Macroecology

Large scale patterns of biodiversity

Macroecology - from pattern to process

Latitudinal Diversity Gradients

Species-Area Curves - ”z”

Species Abundance Distributions – niche apportionment models vs neutral theory

Body size distributions in animal communities – size spectra

Biodiversity is the biological variety and variability of life on Earth. Biodiversity is a measure of variation at the genetic, **species**, and ecosystem level

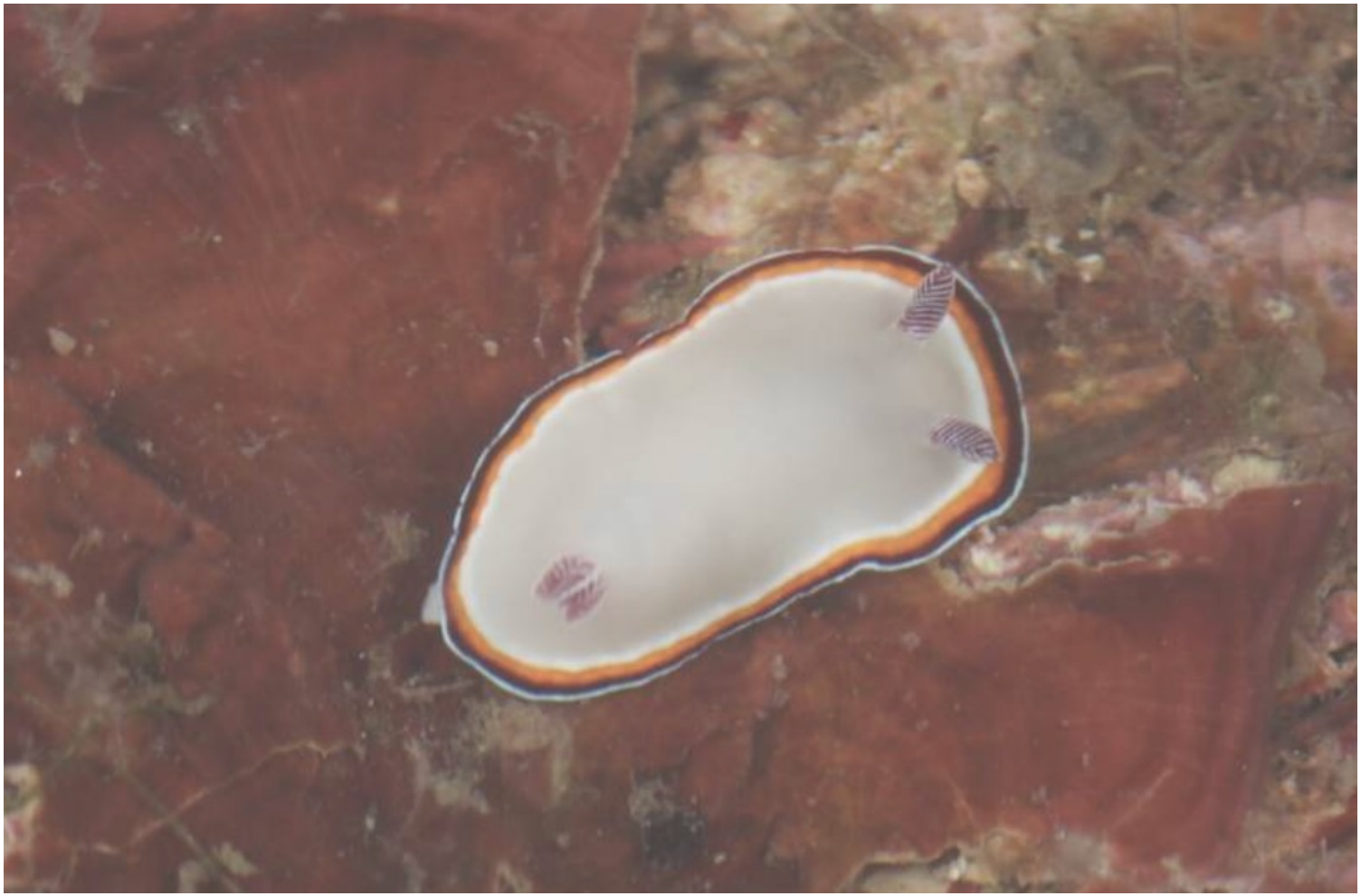
- United Nations Environment Program

Species richness – practical and related to other measures

- scale dependent

- sensitive to sampling intensity

2022- 146 new species described in scientific journals



Including 14 new-to-science sea slugs from the Indo-Pacific region
Goniobranchus fabulus – largest of the 14 at 1.5 cm…….

Species richness

# of species 3-100 million

ca **8.5 million** (Mora et al. 2011)

Scale

Local – alpha diversity

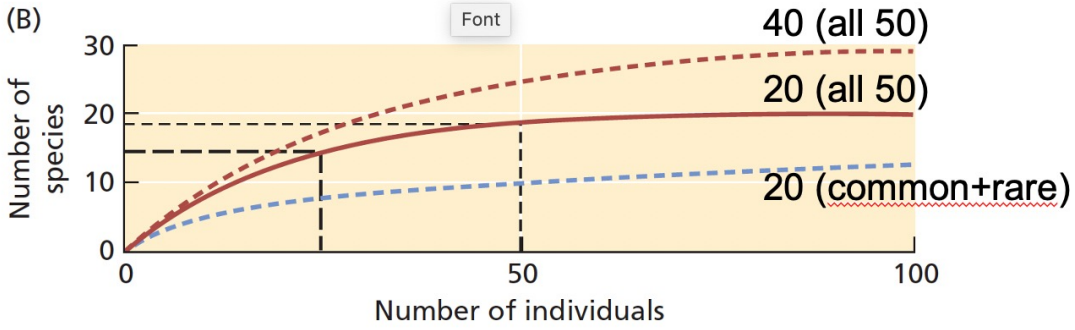
small area within which species likely to interact

Regional – gamma diversity

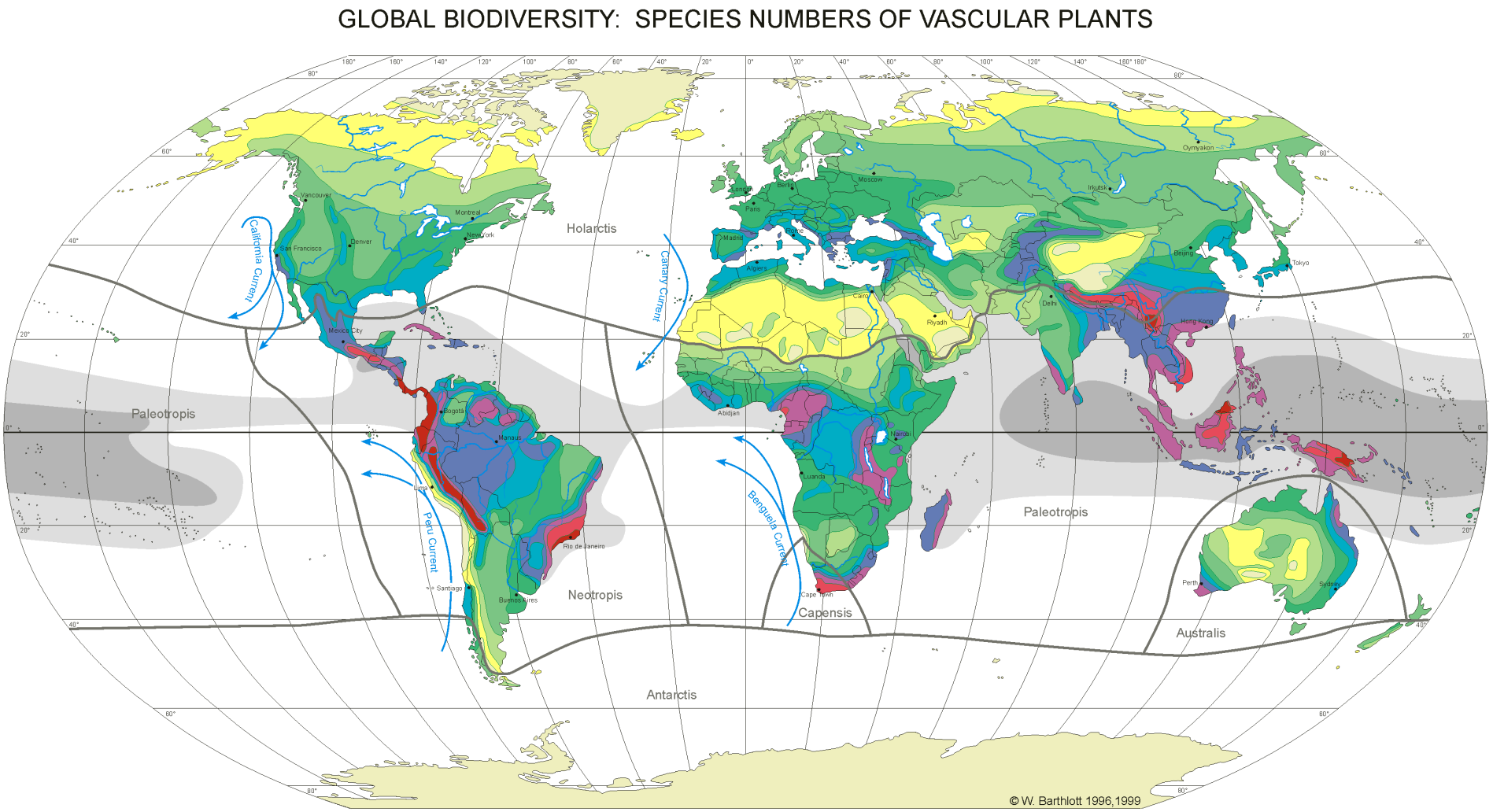
- large area within which speciation and extinction operate
- area that provides the pool of species that can over time colonize a local community

Sampling

"rarified" species richness



Where do we find the most species?
What patterns are there?



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

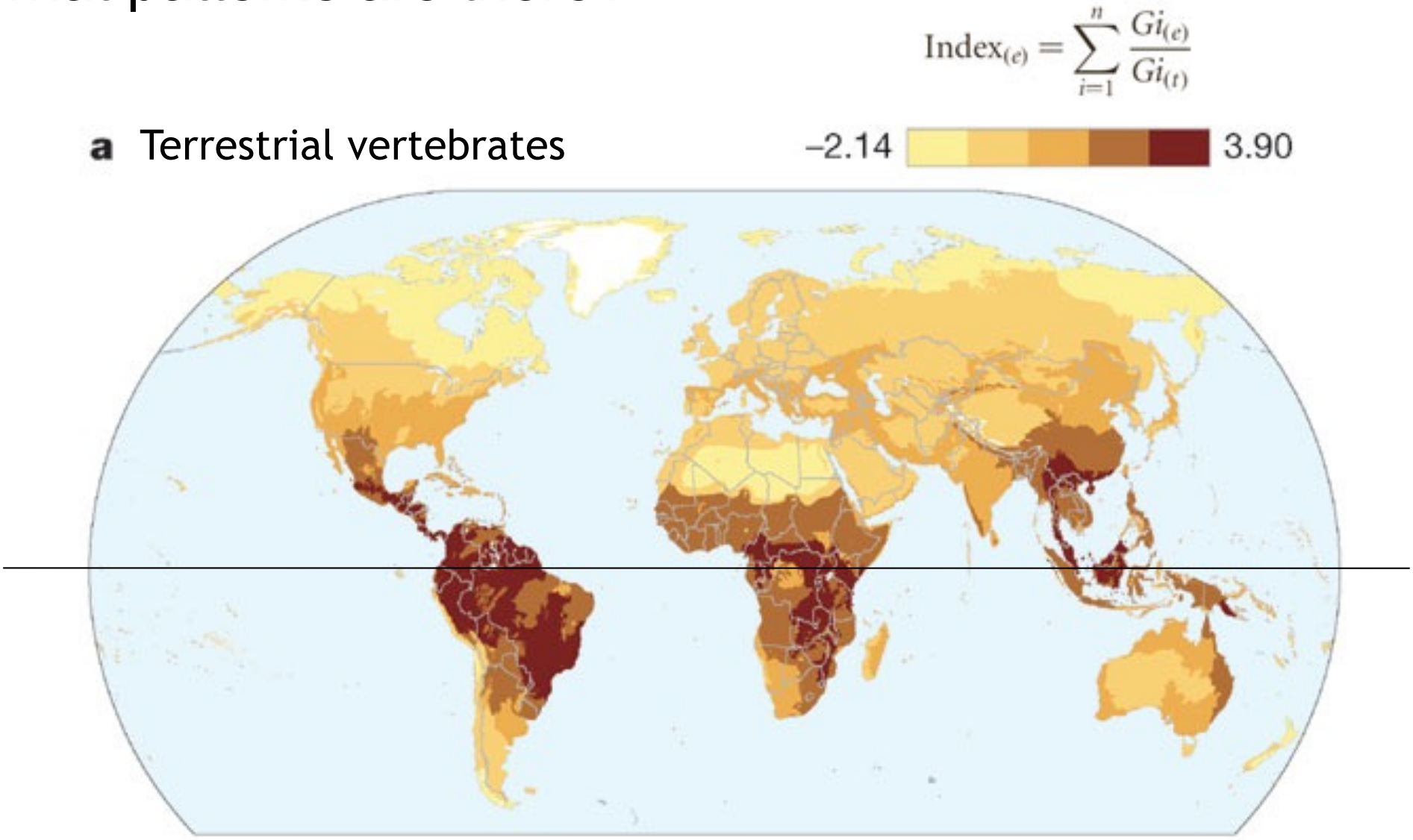
sea surface temperature

- >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

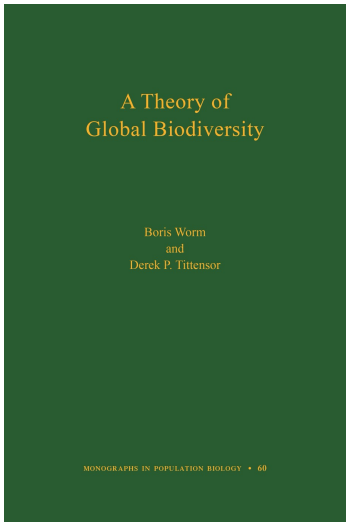
Where do we find the most species? What patterns are there?



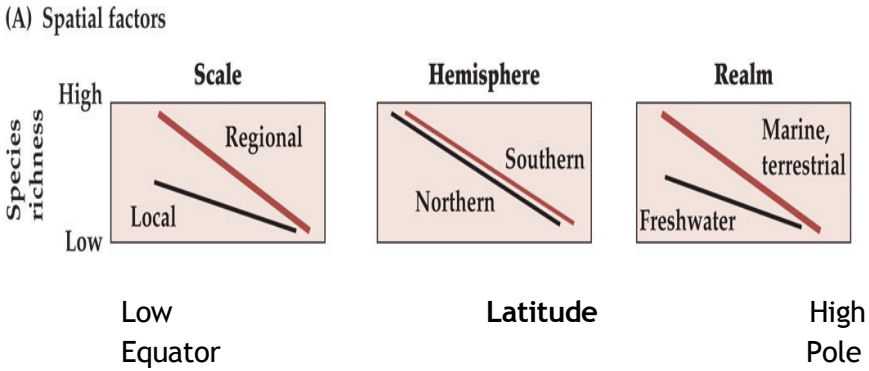
How general is the latitudinal diversity gradient?

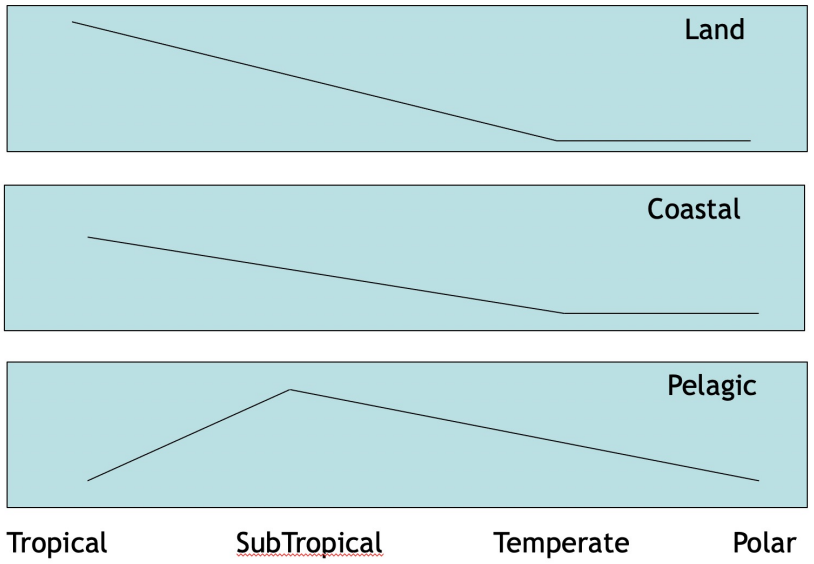
Hillebrand (2004)
American Naturalist

Meta-analysis -600 gradients



2018





Hypotheses

Vol. 100, No. 910 The American Naturalist January–February, 1966

LATITUDINAL GRADIENTS IN SPECIES DIVERSITY: A REVIEW OF CONCEPTS

Eric R. Pianka

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INTRODUCTION: DIVERSITY INDICES

The simplest index of diversity is the total number of species, usually of a specific taxon under investigation, inhabiting a particular area. Since this index does not take into account differing abundances of species, divergent communities may show similar "diversities." Because of this, more sophisticated measures have been proposed which weight the contributions of species according to their relative abundances. As early as

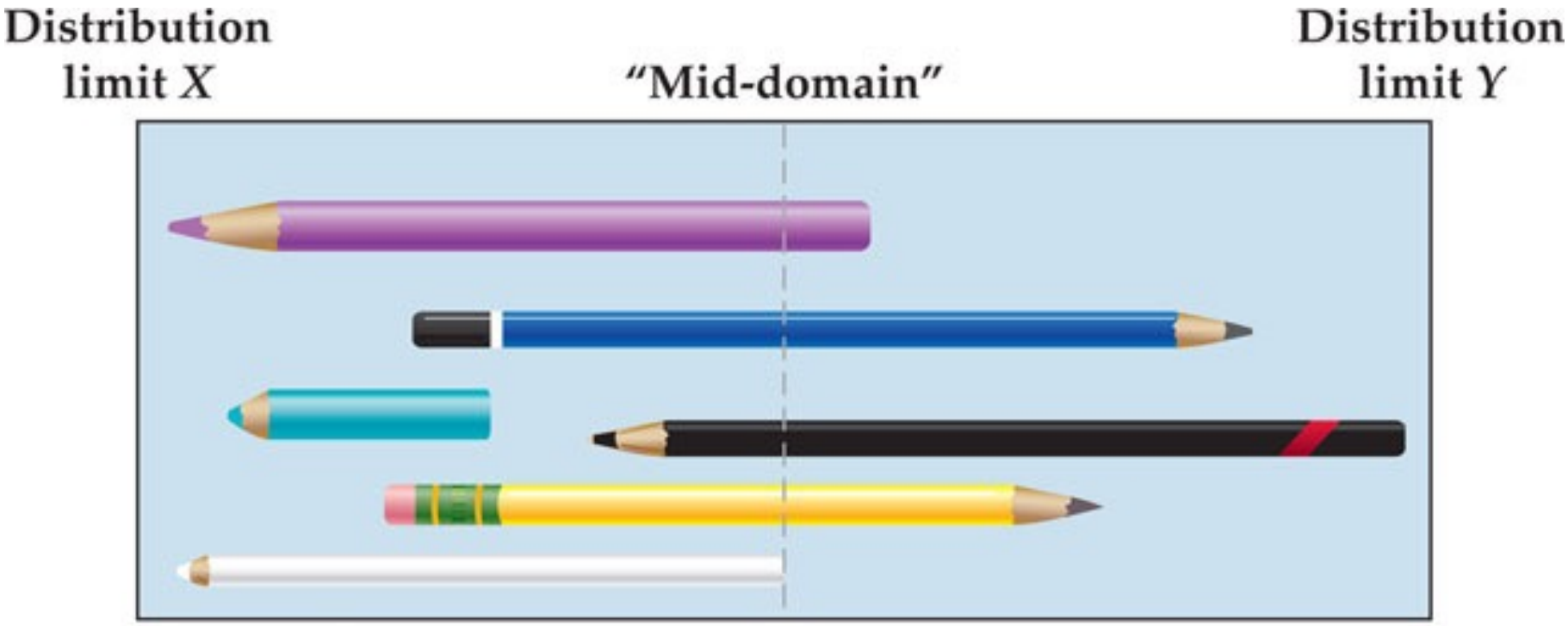
>1200 citations

Hypotheses

- Null models
  - Mid-domain effect
  - Neutral theory
- Ecological hypotheses
  - More Individuals Hypothesis (aka Species-energy model)
- Historical hypotheses
  - Time
  - Area
  - Time-integrated Area
- Evolutionary hypotheses
  - Climate stability
  - Evolutionary speed theory
  - Biotic interactions hypothesis

Null models – the mid-domain effect (Colwell and Hurtt 1994)

Random set of pencil lengths with a constraint

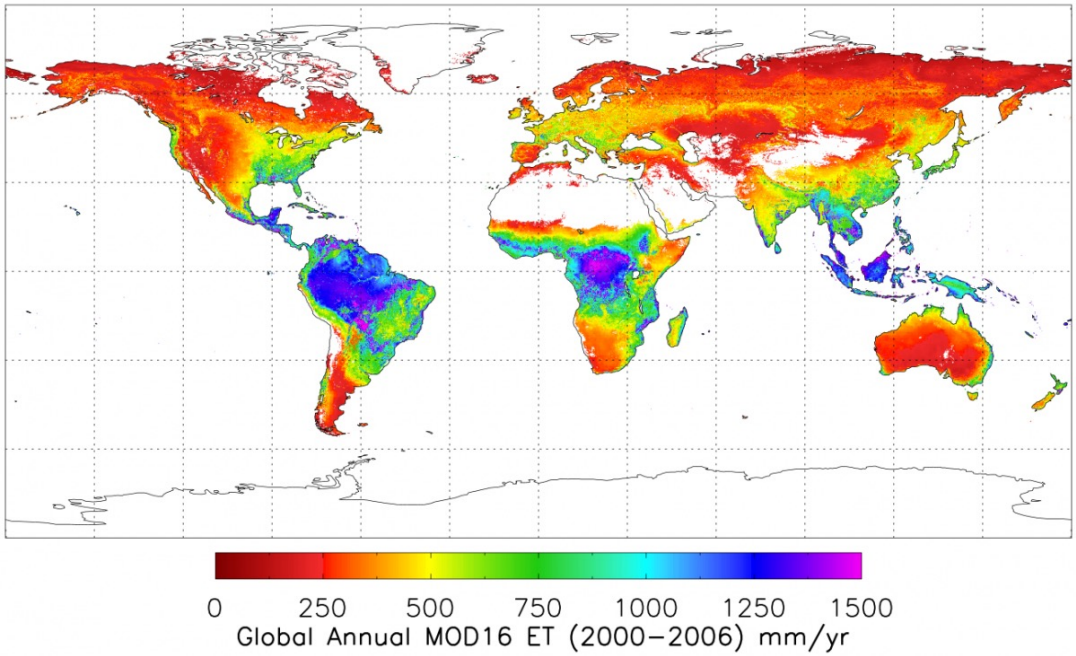


COMMUNITY ECOLOGY, Figure 2.4

Ecological hypotheses for diversity gradients –

more individual's hypothesis / species – energy model

Climate sets limit to richness



climate in tropics (temperature+precipitation) → higher NPP

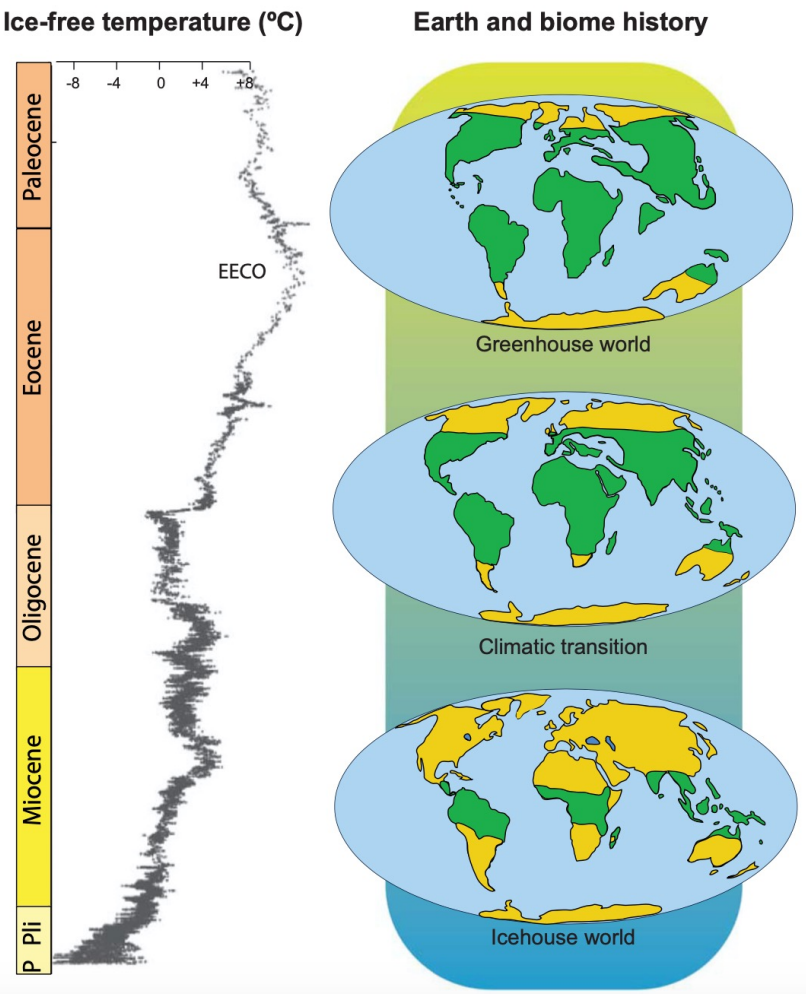
higher NPP → more individuals

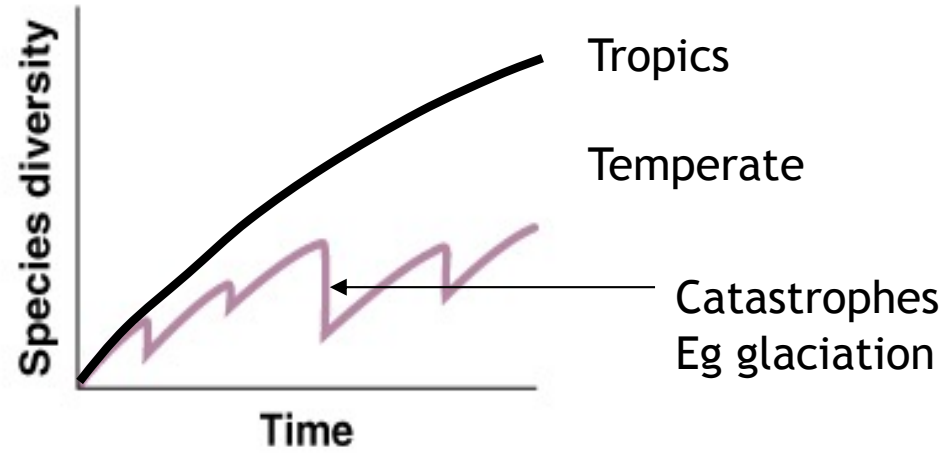
more individuals → more species with viable populations

more viable populations = less extinction

NPP = Net Primary Productivity

Historical hypotheses for diversity gradients





Time – the tropical biomes are older and more stable

Historical hypotheses for diversity gradients

Area

Tropics have a larger “area” now

Larger areas = larger pop’ns
-----> less extinction
Larger areas = more barriers
-----> more speciation

Time-integrated Area

The tropics covered an even larger area 66 Ma

More time
-----> more speciation

Evolutionary hypotheses for diversity gradients –

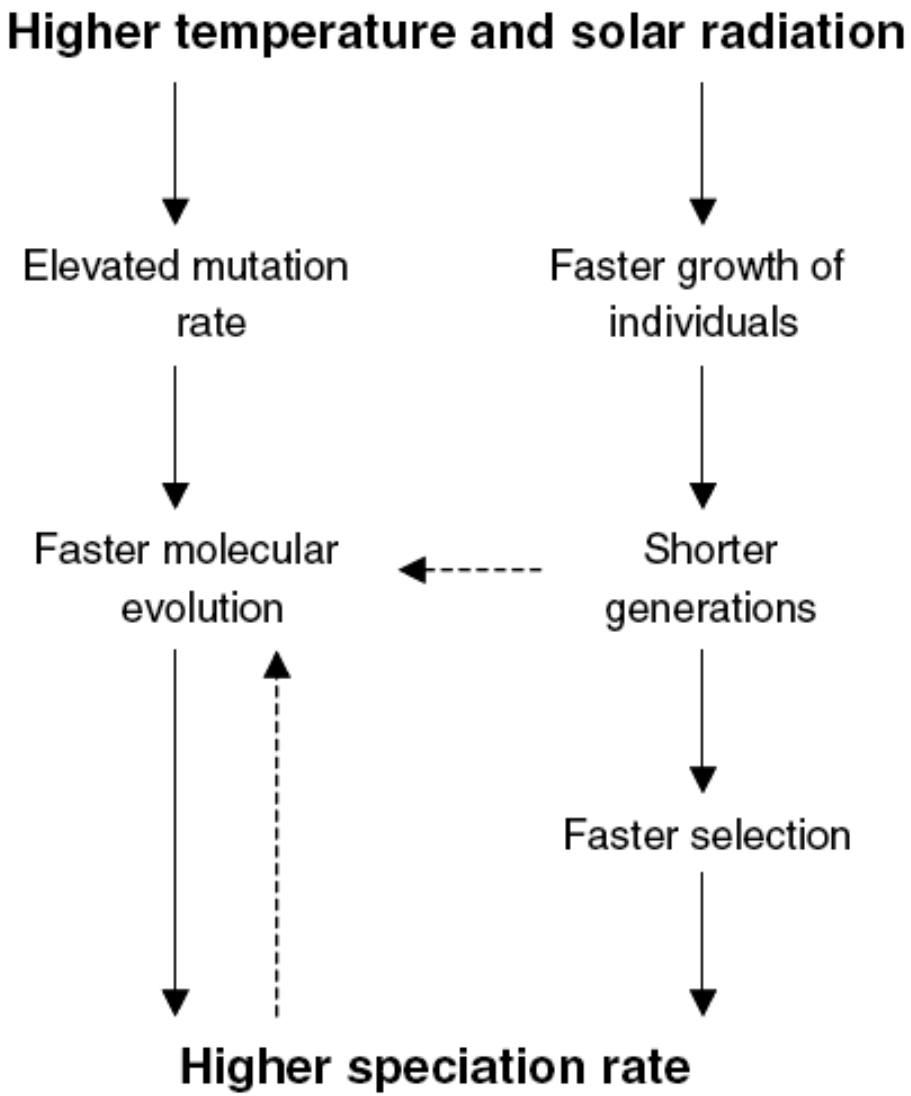
Climate stability hypothesis

High latitudes - unpredictable and severe
→ selection for flexibility
→ larger niches and less speciation
→ less species per habitat
- unpredictable and severe
→ more extinction

Tropics - predictable and mild → greater specialization
→ smaller niches
→ more speciation

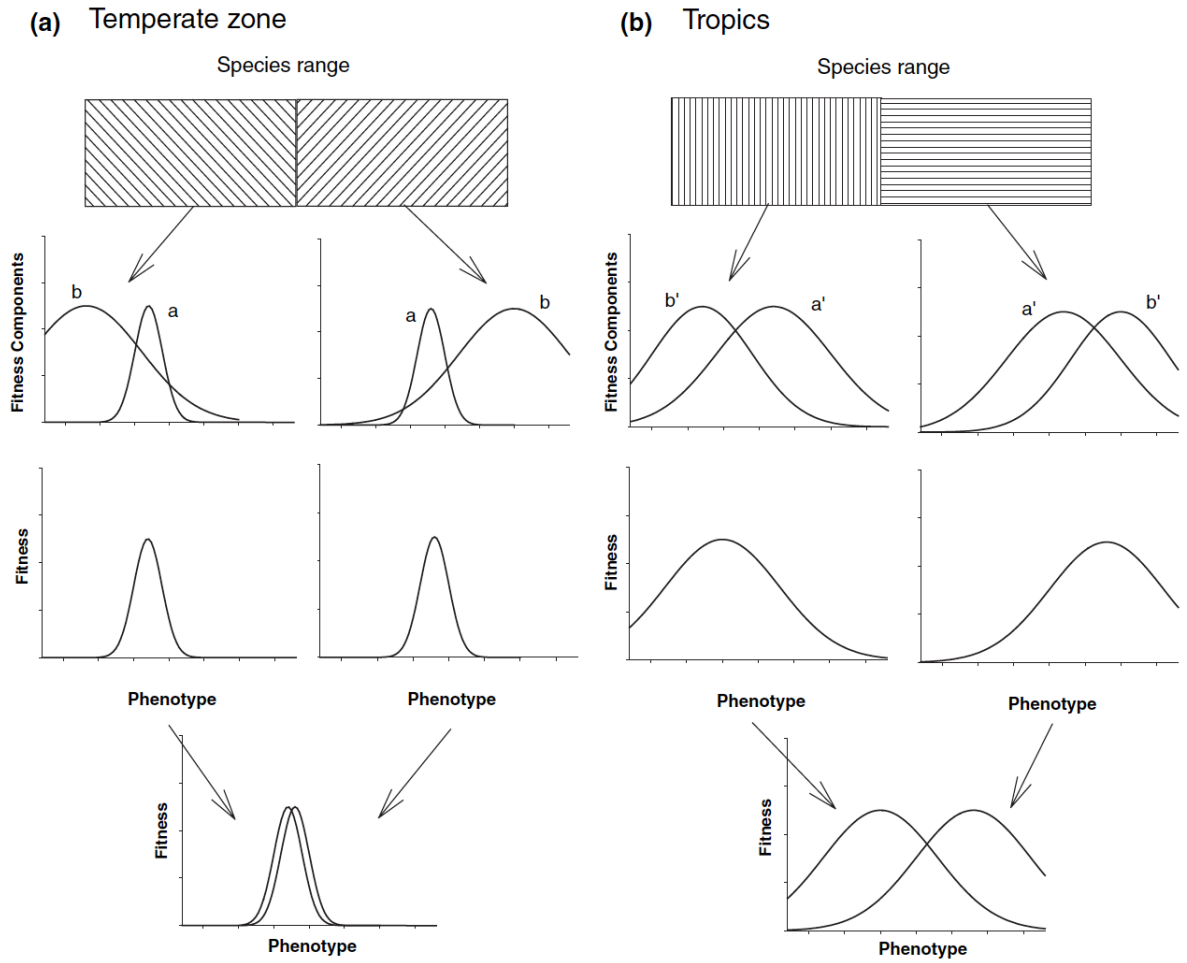
Evolutionary hypotheses for diversity gradients –

evolutionary speed theory (Rohde 1992)



Evolutionary hypotheses for diversity gradients

Biotic Interactions hypotheses (Schemske 2002)



Biotic interactions (b) are a stronger selective force than abiotic factors (a) in the tropics → higher speciation

Hypotheses	Speciation	Extinction
Mid-domain effect	x	x
More-Individuals Hypothesis	x	✔
Time – perturbation	x	✔
Area	✔	✔
Time-integrated area	✔	✔
Climate-stability	✔	✔
Evolutionary speed theory	✔	x
Biotic interactions	✔	x

Some hypotheses are difficult to differentiate because they make the same predictions about speciation and extinction in the tropics and temperate regions

Issues and Ideas

Currie et al. 2004 – should consider mechanism

Vellend - hypotheses for patterns based on lower level processes will proliferate

- should consider higher level processes

selection = selective loss of species (extinction)

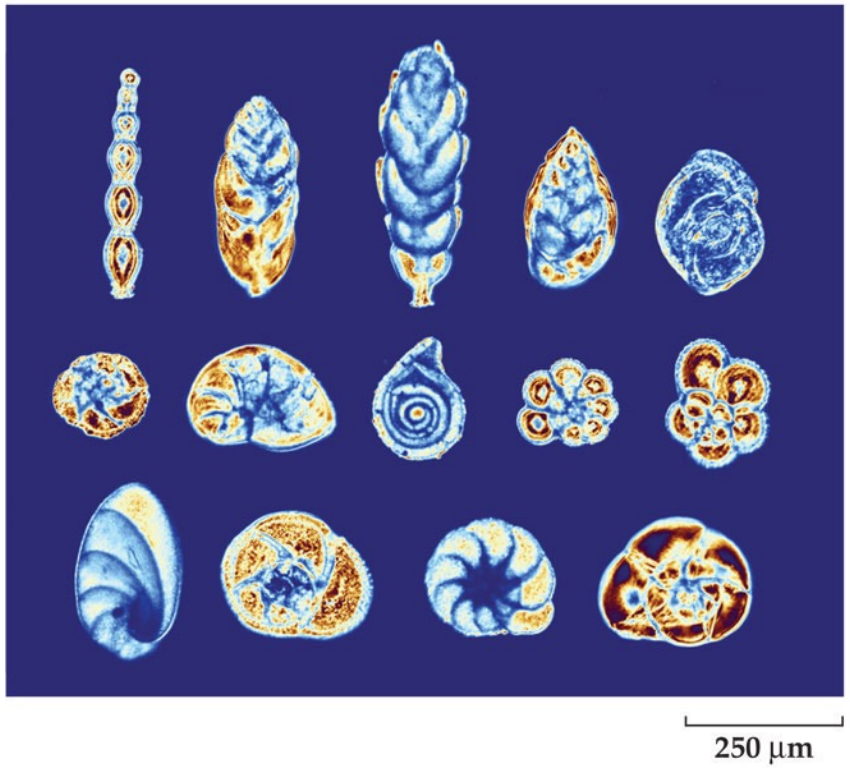
ecological drift = chance loss of species (extinction)

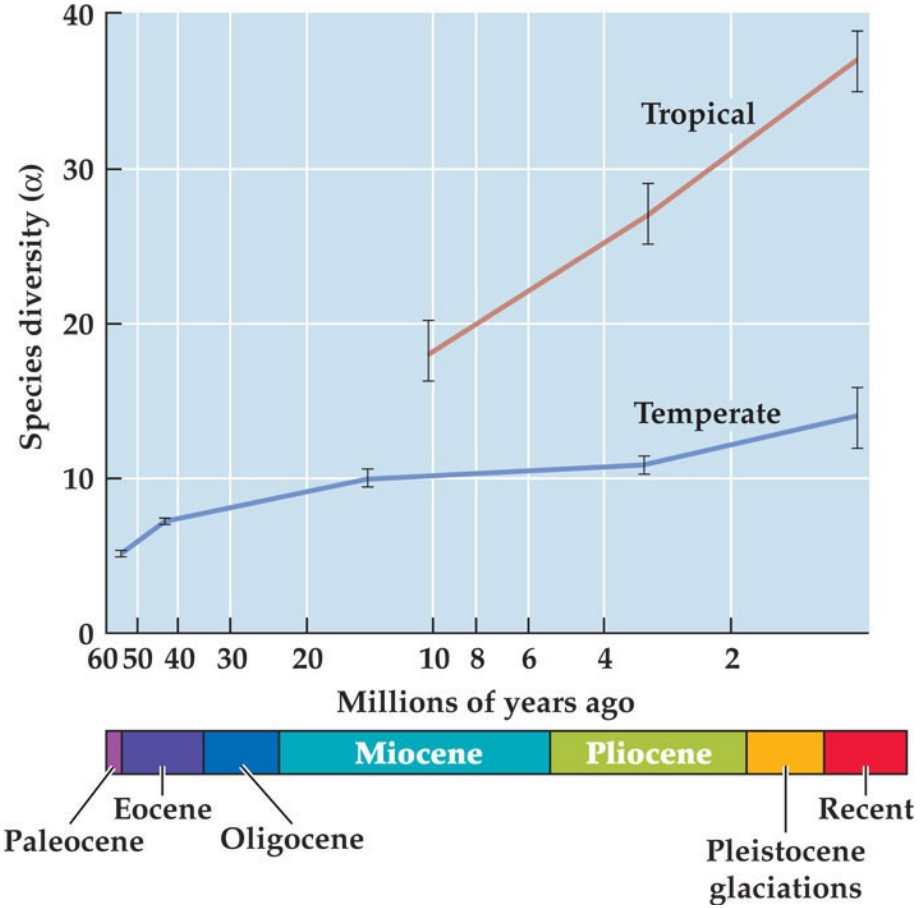
dispersal = movement of species

speciation

Evolutionary hypotheses for diversity gradients –

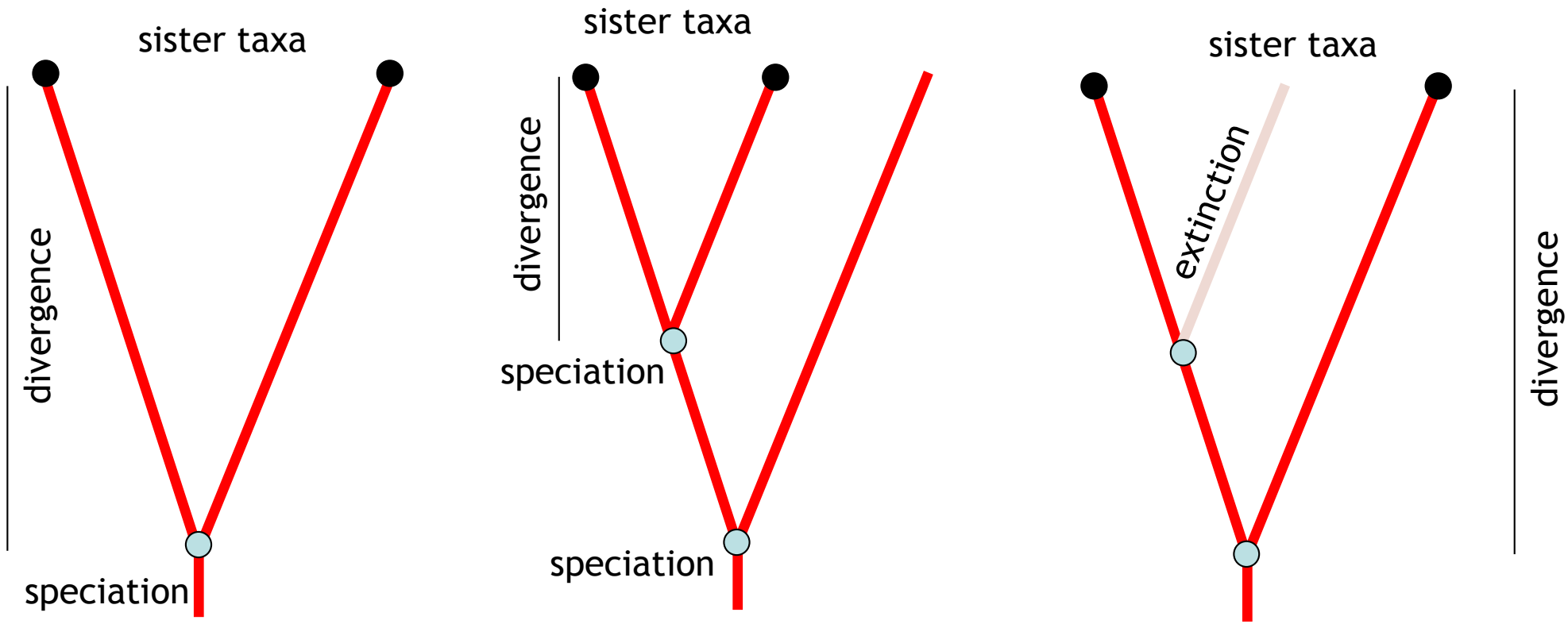
The tropics
a “cradle” for the generation of new taxa
and/or
a “museum” for the preservation of existing biodiversity”
→greater diversification (speciation – extinction)





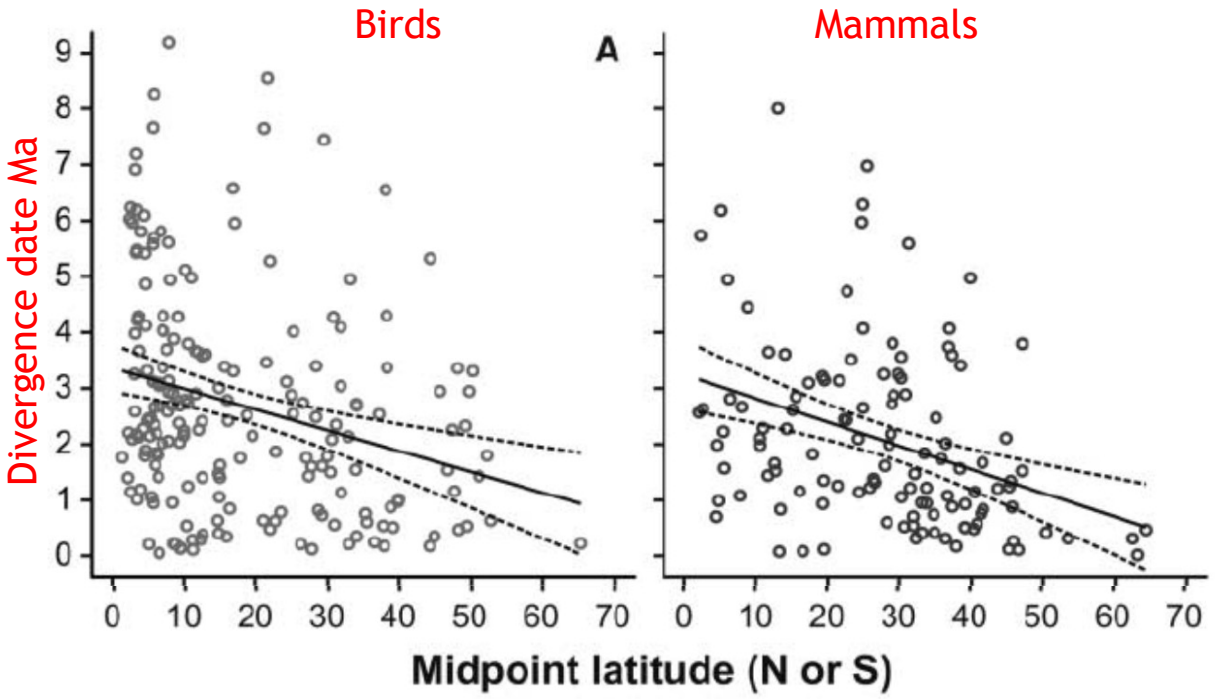
Do rates of speciation/extinction differ across latitude?

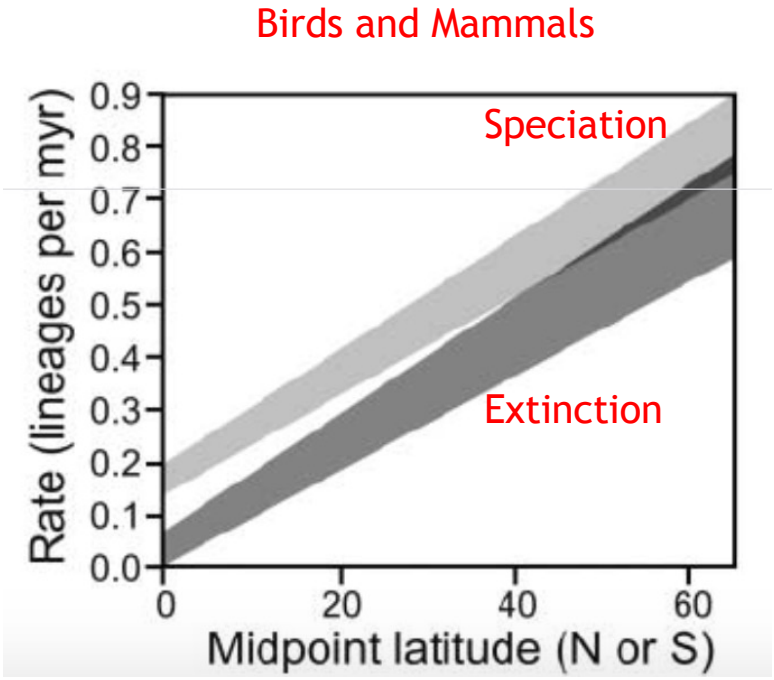
Evolutionary biologists



Weir et al. 2007 Science

Do rates of diversification, speciation and extinction differ across latitude?





Weir et al. 2007 Science

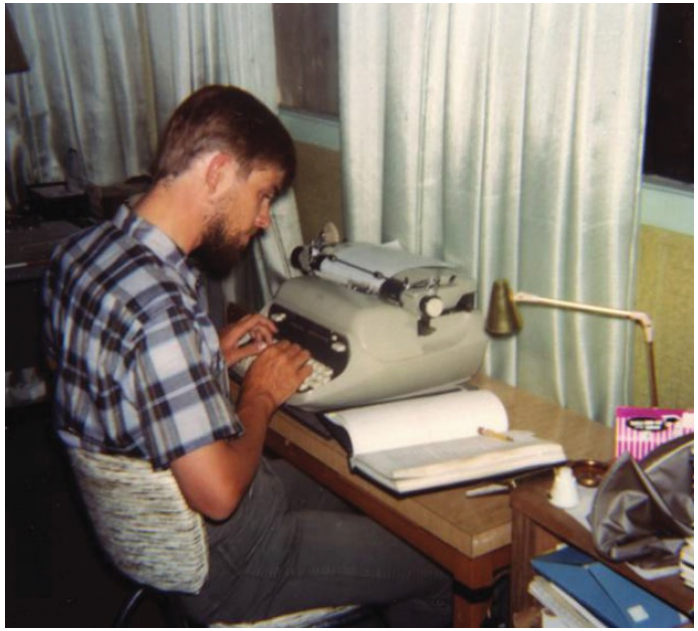
References

Mittelbach and McGill (2019) Community Ecology – Ch 2

Worm and Tittensor (2018) A Theory of Global Biodiversity. Princeton University Press

Currie et al. (2004). Predictions and tests of climate-based hypotheses of broad-scale variation in taxonomic richness. Ecol Lett 7: 1121-1134 **908 citations**

Schemske and Mittelbach (2017). "Latitudinal Gradients in Species Diversity": Reflections on Pianka's 1966 Article and a Look Forward. Am Nat 189: 599-603



Eric Pianka typing his thesis

Selected readings on Latitudinal gradients

Two to be selected by class