# European Platform for Biodiversity Research Strategy

### Informal discussion paper

# Biodiversity research issues of priority for Europe at the start of the 21st Century

## Target audience

The attached paper is addressed to the members of the European Platform for Biodiversity Research Strategy (EPBRS), the members of the cluster of biodiversity projects part-financed by the EC under FP5, and the EUBiodiversityScience electronic discussion group.

## Purpose

The attached paper is a working document with which to begin to outline a possible agenda for research that could be carried out in Europe over the next few years. This should provide on the one hand the basis from which to develop the work programme of the next Community Framework Programme, and on the other the basis of discussion of national funding agencies, policy makers and scientists in this domain.

## Invitation to comment

This version (3.0) of the document takes into account the written comments of participants of the EPBRS, but we would greatly appreciate your help to improve this document, perhaps by better integrating ecosystem research or by highlighting issues of specific importance to marine research.

The document is certainly too comprehensive and does not prioritise the many research needs it picks out. Your suggestions for assigning relative priorities to the issues will be invaluable. If you do not do it, the priorities may be set by persons with no particular expertise in this field.

## Disclaimer

This document is an initiative of the EPBRS. It does not prejudge any proposal that the European Commission may make concerning the European Research Area and the new Framework Programme.

The issues raised and views expressed in this document may not be taken to represent a suggestion by, or state a position of the Research Directorate General, or the European Commission.

## Author

This document has many authors, in that it incorporates a large number of substantial comments from EPBRS participants. Please send remarks to the EPBRS e-group (EPBRS@egroups.co.uk), the EUBiodiversityScience e-group (EUBiodiversityScience@egroups.co.uk) or to:

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## Assigning priorities to issues

In reading the list of research topics that follows, you may find it useful to allocate points out of 100 to each topic, using the following criteria to judge the importance of the issue.

***Criterion 1: is public funding appropriate for this research? (20 points)***

Are the results of research on this issue likely to improve the public good? Is work on this issue likely to improve policy and decision making? Will work on the issue promise potential benefits to the environment, to society or to the economy? Is this issue unlikely to be studied by private foundations or commercial companies?

***Criterion 2: is this issue most relevant to European, national or local research? (20)***

Is this an issue that is important for many of the participating states? Is it one that arises because of European Union policies, or could better scientific understanding of this issue help to generate, improve or implement EU legislation? Is a European approach appropriate to the urgency, importance or probable cost of the issue?

***Criterion 3: is this an issue for research by Europeans? (10)***

Is the issue unique to Europe, or is it particularly significant for Europe? Is it an area of research where we can expect that European scientists can do better than other countries? Does Europe need its own research effort on this issue to counterbalance or provide insight into results from research in other countries?

***Criterion 4: is this a major issue for biodiversity? (20)***

Is the issue widespread, common, or prevalent? Is it one that both experts and lay-people agree is important? Does this issue relate to a major driver of biodiversity loss? Does the issue relate to substantial difficulties for society, perhaps involving economic or social costs? Does the issue require an early or rapid increase in scientific knowledge if we are to prevent things getting significantly worse?

***Criterion 5: will this work benefit biodiversity, or increase the welfare of citizens? (20)***

Will scientific advances on this issue have interesting potential benefits, including the ability to make decisions that will better protect biodiversity? Are potential users likely to be able to capture those benefits? Would research on this topic tend to decrease the probability of extinction of species or destruction of habitat, alleviate poverty or generate income, increase the equity in distribution of benefits gained from biodiversity, or protect biodiversity for future use or enjoyment? Would it remove barriers to other research issues in this list?

***Criterion 6: does this work have high scientific potential? (10)***

Is the issue unique, in the sense that work on other issues will not greatly benefit or illuminate this issue? Will work on this issue throw light on other important issues, or will advances on this issue greatly improve the usefulness of any advances in other issues? Is there good potential for scientific progress on this issue, because it is characterised by promising avenues of research, with many qualified scientists in the domain, with access to suitable technology and facilities?

IUCN comment on priorities:

## Biodiversity research issues of priority for Europe at the start of the 21st Century

### Summary

Research is needed to understand how to slow or prevent the loss of biodiversity, to help Member States and the Commission to implement the Convention on Biological Diversity, the Habitats and Birds Directives, biodiversity action plans and the 6th Environmental Action Plan.

Research on ecosystems and biodiversity must be brought together. Aquatic and terrestrial biodiversity share a coherent conceptual framework. The research required is multi-disciplinary, involving research in biology, socio-economics and law.

**Inventory**: Taxonomy and systematics of many groups must be improved. A primary goal must be to identify European species that are under threat of global extinction.

**Monitoring:** Work is needed to establish and exploit a network aimed to provide long-term biodiversity monitoring capability throughout Europe.

**Genetic variation**: Work on the genetics of populations and species is needed for conservation and to understand ecosystem structure, function and resilience.

The CBD **ecosystem approach** requires substantial research to make it effective as a policy and management tool and to clarify how biological diversity relates to ecosystem processes.

**Classification of habitats** and ecosystems: Research is needed to extend, refine and exploit the existing classifications to adapt them better to the practical needs of users.

**Quality of habitats:** Research is needed to determine how to monitor habitat quality, to manage habitats, to identify ecosystems with low resilience, and to monitor the effect of management.

**Soils**: Research is needed to understand how soil biodiversity responds to stress, the role of soil biodiversity in ecosystem function, resilience and recovery.

**Habitat loss and fragmentation:** Research is needed to understand the causes of loss or fragmentation of habitats, and to understand how to **rehabilitate and restore degraded ecosystems** and fragmented habitats effectively and at reasonable cost.

**Biological invasion**: Research is needed on invasive species, the ecosystems that they invade, and the ecological consequences of GMOs released into the environment.

**Economic drivers** of biodiversity loss: Research is needed to show how conservation of biodiversity and wise use can increase the well-being of local people and to determine the most effective mechanisms for providing citizens with benefits from conservation.

**Climate change**: Research is needed to understand how species and habitats respond to climate change, to suggest actions tending to mitigate the effects of climate change, and to help preserve habitats and species as use of land and water resources change.

**Value of biodiversity:** Research is needed to identify incentives to prevent over-exploitation and to reach economic, social and environmental goals while cherishing our biological environment.

**Traditional knowledge:** research is urgently needed on the traditional use and wise management of natural and semi-natural ecosystems and their biological components.

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## Biodiversity research issues of priority for Europe at the start of the 21st Century

### *Policy framework*

Research results are essential to help EU Member States to implement the Convention on Biological Diversity[i], the Habitats Directive, the Birds Directive and the EC biodiversity strategy. They are also required to help the various Directorates General to implement their biodiversity action plans, and to support the implementation of the 6th Environmental Action Plan[ii] and the Water Framework Directive.

### *Nature of the research required*

Research on biodiversity is more likely to have a positive effect on policy if it is inter-disciplinary, involving natural and social scientists, economists, and experts in environmental law. Researchers and stakeholders should work together to define objectives, to develop arenas of negotiation, to review progress, and to monitor the effect of policy on biodiversity.

Where research on biodiversity is likely to have significant management and policy implications it should be designed with the appropriate users in mind. In making recommendations, researchers should take into account the possible impacts of EU policies on the biodiversity of non-EU countries.

Land use planning is typically scaled to the landscape. Research in support of such planning should be designed to be applied at a similar scale, and should take into account the interactions between the ecosystems – and their components – within each landscape.

Research programmes in Europe should be appropriately designed to be sensitive and responsive to the wide range of social and natural systems in the western Palaearctic region. While the various drivers affecting biodiversity in any given ecosystem may be similar from one part of Europe to another, the relative importance of the drivers and their impacts may vary greatly. Researchers should consult local stakeholders and design their experiments and interpret their results accordingly. The work should be designed so that its results make it possible to compare biodiversity and its drivers from all major ecosystems across Europe.

Biodiversity research projects should, wherever it is sensible, include work packages on taxonomy and systematics, as part of the Community contribution to the Global Taxonomy Initiative[iii], while work to develop taxonomy or systematics should be carried out not as isolated exercises but in conjunction with projects that touch on other issues listed in this document.

Research objectives should be established to assess and support policies and management strategies, to adapt them in the light of their impact on the interactions between climate change and biodiversity, to encourage the sustainable use of biological resources, and to husband the natural environment with regard to the intrinsic value of its components. Data should therefore be collected, analysed and archived in such a way as to make them useful to researchers well into the future.

The biodiversity of our planet is largely contained in two environments: aquatic and terrestrial[iv]. Principles underlying the emergence, maintenance and loss of species, and hence of biodiversity, are common to all living things. We should approach biodiversity research in a single coherent conceptual framework that encompasses the enormous scales of evolutionary space and time.

***Orientation of the research***

Results for policy: European policy makers need research results to inform policy development and to help to establish priorities in the implementation of the EU Biodiversity Strategy and EU Environmental Action Plan.

Results for science: Scientists need basic genetic and ecological data, sound systematics, robust understanding of biodiversity drivers, pressures, processes, and interactions, and an improved understanding of natural systems. Scientists must also understand how ecological communities function, how they interface with social and economic systems, and how to apply this knowledge to the conservation of biodiversity.

Results for conservation: Conservation professionals need research results that will allow them to apply scientific principles to conservation management. Knowledge of interactions and how natural drivers induce changes in genetics, morphology, behaviour, reproductive success, and the structure and functions of ecosystems is of profound importance in our understanding of how human activities may influence and manage ecosystems.

Results for risk assessment: Legislators, technologists, those who exploit biodiversity directly, and society need scientific tools to assess the risk to the environment of various human activities.

Results for wise use: Society also needs research results that lead to the use of components of biodiversity in ways that can be sustained in the long term, both within and outside protected areas.

Results for educators: Teachers and those who develop curricula and design educational programmes or manage living collections need up-to-date results from research to help them to convey their message to the audience.

Results for people: Research will enrich the European citizen to the extent that she has access to an informative, direct and useful expression of the results.

***Main tasks***

Biodiversity covers issues as diverse as taxonomy, the economy, ecosystem functions, conservation and human value systems. Research in this field must tackle an immense range of problems and involve many scientific disciplines. The following text starts with taxonomic issues, which are the basis for the identification and description of biodiversity, but it could equally well have started with ecological processes or from many other potential entry points. The sequence of topics is not intended to indicate a relative research priority. Indeed, this document is intended to stimulate the debate on research priorities.

***A note on nomenclature***

The vocabulary used to describe objectives of research is not neutral. Frequently this document uses words that are appropriate for terrestrial ecosystems but for which no obvious equivalent exists in the marine world. Species have environmental requirements, whether that be for moisture and soil acidity, or salinity and pressure, and they appear and disappear along ecological gradients. In terrestrial environments the co-existence of a certain coterie of species, dominated by a particular association of plants, gives some meaning to the concept of the habitat[v]. For marine biodiversity the habitat concept may sometimes have its uses, but it is more often irrelevant since it fails to capture much of the essence of the marine world. On land, landscapes capture much of human perceptions of scale and biodiversity, and remind us that biodiversity research must cope not only with interactions between spatial scales and the issues to be resolved, but also with the omnipresent influence of humans. Under water there is no equivalent to the concept of the landscape. The worlds are sufficiently different that we may never be able to develop concepts and vocabulary to let us describe underwater and terrestrial

environments in the same terms. It would be artificial to avoid the words "habitat" or "landscape" in this document, but whenever they occur the reader should ask "what is the marine equivalent for research on this topic"?

# 1. Provide scientific information for policy

1.1. Taking stock: building the **inventory** of living things[vi]

While the taxonomy and systematics of some groups of organisms in Europe are well known, many are not. Even among well-known groups, comprehensive Flora and Fauna for the EU do not exist and should be developed. Research is needed both on procedures for inventorying micro-organisms, and on the inventory of this and other poorly known taxonomic groups. Work should advance taxonomy and systematics, and exploit and improve access to collections in museums and botanical gardens (including the activities surrounding GBIF). A major aim is the generation of straightforward identification guides – accessible through the internet where possible – aimed at ecological practitioners and conservation managers. High priority should be given to identifying European species under threat of global extinction or experiencing rapid declines in population.

1.2. Taking stock: assessing environmental genomics and **genetic variation** in species

In view of the huge importance of the subject in the industrial countries and its importance for focusing conservation actions, we should encourage work on the genetic characterisation and structure of populations and species and the evolutionary potential of the genetic diversity within and between populations, especially as this characterisation relates to conservation and to ecosystem structure and function. Research should aim to determine whether it is feasible to identify taxonomic groupings or evolutionary units for which there is evidence that the members have a common origin and are different from other similar groups, and to what extent such a concept will allow conservation effort to be more effectively focused.

1.3. Taking stock: understanding habitats

The existence of a habitat is no guarantee that a species supposedly typical of that habitat will be found there. Without a profound understanding of the habitat, it may turn out that we are managing and protecting increasingly empty habitats as species go extinct piecemeal. Work is therefore needed on the concept of the habitat and its implications for biodiversity conservation.

1.4. Taking stock: improve the **classification of habitats** and ecosystems for the protection and conservation of biodiversity

Species inventories form the basis for much conservation work, but these inventories are only reasonably complete for a small number of taxa such as birds and large mammals. An approach based on habitat types may help to protect both these well-known taxa and lesser-known organisms. For this reason, policy makers, conservation organisations and scientists all require a sound and practical characterisation, inventory, classification and cartography of European marine and terrestrial habitats, ecosystems, and landscapes. Research is needed to improve and refine existing catalogues (PHYSIS[vii], EUNIS[viii]), develop mapping programmes, refine and extend to the whole of European existing (e.g. UK, Belgium) identification keys and parametric databases (e.g. Nordic countries), and to place European habitats in their global context. Of highest priority are habitats and ecosystems in pristine or typical states that retain original species complements, original structures and original processes, and those that contribute most to regional or local biodiversity, including ecosystems traditionally managed for sustainable use.

1.5. Taking stock: investigating **minimum viable areas and effective networks** of habitat

Biodiversity may be well conserved by protecting selected habitats and sites. The biodiversity of sites cannot be maintained in the long term, however, unless the sites cover a certain minimum area or form an effective network, which depends in part on the habitat itself and in part on the abiotic and anthropogenic conditions to which it is subjected. Very little is known about these minimum area and network requirements, and considerable research is needed to provide the basic information on which management decisions can be taken.

1.6. Taking stock: measuring the **quality of habitats** and ecosystems for management

Research is needed to develop low-cost, reliable, rapid assessment methods to monitor habitat quality, and to assess the presence, status and trend of populations of component species. Conservation managers need reliable techniques to manage habitats, and cost-efficient science-based ways to monitor the effect of management. This work would include the development of indicator approaches to the assessment of habitat quality. Research is also needed to assess deviation from pristine conditions and its effect on biodiversity, and to recognise ecosystems with low resilience that are prone to lose species or important processes. Techniques must be developed to assess when use of biological resources is sustainable.

1.7. Taking stock: ecosystem **goods and services**

Research is needed to assess, define and quantify ecosystem goods and services, to evaluate human dependence on them, and to discover how they are related to ecosystem functions. Indicators of capacity to deliver goods and services should be developed, leading to methods of describing the capacity of the ecosystem to sustain the delivery of those goods and services.

1.8. Taking stock: monitoring what we have[ix]

At present no biodiversity data are collected systematically across Europe. Work is needed to improve and extend existing facilities, schemes and sites to establish and exploit a network of long-term terrestrial and marine biodiversity monitoring initiatives throughout Europe and its seas, in direct support of ecological research. Research is needed to develop and promulgate sampling protocols that are non-intrusive and non-destructive of elements of biodiversity, and to investigate and promulgate the use of indicators to assess biodiversity status and trends. Research is also needed on deep ocean benthic communities, about which we know almost nothing.

1.9. Taking stock: species and habitats in critical condition

Europe requires research to help the Council of Europe, local conservation authorities, and conservation practitioners to perfect and manage of their "Red Lists" of endangered or threatened habitats and ecosystems, to develop appropriate methods for habitat management or restoration and to maintain viable populations of threatened species in their original habitats. There is also merit in establishing “Green lists” of species or habitats that are recovering as a result of research and conservation actions, and a “Black list” of potentially harmful organisms. This work should cover ecosystems in reserves, as well as ecosystems that are diminishing in area or declining in quality in Europe.

1.10. Taking stock: assessing awareness and knowledge of the value of biodiversity

For policies to be effective over the long term, the citizen must understand the motivation behind them and support their aims. Research is therefore needed to assess and monitor changes in the attitude of European citizens towards the conservation of biodiversity.

## 2. Quantifying loss and causes of loss: Identify processes and activities and monitor their effects[x]

The risks to the environment and to human well-being that will follow from the loss of biodiversity are largely unknown. Nevertheless it seems clear that a biologically impoverished planet is not only a less interesting place to live, but one at greater risk of biological calamity or collapse. For this reason it is urgent to understand how to slow or prevent the loss of biodiversity in all ecosystems. This involves work to increase our understanding of the inventory of living things and to identify, quantify, understand and counter threats to biodiversity and drivers of biodiversity loss. This increased understanding should be built into models that can then be used to further increase our understanding.

2.1. Identify processes leading to loss of habitat and species

The main planetary drivers of biodiversity loss are thought to be habitat degradation and loss, biological invasions, habitat fragmentation, over-harvesting and over-exploitation, and climate change. To use scarce resources wisely, it is necessary to understand how these and other drivers of diversity and habitat loss impact wildlife in Europe.

2.2. Understand and mitigate **degradation and loss** of natural and semi-natural habitats

Research is needed to understand how to reduce or eliminate the impact of the drivers of habitat loss of natural and semi-natural habitats.

2.2.1. Health of the ecosystems of Europe

Habitat loss is thought to be the main cause of loss of biodiversity in Europe. Research is needed to establish a European system to monitor the status and trends of a standard set of habitat types, and the causes driving the loss or degradation of those habitats.

2.2.2. Restoration of habitats and species[xi]

Research is needed to understand how to rehabilitate and restore degraded ecosystems effectively and at reasonable cost. We also need much more research to understand how to help threatened species to recover in face of continuing pressure on their populations. Research is needed to develop tools to help decide which actions should be taken and to help set priorities corresponding to choices of society.

2.3. Comprehending the biodiversity of managed ecosystems

Research is needed to understand the influence of land use or land management on the biodiversity of managed landscapes (including agricultural and forested lands), and the extent to which changes in managed habitats may influence the components of biodiversity. Research is also needed on the effect on biodiversity of agricultural intensification, specialisation and abandonment.

Research is needed on the effect of marine and freshwater fishery on the biodiversity of the volume of water that is harvested, and of fish farming on the adjoining marine and coastal ecosystems. Information is needed on the fishing methods and the level of

fishing pressure (on fishery species and other marine organisms) of EU Member States on various marine systems, including the waters of the Red Sea and the Western Indian Ocean.

2.4. The biology and sociology of **biological invasions**[xii]

2.4.1. Understanding Biological Invasions: Building a Knowledge Base

Methods and techniques are needed to recognise and characterise organisms that may be invasive and ecosystems that may be particularly vulnerable to invasion; and develop predictions of invasive behaviour and ecosystem vulnerability to invasion. Particular attention should be paid to the effect that the probable modification of climates of Europe will have on the ease with which non-native organisms can invade.

2.4.2. Management of invasive species: Assessment, prevention and control

Monitoring methodology should be improved to detect potentially invasive organisms early; methods are needed to track invasions; to assess ecological and socio-economic impacts of invasions, and, where appropriate, to control them.

2.4.3. Policy and Communication relating to biological invasion

Research is needed to develop multi-disciplinary scientific support for appropriate policy on prevention, management for control, and legislation, public awareness and information.

2.4.4. Invasive aspects of Genetically Modified Organisms (GMOs)

Methods are needed to predict and prevent invasive behaviour of GMOs released into the environment[xiii]. Research is also needed to develop reliable methods to predict and reduce the probability of transfers of genetic material between organisms.

2.5. Combating **habitat fragmentation** and preventing piecemeal extinction of meta-populations

Habitat fragmentation threatens different species differently, depending on how the fragmentation influences their population distribution, size or migration rate. The species composition of fragments is influenced by the size of the fragment. For some species habitat fragmentation reduces genetic variation, and sets up barriers to dispersal. Many organisms are unable to maintain key interactions with pollinators or dispersal agents. These species are affected negatively, but others increase in abundance, and the effects of fragmentation may have significant long-term consequences on the species. Habitat alteration is often unpredictable, making its effect on the component species equally unpredictable. Research is needed to ensure that the design of new and restored habitat networks will help to achieve objectives that society sets for biodiversity.

2.5.1. Impact of habitat fragmentation and connection on species

Research is needed to examine how habitat fragmentation affects key species, and to work out means of determining how to take proper account of the time lag between the fragmentation event and the loss of local population, and other related phenomena in the struggle to protect these species from the threat of extinction in fragmented habitats. Research is also needed to understand and predict how fragmentation of previously continuous habitat, or connection of previously distinct habitats, influences the species and ecosystems in those

habitats. This work should pay attention to the effect on adaptation and genetic variation of the time since the habitat became fragmented.

2.5.2. Fragmentation, diversity and local adaptation

Under some circumstances partial isolation of habitat patches promotes and maintains genetic diversity. Research is needed to examine how the modern patterns, structures and dynamics of habitat fragmentation, interacting with the size of populations in those fragments, influences genetic diversity. Populations surviving in fragments of habitat are exposed to selection pressures that are peculiar to the environments of those fragments. Research is needed to examine how adaptation to habitat fragmentation is a stimulus for evolution, and to what extent this is influenced by the relative scales of the fragments and dispersion distances.

2.5.3. Survival in marginal habitats

In the future organisms will increasingly be found in habitats to which they are only marginally adapted. Major ecological niche shifts can take place under such conditions. Research is therefore needed on phenotypic, genetic, behavioural and ecological diversity in marginal habitats and to understand how to protect marginal or relict habitats and habitats in small patches.

2.5.4. Variation in traits

The history of populations can often be understood by examining genetic markers related to ecologically neutral traits in the phenotype. In fragmented habitats, traits with relevance to the ecology of the organism will provide considerable information on the action of natural selection. These traits will be highly significant to the survival of the population, and research is needed on variation in ecologically relevant traits.

2.5.5. The genetics of habitat restoration

Research is needed to understand how the genetic characteristics of founder members of populations in restored or newly created habitat patches influence the dynamics of the restored ecosystem, and themselves change over time.

2.6. Finding the means to reduce **over-exploitation and promote wise use** of components of biodiversity within an ecosystem approach.

2.6.1. Economic exploitation including poverty as a driver

The economic exploitation of biological resources is central to our existence and is a major factor driving changes to the biodiversity of the planet. Research is needed to investigate what motivates land owners to conserve biodiversity or to give conservation high priority in their management decisions.

In most parts of the world if conservation is not linked strategically with the alleviation of poverty then the rate of loss of biodiversity will continue to increase. Research is needed to show how conservation can increase the well-being of local people and how poor people can be given a stake in conservation.

2.6.2. Impact of trade

Trade[xiv] encourages the cultivation of crops for export. Commercially-driven agriculture, usually involving mono-cropping, replaces the traditional, ecologically sustainable agricultural practices, with procedures that almost always impose considerable costs on the environment, including degradation of the soil,

depletion of water resources and the loss of biodiversity. Research is needed to understand the impact of trade and to find ways to reduce the ecological footprint of European consumers at home and abroad.

2.6.3. Leisure pursuits including tourism

In many countries biodiversity drives the tourism market, but tourism also has a significant impact on biodiversity. Visitors who care very much about the environment unwittingly damage it as water is diverted from natural ecosystems to hotels. Tourists concentrate in areas of outstanding natural beauty, compacting cryptobiotic soils or trampling fragile riparian communities, eroding and despoiling paths, banks, woodlands and camping sites and displacing or disturbing wildlife. Souvenirs, both bought and gathered from the wild, may also have significant impact on local biodiversity. Socio-economic research is needed to understand why measures are not always taken to implement what we already know to protect and cherish the biodiversity that tourists come to enjoy.

2.6.4. Infrastructure developments

Research is needed to encourage, where practical, proper planning, effective property rights and good land management to allow development of infrastructure to take place while conserving biodiversity.

This is especially true for some major infrastructure developments affecting marine systems. An example is the creation of dams and irrigation schemes on the quality and quantity of waters reaching the marine basins of the Mediterranean and Baltic.

2.6.5. Promoting wise use

Research is needed to assess the effectiveness for promoting the wise use of the components of biodiversity of policy and market-led tools, including planning, regulation, incentives, advice and manipulation of consumer demand. The identification and analysis of perverse incentives and their impacts is essential. Work is needed to determine rates of sustainable extraction from marine ecosystems.

2.7. Combating the biological consequences of **climate change**

2.7.1. Understanding species and ecosystem response to climate change

Many species and ecosystems will exhibit non-linear responses to climate change, making some vulnerable even to minor changes in climate. For example, many corals, if exposed to slightly raised temperatures for a short period suffer bleaching and mortality, with serious cascading consequences to all the reef species that depend on their existence. Research is needed to understand how species and habitats respond to climate change and to suggest actions tending to mitigate the effects of climate change.

2.7.2. Movement of species ranges

Global warming, likely to be felt particularly in higher latitudes, will tend to move the optimal temperature bands for vegetation and soils towards the poles or further up mountain sides. At the same time, anthropogenic land cover change, including agriculture, roads, and urban areas now impedes the migration of plant species, as does the fragmentation of habitats in a way that was never the case during previous periods of global climate change. Research is needed to suggest

ways to identify and help preserve species that are likely to be trapped by this combination of factors.

2.7.3. Sea level changes

Climate induced changes in sea level and storm frequency, coupled with inland drainage, have significant consequences for coastal habitats, which also experience losses of biodiversity through urban development and construction of sea defences. Research is needed to determine how coastal sediment movement will interact with engineering works and coastal habitats and the impact of the changes in erosion and sedimentation on components of biodiversity.

2.7.4. Refugia

The concept of refugia is closely related to that of island biogeography. Refugia are important for conservation, and Europe has put in place legislation tending to establish or maintain refugia for wild species and natural habitats in networks of nature reserves. These and other remnant islands of natural habitats in our human-dominated landscapes – "Holocene refugia" – may be the only places in which significant parts of biodiversity will survive the mass extinction of the 21st century. Much more research is needed to understand how the area and habitat diversity of refugia influence their viability, and the viability of meta-populations of organisms depending on refugia, and on how inter-specific competition and small population phenomena drive ecosystem changes within them.

2.7.5. Climate induced changes in land and water use

Biodiversity will be increasingly affected by human response to climate change, and by alterations in access to, patterns of use of, and conflicts over, resources providing food, water and raw materials. Research is needed to assess the impact on biodiversity of probable changes in global, European and regional socio-economic forces and their consequences.

2.8. Establish methods and guidelines to assess **environmental risk** from chemicals and biotechnology, including genetically modified organisms.

We urgently need a set of scientifically sound protocols to assess the hazards associated with technological innovations, and to monitor the environment for early signs of ecological risk or damage.

2.8.1. Assessing environmental risk from pollution

Pollution contributes to a greater or lesser extent to the loss of biodiversity in every ecosystem on the planet. Efforts are needed to increase scientific understanding and to quantify the impact of pollutants on the functions of terrestrial, marine and freshwater ecosystems, and on their component species, and to establish and improve methods for assessing environmental risk from these pollutants.

Effort is particularly needed to assess risk to biodiversity from pollution by toxic chemicals, including endocrine disrupters and other persistent organic compounds, and by inorganic chemicals including the atmospheric deposition of nitrogen and sulphur.

Epidemiological and eco-toxicological research is needed to identify the causes of damage, and to assess, on the one hand, **impacts** on biodiversity of pollutants, and, on the other, the **risk** to biodiversity at every level of biological organisation.

This research should include efforts to standardise methods for measuring the severity of effects.

2.8.2. Assessing environmental risk from biotechnology

Many hundreds of millions of euros are allocated to research on genetic engineering (GE) in Europe. Money expended in risk assessment research is typically associated with programmes whose main interest is to promote GE, and led by genetic engineers, not ecologists. Pro-active environmental risk assessment is now an essential research priority. This work should focus explicitly on the assessment of ecological or environmental risks attributable to GE, taking the true spatial and time scales of exploitation into account, and be led by concern for the environment and our ecological future. Work is needed to understand the ecological and social implications of significant hazards of extremely low probability of occurrence. The research should also examine ways to monitor environmental risk given these exploitation scales and the rate of new releases. The aim of the research would be to develop assessments of ecological risk that can be compared with, and used to evaluate, social and commercial benefits.

2.8.3. Assessing environmental risk from development politics

Research is needed to enable legislators to assess risk to biodiversity of rural and urban planning, industrialisation, and the development of infrastructures.

## 3. Society, biodiversity and sustainable development: humans as a component of ecosystems

Since few services provided by biodiversity have a market value, we under-value and over-exploit natural ecosystems, on the morally uncertain grounds that our species has the capacity and therefore the right to appropriate the entire resources of the planet to its own benefit. Research is needed to identify incentives to prevent over-exploitation, for which a better understanding of the value of biodiversity seems to be essential, including but not restricted to services provided to humans such as recreation, aesthetic pleasure, cultural identity, spiritual enrichment and tranquility.

3.1. **Valuation** and perception of biodiversity

Our own species is directly or indirectly responsible for the present extinction wave that is facing many species on Earth. To define clearly the reasons for allocating increasingly scarce financial resources to conservation, we must understand what we as a species derive from biological diversity, including physical and emotional well-being, and what we will lose because of habitat destruction and species extinction. Research is also needed to develop practical techniques to assess conservation costs and benefits in the light of perceptions of individuals and society. Work is needed on the cultural value of biodiversity, the social drivers of behaviour, and on how progress is made in the dialogue between science and policy. Society needs scientifically sound methods that will help us to choose sensibly between alternative futures.

3.2. **Wise use** of biological resources[xv]

If our descendants are to live healthy and productive lives with access to some of the biodiversity that we currently enjoy, research is needed to develop strategies to reach economic, social and environmental goals without damaging our biological environment. Research is needed on ways to conserve biodiversity while ensuring sustainable livelihoods; to involve local communities in conservation initiatives and their planning;

to develop and promulgate standard project planning techniques and to assess the effect on the environment of biodiversity conservation projects.

Research is also needed on ways to manage landscape mosaics so that the component ecosystems can sustain the balanced delivery of goods and services for all uses to which the land is put, such as agriculture, ecotourism, forestry, hunting, and fishing.

Work is also needed on methods to restore ecosystem capacities to deliver goods and services.

3.3. **Translating** science results **into** nature conservation **policy**

The precautionary principle states that the need for research to reduce uncertainty about the correct course of action should not be taken as an excuse to do nothing. Social-political studies are needed to develop methods to replace intuitively-inspired guidelines by scientifically sound structures. This research should help show decision makers the consequences of encouraging sustainable use, conservation, continuation of current activities, or alternative land use. Further development and research will help to create a more solid basis for adaptive management, in which conservation policy and management practices are guided by science-based monitoring and prediction of their effects.

3.4. **Traditional knowledge**, innovations and practices[xvi]

Traditional knowledge on the use of various natural and semi-natural ecosystems and their biological components may have significance for sustainable use of the ecosystems, and for the husbandry of our natural resources. Traditional and indigenous knowledge of biodiversity is rapidly disappearing as traditional lifestyles are abandoned. Furthermore traditional knowledge may translate into commercial benefit, which can be used as an argument to help to protect biodiversity. If we are to capture some of this knowledge, research is urgently needed.

3.5. **Intellectual property rights**

Industry makes huge investments in research and development, and is clearly a stakeholder in biodiversity. So are those people whose traditional knowledge leads both to the commercial use of biodiversity, and to its conservation and sustainable use. Research is needed to develop international Intellectual Property Rights (IPR) regimes that will protect both industry and the owners of genetic resources and of traditional knowledge and practices.

3.6. ***In-situ* and *ex-situ* conservation** in developing countries[xvii]

The world's remaining biodiversity is being lost fastest in developing countries where economic pressures are extreme. *In situ* conservation maintains species not only as a fixed, identifiable entity, but also the interactions that allow it to adapt to shifting environmental conditions, such as changes in pest populations or climate. *Ex situ* conservation is often a last-ditch attempt to prevent the loss of species or to preserve selected elements of genetic diversity. Research is needed to help Europe fulfil its commitment under the CBD (see footnote xvii) and under its own development policies in these difficult fields. This will involve research by social and natural scientists into techniques to support *in-situ* and *ex-situ* conservation, including work on ways to establish and maintain *ex-situ* conservation facilities.

3.7. The citizen, climate change and biodiversity

Climate change is likely to continue – and perhaps even to accelerate – in the present century. We may therefore expect major changes in biodiversity to become the norm

rather than the exception. It is therefore important to develop models that can test scenarios for biodiversity change, and their implications for society, under various projections of climate change. Research is also needed to examine the potential of citizen-driven approaches, including biodiversity-related climate change associations, and of incentive schemes operating at various levels of organisation of society to encourage behaviour that will tend to reduce climate change or mitigate its effects on biodiversity.

3.8. Biodiversity in the built environment

Most Europeans live in cities and other urban areas. The issue of biodiversity in the built environment impinges on all our lives. Humans deliberately or accidentally help to establish viable populations of many organisms, sometimes from far away, in the many and varied environments that exist in these artificial areas. Inventories of biodiversity in the built environment are regrettably scarce, and research is needed to understand the biodiversity of these areas of high human population density. The aim of this research should be to extend our understanding of the biodiversity of the coterie of obligate or facultative human-associated organisms, including bacteria.

## 4. Biodiversity, biocomplexity and ecosystems

Scientists cannot in general predict how ecosystems or their components will react to disturbance. Nor can we model the workings of an ecosystem in any detail or with much predictive power. If we are to manage ecosystems, this capability is essential, and research on ecosystems and biodiversity must be brought together. Biocomplexity takes account of the interactions and relationships between biological, physical, chemical, and human systems. It therefore includes both biodiversity and ecosystem science, and their reaction to and impact on humans, society and economic systems. This area of research often involves the study of non-linear relationships between cause and effect, or of systems whose behaviour is coupled so that they may sometimes interact strongly.

4.1. Interaction between biodiversity and ecosystem function: Understanding the ecosystem approach[xviii]

The Convention calls for conservation actions based on an ecosystem approach, with the view to encouraging the development of policies that take entire ecosystems into account, while recognising the primordial role of humans in exploiting and modifying biological resources. To develop this outline into an effective management approach requires substantial research, testing, development and adapting to regional circumstances. At present the CBD's ecosystem approach does not provide any easy method to integrate the conservation of target species, and research is also needed on this vital issue.

4.2. Interaction between biodiversity and ecosystem resilience

Work is needed to develop techniques to measure ecosystem structure and function and clarify how biological diversity is related to ecosystem resilience.

4.3. High-priority ecosystems

The CBD singles out "Inland waters", "Marine ecosystems", "Forests", "Agriculture", "Drylands" and "Mountains" as a means of organising work, but this can not serve as a useful guide to priority ecosystems in Europe. Prioritisation between ecosystems must be at a finer scale. Work should focus on developing scientific support to improve the conservation of biodiversity of the coastal zones (singled out in the 6$^{th}$ EAP) and habitats listed in Habitats Directive, both in and outside natural reserves[xix]. Research should focus on these ecosystems in areas where ecological and anthropogenic pressures on

(perhaps endemic) biodiversity are greatest, for example in islands and archipelagos, and in other historically or geographically isolated ecosystems.

4.4. Biodiversity in soil

Underlying the viability of every terrestrial ecosystem are the animals, plants and micro-organisms which sustain and compose the soil. Despite our dependence on the integrity of the soil we do not understand how soil biodiversity maintains that integrity in the face of chemical and sometimes biological assault. Research is needed to understand the most appropriate way to study biodiversity in the soil and the appropriate scales on which to work.

## Annex: Comment by the IUCN on priority issues

While all research fields listed in the EPBRS' Informal Discussion Paper are important, in the view of IUCN priority should be given to the following research fields:

**Inventory**

- Inventory of species/habitats with a particular emphasis on threatened species/habitats
- Inventory of European expertise in taxonomy, systematic, terrestrial and marine ecology, biogeography, forestry, biology, genetics, sociology

**Monitoring**

- Tools: methodology / sampling protocols / indicators
- Threatened habitats / habitat fragmentation / habitat loss
- Impact of human activity changes: agriculture, forestry, fishery, tourism, infrastructures

**Management**

- Management and restoration of ecosystems to sustain needed goods and service and poverty alleviation
- Control of invasive species

**Social sciences**

- cultural value of biodiversity (perceptions of stakeholders)
- social drivers of behaviour
- dialogue between the policy people and the scientists (how and why progress is made)

**Trade/Economics**

- impact of trade
- analysis and impact of perverse incentives
- value of biodiversity
- benefits from protected areas, ecotourism

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[i] Article 12. Research and Training. Articles 12 (b) and (c) are pertinent. 12(b) Promote and encourage research which contributes to the conservation and sustainable use of biological diversity; 12(c) promote and cooperate in the use of biological diversity research in developing methods for conservation and sustainable use of biological resources.

[ii] The research needed is, of course, closely aligned with the CBD. In particular, pollution and eutrophication, land use changes, over-exploitation, infrastructure development, habitat fragmentation, biological invasions and GMOs are singled out as drivers of biodiversity loss. Soil is mentioned as a finite resource under pressure, especially from erosion, reduction in organic content, land abandonment and chemicals.

[iii] COP Decision V/9. Global Taxonomy Initiative: implementation and further advance of the Suggestions for Action

[iv] Recent work shows that organisms also live in rock strata, but this biodiversity is not considered here.

[v] The concept of the habitat can even be dangerous; for example, legislation may protect a habitat, but not the species within it. As species vanish from the protected area, the so-called habitat may soon contain few of the species normally assumed to be associated with it.

[vi] Article 7. Identification and Monitoring (a) Identify components of biological diversity; (b) Monitor the components of biological diversity

[vii] The PHYSIS system of habitat classification (http://webbie.kbinirsnb.be/cb/databases/cb_db_physis_gb.htm) was developed as part of the EU CORINE programme.

[viii] The EUNIS system of habitat classification (http://www.mnhn.fr/ctn/products/eunishabuk.html) was developed by the European Topic Centre on Nature Conservation.

[ix] Article 7. Identification and Monitoring (d) Maintain and organize data derived from (a), (b) and (c)

[x] Article 7. Identification and Monitoring (c) Identify processes and activities which have adverse impacts on biological diversity, and monitor their effects

[xi] Article 8. In-situ Conservation (f) Rehabilitate ecosystems and promote the recovery of threatened species

[xii] Article 8. In-situ Conservation (h) Prevent, control or eradicate alien species that threaten ecosystems, habitats or species

[xiii] Article 8. In-situ Conservation (g) regulate, manage or control risks associated with the use and release of living modified organisms

[xiv] ten Kate and Laird, in "*The Commercial Use of Biodiversity: Access to Genetic Resource and Benefit Sharing*", estimate that the annual global market value of commercial products based on biodiversity (such as pharmaceutical products and medicines, crops and horticulture, crop protection products, cosmetics and personal care products) exceeds US$800 billion.

[xv] Article 8. In-situ Conservation (c) Regulate or manage biological resources to ensure sustainable use; (i) provide conditions needed for compatibility between conservation of biological diversity and the sustainable use of its components; (l) regulate or manage processes and activities with a significant adverse effect on biological diversity

[xvi] Article 8. In-situ Conservation (j) respect and maintain knowledge and practices of indigenous communities relevant for conservation of biological diversity

[xvii] Article 8. In-situ Conservation (m) Cooperate in providing … support for in-situ conservation, particularly to developing countries. Article 9 Ex-situ Conservation (e) Cooperate in providing … support for ex-situ conservation… and in the establishment and maintenance of ex-situ conservation facilities in developing countries. Article 12. Research and Training: The Contracting Parties, taking into account the special needs of developing countries, shall: (a) Establish and maintain programmes for scientific and technical education and training … for the identification, conservation and sustainable use of biological diversity and its components… (b) Promote and encourage research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries… and (c) … promote and cooperate in the use of scientific advances in biological diversity research in developing methods for conservation and sustainable use of biological resources.

[xviii] UNEP/CBD/COP/5/23 COP Decision V/6. Ecosystem approach.

[xix] Article 8. In-situ Conservation (b) Develop guidelines for protected areas to conserve biological diversity; (d) Promote the protection of ecosystems; (e) Promote sound and sustainable development adjacent to protected areas; (f) Rehabilitate ecosystems and promote the recovery of threatened species; (k) Develop or maintain necessary regulatory provisions to protect threatened species and populations; (l) regulate or manage processes and activities with a significant adverse effect on biological diversity