

Novel ecosystems: biodiversity, socio-ecological consequences and future trajectories (BiodivFuture)

INTRODUCTION

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published the Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019) which provided unequivocal evidence that biodiversity is declining at a faster rate than at any other time in history. Multiple anthropogenic direct and indirect drivers are implicated in the unprecedented and rapid change to our natural world. Major direct drivers of biodiversity loss are climate change, land- and sea-use change and intensification, pollution, invasive alien species and over-exploitation of natural resources. Key indirect drivers identified include demographic change, socio-cultural, economic and governance changes, and technological progress. The combined effects of these direct and indirect drivers are leading to detrimental consequences, including negative impacts on ecosystem functioning, water availability and quality, soil quality, food security and nutrition, human, plant and animal health, and resilience to the impacts of climate change (IPBES, 2025). Taken together, our planet and our societies are changing resulting in novel ecosystems (Hobbs et al. 2013; Box 1). Anticipating the future natural world and embedded human social systems create a major challenge for proactively supporting biodiversity and ecosystem services (Evers et al. 2018).

As a response to the global biodiversity crisis, the Convention on Biological Diversity sets out the global 2050 vision of 'Living in harmony with nature', also corresponding to the European Union (EU) vision that, by 2050, biodiversity and its benefits to people will be protected, valued, enhanced and restored (8th EU Environmental Action Programme, EU Biodiversity Strategy for 2030). To achieve these visions, 196 countries adopted in 2022 the Kunming-Montreal Global Biodiversity Framework (KM-GBF, 2022). The framework defines four long-term goals for desirable and resilient socio-ecological systems: (A) to protect, enhance and restore ecosystems; (B) to prosper with nature; (C) to share benefits fairly; and (D) to invest and collaborate.

In this context, the European Biodiversity partnership - Biodiversa+ - is launching a joint research call to **support future-looking research and innovation projects that will address biodiversity and novel ecosystems** (see Box 1), **as well as their socio-ecological dynamics and consequences relating to the sustainability goals of the KM-GBF and associated future pathways and trajectories of change**. Anthropogenic influences on nature are leading to far-reaching changes in ecosystems' functions and species compositions, sometimes up to the emergence of novel ecosystems. In fact, only a very limited proportion of ecosystems can still be

Box 1. Novel ecosystems - a conceptual framework to set the scene

Novel ecosystems have been defined by Hobbs et al. in 2013 as *"a system of abiotic, biotic and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, having a tendency to self-organise, and manifest novel qualities without intensive human management"*. Since the publication of this paper, the limits of this definition have been challenged by different disciplines and other definitions have emerged. Overall, the conceptual framework of novel ecosystems usually comprises of (1) new ecological communities (including species living outside their historical native ranges), (2) which present a suite of interactions and processes consistent with a self-organised, functioning ecosystem, and (3) are unlikely to revert to conditions preceding their emergence, with or without human intervention, due to significant biotic and abiotic changes. Building on this framework and acknowledging the plurality of views and definitions, proposals submitted to this call must demonstrate how they are addressing novel ecosystems.

considered genuinely "natural" or under historically near-pristine conditions. Human-driven changes can have both negative and/or positive outcomes for certain species and ecosystem functions. This raises important questions for biodiversity protection and ecosystem restoration, including how human influence can be adequately considered as a shaping factor, how restoration goals and baselines can be defined under changing conditions, and how ecosystem functions can be maintained or restored in highly modified environment. For example, the implementation of environmental legislation, conservation programmes and sustainable ecosystem management practices in recent decades has, in some contexts, contributed to improvements in the conservation status of species, biodiversity, and certain habitats (EEA, 2020). In any case, the pervasive and accelerating human influence that defines the Anthropocene will continue to shape and

structure novel ecosystems, with a wide range of possible outcomes, that inevitably include risks, opportunities, benefits, and trade-offs. Against this background, this call addresses the need to advance our fundamental understanding of novel ecosystems and their biodiversity, their complex socio-ecological dynamics under current and future trajectories of change, and their ecological, societal, economic and cultural implications, as a basis for a global transition towards ecological sustainability and societal security.

OBJECTIVES OF THE CALL

Moving beyond the traditional approach to biodiversity conservation, which focuses on species assemblage with reference to historical baselines, **this call focuses on understanding novel ecosystems, their evolution and associated (complex) socio-ecological (incl. biodiversity) dynamics along current and potential future trajectories of change.** Applicants should pay particular attention to the ecological functioning as well as the species composition and structure of novel ecosystems, including the present and future environmental, social, economic and political drivers that shape their emergence. They should investigate current trajectories of change and explore future scenarios, encompassing biodiversity, ecosystem functions, and the socio-economic structures and processes that these ecosystems support and are shaped by. Accounting for the diverse world views, applicants should address the risks, opportunities and trade-offs related to novel ecosystems. Intensively managed systems that are highly simplified in their ecological community and processes compared with natural and semi natural ecosystems (e.g. monocultural agricultural systems, intensive aquaculture and plantation forestry) are out of scope. How novel ecosystems interact with and are impacted by these intensively managed systems could be in scope.

In the face of inevitable and potentially irreversible change, **knowledge generated under this call should ultimately lead to actions to achieve impacts that sustain resilient, interconnected, diverse and ecologically functioning ecosystems.** This could include critical reflection on what constitutes ecosystem states that best preserve or restore natural resources by taking multiple costs and benefits (trade-offs) into account and the diversity of contexts, scales, perspectives and world views. Well-functioning ecosystems should benefit people and protect nature at scales from local to global and emphasise biodiversity, trophic complexity, economic vitality, and societal well-being.

Research supported by this call should investigate the causes (drivers), effects (biological responses), and outcomes (including opportunities, risks and trade-offs) of current and future trajectories of change. It should bring to bear the best current understanding of ecosystem assembly rules, of ecosystem dynamics and test our current theories of how ecosystems respond to changes in drivers and composition. It should preferably explore the full range of options to address ongoing change (e.g., the Resist-Accept-Direct [RAD] framework) and identify potential pathways to resilient socio-ecological dynamics that could be supported in a cost-effective manner. The call seeks strategies to better understand and navigate irreversible ecosystem change, including pathways and actions to support resilient outcomes across different ecological and societal contexts. Such outcomes may include the enabling of transitions to new ecological states that are non-degraded, future-resilient ecosystems better adjusted to the new conditions, with

halted or reversed biodiversity loss. Alongside this, it can also include approaches aiming to increase societal acceptance of ecological transitions. Additionally, projects should consider how adaptive management of novel ecosystems can ensure and enhance long-term societal acceptance and economic resilience through ongoing monitoring and adjustment of strategies to promote sustainable outcomes, and responsible use of natural resources in the face of uncertainty. It is critical that advances in knowledge consider, respect and account for diverse worldviews and recognise the plurality of nature's values to human societies.

By doing so, projects are expected to support research, knowledge generation and innovation that will contribute to inform policy and interventions to support progress towards the 2050 sustainability goals adopted through the KM-GBF (2022), and to guide future frameworks for action beyond 2050.

EXPECTATIONS OF FUNDED PROJECTS: EXCELLENCE, IMPACT AND TRANSNATIONAL ADDED-VALUE

Research supported under this call is expected to significantly improve our understanding of novel ecosystems and their related socio-ecological dynamics, based on strong empirical evidence and/or theoretical concepts and system modelling. Projects should provide sound scientific basis to develop and implement concrete practical policy and management strategies leading to resilient futures. The projects are not intended to implement these strategies themselves, but to provide indications on how suggested measures might work in practice. This can be demonstrated by including experimentation and evaluation in the project design, from pilot tests, iterations and validations in real-world conditions up to demonstrating solutions in representative contexts (territorial, urban, rural, productive or sectoral). Also, approaches encompassing new technologies (remote sensing, eDNA, genomics, etc.) as well as qualitative and relational approaches for detecting, understanding, monitoring and predicting changes in ecosystems are welcome under this call. In this regard, the call builds upon the outcomes from research funded under previous Biodiversa+ thematic priorities. The combination of **novel, excellent research, high societal and political impact and significant transnational added-value** are core expectations of this call. Regardless of the geographical location of the ecosystems studied, proposals should clearly demonstrate how the findings and recommendations of the funded projects will be of broad relevance to Europe and/or at the global level, even when novel ecosystems outside Europe are included.

Projects are strongly encouraged to pursue inter- and transdisciplinary approaches, underpinned by effective communication, targeted outreach, and open science principles. This covers both blue

skies fundamental and applied research, with an integrative perspective on novel ecosystems and socio-ecological dynamics, and underpinned by a clear and robust theoretical framework. Knowledge gaps on novel ecosystems and their emergence, functioning, and resilience should therefore be addressed by consortia comprising researchers from a range of relevant disciplines, which may consist of the natural sciences, social sciences, humanities, environmental economics, policy studies and/or the arts. Engagement of experts and stakeholders outside academia¹ is encouraged while ensuring that such transdisciplinary collaborations adhere to the ethics and principles of responsible research. Collaborations may include local communities, indigenous peoples, managers, policy makers, local governments, and industry, etc.). The Biodiversa+ Stakeholder Engagement Handbook is a practical guide on how projects can be co-designed and co-produced with relevant stakeholders.

Projects are encouraged to develop research methods that can be used by different research communities to explore pathways of socio-ecological dynamics in the context of novel ecosystems. Of particular interest are interdisciplinary methods and tools to assess, monitor and forecast biodiversity status or changes/trends that can be applied across multiple spatial and time scales. Projects are expected to apply or develop approaches and indicators to evaluate the progress to resilient socio-ecological dynamics and to assess changes under different ecological and societal conditions.

RESEARCH PRIORITIES

Research priorities to be addressed under this call have been structured into three themes mirroring the KM-GBF sustainability goals (2022). Projects are welcome to address one or several of these themes and may freely combine specific topics. The work plan must be realistic for 3-year projects.

THEME A – NOVEL ECOSYSTEM FUNCTIONING

¹Note however that Funders cannot endorse or support specific proposals during the evaluation phase, and can therefore not be engaged as stakeholders. Applicants may list government authorities or ministries—including organisations that are members of the partnership—as relevant stakeholders. Nevertheless, during the application process these bodies will not express institutional interest in a proposal's objectives or potential impact, nor can they provide any form of support to individual applications submitted to our joint Calls.

Under this theme, projects should focus on understanding the functioning of novel ecosystems and their links to socio-cultural and socio-economic dynamics, identifying mechanisms and developing approaches that can facilitate biodiversity gains. Specific topics that could be considered are (non-exhaustive list):

- Understanding novel ecosystem functioning, ecological integrity and trophic interactions, including how functional processes relate to biodiversity outcomes and ecosystem services under future conditions.
- Identifying when and how ecological changes become persistent, including changes in species composition, and determining when functional integrity can compensate for compositional change and how it effects ecosystem services.
- Assessing how novel ecosystems affect biodiversity, including extinction risk, species persistence and their potential recovery under different environmental and socio-ecological conditions.
- Evaluating genetic diversity, adaptive potential and the genetic consequences of rapid species turnover, including implications for resilience under climate change.
- Developing models and scenarios to analyse the functioning of novel ecosystems and their ecological and societal implications.
- Developing tools (e.g. social, economic, and environmental diagnostics, remote sensing and socio-ecological decision support systems) to map novel ecosystem conditions and prioritise conservation and restoration interventions, supported by transparent and replicable metrics and inclusive participatory processes.
- Evaluating and developing robust quantitative and qualitative indicators compatible with KM-GBF reporting frameworks on the health, quality and functionality of novel ecosystems, while accounting for the socio-ecological dimensions.

THEME B – PATHWAYS TO NOVEL ECOSYSTEMS

Under this theme, projects should focus on studying robust, plausible, and concrete pathways to novel ecosystems and associated socio-ecological dynamics to prosper under temporal asynchronies and uncertainties. Specific topics that projects could consider under this theme are (non-exhaustive list):

- Understanding ecosystem functions, services and disservices in changing socio-ecological systems, including trade-offs and context-specific outcomes across sectors (e.g. urban systems, food, climate)

- Developing and testing robust data- and/or model-driven scenarios to analyse drivers of ecosystem and biodiversity change leading to novelty, including future biodiversity trajectories.
- Examining broader drivers and implications of ecosystem change, including global interconnections, socio-economic factors, and issues of equity and distribution across regions and generations.
- Assessing how biodiversity and society respond to different trajectories, recognising temporal asynchronies between environmental change, biodiversity responses (e.g. extinction debts, and lags in recovery and dispersal), and societal and economic impacts, which may disproportionately affect future generations rather than those who initiated the change.
- Understanding uncertainties in trajectories of socio-ecological dynamics and how they can be better reflected and ideally reduced to improve forecasting, including investigating long-term stability and regime shifts: evaluating if novel ecosystems are alternative stable states and how to predict and anticipate successional trajectories.
- Studying socio-ecological pathways for embedding emerging nature in spatial planning: biodiversity responses and governance dynamics within land-use change processes.

THEME C – BIODIVERSITY BENEFITS AND EQUITY IN THE CONTEXT OF NOVEL ECOSYSTEM

Under this theme, projects should focus on studying fair and equitable sharing of biodiversity benefits in the context of novel ecosystems, supported by inclusive, collaborative, and investment-oriented pathways for nature-positive socio-ecological transformation. Specific topics that projects could consider under this theme are (non-exhaustive list):

- Assessing costs, benefits and trade-offs in relation to novel ecosystems across different contexts, including implications for well-being, equity, and distribution of benefits focusing on the diversity of contexts, scales, perspectives and world views.
- Analysing governance, power relations, justice and equity perspectives to understand who benefits, who is affected, and how decisions on novel ecosystem management are shaped, considering intergenerational and international contexts.
- Understanding how global structures, processes and (geo-)political trends shape the emergence, functioning, and trajectories of novel ecosystems, including the ways in which biodiversity change is interconnected with global markets and inequalities, and how actions

by consumers, policy makers, and other stakeholders across sectors and regions generate distant socio-ecological effects (telecoupling).

- Developing inclusive and participatory approaches for co-creation, knowledge exchange, and long-term stewardship, including and working with diverse knowledge systems and communities.
- Exploring the ethical aspects of whether management for ecological novelty conflicts with cultural or conservation values, whether it risks supporting economic exploitation, and the risks of normalising environmental degradation under the concept of novel ecosystems could be.
- Exploring how individuals and social groups (including stakeholders, Indigenous Peoples and Local Communities) understand, interpret, value, accept, resist and/or adapt to ecological novelty, and what significance or influence this could or should have on socio-ecological transformation. This could include understanding local drivers and barriers of ecosystem stewardship and how ecosystem stewardship may be maintained over time.
- Conceiving novel ecosystems and trajectories of change that motivate people to contribute to the maintenance, enhancement, or restoration of the functional integrity, connectivity, and resilience of novel ecosystems over the long-term.
- Identifying pathways, decision-support tools and governance frameworks under deep uncertainties, as well as leveraging financial resources, capacity building and knowledge transfer to support fair, adaptive and sustainable management of novel ecosystems under changing conditions.

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