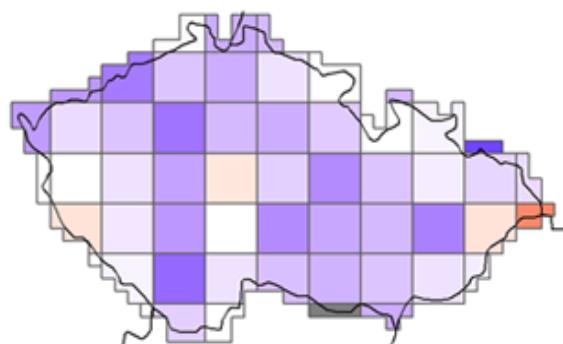
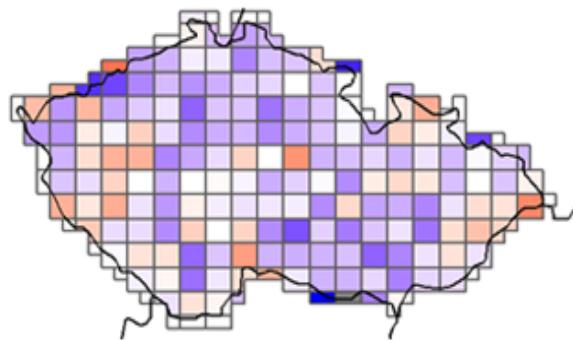
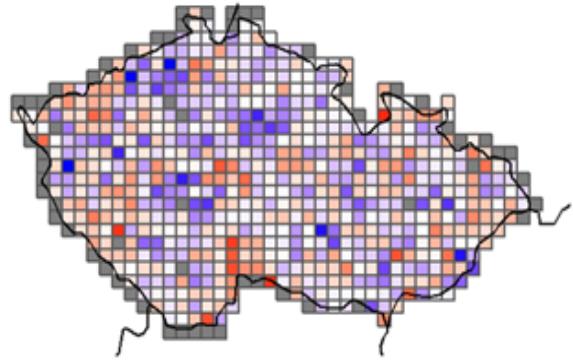


Untangling biodiversity changes across a continuum of spatial scales

PhD Presentation

PhD candidate: François Leroy
Supervisor: Petr Keil
Czech University of Life Sciences
Prague



Biodiversity changes are scale dependent

- Global biodiversity is declining

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- Global biodiversity is declining
- 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](#)

SCIENCE • 18 April 2014 • Vol 344, Issue 6181 • pp. 296-299 • DOI:10.1126/science.1248484

Review

CellPress

ECOLOGY LETTERS

Letters | Full Access

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

Fifteen forms of biodiversity trend in the Anthropocene

Brian J. McGill¹, Maria Dornelas², Nicholas J. Gotelli³, and Anne E. Magurran²

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

Biodiversity changes are scale dependent

- Global biodiversity is declining
- Local, regional or national trends are not always similar

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

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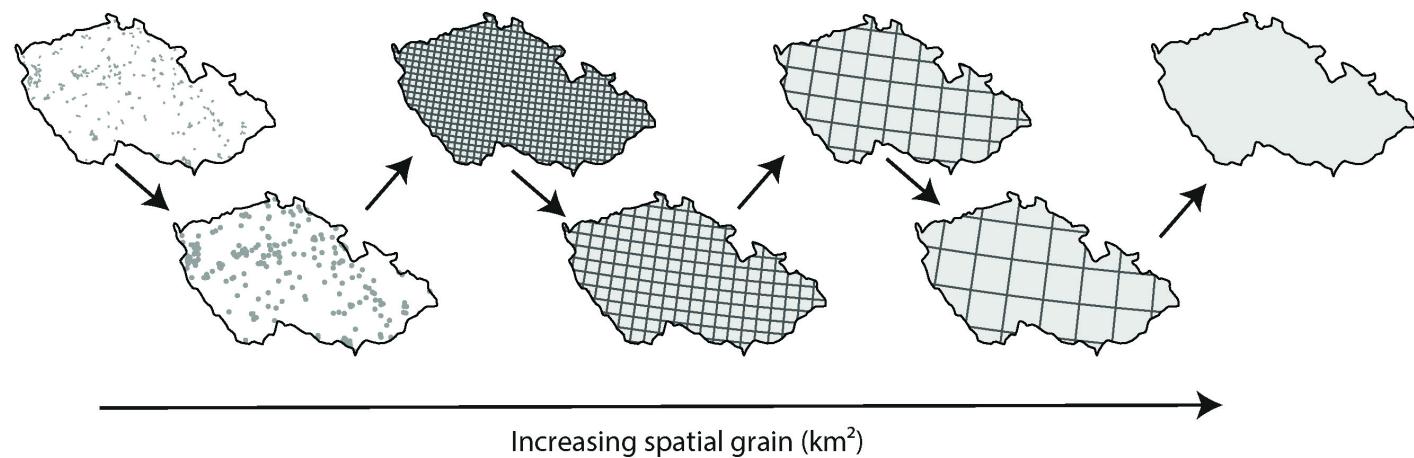
⇒ Biodiversity trends have to be assessed across spatial scales

Objectives

- ⇒ How are avian biodiversity changes scale dependent across Czechia?
- ⇒ Why do we observe this scale dependency of biodiversity changes?

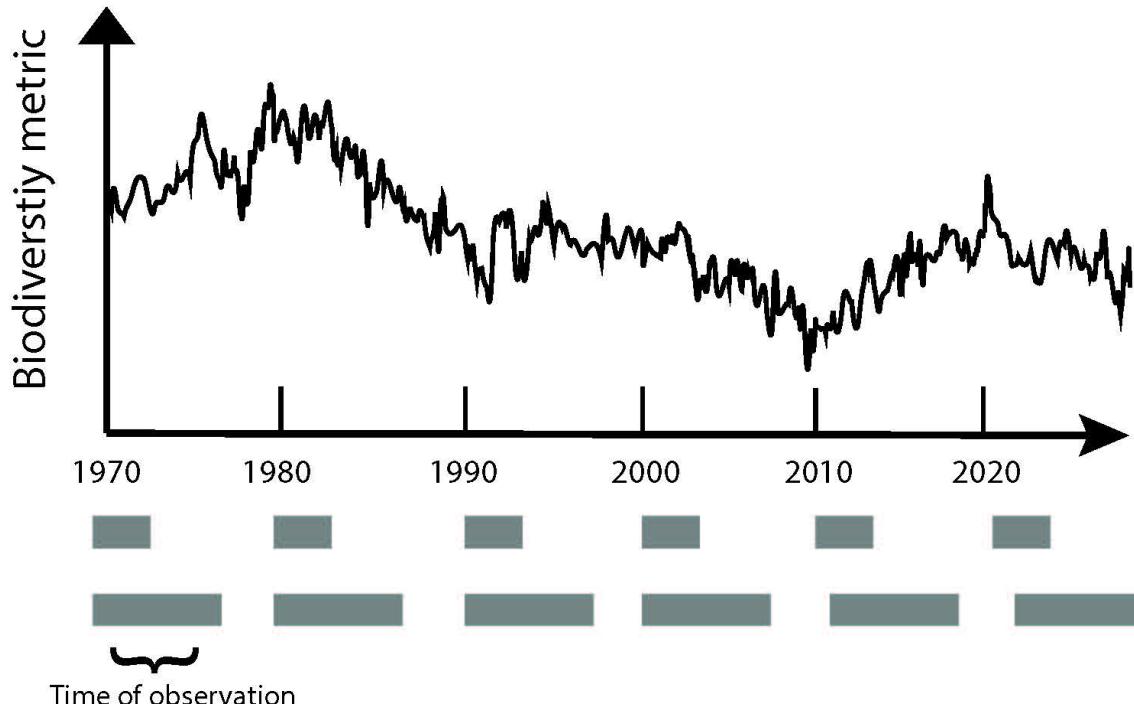
Scales

- 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

Biodiversity data

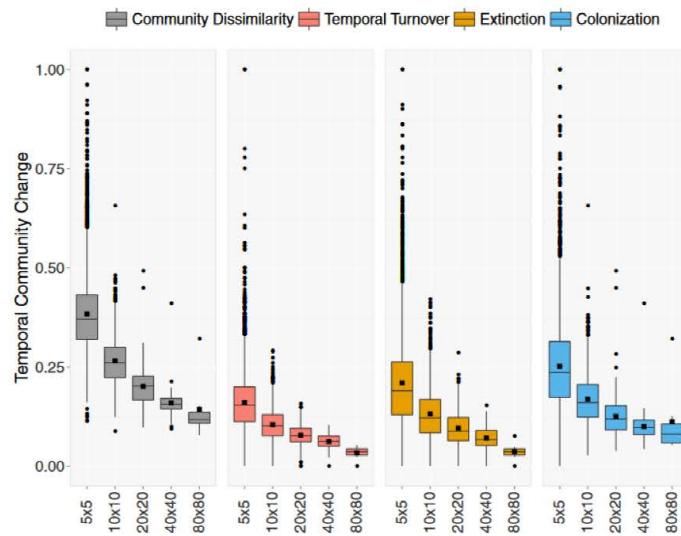
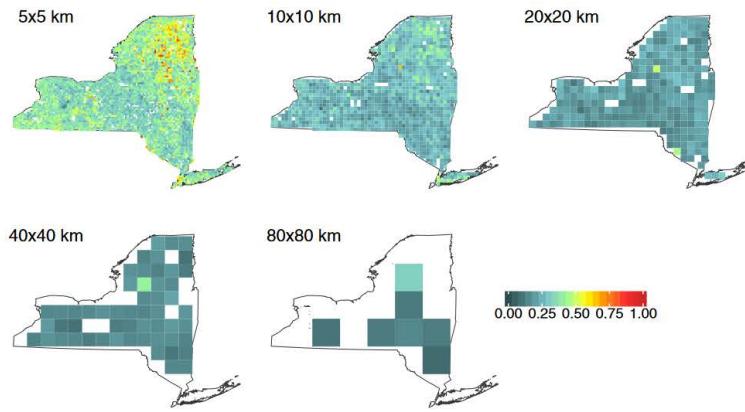
- One dataset express the biodiversity at its specific spatial and temporal grains
- Data heterogeneity in spatial and temporal grains and extent
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Problem:

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

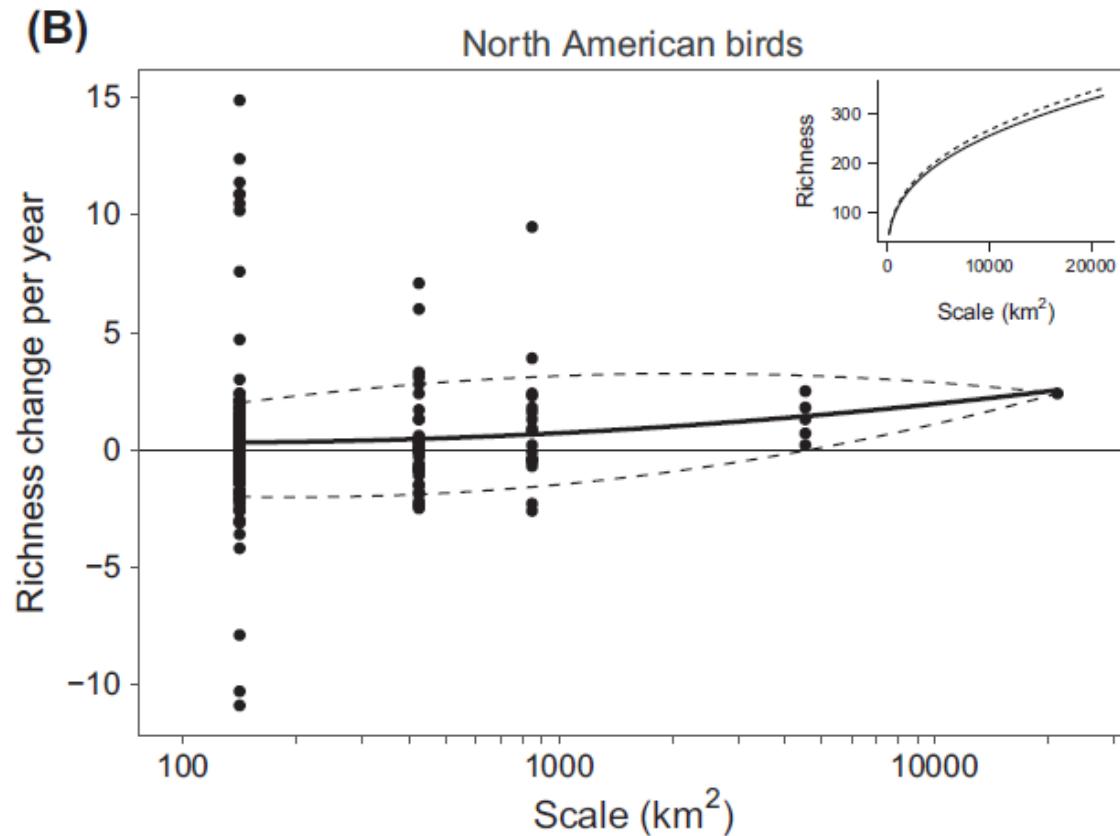
Spatial aggregation

Jarzyna *et al.* (2015)



Spatial aggregation

Chase *et al.* (2019)



Model

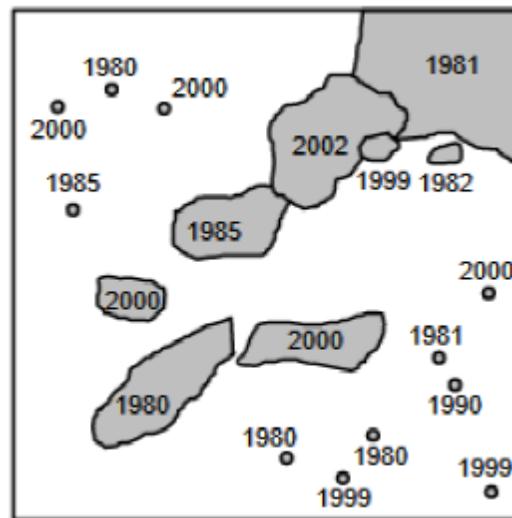
- Use biodiversity data with heterogeneous: **spatial grain, temporal grain, location, spatial extent and temporal extent.**
- Use this component as **covariates** to predict species richness at desired (spatial & temporal) grain and location (in space & time)

Keil & Chase

Interpolation of biodiversity change

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

Petr Keil ^{1*} c/o Jonathan M. Chase ^{2,3}



Model

In practice:

```
treeBasedModel(species richness ~ area,  
temporal grain,  
latitude,  
longitude,  
date)      -> Species-area relationship  
           -> Species-time relationship  
           -> Location in space  
           -> Location in space  
           -> 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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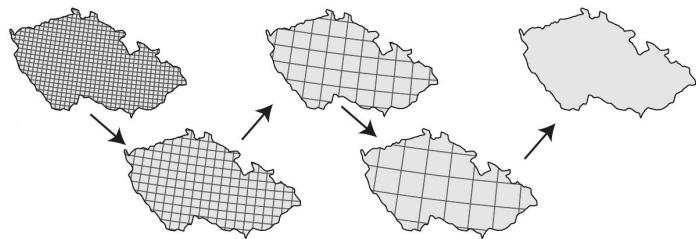
The species-area and species-time relationships allows to down/upscale species richness

⇒ **We need data at different spatial and temporal grains**

Bird atlas of Czech Republic

Spatial scales

Large scale dataset. Ranging from less than **100 Km²** to **80 000 Km²** (the entire Czech Republic)



Temporal scales

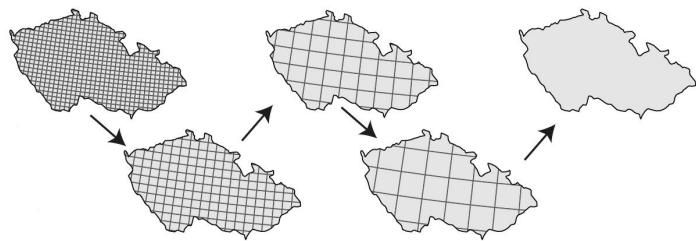
3 time periods, 3 different time spans:

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

Bird atlas of Czech Republic

Spatial scales

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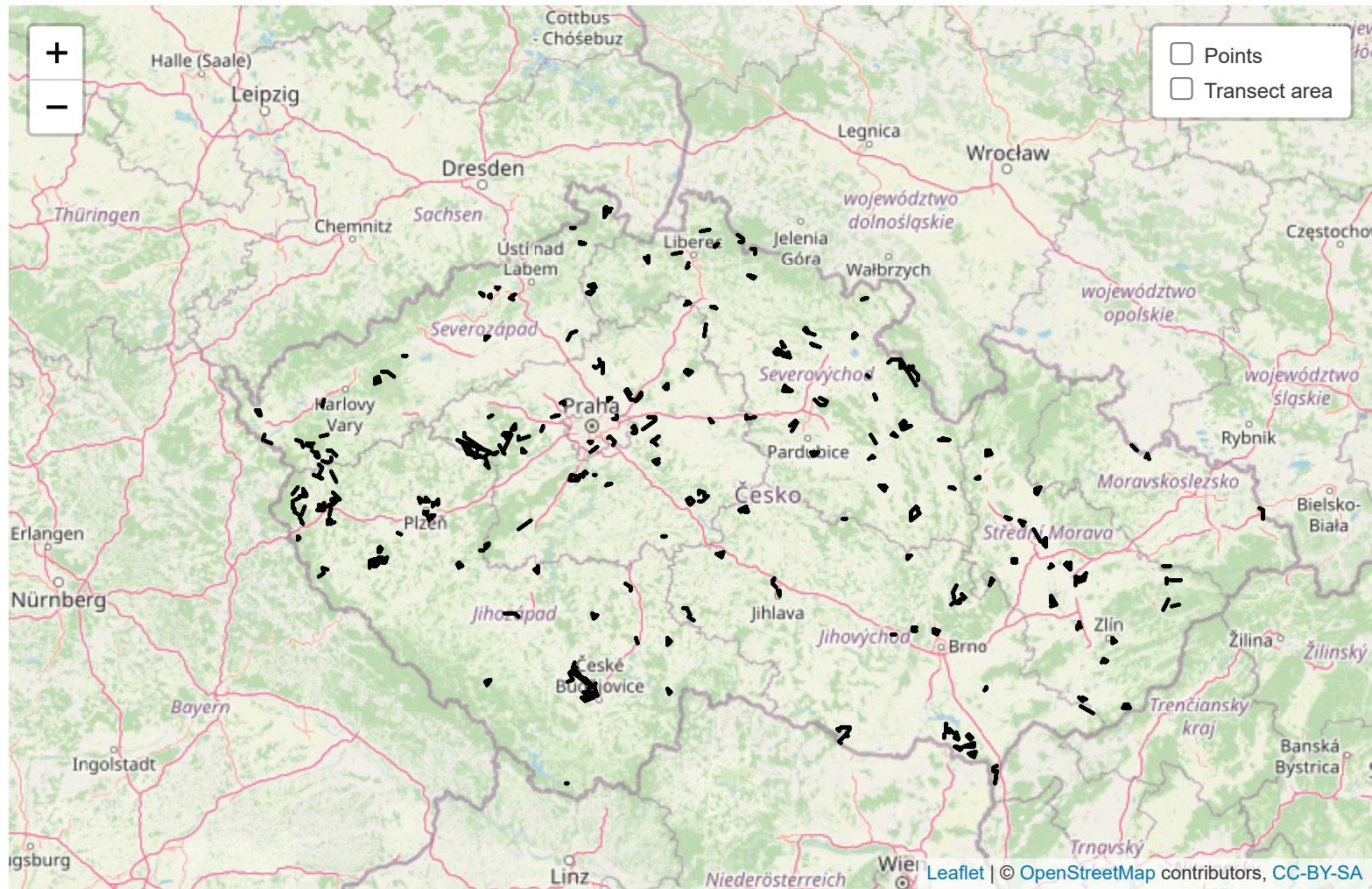
Temporal scales

3 time periods, 3 different time spans:

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

⇒ The model homogenize the temporal grain and the sampling effort

Breeding bird survey (BBS)

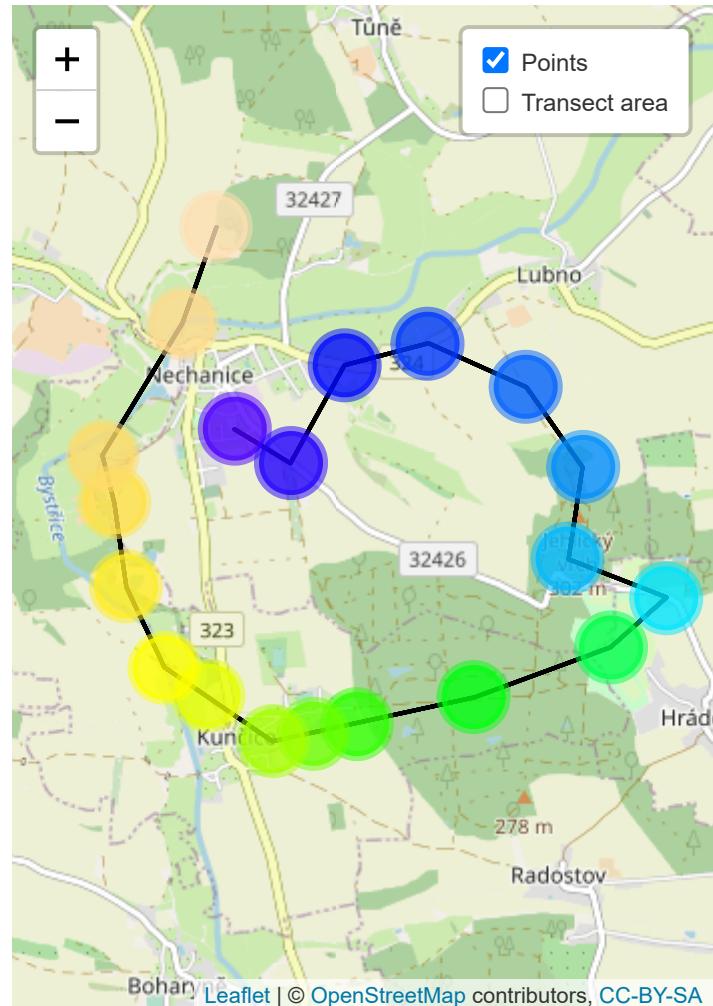


Breeding bird survey (BBS) dataset

Spatial scales: very local

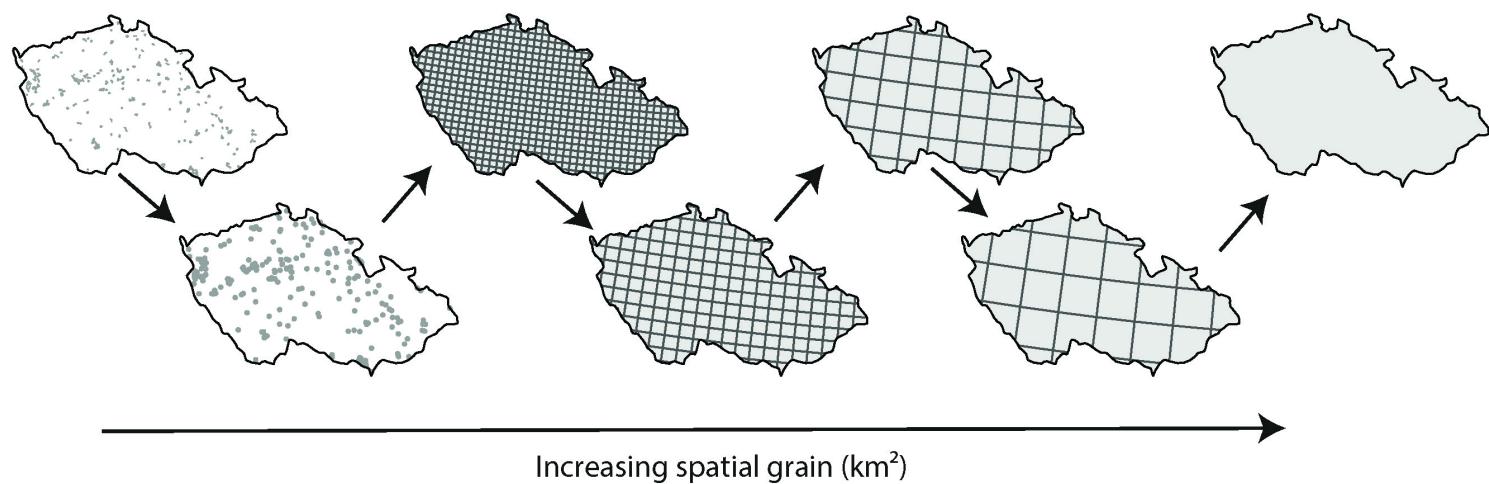
Temporal scales: from 0.5 year to 10+ years

⇒ The model predict species richness for missing years

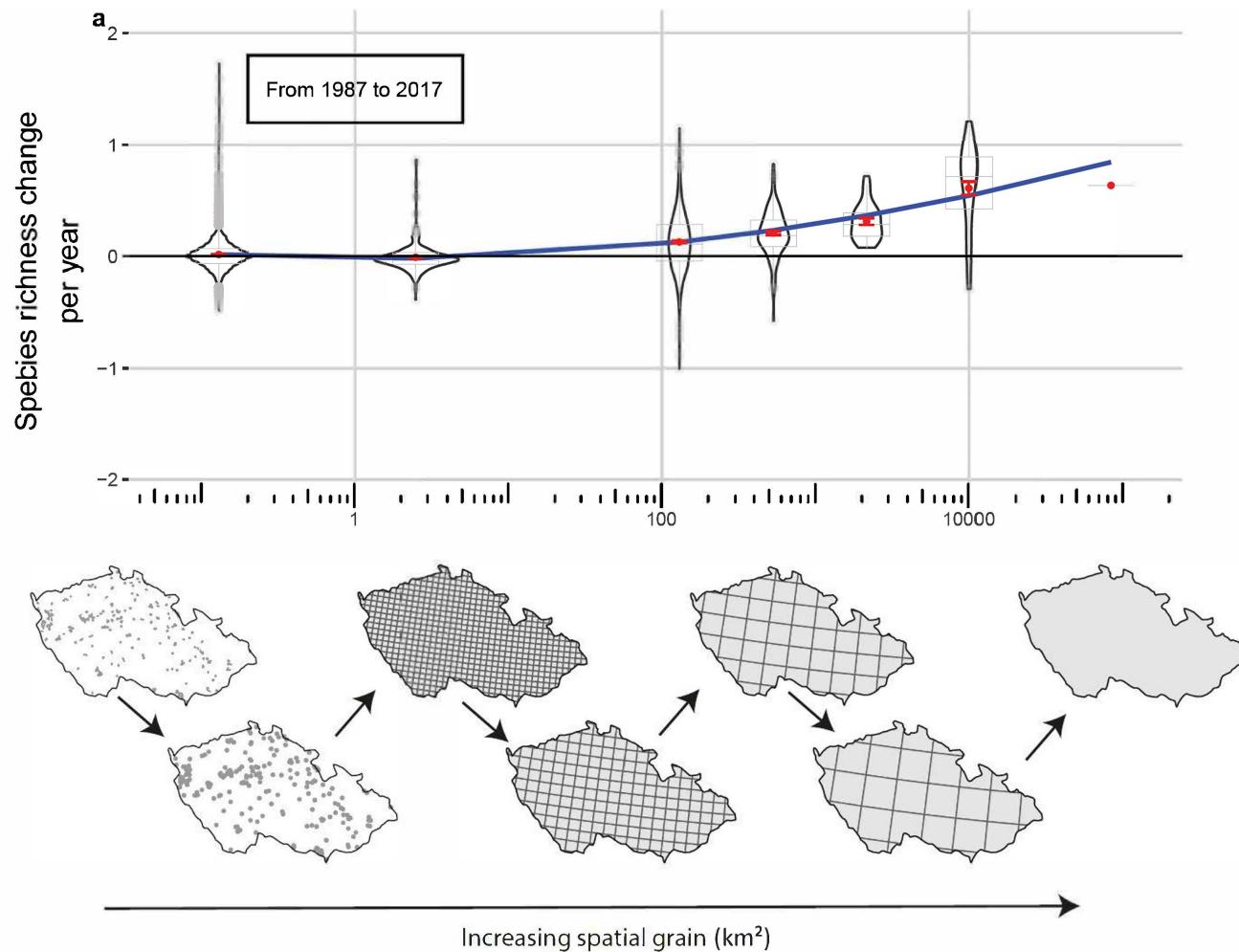


Richness change across scales

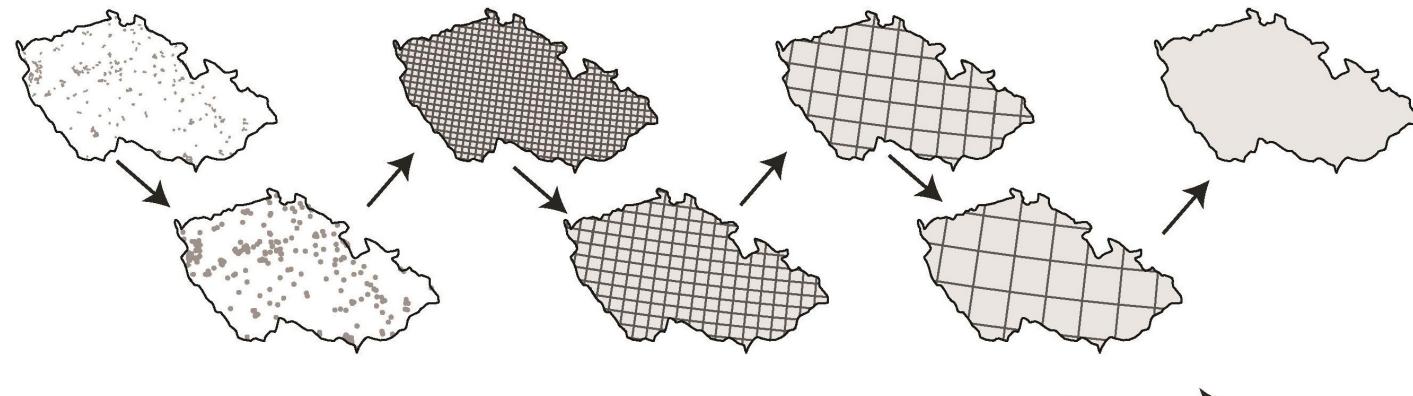
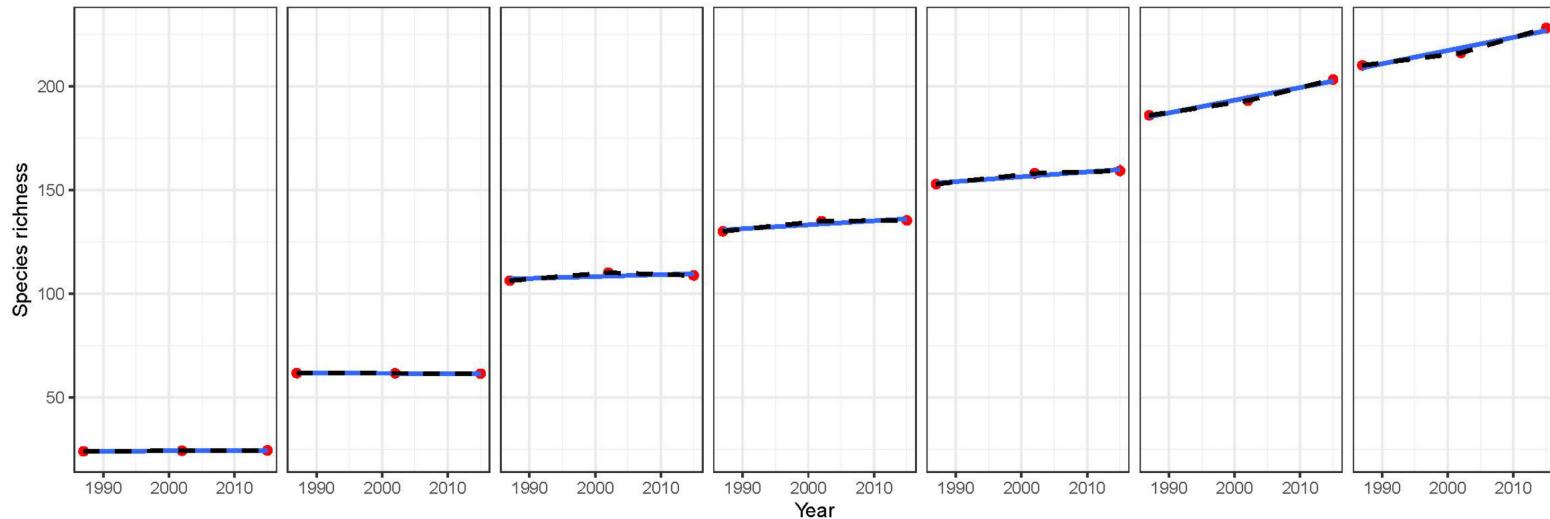
- For each spatial scale: predictions of species richness from 1987 to 2017
- Assessment of the species richness change per year



Richness changes across scales



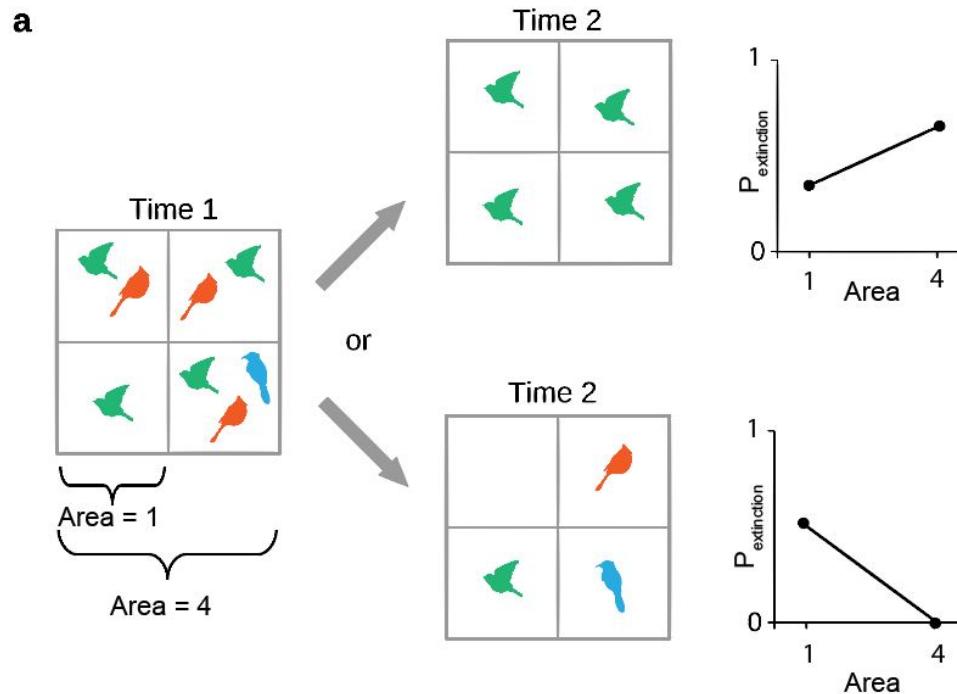
Richness changes across scales



Increasing spatial grain (km^2)

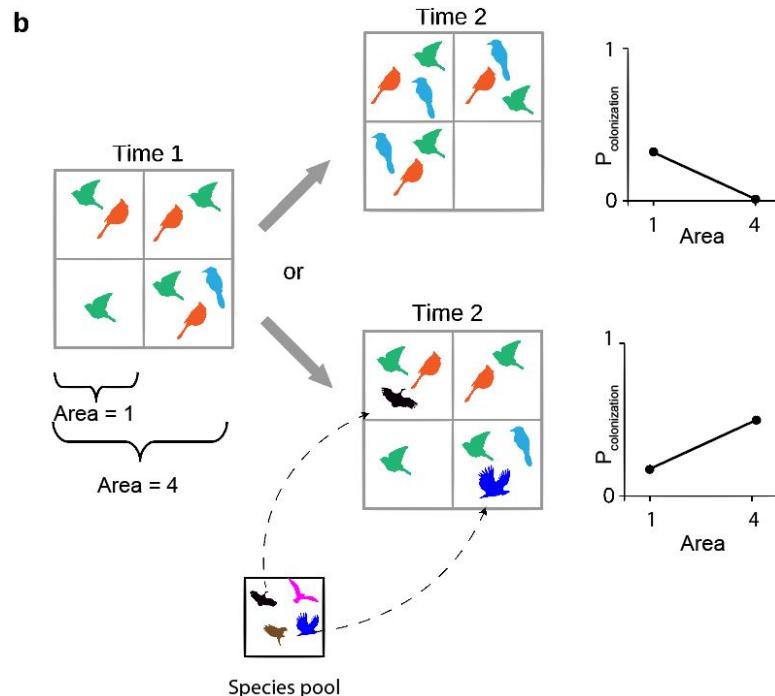
Colonization, extinction, persistence across scales

Extinction

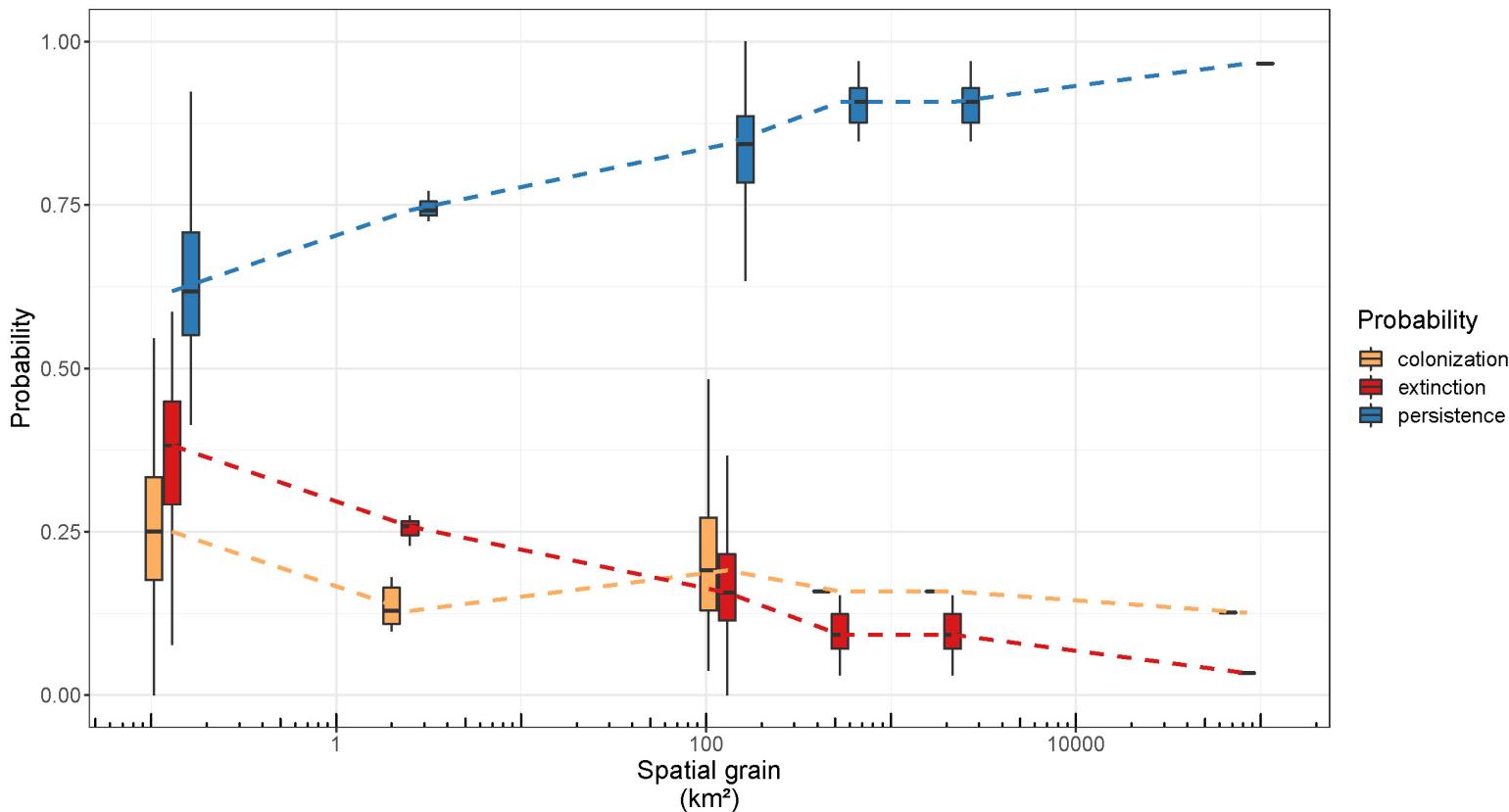


Colonization, extinction, persistence across scales

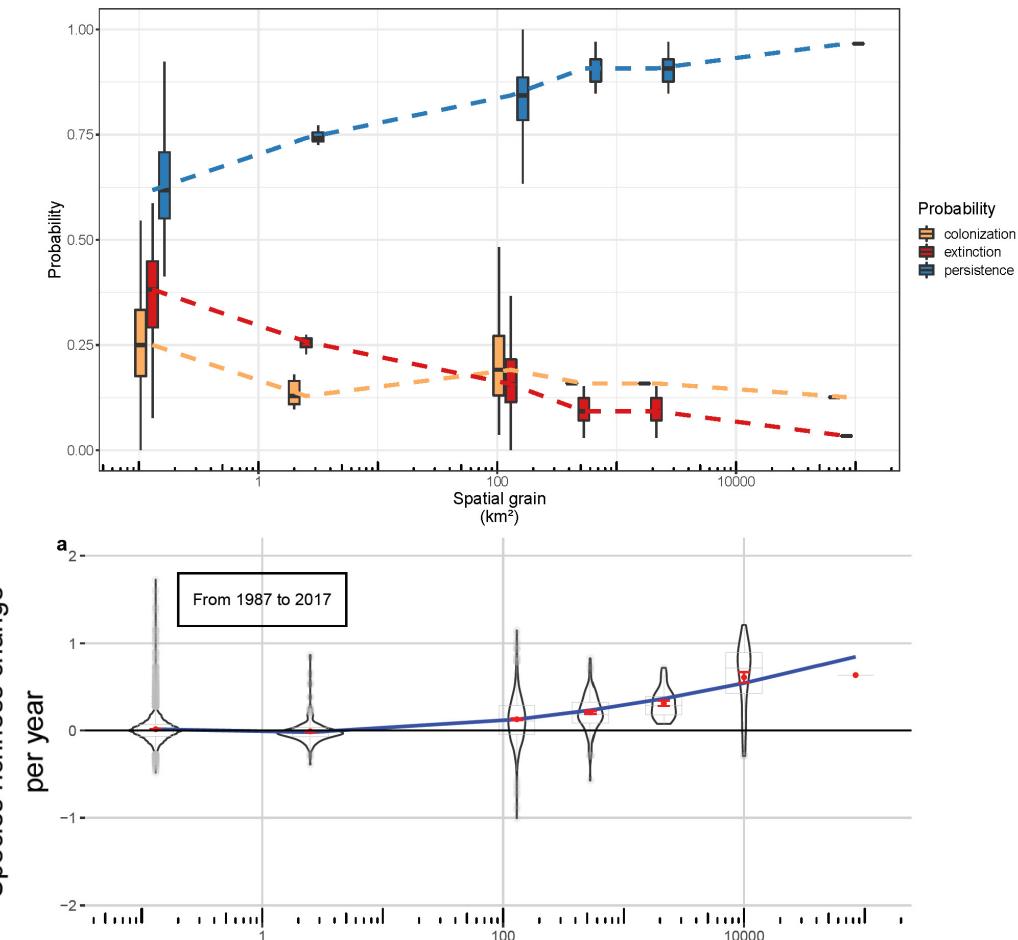
Colonization



Colonization, extinction, persistence across scales

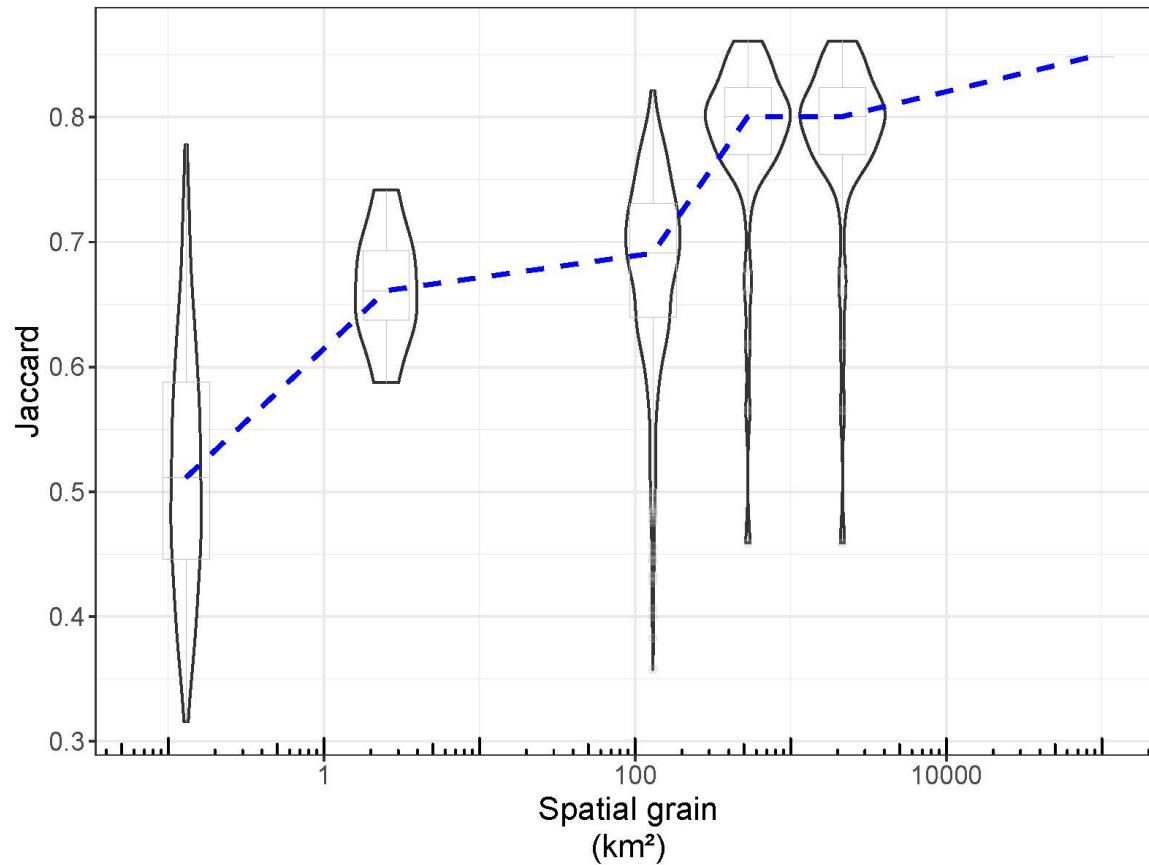


Colonization, extinction, persistence across scales



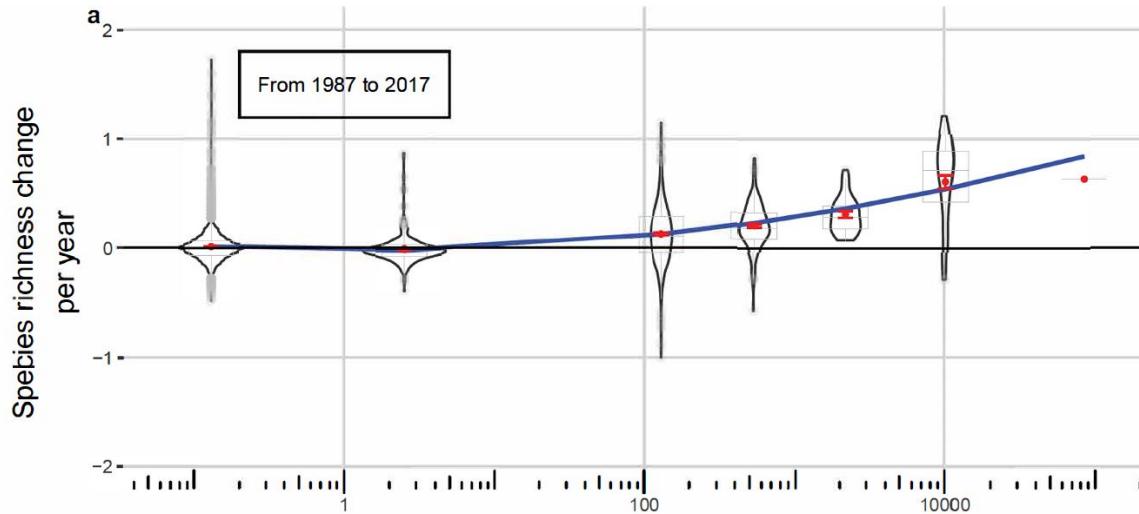
Similarity across scales

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



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

⇒ As colonization, extinction and persistence are scale dependent, we observe a scale dependency of biodiversity change

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Conclusion

- ⇒ As colonization, extinction and persistence are scale dependent, we observe a scale dependency of biodiversity change
- ⇒ Assessing biodiversity trends at national scale doesn't inform much about local dynamic and vice-versa
- ⇒ Using heterogeneous dataset allows to model biodiversity at location and time where data is missing

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

- ⇒ 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
- ⇒ Increase of species richness at large scale isn't a sign of ecosystems well-being: it can be due to invasive alien species
- ⇒ Species richness is linked to high extinction debt

Acknowledgments

Collaborators



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Ivan Mikuláš



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Jiří Reif



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The hundreds volunteers

Pavel Benda

Petr Moutelík

Roman Neckár

Honza Havlíček

Monika
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Veronika
Zavadilová

Alexej Král

Mojmír Sedláček

Jirí Mikšíček

Marie Hánová

František Kral

Marek Lohajka

Thank you for your attention

✉️ leroy@fzp.cz



👉 <https://frslry.github.io/>

Supplementary slides

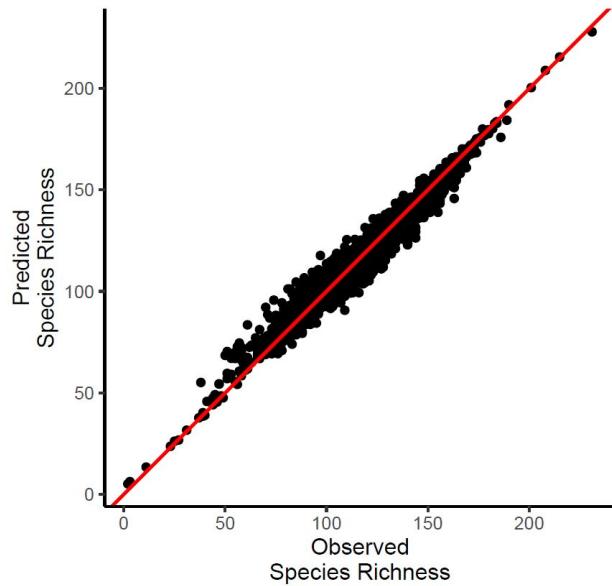
Performance

Atlas model

XGBoost

$$R^2 = 0.77$$

$$MAE = 9$$

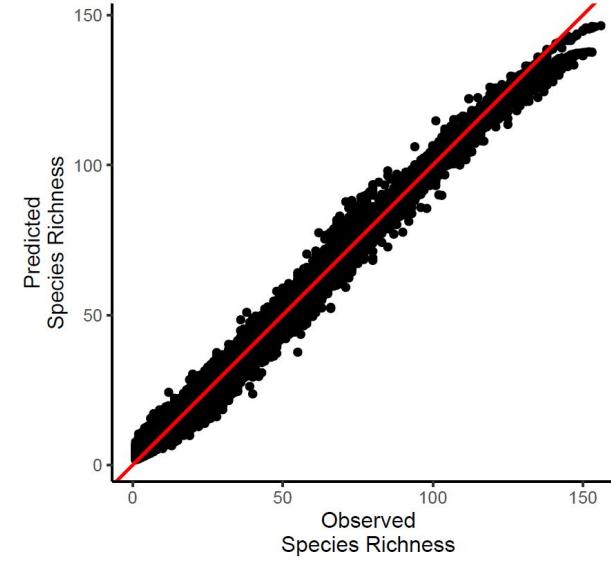


BBS model

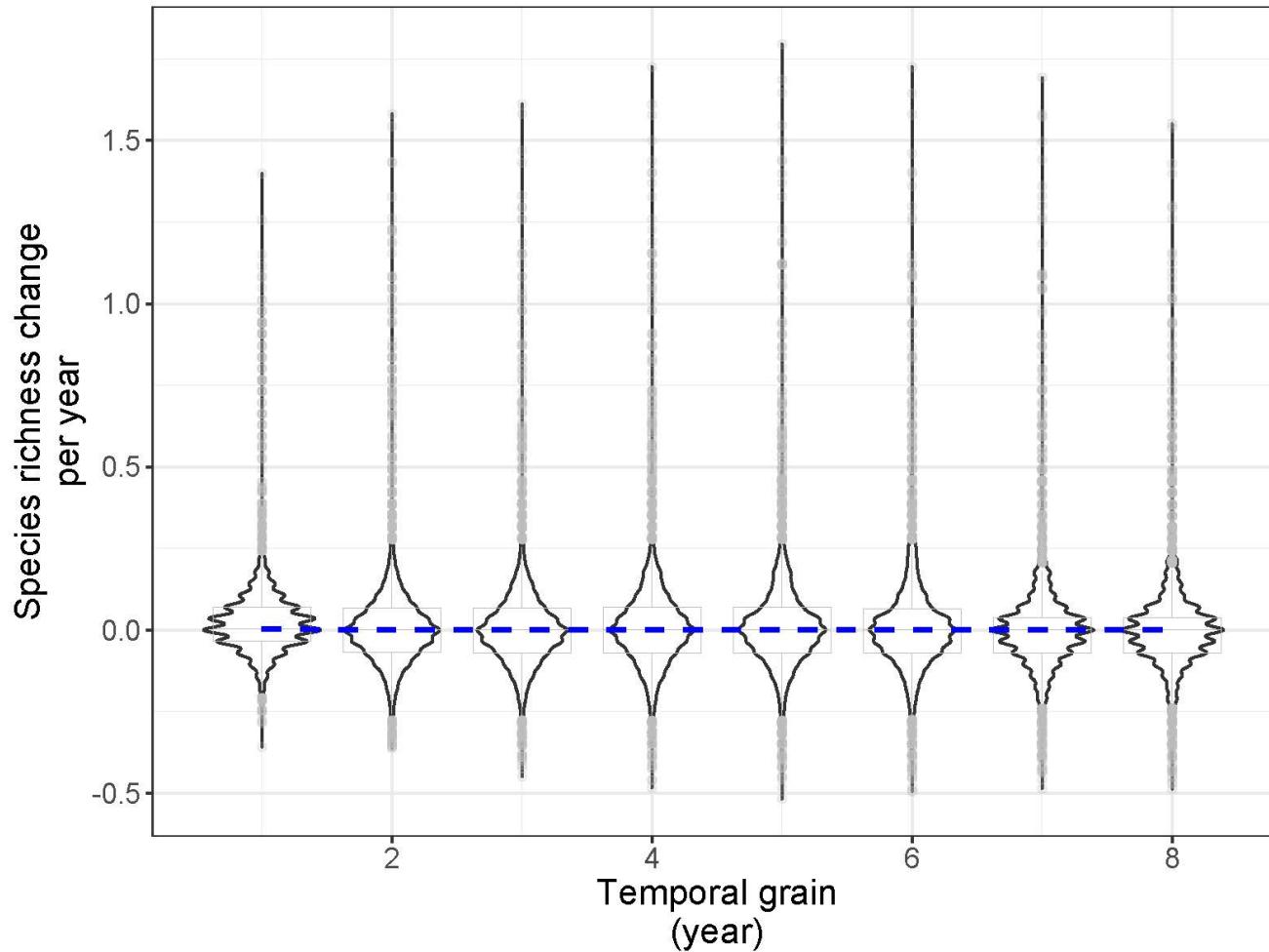
RandomForest

$$R^2 = 0.74$$

$$MAE = 10$$



And what about temporal scaling?



Turnover across scales

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

