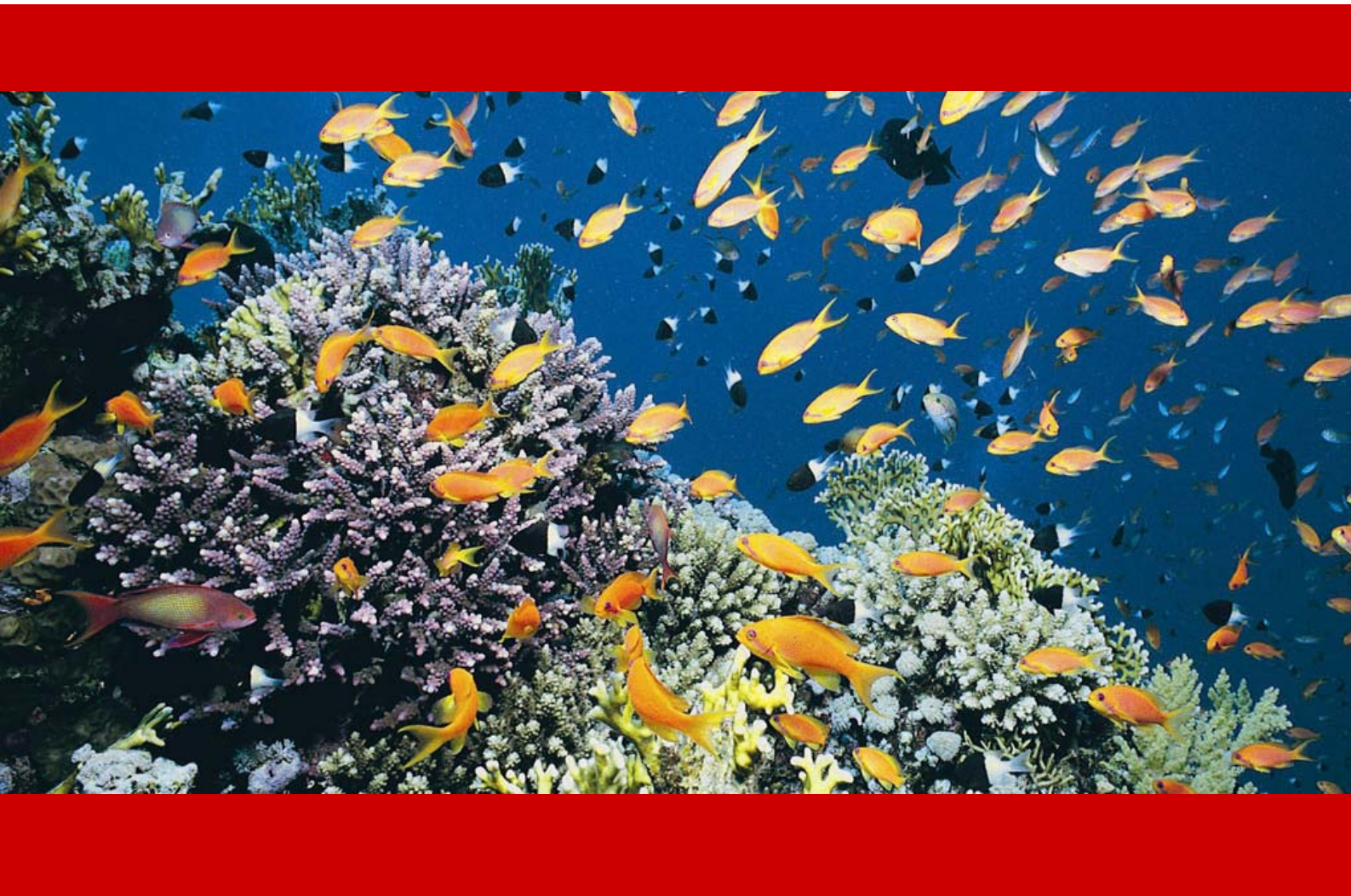


Science Theme Reports
NERC Strategy 2007 – 2012
Next Generation Science for Planet Earth



NATURAL ENVIRONMENT RESEARCH COUNCIL

Science Theme Report

Biodiversity

November 2007

Biodiversity

The variety of life from microbes to ecosystems

1. Introduction

1.1 This report

Theme reports are the core of NERC Science and Innovation Strategy, which sits within the overall strategy for 2007 – 2012 *Next Generation Science for Planet Earth*. The Reports are the culmination of consultation, advice and decision-making that took place over 2006 and 2007. They are working documents that provide the basis for implementation, informing Theme Action Plans. The science theme sections of the published NERC strategy document are a summary of the information in the reports.

The Reports were produced by Strategy Development Panels in 2006 and underwent further development in 2007 to incorporate changes to the strategy resulting from a public consultation. The overall process for development of the Biodiversity Theme Report is summarised below:

In November 2005 NERC Council identified seven strategic science themes, and a strategy development panel was set up for each theme. The panels' role was to recommend to NERC's Science and Innovation Strategy Board (SISB) NERC's future research priorities within each theme. The Biodiversity panel met on 10-11 May 2006.

Each panel prepared a report following a common format that was presented by the panel chair to SISB on 11-12 July 2006. At this meeting SISB provided its initial view on the relative priority of the challenges identified within each theme.

Following the SISB meeting the panel reports were updated. The conclusions from the SISB discussion together with a response from the panel chair were appended to panel reports and presented to Council on 26 - 27 September 2006. The report was further updated following the discussions at both SISB and Council to reflect the overall priorities agreed at Council for this theme.

A draft NERC Strategy Document was developed from the panel reports and was opened for public consultation in February – April 2007. A final version of the Strategy, incorporating recommendations from the consultation, was approved by Council in June 2007 and published in November 2007. In October 2007 the theme reports were updated again to reflect this evolution of the strategy document.

1.2 Background

Biodiversity contributes to all elements of human well-being, yet our activities are now fundamentally, and to a significant extent irreversibly, changing life on Earth resulting in a loss of biodiversity. As reported by the Millennium Ecosystem Assessment (2005), changes in important components of biological diversity have been more rapid in the past 50 years than at

any time in human history. Projections and scenarios indicate that these rates of change will continue or accelerate in the future.

In the recent past the conversion of natural ecosystems to human-dominated ones and the exploitation of biodiversity have benefited many people. Yet current losses in biodiversity and consequent changes in ecosystems are now expected to lead to problems such as water shortages, flooding, increased nutrient loading, invasive species, and the emergence of new diseases or re-emergence of old ones, as well as the loss of genetic resources and of the biodiverse natural landscapes which continue to inspire and bring pleasure to people.

At a time of rapid environmental change affecting climate, water and nutrient flows, loss of the moderating influence of biodiversity is expected to lead to further unpredicted and irreversible changes. We must increase our fundamental knowledge about the earth's biodiversity and how it underpins the many functions of ecosystems which we depend upon, so we are able to manage and mitigate ongoing changes such as climate change.

1.3 Scope of the theme

Within this report 'Biodiversity' is considered in its widest sense encompassing the variability, amount and distribution of all components of biodiversity from genes to ecosystems, as well as the interactions among them. All environments are included (freshwater, marine, terrestrial) including poorly known but potentially significant components of biodiversity in ecosystems based in media such as ice, rock, soil and the deep oceans providing practical obstacles to investigation.

The relationships to other Earth system processes are important, especially climate change. Here we emphasise the need to consider both the impact of changes to biodiversity on climate change, as well as also the impact of climate change on biodiversity.

When considering possible overlaps with the remits of the other Strategic Science themes, it is considered that Biodiversity delivers the raw materials for several other themes. There are significant common science areas, in particular with the Sustainable Use of Natural Resources theme.

1.4 Key drivers

The following key drivers have been identified for the Biodiversity theme.

1.4.1 Policy commitments

- **The 2010 target** In 2002, the UK along with all other Parties to the UN Convention on Biological Diversity (CBD), made a commitment *“to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth.”* This commitment was subsequently endorsed by world leaders at the World Summit on Sustainable Development. At its meeting in Gothenburg in 2001 the European Council agreed to halting biodiversity decline with the aim of reaching this objective by 2010;
- **Millennium Development Goals** It seems likely that the 2010 biodiversity target will become incorporated into the Millennium Development Goals (MDGs) – as one of the targets under MDG 7 (Ensure environmental sustainability);

- **European and international drivers** The UK cannot work alone in this area. In particular we need the science to support implementation of EU and UK policy: Habitats and Birds Directives, Biodiversity Strategy, Water framework directive, CAP – single farm framework, Rural Development Regulation, Common Fisheries policy, Climate Change Adaptation, OSPAR Convention;
- Key areas for policy are **environmental limits** (**‘tipping points’**), soils, urban biodiversity, marine ecosystems and impacts of land use change and agri-environment schemes.

1.4.2 Economic drivers

- **Natural resource economics** Outcomes of biodiversity research could change the way we manage natural resources and have economic benefits;
- **Environmental valuation** Biodiversity and ecosystem studies provide new means of valuing the environment that are more compatible with sustainable development;
- **Environment friendly consumers** Changes in the food preferences (away from processed foods, minimising ‘food miles’ and global impacts; towards fair trade, local and organic production) have impacts on biodiversity and natural ecosystems.

1.4.3 Biodiversity in a changing society

- Biodiversity is popular with **many audiences**;
- Demand for **wilderness** and experience of the wild;
- **Digital Society**. Because information and entertainment are increasingly transmitted via computers, there is a danger individuals will lose their appreciation for the natural environment;
- **Population** growth, economic growth, leading to greater human consumption with increasing demands for food and resources, coupled with increasingly limited options for more **agricultural land**;
- **Demographic** trends towards mega-cities and increasing rural poverty;
- Increasing impact of **GMOs, alien invasive species** and emerging diseases.

1.4.4 The science drivers

- The increasing sophistication of **bioinformatics**, data management and distributed computing for analysis, interpretation and archiving of environmental and biodiversity data. This includes the ‘omics’, remote sensing and newly emerging web-based taxonomy. For example, our ability to sequence and interpret large tracts of DNA means we are beginning to develop and apply new high-throughput techniques that herald a new level of sophistication in our capacity to monitor, manage and exploit diversity at all scales;
- **Long term measurements** from survey and experimentation are fundamental to success in understanding and managing biodiversity. Too often assessments have been undertaken using new methods, new measures or new places without reference to baselines. Trends, which are critical to many current questions, rely on a time series of comparable measures;
- **Microorganisms** drive the biogeochemical cycles (N₂; carbon etc.) of ecosystems but our knowledge is rudimentary, and there continues to be a need to be able to link species identity to environmental function in order to decipher species interactions within complex communities. This is especially true for Archaea and viruses (e.g. bacteriophages acting as controllers of prokaryote function and abundance);

- **Local and regional linkages.** A better understanding of the relationship of local to global processes, and the development of techniques to allow local dynamics to inform predictions and decisions at larger spatial scales, where such comprehensive information may not be available;
- **Evolutionary** responses need to be understood in assessing present and future adaptability to changing environments. There are few long-term or large-range studies at the genetic level;
- **Marine and freshwater** biodiversity is less well known than terrestrial systems, yet offers much potential for both important science and ecosystem services;
- **Systematics and taxonomy** are essential underpinning for any work on biodiversity. There are a number of challenges and opportunities for systematic biology including e-science, DNA barcoding, and providing increased human capacity to reverse declining taxonomic expertise.

2. Key Outcomes

Two high level overarching outcomes have been identified as follows:

- Reducing the rate of loss of biodiversity;**
- Quantifying and communicating the benefits of biodiversity to the economy and society to influence policy.**

These two require six lower level outcomes:

1. **Assessment** Validated methods for assessing biodiversity across taxa, systems and scales;
2. **Prediction** of biodiversity status under plausible futures;
3. **Role** of biodiversity in ecosystem functioning and predicting the consequences of biodiversity changes on functions and services (and human well being);
4. **Management** Applying this knowledge to conserve, manage and restore biodiversity in natural and managed ecosystems;
5. **Valuation** A commonly agreed means of valuing biodiversity for policy and management;
6. **Society** Make an understanding of the environment/biodiversity accessible to people from diverse backgrounds so that there is greater opportunity to share and enjoy this knowledge.

3. Science Challenges

The whole ecosystems approach is seen as a unifying concept for this theme. Council recognised that the first challenge (with its two constituent sub-challenges) is the highest priority.

This is:

1. **Improve understanding of biodiversity's role in ecosystems: processes, resilience and environmental change**

This challenge represents the fundamental science that needs to be undertaken to support the first overarching outcome: 'Reducing the rate of loss of biodiversity'.

The other four challenges represent important delivery mechanisms for this first challenge.

These are:

2. **Develop new tools and techniques to describe biodiversity and its function.**
3. **Improve approaches for measuring abundance and distribution of biodiversity and its functions.**
4. **Enable society to predict and mitigate effects of biodiversity change on processes that sustain life.**
5. **Develop integrated tools for assessing the benefits of biodiversity.**

Challenges similar to 4 and 5 were identified within the Sustainable Use of Natural Resources theme and elements from within that theme have been integrated in to this challenge.

3.1 Challenge 1: Improve understanding of biodiversity's role in ecosystems: processes, resilience and environmental change.

This challenge is to understand how ecosystems work and their components interact, how they respond to environmental change and how diversity contributes to ecosystem function, from the gene level to populations and species.

Two sub-challenges have been identified:

- 1a Whole ecosystems: the role of biodiversity in key ecosystem processes and resilience.
- 1b Biodiversity and ecosystems in the face of environmental change.

The first of these highlights fundamental studies needed to uncover the role of biodiversity in key ecosystem processes. These studies are needed to provide the understanding of processes that will be affected by environmental change, which is addressed in the second sub-challenge.

Understanding the interactions and functions of different components of biodiversity, and how they interact and relate to ecosystem function is crucial to many ecosystem services upon which people depend.

3.1.1 Challenge 1(a): Whole ecosystems: the role of biodiversity in key ecosystem processes and resilience

What is it?

The relationships between biodiversity and ecosystem function and resilience and, in particular, the context-dependence of these relationships.

Why is it important?

To identify the roles of abiotic and biotic interactions, including feedbacks and linkages within and among ecosystems, to understand:

- the mechanisms of ecosystem function and ecosystem stability;
- how ecosystems can be managed, conserved and restored;
- the consequences of biodiversity change for specific ecosystem processes;
- the existence of pivotal species (e.g. bacterial nitrifiers) sensitive to environmental change.

NERC's contribution

This topic has been supported by NERC for many years, and while much progress has been made, the issues are complex. Progress to date has come both from microcosm and theoretical

studies and from large scale, natural or semi-natural experiments. The latter depend upon NERC-type funding. New work should support/establish experimental perturbations/manipulations of specific ecosystems across environmental gradients, to both understand mechanisms and to develop predictive models for the consequences of perturbations on ecosystem integrity. This will require the generation of inter/multidisciplinary teams with expertise at all scales from molecular to landscape.

Contribution of others

Collaborations between land managers, conservation agencies and other funders, e.g. BBSRC, Defra. Collaboration and co-funding with BBSRC's systems biology programmes. EU framework funding.

Deliverables.

- First large-scale, multidisciplinary testing of ecosystem level stability across major environmental gradients;
- Functional role of biodiversity in different ecosystems described and quantified;
- Between-ecosystem interactions and feedbacks (e.g., between above-and below-ground systems, freshwater/marine, terrestrial/freshwater, terrestrial/air) described and quantified;
- Developed tools and methods developed to evaluate the consequences of policy and management decisions at the population, species, community, landscape and seascape scale;
- Practical guidance on options/actions to restore resilient ecosystems at site, landscape and seascape scales;
- Indicators of ecosystem integrity and favourable conservation status developed and tested.

3.1.2 Challenge 1(b): Biodiversity and ecosystems in the face of environmental change.

What is it?

Assessing the adaptability of nature; gaining knowledge of the effects of environmental change on genes, populations, species, communities and ecosystems. This challenge places information from Challenge 3.1a in the context of a changing world.

Why is it important?

We need to predict the impact of natural and anthropogenic change on biodiversity, especially on critical ecosystem functions and services, priority species and habitats in order to develop effective management interventions. For some biodiversity components, e.g. microbial biodiversity, there are huge gaps in our understanding, such as the limits of microbial genome plasticity in relation to environmental change. The need to address knowledge gaps in marine ecosystems (e.g. the consequences of ocean acidification) is particularly important.

NERC's contribution

Empirical and theoretical studies to elucidate the effects of environmental change on biodiversity, including the autecology of key species, dispersal, colonisation and metapopulation dynamics in fragmented ecosystems, and the management options available to sustain species of conservation concern. NERC is the leader in the fundamental science, including modelling and linkage to other environmental processes and change.

Contribution of others

Collaborations with land managers, conservation agencies and other funders, e.g. BBSRC, Defra. Collaboration and co-funding with BBSRC – systems biology programmes.

Deliverables

- Limits to evolutionary or environmental adaptability better understood, thresholds beyond which change is irreversible identified;
- Magnitude of impacts of ocean acidification on biodiversity better known and mitigation/management options explored;
- Practical guidance issued on the identification, description and quantification of vulnerability and resilience;
- Practical guidance on options/actions to manage biodiversity, including priority species and habitats, and prescriptions for agri-environment schemes;
- Accessible, robust, long term datasets linking change in physical, chemical and biological parameters and biodiversity;
- Models developed which allow the impacts of individual and multiple stressors on biodiversity and ecosystems to be predicted, to better inform political and economic decision making;
- Identification of the key environmental drivers of biodiversity change and of how multiple drivers are likely to interact with one another;
- Drivers in freshwater and marine ecosystems, including in polar regions and the deep sea discriminated and quantified;
- Systems for monitoring emerging pathogens and risk assessment for invasive species/pathogens developed and tested;
- Likely outcomes on biodiversity and ecosystems (functioning and services) described if current practices and economic trajectories continue;
- Predictions of the frequency of and circumstances contributing to complex changes leading to phase shifts, irreversible changes etc.

3.2 Challenge 2: Develop new tools and techniques to describe biodiversity and its function

What is it?

The development and application of new (e.g. molecular) approaches to rapidly assess biodiversity, and the functions of organisms, populations, species and/or communities. These methods will enhance discovery, inventory and characterisation of biodiversity, especially of unknown elements (e.g. deep sea, Archaea, uncultured microorganisms). The methods should be rapid, high throughput, and exploit new technologies to scale up the rate of analysis and discovery. This challenge is to exploit molecular technologies and other methods for rapid assessment of the biodiversity:

- unknown biodiversity (both inventory and description);
- functions, and changes in functions;
- changes in distribution and abundance;
- phylogenetic information and higher taxon biodiversity;
- variation in molecular form and function below the species level.

Why is it important?

This topic is important in both fundamental and applied areas:

- This challenge is seen as being timely and important for the UK. There is expertise in this area and there is real potential for development and exploitation;

- Halting/slowing biodiversity loss is a political imperative and a major policy driver that can only be tackled by utilising new technologies. Fast and pragmatic techniques are needed to provide an inventory for conservation and management. Without these we risk losing biodiversity at a greater rate than it can be described;
- These state of the art techniques are essential for deciphering microbial diversity in any ecosystem and making the link between species identity and in situ function;
- Increases in knowledge and development of techniques in this area will reveal how biodiversity is structured from the nano- to macro- scale. Without investment we face continuing problems of overload of detail and orders of complexity;
- These techniques offer tools for rapid, remote and efficient monitoring of environmental change (including molecular sentinels, e-taxonomy);
- Wide application in other areas of science, and many possible spin-offs for environmental technologies.

NERC's contribution

NERC is central to this, and likely to be only body doing the basic science for non-commercial applications. Application of new bioinformatics tools and techniques will be critical to success.

Contribution of others

Exploiting the Technology Partnerships with Water Boards, EA, pollution control, disease control, forestry, invasive species and pathogens.

EPSRC – technology development, model genomes.

International collaborations, EU, NSF. BBSRC – agricultural field. Possible links with private sector.

Deliverables

- Molecular tools and methodologies (e.g. phylo-chips) to produce the raw data;
- Computing and bioinformatics tools to analyse and exploit the data. It is now possible to clone and sequence a number of whole prokaryote genomes rapidly but our ability to analyse and exploit these data is slow and laborious;
- Web enabled techniques for data gathering and dissemination on new scales of size and complexity;
- Environmental sentinels/marker systems (biomarkers);
- An in depth study of one system as a demonstration – comprehensive survey, characterisation of form and function as proof of concept to establish the principles and implementation of a Systems Biology approach;
- Identifying the role of non-cultured organisms and functionally distinct organisms;
- Solutions to the problems caused by shortage of taxonomists: a plan for 21st century taxonomy;
- Facilitating knowledge exchange for wealth creation through gene mining and discovery of novel organisms and activities.

3.3 Challenge 3: Improve approaches for measuring abundance and distribution of biodiversity and its functions.

What is it?

Development of a coherent set of validated measures of biodiversity across taxa, scales and ecosystems. This should be a whole ecosystem approach to replace current means of measuring

biodiversity that tend to be focussed on individual taxa. It should include the functional components of biodiversity. The measures must be of abundance, distribution and variability at all levels from genes to ecosystems at relevant temporal and spatial scales, be suitable for assessing both status and trends (therefore repeatable), and be robust under a wide range of conditions. They must also be applicable to systems that are currently relatively poorly understood (e.g., microbial populations in different ecosystems, deep sea marine systems).

Why is it important?

Measuring biodiversity has become over-complicated, compromising our ability to monitor and report on its status and trends. Large gaps in knowledge exist for even well-studied organisms and ecosystems, so we must find more efficient ways to measure biodiversity in poorly known systems.

NERC's contribution

Developing, testing and validating of new and existing measures. NERC could lead in techniques internationally, using established datasets and applying developed and novel methods. It needs to be determined whether the monitoring currently being undertaken is fit for purpose. Carefully targeted systematic monitoring of biodiversity is required that works across taxa, environments and geographical scales.

Contribution of others

International collaboration. NGO volunteers, institutes and universities. Industry (monitoring their own impact and application of the tools). Government agencies.

Deliverables

- Validated and efficient indicators developed and tested for the status and trends of UK biodiversity and its functions, that work across taxa, in marine, freshwater and terrestrial systems, across geographic and biological scales, and with relevance for policy objectives;
- Systematic monitoring of biodiversity developed and tested;
- Development of Environmental Change Network and marine monitoring sites;
- Provision of data for production of predictive models;
- Robust measures, across taxa and habitats, of changes in insect, plant and marine biodiversity to supplement existing measures of biodiversity (e.g. birds and butterflies);
- Excellent UK data could be used to model how to measure biodiversity and its function; the UK could then lead internationally on global biodiversity monitoring.

3.4 Challenge 4: Enable society to predict and mitigate effects of biodiversity change on processes that sustain life

What is it?

Measuring and predicting the impact of biodiversity change on human well being. This will include how biological resources can be used in a sustainable way to benefit society's long-term interests.

Why is it important?

Biodiversity change has direct impacts on human well-being especially in communities which rely on local biodiversity for food, medicine, shelter and inspiration. Healthy ecosystems are critical in maintaining sustainable food resources. Biodiversity change also affects the incidence and impact of human disease. World leaders are committed to global poverty reduction but the extent of our ultimate reliance on biodiversity is poorly understood. Development decisions often

fail to take account of the benefits provided by biodiversity. The genetic diversity within the natural world provides a resource that can positively contribute to human wellbeing.

NERC's contribution

Multi-disciplinary approaches are needed. NERC has a lead role in supporting the natural environment component.

Contribution of others

ESRC, MRC, DfID, other EU member states and other international organisation are potential partners. Projects need to be undertaken in partnership with institutions in developing countries. There are strong links with BBSRC in terms of the genetic approaches to biodiversity.

Deliverables

- Consolidated/quantified evidence of impacts of biodiversity change on human well-being, including disease;
- Indicators demonstrating trends in biodiversity change and human wellbeing at national and sub-global scales;
- Models to predict for trends in human well-being/disease in communities heavily reliant on biodiversity;
- Tools for the sustainable management of biodiversity;
- Identifying the processes determining the distribution and abundance of marine bioresources;
- Characterisation of novel genes, chemicals and micro-organisms to support the understanding of the environment and environmental issues.

3.5 Challenge 5: Develop integrated tools for assessing the benefits of biodiversity

What is it?

Development of an objective method to directly and indirectly estimate the benefits of biodiversity, including ecosystem functions and services, to human health, wealth and well-being.

Why is it important?

Development, testing and validation of practical tools and techniques for assessing the benefits of biodiversity, recognising the full range of possible values, including economic, social, health, well being, aesthetic and cultural. This will enable rational decision making in cases that require weighing up alternative benefits because currently, biodiversity and ecosystems often have no currency despite their fundamental value to society. Meeting this challenge will raise the profile of biodiversity, give NERC strategic leverage and promote market approaches for ecosystems.

NERC's contribution

NERC could lead in stimulating this initiative (the basic science inputs). Must ensure the measures are based on sound science, especially at the biodiversity-ecosystem level. NERC cannot start to do this alone.

Contribution of others

ESRC and MRC are essential partners. Defra, Natural England, RSPB, international partners, politicians, OSI, economists.

Deliverables

- Toolbox for valuing biodiversity;
- Method for communicating this to the decision makers to enable them to prioritise programmes and projects;
- Knowledge of the values of ecosystem services;
- Balance sheet for UK biodiversity.

4. Meeting the Challenges

The published NERC Strategy highlights some of the ways in which the NERC will be “Meeting the Challenges” for each Theme. These are essentially some of the potential key deliverables. They often cut across several of the Theme’s challenges. For consistency, we have included those for the Biodiversity theme below, against the challenges that they most strongly relate to. They are not exclusive and may evolve during the Strategy’s lifetime.

“Meeting the Challenges” (from the NERC Strategy)	Biodiversity Challenges					
	1a	1b	2	3	4	5
Explore ecosystems to discover novel biodiversity and increase knowledge of the function, distribution and abundance of biodiversity	X			X		
Describe novel genes, biochemicals and microbes to help explain how ecosystems function	X		X			
Develop tools for analysing and managing data which can handle the massive amounts of information coming from high-throughput technologies that rapidly sequence large amounts of DNA	X		X	X		
Produce, maintain and analyse long-term datasets, linking changes in biodiversity to physical, chemical and biological processes. Advance Theory and modelling to enhance understanding of the role of biodiversity in ecosystem services.	X	X	X	X	X	
Develop integrated physical and biological models that predict the impacts of individual and multiple pressures on biodiversity and ecosystems, particularly in poorly explored ecosystems, such as in marine, polar and freshwater environments.	X	X		X	X	
Provide evidence for the impact that biodiversity loss has on people’s well-being and health. Develop improved indicators of trend and patterns in biodiversity loss and develop new methods for assessing the direct and indirect value of biodiversity to society.					X	X
Investigate the thresholds beyond which a change in biodiversity will lead to extinctions and irreversible ecosystem change.	X	X			X	

5. Links with other science themes.

The Biodiversity theme has links with a number of the other themes.

- (i) Environment, Pollution and Human Health.
 - Ch 4 – ‘Impacts of waste management activities on the environment and human health’. Natural ecosystems are both affected by waste management activities, and can also have a role in attenuating the impact of pollutants and pathogens;
 - Ch 3 - ‘Assessments of pollutant and pathogen exposure risk to humans’ has links both in terms of the use of natural organisms but also the ‘omics’ technologies that may be required for biomarkers and biometrics.
- (ii) Sustainable Use of Natural Resources.
 - The Biodiversity theme has included challenges relating to the diversity of life as a sustainable resource which was also initially identified within the Sustainable Use of Natural Resources (SUNR) theme;
 - A closely related challenge ‘Valuing Environmental Services’ was identified within the SUNR theme which closely matches challenge 5 within the Biodiversity theme. It also has links with Natural Hazards, Environment Pollution and Human Health and Climate System themes. These areas will need to be developed as a cross cutting challenge on Environmental Evaluation, that reflects the overarching driver to enable society to account for the various values of the environment in decision-making.
- (iii) Climate System
 - This theme has strong links with Biodiversity Challenge 1(b).
 -
- (iv) Earth System Science
 - This panel identifies links to Biodiversity in all three of its major challenges.
- (v) Technologies
 - The Technologies theme proposes ‘clusters’ in novel laboratory instrumentation and informatics. These should directly link with the Biodiversity Challenge 2.

6. Implications for the science base

- i) **Collaboration** with economists, social scientists, other environmental scientists. Work needs to be undertaken in large broad teams, using an interdisciplinary approach.
- ii) **Funding** Pump prime funding for new projects - support to build large and broad collaborative teams, including access to funding for international collaboration.
- iii) **Facilities**
 - Isotopic facilities;
 - Planes, ships;
 - ‘omics’ technologies;
 - Remote sensors, field data loggers, GIS, systems for real-time in situ monitoring and analysis;

- Large field sites, selected and replicated including a suite of terrestrial, marine and freshwater sites.
- iv) Improved access to data and information management**
- Custodianship of environmental data is needed to meet the biodiversity/bioinformatics challenge;
 - Wider investment in bioinformatics for the environmental sciences. Distributed information networks;
 - Non-electronic methods to digitise/store/archive/retrieve key data;
 - Improved visualisation/geo-statistical tools and access to them;
 - Access to relevant government agency databases (e.g. EA databases on river water quality, Natural England (English Nature/RDS) data on SSSIs and agri-environment schemes);
 - Means to integrate data from multiple sources;
 - Library of long term monitoring datasets;
 - Solutions to storage and retrieval of ‘omics’ data; currently only direct sequence DNA data is well managed.
- v) New taxonomy**
- We need a new taxonomy, a plan for it to transform it into a 21st century science – web based tools and e-resources may be a way to solve this problem.

7. Synergies and Partnerships

Biodiversity research requires programmes of work involving the widest range of users and producers of science. In particular there is need for collaboration between research funders both in the UK and Europe.

Partnerships are needed with:

- European bodies – EU, BiodivERsA, Eranet, EPBRS, EU framework programme.
- Government departments and government agencies, who need a secure evidence base for policy and action. (Defra, DFID, English Nature, SNH etc.)
- Cross Research Council
- NSF (US) – particularly in current and future spin-offs of the ‘Biocomplexity in the Environment’ Programme
- Landowners UK and Europe, Industry

8. Knowledge

End-users

Detailed involvement of key users from beginnings of research projects will contribute to knowledge exchange.

Particular opportunities for commercialisation

Gene mining, dipstick technology, ‘omics’ and bio-indicators, knowledge of the economic impact of biodiversity.

Science into Society

Need process where science done in NERC engages scientists in communicating to the public.

Policy

National and international requirements – how can policy needs influence the science that is funded by NERC?

Policy and practice need science inputs at both the broad strategic level (e.g. impacts of climate change) and at the small, local scale (e.g. Re-introduction of a threatened species). NERC strategy should be flexible enough to address them both requirements.

9 Links and interfaces with organisational themes

Sections 7 and 8 above set out specific opportunities for partnerships and knowledge exchange within the Biodiversity theme. At a strategic level, these have been incorporated into the corresponding organisational themes of the NERC Strategy.