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Edificio Los Tilos 102
Montevideo, Uruguay 11500
info@belmontforum.org

Proposals of new Collaborative Research Actions (2025 CRAs)

BIODIVERSITY III

Enhancing Long-Term Biodiversity Monitoring through Transdisciplinary Approaches for Holistic Ecosystem protection

Summary

Global environmental changes are impacting biodiversity worldwide, with several planetary boundaries (eg. Rockström et al 2009; Steffen et al 2015) —such as those for biodiversity integrity, climate change, and land-system change—already transgressed; many scientists now believe we have entered a sixth mass extinction crisis[1–5]. In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) evaluated 1 million plant and animal species of estimated 8 million to be at risk of extinction, and 75% of Earth's land area to be severely altered by human activities[6].

This matters because extensive research has now clearly demonstrated the central role of biodiversity in sustaining ecosystem function and stability, with direct and measurable impacts on human societies. For instance, the economic cost of replacing ecosystem services, from pollination, to photosynthesis, carbon sequestration, water regulation, ecotourism to so many more, is simply staggering: an estimated 125 trillion USD per year[8]. We cannot afford to lose such services. Rapid and informed action is needed that holistically encompasses the complexities and requirements of natural ecosystems, integrating systems thinking and the full spectrum of biodiversity—from microbes to megafauna—with the socio-economic demands of an ever-growing human population. This includes preserving ecological functions, supporting long-term resilience, and recognizing the interdependence between ecosystem services and human well-being.

Our ability to sustainably manage biodiversity and our ecosystems hinges on a critical imperative: understand and anticipate ecosystem spatio-temporal dynamics. This requires long-term ecological monitoring and experimentation[9–11]. Only through sustained, long-term, meticulous observation and standardized data recording of individuals, populations, species and ecosystem interactions can we truly grasp the conditions required to maintain the resilience of our ecosystems and the far-reaching consequences of global change for natural as well as managed ecosystems (Blanc & Thrall, 2024). This is, for example, particularly important for soil biodiversity and the soil compartment, which together constitute a fundamental ecological component supporting terrestrial biomes through the interplay of both rapid and slow processes. These systems can exhibit complex dynamics including the coexistence of alternate stable states, which can only be understood by long term monitoring. In addition, while it has been recently estimated that soils host close to 60% of global biodiversity, most of this biodiversity is poorly described and its function unknown. There is a clear lack of large-scale and long-term monitoring of soil biodiversity across terrestrial biomes and land use. This is especially true in intensively farmed landscapes, where changes in land management practices can have far-reaching consequences for below-ground biodiversity and ecosystem functions.

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This vigilant watch must span not just years – but decades – allowing us to witness transformations not only across ecological and evolutionary timescales but also across societal dynamics, within and with rapidly changing climates. However, ecosystem protection requires more than species counts: it is only with a profound understanding of the mechanistic pathways through which global change affects biodiversity that we can reasonably plan for effective management practices and conservation actions. We need holistic, long-term integration of data on species biology (including genetics, physiology, behaviour, life history, ecology), ecological interactions, abiotic conditions, and human pressures to move beyond fragmented knowledge and understand ecosystem vulnerability, adaptability, and tipping points across multiple scales. The fundamental knowledge on ecological and evolutionary processes gained from long-term studies provide the power to forecast biodiversity's future with precision and insight, potentially averting ecological catastrophes before they unfold.

This vision aligns with and builds upon existing long-term ecological research infrastructures (e.g; the International Long-Term Ecological Research Network (ILTER) and connected national and regional networks, the National Ecological Observatory Network (NEON) in the USA, the Group on Earth Observations Biodiversity Observation Network (GEO BON) and connected facilities such as GBIF, CETAF and iDiv). These infrastructures have pioneered sustained observations of biodiversity and ecosystem processes, often with a strong regional or biome-specific focus. However, they need complementary initiatives to expand, innovate, or integrate new dimensions of biodiversity research. This is where shorter-term, transdisciplinary projects — such as those fostered by the Belmont Forum — play a crucial catalytic role. Although typically funded for three years, these projects do not replace long-term programs: they serve as pilots and accelerators. They test innovative methods (e.g. mechanistic and socio-ecological approaches), develop and validate protocols and indicators, and explore under-represented compartments such as soil biodiversity. They also build international and cross-sectoral partnerships, train early-career researchers, and engage stakeholders through living labs and citizen science. By embedding research within societal contexts, such projects generate the political and societal momentum required to secure and sustain true long-term investment in biodiversity monitoring.

The goal of BIODIVERSITY III is to complement and connect existing infrastructures at a broader international and transdisciplinary scale, and actively bridge the gap between short-term, co-designed research and the establishment of durable, mechanistic long-term biodiversity monitoring programs.

Indeed, whereas our need for long-term data on species and ecosystem responses to change has never been greater, too little support is available for long-term ecological research[12,13]. Specifically, national initiatives that support long-term ecological research programs are few and far between, and there is a lack of programs that go beyond the simple inventory of biodiversity (presence/absence of species) to study holistically the genetic, morphological, physiological and behavioural mechanisms of adaptation to change at all levels of organisation, from the cell and individual right up to populations, species and ecosystems[14,15]. Such data are uniquely powerful in enabling robust modelling of biodiversity futures and assessing the potential effectiveness of governmental policies and international agreements—such as shown by Jenouvrier et al., who demonstrated that achieving the Paris Agreement targets could halt projected declines in emperor penguin populations[17].

Not only is there an urgent need for long-term mechanistic programs at an international scale – in particular because conservation measures need to inclusively account for species and ecosystem interactions that range across time and space, sometimes several tens of years[18], or several thousands of kilometres apart[19] – there is an urgent need for integrative research programs that encompass the natural sciences, humanities and stakeholders in understanding global change consequences on biodiversity. Living labs are particularly powerful tools in this context, as they

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facilitate real-world, co-designed, and iterative experimentation involving researchers, citizens, decision-makers, and other actors. By embedding research within local contexts, living labs enable transdisciplinary collaboration, mutual learning, and adaptive solutions grounded in both science and societal relevance. Holistic protection recognizes that ecosystems are embedded in socio-cultural contexts, and that lasting conservation outcomes depend on engaging local communities, integrating Traditional Ecological Knowledge, and promoting inclusive, co-designed stewardship practices. Critically, long-term ecological research programs have the potential for meaningful societal transformation if and when feedback loops are established among natural and social scientists, local communities, the industry and policy makers[20]. We must therefore invest in the development and support of long-term biodiversity monitoring programs. Citizen engagement through education generates momentum for conservation efforts [21,22].

In short, predicting biodiversity responses to global change cannot be done (1) without a proper understanding of the mechanisms shaping biodiversity and ecosystem responses to change; and (2) understanding and accounting for societal needs and practices. Such transdisciplinary projects are urgently needed for the future of our living planet.

Presenting BF Member and Co-leads

Agences de Programmation de la Recherche (CBSD / AgraLife), Agence Nationale de la Recherche.

Main knowledge gap addressed by BIODIVERSITY III

The fact that understanding the resilience of our ecosystems and the future of our biodiversity in response to global change requires long-term data is globally recognized[11,13,23,24]. On one hand, disciplinary, short-term studies only provide partial and fragmentary information on the variability of conditions occurring in natural and managed ecosystems over time and only partial information on organismal responses to environmental change. This is particularly the case of critical but often neglected components like soil biodiversity and soil health, for which no large-scale, long-term monitoring program exist. For instance, results on population demographics from short-term field studies do not always scale-up to those found over decades[25], making it hard to predict the outcome of populations in the face of global change. Recent meta-analyses indeed indicate that defining population trends require studies spanning a minimum of 10 years[26,27] (sometimes up to 20 years[26]) to generate reliable results. Further, long-term studies of population or individuals at ecological time-scales allow critical insights into fundamental evolutionary processes, many of which are not yet fully understood [23,28–30].
In addition to evolutionary processes, it is important to consider that many living organisms shape their environment, with consequences over short or long-term on themselves or the whole ecosystem. For soils typically, changes occurring over short temporal scales (up to a few years) have been extensively studied, as well as over very long scales (millennia to millions of years) when it comes to soil formation and evolution (pedogenesis). There is very limited information of how soil properties evolve over decades, and supposedly stable properties may significantly change (for example, soil pH has been shown to decrease significantly as a consequence of a greater abundance of legumes in grasslands in Australia or New Zealand, with potential feedback of other biota. But this could be evidenced only after several decades of grassland management). Earth system models do not account for such changes, in spite of their likely relevance.

The importance of long-term ecological and evolutionary studies in predicting biodiversity response to global change further needs to bridge the gap between academic knowledge and societal realities: This process will likely greatly benefit from the inclusion and co-construction of research programs together with the social sciences, humanities and stakeholders from the public service and the industry. Education towards sustainable living in a more biodiverse world needs to be proactive: citizens need to participate in research that will help defining the policies that rule their day-to-day lives.

The CRA **BIODIVERSITY III** will:

- Complement existing long-term biodiversity monitoring programs, carried out in the various partner countries, encouraging novel experimental approaches (for example, but not limited to: high throughput imaging, AI-based techniques for inventorying species, “omics” approaches, etc.) during the project's three-year scope, grounded in prior long-term observations.
- Ensure international, cross-study standardization, access and sharing of FAIR biodiversity data, including legacy datasets. In doing so, BIODIVERSITY III will coordinate closely with existing global frameworks (see above), which provides guidance on biodiversity Essential Variables and data standards. By aligning with GEO BON’s goals of harmonized biodiversity observation and decision support, the initiative will ensure that its data products contribute directly to global biodiversity assessments and policy frameworks.
- Deploy complementary approaches of the long-term study of biodiversity by merging disciplines beyond biology, including ecology, biogeochemistry, etc. to understand driving factors as well as consequences of biodiversity shifts.
- The questions will encompass inter- and transdisciplinary aspects linked to the cultural, identity, economic and agronomic values of the biodiversity in question, integrating citizen science and Traditional Ecological Knowledge (TEK).
- Link academic monitoring of biodiversity with actions to restore or protect key wild areas, as well as restore or “rewild” human- managed/impacted systems. It will therefore be necessary to find non-scientific intermediaries to change current practices, whether of cultural or economic origin, and to demonstrate to the public and to political and economic decision-makers the merits of protecting biodiversity through the many ecosystem services it provides (e.g., food security, climate regulation, water purification, soil fertility, disease control, cultural and recreational value, and significant financial benefits—since prevention is far less costly than restoration or compensation for lost services).
- Promote opportunities for inclusive education and professional development through university programs tailored to function in conjunction with long-term research programs, and by promoting citizen-science initiatives to engage the larger public and educate to the critical importance of biodiversity and ecosystem services

In sum, BIODIVERSITY III will ensure that new initiatives not only innovate, but do so in close synergy with existing efforts (e.g. as mentioned above), leveraging past investments and data to forge a deeper, more actionable understanding of our changing planet.

Societal Relevance/Impact Expected

BIODIVERSITY III will seek to support society-oriented action research programs with the ultimate aim of (i) changing the way people and economic and political decision-makers view biodiversity, (ii) change practices, whether cultural, agricultural, industrial, on land and at sea, (iii) change legislation relating to the protection of biodiversity (see below, second point), (iv) develop platforms for exchange between academia and society.

Added value for the research community

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The added value of BIODIVERSITY III to the research community has many faces. **Logistic:** Of the necessary costs involved in maintaining long-term ecological and evolutionary research programs, including the costs of data collection (permits, personnel, logistics, equipment, consumables) and curation (personnel, storage), data analyses (personnel, laboratory equipment and consumables, storage and IT), and valorization (publications, reports, books, etc.) – the key bottlenecks are data collection and personnel costs. By adopting a holistic approach—protecting entire ecosystems, fostering adaptive capacity, supporting human–nature relationships, and recognizing the full spectrum of biodiversity—BIODIVERSITY III offers a transformative model for sustainability-oriented research and policy.

Scientific and societal: By promoting exchanges among research teams involved in long-term monitoring and action research aimed at preserving biodiversity in conjunction with society, BIODIVERSITY III will encourage FAIR, equitable, sharing of data, know-how (including TEK) and students trained in inter- and transdisciplinary approaches. In this way, BIODIVERSITY III will prepare future generations of natural and social scientists, as well as future local players and political decision-makers, who will make biodiversity and its implications part of their professional culture.

Added value for research funders

BIODIVERSITY III has the ambition to contribute to six of the 17 Sustainable Development Goals (SDGs) of the UN. Through the reasons detailed above, long-term research programs in ecology not only have the potential to define the boundaries of biodiversity's requirements in terms of functional space and niche, they have the potential for transformative societal change for a better world. BIODIVERSITY III, through its support to long-term studies in Ecology will naturally and directly answer to many of the targets of SDG13 (climate action), SDG14 (life below water) and SDG15 (life on land). Soil biodiversity and health are a priority target (SEDG15.3). By understanding the requirements of marine biodiversity and the resilience of marine ecosystems, BIODIVERSITY III will allow for the direct definition of MPAs, and the definition of sustainable catch policies accounting for the larger social environment and local communities.

By understanding the threats facing biodiversity on-land and at-sea and its capacity to adapt, BIODIVERSITY III will promote the definition of reasoned management practices (e.g. forest and agriculture planning, definition of protected areas), within and for socio-ecosystems. But more than that – BIODIVERSITY III has the greater potential of benefitting SDGs 3 (good health and well-being), 4 (quality education) and 5 (gender equality) by: (1) embracing the one-health concept and allowing for the surveillance and early detection (including real-time public access to this information) of non-indigenous species, or emerging and current epidemics affecting wild fish, mammals and birds[31,32], both with direct health consequences, and indirect economic consequences for human populations (SDS3; target 3.d). (2) promoting inclusive education (SDS4; targets 4.3- 4.7, 4.b) by empowering students through program and course-based funding independent of gender, age, sexual orientation or ethnicity (SDS5, target 5.1). (3) contributing directly to the implementation of the Kunming–Montreal Global Biodiversity Framework (GBF) Targets — for example (but not exclusively) Target 1 (biodiversity-inclusive spatial planning), Target 2 (30% restoration), Target 3 (30% conservation), Target 4 (species recovery), Target 10 (sustainable use of biodiversity in agriculture, forestry, aquaculture), Target 11 (maintaining and enhancing nature's contributions to people, including ecosystem services), Target 22 (ensuring participation, access to information, and equitable governance), and Target 23 (advancing gender equality in biodiversity action). By explicitly aligning its objectives with these GBF targets, BIODIVERSITY III not only reinforces the achievement of the SDGs but also ensures institutional and political anchoring within a binding multilateral agreement endorsed by Parties to the CBD. This articulation will further facilitate integration with the GBF monitoring framework currently being established, providing a clear mechanism to track progress and strengthen state-level commitments.

Contribution to the Belmont Challenge & Global Environmental Change Research

The Belmont Forum challenges research institutions to transdisciplinary research providing knowledge for understanding, mitigating and adapting to global environmental change. This is the first and primary objective to long-term studies in ecology and evolution. Mitigating the impacts of global environmental change and adapting, requires a functional and mechanistic understanding of our biodiversity. This can only be achieved through long-term, transdisciplinary research (including fields spanning all the way across the humanities and natural sciences) considering biodiversity in the complexity of socio-ecosystems in which it thrives. Long-term studies do so by:

1. Providing advanced observation systems on the state of biodiversity and the environment,
2. Providing knowledge on the vulnerability of biodiversity, ecosystems and ecosystem services to global change, and predictions on the risks and futures, at decadal time scales and geographical scales ranging from local to global,
3. Providing mechanistic knowledge on the capacity of organisms (evolution, phenotypic plasticity) and ecosystems (resilience and limits thereof) to adapt to change
4. Providing data allowing for informed planning and protection of Earth's biodiversity and endangered ecosystems and ecosystem services,
5. Providing knowledge on the interactions among biodiversity, ecosystems and human societies, including the sustainable use of environmental resources, the emergence and control of epidemics, and best practices for urbanization spatial planning that accounts for the maintenance of biodiversity.

BIODIVERSITY III will promote all of the above by enabling transdisciplinary research across the scientific community and non-scientific stakeholders with the number 1 view of sustainably managing the environment that we call home. BIODIVERSITY III will ensure that new initiatives not only innovate, but do so in close synergy with existing monitoring efforts.

BIODIVERSITY III will act as a transdisciplinary bridge that connects and extends the efforts of long-standing infrastructures (listed in summary), while also integrating perspectives from the humanities, Indigenous and Local Knowledge systems, and citizen science. This integrated approach will provide a fuller understanding of biodiversity change within complex socio-ecosystems and support more effective decision-making under the Belmont Challenge framework.

Anticipated funding instruments and call theme periodicity:
Anticipated funding for foresight, networking, capacity building, research projects, repeated calls.

Potential funding/co-alignment partners:
BIODIVERSA+ ? (to be discussed)
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Tentative Timeline :

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info@belmontforum.org

Relation to existing Belmont Forum CRAs:

While BIODIVERSITY I (2014) and BIODIVERSITY II (2017) focused on the development and application of scenarios of biodiversity and ecosystem services, BIODIVERSITY III will focus on supporting long-term biodiversity monitoring through the development of theoretical and methodological transdisciplinary advances, with a focus on understanding the mechanisms of adaptation / resilience of biodiversity / ecosystems to change.

BIODIVERSITY III has strong links with current and future CRAs, such as OCEANS2, which aims at using scenarios to study the roles and places for biodiversity in marine socio-ecosystems by 2050. BIODIVERSITY III can provide the fundamental, long-term data to forecast the place of biodiversity in future socio-ecosystems. Likewise, strong links can be made between BIODIVERSITY III and FORESTS and ARC (AFRICA REGIONAL CALLS), in which biodiversity-so is center-stage. BIODIVERSITY III can also build upon past CRAs, such as BIODIVERSITY 2014 and 2017, ARCTIC 2014 and 2019, MOUNTAINS2014, and OCEANS 2018.

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