GC Insights: Fostering transformative change for biodiversity restoration through transdisciplinary research

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Abstract

According to a 2019 United Nations' report, of all the known species, up to one million face extinction globally. Despite being considered a pressing global risk with several international efforts to protect and to restore, biodiversity loss and the degradation of ecosystems continue at an alarming rate. In December 2022, COP15 saw the adoption of the Kunming-Montreal Global Biodiversity Framework, where four overarching ~~goals for biodiversity and 23 targets~~ international goals for biodiversity, and 23 targets were set. ~~Despite global awareness of biodiversity loss, biological diversity continues to decline at an alarming rate with the degradation of many ecosystems accelerating as a result of climate change, resource exploitation, habitat fragmentation, and land use change. While research and impact assessments on biodiversity loss and its drivers are being researched, knowledge alone is not enough to solve the biodiversity crisis. It is vital that we, as a scientific community, fundamentally transform the way in which science is 40 conducted and communicated so that it can be effectively integrated and used by other sectors and decision-makers. This manuscript uses the 2022 Kunming-Montreal Global Biodiversity Framework as a foundation to discuss how the scientific community can take part in transformative change and promote transdisciplinary research that can be effectively used by policymakers to address the biodiversity crisis.~~ While a positive step to addressing the drivers of biodiversity loss, to reach the goals and targets outlined, we will need not just public and political will, but also more effective methods to integrate and use scientific information. To facilitate this, scientists

and research institutions need to establish alternative and new approaches to transform the way science is conducted, communicated, and integrated into the policymaking process. This will require the scientific community to become proficient at working in inter- and transdisciplinary teams, establishing connectivity across scientific disciplines, and engaging in the policymaking process to ensure that the best available scientific evidence is not only comprehensible to decision-makers, but also timely and relevant. This commentary details how scientists can embrace transformative change within and outside of their own communities to increase the impact of their research and help reach global targets that benefit society.

Keywords: biodiversity, transdisciplinarity, connectivity, policy

"Calls for 'transformative change' point to the fundamental reorganisation necessary for global conservation initiatives to stem ecological catastrophe. However, the concept risks being oversimplified or overcomplicated, and focusing too little on power and the political action necessary for change" (Fougéres et al., 2022).

Continuous and large-scale degradation of ecosystems by means of anthropogenic interference is one of the many pressures that is leading to irreversible biodiversity loss and, with it, the loss of potential

knowledge about the world around us (Wilson et al., 2016). While societal efforts and policy regulations attempting to prevent and restore nature are genuine, they often fall short of meeting their targets. In the EU, for example, 81% of protected European habitats are reported to be in poor condition despite legislation such as Natura 2000, designated under the Birds and the Habitats Directives, that represents the largest coordinated network of protected areas in the world (Naumann et al., 2020). ~~It is hoped that~~ While the four goals and 23 targets outlined in the Kunming-Montreal Global Biodiversity Framework (GBF) (Convention on Biological Diversity, 2023) may catalyse effective action, to achieve this, transformative change and informed governance will be needed.

The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) defines transformative change as a "fundamental, system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values" (Transformative Change, 2021). Carrying this notion to the intersection of science and policy, we hereby recommend a plural and transformative way to do science by integrating transdisciplinarity, connectivity across disciplines and sectors, and informed policymaking through scientific advice for timely and maximum impact. We understand this radical shift in our scientific approach will bring with it many challenges; however, this may be our last chance, as noted already more than 20 years ago by Edward O. Wilson, "to bring with us as much of the environment and biodiversity through the bottleneck as possible" (2001)~~.~~; Wilson's "bottleneck" acting here as a metaphor for the anthropogenic stressors on biodiversity, fast closing the window of opportunity for us to reverse this trend.

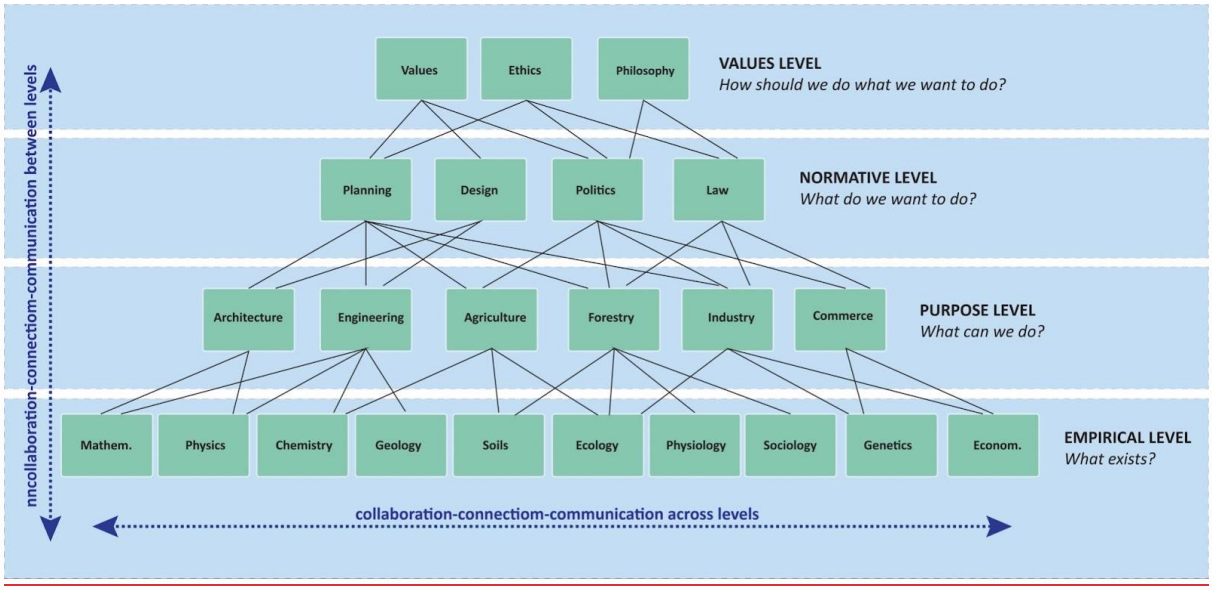
Thus, we propose meaningful strategic action on biodiversity by establishing biodiversity benchmarks and baseline data, ~~fostering connectivity across disciplines and sectors, and encouraging the research community to actively engaging in policymaking to ensure timely and relevant scientific evidence reaches decisionmakers.~~ for transparency, replicability, and standardisation of the "research language" to foster connectivity across disciplines and sectors; and encourage the research community to actively engage in policymaking to ensure that timely and relevant scientific evidence reaches decision makers.

Methods of promoting transdisciplinarity for transformative change

Transdisciplinarity - being endowed with united knowledge from different fields of science - favours a holistic approach that facilitates a systemic way of addressing challenges across scientific boundaries. ~~Effectively comprehending how ecosystems function, develop, interact, degrade, and are impacted by anthropogenic processes is fundamental to establish impactful policies and methods to prevent further degradation and promote effective restoration.~~ Transdisciplinary research, therefore, often seeks to engage stakeholders in meaningful ways throughout the research process (Rigolot, 2020). Comprehending the different levels at which ecosystems function, develop, interact, degrade, and are impacted by anthropogenic processes is fundamental to establishing impactful policies and methods to prevent further degradation and promote effective restoration. By adopting a transdisciplinary approach, scientists are better able to understand the multifaceted dynamics of changing ecosystems, in turn allowing the direct and indirect consequences of these changes to be understood and sustainable strategies to protect, conserve, and restore ecosystems to be identified (Naveh, 2005).

However, conducting transdisciplinary scientific research, and in most cases with an interdisciplinary team, requires both a theoretical and practical transformation in how we conduct our research as scientists: collaborating in diverse groups that encompass various scientific disciplines and sectors while carefully assessing how to achieve effective and usable outcomes through such collaborations. ~~Scientific communities should not only collaborate in diverse groups that encompass various scientific disciplines and sectors but should also carefully assess how to achieve effective and usable outcomes through such collaborations.~~

As outlined by Rigolot (2020), for transdisciplinarity - and with it, interdisciplinary research - to be effective, it must be well planned and effectively implemented. Researchers suggest the transition to a transdisciplinary approach can be accomplished within a framework which recognises that knowledge is organised within a pyramid of four hierarchical layers as shown in Fig. 1. The bottom layer of the pyramid is composed of knowledge within empirical disciplines – the life sciences, Earth sciences, engineering sciences, and social sciences. Collaboration, connections, and communication occur across and between all levels in a process of mutual learning. Understanding the relevance of our own scientific expertise to other scientific disciplines and non-academic sectors can be the first step to thinking and subsequently working in a more inter- and transdisciplinary manner. Interacting with non-academic sectors and joining diverse working groups can also help to break down silos (Knapp et al., 2019). However, for transdisciplinarity to become the norm rather than the outlier, both its challenges (i.e. the time, effort and resources necessary to adapt this approach) and benefits (i.e. a multi-tiered approach to scientific analysis from a wider perspective) need to be recognised by institutions and purposefully incorporated into the way in which the organisation functions.



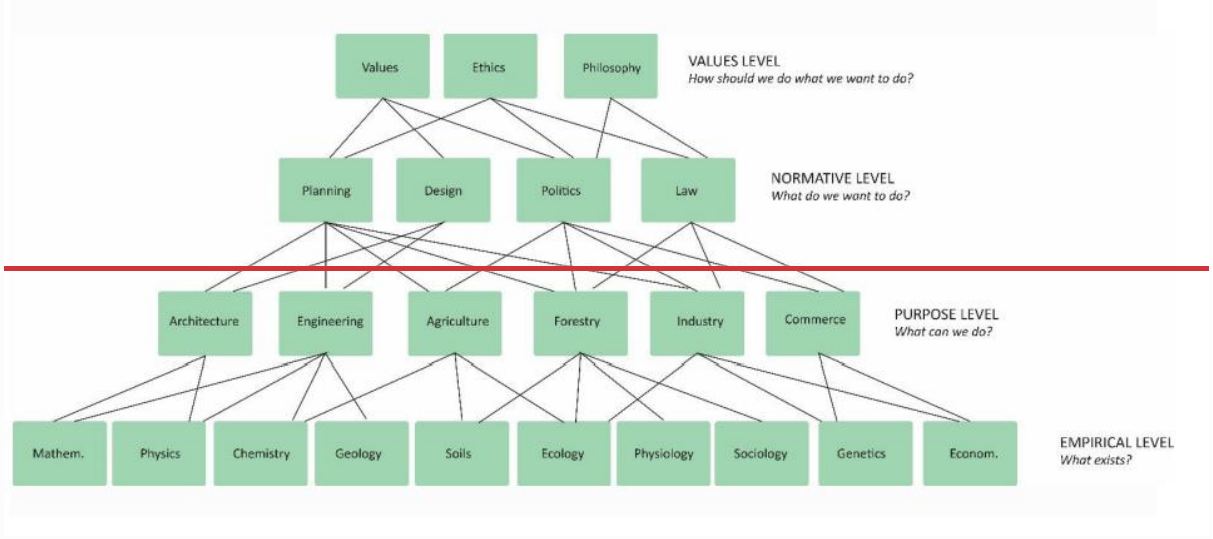


Figure 1. ~~The pyramid of transdisciplinarity: continuous coordination/exchange between all hierarchical levels (adapted by Carrasco from Max-Neef, 2005).~~ The pyramid of

transdisciplinarity: continuous coordination/exchange between all hierarchical levels (adapted from Max-Neef, 2005; relations between tiers are suggestive and may change based on the project at hand).

Embracing connectivity through a systems approach

~~Modellers may think of connectivity as a process based dynamic model, whereas statisticians may consider it from a Bayesian perspective, involving multilayered two-way interactions, across science, society, and policy, where feedback from one component or discipline continuously morphs the results of the ones it feeds into.~~ Connectivity involves multi-layered two-way interactions across science, society, and policy, where feedback from one component or discipline continuously morphs the results of the ones it feeds into. It is, in essence, a basic version of how nature operates: through an efficient feedback mechanism and information exchange, constantly morphing, changing, and evolving. Where transdisciplinarity in scientific practice encourages advances and provides new perspectives (Knapp et al. 2019), one can think of connectivity as the core, where these perspectives can be further shaped, changed, broken, and rebuilt through continuous feedback. The benefits of connectivity between disciplines and iterative learning processes to scientific practices are further stimulated by transdisciplinarity and interdisciplinary research, and preferably, with the engagement of external stakeholders and community participation (Angelstam et al., 2013).

~~The notion that~~ Eengaging stakeholders and society for reversing biodiversity loss has been widely acknowledged by intergovernmental actors (Díaz, 2019)~~. This engagement is~~ as an integral part of

generating change which has enough momentum for transformation and impact. While stakeholder engagement in scientific processes and projects often falls short for conceptional reasons and lack of best practice examples (Lavery, 2018), small scale land practices frequently adopt sustainable approaches that are locally optimised to consider both the needs of the community and their environment. A growing number of studies (Newig et al., 2023; Flanagan et al., 2022; Holifield and Williams, 2019) indicate that ~~C~~considering the needs of the local population, including indigenous communities, through knowledge exchange and assessment provides greater research context, subsequently delivering more relevant and useful outcomes, and for the purposes of this commentary: aids the possibility for transformative change (Fougéres et al. 2022). In the context of the GBF and biodiversity-related goals, this is particularly relevant, as the environmental health of lands that are managed by local and indigenous communities are observed to decline more slowly (Díaz, 2019). Conversely, the atrophy in regional heritage and identity and the loss of local and indigenous knowledge has been shown to have significant adverse effects on biodiversity (Wilder et al., 2016).

The global nature of the biodiversity crisis demands that we transform the way in which we connect and collaborate across political borders to find solutions and achieve the goals and targets set by the GBF (Convention on Biological Diversity, 2023). Ecosystems may span international boundaries, and nations managing such expansive ecosystems may fail to appropriately account for biodiversity due to conflict or international policy when weighing national interests against those of their neighbours (Dallimer & Strange, 2015). Often fragile ecosystems/biodiversity hotspots, such as the Eurasian grasslands and primary forests, the Sonoran Desert, Amazonia, and the Sahel, adjoin one or more international borders and subsequently, their management demands institutionalised cooperation. For

this, it is essential that transboundary cooperation is established among scientists, policymakers, and local and regional authorities, to ensure delegation of responsibilities to facilitate the timely sharing of information, resources, and management approaches. Ensuring greater integration between adjacent nations by means of centralised data monitoring platforms and international forums (Bruckman et al. 2018), promoting dialogue, and encouraging the development of shared interests is vital for building evidence-based policy for greater impact.

More transdisciplinarity is needed for evidence informed policymaking

Embracing transdisciplinarity and connected science can help us define and analyse challenges from multiple perspectives and move towards workable and sustainable solutions. However, to meet the ambitious targets and goals of the GBF, we must also ensure that the underlying issues, various policy options, and their potential consequences are considered by policymakers and integrated into evidence-informed policies. For ~~transdisciplinary~~ science advice to be transformative, it needs to be relevant, clear, timely, accessible, and useful to the policymakers who determine the priorities, biodiversity targets, and their implementation (Šucha & Sienkiewicz, 2020). It is therefore vital that scientists and their inter and transdisciplinary teams understand the information needs of policymakers and the policy landscape in which they operate (Topp et al., 2018).

While o~~O~~rganisations such as IPBES continue to produce excellent summary reports for policymakers for this purpose~~. However~~, the integration of science into the policymaking process requires a village rather than just a few individuals or organisations. Policymakers often need context or specific information that is tailored to individual policy discussions and legislations which is relevant to their

region and may even need to be in the policymaker's native language. Therefore, it is important that scientific organisations and research institutions recognise their key supporting role in contributing to evidence-informed decision-making at a regional scale. Thus, t~~T~~o participate in and promote transformative change, we encourage the scientific community to not only generate transdisciplinary scientific information, but also to institutionalise the integration of this research into formats (i.e. simple infographics, sharable files, plain word summaries, open data) that are accessible and useful for policymakers. This transformative change requires the involvement of individual researchers who are willing to engage with policymakers to understand their needs and share relevant and timely information, as well as scientific institutions that create opportunities and activities for science-to-policy interaction. We encourage readers to consider how they can integrate these important aspects into their work and ~~institutions~~institutions and become agents of transformative change.

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Author Contributions

All authors contributed to the conceptualisation of this article and participated in writing the original draft. ARC supported the article's visualisations and formatted Figure 1. BE, ARC, and CH were the most active authors during the reviewing & editing process.

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Competing interests

The contact author has declared that none of the authors has any competing interests.

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(EGU's Policy Priority Area 2022-2024, 2022). While incorporating transformative change into a scientific working environment is challenging, we believe that the success that the Task Force has thus far experienced demonstrates that it is possible.

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