GERC paper on priorities in the science area: Biodiversity

The third of a series of rolling reviews carried out under the guidance of the Royal Society's Global Environment Research Committee.

Executive recommendations of GERC on the topic "Biodiversity"

GERC recognises four topical areas of biodiversity science where progress can be made, and recommends that UK funding agencies should take note of these in deciding priorities for funding in the next few years. These four main areas area are:

1) consideration of biodiversity in a broader sense, including compositional change, traits and functions, and the relationships between these and nature's benefits to people;

2) transition of data source and type towards big data and developing automation in data collection, management and analysis, while maintaining data quality and consistency;

3) scaling over time and space and the consideration of the strengths and limitations of different scientific approaches across scales;

4) consequences and implications of human actions, including considering the scientific, socioeconomic and moral aspects of interventions intended to engineer improved biodiversity: how should biodiversity science be translated into policy.

Background and discussion

The Convention for Biological Diversity definition of biodiversity is purposely broad:

"the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems"

High biodiversity is generally believed to enhance ecosystem function and increase resistance and resilience to disturbance. High biodiversity offers many benefits to society, including the provision of food and chemical resources, the regulation of climate and cycling of nutrients, the support of planetary processes, as well as cultural and recreational benefits that enhance human wellbeing. Biodiversity is equally relevant in the ocean and on land, and across taxa from microbes to plants and vertebrates.

The context to this discussion is a consensus that a biodiversity transformation is underway at a global scale, driven by climate change, land use change, overexploitation, pollution and the transport of species around the world. However, the extent and nature of this transformation remain uncertain, leading to uncertain consequences for ecosystem function and services. The following themes emerged as particularly important to develop future understanding and to develop future mitigation strategies:

1. Broader role of biodiversity: beyond species

Despite the broad definition of biodiversity, much of biodiversity research focuses on population trends and species richness. A critical and emerging area of biodiversity research expands this focus to include the identities of the species, as well as traits (genetic, phenotypic and behavioural), evolutionary history, and interactions within and among species. This broadened focus has the potential to develop causal links with ecosystem function and ecosystem services.

2. Transition of data sources and types: towards big data

Biodiversity research is changing towards big data, as a consequence of: the synthesis of published data into large databases, novel technologies in molecular sampling, digital imagery and remote sensing, and through the use of citizen science data. This fundamental change creates critical opportunities to answer questions at scales which were previously unachievable.

It also creates exciting opportunities to remove data collection and management bottlenecks, namely by automating many of the processes and in developing analytical methods suitable to these new types and volume of data. It is, however, crucial to ensure that this transition does not undermine expertise in taxonomy and traditional data collection, and that transitions to new forms of data allow comparisons with the past so that temporal change (a critical aspect of the biodiversity crisis) can be quantified.

3. Scaling over time and space: understanding dynamic connections

The nature of biodiversity change operates in fundamentally different ways at different spatial and temporal scales, from local to global, and from short-term to changes over millions of years. Divergent trends at these different scales have the potential to undermine environmental management, requiring a deeper fundamental understanding of the patterns and processes involved. One major constraint is that different types of scientific research and data inform conclusions different scales, leaving uncertainty regarding whether some of the inconsistencies are real or methodological. We need to develop a better understanding of the scaling properties themselves, and how they are linked through the dynamics of ecology, evolution, and human intervention.

4. Biosphere transformation: the human dimension

Human actions are transforming the biosphere in many ways, resulting in the emergence of novel ecosystems. Consequently, we need to understand how novel and otherwise transformed ecosystems function, as well as the potential to engineer desirable ecosystem change and prevent undesirable change. This approach embeds humans and ecosystem services into biodiversity science, and broadens the study object towards socio-ecosystems. This results in policy relevant insight into how human actions should be shaped to promote desirable ecosystems.

Societal and policy implications of biodiversity science

Biodiversity science underpins many aspects of sustainable development policy. Two of the sustainable development goals (SDGs) (life on land and life under water) directly relate to biodiversity, and hence rely on creating policy that is consistent with the science of biodiversity. A third one, the SDG of zero hunger, requires understanding how maximising food production (which can lead to overexploitation or monocultures) can be reconciled with maintaining the diversity needed for sustainable ecosystems as systems of food production that are resilient to changing conditions. Biodiversity is also a critical source of genetic and chemical resources essential for protecting human health. Biodiversity is highest and least studied in the tropics and in developing countries. There is, therefore, a strong imperative to support studies of biodiversity in geographic areas of high biodiversity, where biodiversity science has been neglected, where human populations are directly dependent on well-functioning ecosystems, and where it is particularly at risk, so that we can have research programs that promote global sustainability.

The context for GERC reports

The Royal Society's Global Environment Research Committee (GERC) is charged with advising the Royal Society, and interacting with research councils, the environmental science community and other bodies. To do this, it is undertaking a rolling series of reviews of areas of science within its remit. The areas it has identified are (in alphabetical order): Air quality, Biodiversity, Carbon and other biogeochemical cycles, Climate, Natural resources (including land use) and food, Oceans and polar science, Water. In each area, GERC uses its own expertise, and that of a small number of invited experts to consider the questions:

1. What are the hot research topics in this area at present?

2. What is the status of UK science within this area?

3. What are the most pressing research needs in the next 5-10 years?

4. Are there specific areas where UK science should be focussed to meet these needs?

5. How should priority topics be incorporated into multidisciplinary (funded across research councils) issues that Future Earth and its UK committee should consider?

This paper is the one resulting from the discussion about Biodiversity, held in June 2017. In addition to contributions from its regular and co-opted members, the committee was advised in person by Professor Anne Magurran (University of St Andrews), Professor Tom Bell (Imperial College, London), Professor Guy Woodward (Imperial College, London), Professor Andy Hector (University of Oxford), Professor Piran White (University of York) and Professor Dame Georgina Mace FRS (University College of London). The resulting paper evidently represents only a snapshot of issues, and is not a comprehensive survey of the science area. It does not represent the view of the Royal Society, but aims to advise the Royal Society Council. Exclusion of a topic from this document does not negate its importance, and many areas that are already under intense research are not highlighted here. However, we hope that this document will put a spotlight on some trends that will inform future activity by the Royal Society, Research Councils (and in future UKRI), and UK Future Earth.

Membership of GERC (including co-opted members) at the time this topic was discussed (May 2017) was: Professor Eric Wolff FRS (chair), Professor Mike Bentley, Professor Peter Cox, Dr Maria Dornelas, Professor Joanna Haigh FRS, Dr Kate Hamer (NERC), Professor Gideon Henderson FRS, Dr John Ingram, Professor Corinne Le Quéré FRS, Professor Yadvinder Mahli FRS, Professor Paul Monks, Professor Peter Smith FRS, Professor Martin Solan, Professor Chris Thomas FRS. Dr Scott Hosking acted as Secretary.