

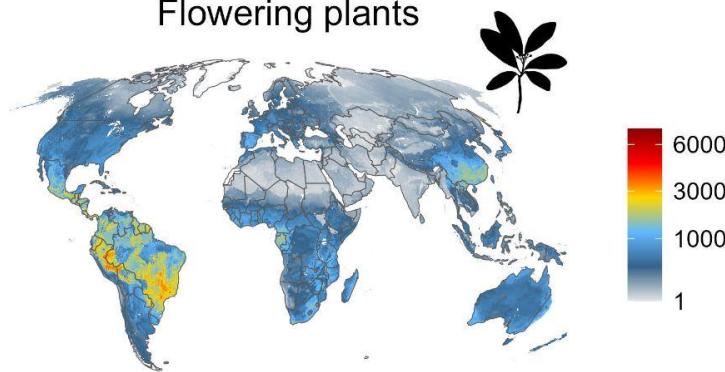
# Diversity Patterns

## Today's Agenda:

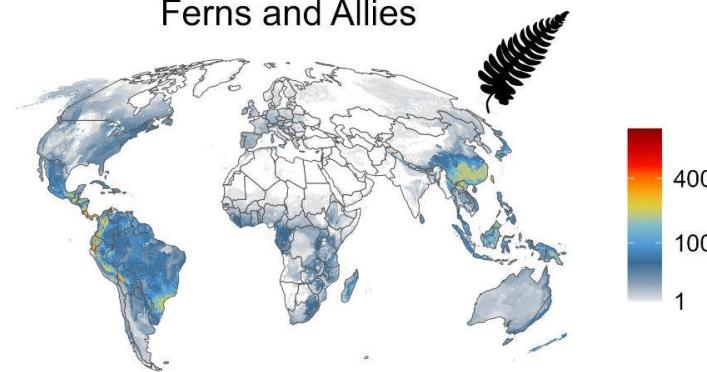
- Quiz
- Diversity Pattern Examples
  - Measuring Diversity
  - Types of Diversity

# Species Richness: Plants

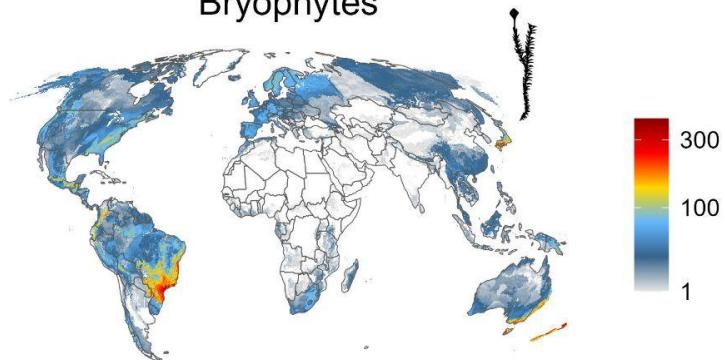
Flowering plants



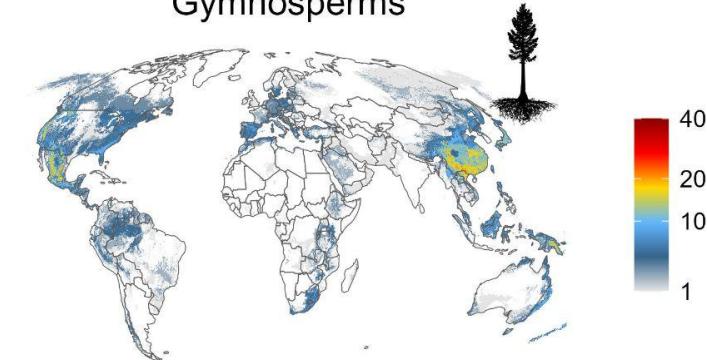
Ferns and Allies



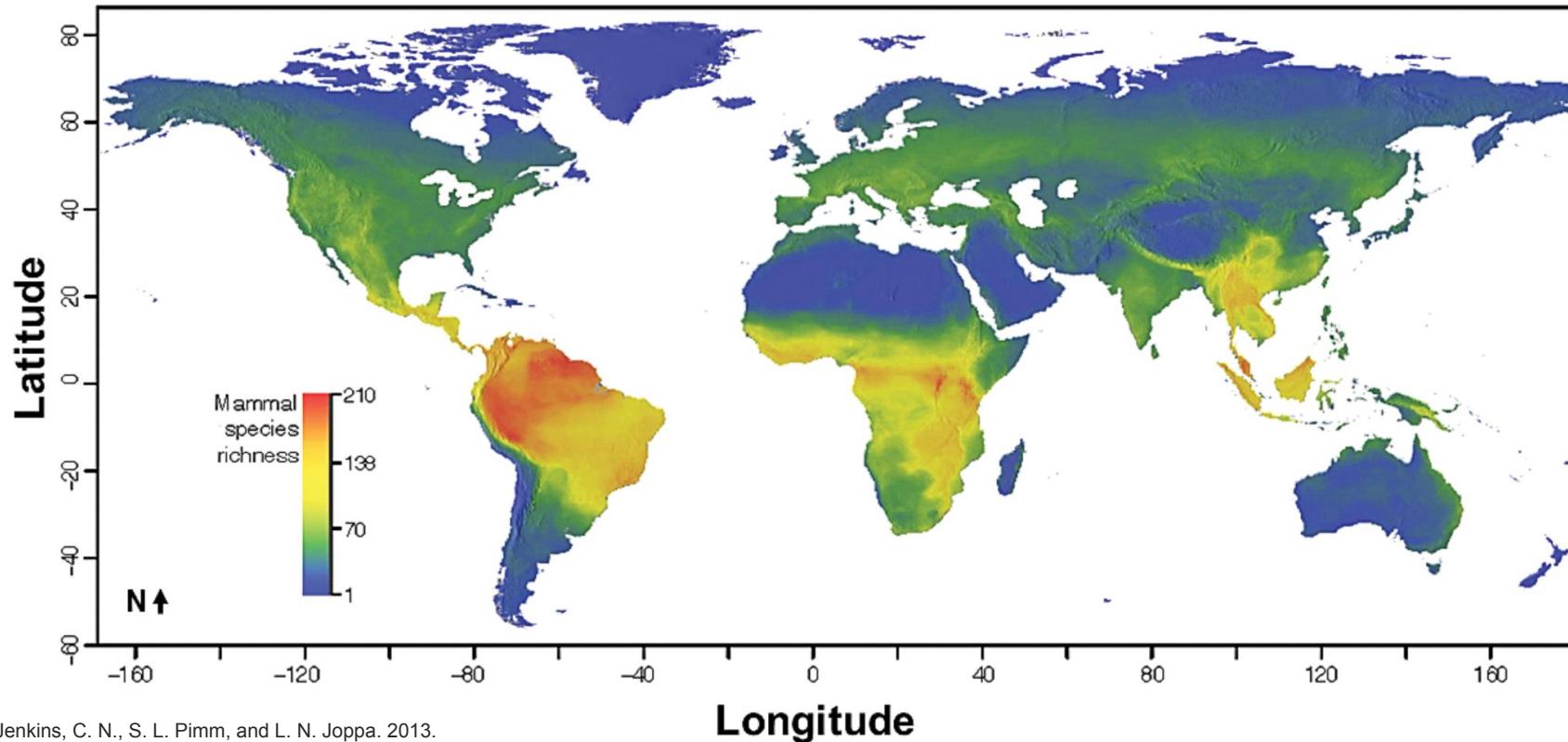
Bryophytes



Gymnosperms

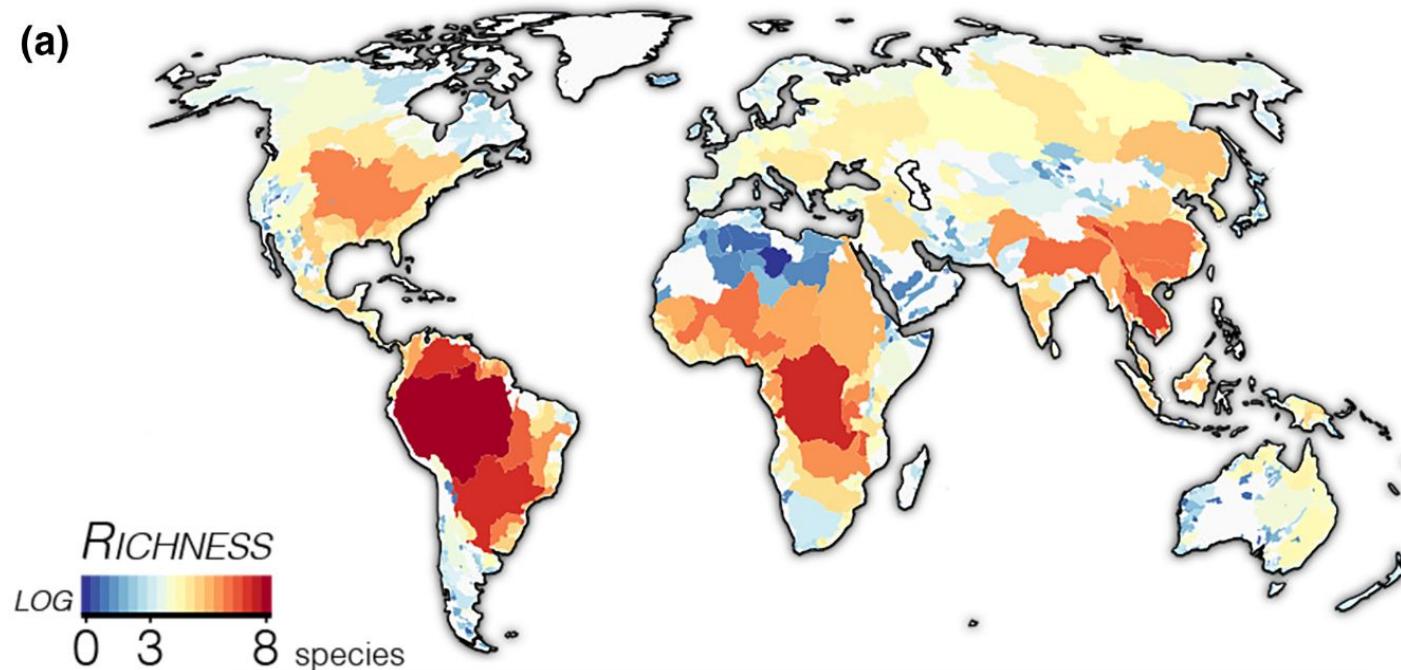


# Species Richness: Mammals



# Species Richness: Freshwater Fish

(a)

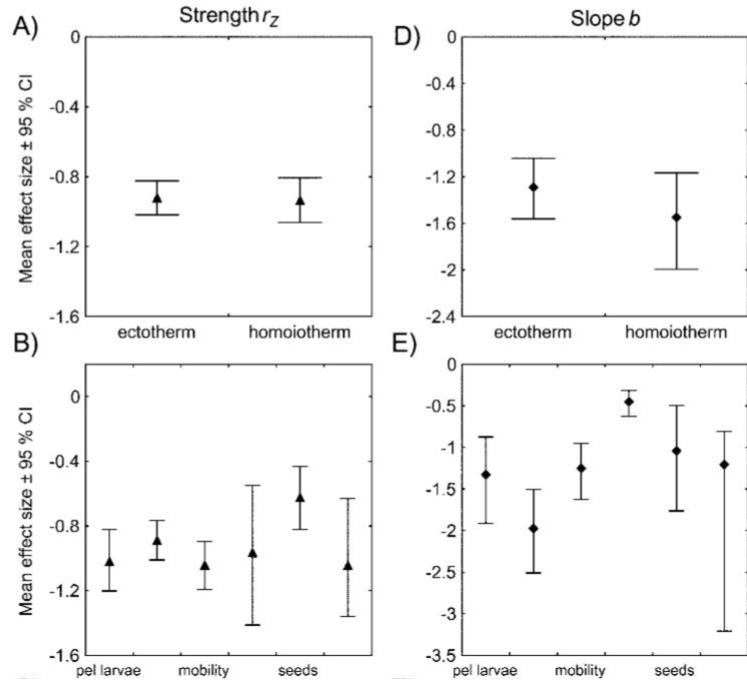


# Latitudinal Diversity Gradient

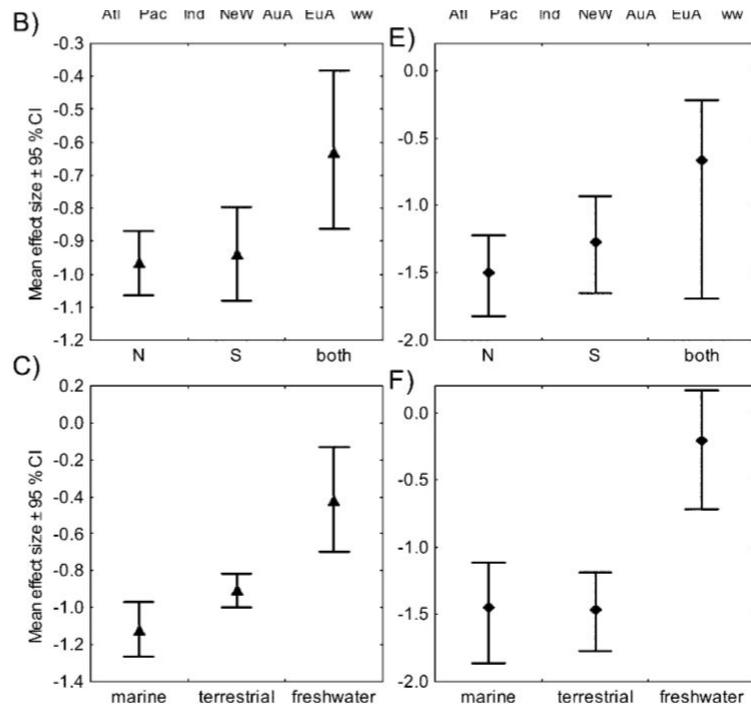
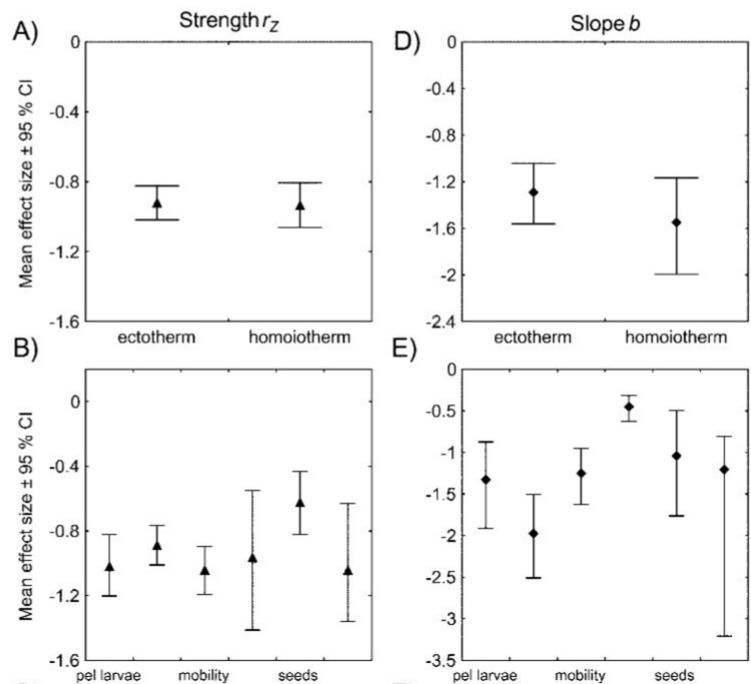
Species diversity tends to diminish towards the poles

- Can folks think of other groups with a similar latitudinal diversity gradient?

# Latitudinal Diversity Gradient



# Latitudinal Diversity Gradient

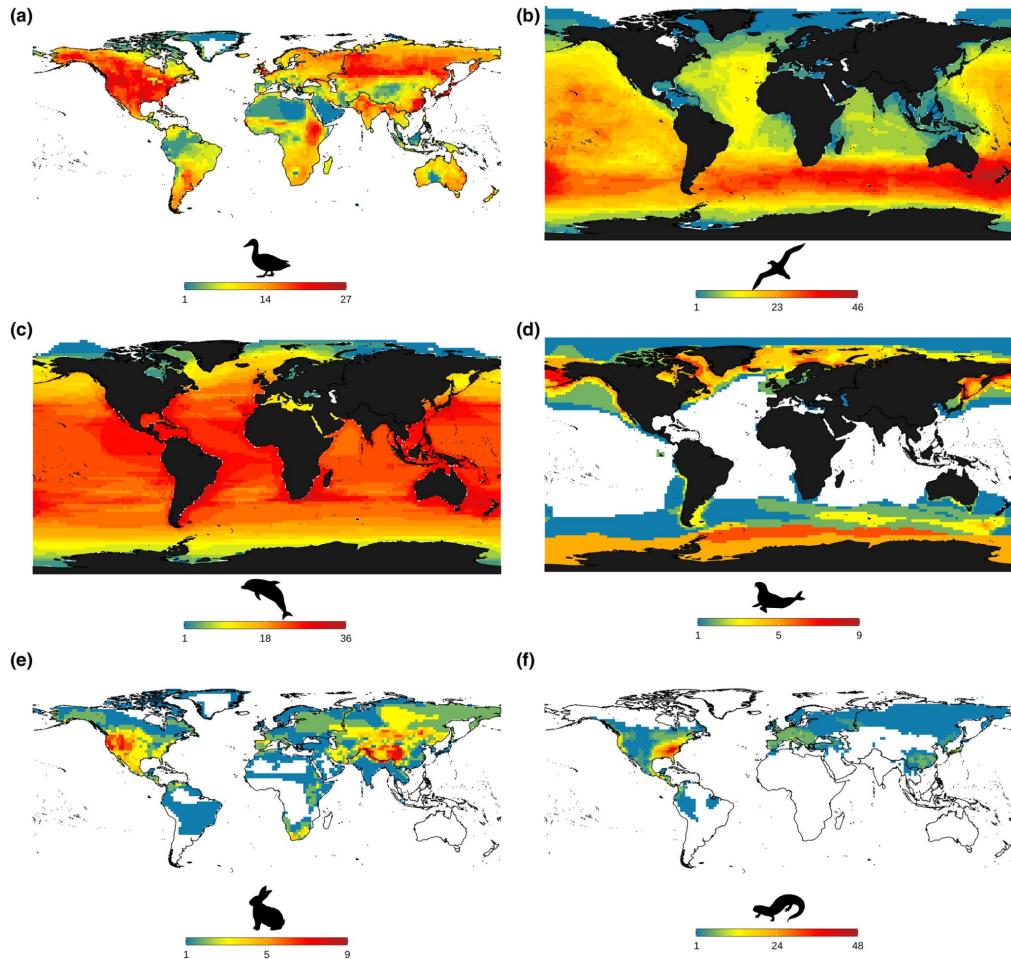


# Latitudinal Diversity Gradient

- Can anyone think of any counter-examples?

# Exceptions to the Rule

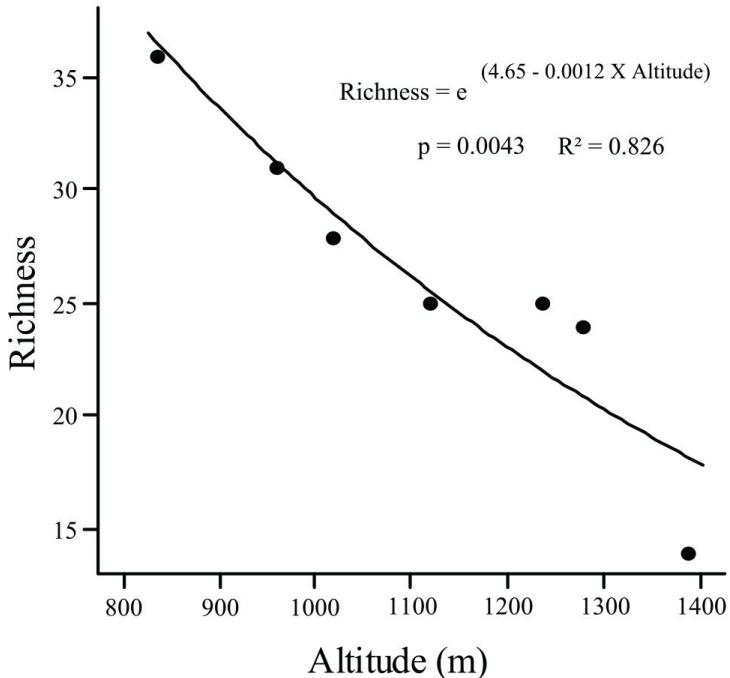
- Ducks and geese
- Albatrosses and petrels
- Whales and dolphins
- Seals and sea lions
- Rabbits and pikas
- Salamanders and newts



# Other Diversity Patterns?

# Altitude

a)



RESEARCH ARTICLE

## Dung Beetles along a Tropical Altitudinal Gradient: Environmental Filtering on Taxonomic and Functional Diversity

Cássio Alencar Nunes<sup>1\*</sup>, Rodrigo Fagundes Braga<sup>2</sup>, José Eugênio Cortes Figueira<sup>1</sup>, Frederico de Siqueira Neves<sup>3</sup>, G. Wilson Fernandes<sup>4</sup>

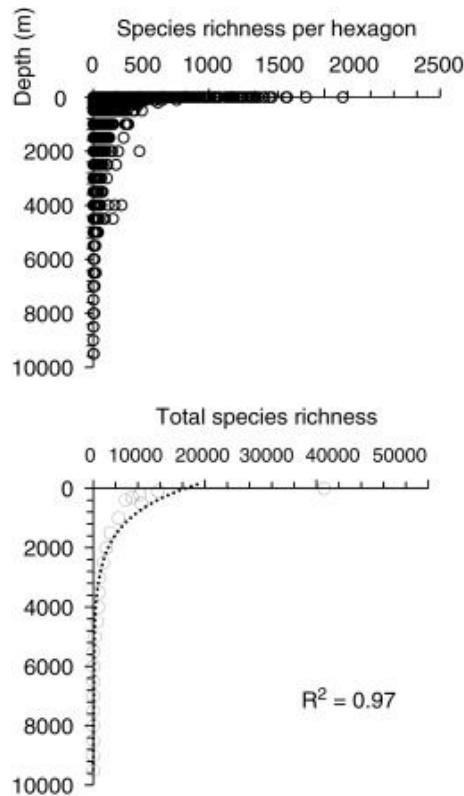
<sup>1</sup> Laboratório de Ecologia de Populações, Departamento de Biologia Geral, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, CP 486, 31270-901, Belo Horizonte, Minas Gerais, Brazil

<sup>2</sup> Laboratório de Ecologia e Conservação de Invertebrados, Departamento de Biologia, Setor de Ecologia, Universidade Federal de Lavras, CP 3037, 37200-000, Lavras, Minas Gerais, Brazil. <sup>3</sup> Laboratório de Ecologia de Insetos, Departamento de Biologia Geral, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, CP 486, 31270-901, Belo Horizonte Minas Gerais, Brazil. <sup>4</sup> Ecologia Evolutiva & Biodiversidade /DBG, ICB/ Universidade Federal de Minas Gerais, CP 486, 31270-901, Belo Horizonte Minas Gerais, Brazil

\* cassialencarnunes@gmail.com



# Ocean Depth



Current Biology



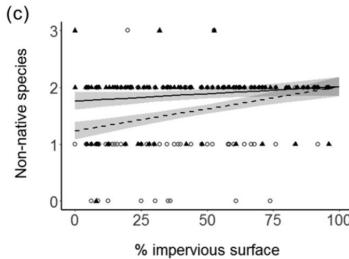
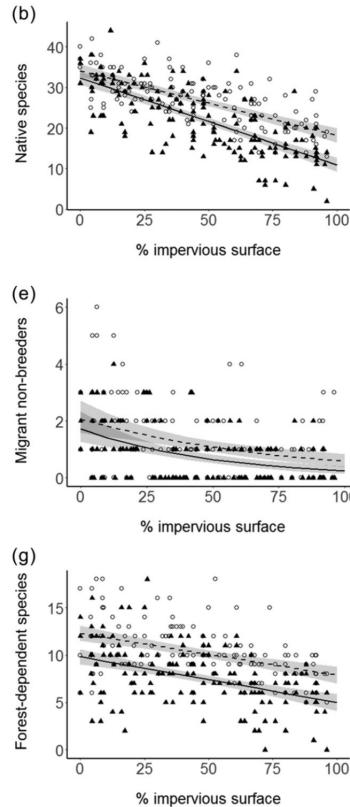
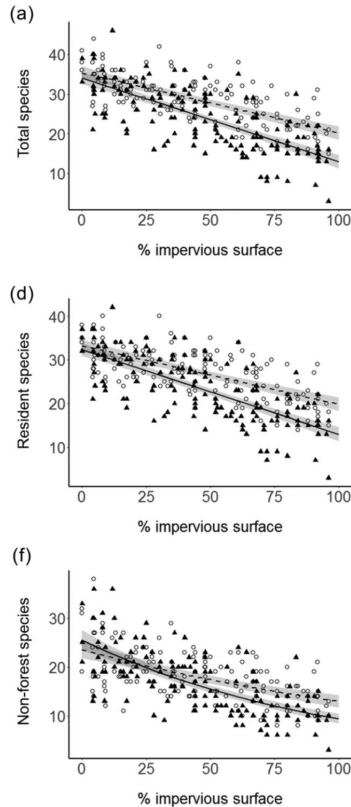
Volume 27, Issue 11, 5 June 2017, Pages R511-R527

Review

## Marine Biodiversity, Biogeography, Deep-Sea Gradients, and Conservation

Mark J. Costello , Chhaya Chaudhary

# Urbanization



Location type

- Randomized
- Woodland

ECOLOGICAL  
APPLICATIONS  
ECOLOGICAL SOCIETY OF AMERICA

ARTICLE | Open Access |

**Avian species richness and tropical urbanization gradients:  
Effects of woodland retention and human disturbance**

Phakhawat Thaweepworadej Karl L. Evans

First published: 25 March 2022 | <https://doi.org/10.1002/eap.2586> | Citations: 2

# How to we measure diversity?

# How to we measure diversity?

- Species Richness



# How to we measure diversity?

- Species Richness = 4



# Beyond Species Richness

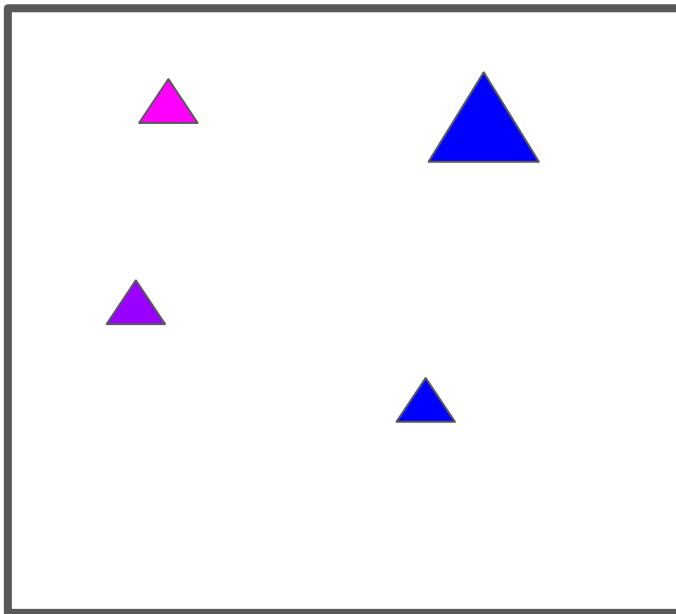
Taxonomic diversity only tells you so much

Phylogenetic + functional

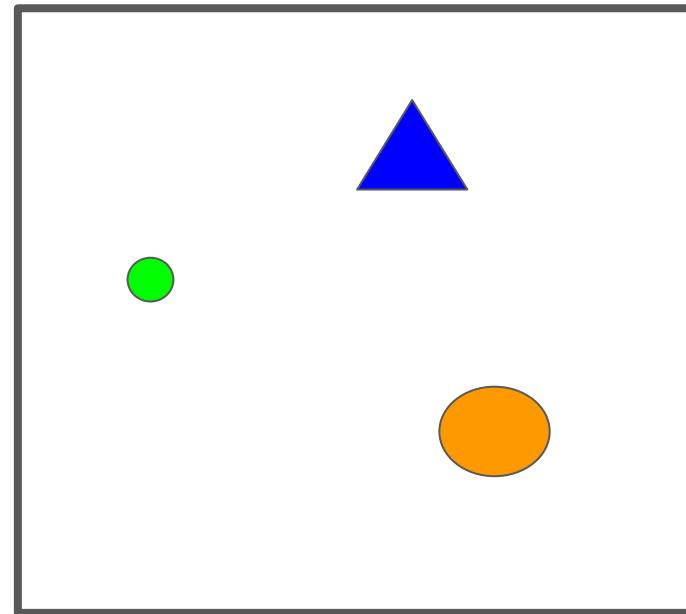
# Phylogenetic Diversity

# Phylogenetic Diversity

Community A

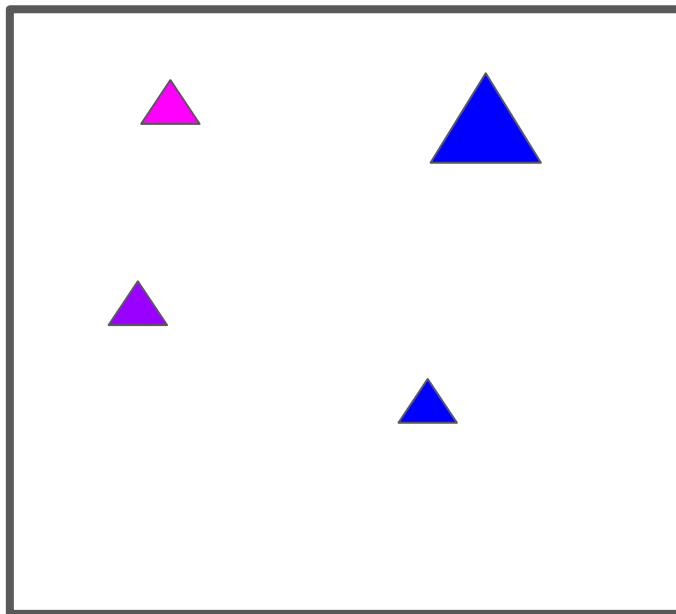


Community B



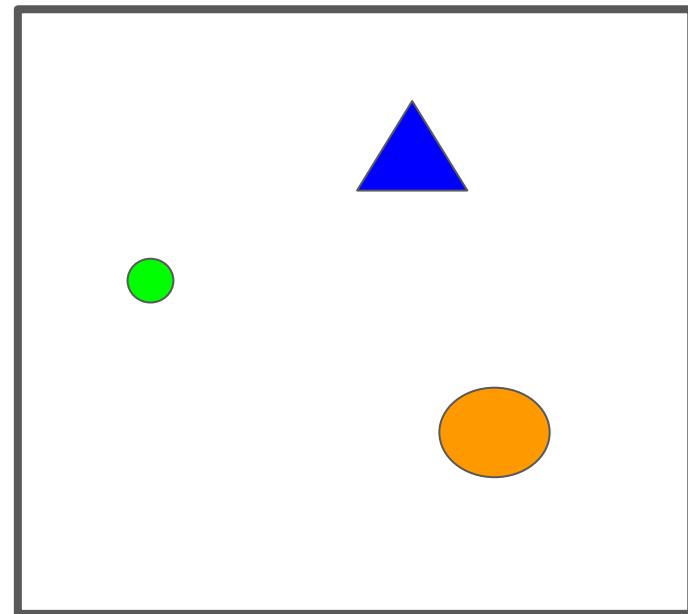
# Phylogenetic Diversity

Community A



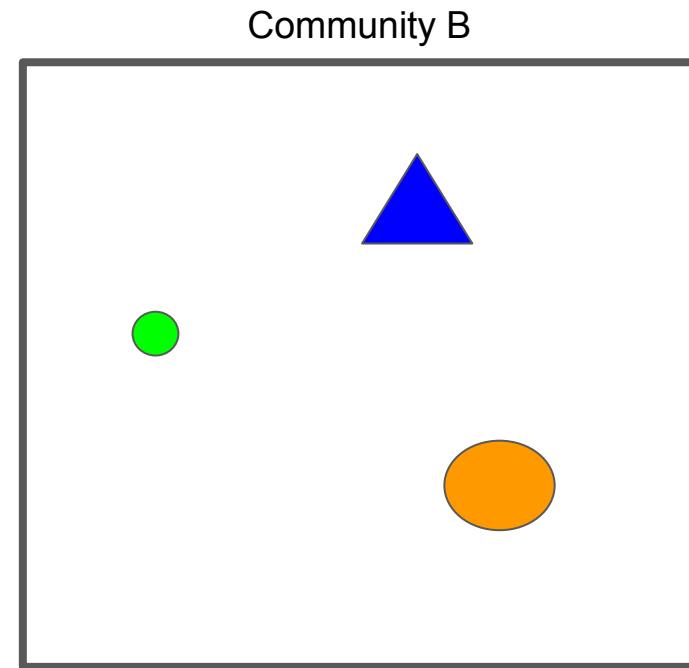
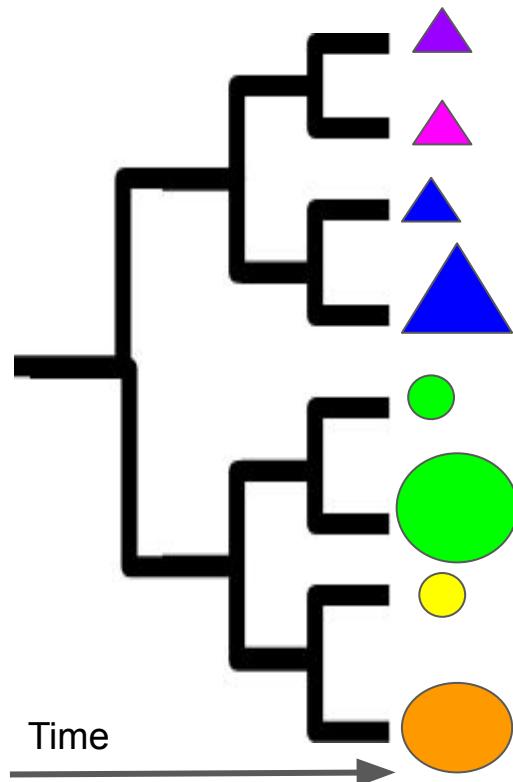
Richness = 4

Community B

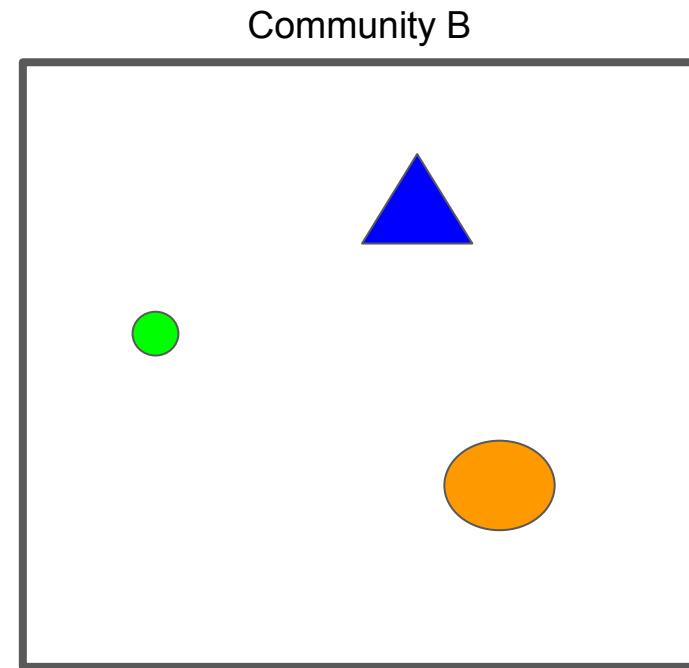
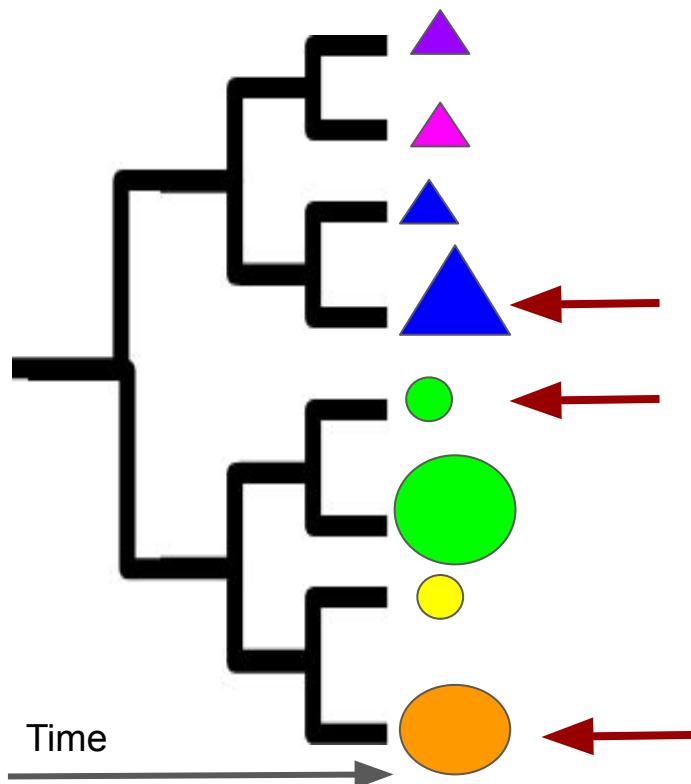


Richness = 3

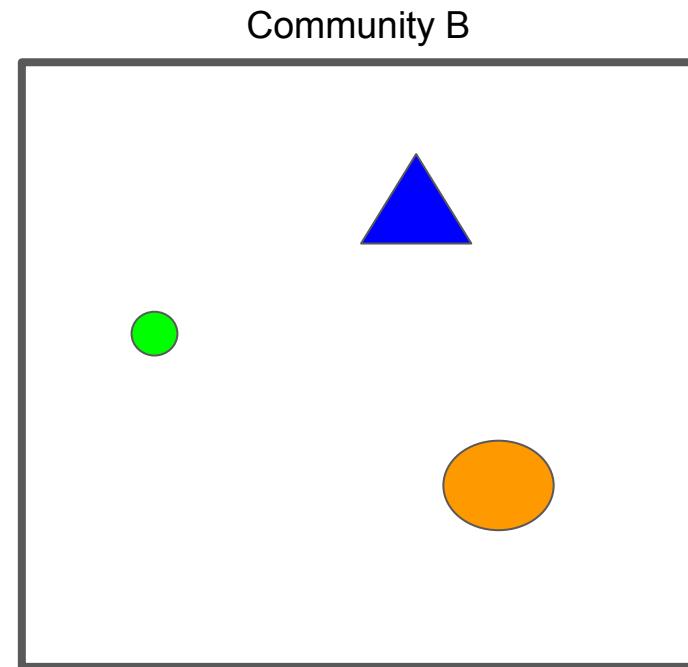
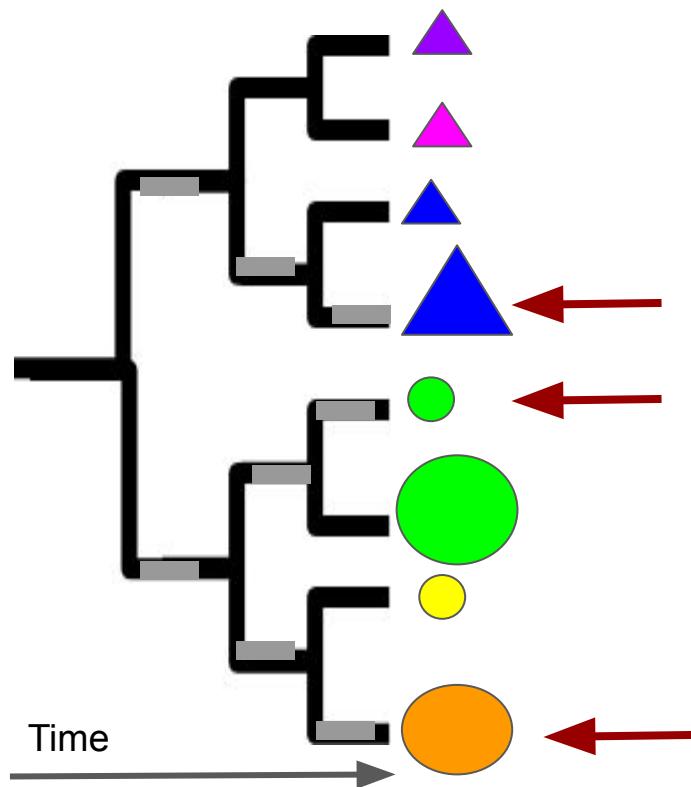
# Phylogenetic Diversity



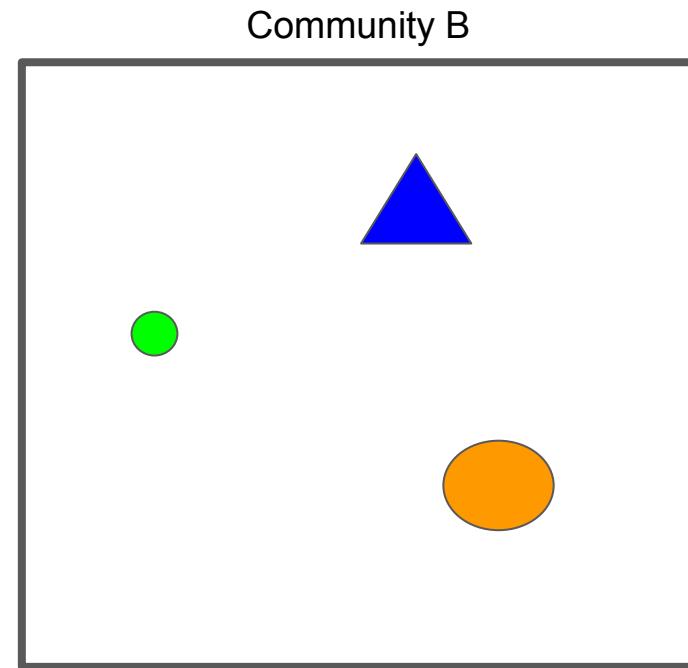
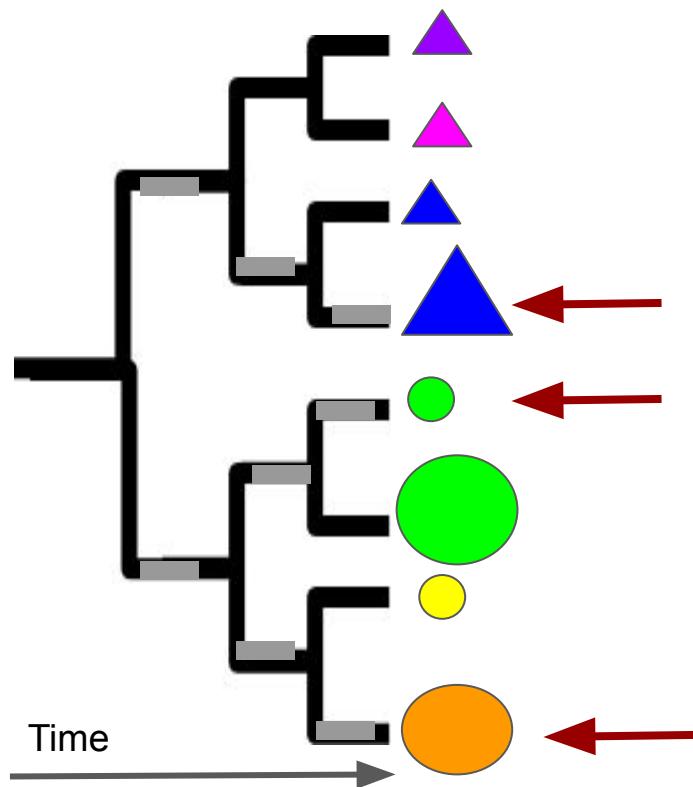
# Phylogenetic Diversity



# Phylogenetic Diversity

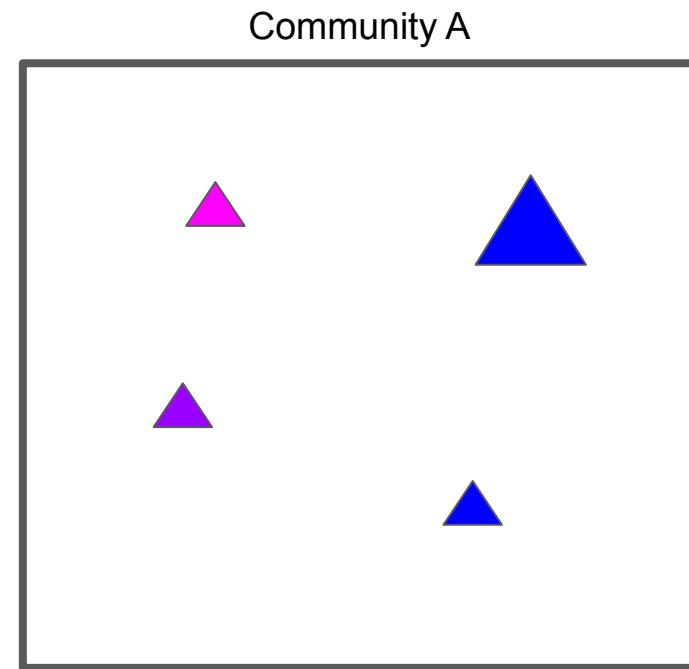
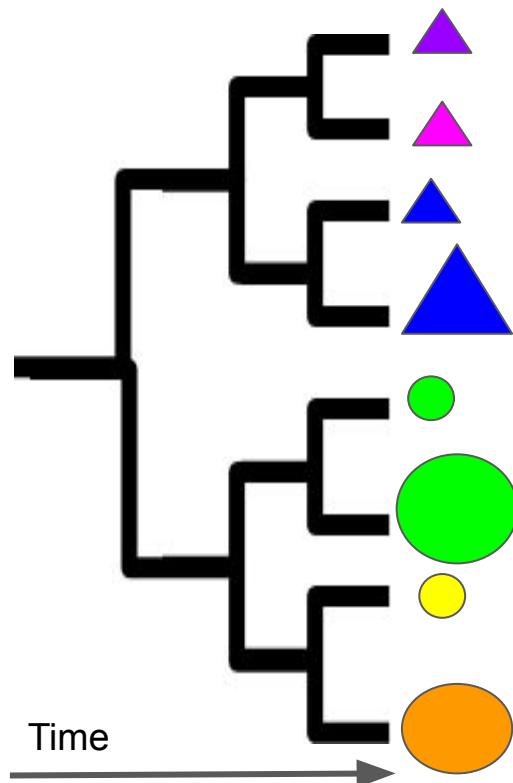


# Phylogenetic Diversity

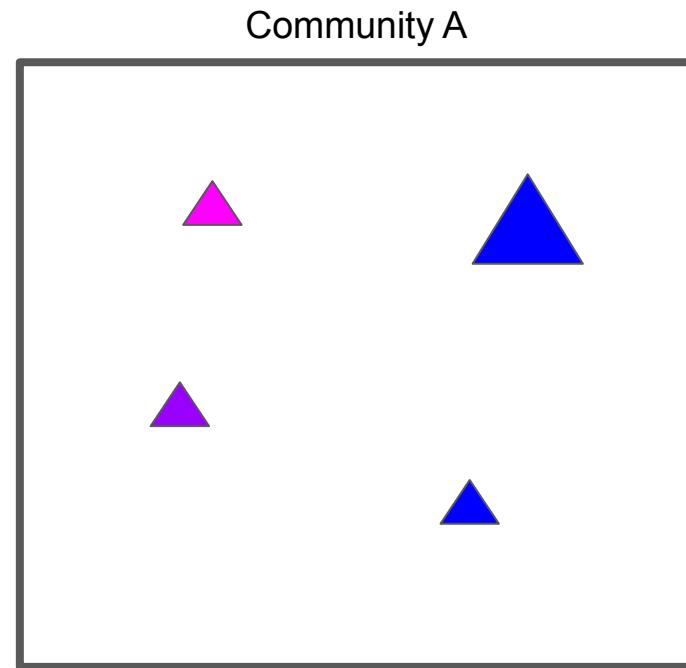
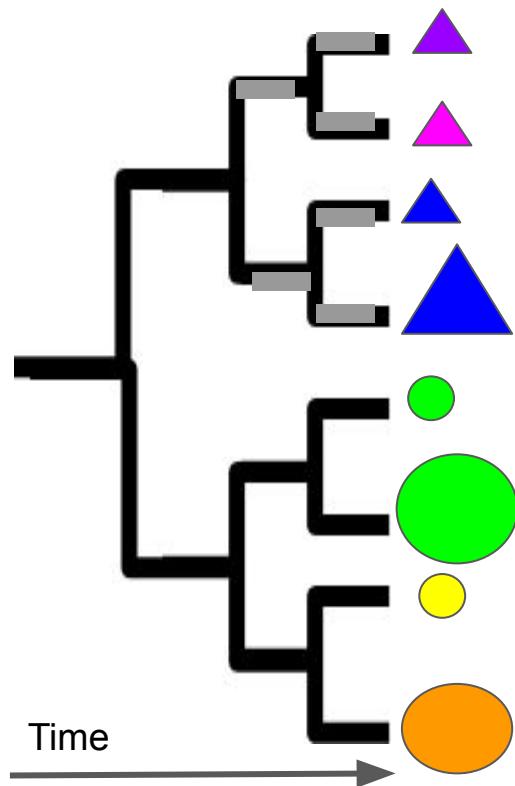


Phy. Diversity ~ 8 million years

# Your turn!

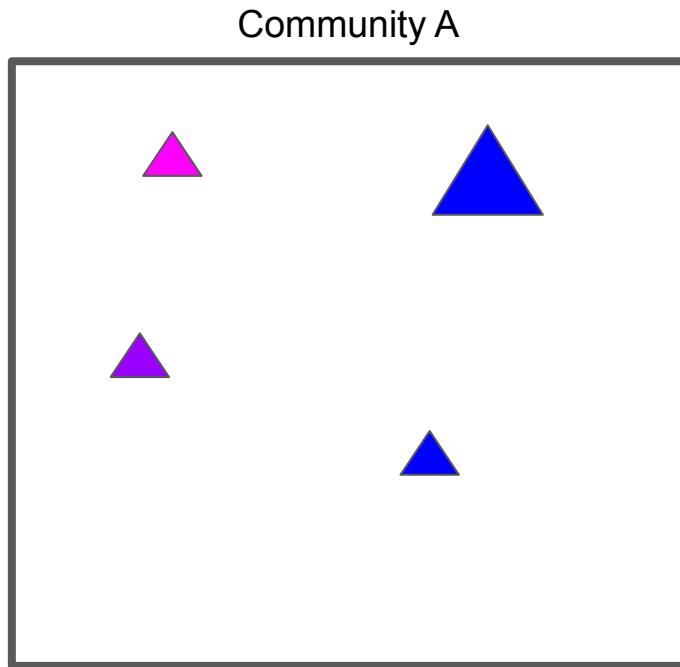


# Your turn!

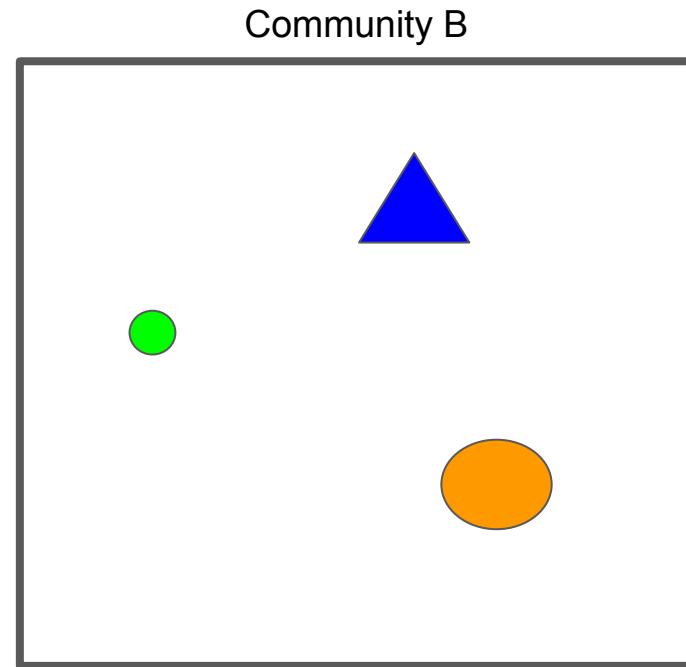


Phy. Diversity ~ 6 million years

# Phylogenetic Diversity



Richness = 4  
Phy diversity = 6 million years



Richness = 3  
Phy diversity = 8 million years

# ... but why?

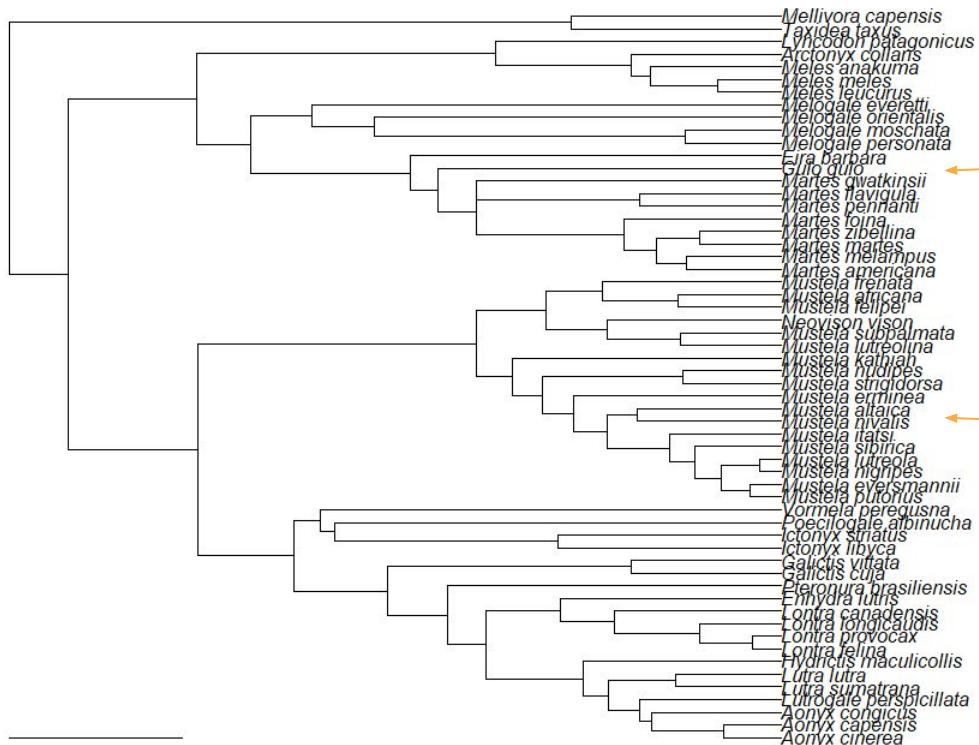
Why might measuring phylogenetic diversity be useful?

- Discuss with those around you and then we'll compare ideas

# Why Phylogenetic diversity?

- As a proxy for traits
- As a measure of irreplaceability

## Example: Mustelids



## 5 Million Years



Matthias Kabel



Keven Law



Frank Wouters

# Why Phylogenetic diversity?

RESEARCH ARTICLE

## Phylogenetic structure of soil bacterial communities predicts ecosystem functioning

Eduardo Pérez-Valera, Marta Goberna and Miguel Verdú\*

Ketola et al. BMC Ecol (2017) 17:15  
DOI 10.1186/s12898-017-0126-z

BMC Ecology

RESEARCH ARTICLE

Open Access



## Propagule pressure increase and phylogenetic diversity decrease community's susceptibility to invasion

T. Ketola<sup>1</sup>, K. Saarinen and L. Lindström

esa

ECOSPHERE

Jointly modeling niche width and phylogenetic distance to explain species co-occurrence

TAMMY L. ELLIOTT<sup>1,†</sup> AND T. JONATHAN DAVIES<sup>2,3</sup>

LETTER

doi:10.1038/nature14372

## Phylogenetic structure and host abundance drive disease pressure in communities

Ingrid M. Parker<sup>1,2\*</sup>, Megan Saunders<sup>3</sup>, Megan Bontrager<sup>1</sup>, Andrew P. Weitz<sup>1</sup>, Rebecca Hendricks<sup>3</sup>, Roger Magarey<sup>4</sup>, Karl Suiter<sup>4</sup> & Gregory S. Gilbert<sup>2,3\*</sup>

ECOLOGY LETTERS

Ecology Letters, (2011) 14: 782–787

doi: 10.1111/j.1461-0248.2011.01644.x

LETTER

## Phylogenetic limiting similarity and competitive exclusion

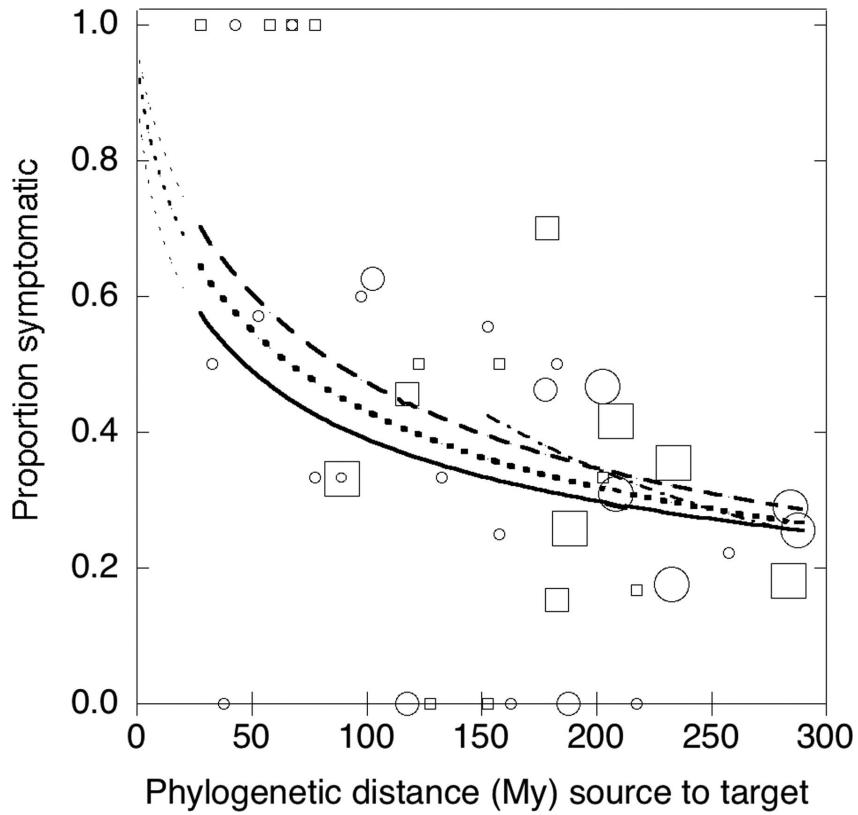
Cyrille Violle,<sup>1,2,3\*</sup> Diana R. Nemergut,<sup>4,5</sup> Zhichao Pu<sup>1</sup> and Lin Jiang<sup>1</sup>

### Abstract

One of the oldest ecological hypotheses, proposed by Darwin, suggests that the struggle for existence is stronger between more closely related species. Despite its long history, the validity of this phylogenetic limiting similarity hypothesis has rarely been examined. Here we provided a formal experimental test of the hypothesis using pairs of bacterivorous protist species in a multi-generational experiment. Consistent with the hypothesis

# Phylogenetic Diversity

- Very important for disease



# Phylogenetic diversity

- Usually relies on assumptions about evolutionary distance and traits
- Why not just measure the traits?

# Functional Diversity

# Functional Diversity

- Focuses on measurable attributes
- “Functional” refers to linkages between traits and processes
  - (we’ll talk more about this in later chapters)

# Functional Diversity

- Focuses on measurable attributes
- “Functional” refers to linkages between traits and processes
  - (we’ll talk more about this in later chapters)
- Examples:
  - Leaf area
  - Body size
  - Lifespan
  - Clutch size
  - Snout-vent length
  - Ploidy level
  - CT max / CT min

# Functional Diversity

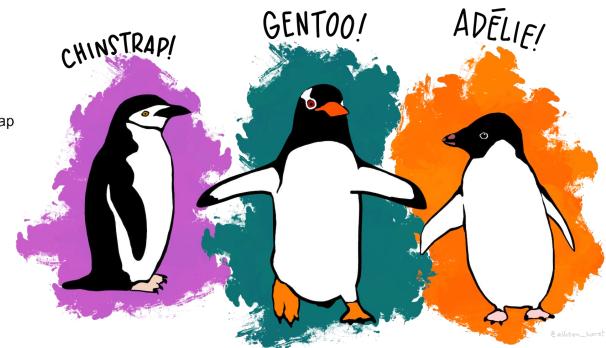
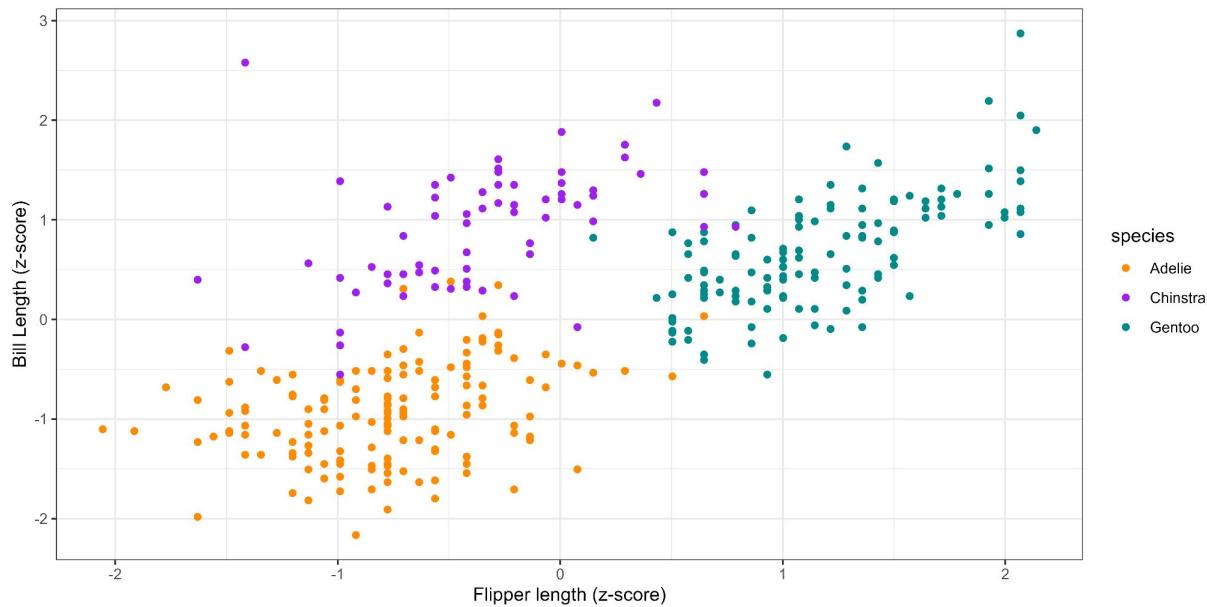
- Are any of you measuring any “functional” traits?
  - If so what and why?

# Measuring functional diversity

- Multiple approaches
- Probably the most common is the n-dimensional hypervolume approach

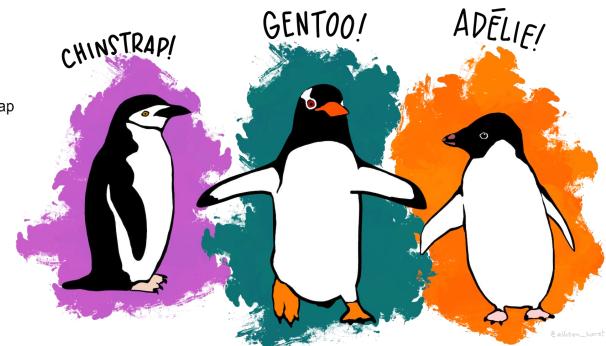
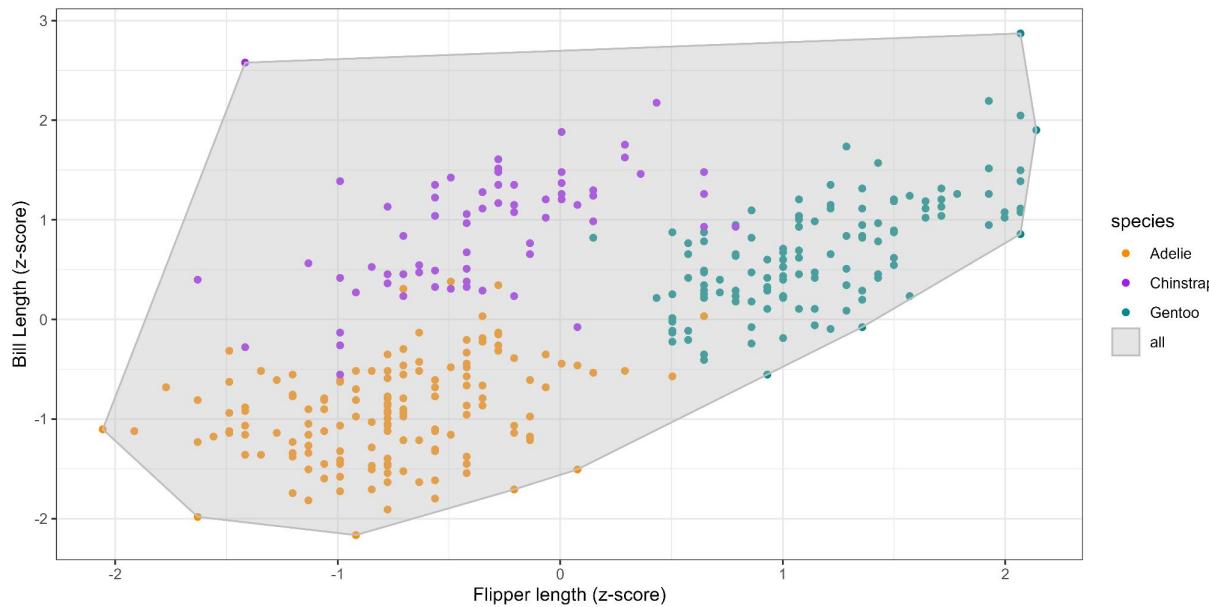
# Measuring functional diversity

- Example in 2 dimensions



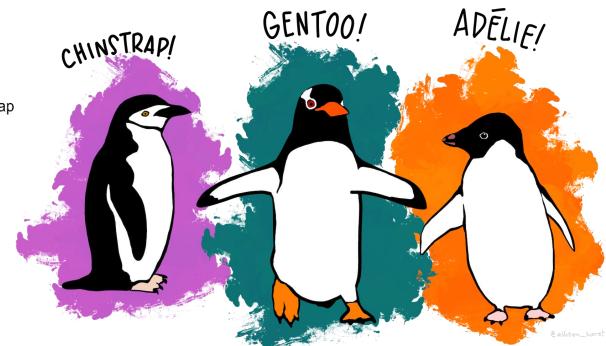
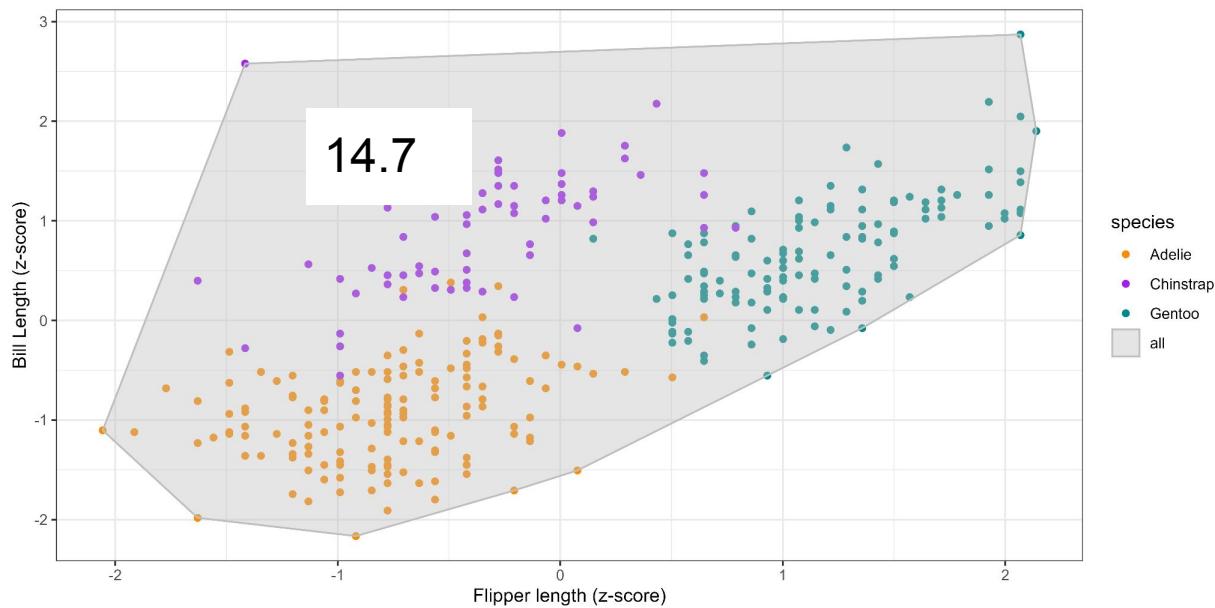
# Measuring functional diversity

- Community-level diversity



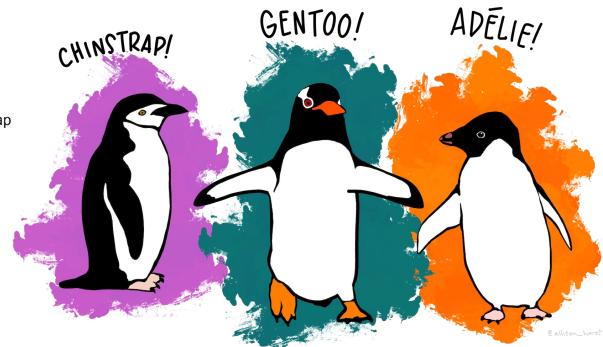
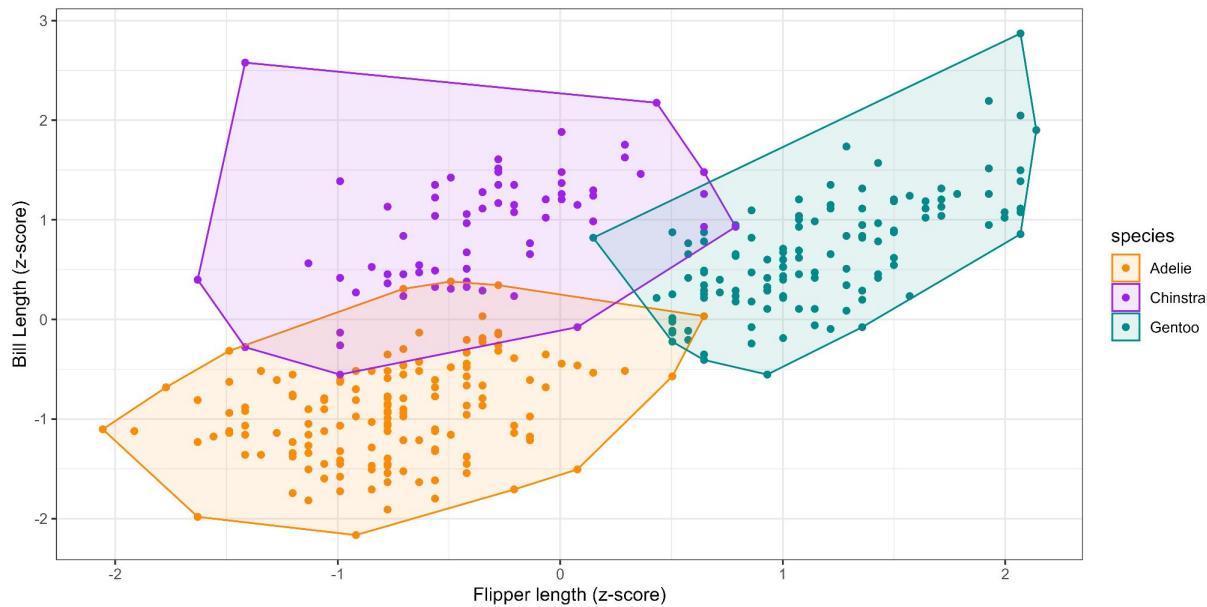
# Measuring functional diversity

- Community-level diversity



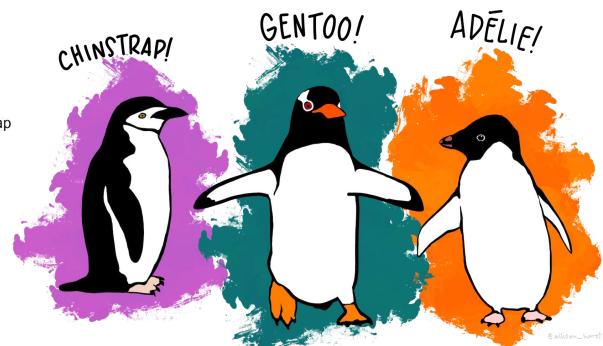
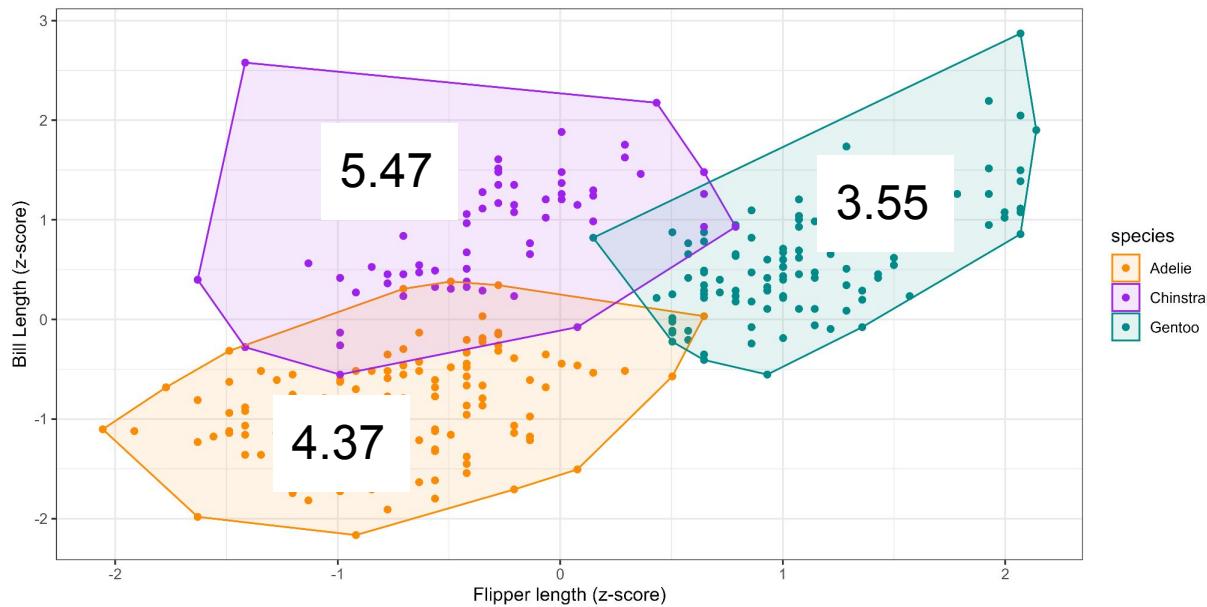
# Measuring functional diversity

- Intraspecific diversity



# Measuring functional diversity

- Intraspecific diversity



# Measuring functional diversity

- Sensitive to which traits are included
- Need to think about which traits are relevant
- Will discuss more later in the semester

# Types of diversity

- We've discussed different ways to measure diversity (e.g., function)
- There are also different TYPES of diversity: alpha, beta, gamma

# Types of diversity: alpha



$\alpha$ -diversity: local scale, n = 2

# Types of diversity: gamma



$\gamma$ -diversity: regional scale  
n = 5



# Types of diversity: beta



$\beta$ -diversity:

- It varies
- Measure of turnover

$$\beta = \gamma / \alpha$$

$$\beta = \gamma - \alpha$$

Measures of distance

etc.



# Types of diversity: beta



$$5 / 2 = 2.5$$



$$5 / 2 = 2.5$$



$$5 / 4 = 1.25$$



$\beta$ -diversity:

- It varies
- Measure of turnover

$$\beta = \gamma / \alpha$$

$$\beta = \gamma - \alpha$$

Measures of distance

etc.



$$5 / 3 = 1.7$$

# Types of diversity: beta

- Dozens of ways of measuring beta diversity
- See Anderson *et al.* for more details
- In practice, focus on what makes sense for your questions

The image shows the cover of a scientific article from the journal *Ecology Letters*. The title of the article is "Navigating the multiple meanings of  $\beta$  diversity: a roadmap for the practicing ecologist". The authors listed are Marti J. Anderson, Thomas O. Crist, Jonathan M. Chase, Mark Vellend, Brian D. Inouye, Amy L. Freestone, Nathan J. Sanders, Howard V. Cornell, Liza S. Comita, Kendi F. Davies, Susan P. Harrison, Nathan J. B. Kraft, James C. Stegen, and Nathan G. Swenson. The article is categorized under "IDEA AND PERSPECTIVE". The abstract discusses the confusion in studies of  $\beta$  diversity due to various approaches and provides a roadmap for analysis.

ECOLOGY LETTERS

*Ecology Letters*, (2011) 14: 19–28

doi: 10.1111/j.1461-0248.2010.01552.x

IDEA AND  
PERSPECTIVE

Navigating the multiple meanings of  $\beta$  diversity: a roadmap for the practicing ecologist

**Abstract**

Marti J. Anderson,<sup>1\*</sup> Thomas O. Crist,<sup>2</sup> Jonathan M. Chase,<sup>3</sup> Mark Vellend,<sup>4</sup> Brian D. Inouye,<sup>5</sup> Amy L. Freestone,<sup>6</sup> Nathan J. Sanders,<sup>7</sup> Howard V. Cornell,<sup>8</sup> Liza S. Comita,<sup>9</sup> Kendi F. Davies,<sup>10</sup> Susan P. Harrison,<sup>8</sup> Nathan J. B. Kraft,<sup>11</sup> James C. Stegen<sup>12</sup> and Nathan G. Swenson<sup>13</sup>

A recent increase in studies of  $\beta$  diversity has yielded a confusing array of concepts, measures and methods. Here, we provide a roadmap of the most widely used and ecologically relevant approaches for analysis through a series of mission statements. We distinguish two types of  $\beta$  diversity: directional turnover along a gradient vs. non-directional variation. Different measures emphasize different properties of ecological data. Such properties include the degree of emphasis on presence/absence vs. relative abundance information and the inclusion vs. exclusion of joint absences. Judicious use of multiple measures in concert can uncover the underlying nature of patterns in  $\beta$  diversity for a given dataset. A case study of Indonesian coral assemblages shows the utility of a multi-faceted approach. We advocate careful consideration of relevant questions, matched by appropriate analyses. The rigorous application of null models will also help to reveal potential processes driving observed patterns in  $\beta$  diversity.

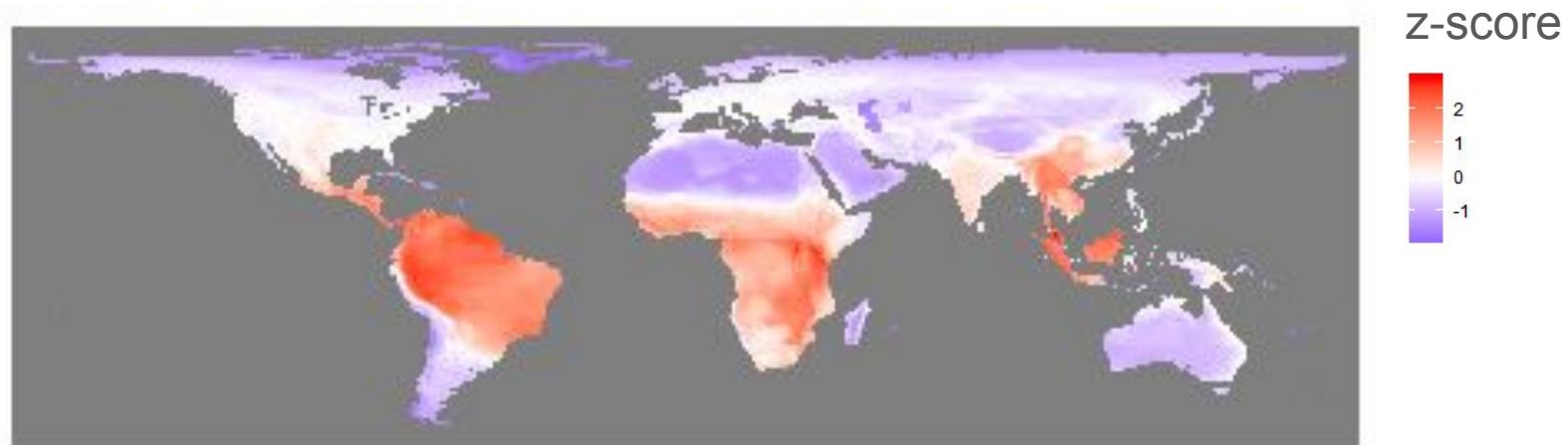
# Types of diversity across other measurements

- alpha, beta, and gamma metrics for functional and phylogenetic diversity
- beta diversity is the most variable in terms of approaches

# Other types of diversity patterns

- Increasing efforts studying phylogenetic and functional patterns
- Studying multiple types of diversity can be useful

# Mammal Phylogenetic Diversity

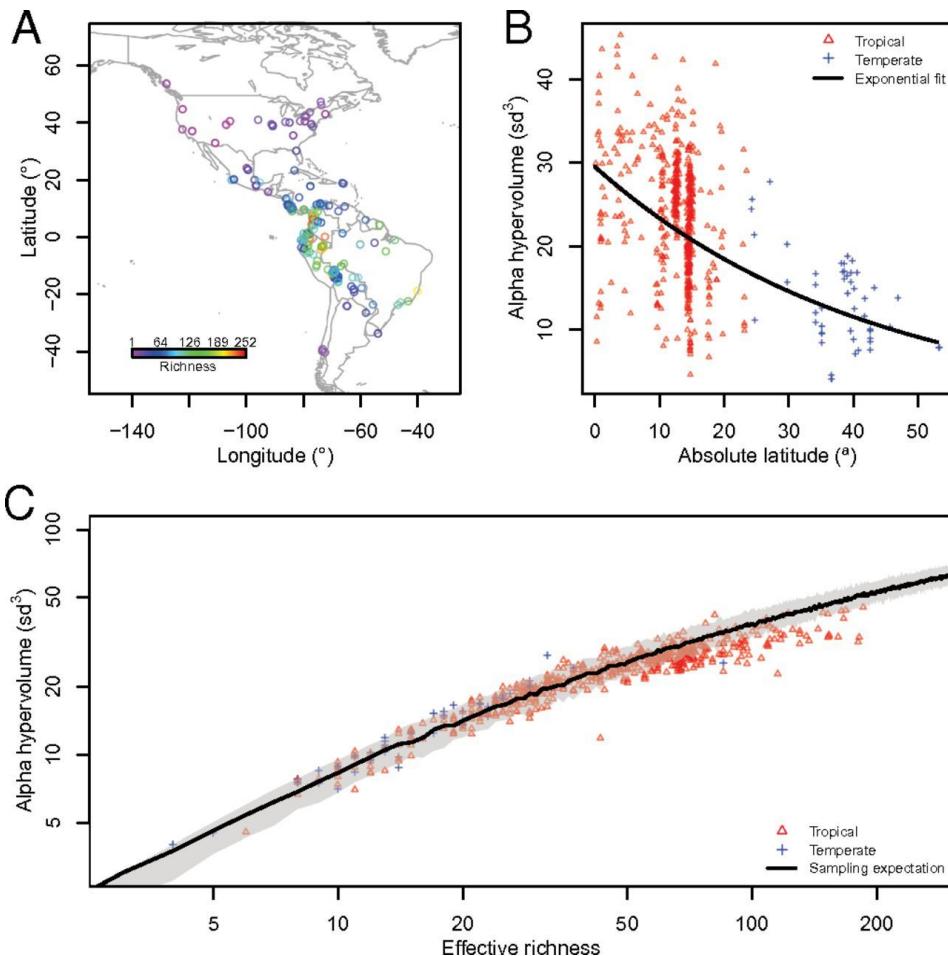


# Plant Functional Diversity

## Functional trait space and the latitudinal diversity gradient

Christine Lamanna<sup>a,1</sup>, Benjamin Blonder<sup>b,c,1</sup>, Cyrille Violle<sup>d,1,2</sup>, Nathan J. B. Kraft<sup>e</sup>, Brody Sandel<sup>f,g</sup>, Irena Šimová<sup>h</sup>, John C. Donoghue<sup>i,h</sup>, Jens-Christian Svenning<sup>j</sup>, Brian J. McGill<sup>b,j</sup>, Brad Boyle<sup>b,i</sup>, Vanessa Buzzard<sup>b</sup>, Steven Dolink<sup>k</sup>, Peter M. Jørgensen<sup>l</sup>, Aaron Marcuse-Kubitza<sup>m</sup>, Naia Morueta-Holme<sup>e</sup>, Robert K. Peet<sup>n</sup>, William H. Piel<sup>o</sup>, James Regetz<sup>m</sup>, Mark Schildhauer<sup>m</sup>, Nick Spencer<sup>p</sup>, Barbara Thiers<sup>q</sup>, Susan K. Wiser<sup>r</sup>, and Brian J. Enquist<sup>b,l,r</sup>

<sup>a</sup>Sustainability Solutions Initiative and <sup>b</sup>School of Biology and Ecology, University of Maine, Orono, ME 04469; <sup>c</sup>Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721; <sup>d</sup>Center for Macroecology, Evolution, and Climate, Copenhagen University, 2100 Copenhagen, Denmark; <sup>e</sup>Centre d'Ecologie Fonctionnelle et Evolutive, Unité Mixte de Recherche 5175, Centre National de la Recherche Scientifique–Université de Montpellier–Université Paul-Valéry Montpellier–École Pratique des Hautes Études, 34293 Montpellier, France; <sup>f</sup>Department of Biology, University of Maryland, College Park, MD 20742; <sup>g</sup>Center for Environmental and Biological Sciences, Department of Biological Sciences and <sup>h</sup>Center for Mexican Maya Archaeology, Department of Classics

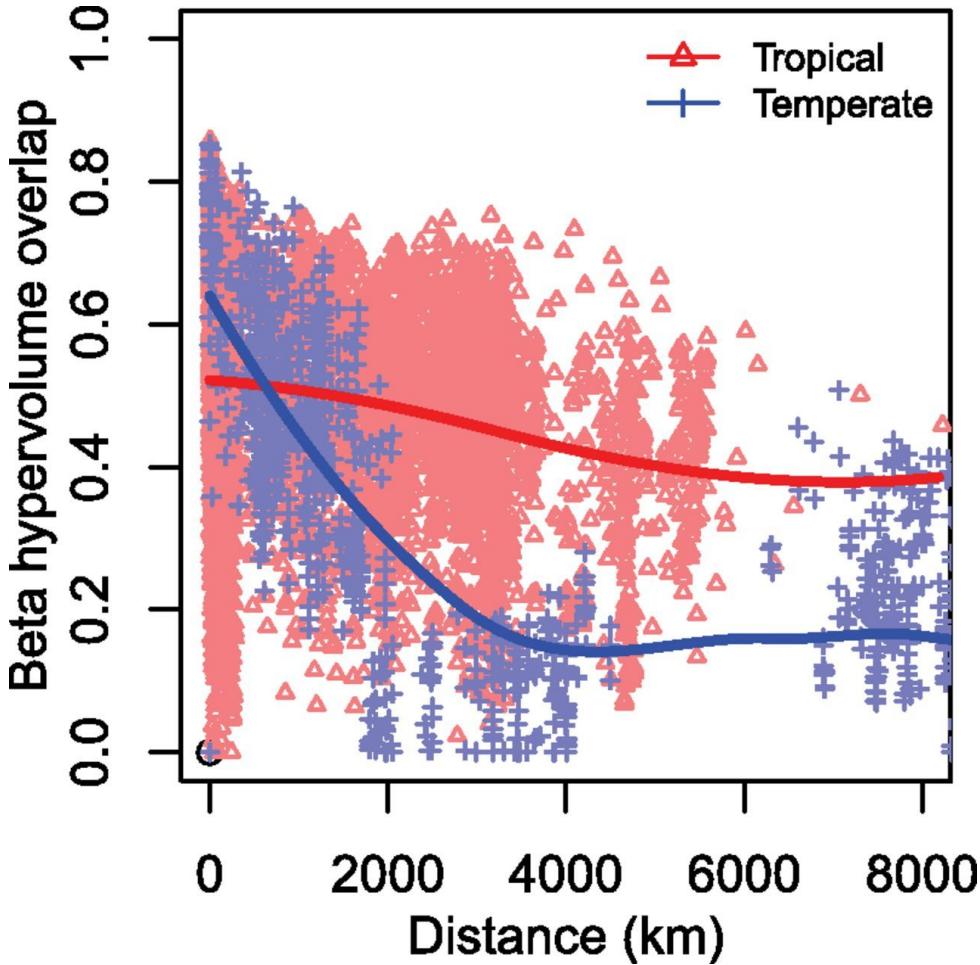


# Plant Functional Diversity

## Functional trait space and the latitudinal diversity gradient

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