

Innovation Challenge 3

To advance understanding of ecological feedbacks in the Earth System

Perspective piece on Ecological Feedbacks

The planned Perspective paper has developed to encompass both marine and terrestrial ecosystems. The authorship includes a number of IMBeR community scientists, and also specialists in aspects of terrestrial and freshwater ecosystem science, modelling and climate change impacts. As part of the development of the paper we have commissioned a series of figures.

The Perspective paper has been generated and submitted for review.

Ecological feedbacks in the Earth System

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Abstract

Ecological feedbacks are fundamental features of the Earth system, affecting physical processes and chemical cycles. Our understanding of the interactions underlying these feedbacks at different spatial and temporal scales and the extent to which feedbacks affect Earth system functioning remains limited. Climate change and other anthropogenic pressures are already negatively affecting ecological processes in marine, freshwater, and

terrestrial ecosystems. These will most likely be amplified in the coming decades under our current warming and socioeconomic pathways. The knock on impacts on ecological feedbacks have the potential to cause rapid perturbations to the Earth system, and may significantly impact the structure and functioning of ecosystems. Yet, the role of our planet's diverse ecological feedbacks in Earth system process and the impacts of perturbations are major knowledge gaps. Here we review and synthesise current understanding of ecological feedbacks, and how they affect physical and chemical processes. We then consider the implications of ecological feedbacks for analyses of anthropogenically-driven change, development of scientific understanding and models, and provision of scientific advice for policymakers. Finally, we identify three key future research area for the rapid assessment and integration of ecological feedbacks in Earth system science. Overall, this review presents an urgent call to the scientific community for the rapid development of understanding of ecological feedbacks and integrated ecosystem – Earth system research.

We are grateful to IMBeR and ICED for the support in the generation of the manuscript and in the publication process. Once the publication process is complete, we will consider the next stage in the development of this activity. The paper makes a number of recommendations that could form the basis for future discussions within the IMBeR community on the development of approaches to improve understanding of ecological feedbacks in the ocean and their role in the Earth system.

Eugene Murphy 12th June 2025

Co-leads on the paper development are Emma Cavan and Jess Williams