Systematic variation in North American tree species abundance distributions along macroecological climatic gradients

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BIFoR Community Meeting

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Macroecology

"the subfield of ecology that deals with the study of relationships between organisms and their environment at large spatial scales to characterise and explain statistical patterns of abundance, distribution and diversity"

What is macroecology?

Biogeography

Tries to understand large scale distributions of living things

Ecology

Tries to understand interactions among organisms and (biotic and abiotic) environment

Evolutionary Biology

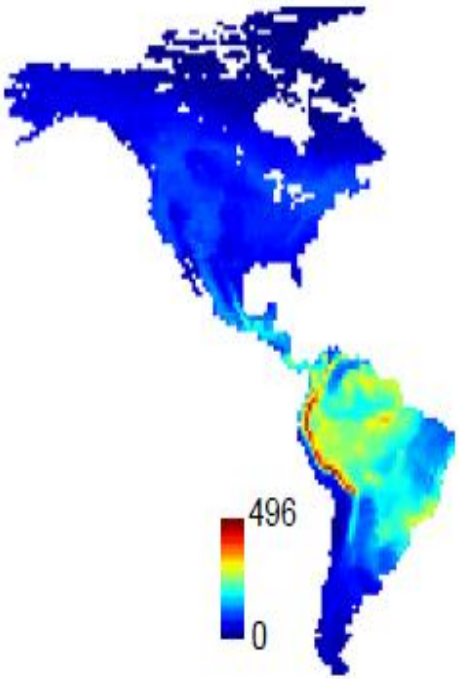
Tries to understand evolutionary processes that produced diversity of life on Earth

Macroecology

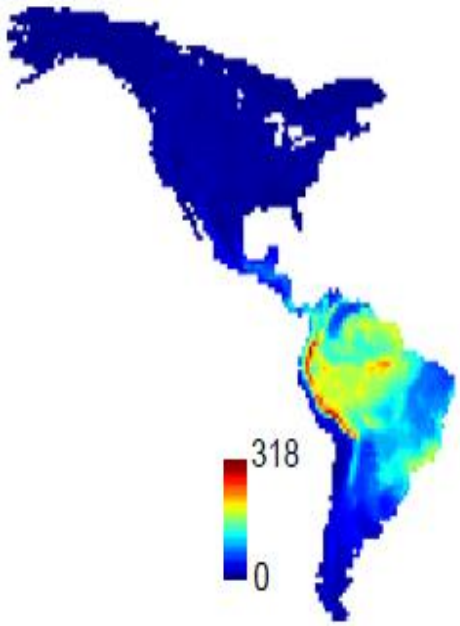
Intersects different fields of biology and tries to explain large scale ecological patterns and processes in space and time

Focuses on **explanation** and **model building** and not on simple description.

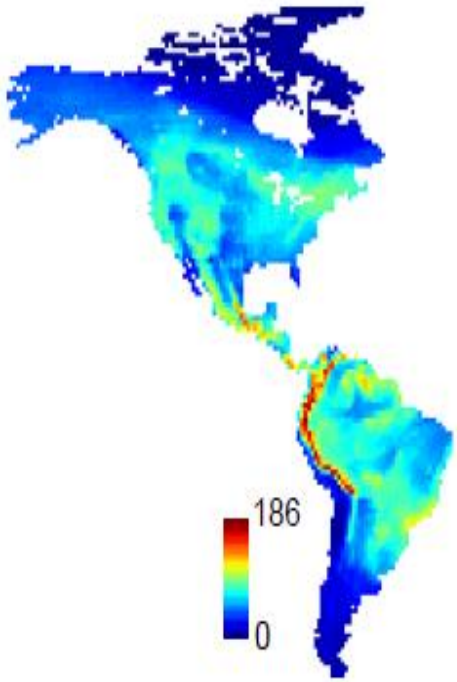
Uses natural variation as observed in nature to **disentangle process from pattern**, and identify general mechanisms or '**ecological laws**'.



Passerines



Suboscines



Oscines

Kennedy et al (2014) *Journal of Biogeography, **41,*** 1746-1757

Species Abundance Distribution

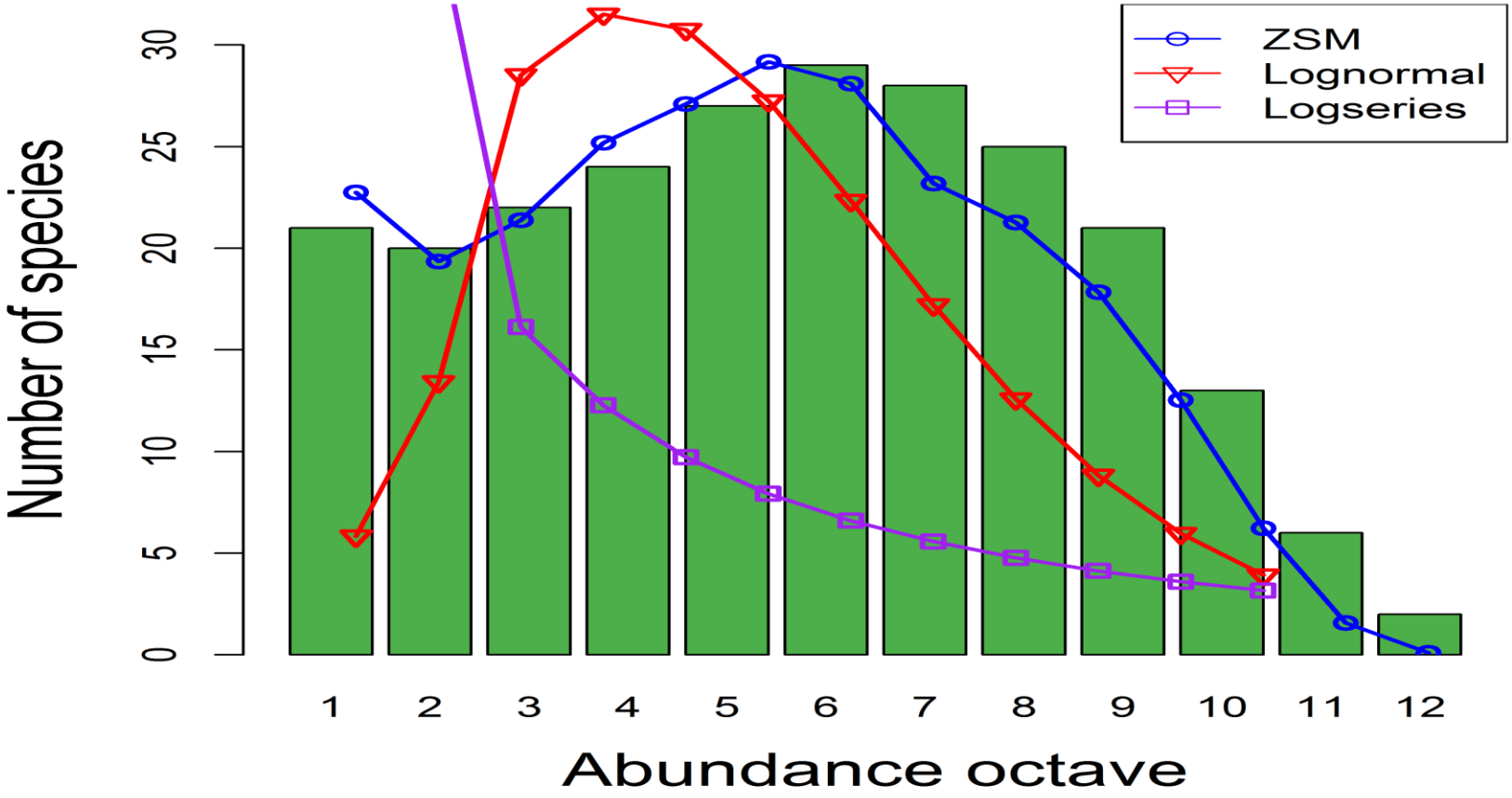
- SADs describe the abundance of all species in a sample/community for a particular taxon

50 YEARS WITH IMPACT
Journal of Applied Ecology
British Ecological Society
Journal of Applied Ecology 2015, **52**, 443–454 doi: 10.1111/1365-2664.12380

REVIEW

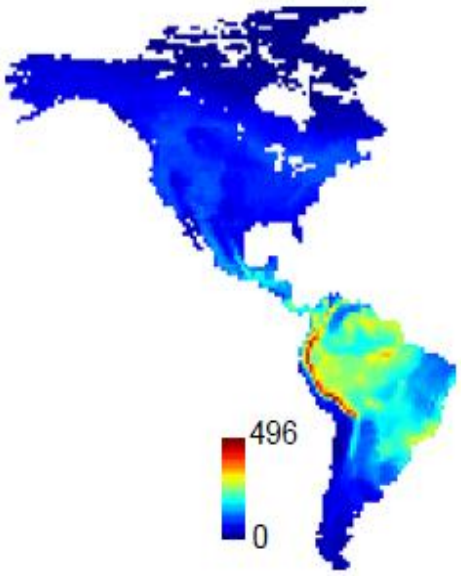
On the species abundance distribution in applied ecology and biodiversity management

Thomas J. Matthews[1,2*] and Robert J. Whittaker[1,3]



Species Abundance Distribution

- SADs describe the abundance of all species in a sample/community for a particular taxon
- The observation that ecosystems contain a few very abundant species and numerous relatively rare species is often described as one of ecology's few universal laws
- Studied for nearly 100 years – around 30 published models
- Two main approaches to studying SAD variation



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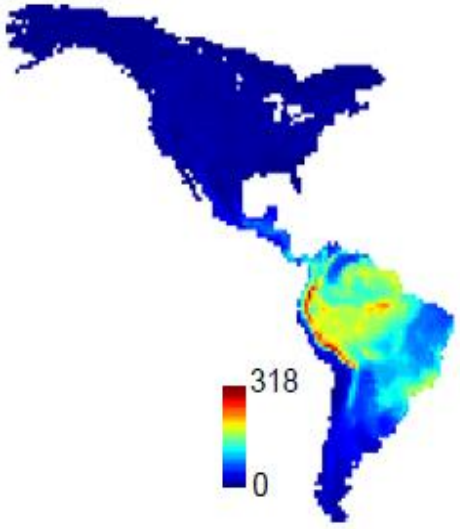

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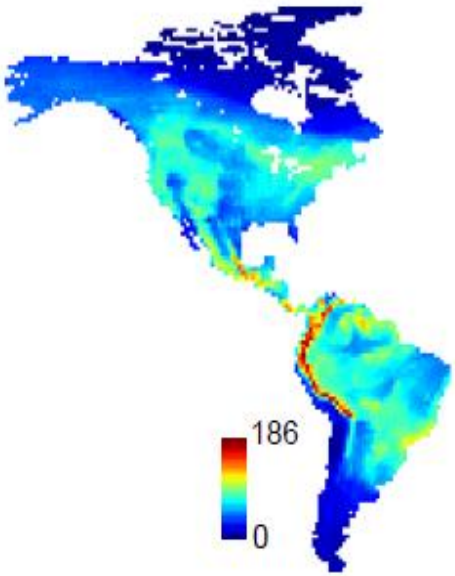
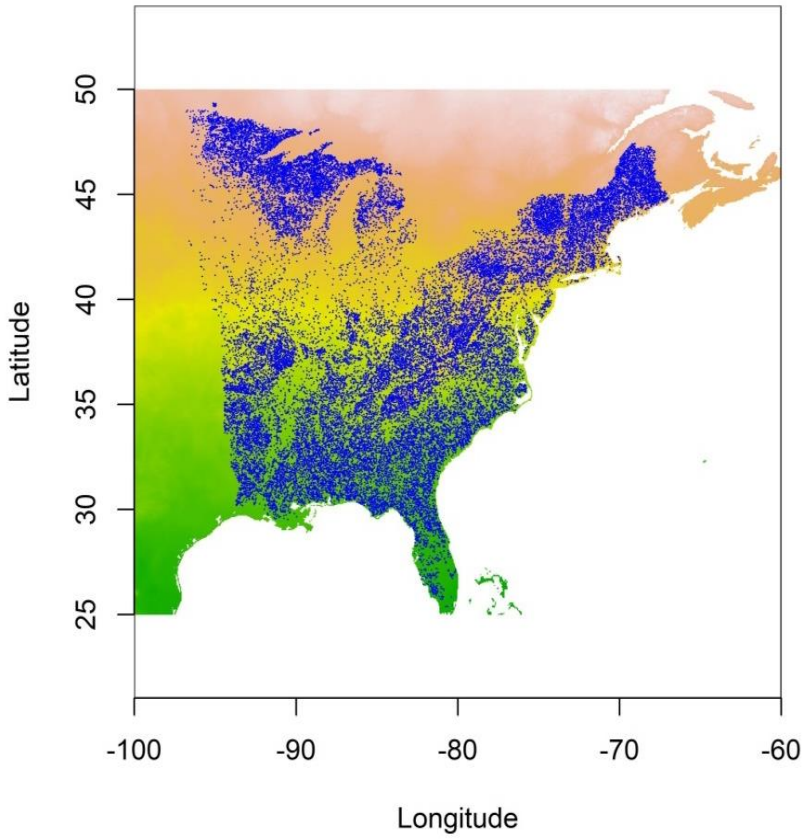


Oscines

Understanding how SADs vary spatially is important from a theoretical perspective as it enables greater understanding of what underpins the relative abundance of species

North American Forest Plot Data

- Used the FIA forest plot data - 0.10 ha macroplots
- All free-standing woody stems (live and dead) with a diameter ≥ 12.7 cm are sampled
- 33,282 plots containing 863,930 individual trees representing 214 species
- Using a ca. 44km by 44km grid square and a minimum number of individuals threshold of 500, there were 763 coarse-scale SAD samples.
- Annual mean temperature and annual mean precipitation data for each plot were sourced from the WorldClim database



Gambin Model

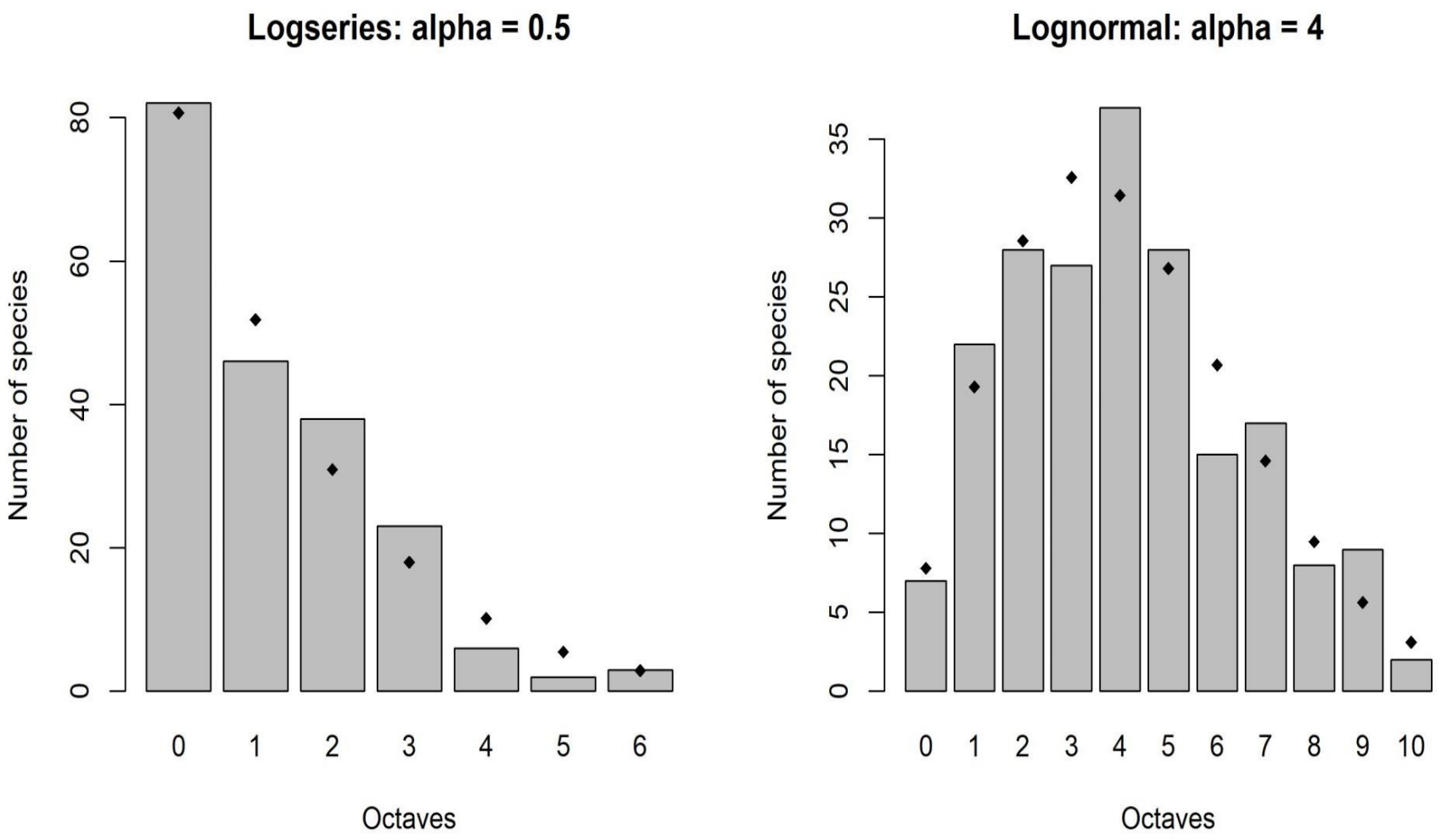
- A stochastic model which combines the gamma distribution with binomial sampling
- A very flexible distribution that can fit most empirically observed SAD shapes well
- Has a single free parameter (alpha) which characterises the shape of the distribution
- Alpha has been used as a diversity metric in comparative analyses

Ecography 37: 1002–1011, 2014
doi: 10.1111/ecog.00861

Subject Editor: Joaquin Hortal. Accepted 3 April 2014

The gambin model provides a superior fit to species abundance distributions with a single free parameter: evidence, implementation and interpretation

Thomas J. Matthews, Michael K. Borregaard, Karl I. Ugland, Paulo A. V. Borges, François Rigal, Pedro Cardoso and Robert J. Whittaker


Logseries: alpha = 0.5
Number of species
0
20
40
60
80
0
1
2
3
4
5
6
Octaves
Lognormal: alpha = 4
Number of species
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7
8
9
10
Octaves

Predictions

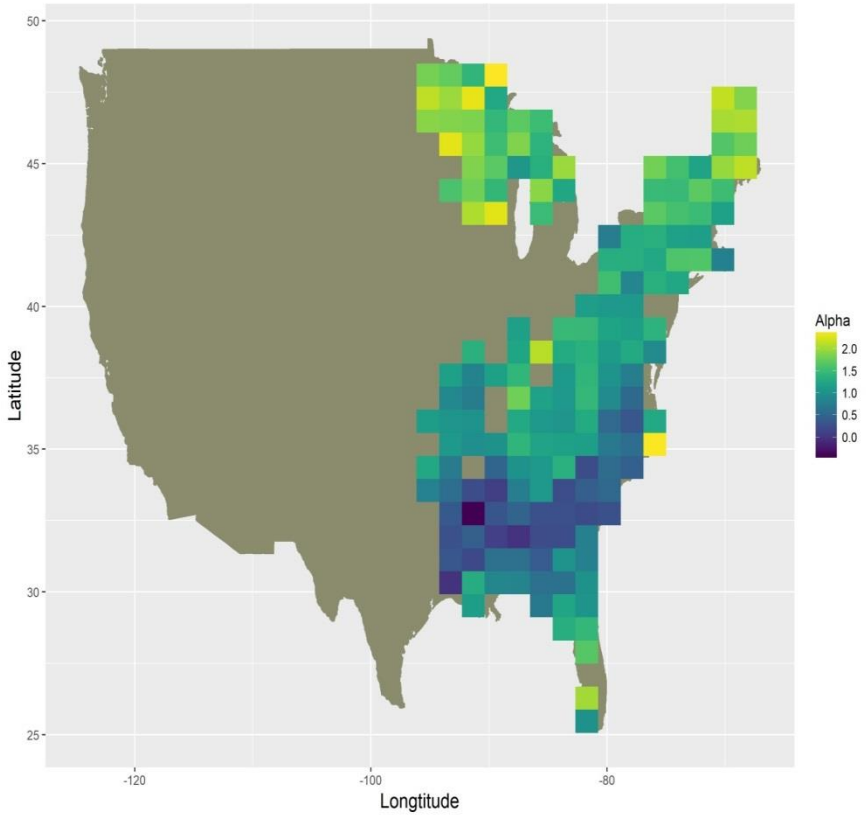
- We predicted logseries SAD shapes to be more prevalent with increasing temperature and precipitation

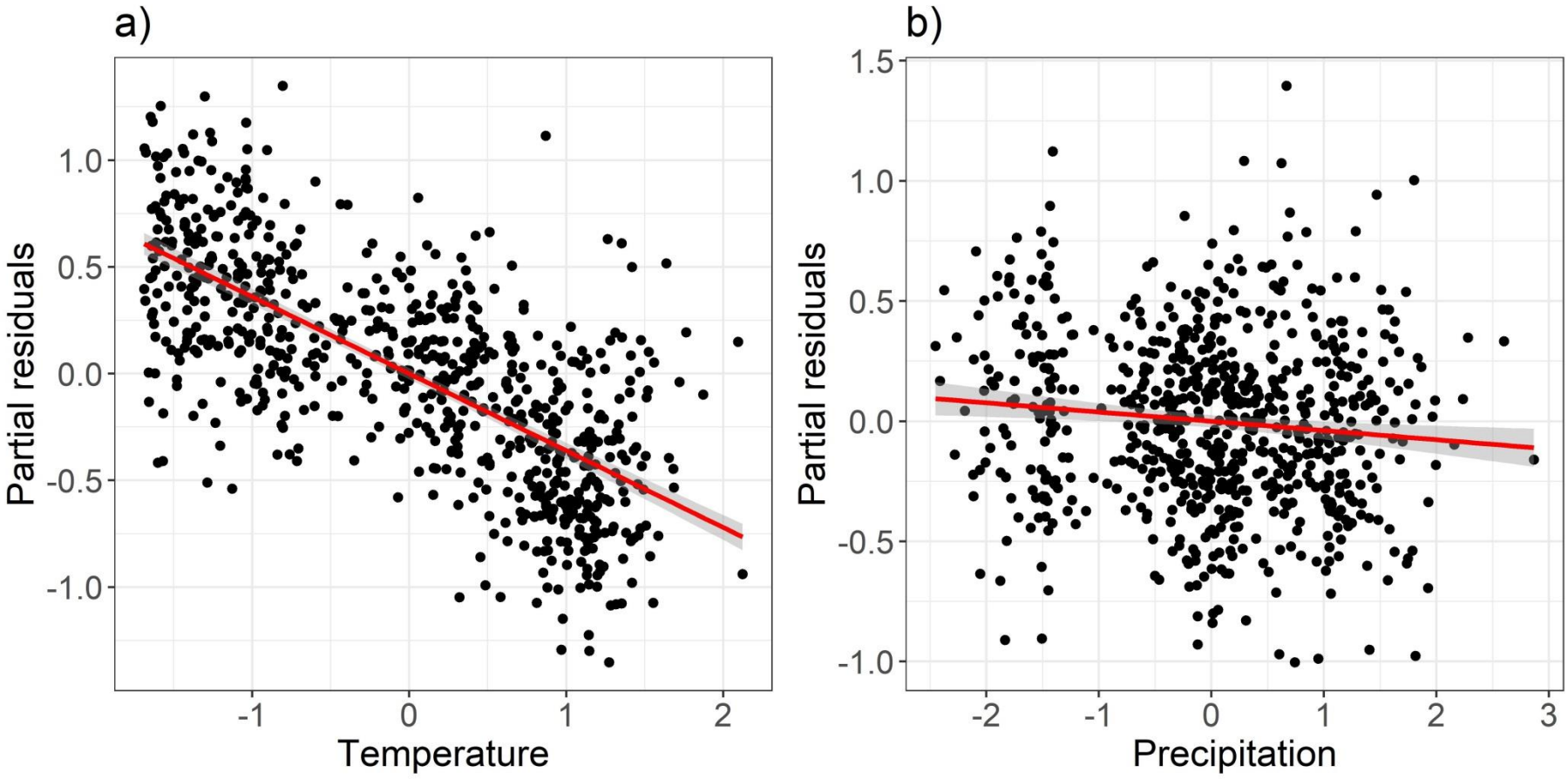
- Primary productivity correlates strongly with climatic variables, and higher energy and productivity is known to:
  - result in finer scale divisions of niche space
  - enable areas to support species at smaller minimum viable population sizes

- Also some empirical evidence that when you have more species (in a given area) then populations are smaller – if resources are limiting

Results

- There was substantial spatial variation in α
- Temperature had the largest effect on α and explained ~ two thirds of the variation
- In line with our prediction, the effect of temperature was negative; increasing temperature resulted in lower α and thus more logseries-like SADs
- Didn't find a significant effect of precipitation




a)
Partial residuals
1.0
0.5
0.0
-0.5
-1.0
-1
0
1
2
Temperature
b)
Partial residuals
1.5
1.0
0.5
0.0
-0.5
-1.0
-2
-1
0
1
2
3
Precipitation

Conclusions

- Our results indicate that temperature is a key environmental driver governing the form of ENA tree SADs at large-scales.

- Lower latitudes have more species, but also a ***higher proportion*** of species with small population sizes

- The strong role of temperature and thus energy availability implies that niche processes (e.g. niche division) may leave an imprint on the SAD

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RESEARCH PAPER

WILEY Global Ecology and Biogeography A Journal of Macroecology

Systematic variation in North American tree species abundance distributions along macroecological climatic gradients

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