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The effect of climate and human pressures on functional diversity and species richness patterns of amphibians, reptiles and mammals in Europe

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Abstract: The ongoing biodiversity crisis reinforces the urgency to unravel diversity patterns and the underlying processes shaping them. Here, we explored the effect of key climatic factors *(temperature, precipitation temperature seasonality, precipitation seasonality)* and factors reflecting human pressures *(agricultural land, urban land, land-cover diversity, population density)* on functional diversity *(functional richness and Rao quadratic entropy)* and species richness of *amphibians* (68 species), *reptiles* (105 species) and *mammals* (160 species) in Europe. We explored the relationship between different predictors and diversity metrics using *Generalized Additive Mixed Model* analysis, to capture non-linear relationships and to account for spatial autocorrelation. We found that at this broad spatial scale, *climatic variables exerted a significant effect* on functional diversity and species richness *of all taxa*. On the other hand, variables reflecting *human pressures* exerted a significant effect only on reptile and mammal diversity, and their *explanatory power was lower compared to climatic variables*. In most cases, functional richness and Rao quadratic entropy responded *similarly* to climate and human pressures. Concluding, *climate is the most influential factor* in shaping both functional diversity and species richness patterns of amphibians, reptiles and mammals in Europe. However, incorporating factors reflecting *human pressures* complementary to climate could be *conducive* to our understanding the drivers of functional diversity and richness patterns.

Keywords: functional richness; Rao quadratic entropy; climatic variables; Generalized Additive Mixed Models; macroecological patterns; diversity drivers

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Background

- Functional diversity measures the diversity of species' functional traits within communities and ecosystems and links biodiversity to ecosystem functioning

- Climate, seasonality, land uses, human pressures could act either as drivers or filters of functional traits and thus affect functional diversity patterns

- Different taxonomic groups might either have similarities in key functional roles or differ in ecological roles but having a direct linking, thus similar or different functional diversity patterns and responses to the environment could emerge

- **Q1:** Which are the functional diversity patterns of amphibians, reptiles and mammals of Europe?
- **Q2:** How climatic variables and human pressures affect functional diversity patterns of amphibians, reptiles and mammals of Europe?

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Methods

- **Species distribution data:** atlas; presence/absence distributional data; Europe; grid cell size: 50 km x 50 km

- **Trait data:** body length (body mass for mammals); clutch size (litter size for mammals); age at sexual maturity; reproductive period (only for amphibians and reptiles); oviposition site (only for amphibians and reptiles); activity time; diet type; foraging location and mobility mode (only for amphibians and reptiles)

- **Functional diversity indices:** (i) functional richness: the convex hull volume occupied by the species of each grid cell; (ii) functional Rao quadratic entropy measured as the distance between two randomly selected species within the grid cell; Principal Coordinates Analysis (PCoA)**;** "FD" R Package

- **Environmental data:** temperature, precipitation, temperature seasonality and precipitation seasonality (WorldClim); agricultural land area, urban land area, land-cover diversity (land cover dataset CLC2000); human population density (HYDE Gridded Population version 3.1)

- **Statistical analysis:** Generalized Additive Mixed Models; "mgcv" R package

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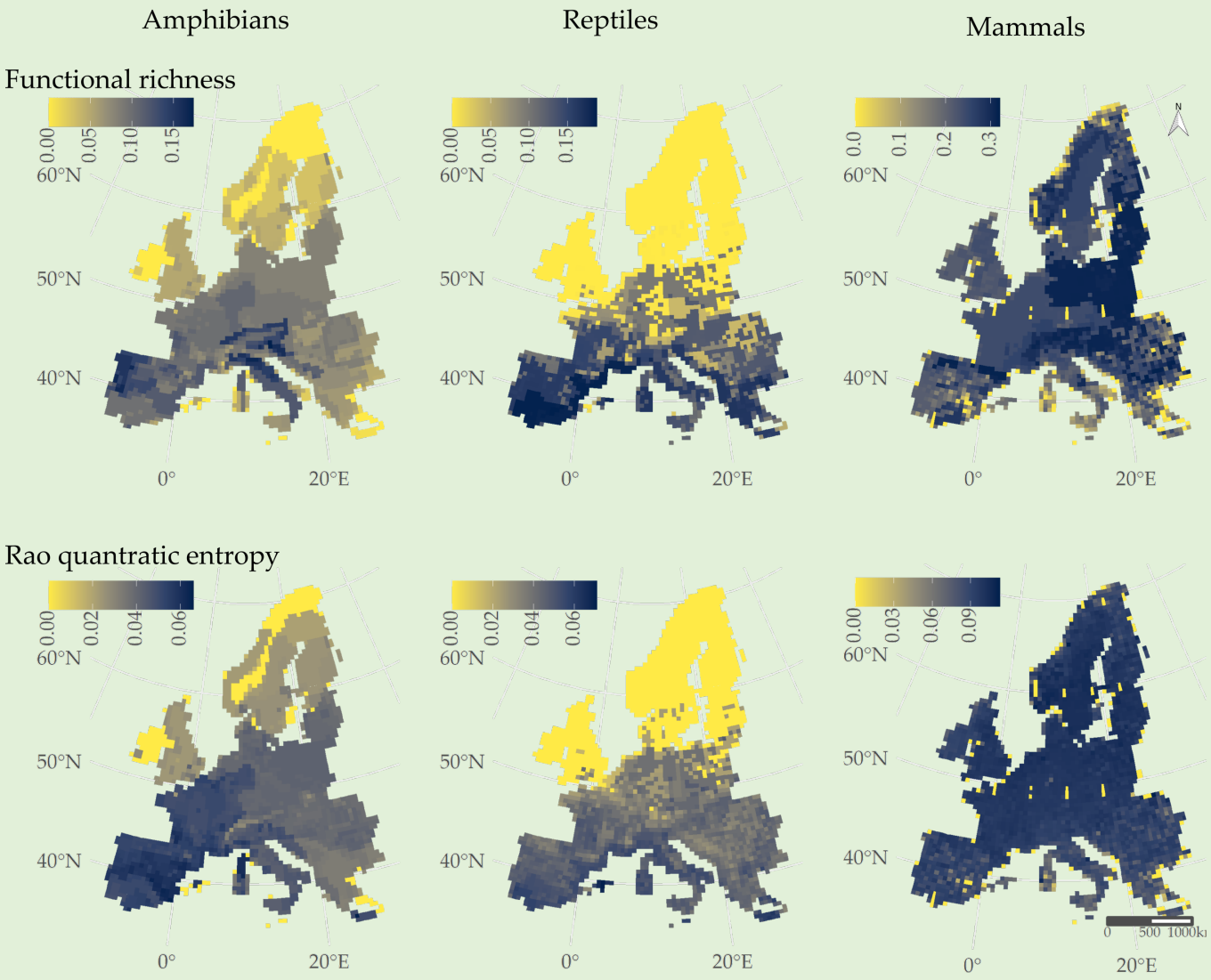
Results and Discussion



- Functional diversity (functional richness and Rao quadratic entropy) distribution patterns of amphibians, reptiles and mammals of Europe (scale 50 km x 50 km)
- Cross-taxon relationships amphibians - reptiles (FRic: $R^2 = 0.24$, RaoQ: $R^2 = 0.46$), mammals - amphibians (FRic: $R^2 = 0.01$, Rao Q: $R^2 = 0.05$), mammals - reptiles (FRic: $R^2 = 0.07$, Rao Q: $R^2 = 0.14$). All p-values<0.001

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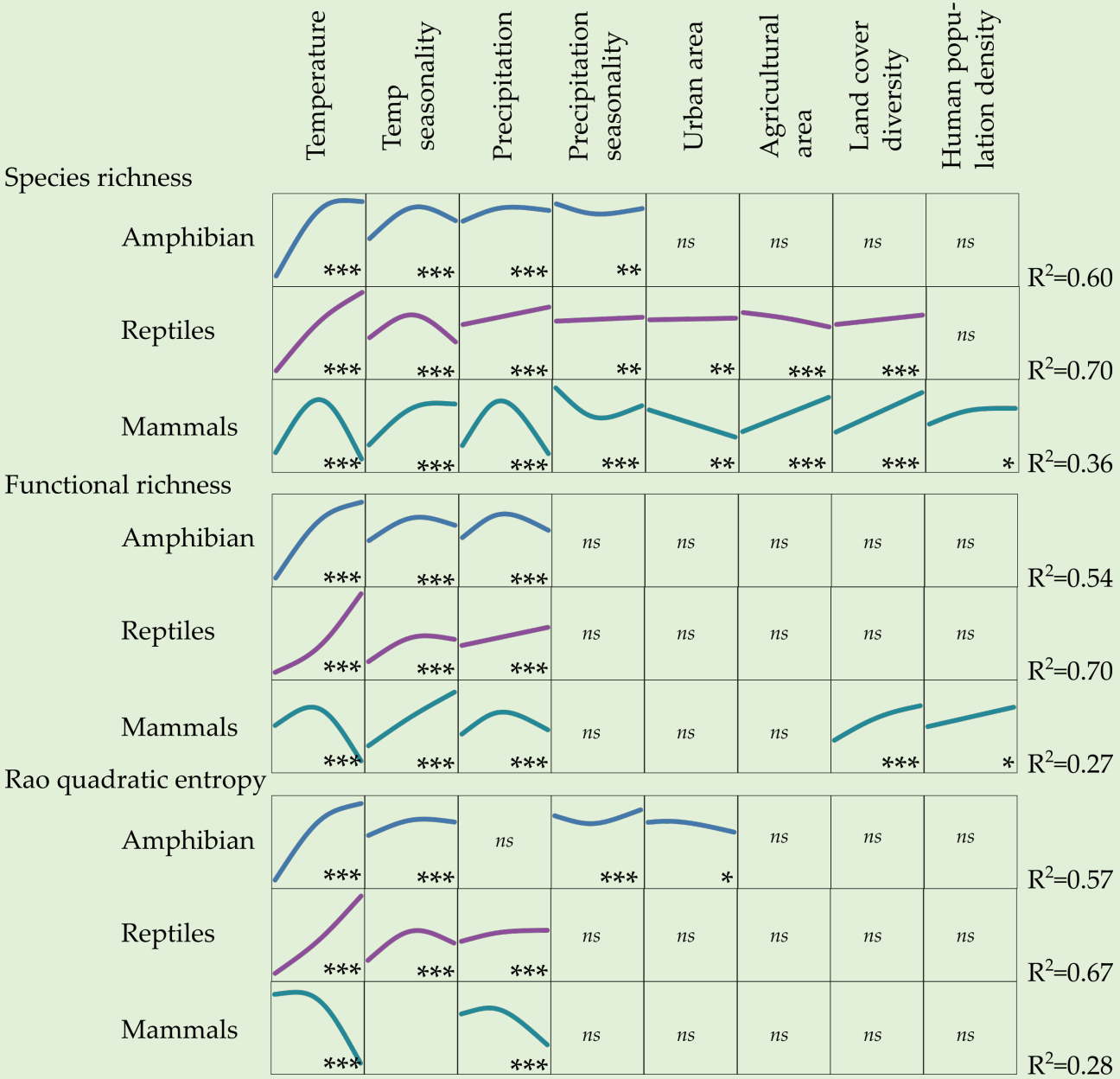
Results and Discussion



- Summary plot showing the results of Generalized Additive Mixed Models predicting species richness, functional richness and Rao quadratic entropy of amphibian, reptiles and mammals of Europe as function of of climatic, land uses- and human pressures related variables

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Conclusions

- Climate showed strong significant relationships with species and functional richness, and Rao quadratic entropy of all taxa
- Human – landscape factors significantly affected diversity patterns at broad spatial scales although their role is of lower impact in relation to climate
- Climate seasonality has been performed either as a driver or filter for functional diversity of amphibians, reptiles and mammals of Europe
- Amphibians, reptiles and mammals might differ in their ecological roles, but their responses to the various determinants was largely consistent
- The effects of urban land area and human population density on functional diversity patterns might have irreversible negative impacts on taxonomic groups resulting in impaired provision of ecosystem services
- Climate, land uses and other human related factors influence species assemblages synergistically, rendering hard to decipher their individual effect on distribution patterns, but this might be related to scale analysis

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Thank you for your attention!

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