Untangling biodiversity changes across a continuum of spatial scales

PhD Presentation

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Biodiversity changes are scale dependent

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- **Local, regional or national** trends are **not always** similar

Global meta-analysis reveals no net change in local-scale plant biodiversity over time

Mark Vellend[a,1], Lander Baeten[b,c], Isla H. Myers-Smith[a,d], Sarah C. Elmendorf[e], Robin Beauséjour[a], Carissa D. Brown[a], Pieter De Frenne[b], Kris Verheyen[b], and Sonja Wipf[f]

REPORT

Assemblage Time Series Reveal Biodiversity Change but Not Systematic Loss

MARIA DORNELAS, NICHOLAS J. GOTELLI, BRIAN MCGILL, HIDEYASU SHIMADZU, FAYE MOYES, CAYA SIEVERS, AND ANNE E. MAGURRAN Authors Info & Affiliations

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Review

CellPress

Fifteen forms of biodiversity trend in the Anthropocene

Brian J. McGill[1], Maria Dornelas[2], Nicholas J. Gotelli[3], and Anne E. Magurran[2]

ECOLOGY LETTERS

Letters | Full Access

More is less: net gain in species richness, but biotic homogenization over 140 years

Tora Finderup Nielsen, Kaj Sand-Jensen, Maria Dornelas, Hans Henrik Bruun

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$\Rightarrow$ **Dynamic processes (*i.e.* colonization, extinction, turnover...) vary with spatial scales**

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⇒ **Dynamic processes (*i.e.* colonization, extinction, turnover...) vary with spatial scales**

⇒ **Biodiversity trends have to be assessed across spatial scales**

Objectives

⇒ How are avian biodiversity changes scale dependent across Czechia?

⇒ Why do we observe this scale dependency of biodiversity changes?

Scales

- Spatial scale = Spatial grain

Scales

- Temporal scale = Temporal grain

Biodiversity data

- One dataset express the biodiversity at its specific spatial and temporal grains
- Data heterogeneity in spatial and temporal grains and extent
- Lack of data in space and time

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Problem:

With the actual data, it is not straight forward to assess biodiversity trends for a continuum of spatial scales

Spatial aggregation

Jarzyna *et al.* (2015)

Spatial aggregation

Chase *et al.* (2019)

Model

- Use biodiversity data with heterogeneous: **spatial grain, temporal grain, location, spatial extent and temporal extent**.

- Use this component as **covariates** to predict species richness at desired (spatial & temporal) grain and location (in space & time)

Interpolation of temporal biodiversity change, loss, and gain across scales: a machine learning approach

Petr Keil [1] & Jonathan M. Chase [2, 3]*

Model

In practice:

```
treeBasedModel(species richness ~ area,           -> Species-area relationship
                                  temporal grain, -> Species-time relationship
                                  latitude,       -> Location in space
                                  longitude,      -> Location in space
                                  date)           -> Location in time
```

Tree based models: the flexibility grasps the interactions between **species area/time relationship** and their location in space and time.

The species-area and species-time relationships allows to down/upscale species richness

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$\Rightarrow$ **We need data at different spatial and temporal grains**

Bird atlas of the Czech Republic

Spatial scales

Large scale dataset. Ranging from less than **100 Km** ^{2} to **80 000 Km** ^{2} (the entire Czech Republic)

Temporal scales

3 time periods, 3 different time spans:

- M2 = 1985-1989 (**5 years**)
- M3 = 2001-2003 (**3 years**)
- M4 = 2014-2017 (**4 years**)

Courtesy of Vladimír Bejček, Karel Šťastný and Ivan Mikuláš

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$\Rightarrow$ **The model homogenize the temporal grain and the sampling effort**

Courtesy of Vladimír Bejček, Karel Šťastný and Ivan Mikuláš

Breeding bird survey (BBS)

Breeding bird survey (BBS) dataset

Spatial scales: very local

Temporal scales: from 0.5 year to 10+ years

⇒ The model predict species richness for missing years

Courtesy of Jiří Reif

Richness change across scales

- For each spatial scale: predictions of species richness from 1987 to 2017
- Assessment of the species richness change per year

Richness changes across scales

Richness changes across scales

Colonization, extinction, persistence across scales

Extinction

modified from Keil et al. (2017)

Colonization, extinction, persistence across scales

Colonization

modified from Keil et al. (2017)

Colonization, extinction, persistence across scales

Colonization, extinction, persistence across scales

Similarity across scales

$$jaccard = \frac{persistence}{persistence + colonization + extinction}$$

Conclusion

This pattern:

Can be explained by the spatial scaling of dynamic processes:

- ↗ **persistence** with increasing spatial grain
- different ↘ slope of **extinction** and **colonization** with increasing spatial grain
- ↘ temporal turnover with increasing spatial grain

Conclusion

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⇒ Is this scale dependance universal? Toward a *richness change-area-relationship*?

So what has happened with bird biodiversity from the 80's through now in Czechia?

$\Rightarrow$ Even though we may not notice change at the spatial scale we experience everyday (*i.e.* local), species richness at Czechia's scale has increased

$\Rightarrow$ Increase of species richness at large scale isn't a sign of ecosystems well-being: it can be due to invasive alien species

$\Rightarrow$ Species richness is linked to high extinction debt

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Collaborators

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Thank you for your attention

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@FrsLry

FrsLry

https://frslry.github.io/

Supplementary slides

Performance

Atlas model

$XGBoost$

$R^2 = 0.77$

$MAE = 9$

BBS model

$RandomForest$

$R^2 = 0.74$

$MAE = 10$

And what about temporal scaling?

Turnover across scales

$$betasim = \frac{min(extinction, colonization)}{persistence + min(extinction, colonization)}$$