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Editorial: Models in population, community and ecosystem dynamics

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Editorial on the Research Topic
Models in population, community and ecosystem dynamics

When first published, the call for this special topic was left very broad, with the aim to "welcome models for all significant aspects of population, community and ecosystem dynamics". The purpose was to obtain —hopefully— an unbiased instantaneous picture of the current directions in the field of ecological modelling. As in most fields of science, the number of publications, methodologies, and models generated in theoretical ecology have inflated in the very recent decades (Rossberg et al., 2019; Zhang and Wang, 2020), so it was an interesting exercise, we thought, to see what a sample of voluntary submissions —self-identified as modelling works by their authors— could provide as a picture of the ongoing trends and research directions in the field.

As expected, the scope of covered topics was very broad, spanning several of the classically-studied processes of interest in ecology, from evolutionary dynamics (Wang and Wang, Fussmann and Kopp) to biogeochemical cycles in ecosystems (Bian and Xia, Zelnik et al.), while several articles concerned the study of interactions of species with their environment or with other species (Guo et al., Hooker et al.) trying to develop novel methods (Lindo et al.), or infuse new paradigms (Dobson et al.).

There was no unifying theme, as expected given the broad scope of the topic. However, we could detect an underlying concern, shared by a majority of the articles. Bian and Xia take an explicit look at the propagation of uncertainty from satellite measurements of leaf area index to estimates of the nitrogen and phosphorus cycles. Dobson et al. speculate whether the specificities of trees (their longevity, and seasonal productivity) could affect the relation between the complexity and stability of the associated food web. Fussmann and Kopp look at populations that witness rapid changes in their environment, questioning the validity of current reciprocal transplant experiments to assess maladaptation. Guo et al. look at spatial heterogeneity and how it affects the stability of competition between species. Hély et al. lay foundation for a novel modelling approach to ecosystem dynamics that incorporates inherent stochasticity and variability to better predict stable and alternative stable states. Hooker et al. start from an extensive dataset to disentangle the drivers of synchrony —and asynchrony— between two species, showing that trophic interactions and environmental stochasticity interact in yielding synchrony. Lindo et al. tackle the issue of stochasticity, offering practical methods for its inclusion in soil dynamical models. Wang and Wang show how chaotic dynamics may result in unpredictability, despite the deterministic evolution of a phenotypic trait. You may have already understood where we are reaching: all these articles were concerned with one aspect or another of uncertainty. Whether it is background noise, stochasticity, heterogeneity, or dynamic stability (the mirror concept). Only two articles out of the 10, more classically, tried to ascertain the state of the ecological system at equilibrium, whether it was microbial decomposition (Manzoni et al.), or net primary production under nutrient subsidies (Zelnik et al.).

Coincidence or not, we live in times that are perceived by an increasing number of people as uncertain. Incoming challenges are numerous and their complexity hard to fully grasp: the advances of artificial intelligence (Weiser and Von Krogh, 2023), global security challenges (Booth and Wheeler, 2023), pandemics (Batty, 2020), the impending climate breakdown (Barnett, 2023), the absence of clearcut political projects and effective policies (Turk, 2022), the looming prospect of a biodiversity collapse (Maechler and Graz, 2022), economic volatility (Ahir et al., 2022), etc.

We will not enter into the otherwise fascinating debate of the influence of the social context on science (Latour, 1987) or of the effect in return of ecological theory on society (Bosselman and Tarlock, 1994; Scoones, 1999). Nor will we resolve the question of whether ecological paradigms reflect the dominant philosophical ideas in the contemporaneous society (Simberloff, 1980) or whether they are rather shaped by pragmatism reflecting the characteristics of the object they study (Travassos-Britto et al., 2021). What is certain is that all current research efforts aimed at understanding and including uncertainty into ecological theories are welcome and timely.

In conclusion, what have we learnt from the rather limited set of papers published in this Research Topic on ecological modelling? Regarding uncertainty, we will take home the variety of practical methods described that aim at explicitly including e.g., noise and error propagation (Bian and Xia), demographic and environmental stochasticity (Lindo et al.), chaotic dynamics in eco-evolutionary processes (Wang and Wang), and the upscaling of disturbance to a continental scale (Hély et al.). The articles helped us realize as well that, rather than being a nuisance to be reduced, uncertainty and variability is a fundamental component of the functioning of ecological (Lindo et al.) and evolutionary systems (Fussmann and Kopp) to be understood and explained (Guo et al., Wang and Wang, Hooker et al., Dobson et al.). Finally, the works of Manzoni et al. and Zelnik et al. are here to remind us that a mechanistic understanding of ecological processes is as necessary as ever, if only because variability is a process in itself, with mechanisms that generate it. Variability is so intrinsic to complex ecological systems (Roy et al., 2020), and multi-scale that a holistic approach to transcend rather focused studies, such as those included in this Research Topic, might be the next challenge to tackle in ecological modelling (Holyoak and Wetzel, 2020).

We hope that the readers of this special topic will find similar inspiration for their own research from one or several of the published articles in this Research Topic. As editors, we would be gratified if our Research Topic pave the way to future contributions that will help tackle uncertainty in our understanding of the functioning of ecological systems that are put under incomparable strain since the establishment of mankind as a major actor in the biosphere of or planet.

Author contributions

MC: Writing – original draft. JK: Writing – review & editing. RW-W: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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