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# Biodiversity and ecosystem services science for a sustainable planet: the DIVERSITAS vision for 2012–20

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DIVERSITAS, the international programme on biodiversity science, is releasing a strategic vision presenting scientific challenges for the next decade of research on biodiversity and ecosystem services: ''Biodiversity and Ecosystem Services Science for a Sustainable Planet''. This new vision is a response of the biodiversity and ecosystem services scientific community to the accelerating loss of the components of biodiversity, as well as to changes in the biodiversity science-policy landscape (establishment of a Biodiversity Observing Network — GEO BON, of an Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services — IPBES, of the new Future Earth initiative; and release of the Strategic Plan for Biodiversity 2011–2020). This article presents the vision and its core scientific challenges.

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## Introduction: the unique role of DIVERSITAS for integrative biodiversity science

The 2010 biodiversity target ('... to achieve by 2010 a significant reduction of the current rate of biodiversity loss...'), endorsed by the 2002 World Summit on Sustainable Development and the United Nations General Assembly, has not been achieved. Evidence is growing that human well-being depends on multiple services

provided by ecosystems, many of which are underpinned by biodiversity. In many regions and systems, biodiversity is changing in ways that severely undermine the delivery of these ecosystem services. At the same time, scientific assessments demonstrate that action to protect biodiversity and maintain ecosystem services would deliver widespread benefit, contributing to global human well-being [1,2••]. The 10th Conference of the Parties to the Convention on Biological Diversity, meeting in Aichi-Nagoya, Japan, recognizing the need for action, adopted the Strategic Plan for Biodiversity 2011–20, with 20 Aichi Biodiversity Targets [3].

DIVERSITAS — the international programme of biodiversity science — is responding to the accelerating loss of the components of biodiversity by focussing the efforts of the international scientific community on filling the key gaps needed to address policy relevant issues. It does so in the context of the new Strategic Plan for Biodiversity 2011–2020 adopted by CBD-COP10 and entitled 'Living in harmony with Nature' [3]. The need for biodiversity science to focus on the dimensions and consequences of this accelerating loss and to strengthen its contribution to the development of policy is at the heart of the new DIVERSITAS vision on biodiversity and ecosystem services science. Other drivers of the new DIVERSITAS vision are:

- Changes over the past five years in the science-policy landscape, with the establishment of two new components, an observation system called GEO BON (Global Earth Observation-Biodiversity Observation Network), and an assessment mechanism, called IPBES (Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services). DIVERSITAS played an important role in the establishment of these two key mechanisms and must now become their strategic scientific partner;
- The 'Visioning process' launched by ICSU[a] and ISSC,[b] which entails building a new Earth system science initiative called 'Future Earth'[c] [4•], creates an opportunity for DIVERSITAS to strengthen interactions with sister programmes (IGBP,[d] IHDP,[e] PECS,[f] and WCRP[g]) in order to reinforce the role of the social sciences within biodiversity sciences, and develop an integrated biodiversity science in the context of a focus on global sustainability within the limits of the Earth system.

DIVERSITAS, the international programme dedicated to biodiversity and ecosystem science, under the auspices of ICSU, UNESCO,[h] IUBS[i] and SCOPE[j] has a dual mission:

- Promoting, facilitating and conducting integrative biodiversity science, that links biological, ecological and social disciplines, and
- Providing the sound scientific basis for decision-making to secure the planet's variety of life, while contributing to human well-being and poverty eradication.

The new DIVERSITAS vision presented in this article 'Biodiversity and ecosystem services for a sustainable planet' is the product of a community-wide consultative effort initiated in 2008. It followed a three-step approach. The first step (2008–9) entailed an analysis of stakeholder needs and views through e-consultation, followed by workshops, conferences, and initial presentation at the DIVERSITAS Open Science Conference in Cape Town, South Africa (2009). The second step, during 2009–10, was undertaken by members of the DIVERSITAS Scientific Committee, based on stakeholders' views collected during step 1, to formulate the vision. These resulted in the development of key challenges (top-level science objectives) and priorities (deliverable science contributing to the challenges). Finally, there was a substantial period for consultation and revision of the challenges by the entire DIVERSITAS community.

The new vision shares the grand vision of the CBD Strategic Plan for Biodiversity 2011–2020: 'By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people'. The vision identifies three scientific and one political challenge to achieve this vision:

- Critical detrimental changes in biodiversity and ecosystem services: Identify critical detrimental changes in biodiversity and ecosystem services and provide the knowledge to avoid, limit or mitigate such changes;
- Capacity of social–ecological systems to adapt: Enhance the capacity of social–ecological systems to support biodiversity and ecosystem services under global change;

[a] International Council for Science.
[b] International Social Science Council.
[c] Future Earth — research for global sustainability: a new 10-year initiative is being jointly established by ICSU, ISSC, the Belmont Forum, a high level group of major funders of global environmental change research, together with UNEP, UNU and UNESCO, and with WMO as observer. It aims at delivering knowledge to enable societies to meet their sustainable development goals in the coming decades.
[d] International Geosphere-Biosphere Programme.
[e] International Human Dimensions Programme on global environmental change.
[f] Programme on Ecosystem Change and Society.
[g] World Climate Research Programme.
[h] United Nations Educational, Scientific and Cultural Organization.
[i] International Union of Biological Sciences.
[j] Scientific Committee on Problems of the Environment.

- Patterns, origins and changes in biodiversity: Develop a sufficient understanding of the patterns, trends, origins and function of biodiversity and their underlying drivers to enable effective interventions to preserve unique elements and sustain ecosystem services and human well-being;
- A global network of biodiversity science: Build an effective global network of biodiversity science.

## Challenge 1: Critical detrimental changes in biodiversity and ecosystem services

### Identify critical detrimental changes in biodiversity and ecosystem services and provide the knowledge to avoid, limit or mitigate such changes

In this vision we define detrimental biodiversity change as change that puts ecosystem functions, services, aesthetic, ethical or cultural values and human well-being, at risk. Research to address this challenge seeks to provide and implement a framework for identifying the most urgent or serious cases of biodiversity loss as well as their causes and drivers, to explore the dynamics involved, including non-linear processes, thresholds, and Earth system tipping points, and to identify key intervention points in order to limit or stop these changes.

Considering the multiple scales of biological organisation inherent in biodiversity and the multi-scale nature of many of the drivers of change in and management response for biodiversity, research performed under this challenge will need to take place at local to global scales, and between scales, to consider diversity at all levels of biological organisation from genes to landscapes and biomes, and to involve observation, experiments as well as modelling.

Challenge 1 includes the following scientific priorities:

- Develop assessment, monitoring tools, and reporting systems to detect detrimental change in biodiversity and ecosystem services as well as identify components, services, and people at risk, especially those under immediate threat;
- Improve understanding of and methods to identify drivers of change in order to design well-targeted interventions to tackle the changes identified;
- Develop interventions (including adaptation) to avoid, mitigate, and limit impacts, and to restore systems. Interventions include technological, ecological, social, and economic solutions.

Examples of key questions to address these priorities include:

- What are the criteria for the identification and characterisation of detrimental change (e.g. risk, magnitude of impact, reversibility)?
- What are the consequences of detrimental change?
- Which systems and societies, around the world, are most vulnerable to such change?
- What interventions exist to mitigate and adapt to the detrimental change, and what can be done in the long term in order to stabilize (if not improve) the situation?

## Challenge 2: Capacity of social–ecological systems to adapt

### Enhance the capacity of social–ecological systems to support biodiversity and ecosystem services under global change

The magnitude and rate of global environmental changes — as well as interactions between them — present deep and unprecedented threats to social–ecological systems. While identifying the urgent cases and addressing them (challenge 1) is a first priority, sustainable ecosystems will depend on an improved ecosystem management for multiple ecosystem services in the context of increasing resource scarcity and competing demands on uses. Effective and sustainable management will depend on a fundamental understanding of the ecological and evolutionary processes involving biodiversity, as well as the means by which these processes are influenced by governance and decisions.

These connected social–ecological systems of the future will likely be different from those of the familiar past, yet what we do today will also shape the future dynamics of these systems. How can we negotiate the transitions between worlds we know to worlds that are still undefined? We cannot assume a priori that there is an optimal way to adapt to a given environmental change, just as we cannot assume that the continued provision of ecosystem services is given. This challenge asks scientists to explore strategies that enhance learning and governance, including multi-scale governance of complex systems.

Challenge 2 includes the following scientific priorities:

- Build the knowledge base for management practices that enhance the ability of current social–ecological systems to maintain biodiversity and ecosystem services.
- Enhance the governance capacity of social–ecological systems to reflect, cope with, and shape the evolving dynamics of biodiversity over the long term, including building transformative capacity and the consequences for the equitable access to ecosystem services by local and global human populations.

Examples of key questions to address the priorities above include:

- Within a given social–cultural and political context, what are the trade-offs and synergies among ecosystem

services and between ecosystem services and human well-being?
- How have societies maintained biodiversity in the face of environmental changes in the past and how can their capacity for adaptation and transformation, including the maintenance and development of ecosystem services, be strengthened?
- How can the changes in society and human behaviour needed to allow for coping with and adapting to biodiversity and ecosystem service change be encouraged?

## Challenge 3: Patterns, origins and changes in biodiversity

**Develop an understanding of the patterns, trends, origins and functions of biodiversity and their underlying drivers to enable effective interventions to preserve unique elements and sustain human well-being**

This challenge focuses on the fundamental but socially relevant research required to provide a critical understanding of the origins of biodiversity and the consequences of biodiversity loss across scales. The challenge includes the full conceptual chain from the origins of biodiversity, its links to ecosystem services, the causes of changes in biodiversity and ecosystem services, and the impacts of these changes for human well-being.

Stakeholders such as international treaty bodies, international conservation organisations, and national biodiversity agencies need to know the status, distribution and trends, and functional roles of various components of biodiversity, in order to define and implement effective environmental actions and policies.

Challenge 3 includes the following scientific priorities:

- Quantify status and trends in global biodiversity.
- Gain a robust predictive understanding of the evolutionary and ecological mechanisms that drive the generation and organisation of biodiversity at genome, species, community, and ecosystem levels at different spatial and temporal scales.
- Gain an understanding of how human actions (direct and indirect, e.g. through land use or climate change) impact on mechanisms that drive generation and organisation of biodiversity at different levels and how these actions contribute to maintaining or changing biotic diversity.

Examples of key questions to address the priorities above include:

- Which biophysical processes and ecological features are critical to the provision of specific services; how can ecosystem service production functions and their trade-offs be quantified?
- How much will contemporary and future evolutionary processes modify the outcomes of environmental change? How do human activities influence the ability of organisms to evolve, adapt and migrate in response to a changing environment?
- What are the relationships between biodiversity and the health and well-being of humans, their domesticated animals and cultivated plants, and the persistence of wild populations?

## Challenge 4: A global network of biodiversity science

**Build an effective global network of biodiversity science**

To address these three scientific challenges, DIVERSITAS — as part of the Future Earth initiative — will need to strengthen efforts to develop a balanced and truly global community of biodiversity scientists. It must involve the best scientists, from all regions of the world, and be active where it is most needed. This will help ensure not only that science is informed by and relevant to the needs of all cultures and societies, but also that it is considered legitimate and used by all.

This challenge includes the following priorities:

- Foster the involvement of scientists from all geographical regions of the world, in particular from high-biodiversity countries; ensure a balanced gender participation; and promote the engagement of young scientists in all relevant fields of biodiversity and ecosystem services science;
- Identify and ensure the involvement of all relevant disciplines and continue to promote an interdisciplinary approach (both within and between the natural and social sciences); recognise and respect the contribution of indigenous and local knowledge to biodiversity science and use, and, where necessary, develop ways to allow the full use of this knowledge;
- Identify and ensure the involvement of scientists who work across sectors of society, that is, transdisciplinary scientists, especially those working at the interface between science and policy;
- Encourage the development of national networks of biodiversity scientists, through national membership or other means.

## Forging strategic partnerships

DIVERSITAS, within Future Earth, puts an emphasis on generating solutions to the biodiversity crisis. It does so by addressing the needs of the users of scientific information, and in particular, the needs of the users of IPBES.

DIVERSITAS has led the input of the scientific community into IPBES since the beginning of the IPBES consultation [5•]. Together with partner programmes,

such as IHDP, it sees itself playing an important role in catalysing the production of new knowledge needed for the future assessment work of IPBES. DIVERSITAS and DIVERSITAS-related scientists will also play a role in the assessment process itself.

Implementing the challenges presented in this article requires an active dialog with users and funders of science, and strengthening a number of key partnerships with members of the science-policy interface on biodiversity and ecosystem services. It also requires a stronger partnership with sister programmes (IHDP, IGBP, PECS, and WCRP) as part of the new Future Earth initiative under development by ICSU, ISSC, and their partners; and tighter collaboration between the broad range of natural and social disciplines. During the past decade, DIVERSITAS has built bridges between new domains of biodiversity science, such as between modellers working on evolution and global vegetation, or between ecologists and economists. Now, the community needs to fully bring on board other domains such as political science, anthropology, and behavioural sciences.

The scientific challenges presented in this paper emerged from a community-wide consultative effort. They will be addressed by this community. The authors of this science vision for biodiversity and ecosystem services therefore hope that the challenges highlighted here will be widely used and adapted to fit regional and national priorities. The vision is a more sustainable and equitable future, founded on biodiversity and the ecosystem services it provides.

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## References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
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