Challenges and lessons from predictive ecological modeling for designing an integrative biodiversity monitoring program

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Background

Assessing past and future biodiversity responses are key for countering biodiversity loss. Predictive ecology is critical for improving biodiversity management and policy through delivering essential forecasts used by stakeholders and decision-makers during the decision-making process.

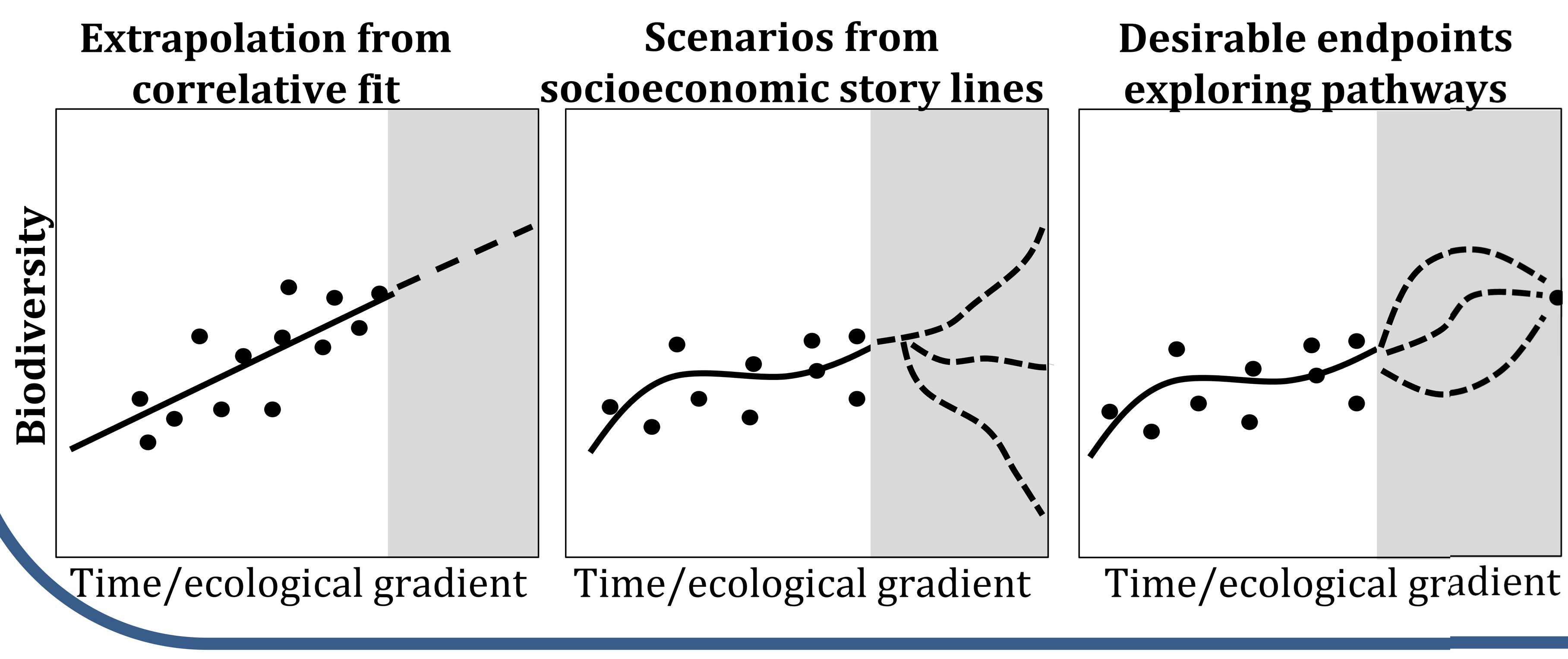
Problematic

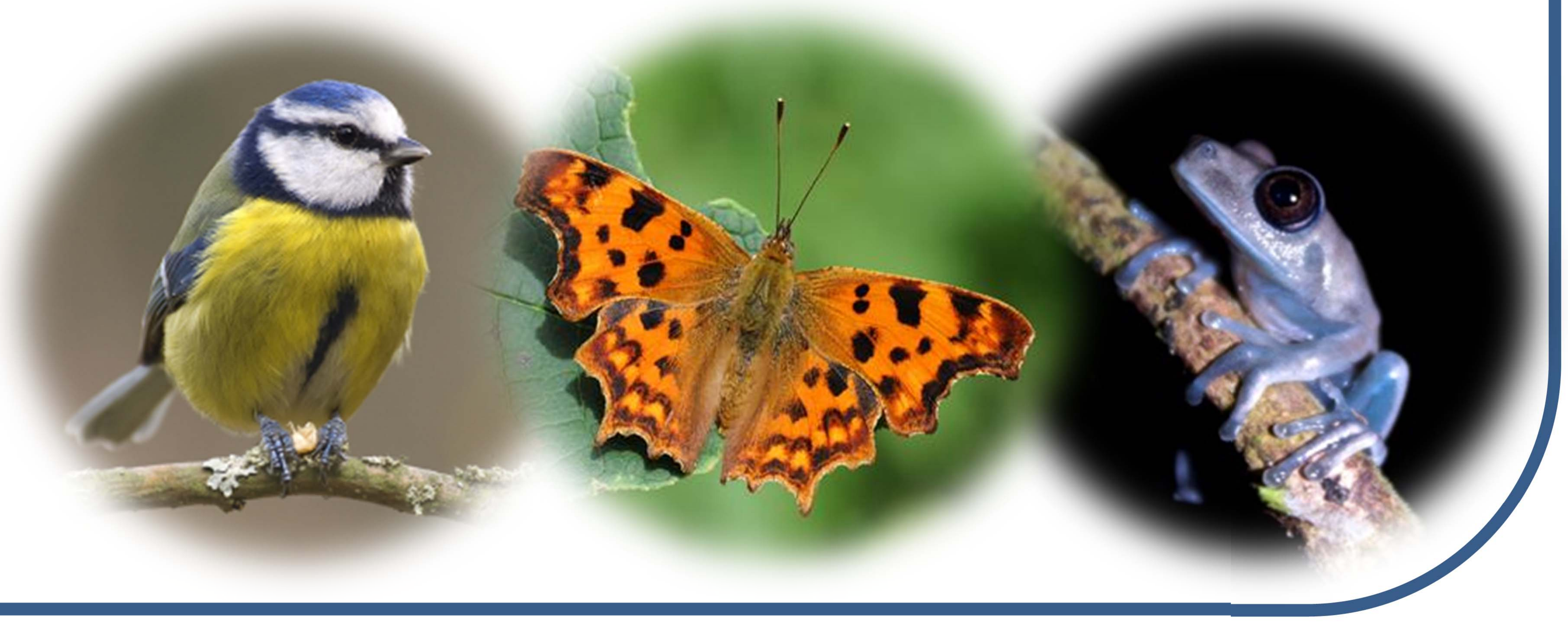
Current gaps in biodiversity information might limit the development of predictive ecology (Box 1). It is however unclear how important the mismatch and the consequences are for predictive ecology, and what it implies for biodiversity monitoring.

Box 1: Situation of predictive ecological modeling vs. Challenges in biodiversity monitoring

Biodiversity forecasts range from extrapolations derived from simple statistical models to integrative projections emerging from complex, mechanistic, process-based models [1,2,3,4]. The availability of critical information on biodiversity and ecological knowledge required for predictive models is often limited.

Biodiversity monitoring are biased toward particular taxonomic groups, geographic areas or survey methodologies [5,6,7] Existing gaps suggest revising biodiversity data collection. The Essential Biodiversity Variables (EBVs) has been proposed as a common framework unifying the different ecological fields [7].





Methods

We investigated limitations in predictive ecology and identified priorities for biodiversity monitoring by reviewing ecological model power and data requirements in line with biodiversity monitoring data collection and using the EBV concept.

Results

Biodiversity monitoring mainly document patterns in Species Population and Community Composition. Underlying ecological process required for parameterizing the most suitable predictive models and for validating their outcomes (e.g. Species Traits, Ecosystem Function and biotic interactions) are dramatically lacking (Box 2).

Box 2: Balancing predictive power and data requirements vs. Gaps and bias in biodiversity monitoring

Mechanistic, process-based models offer the best practical trade-off between model complexity, data requirements, predictive power and reliability to forecast biodiversity in changing conditions[1,2,3]. They require quantitative information on species traits such as demography and dispersal as well as biotic interactions as input parameters, and on species population, community composition or ecosystem function and structure to validate their projections.

Biodiversity monitoring mostly inform about large-scale patterns in species distribution, population abundances and community diversity from species count and occurrence data. Other ecological variables and processes are dramatically under documented even in popular taxa and intensively monitored areas. Most of the few information available for ST, or essential ecological mechanisms come from a scattered monitoring programs conducted at small scales.

Conclusions

Biodiversity monitoring focus on EBV classes Species Population and Community Composition, and largely overlook other EBVs. We argue that such practices are unsuitable for optimal developments in predictive ecology by restricting model parametrization and validation. Failure to anticipate future biodiversity changes might be partly due to insufficiently comprehensive data collection. One of the main challenge is re-prioritizing biodiversity monitoring at large-scale to access more integrative information on biodiversity and ecosystems. In particular, biodiversity data collection need to target Species Traits, Ecosystem Function as well as mechanistic and functional ecological interactions between and within EBVs.

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Refs: 1- Evans et al. 2013; 2- Harfoot et al. 2014; 3- Oliver & Roy 2015; 4- Global Biodiversity Outlook 4; 5- Marsh & Trenham 2008; 6- Costello et al. 2010; 7- Pereira et al. 2013; 8- Geijzendorffer et al. 2015