External review of PhD Thesis

titled **Spatial scaling and decomposition of macroecological changes**

by **François Leroy**

François's thesis addresses an essential macroecological and conservation biology question about what is happening with biodiversity across spatial and temporal scales. In answering this key question, the thesis further aims to elucidate how the spatial and temporal resolution of the analyses (grain and binning size) influences the results.

François addressed these questions in four manuscripts/chapters. (1) He reviewed the literature on avian biodiversity and showed how biodiversity metrics change across spatial and temporal scales. He then proposed a framework that links temporal scales to biodiversity dynamics, and highlighted regions in need of data. In doing so, he provides boundaries and clear definitions to help standardise and advance the field. (2) François dived deeper into the scaling. He showed how separate scaling (binning) of colonisation and extinction explains the scaling of changes in species richness. Specifically, for Czech birds, as area increased, colonisation increased, extinction mainly decreased (actually following a hump-shaped pattern), resulting in a temporal increase in species richness. In this way, François identified scale-dependent mechanisms driving change in biodiversity, and hence explained confusing patterns of biodiversity change across different spatial scales. (3) Using simulations, François further revealed how the spatial scaling of extinction probability links to the density dependent mortality rate. Finally, (4) using comprehensive data on the North American birds and complex statistical tools, François linked accelerated bird declines to human activities and identified declining recruitment rates even for the species that are currently on the rise. Thus, François's results highlight the need for conservation efforts to focus not only on reducing losses, but also on increasing recruitment.

In sum, the thesis highlights that often inconsistent results from analyses performed at different spatial and temporal scales are not just methodological artefacts, but may inform us about the ecology of species richness. The thesis provides answers to its main questions, using state-of-the-art methods, and hence meets its aims well. The thesis fills major gaps in the field of macroecology and generates unique questions worth pursuing in the future. The results of the thesis also have practical conservation implications.

I have no major comments on the form or style of the thesis. I have, however, struggled with the, in my opinion, excessive use of "mathematical symbols" as placeholders for already clear and informative variables (e.g. E – extinction, C – colonisation) and the use of jargon where perfectly clear and informative terms are available (e.g. Jaccard index - temporal turnover). I believe that, at least within the main text, the use of spelt out variables and informative variable names would improve the readability and hence understanding of the text. In addition, I would appreciate a more nuanced presentation of the results within the abstract of the key Chapter 4 (e.g. by also stating that 37% of declining species had increasing recruitment rates).

I commend the quality and efficiency of François's PhD journey. Managing four manuscripts in four years is not an easy feat. Moreover, the topics of the four manuscripts are not the simple ones, but rather reflect a deep exploration of complex matters that are non-trivial. The thesis demonstrates François's ability to review the literature (Chapter 1), to develop theoretical models and test them with complex empirical data (Chapter 2), to explore ideas with simulations (Chapter 3), and to use complex long-term data, while learning and applying new state-of-the-art analytical methods (Chapters 2 and 4). The thesis further demonstrates François ability to collaborate locally and internationally, in order to achieve a scientific goal.

I recommend François's thesis for defence. I have truly enjoyed the read, have learned a lot and have several questions that I hope to ask during the defence. I look forward to the scientific discussions during the defence and beyond.

Yours sincerely,

Martin Bulla
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