

Background to BECC's challenge-driven Research Themes

A Grand Challenge refers to an issue where gaps in scientific understanding seriously constrains the ability to make informed decisions on matters of pressing concern for the well-being of people and the environment, today and in a future world affected by continued global change.

BECC revolves around three Grand Challenges, carefully selected, that must be tackled to find solutions to the combined consequences of anthropogenic emissions, land-use and climate change on biodiversity and ecosystem services.

Current BECC Grand Challenges:

- Grand Challenge - develop a scientific basis for effective and biologically meaningful conservation strategies under on-going and future global change in socio-ecological land-use systems
- Grand Challenge – reduce wide uncertainty in the components of the carbon cycle, its responses to anthropogenic and biophysical drivers, and the legacy effects of slow-responding processes of vegetation and soils
- Grand Challenge - integrate the private and public value of ecosystem services into management and policy while accounting for the projected impacts of climate, land-use and other drivers of change

Under this challenge-driven umbrella, BECC is organized in three Research Themes (Themes for short), each focusing on an overarching issue of scientific importance, in need of scientific coordination and continuous development, with high relevance to decision making and with potentially high impact on international research, today and in coming years. Apart from producing excellent science, a central part of BECC is to contribute to societal sustainable development, by our research being used to inform local, national, and international management decisions and policies; therefore, dialogue and collaboration with stakeholders is supported.

The Themes function as open platforms for intellectual exchange and mutual learning, where researchers meet and develop ideas for new collaborations, research projects, networking, outreach, and dissemination activities. To utilize the full potential of the wide range of experience and expertise represented within BECC, Themes cut across disciplines, departments as well as Lund and Gothenburg universities, allowing for an understanding of the Grand Challenges from different viewpoints, which may be critical for finding solutions to them. The Themes may overlap in some topics, given the complexities of the challenges BECC addresses. As a result, researchers are not constrained to one Theme, but, on the contrary, are encouraged to take part in all.

BECC Research Themes:

- Biodiversity under Global Change
- Carbon cycle & Climate change – 4C
- Ecosystem Services under Global Change

Strategic Plan for the BECC Research Theme

Biodiversity under Global Change, 2021-2025

Introduction

The biodiversity theme focuses on conservation of biodiversity at multiple governance levels under concurrent climate and land-use change, including both species of conservation concern and functionally important biodiversity. Effective conservation strategies need to integrate conservation interventions that increase the resilience of biodiversity with approaches that enhance the ability of species to ecologically and evolutionarily adapt to direct effects of climate change as well as indirect effects arising through changing land-use. Furthermore, land use is essentially a socio-ecological phenomenon and therefore both natural and social science perspectives need to be considered to understand these relationships. In addition, evidence-based policy advice must be interfaced with societal demands to become feasible. In summary, the **grand challenge the theme addresses, is to develop a scientific basis for effective and biologically meaningful conservation strategies under on-going and future global change in socio-ecological land-use systems.**

Sub-challenges and knowledge gaps

Within the theme, there are three sub-challenges when it comes to approaching the grand challenge: one regarding methodological development, a second regarding interdisciplinary integration, and a third regarding transdisciplinary outreach.

Many biodiversity models – such as forecasts of species distributions – do not account for the complex ways in which organisms interact with their environment, e.g. by considering the importance of biotic interactions or species-specific abilities to disperse or adapt to climatic change. Not only is the understanding of how the combined effect of climate and land-use change impact biodiversity scant, but also interactions with other drivers, such as invasive species and pathogens remain poorly researched. The first sub-challenge is therefore **to improve the assessment of combined effects of land-use, climate change and other drivers on biodiversity through further methodological developments.**

Land use decisions and strategies cannot be seen as separate from other environmental decisions or wider societal priorities. To bring conservation science to fullest fruition within society, societal preferences and conflicts of interest related to competing conservation strategies need to be considered. Evidence-based decision support for effective conservation policies therefore require socio-ecological system perspectives and thus the integration of both natural and social sciences. A second challenge for evidence-based biodiversity conservation strategies is thus **to identify synergies or trade-offs between conservation goals and other societal needs, and the conditions under which they emerge.**

To provide evidence-based decision support for, inter alia, the Convention of Biological Diversity, the EU Biodiversity strategy for 2030, and the Intergovernmental Platform for Biodiversity and Ecosystem Services, the theme needs to improve transdisciplinary outreach. An integration of scientific evidence into decision support systems depends on an understanding of the context in which local, national and international decisions are made. This is knowledge corresponding actors hold. A third important challenge is therefore **to find effective ways to integrate scientific evidence into decision support systems by engaging more strongly with stakeholders in formulating questions and identifying management strategies.**

Aims and approaches

In support of the overall BECC research strategy 2021-2025, the theme aims to provide a platform for biodiversity related research and corresponding exchange by offering a focal point and regular meetings. In particular, the facilitation of both specialist and interdisciplinary collaboration shall be a guiding principle for the topical biodiversity theme meetings. The ambition of the biodiversity theme is to operationalise the strategy as follows:

- ***Strengthen our competence and allocate resources, through***
 - identifying conservation strategies that preserve the evolutionary potential and thus the long-term persistence of biodiversity, by understanding the potential for resilience through micro-evolutionary change
 - the integration of natural and social sciences to increase the ability to devise effective and biologically meaningful conservation policies under simultaneous climate and land-use change
 - evaluating policies and data relating to research on the interaction between climate/land-use change, governance systems, and biodiversity
- ***Inspire BECC researchers to pursue novel interdisciplinary research on biodiversity, by***
 - hosting cross-cutting thematic workshops that provide forums of exchange, such as action groups
 - joining research efforts together with the two other BECC themes, e.g. in terms of integrating biodiversity models (and data) within integrated assessments
 - strengthening research on trade-offs and synergies between biodiversity conservation and enhancing ecosystem services by inviting and facilitating the participation in joint interdisciplinary applications to BECC and other funding calls
- ***Strengthen networks between researchers and societal actors, by***
 - strengthening collaboration between BECC, the strategic research area MERGE, the Gothenburg Global Biodiversity Centre (GGBC), and the Bolin Centre for Climate Research
 - encouraging and supporting PIs to engage in international project applications such as ERA-net, Horizon Europe, ERC, with a focus on joint initiatives utilizing monitoring and big data on biodiversity
 - developing actions together with the stakeholder reference group to identify knowledge and research needs, for example from the management side, e.g. implementation of the Nature Directives
- ***Increase links between biodiversity research and education, by***
 - contributing to the graduate school ClimBEco; organising, facilitating and encouraging the establishment of new courses on interdisciplinary land use and conservation strategies
 - organising possibilities for master students and PhD students affiliated with BECC to participate in research, e.g. in student-driven systematic reviews and meta-analyses
 - exploring possibilities of a new socio-ecological land use policy Master with an emphasis on biodiversity, e.g. in collaboration with the Gothenburg Global Biodiversity Centre

Strategic Plan for the BECC Research Theme

Ecosystem Services under Global Change, 2021-2025

Introduction

The theme *Ecosystem services under Global Change* focuses on the structures and processes by which natural and managed ecosystems contribute to human welfare, focusing on how ecosystem services¹ are generated, consumed and managed, in a context of biodiversity, land-use and climate change. We include the full spectrum of benefits to humans, including both instrumental and relational values and realizing that the value may be highly context dependent. The global assessment of biodiversity and ecosystem services by IPBES showed that nature's capacity to provide these services is under severe threat at local to global scales from multiple anthropogenic activities, including land-use and climate change, often because their value is not acknowledged in management and policy decisions. A grand challenge identified within BECC is therefore:

“to integrate the private and public value of ecosystem services into management and policy while accounting for the projected impacts of climate, land-use and other drivers of change.”

A central task is to support decision making and to identify policy options that strengthen the ability of ecosystems to deliver services to humans and contribute to the Sustainable Development Goals.

Sub-challenges and knowledge gaps

A key sub-challenge is to develop evidence-based governance strategies that integrate multiple values at landscape scales and simultaneously account for different land use sectors, and that harness biodiversity and ecosystem services for the sustainable production of food and biomass, while counteracting climate change, conserving biodiversity and benefitting public-good ecosystem services. Currently most land use planning and research efforts focus on a single sector, often at local scales, resulting in models, data and approaches to differ between land-use types. Instead, integrative approaches are needed, that account for patterns and processes at multiple scales from local to landscapes, and enables analyses of trade-offs over sector boundaries. Moreover, policy instruments that allow for landscape-based management strategies needs to be identified, that are able to alleviate conflicts between how private land-owners and the public value ecosystem services.

Another sub-challenge is to improve methods and indicators for predicting and communicating the responses of ecosystem services and biodiversity to a range of actions that attempt to mitigate climate and adapt to climate change or conserve biodiversity, to identify means to avoid trade-offs and even identify synergies that may enable their efficient implementation. Importantly, such analyses need to consider how trade-offs are modified by the spatial and temporal scale in focus, to understand both current local constraints for their uptake and long-term consequences for sustainable development. Such trade-offs and synergies are not at present adequately taken into account in decision-making, partly due to lack of knowledge of the effects of actions.

Enabling society to make well-informed choices requires consideration of impacts on ecosystems as well as the interaction with the social and economic systems to which they are linked. This means that questions about ecosystem service governance in relation to justice, equity and power are in focus. A third sub-challenge is thus to deepen the understanding of how ecosystem service trade-offs manifest themselves in the real world, to enable the design of policies that minimize the

¹ We use the term ecosystem services in a way that largely aligns with the IPBES conceptual framework

pervasive trade-offs associated with land-use, and to identify common ground. This includes, but is not limited to, knowledge on the types of stakeholder groups, value systems, environmental justice dimensions and ecosystem services typically involved in trade-offs, the drivers causing trade-offs, the way stakeholders respond to them, as well as the spatial and temporal scales at which trade-offs can be solved.

Aims and approaches

To achieve the grand challenge, the theme aims to provide a platform for interaction between disciplines for the generation of innovative science on (1) the generation and use of ecosystem services and (2) goal conflicts and potential trade-offs related to land use strategies and climate change. Our ambition is to provide insights useful in decision making. We have identified approaches required to meet the grand challenge, covering a broad span from basic research within one discipline to transdisciplinary research in the science-policy interface:

- Combine existing data and models across disciplines, sectors and scales, to generate state-of-the-art research and synthetic papers with a broad participation by BECC PIs.
- Stimulate new research that pushes the frontiers in ecosystem service research by developing new areas, approaches and technological advances
- Stimulate new research that combines existing cutting-edge approaches (different kinds of models, measurements, remote sensing, etc.) in novel ways.
- Increase inter-disciplinary synthetic and innovative research at the interface between the biodiversity, carbon cycle and ecosystem services themes within BECC, e.g. through arranging integrative meetings across more than one theme, focused on one or more sub-challenges.
- Carry out transdisciplinary studies, with stakeholder involvement throughout the research process.

Strategic Plan for the BECC Research Theme

4C - Carbon Cycle and Climate Change 2021-2025

Introduction

We have entered an era where human activities dominate over natural processes in forming the Earth System, sometimes called the Anthropocene. This includes climate change, which is both a symptom and cause of a carbon cycle disturbed by human activities. Anthropogenic emissions of CO₂ to the atmosphere originate from the burning of fossil fuels and land-use and land-cover changes affecting carbon stocks in vegetation, soils and water bodies. Because of the consequences for ecosystems and their functions, it is crucial for the survival and prosperity of human societies that these emissions are reduced and even turned into net carbon uptakes. However, this requires a significantly improved understanding of how anthropogenic factors influence the carbon cycle.

The carbon cycle dynamically couples the biosphere, pedosphere, hydrosphere and atmosphere, links societal and biophysical dimensions of the Earth system, and is tightly coupled to biogeochemical cycles of other elements such as phosphorus (P) and nitrogen (N). The disturbances in the carbon cycle can be assessed at different spatial scales, from molecular to global, and by their effects on the atmosphere and ultimately on natural and managed systems including the development of human societies. Direct and indirect feedback mechanisms may enhance or dampen climate change.

The 4C Theme within BECC and its research strategy 2020-2025

The BECC *Carbon Cycle and Climate Change* (hereinafter abbreviated *4C*) theme is a hub for interdisciplinary research and connections to stakeholders interested in questions of climate change and the terrestrial carbon cycle. It provides a platform to initiate and support novel research activities within our scope. It especially supports interdisciplinary projects during their establishment phase to bring forward synergies and insights that could not have been achieved without the collaboration.

The BECC *4C* theme welcomes and encourages all BECC researchers to join the theme and contribute to *4C* theme meetings. It tightly interacts and collaborates with the other BECC research themes Biodiversity and Ecosystem *Services* for the organization of joint meeting and research activities. It also tightly connects with MERGE and LU Land.

This strategic plan identifies the scope and challenges of the BECC research *4C* theme.

4C Theme Vision for 2021-2025 and beyond

4C's grand challenge is to reduce wide uncertainty in the components of the carbon cycle, its responses to anthropogenic and biophysical drivers, and the legacy effects of slow-responding processes of vegetation and soils. Those uncertainties translate directly into uncertainties in the needs of adaptation and mitigation of climate change.

To address this challenge, it is necessary to combine empirical ecology and modeling, accounting for links across scales from the local to the global, to other biogeochemical cycles (e.g. N and P), and to make use of information from studies of the past. It also requires increased understanding of how

human activities currently affect the C cycle and what the opportunities are to modify the carbon cycle to reduce emissions, including how to incentivize such changes. Together this provides a sound basis for understanding and predicting climate change and its impacts on ecosystems and biodiversity, the design of effective mitigation strategies to sequester greenhouse gases from the atmosphere through land use and management interventions. 4C focusses on Nordic terrestrial ecosystems, but research endeavours beyond those are welcome as long as their results are of general relevance for ecosystem processes and environmental policy.

Sub-challenges and knowledge gaps

The most important knowledge gaps and sub-challenges for the 4C theme include, but are not limited to:

- Increase our understanding of the impact of land use, land cover and disturbances on carbon stocks, both in vegetation and soils, and the potential to manage those for reduced emissions and sequestration of carbon
- Increase our understanding of long-term persistence of soil organic matter, and other yet insufficiently quantified important C fluxes and stores, to find ways to increase their stocks
- Increase our understanding of the coupling of nutrient and C cycles, to be able to manage nutrient cycles in sustainable ways without reducing and potentially enhancing carbon stocks
- Identify significant feedback mechanisms in ecosystems, to determine the most urgent and most efficient intervention options
- Improve ways to scale C cycle processes over space and time, to be able to improve large-scale predictions with help of smaller-scale empirical data.
- Identify and improve policy instruments including economic incentives that could contribute to an increase the sustainability of land use, despite potential conflicts arising with global benefits at local costs
- Identify connections between biodiversity and C stocks in ecosystems to prevent negative feedbacks and promote synergies
- Increase our understanding of cultural and psychological aspects connected to climate change, such as its communication in society and the effects of this, to optimally inform policy makers, managers and the public.

Aims and approaches

To achieve our challenges, 4C aims to support **interdisciplinary collaborations** including the combination of empirical data with modeling and linking across scales, to better predict the consequences of human actions on atmospheric CO₂ concentrations. Our ambition is to identify and priority rank the strongest ecosystem impacts to aid identification of optimal mitigation strategies, including their effectiveness and efficiency. We have identified approaches required to meet our challenges:

- **Standardization of protocols and databases**, such as for estimation of the C content of a site
- **Support of large-scale projects**, such as the collaborative creation of a full carbon budget for Sweden and collaboration with other themes towards a report on the state of Swedish environment
- **Utilization of large infrastructures and their existing data sets**, such as those produced at ICOS, SITES and Max IV

- **Conceptualization** to stimulate novel comprehension of C cycling and climate change mitigation strategies
- **Identifying synergies** between carbon sequestration and other benefits that may function as incentives