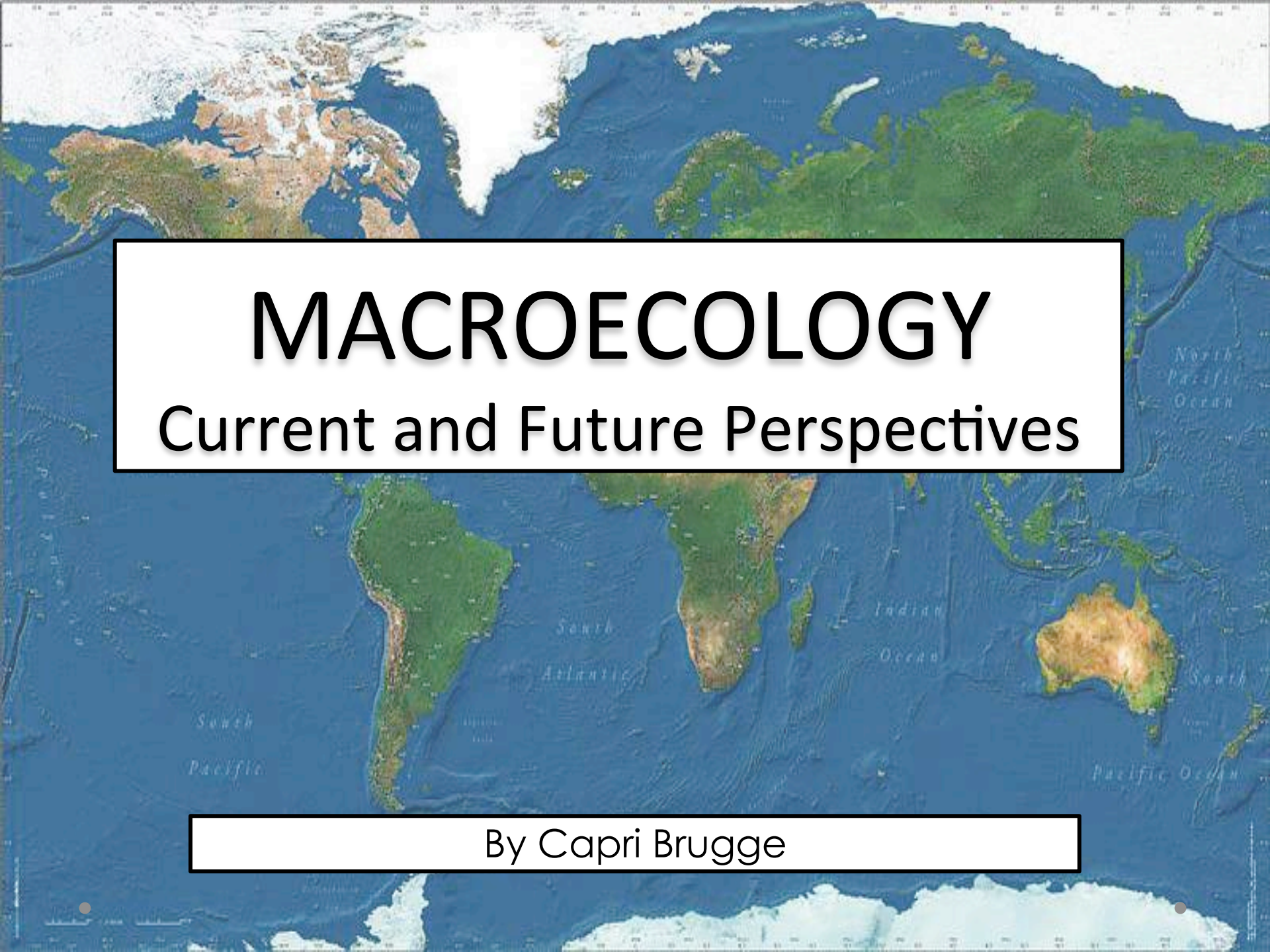


MACROECOLOGY

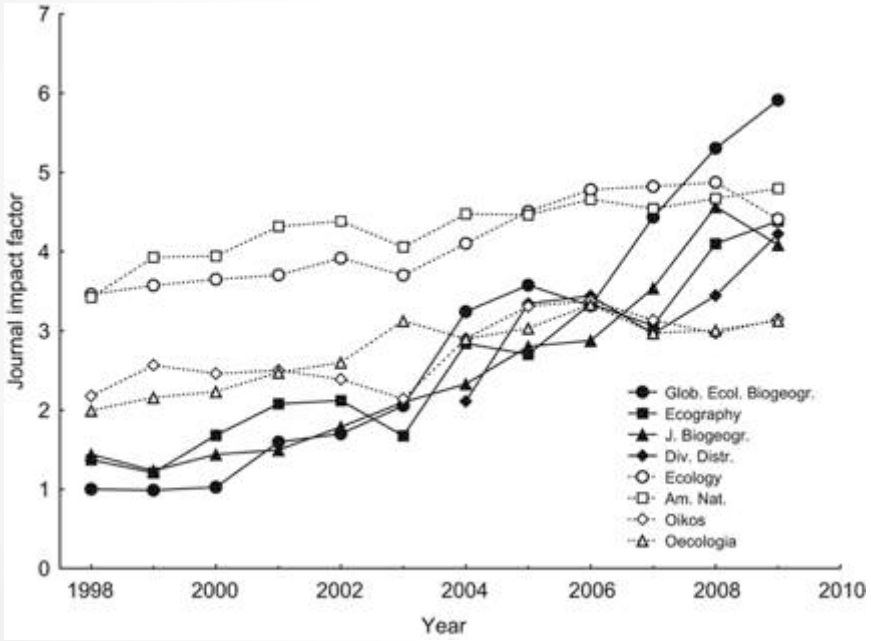
Current and Future Perspectives

By Capri Brugge

Outline

- What exactly is macroecology again?
- Where the field is at now and future direction
- 4 main challenges
- Conclusions

What is Macroecology?



- Analysis of ecological patterns and processes at large spatial and temporal scales
- Coined by Brown and Maurer in 1989
- Over the last two decades, macroecology has risen to be an influential area of study in ecology

Current themes and future direction

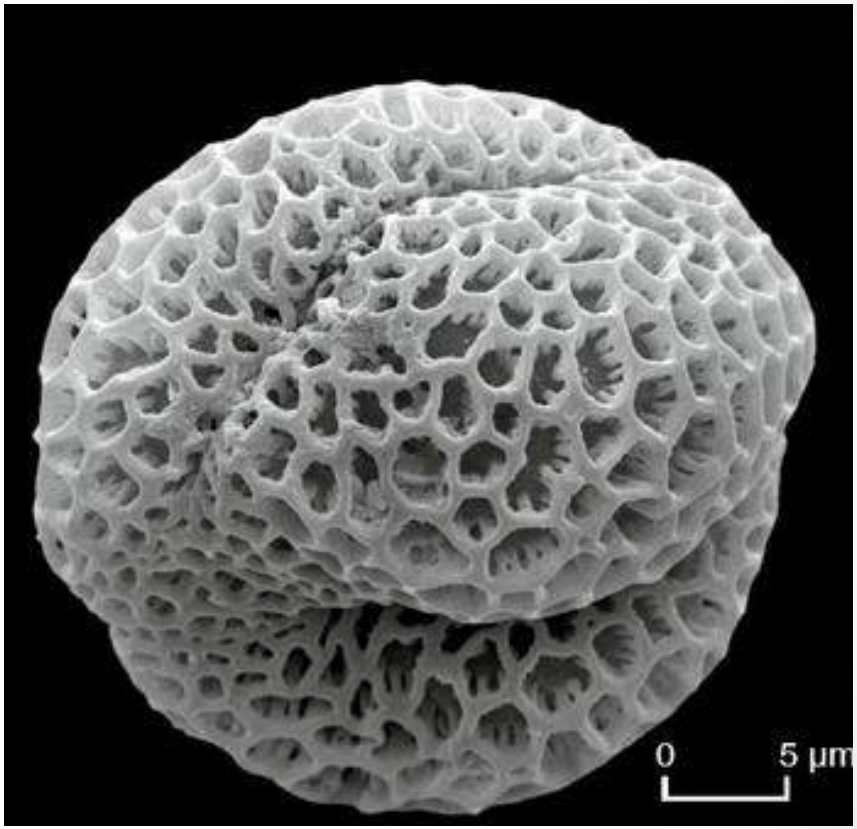
- Traditionally examines the abiotic variables and biotic responses
- Resulted in many recurrent themes
- Current research tend to focus on more complex patterns related to species distribution
- Four challenges that will determine the future of the field

Four Major Challenges

1. Role of biogeographic and phylogenetic history
2. Local processes that lead to large-scale patterns
3. Dependence on data availability
4. More statistical analyses are needed

1. Role of History

- Fluctuations in environmental conditions and phylogenetic history
- Currently studies focus on current conditions
- Anthropogenic effects distort patterns



http://www.gns.cri.nz/Home/Learning/Science-Topics/Fossils/NZ-fossils/Fossil-Plants/Spores-and-Pollen

1. Role of History

Three main avenues for integrating historical data

1. Incorporating paleo-data

- Temporal variation of patterns and trait variation
- Reconstruction abiotic and biotic conditions
- Ecological niche modeling

- Benefit from novel ways to quantify the degree of climate fluctuations

http://geology.com/articles/green-river-fossils/plant-fossils.shtml

1. Role of History

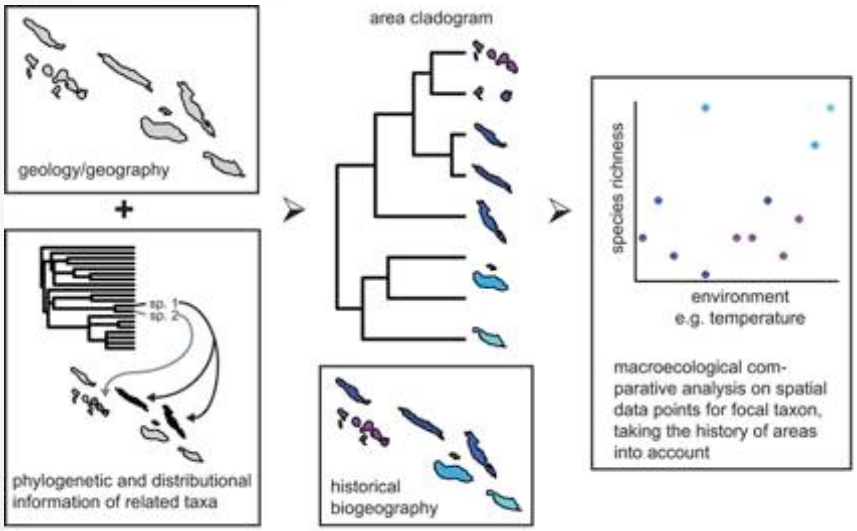
2. Integration of phylogenetic information

- Many currently used approaches
- Techniques are currently being devised
- Links between phylogenies and emergent traits
- Phylogeography allows for spatial context

- These approaches may benefit from the use of cladistic biogeography

1. Role of History

3. Integrating cladistic biogeography



- Use phylogeny to infer historical events
- Area cladograms reflect evolutionary geographic history
- Existing info should be utilized more often

Case Study

Global Ecology and Biogeography, (Global Ecol. Biogeogr.)(2009) 18, 393–405

RESEARCH PAPER

Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed *Halimeda*

Heroen Verbruggen[1]*†, Lennert Tyberghein[2]†, Klaas Pauly[2]†, Caroline Vlaeminck[2], Katrien Van Nieuwenhuyze[2], Wiebe H.C.F. Kooistra[3], Frederik Leliaert[1] and Olivier De Clerck[2]

Study aimed to characterize the evolutionary niche dynamics of the seaweed, genus *Halimeda*

- Groups of species are restricted to either the Indo-Pacific or Atlantic basins
- Habitat unsuitability or dispersal limitation?
- Used molecular phylogenetics and global satellite imagery

http://www.conservation.bm/aquatic-plants-algae/

Case Study

- Results of phylogenetic analysis revealed 5 lineages originating from an ancestral species that adapted to high surface temperature and low productivity
- Indo-Pacific species are able to inhabit Atlantic waters based on the niche prediction and vice versa
- Vicariance event likely limits dispersal
- Pooled Caribbean species reveal three hot spots

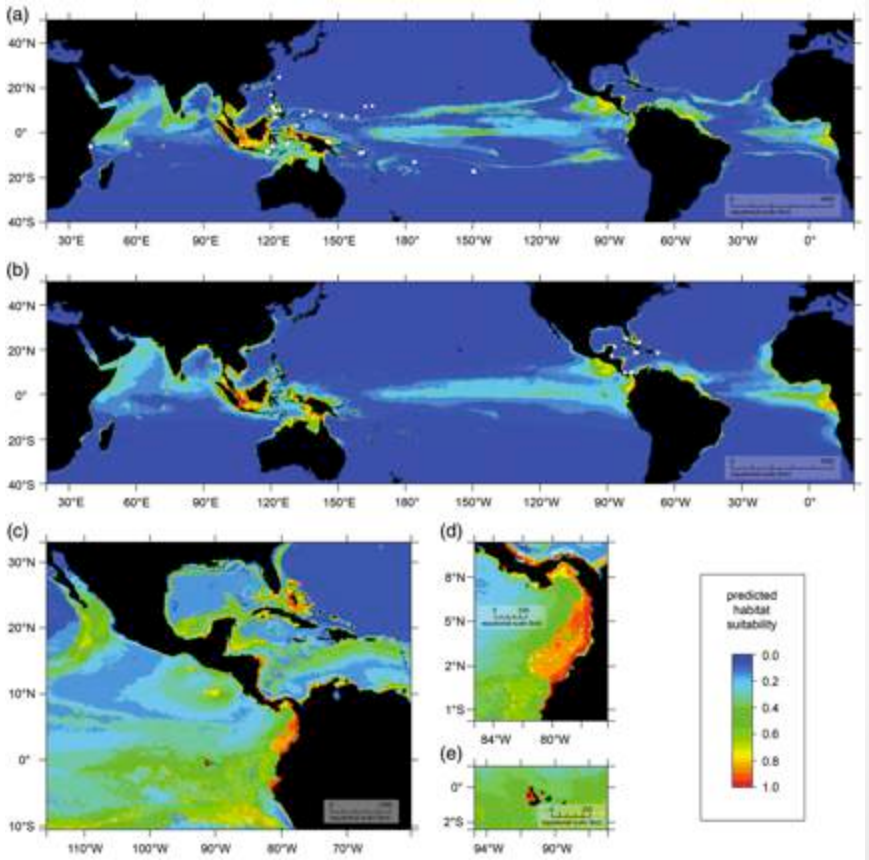


Figure3. Verbruggen et al. 2009. Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed *Halimeda*

2. Processes in macroecology

- Currently, macroecology is good at identifying patterns but is insufficient at inferring causalities
- Lack predictive power
- Processes likely act differently at different scales
- Beck et al. suggest analysis of scale-dependence, collection of standardized experimental data, process-based simulations

2. Processes in macroecology

- Interspecific competition may influence distribution

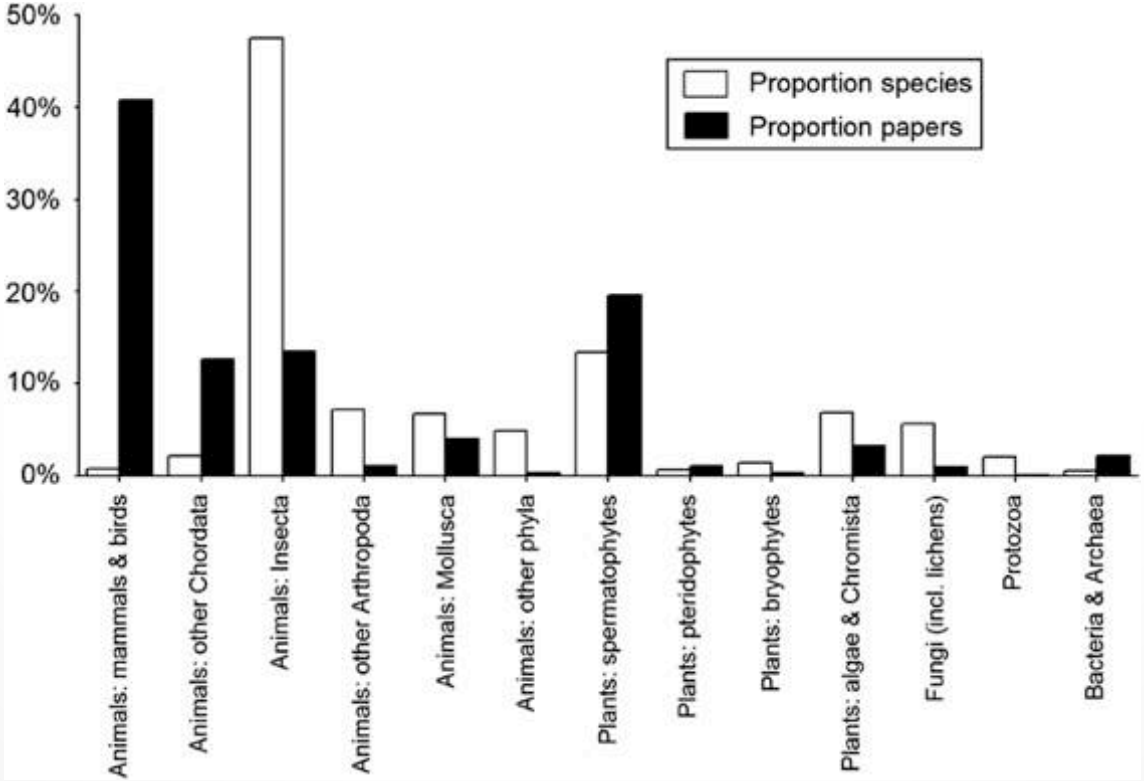
- Beck et al. suggest including ecological assembly rules, such as:
  1. Functional traits that link species to their environment
  2. Phylogeny as it takes into account evolutionary history of community structure

"…we shall find parts extremely similar in their conditions, yet it would not be possible to point out three faunas and floras more utterly dissimilar"

-Charles Darwin

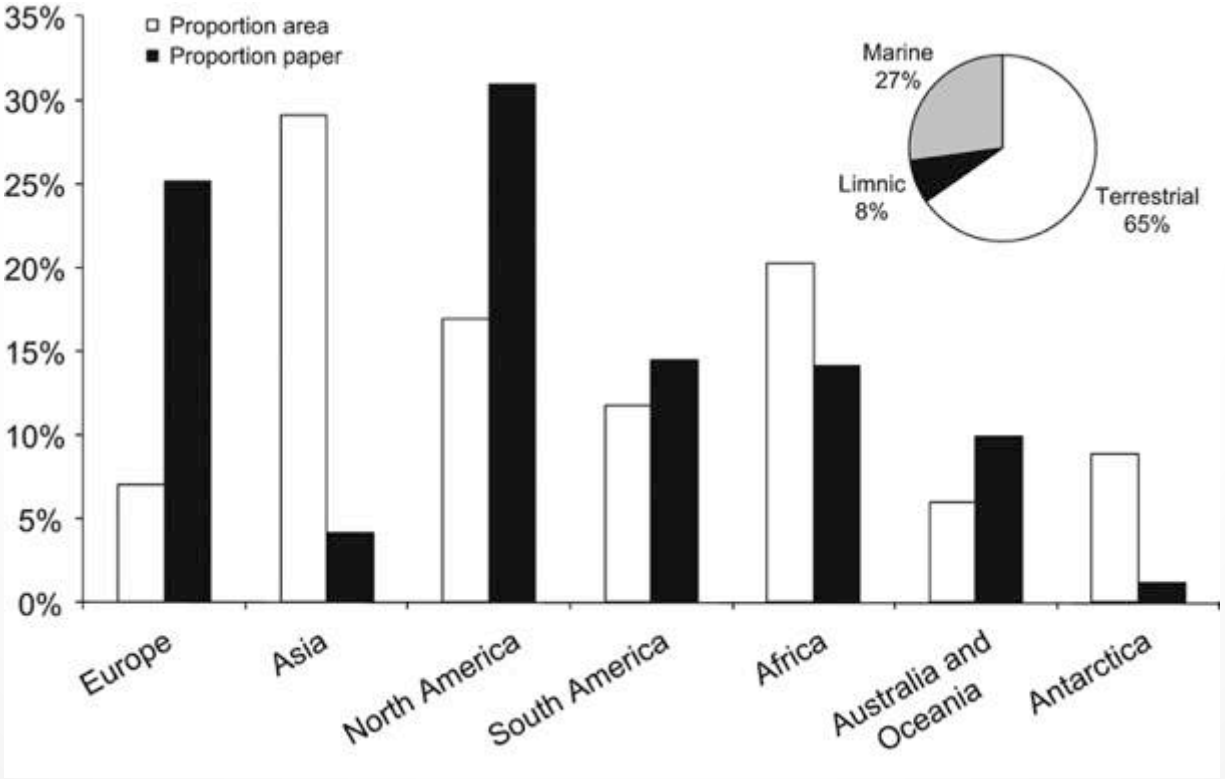
3. Data deficits and solutions

- Missing data on species traits, distributions and phylogeny make it difficult to assess patterns and processes



3. Data deficits and solutions

- Majority of studies are terrestrial
- Occur mainly in Europe and North America and less in diverse tropical regions



3. Data deficits and solutions

- Many relevant traits are not recorded

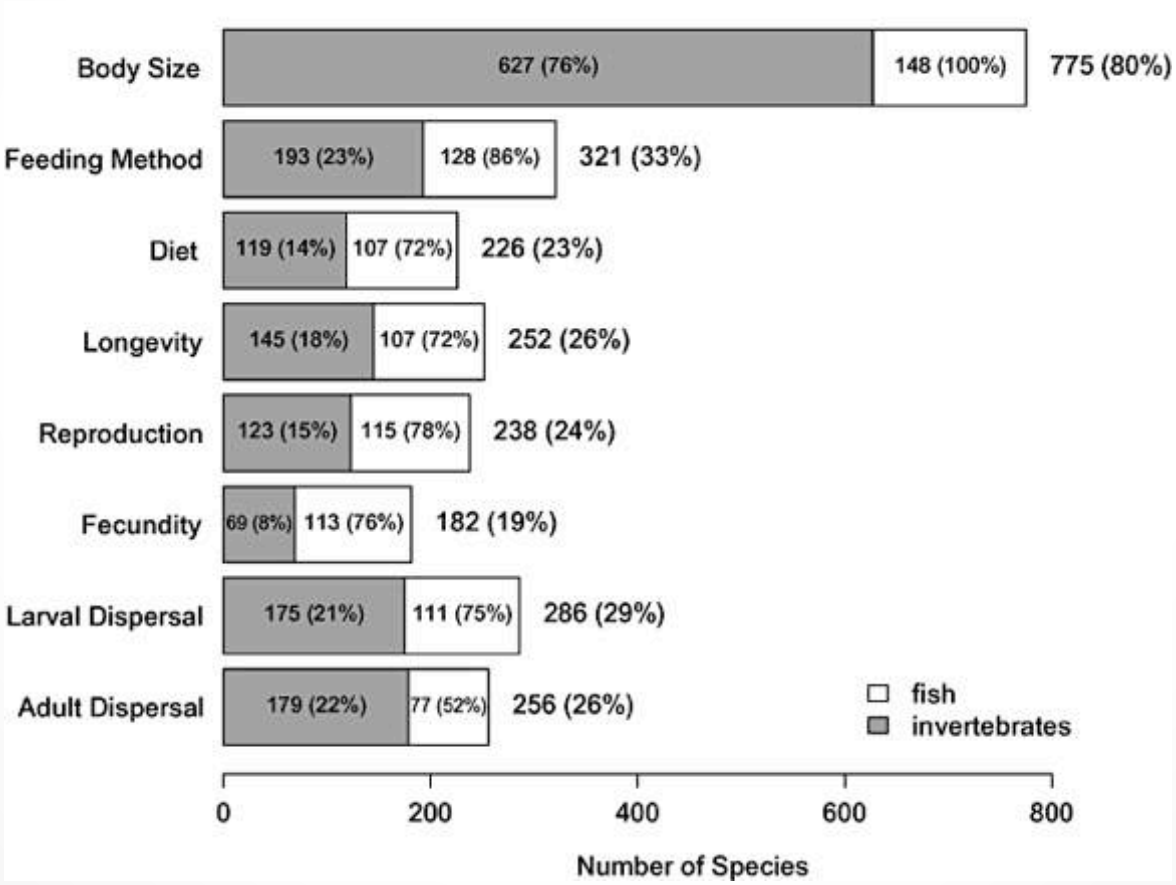
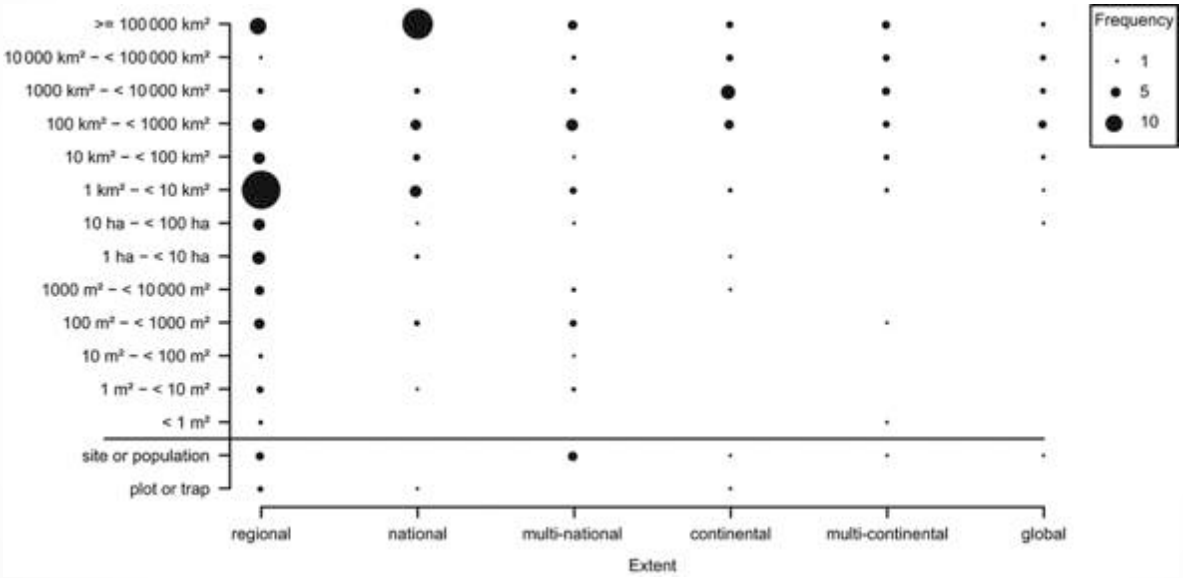


Figure 1. Tyler et al. 2011. Extensive gaps and biases in our knowledge of a well-known fauna: implications for integrating biological traits into macroecology. Global Ecology and Biogeography.

3. Data deficits and solutions

- Macroecolological studies are typically conducted at large grain size (>100km^2)



- Standardization and monitoring schemes
- Cooperation between macroecology and bioinformatics!

4. Analytical Methods

- Over the last two decades, macroecology has introduced many advanced statistical methods to ecology

- Three challenges
  1. Data Bias (stochastic processes and sampling effort)
  2. Correlated but causally hierarchical predictors (temp. vs altitude)
  3. Quantification of uncertainty

- Beck et al. suggest incorporating a Bayesian framework to statistical analyses

- Know system well enough to apply as many models as possible

Conclusions

- Macroecology faces four major challenges to it's growth as a field
- Beck *et al.* outline several solutions to each of these challenges
- With the advancement of data quality, statistical methods, and theory we will be able to move past looking at patterns and be able to test the underlying processes

References

- Beck *et al.* 2012. What's on the horizon for macroecology? Ecography. 35(8): 673-683

- Tyler et al. 2011. Extensive gaps and biases in our knowledge of a well-known fauna: implications for integrating biological traits into macroecology. Global Ecol Biogeogr. 21(9):922-934.

- Verbruggen et al. 2009. Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed *Halimeda*. Global Ecol Biogeogr. 18 (4): 393-405

Thank You!