

Helsinki, Finland  
April 13<sup>th</sup>, 2022

Dear Editor,

On behalf of myself and seven co-authors, I am pleased to submit a quantitative review entitled “*Towards a cohesive understanding of ecological complexity*” for consideration in *Science Advances*.

The 2021 Nobel Prize was awarded to Parisi, Manabe, and Hasselmann for their “*groundbreaking contributions to our understanding of complex systems*”. This is a timely reminder that complexity is at the core of the scientific enterprise. Indeed, in the past two decades alone, some 23,000 manuscripts mentioned complexity in ecology and the environmental sciences (Web of Science data). Yet, complexity remains an elusive concept, which was even described as a “*placeholder for the unknown*”.

Difficulties in defining complexity resulted in a myriad of definitions for “ecological complexity”, hampering conceptual advancements and synthesis in ecology. Meanwhile, humanity is facing widespread environmental crises where multiple anthropogenic threats act synergistically upon species and ecosystems. Since understanding how natural systems will respond to global change will require understanding complex systems, here we contend that one cannot properly coordinate efforts to combat global environmental changes without first organizing the study of ecological complexity.

We tackled the long-standing issue of defining complexity in a novel way, by (i) synthesizing the properties typical of complex systems, based on a review of the literature in complexity science; and (ii) assessing empirically which of such properties are typically addressed in studies that invoked ecological complexity. Beyond reviewing previous studies in complexity science, our analysis leverages modern analytical methods such as text mining, scientometrics, and network analysis to identify major research venues and gaps in the study of complexity in ecology.

We found that papers referring to ecological complexity do not share a consistent set of ideas, confirming that the field requires better organization to maximize progress. Yet, authors that refer to complexity refer more frequently to the signatures of complex systems identified in our review of complexity science, and do so in distinct ways, suggesting that there is potential to better organize this field. We therefore argue that acknowledging the trends highlighted by our analysis and being aware of the theoretical foundations of complexity science will facilitate organizing the study of ecological complexity.

We discuss our findings with the goal of being accessible to the ecological community at large. Not only we synthesize concepts from the field of complex system science, which typically remain unknown to most ecologists (as highlighted by our results), but we also minimize jargon and outline five prescriptive steps to stimulate the organization of the study of ecological complexity. Our manuscript will therefore be especially useful for ecologists that are not specialized in the study of complex systems, which are the ones producing most papers appealing to complexity in ecology and the environmental sciences.

Ultimately, we are confident that our work will contribute to fostering a new, more focused stage of complexity research in ecology. Thank you for considering our manuscript, we are looking forward to your response.

Yours sincerely,

Dr. Caio Graco-Roza