Vertical gradient in environmental conditions (β-diversity)
- Succession (really common?)
- Niche vs. dispersal assembly

Community assembly

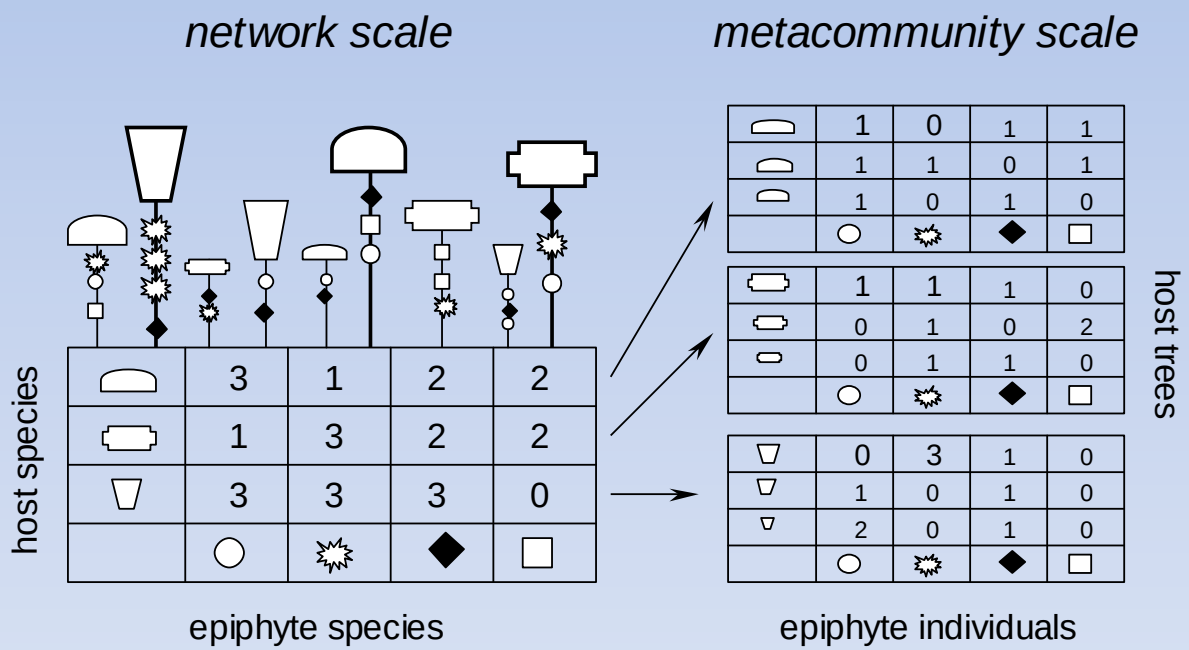
- Interaction with host tree (ordinations)



Zotz 2008

Community assembly

- Interaction with host tree (network analysis)



Burns & Zotz 2010

Community assembly

- Interaction with host tree (network analysis)

A) Clumped distributions at both scales -> dispersal limitation!

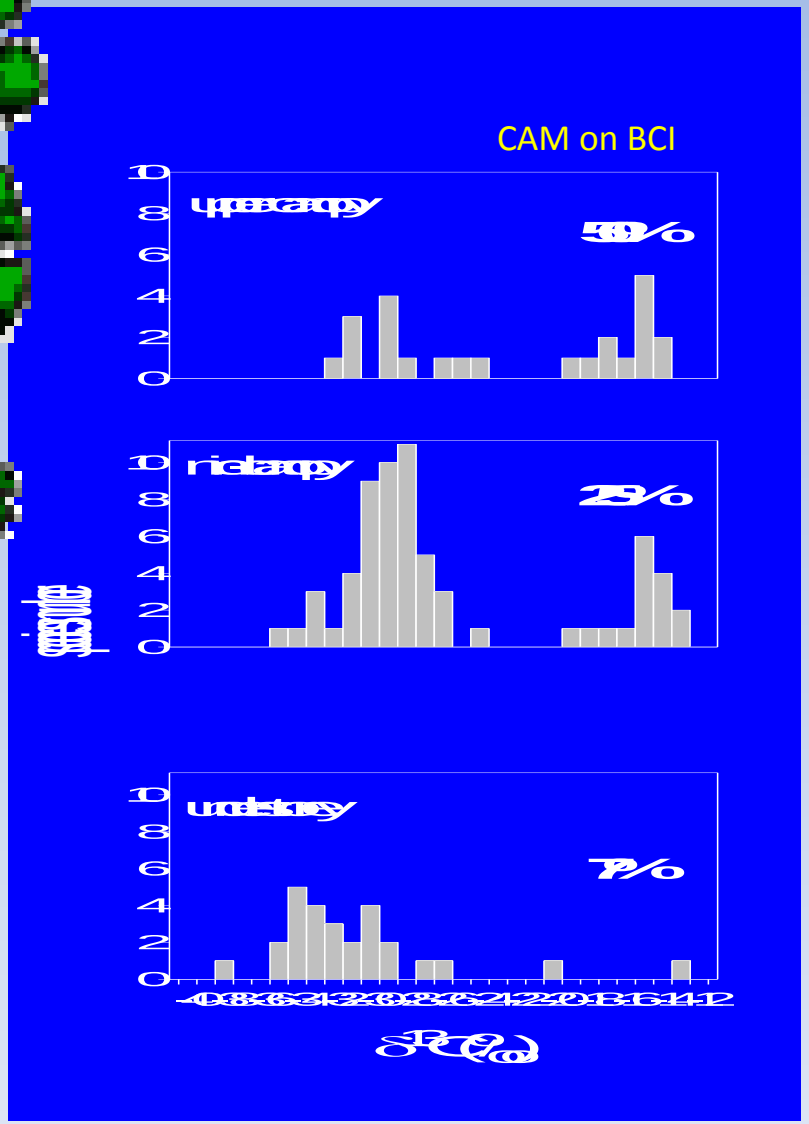
B) Mechanisms are scale-dependent!

1. Negative co-occurrence patterns - Epiphyte species tend to interact preferentially with different host tree species (**evolutionary time scale)**

2. Generally no negative co-occurrence - Epiphyte assemblages on the individuals of a tree species show little evidence for negative co-occurrence **(ecological time scale)**

Burns & Zotz 2010

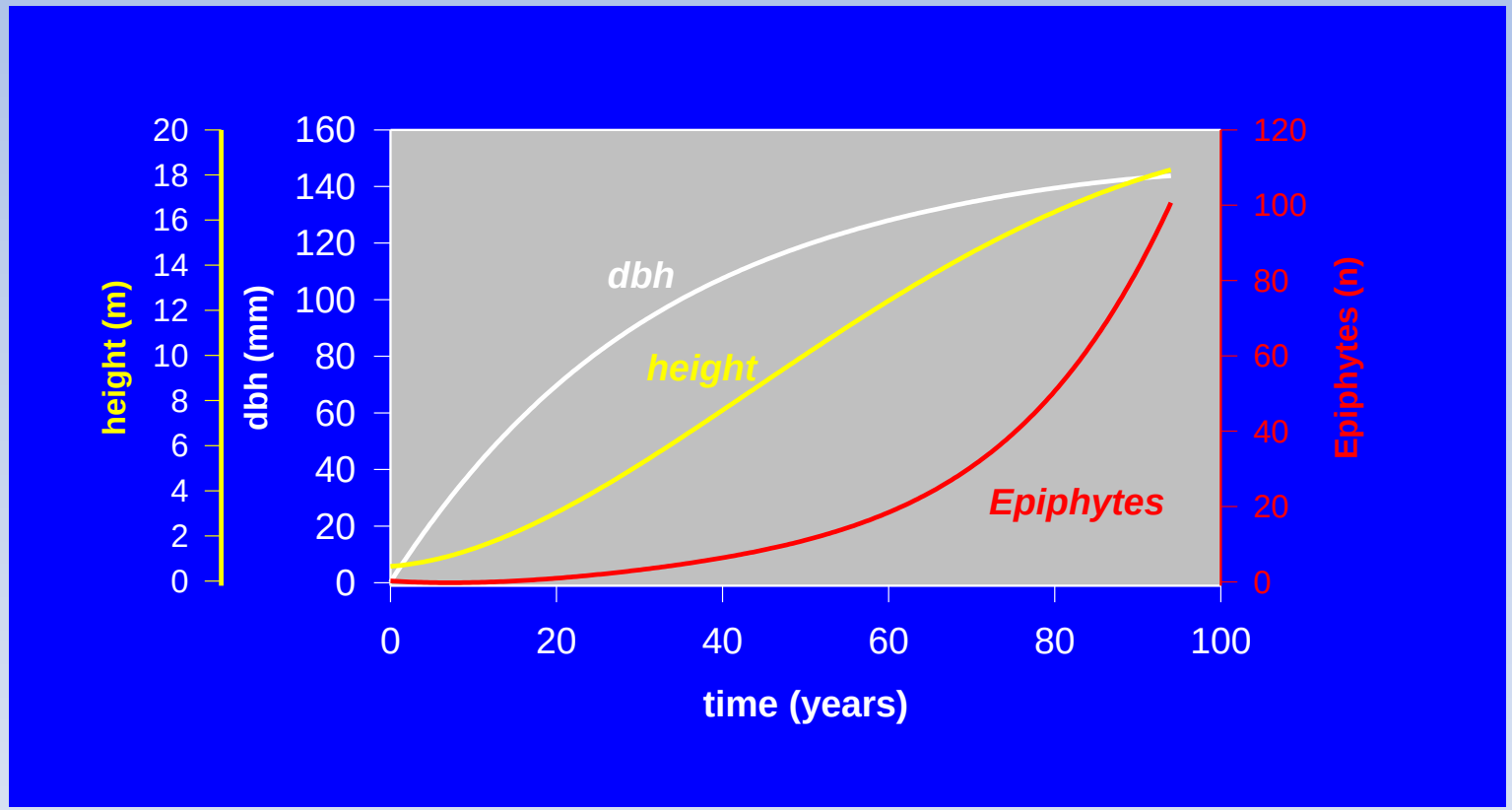
Community assembly - functional traits



Zotz & Ziegler 1998

Community dynamics

1. the individual tree



Zotz & Vollrath 2003

Community dynamics

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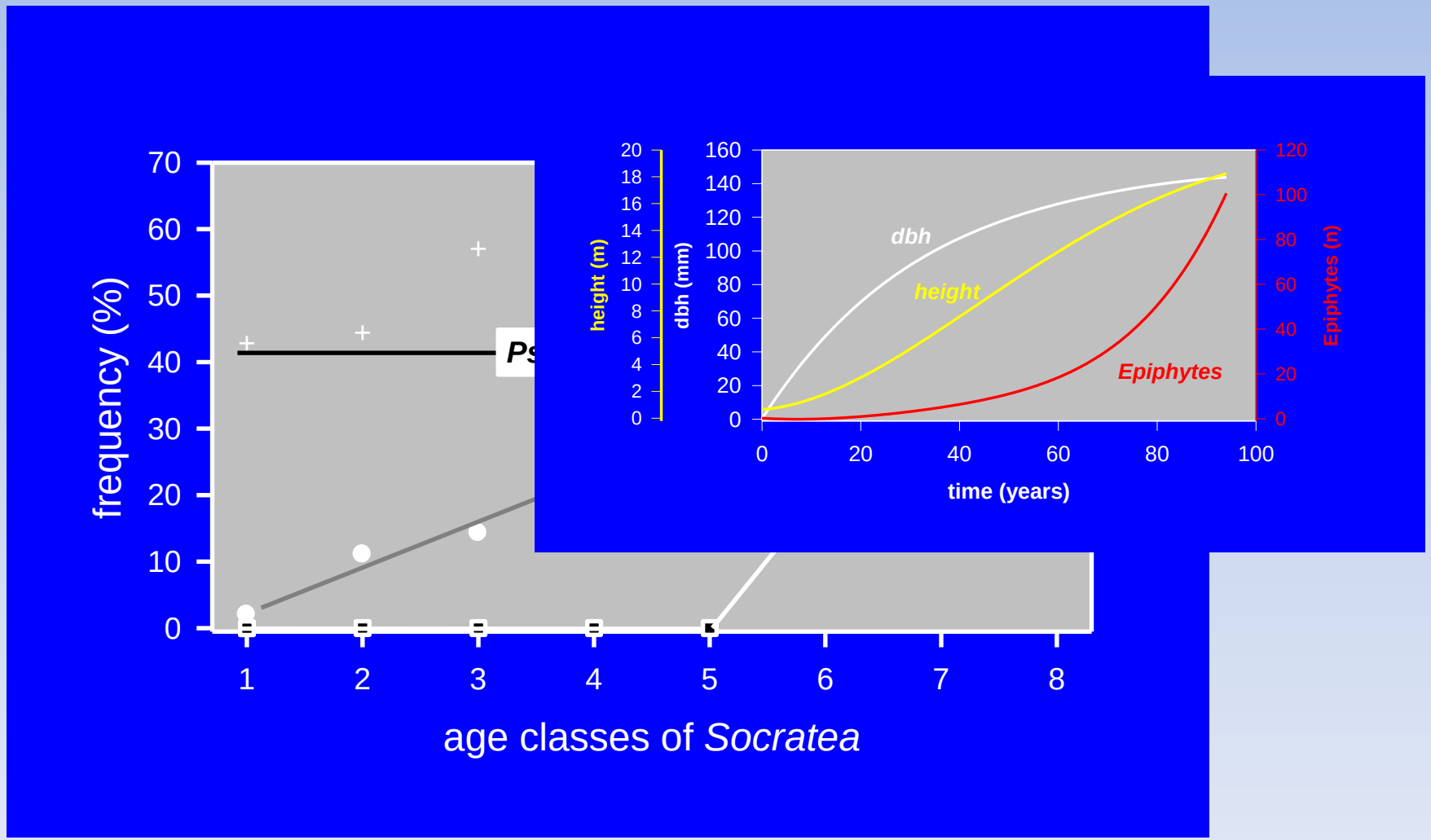
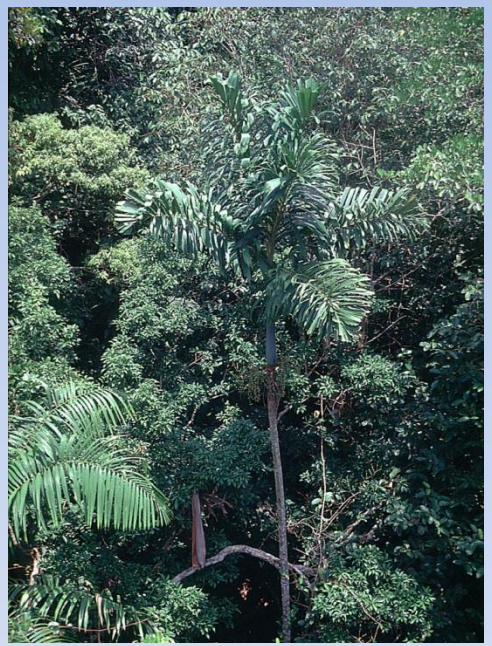
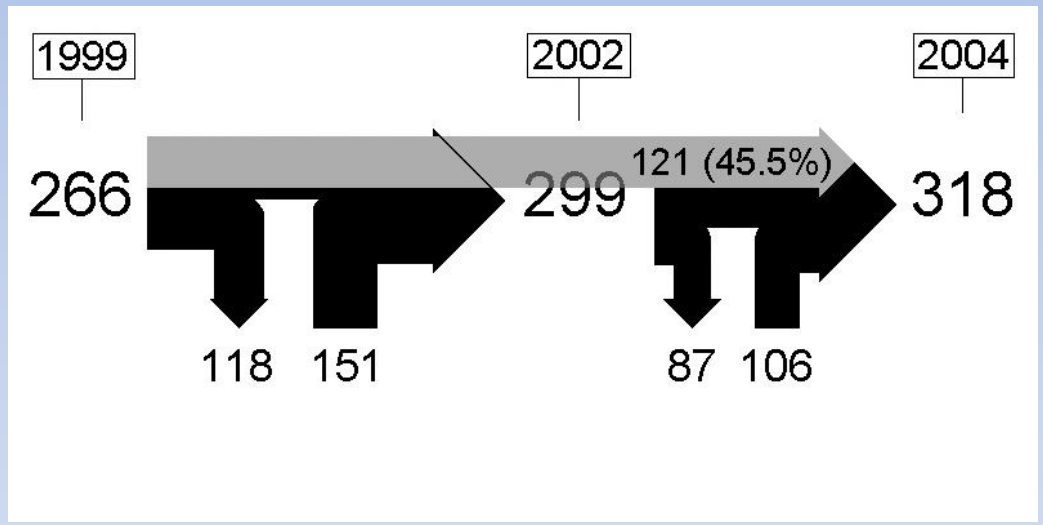


Zotz & Vollrath 2003

Community dynamics

2. the community – species numbers



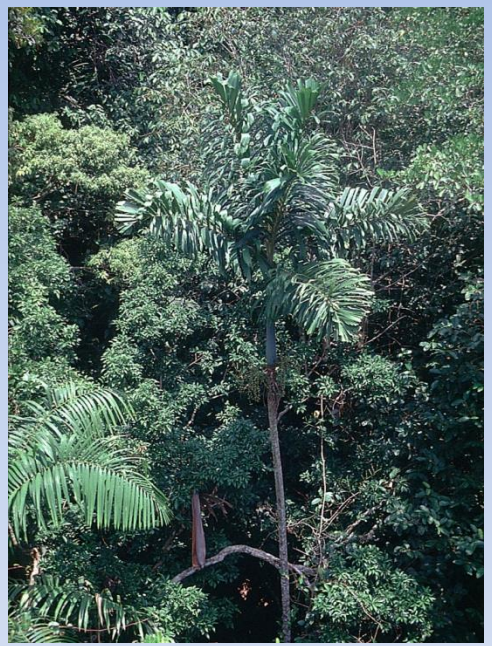


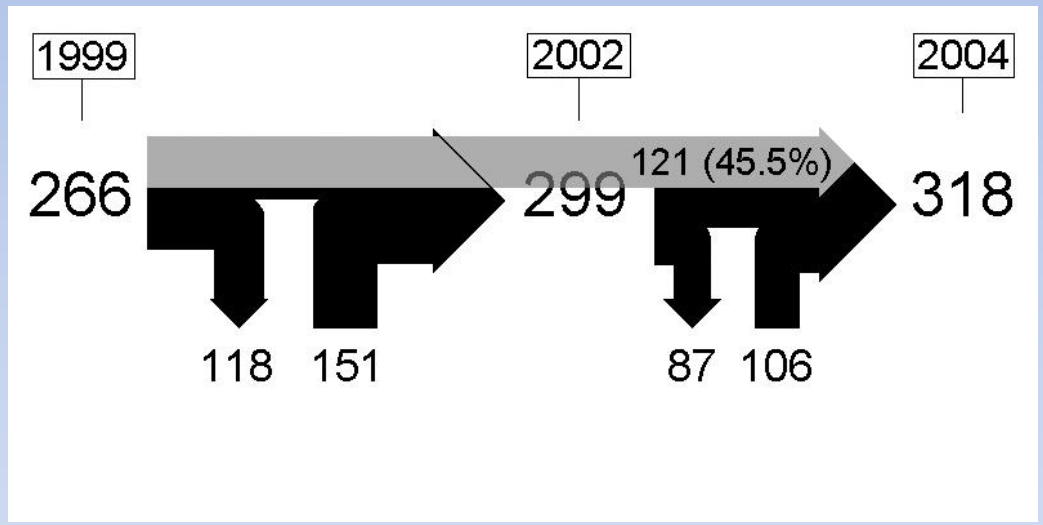
„giants“

Laube & Zotz 2006

Community dynamics

2. the community – species composition





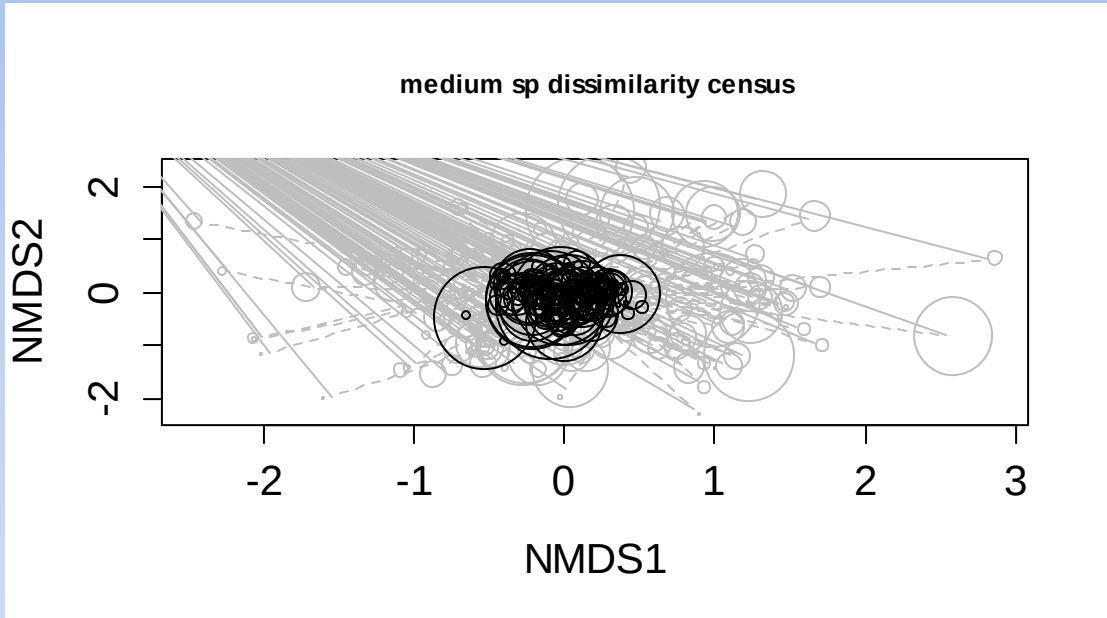
Epiphyte assemblages on individual palms vary a lot with time, while the assemblage on all palms becomes increasingly similar…

(based on Chao-Sørensen similarity index)

Laube & Zotz 2006

Community dynamics

2. the community – species composition

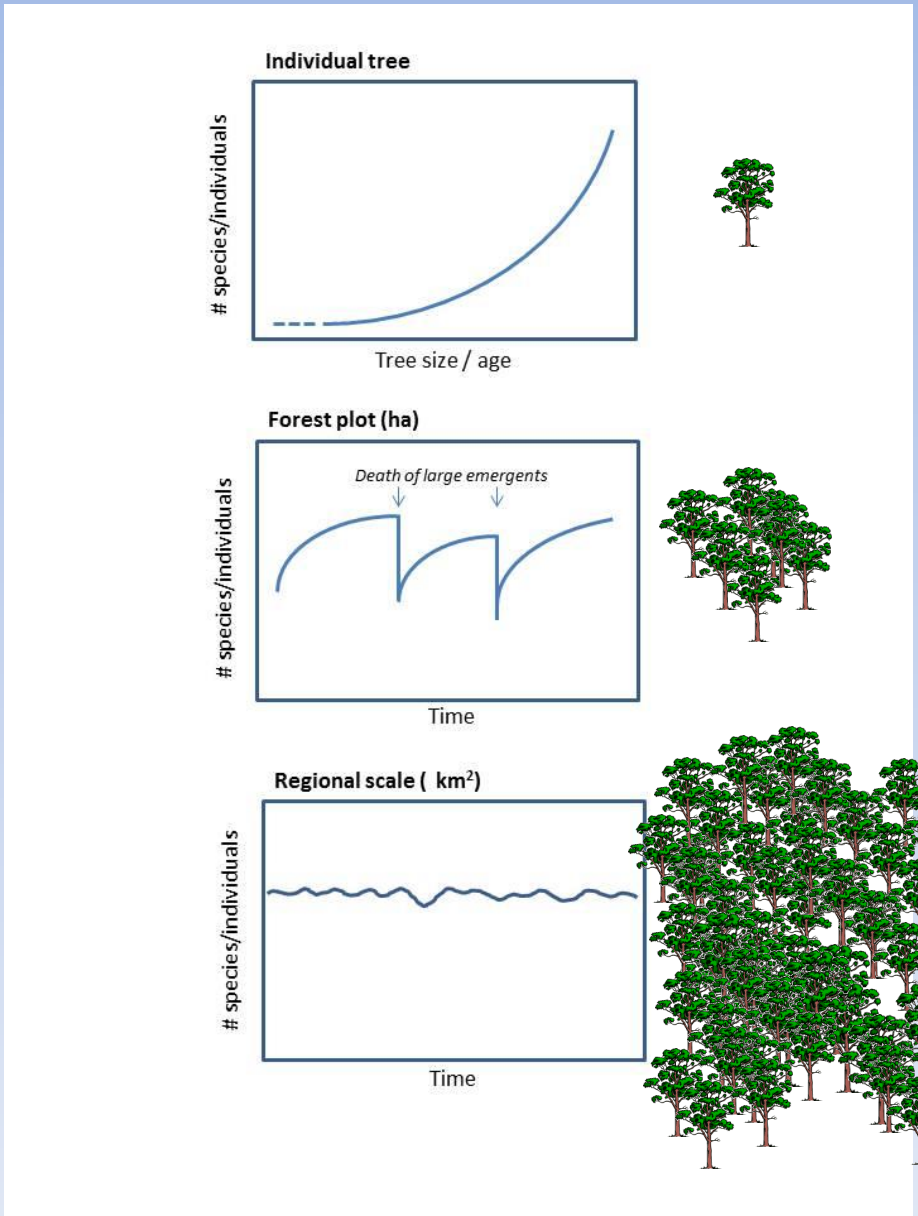


Census data from San Lorenzo plot, Panama, from 2002 and 2012

Mendieta et al unpubl.

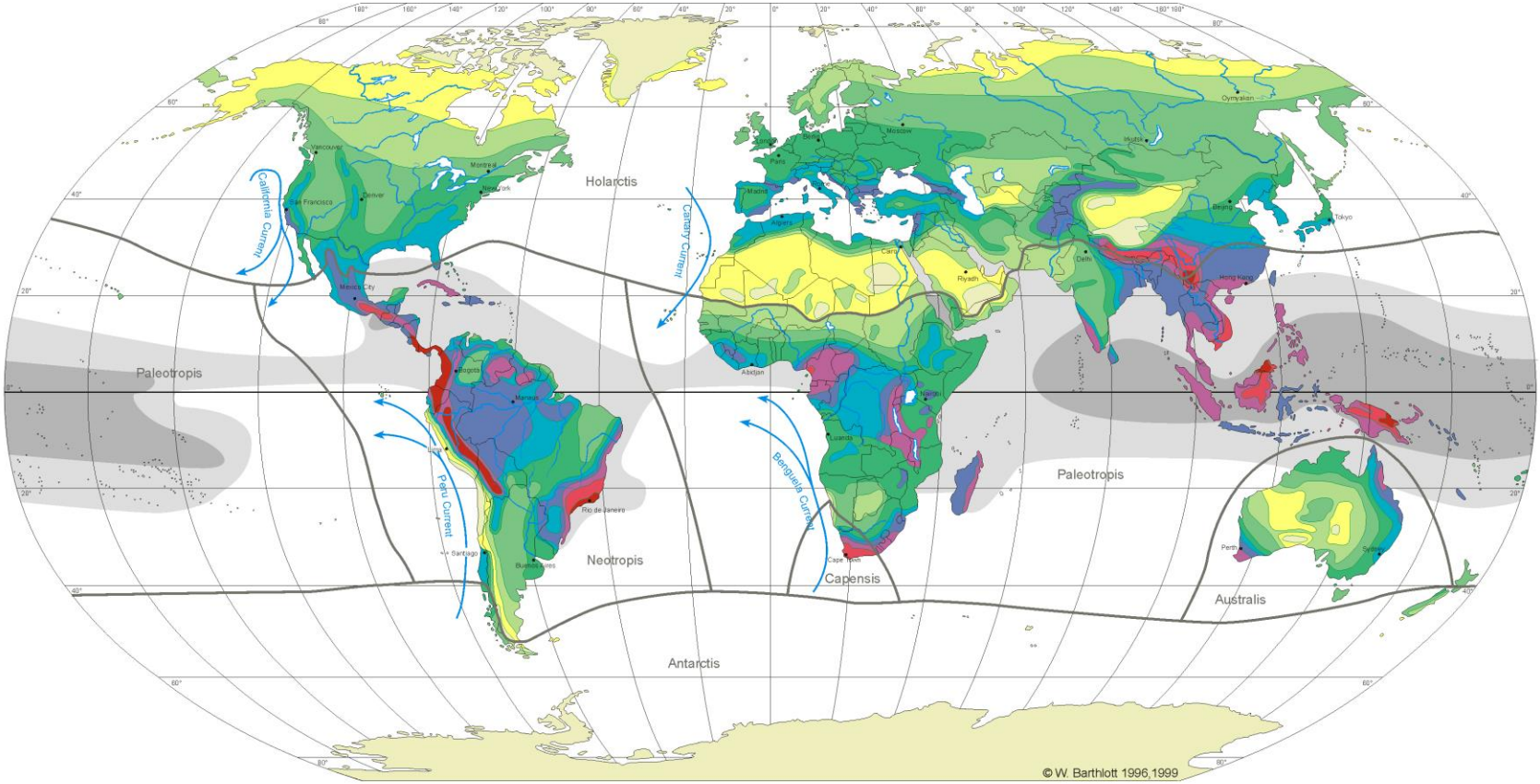
Community dynamics

3. Dynamics at different scales



Epiphytes - a global view

GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS



Robinson Projection
Standard Parallels 38°N und 38°S

Diversity Zones (DZ): Number of species per 10 000km²

- DZ 1 (<100)
- DZ 2 (100 - 200)
- DZ 3 (200 - 500)
- DZ 4 (500 - 1000)
- DZ 5 (1000 - 1500)
- DZ 6 (1500 - 2000)
- DZ 7 (2000 - 3000)
- DZ 8 (3000 - 4000)
- DZ 9 (4000 - 5000)
- DZ 10 (≥ 5000)

Capensis floristic regions

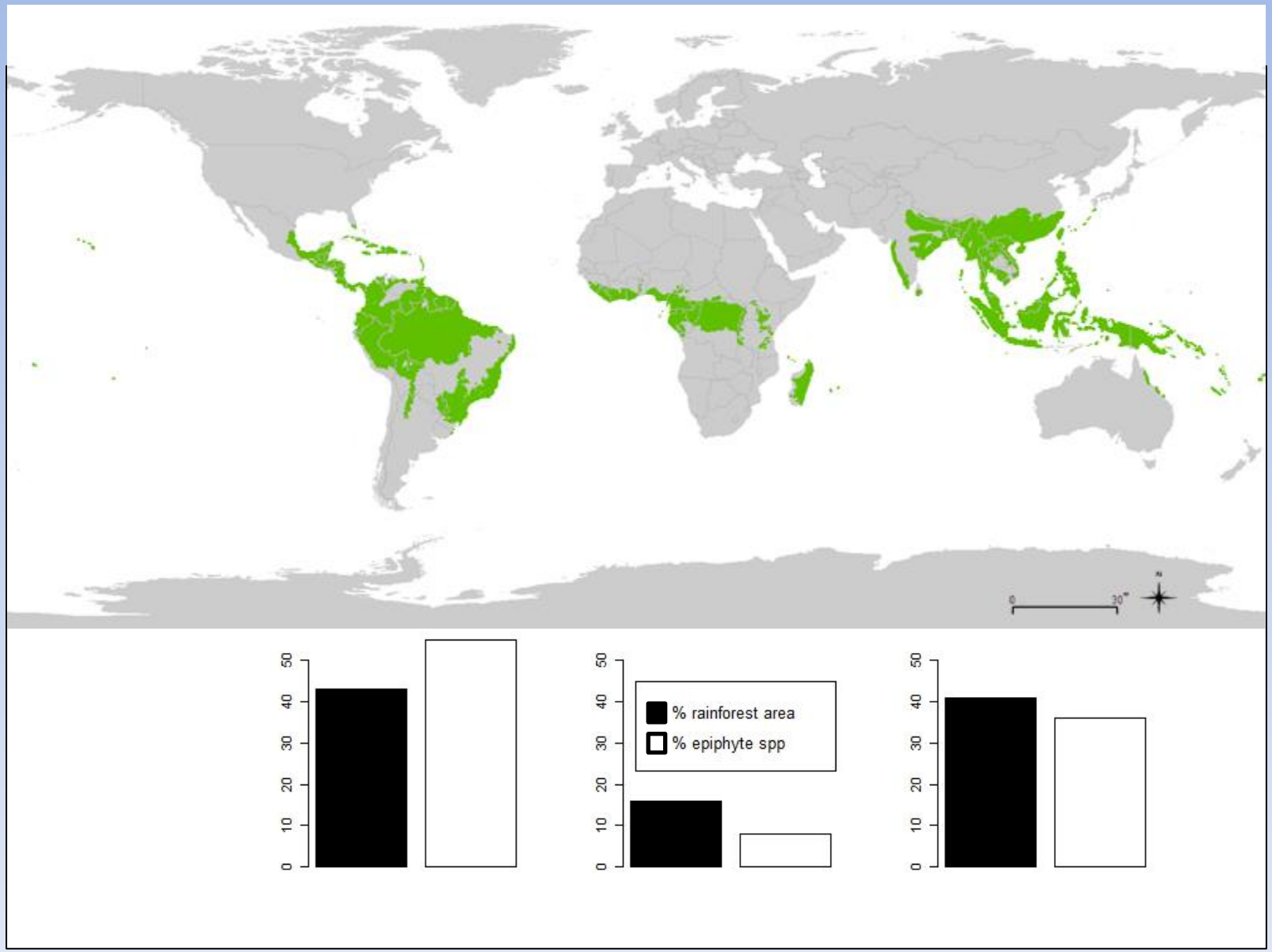
sea surface temperature

- >29°C
- >27°C

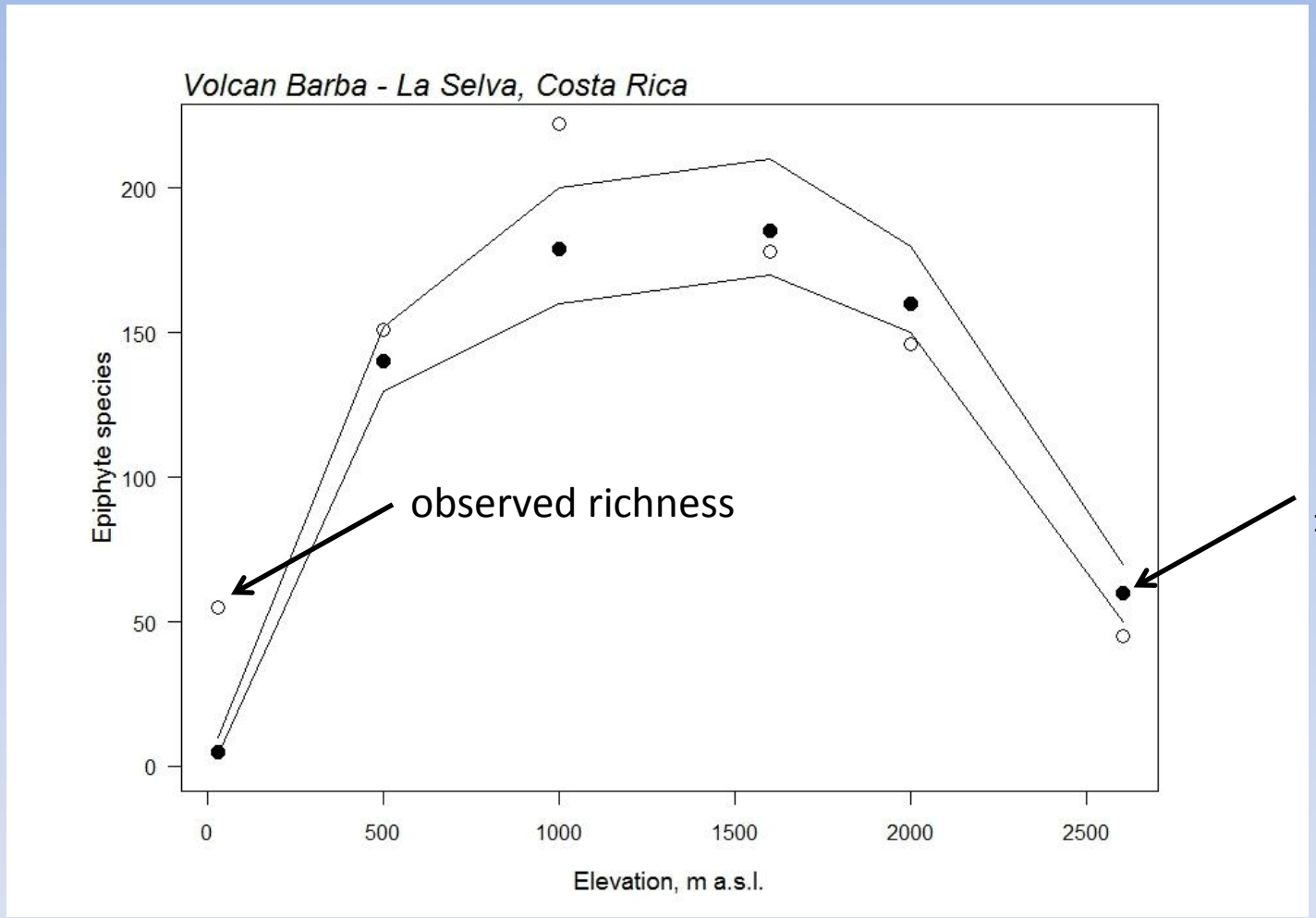
cold currents

W. Barthlott, N. Biedinger, G. Braun, F. Feig, G.Kier, W. Lauer & J. Mutke 1999
modified after
W. Barthlott, W. Lauer & A. Placke1996
Department of Botany and Geography
University of Bonn
German Aerospace Research Establishment, Cologne
Cartography: M. Gref
Department of Geography University of Bonn

Continental Trends

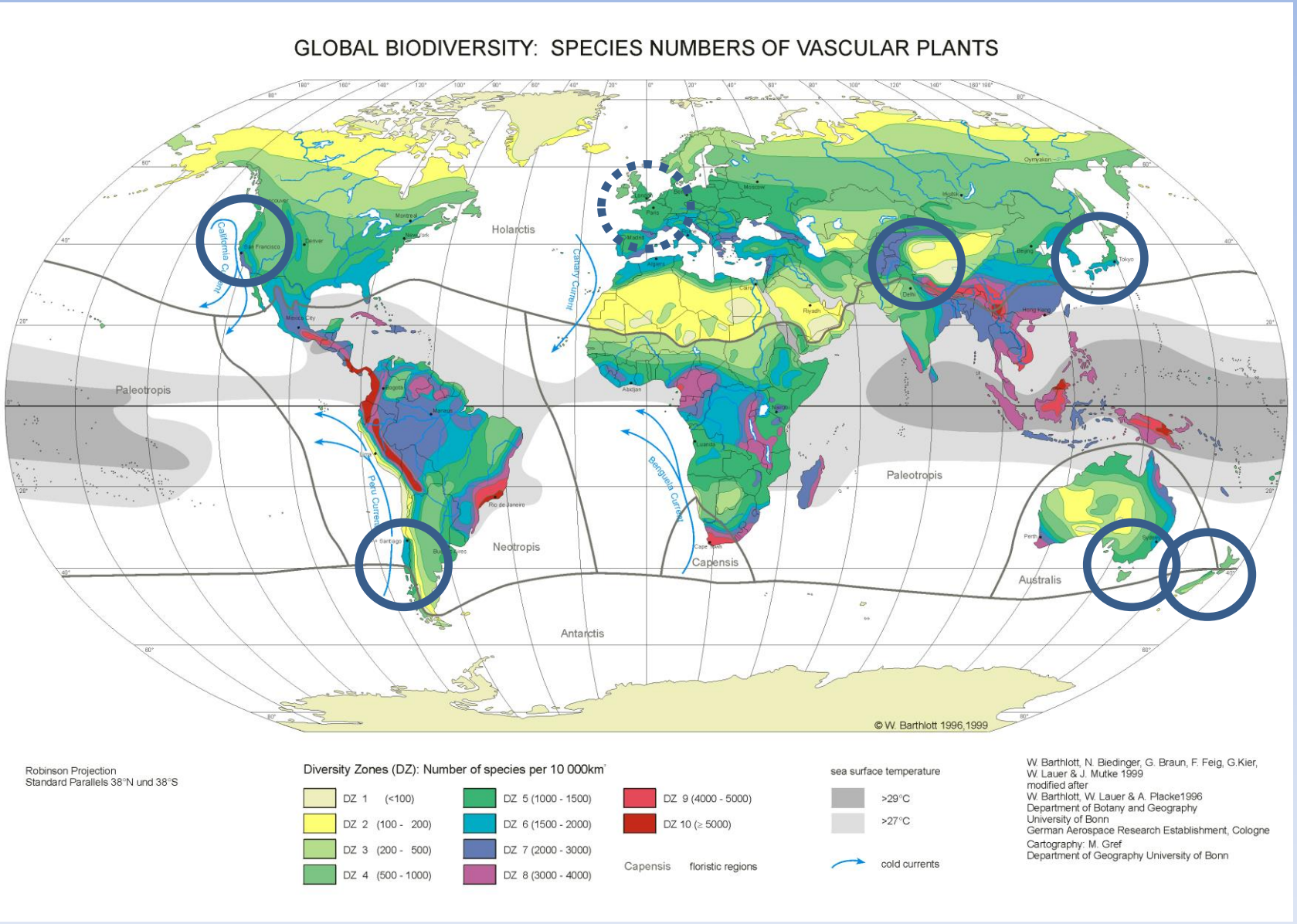


Elevational Trends



Cardelus et al 2006

Latitudinal Trends



Epiphytes

a critical review of concepts, facts and assumptions

Basics	still struggling with definitions
Taxonomy	research opportunities in a variety of taxa unexplored
Physiology	some taxa well studied – others terra incognita
Continental trends	no recent numbers – mechanism unclear
Elevational trends	pattern well-established – mechanism unclear
Latitudinal trends	pattern well-established – mechanism unclear

Epiphytes

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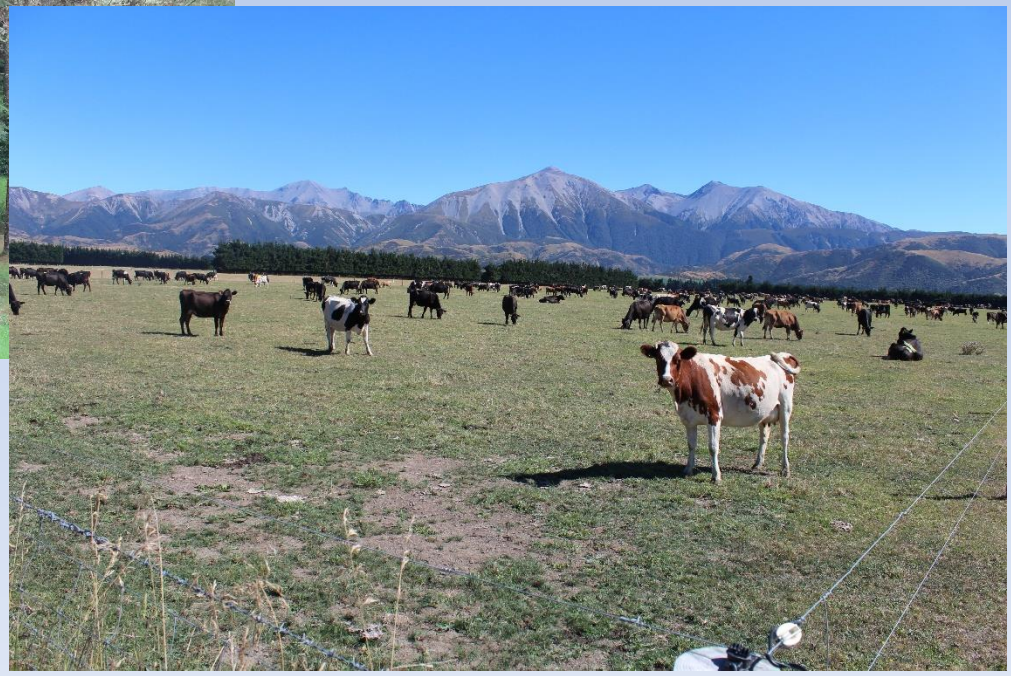
Latitudinal trends	pattern well-established – mechanism unclear

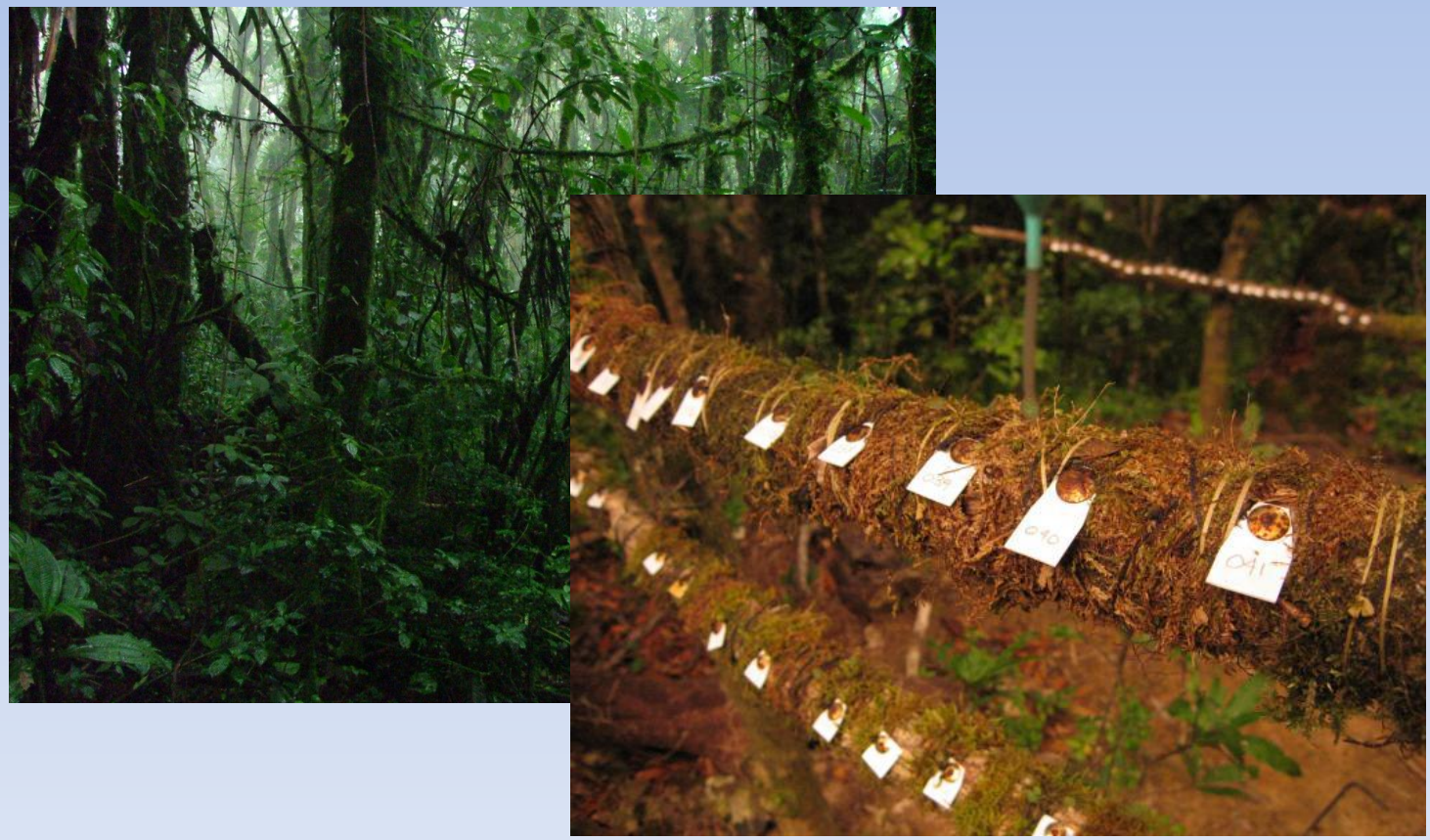
Conservation – anything special?

Epiphytes …
“particularly vulnerable“?

Epiphytes …
“particularly vulnerable“?



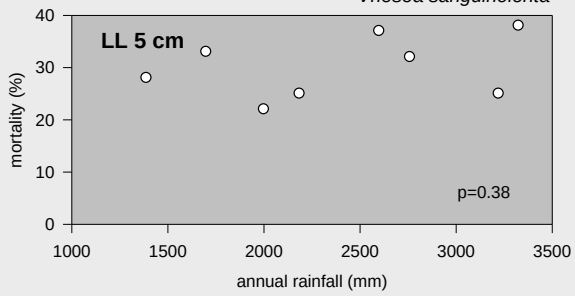
Epiphytes in wet forests

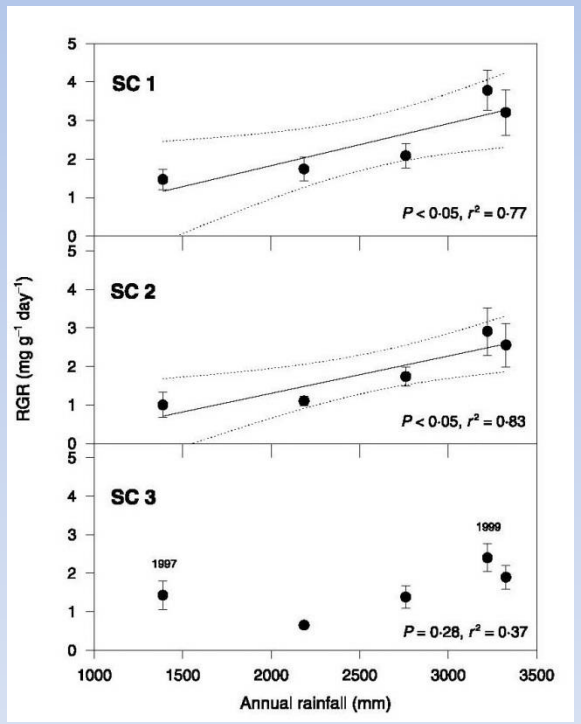


K. Masters, unpublished

Epiphytes in seasonal forests

Vriesea sanguinolenta





Zotz et al, 2006

… there may be other options

EpiNet -

Vascular epiphytes in the temperate zones

Opera | NutNet Home | Nutrie... | Web | www.nutnet.umn.edu | hillebrand nutrients

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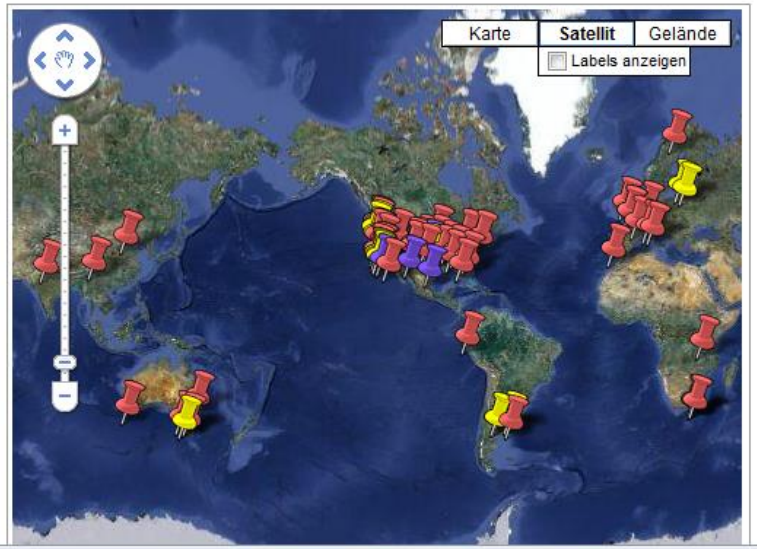
- Authorship Guidelines
- Protocols & Templates
- Data
- Participating Sites
- Annual Meetings
- Education-Outreach-Jobs

NutNet Home

Welcome to the Nutrient Network!

NutNet sites



Latest Publications

Lind, E.M. et al. 2013. Life history constraints in grassland plant species: a growth-defence trade-off is the norm. *Ecology Letters.*

O'Halloran L.R. et al. 2013. Regional Contingencies in the Relationship between Aboveground Biomass and Litter in the World's Grasslands. *PLoS ONE*

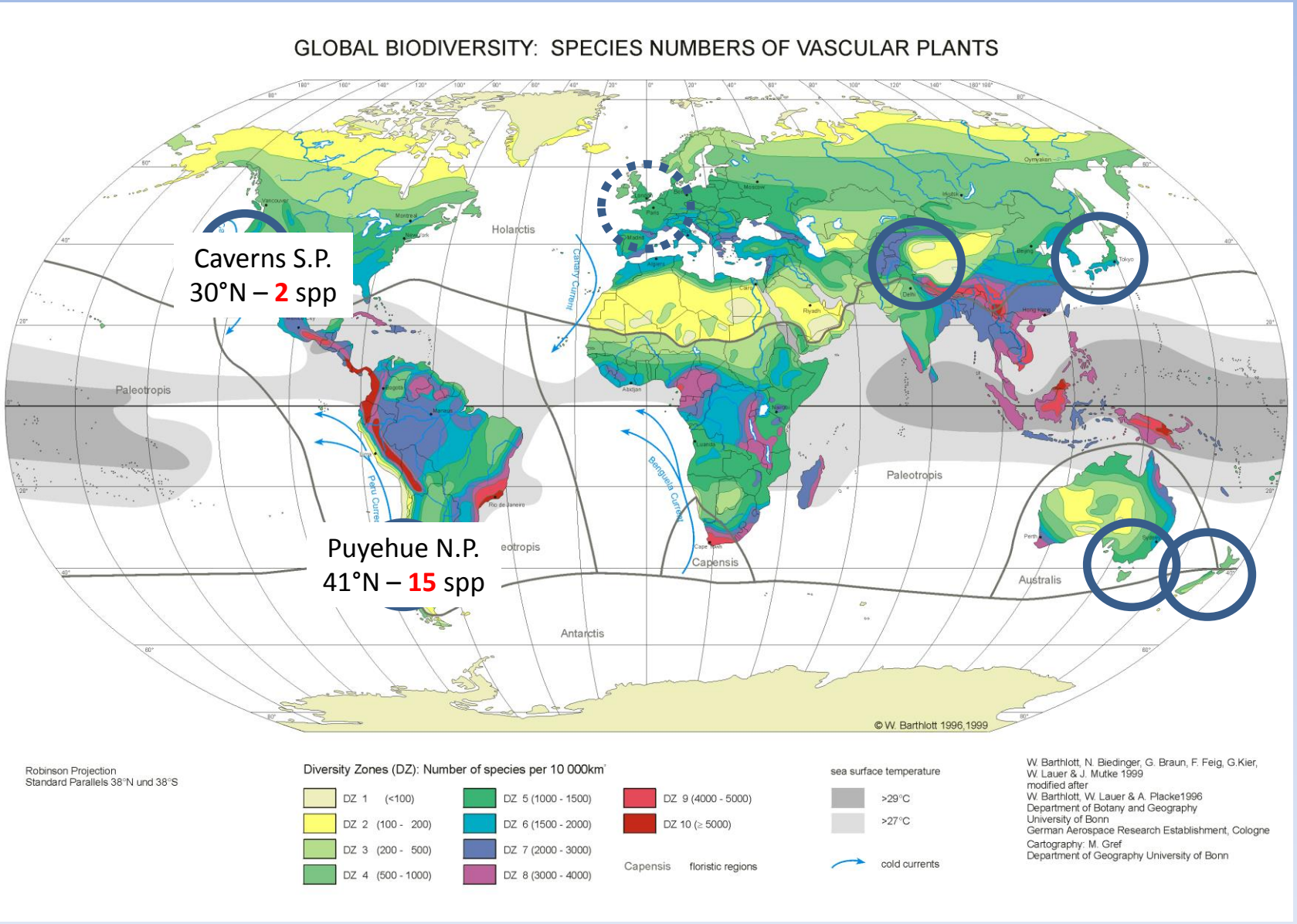
See all of the NutNet Publications to date.

NutNet News

Elizabeth Borer will present on the Nutrient Network in a symposium at the upcoming

DE 10:
21.02.

Latitudinal Trends



The latitudinal gradient

Possible explanations

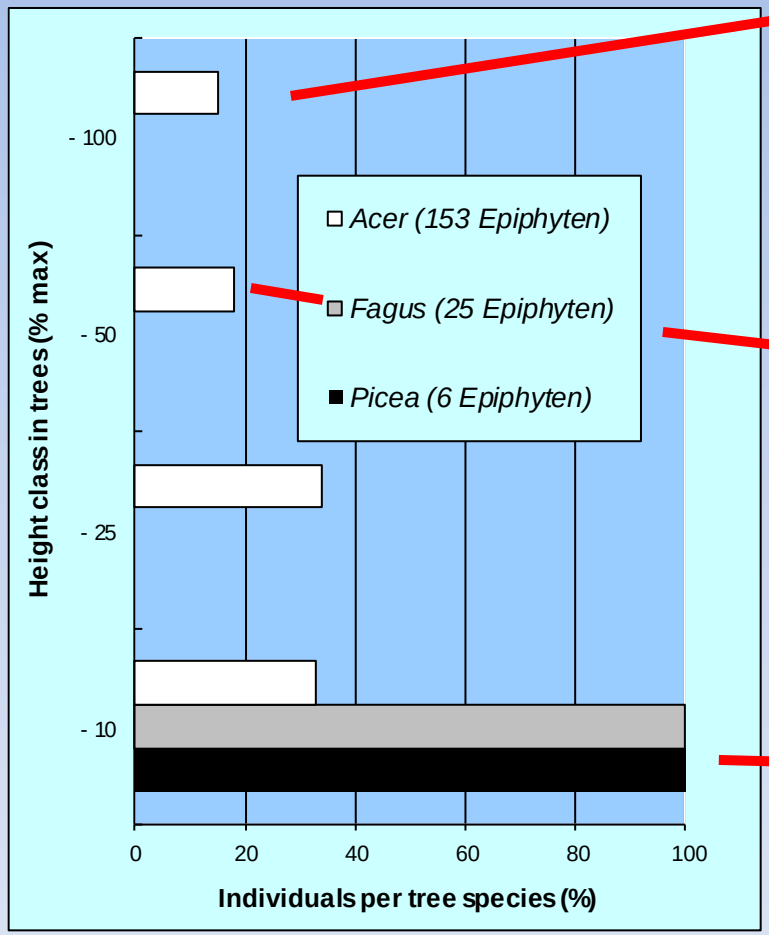
- Frost
- Low moisture
- Host tree characteristics
- History (glaciations)
- Geography (distance to current source regions)

The latitudinal gradient

Polypodium vulgare in central Europe

The latitudinal gradient

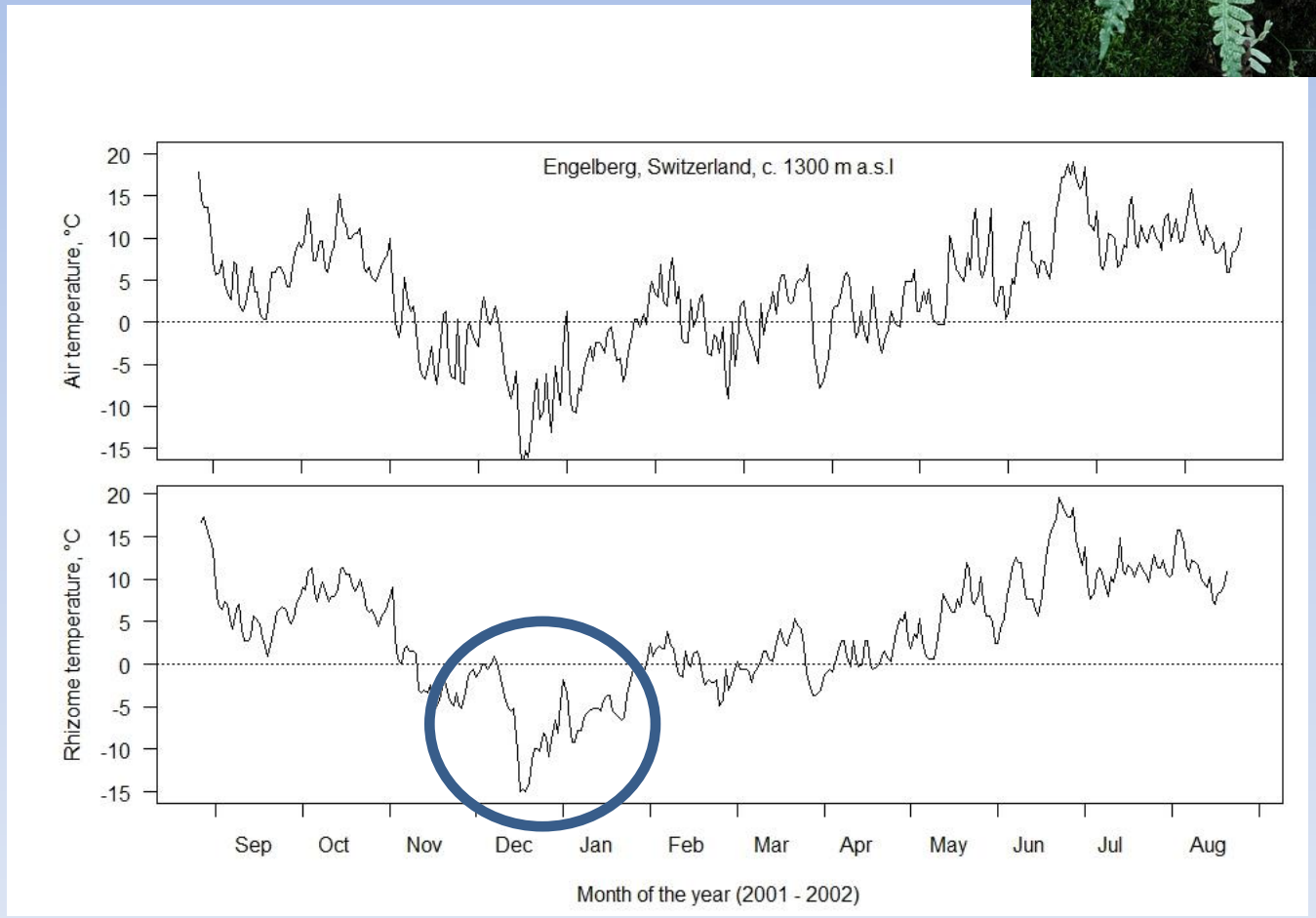
Polypodium vulgare in central Europe



20 species /184 Individuals in 45 trees (dbh >30cm)

The latitudinal gradient

Polypodium vulgare in central Europe



The latitudinal gradient and global change

Tillandsia usneoides

The latitudinal gradient

Epiphytes in the temperate zones - drought

EpiNet

… some ideas

Occurrence of frost / drought (global data logger campaign both in the temperate zones and altitudinally in the tropics)

Climate envelopes and modelling → John´s data base

Combine 1 and 2 with “simple” autecology

Demographic data (“How viable are populations within temperate epiphyte hotspots?”)

Community data (“base line data for community dynamics”

Global change – shifts towards the poles? (historical records? Current distributions at the range limits)

EpiNet

… more ideas

Host preference (“simple” systems may be more amenable to answer this question – e.g. because of better replication)

….
….

Accidental epiphytes: traits of common accidentals compared to the local flora at large