Towards a Strategy on Climate Change, Ecosystem Services and Biodiversity

A discussion paper prepared by the EU Ad Hoc Expert Working Group on Biodiversity and Climate Change

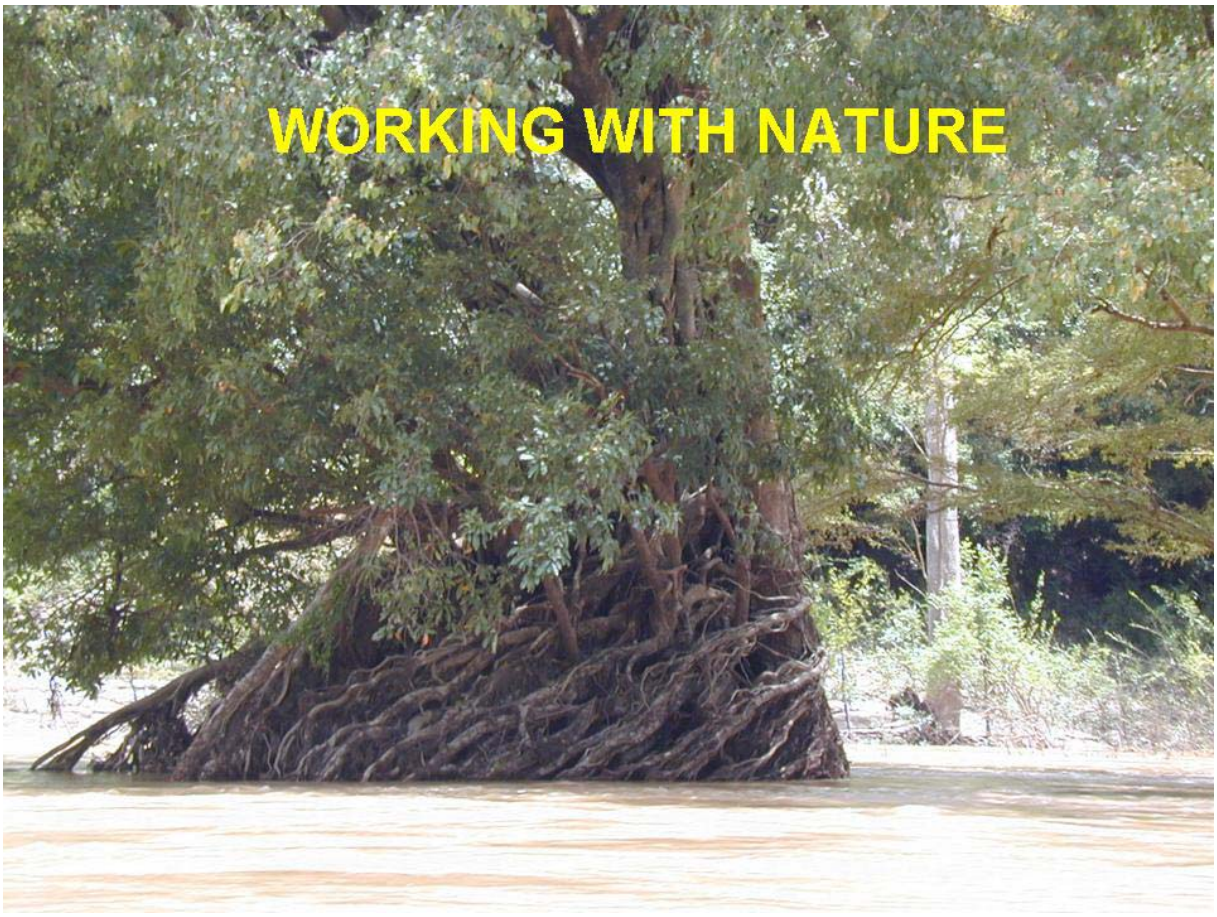

Photo: Ramsar Convention side event at CBD COP9

Status Box:
The Draft Strategy Paper was presented to and discussed with:
the ENCA adaptation group at its Workshop on "Developing ecosystem-based adaptation to climate change - why, what and how" in Vilm 23-24 June 2009;
the participants of the EIONET workshop on adaptation in Copenhagen 30 June – 1 July 2009;
the Group of Experts on Biodiversity and Climate Change under the Bern Convention at its meeting in Strasburg 2-3 July 2009.

Disclaimer:
This document has been developed by the EU Ad Hoc Expert Working Group on Biodiversity and Climate Change that brings together Member State representatives, staff of the European Commission, scientists and civil society. The document does not represent the official, formal position of any of the partners. Hence, the views expressed in the document do not represent the views of the European Commission.

Table of Contents

Executive Summary

In March 2009 over two thousand scientists met in Copenhagen and sounded an urgent alarm. They stated that: *"Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised. For many key parameters, the climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived. These parameters include global mean surface temperature, sea-level rise, ocean and ice sheet dynamics, ocean acidification, and extreme climatic events. There is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts...Inaction is inexcusable".*[1] Efforts to reduce emissions including clean energy technologies, increased energy efficiency, low carbon agriculture, avoided deforestation and forest degradation must therefore be continued and intensified. Efforts to maintain and increase the carbon capture and storage capacity of ecosystems are equally essential. Protecting and enhancing ecosystem resilience through biodiversity and ecosystem service conservation, are amongst the best and most cost effective ways of tackling both the causes and consequences of climate change.

Globally and locally, the conservation and sustainable use of biodiversity[2] and ecosystem services has the potential to contribute significantly to mitigating climate change and to help human societies adapt to its impacts. In April 2009, the CBD AHTEG stated that: *"maintaining natural ecosystems (including their genetic and species diversity) is essential to meet the ultimate objective of the UNFCCC because of their role in the global carbon cycle and because of the wide range of ecosystem services they provide that are essential for human well-being*"[3].

Working with nature rather than against it enables sustainable development; involving people and sharing responsibility for a future built on welfare, equity, security, human development and wellbeing. Currently too little attention is given to the need to integrate climate and biodiversity actions and to fully use the potential of biodiversity and ecosystem services to mitigate climate change and adapt to its impacts. We need a portfolio of tools to tackle the climate crisis including technology, financing, building adaptive capacity, community engagement *and* ecosystem-based approaches. *"Biodiversity needs to be an integrated part of the general mitigation and adaptation efforts"*[4]. *"We cannot halt biodiversity loss without addressing climate change, but it is equally impossible to tackle climate change without addressing biodiversity loss"*[5]. Therefore we need to:

- Use ecosystem-based approaches to address climate change and biodiversity loss and ecosystem service degradation in an integrated manner and develop strategies that achieve mutually supportive outcomes. This implies addressing the wider ecosystem challenges and potential in the climate change negotiations e.g. by establishing a REDD+ like

[1] See http://climatecongress.ku.dk/
[2] The Convention on Biological Diversity (CBD) defines biodiversity as the variability among living organisms on the genetic, species and ecosystem level
[3] See http://www.cbd.int/climate/
[4] One of the 7 Aarhus Statements on Climate Change see http://www.klima.au.dk/dk/forside/konferencebeyondkyotoconferen/
[5] The Message from Athens. April 2009 see http://ec.europa.eu/environment/nature/biodiversity/conference/index_en.htm

mechanism[6], promoting a similar approach for other land use and ecosystems and, by including ecosystem-based approaches as an integral part in the UNFCCC Framework for Adaptation Action. (See 2.1).

- Take immediate action to conserve and restore terrestrial and marine biodiversity and ecosystem services as these are the basis for cost-effective climate change adaptation and mitigation and can provide multiple economic, social and environmental benefits. (See 2.2).

- Engage other sectors, for example agriculture, finance, transport, energy, regional planning, water management, fisheries, forestry, tourism, development policy, health, built environment to maintain and increase ecosystem resilience and to ensure that their activities do not further damage biodiversity and ecosystem services. (See 2.3).

- Raise awareness of the linkages between climate change, biodiversity and ecosystem services through communication and education initiatives, make use of local knowledge and build institutional capacity and partnerships to facilitate integration. (See 2.4).

- Strengthen the knowledge base on the climate change-biodiversity linkage through increased research effort, long-term monitoring, and valuation. (See 2.5).

- Appropriately address the issue of biodiversity, ecosystem services and climate change in upcoming financial reviews. (See 2.6).

Changes in ecosystem structure, function and composition have important implications for the interactions between the biosphere and the climate system. Terrestrial and marine ecosystems currently absorb around half of anthropogenic CO_2 emissions, therefore the carbon capture and storage capacity of oceans, forests, grasslands, wetlands and in particular peatlands is essential for mitigating climate change. On the other hand the degradation or destruction of these ecosystems can lead to the release of significant amounts of greenhouse gases. Globally, degraded peatlands contribute to 10% of human emissions; deforestation and degradation to 23%. There is growing evidence that the capacity of the Earth's carbon sinks is weakening due to global warming itself, but also due to the degradation of ecosystems caused by other stress factors such as deforestation, soil erosion, inappropriate infrastructure development and poor management of fresh water and marine resources. These multiple pressures, which interact in different ways, reduce the resilience and buffering capacity of the ecosystems to respond to future stresses. (See section 1.1)

Managing, restoring and protecting biodiversity and ecosystem services provides multiple benefits to human society. These ecosystem-based approaches contribute to protecting and restoring natural ecosystems by conserving or enhancing carbon stocks, reducing emissions caused by ecosystem degradation and loss, and providing cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems such as saltmarsh, and barrier beaches provide natural shoreline protection from storms and flooding and urban green space cools cities (reducing the urban-heat island effect), minimises flooding and improves air quality. Ecosystem-based approaches provide multiple benefits, are cost-effective, ready now and likely to be more accessible to rural and poor communities. Thus

[6] REDD+ stands for "Reducing emissions from deforestation and forest degradation in developing countries, promoting conservation and the sustainable management of forests, and to enhancing forest carbon stocks", a mechanism currently under negotiation in the frame of the United Nations Framework Convention on Climate Change (UNFCCC).

they can align with and enhance poverty alleviation and sustainable development strategies. There are also powerful economic and social arguments for taking action to protect biodiversity and ecosystems. (See section 1.3).

Nevertheless, true integration of climate and biodiversity policies remains the exception. Where climate change programmes include biodiversity sections, they often only tackle climate change impacts on biodiversity, while in biodiversity action plans climate change aspects are often limited to adaptation measures for biodiversity. The role of biodiversity and ecosystem services in climate stabilisation is often missed, as is the potential of other sectors such as agriculture, transport and energy to respond to climate change in a way that uses ecosystem-based approaches to enhance the resilience of biodiversity and provide sectoral benefits. The role of biodiversity and ecosystem services in both climate change mitigation and adaptation is rarely appreciated or understood. Given the uncertainties surrounding future rates and impacts of climate change, as well as the gaps in knowledge and uncertainty of responses to policy initiatives, a precautionary approach is necessary. This would make use of a variety of policy options including regulation, market based instruments, insurance, soft options (e.g. awareness raising and education measures), research and development thereby combining top-down and bottom-up approaches and giving the potential for policy integration.

Biodiversity and ecosystem services are not just the victims of our mismanagement, but are our ally in dealing with the problems of global environmental change. Ecosystem-based approaches contribute to tackling the causes and consequences of climate change, provide multiple benefits across society and protect the vital natural functions on which human well-being depends. An increasing number of recent reviews, policy documents and reports e.g. "The Natural Fix? – the role of ecosystems in climate mitigation" by UNEP[7] and "Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change" by the Environment Department of The World Bank[8] emphasise the two-way link between biodiversity and climate change and demonstrate an increasing awareness of the important role of ecosystems in the climate system as well as of the value of protecting biodiversity as a route to moderating climate change. Without healthy and resilient ecosystems it will not be possible to stabilise the climate system or to adapt to the unavoidable impacts of climate change. Therefore urgent action is needed to halt the further loss and degradation of biodiversity and ecosystem services, if we are to retain the ability to reduce the extent of climate change and manage its impacts.

Ecosystem-based approaches provide an important route to sustainable action and represent a vital insurance policy against irreversible damage from climate change, whereas failure to acknowledge the relationship between climate change and biodiversity and failure to act swiftly and in an integrated manner could undermine efforts for improvements in both areas. Therefore the maintenance and restoration of diverse, functioning healthy ecosystems across the wider terrestrial, freshwater and marine environment is an important guiding principle as we move forward to "climate proof" our policies and adapt to climate change.

[7] See http://www.unep.org/pdf/BioseqRRA_scr.pdf
[8] See http://siteresources.worldbank.org/ENVIRONMENT/Resources/ESW_EcosystemBasedApp.pdf

Introduction

This paper aims to demonstrate the interdependencies between climate, biodiversity and ecosystem services and how strategies that achieve mutually supportive outcomes can support society to successfully tackle both climate change and biodiversity loss. Based on this rationale, policy recommendations and actions for immediate implementation applicable at national, European and international level are suggested. The paper is primarily targeted at decision makers in the fields of climate change and biodiversity at the national, regional and international level including the European institutions. It will feed into the ongoing discussion on the development of climate change policies and of biodiversity vision and targets beyond 2010. Issues and recommendations presented in this paper are relevant on global, European and national levels.

The document consists of two sections. The first section "The Climate Change-Biodiversity Linkage" describes in three subsections the role of biodiversity and ecosystem services in relation to climate change, the threats of climate change and climate change measures to biodiversity and ecosystem services as well as the challenges for existing policies and the opportunities resulting from integrated approaches. The second section "The Way Forward" is divided into six subsections presenting recommendations for actions and policy development in each of the following activity areas: ecosystem-based approaches, immediate action (including adaptation for biodiversity), engagement of other sectors, communication and collaboration, increased understanding and funding.

Section 1: The Climate Change-Biodiversity Linkage

Climate change, ecosystem services and biodiversity are closely linked. The impacts of climate change on biodiversity present new challenges for nature conservation. *"Support biodiversity adaptation to climate change"* is one of the objectives of the EU Biodiversity Action plan.[9] Adaptation measures will be necessary to ensure that nature conservation objectives are met under changing climatic conditions. At the same time, the conservation and sustainable use of biodiversity and ecosystem services has the potential to contribute significantly to mitigating climate change and to helping human societies adapt to its impacts. Therefore maintaining healthy ecosystems is essential for the implementation of any climate change adaptation and mitigation strategy.

1.1 The Role of Biodiversity and Ecosystem Services in Relation to Climate Change

Under the UNFCCC the *"climate system" means the totality of atmosphere, hydrosphere, biosphere and geosphere and their interaction*.[10] Changes in species composition, ecosystem structure and function, can have important implications for the interactions between the biosphere and the climate system, as well as for the ecosystem services on which society depends. The "climate regulation" ecosystem service refers to the role of ecosystems in managing levels of green-house gases (GHGs) in the atmosphere. It is acknowledged that current climate change is largely driven by the increase of GHGs. A significant proportion of these come from the rapidly increasing use of fossil fuels as well as from changes in land-use – current emissions from land use changes worldwide are as big as the emissions from the transport sector. Soil microbes regulate other GHGs - notably methane (CH_4) and nitrous oxide (N_2O). Carbon dioxide (CO_2) is absorbed by vegetation, phytoplankton and water, leading to storage in the oceans, biomass and soils. CO_2 uptake was quantified in the IPCC Fourth Assessment Report (AR4) demonstrating the accumulating evidence of the importance of natural ecosystems in the carbon cycle[11]. Recent research findings[12] show that terrestrial and marine ecosystems currently absorb roughly half of anthropogenic CO_2 emissions (see Figure 1).

[9] SEC(2006) 621; see http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/sec_2006_621.pdf
[10] UNFCCC, Article 1 DEFINITIONS
[11] Van Minnen et al., 2009:
[12] Canadell et al., 2007

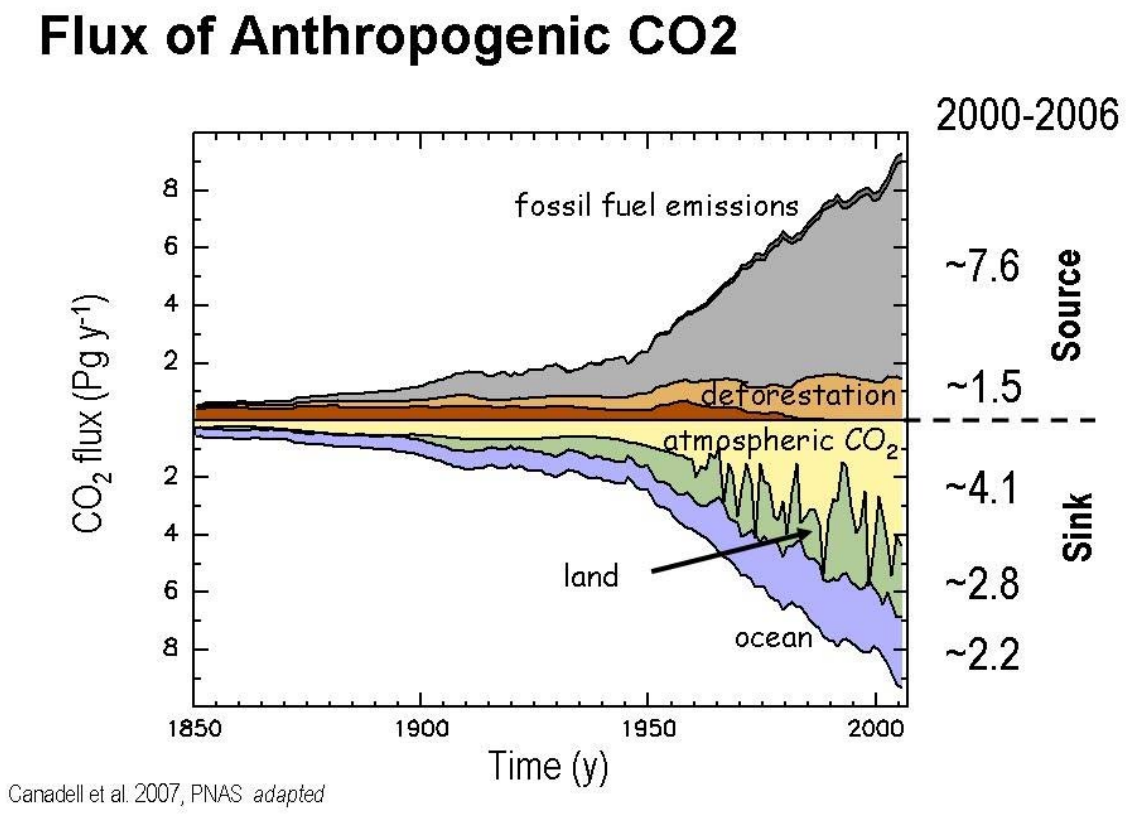

Figure 1: Flux of Anthropogenic CO_2
The schema shows that out of 9.1 billion tons anthropogenic Carbon (C) (resp. 33.4 billion tons anthropogenic CO_2) emissions per year resulting from fossil fuel emissions, cement production and land-use change (including deforestation) 4.1 billion tons C per year remain in the atmosphere and 5 billon tons C are currently absorbed by terrestrial and marine ecosystem sinks. The high interannual variability in the CO_2 absorption by terrestrial ecosystems is mainly due to the responses of the natural sinks to interannual climate variability (e.g. El Nino, seasonal changes) and volcanic eruptions.

Ecosystem-based approaches, therefore, can play a key role in helping to maintain these natural carbon sinks. The largest single store of carbon in terrestrial ecosystems is in the peat soils of the boreal and cool temperate zones of the northern hemisphere. The response of peatlands to climate change and other drivers is crucial to understanding potential feedbacks on the global carbon cycle. Forests are the only major ecosystems where the amount of carbon stored in plant biomass exceeds that in the soil. Deforestation therefore is a major emission source. Forests contribute to climate regulation not only through carbon storage, but also through aerosol production (producing cloud condensation nuclei) and regulating albedo.

The exchange of CO_2 between the atmosphere and the ocean is larger than that with terrestrial ecosystems. This exchange occurs partly through physical processes, but biological processes account for a significant proportion of the exchange. The ocean's great "biological pump" transports carbon fixed in organic material by photosynthesis from shallower regions to the deep sea, where it is stored and chemosynthetic microbes living in the deep sea absorb almost all of the oceanic methane emissions. Increasing ocean acidification, resulting from the increased absorption of carbon dioxide by the oceans, represents an additional serious threat to marine biodiversity.

	Vegetation growth	Vegetation decomposition	C Source or Sink	Current C storage (t C / ha)	Where majority of C is stored	Main threat(s) for potential C emission
Tundra	Slow	Slow	Sink	Approx. 258	Permafrost	Rising temperatures
Boreal Forest	Slow	Slow	Sink	Soil: 116–343; Vegetation: 61–93	Soil	Fires, logging, mining, increased pest out breaks, rising temperature
Temperate Forest	Fast	Fast	Sink	156–320	Biomass above and below-ground	Historic losses high but largely ceased
Temperate grassland	Intermediate	Slow	Likely sink	Soil: 133; Vegetation: 8	Soil	Historic losses high but largely ceased
Desert and dry shrublands	Slow	Slow	Sink (but uncertain	Desert soil: 14–102; Dryland soil: < 266; Vegetation: 2–30	Soil	Land degradation
Savannas and tropical grasslands	Fast	Fast	Sink	Soil: < 174; Vegetation: < 88	Soil	Fire with subsequent conversion to pasture or grazing land
Tropical forests	Fast	Fast	Sink	Soil: 94–191; Vegetation: 170–250	Aboveground vegetation	Deforestation and forest degradation
Wetlands in particular Peatland	Slow	Slow	Sink	1450	Soil	Drainage, conversion, fire
Oceans and coasts	In terms of plankton: Fast	Fast	Sink	(Total) Surface: 1020 Gt C; DOC: 700 Gt C; Deep ocean: 38100; Sediments: 150	Deep ocean	Not emission but decreasing uptake capacity

Figure 2: Carbon in natural ecosystems[13]

[13] Adapted from UNEP. June 2009. The Natural Fix? The role of ecosystems in climate mitigation

Loss and damage to ecosystem functioning through the direct and indirect effects of human activities is also reducing the capacity of ecosystems to capture and store CO_2. There are many positive and negative feedbacks in the climate system, including tipping points when fluxes in ecosystems become unpredictable and ecosystems lose resilience, and when carbon sinks turn into sources - AR4 states that this will happen with a temperature increase of above 2-2.5°C. Most feedbacks are poorly understood. For example, to take a potential beneficial feedback: some species of algae release the chemical dimethyl sulphid (DMS) into the atmosphere. When ocean temperatures rise more DMS is released, which is also associated with the formation of clouds. Terpenes emitted by trees have a similar cloud forming effect. Cloud cover can help decrease temperature, as it reduces the amount of radiation that reaches the Earth's surface.

Information Box 1:

Biodiversity, ecosystem services and human wellbeing

Components of biodiversity – such as communities of animals, plants and microorganisms – together with abiotic factors form ecosystems, which perform a number of environmental functions. Many of these ecosystem functions are directly useful for humans and some are essential for us. The benefits which humankind derives from ecosystems are called "ecosystem services" and depend in many cases on the maintenance of biodiversity. Natural ecosystems are also the source of many life-saving drugs as well as providing sinks and recycling options for our wastes, and buffering climate change through carbon capture and storage. Human society is underpinned by countless benefits from ecosystems in the form of goods and services as described above. The environment has also shaped human development, and this inter-linkage has strong social, cultural and aesthetic importance. The well being of every human in the world is directly and indirectly dependent on ecosystem services.

Ecosystem services are usually divided into the following categories[14]:
Supporting services, which provide the basic infrastructure for life on Earth. These include the formation of soils, the cycling of water and of basic nutrients, and primary production of materials for all the other services.
Regulating services, which maintain the environment in a fit condition for human habitation and society. Key examples are regulating climate, mitigating the effects of pollution and control of flooding.
Provisioning services, providing food, clean water, energy, and materials for building, clothing and medicines.
Cultural services, which connect people with the environment. People, communities and societies place value including economic value on nature and the environment for their own sake, for recreation, tourism and other activities, or simply find pleasure in it.

There is growing evidence that, for the proper functioning of ecosystems and the delivery of ecosystem services, the interaction of their individual components – the biodiversity present – is essential. While we do not fully understand the mechanisms by which biodiversity enhances the delivery of ecosystem services, there are key species and groups of species that perform particular ecological functions which play a major role in delivering these services.

[14] Millennium Ecosystem Assessment. 2005; Ecosystem services and biodiversity in Europe, EASAC report 2009

Maintaining biodiversity ensures their presence and activity in a system, thus helping to build resilience for providing these services.

The Economics of Ecosystems and Biodiversity
Current trends in the loss of terrestrial and marine ecosystem services demonstrate the severe dangers that biodiversity loss poses to human health and welfare. In the interim report of the study on the economics of ecosystems and biodiversity (TEEB)[15] it was estimated that we are losing $2-5 billion of natural capital each year from deforestation alone. It shows that if we do not adopt the right policies, the current decline in biodiversity and the related loss of ecosystem services will continue and in some cases even accelerate. Some ecosystems are likely to be damaged beyond repair. The interim report proposes a general framework for evaluating the loss of biodiversity and ecosystem services that acknowledges that not all values of biodiversity can be measured in economic terms.

Maintaining genetic and species diversity is important for ecosystem function, since it is widely regarded to increase ecosystem resilience by ensuring that enough redundancy of response capacity exists to maintain ecological processes and to protect against unforeseen disturbances. Therefore conservation sites should encompass large areas, including both a broad range of habitats and a high genetic and species diversity.

The range and extent of ecosystem services provided by the Natura 2000 network[16] and other relevant national and regional protected areas and networks are often not recognised, but they contribute to a variety of human needs (e.g. clean water, air, recreation, flood protection, carbon capture and storage, reservoir of genetic resources). They form the central pillar in our efforts to maintain the critical mass and variety of ecosystems necessary to cope with changing conditions. It is vital to maintain these areas as spaces for nature, even if the species for which they had been originally designated may move away in the future. They will provide necessary habitat for other shifting species and will continue to deliver ecosystem functions.

Increasing resilience can also help the dispersal of species by raising their breeding productivity and thereby their migration rates. Healthy populations will also produce fitter migrants that are more likely to survive long distance movements and be able to colonise new sites.

Protected areas alone will not be sufficient to address the challenge of climate change and biodiversity loss. Healthy ecosystems both within and outside protected areas are a precondition for stabilising the climate system and supporting societal adaptation. We need to counteract the destabilisation of ecosystems in many places in Europe and around the world in order to ensure an environmentally sustainable future. The conservation and sustainable use of biodiversity both inside and outside protected areas is vital if we are to avoid an ecological crisis, which would dwarf the consequences of the present economic crisis. Human development must respect the ecological boundaries of the global system. Adaptive management in the wider environment and promoting green infrastructure are equally important to maintain and increase the resilience of ecosystems.

[15] See http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf
[16] See http://ec.europa.eu/environment/nature/natura2000/index_en.htm

1.2 Need to Address the Climate Change – Biodiversity Linkage to Achieve Policy Goals

The following two subsections address climate change impacts and threats for nature conservation, biodiversity and climate change policies.

Information Box 2: Current goals of nature conservation, biodiversity, and climate change policy frameworks

The EU Nature Conservation and Biodiversity Policy[17]

EU "Nature Directives" (Birds[18] and Habitats[19] Directives) form the cornerstone of Europe's nature conservation policy. It is built around two pillars: the Natura 2000 network[20] of protected sites and the strict system of species protection across their natural ranges. The directives protect over 1.000 animal and plant species and over 200 so called "habitat types" (e.g. special types of forests, meadows, wetlands, etc.), which are of European importance. With 25,000 sites Natura 2000 now covers an area larger than any single Member State. It is the largest network of protected areas in the world and is one of the most significant achievements in EU environmental policy. The requirement to protect species outside protected areas has so far received less focus than the establishment of Natura 2000.

The European Council agreed in March 2001 that the EU should halt biodiversity loss by 2010. In 2006, the Commission Communication "Halting Biodiversity Loss by 2010 and Beyond"[21] set out a detailed Biodiversity Action Plan, identifying what still needed to be done in order to halt biodiversity loss. A review of progress towards the delivery of the Biodiversity Action Plan, published by the Commission in December 2008[22], made clear that a significant number of the actions had still not been carried out. While more effort is needed to address the impacts of climate change, the action plan remains essentially valid. The recent indicator-based assessment conducted by the EEA "Progress towards the European 2010 biodiversity target" states that "*European biodiversity remains under serious pressure and our policy measures have been insufficient to halt its general decline*".[23]

The EU climate change policy[24]

In 2000, the Commission launched the European Climate Change Programme (ECCP). This led to the adoption of a wide range of new policies and measures in the field of climate change mitigation and adaptation. Regarding mitigation, important policy processes include the EU Emissions Trading Scheme, the Kyoto protocol (requiring an 8% cut in EU greenhouse gas emissions by 2008-2012), the European Commission proposals and options for "Limiting Global Climate Change to 2 degrees Celsius: The way ahead for 2020 and

[17] See http://ec.europa.eu/environment/nature_biodiversity/index_en.htm
[18] Council Directive 79/409/EEC on the protection of wild birds
[19] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
[20] http://ec.europa.eu/environment/nature/natura2000/index_en.htm
[21] COM(2006) 216 final
[22] COM (2008) 864 final
[23] EEA, 4/2009, p.5.
[24] See http://ec.europa.eu/environment/climat/home_en.htm

beyond"[25], and the climate change energy package -adopted in December 2008- to help transform Europe into a low-carbon economy and increase its energy security. The EU is committed to reducing its overall emissions to at least 20% below 1990 levels by 2020**,** and is ready to scale up this reduction to as much as 30% under a new global climate change agreement as result of the international negotiations under the UNFCCC. It also set the target of increasing the share of renewables in energy use to 20% by 2020**.**
In the field of climate change adaptation, the Commission adopted in April 2009 a White Paper on "Adapting to climate change: Towards a European framework for action"[26] that – *inter alia* - highlights the close inter-relationship between climate change and biodiversity and the need for an integrated approach to policy development. EU and Member States shall *"explore the possibilities to improve policies and develop measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming."*

1.2.1 Climate Change Impacts on Biodiversity and Ecosystem Services

It is widely accepted that the "safe" level of climate change, which can be countered by adaptation measures across many human systems at acceptable economic, social and environmental costs, is a global mean temperature increase of up to 2°C above pre-industrial levels. However, the ability of many natural ecosystems to adapt to the rapid rate of current climate change is limited and may be exceeded before a 2°C temperature increase occurs. Indeed AR4[27] suggests that the resilience of many ecosystems has already been exceeded.

Increasing levels of climate change mean increasing pressure on ecosystems and the services they provide. Particularly vulnerable ecosystems include coral reefs, Arctic ecosystems, Alpine ecosystems and tropical forests, all of which provide important adaptation and mitigation services. In addition to combating climate change, other environmental pressures need to be reduced; otherwise life-supporting ecosystem services will degrade further and finally be lost.

A growing number of reports and reviews[28] describe the impact of and vulnerability to climate change of biodiversity and ecosystem services, both within and outside nature conservation areas. The impacts of climate change on biodiversity and ecosystem services are complex. The drivers include temperature increases, shift of climatic zones, melting of snow and ice, sea level rise, precipitation changes, droughts, floods and other extreme weather events. Increased winter precipitation could favour certain habitats such as wet heath, but this effect is likely to be counter-balanced by more summer droughts. The Arctic is witnessing reductions in perennial sea ice, which is thinning and being replaced by seasonal ice. Tundra habitats are expected to become highly fragmented and reduced, with potential new area limited by, for example the Arctic Ocean. On its southern border, tundra is likely to be

[25] COM(2007) 2 final; http://ec.europa.eu/environment/climat/future_action.htm
[26] COM (2009) 147 final
[27] AR4 stands for Fourth IPCC Assessment Report
[28] This includes work by the European Topic Centre, by the Group of Experts on Biodiversity and Climate Change under the Bern Convention, work under the Commission service contract on Biodiversity and Climate change in relation to the Natura 2000 network, outcomes of the EU research projects ALARM and MACIS, WWF Vulnerability Assessment for NE Atlantic, Climatic Atlas of European Breeding Birds, Climatic Risk Atlas of European Butterflies and many more; see also list of sources

replaced by coniferous boreal forest and scrublands. This reduction in tundra and permafrost is also expected to reduce the reflectance of solar radiation and may increase the incidence of wildfires. Warming may also release carbon stored in the permafrost. At the extreme of the altitudinal gradient, mountainous ecosystems have been identified as being very vulnerable to climate change. The Alps are likely to experience warmer and wetter winters and drier summers. The snow pack on many mountains is close to its melting point and therefore particularly sensitive to temperature change. Mediterranean biodiversity is likely to suffer from water scarcity and heat stress.

The potential geographical distributions of many European species are likely to shift by several hundred km (or even more than a thousand km – the scenarios differ) by the end of the century. The success of this dispersal will depend on various factors, including the capacity of the species to migrate and the landscape structure i.e. the availability of stepping stones and/or corridors and of suitable habitat in the area of appropriate climate space. This is obviously problematic in densely populated, intensely used and built-up areas.

For Alpine and Arctic biodiversity the areas with suitable climate range are projected to decrease dramatically. In fact, for most species the potential future range in Europe is smaller in extent than the present range and some species will have no potentially suitable climate space by the end of the century. Some species have no overlap between their potential future range and their present range.

Isolated habitats are a problem for species needing to migrate and colonise new areas of climatic suitability. Therefore, isolated areas need to be functionally linked within new climate zones to the nearest climatically suitable habitats, which could provide a refuge for dispersing species. This can be facilitated by modelling the dispersal patterns of species, and where necessary, linking habitat patches by creating new habitats where they are likely to be most effective. There is a need to consider how species and landscape interact, particularly in the intensively managed and fragmented landscapes of many European regions. Thus our modelling efforts have to distinguish between the physical connectedness of habitats and connectivity as a function of the ability of species to disperse through landscapes. In addition, it is important that structural and functional linkages between habitats extending from the lowlands to the uplands are put in place, as a vertical component in our adaptive landscape planning. However, measures to increase connectivity may also affect the spread of invasive species, whose invasive capacity may even increase due to warmer temperatures. Therefore care will have to be taken to balance the pros and cons when planning individual measures. There are no “one size fits all” measures.

Climate change is disrupting species interactions and ecological relationships. Important changes in species communities are to be expected, with some species favored by climate change and others negatively affected. The extent to which these new species assemblages and interactions within them (such as predator-prey, host-parasite relations) will affect ecosystem functioning is highly uncertain. These impacts also threaten managed ecosystems on which many sectors depend, including agriculture, forestry, fishery, tourism, industry and others. Although there are also certain species and regions that will benefit from climate change, the overall balance is clearly negative.

A warmer climate with changes in patterns of drought and/or increased precipitation, will affect agricultural production: some agricultural land will no longer be possible to cultivate, growing seasons will change and crop production will decrease, not the least in Africa. In certain countries the harvest from non-irrigated agriculture might decrease by up to 50 % by

2020. Loss of biodiversity will result in a disruption of ecosystem services important for agriculture, such as pollination.

Climate change does not act in isolation. It interacts with and often exacerbates other existing pressures such as pollution, over-exploitation, invasive species, habitat fragmentation by changes in land use, and habitat degradation and loss. Reducing these impacts will also help species adapt to climate change. Furthermore, land use change driven by human responses to climate change such as changing agricultural patterns and the demand for biofuels or building of hard flood defences will also affect biodiversity. It is important that climate change driven land use change is sustainable.

Weakened by drought and with leaves wilted by heat, trees become susceptible to pests. Warm winters and extended growing seasons have resulted in large increases of pest populations. Trees can normally keep populations of beetle and other invaders in check, but once weakened they are infested faster and eventually die. The risk of forest fires also increases. The delicate balance between trees, insects and other organisms is disturbed. Rapid widespread climate and disease-induced forest dieback is a plausible scenario for forests in many areas and has already been observed in some countries, for example Canada.

Climate change over the past half century has already affected forest ecosystems and will have increasing effects on them in the future. The carbon regulating services of forests are at risk of being lost entirely unless current carbon emissions are substantially reduced; loss of this service would result in the release of huge quantities of carbon to the atmosphere, exacerbating climate change.[29]

Increasing temperatures impact on freshwater and marine ecosystems, which are often already weakened by over-exploitation and pollution. This will impact the food-chain and thus fish stocks in both marine and fresh waters, and is expected to have negative consequences for both fisheries and aquaculture (cultivation of plants and animals in water). In addition, increasing levels of carbon dioxide in the atmosphere are expected to lead to a gradual acidification of the ocean with likely dramatic consequences for those marine organisms with calcium-based shells (e.g. corals) and species which are dependent on these, e.g. as nurseries. Scientists alert us that the pH of many oceans is close to or even already below the critical values that ensure their continued functioning.[30] Taken together, these effects will negatively impact food security, especially for those directly dependent on fishing.

As biodiversity declines, so does the resilience of the ecosystem when subject to shocks and disturbance. Ecosystems with low resilience, may reach thresholds at which abrupt change occurs. Biodiversity loss, ecosystem degradation and consequent changes in ecosystem services lead to a decline in human well-being. For example, the loss of reefs as tourist attractions and the loss of protection provided by reefs against storm surges, together with sea level rise, will create human catastrophes in low lying islands and for coastal communities.

In the absence of precise knowledge and understanding, our best insurance strategy to ensure we meet climate change and biodiversity goals and to sustain human well-being is to maintain diversity on genetic, species and ecosystem levels including through strong adaptive conservation programmes building on existing efforts such as the EU Natura 2000 network

[29] "Making the forests fit for climate change". Policy Brief by the Ministry of Foreign Affairs of Finland, 2009
[30] Climate Change Congress, Copenhagen: "Acidic seas fuel extinction fears", BBC News, Wednesday 11 March 2009

and other protected areas networks, thus maintaining adaptive capacity (see also subsection 2.2).

Information Box 3: Biodiversity & ecosystem services in other EU policies

The **Water Framework Directive**[31] (WFD) includes a general requirement for ecological protection, and a general minimum chemical standard, to cover all freshwater bodies. The two key elements are "good ecological status" and "good chemical status". Good ecological status is defined in Annex V of the WFD, in terms of the quality of the biological community, the hydrological and chemical characteristics. The Directive also requires users of "water services" to make an adequate contribution to the recovery of the costs of providing these services including the environmental and resource costs.

The **Marine Strategy Framework Directive**[32] establishes European Marine Regions on the basis of geographical and environmental criteria. Each Member State - cooperating with other Member States and non-EU countries within a marine region - is required to develop strategies for their marine waters. The marine strategies to be developed by each Member State must contain a detailed assessment of the state of the environment, a definition of "good environmental status" at regional level and the establishment of clear environmental targets and monitoring programmes.

Both legal instruments, Water Framework Directive and Marine Framework Strategy Directive, can contribute to the conservation of biodiversity and ecosystem services in the freshwater and marine environments respectively.

1.2.2 Obstacles to Reaching Climate Change Targets

Ignoring the role of biodiversity and ecosystem services in the climate system may undermine our efforts to meet climate change targets. In spite of that, many climate change adaptation and mitigation measures are implemented with little regard for their wider impact. Without adequate environmental safeguards, some sources of renewable energy, e.g. the construction of dams and the expansion of biomass and biofuel crops, will have a negative impact on biodiversity (although going some way to replace fossil fuels).The MACIS[33] research project on "Minimisation of and adaptation to climate change impacts on biodiversity" delivered a detailed report on "Climate change adaptation and mitigation measures and their impact on biodiversity"[34]. These impacts can vary according to how measures are implemented, the habitats and species affected and the temporal and spatial scales involved, but they nonetheless represent a major risk. In Europe, the possible impacts of biofuels on biodiversity vary spatially and depend also on the crop species choice: woody crops have a lower risk to have negative impacts than arable crops.[35]

[31] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for community action in the field of water policy (EU Water Framework Directive, WFD)
[32] Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of environmental policy (Marine Strategy Framework Directive)
[33] See http://www.macis-project.net/links.html
[34] http://www.macis-project.net/MACIS-Deliverable-2.2-2.3-Oct.2008.pdf
[35] Eggers J. et al, "Is biofuel policy harming biodiversity in Europe? ", GCB Bioenergy (2009) 1, 18-34

Ecosystems are already suffering the impacts of climate change[36] and of other non-climate pressures, which weaken their ability to act as a buffer against climate change and to provide other ecosystem services essential for human society. There is general agreement about the existence of irreversible "tipping points" in life-supporting ecosystems, and increasing concern about the impacts climate change may have on reaching these. Ecosystem development is usually not linear and there are significant knowledge gaps with regards to the positive and negative feedbacks within ecosystems and the climate system.[37]

Efforts for emissions reduction that disregard the wider ecosystem challenge may result in an overall unfavourable CO_2 balance (and increasing atmospheric CO_2). The uncontrolled extension of biofuel crops, for example, may lead to deforestation causing more emissions than are prevented.

Geo-engineering techniques for mitigation involve manipulation of the natural environment, particularly the marine environment, which could have substantial impacts on biodiversity and ecosystem services. Carbon Capture and Storage technology (CCS) from fossil based power generation has the potential to contribute both to the EU's climate goals and to its security of energy supply. But it must be deployed safely and sustainably.

There is growing evidence that old-growth forests sequester carbon in woody tissues, in slowly decomposing litter on the ground and buried in soil, thereby acting as effective carbon sinks. Yet, such forests, which are very important for biodiversity conservation, are not protected by international treaties and are usually excluded from national carbon budgets.

Recent surveys of grasslands estimate their carbon sequestration potential to be between 1.3 and 1.5 Gt CO_2 equivalents, which could be realised through a combination of grassland restoration[38] and improved, less intensive management practices avoiding overgrazing. Obviously there are trade-offs with other land-uses. Care should be taken to obtain the best carbon balance. Efforts should be made to integrate carbon sequestration goals with other land-use objectives while not harming biodiversity.

Drainage and infilling of wetlands means natural water storage is lost and recharge of groundwater reduced, reducing dry-season flows and the options available for coping with drought. Where rivers are disconnected from floodplains by levees and canalization, water is rushed downstream, raising exposure of towns and cities to flood peaks. Clearing of vegetation and erosion of upland slopes means buffering of runoff by retention of water in soils is weakened, increasing the exposure of downstream communities to hazards from flash flooding. Drainage of peatlands releases CO_2 and leads to the gradual loss of an important carbon sink.

Changes in land use that lead to loss of biodiversity can also lead to increased green-house gas emissions. Also, additional releases of CO_2 and CH_4 are possible from melting permafrost, peatlands, wetlands and large stores of marine hydrates at high latitudes[39]. Losses of carbon from peat and other soils could easily outweigh savings made by any feasible reduction in fossil fuel use. These feedbacks are generally expected to increase with climate

[36] See items 1.1 and 1.2
[37] See Lenton et al., 2008, Tipping elements in the Earth's system, PNAS Vol 105: 1786-1793
[38] FAO submission to UNFCCC; http://climate-1.org/2009/04/29fao-submission-to-unfccc-potential-of-grasslands-for-climate-change-mitigation
[39] IPCC AR4 WGII, Ch.4.4.6 and 15.4.2

change. Even though a catastrophic sudden increase of large amounts of methane, e.g. from melting permafrost, is considered unlikely to happen in the short to medium term, ongoing chronic release of methane as a result of anthropogenic warming could result in a substantial increase in its atmospheric concentration, thus further amplifying climate change[40].

In addition, the more humankind limits the capacities of natural systems, e.g. the capacity to regulate climate, and the more non-renewable energy (fossil fuels) we use, the smaller the ability will be for ecosystems to be self-sustaining, in turn causing them to become progressively weaker and provide less effective and fewer ecosystem services. Human beings are endangering the functioning of the "bio turbine", the complex system of interacting ecosystems which make our planet a habitable place to live.

1.3 The Benefits of Ecosystem-based Approaches

Globally and locally, the conservation and sustainable use of biodiversity and ecosystem services have the potential to contribute significantly to mitigating climate change and to helping human societies adapt to its impacts. In addition there are powerful economic and social arguments for taking action to protect biodiversity and ecosystem services.

Ecosystem-based approaches recognise and value natural resources including land, soils, air, water and living resources. They represent potential triple-win measures: they contribute to the protection and restoration of natural ecosystems, mitigation of climate change by conserving or enhancing carbon stocks or by reducing emissions caused by ecosystem degradation and loss and, provide cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems like wetlands, mangroves, coral reefs, oyster reefs, and barrier beaches all provide natural shoreline protection from storms and flooding in addition to their many other services. Ecosystem-based approaches are cost-effective, ready now and likely to be more accessible to rural and poor communities, as often they are already used locally and are underpinned by traditional knowledge. Thus they can align with and enhance poverty alleviation and sustainable development strategies. Put simply using ecosystem-based approaches means working with nature for human well-being.

Information Box 4 : Some examples for ecosystem-based approaches

Ecosystem-based Approach	**Expected Benefits**
Maintain and restore floodplains, forests, wetlands and peatland	Adaptation, mitigation, nature conservation, flood protection, water purification
Use soft coastal defences, maintain and restore mangroves and other coastal forest; protect coral reefs	Adaptation, mitigation, nature conservation, coastal protection, fishing nursery leading to revitalised fish stocks thus improving livelihoods
Maintain and restore vegetation cover, e.g. diverse mountain forest, grasslands	Adaptation, mitigation, nature conservation, erosion and landslide protection, water storage and purification
Increase green spaces in cities; planting	Adaptation, mitigation, cooling, filtering

[40] IPCC AR4 WGI, Ch. 7.4.1.2

trees and installing vegetal roofs	of the air, provision of habitat, stepping stones, improved quality of life
Use diverse crops in agriculture, Improve input management, Preserve high quality soils for agriculture	Adaptation, enhanced food security, increased agriculture biodiversity, increased soil quality, improved water storage and purification
Diversify forest stands and conserve old growth forest	Adaptation, nature conservation, storm protection, water storage and purification

Biodiversity is not just the victim of our mismanagement; it is our ally in managing better. We can devise effective responses to climate change with nature as our ally. Clearly, working with nature, maintaining, enhancing and restoring healthy ecosystems and increasing their resilience, are some of the best and most cost-effective measures to adapt to climate change, that often contribute to mitigation, too.

To preserve the ability of global ecosystems to continue to function as sinks for greenhouse gases and to avoid ecosystem feedbacks that accelerate global warming, climate change policy must address the wider ecosystem challenges of climate change and efforts to halting biodiversity loss must be stepped up. The challenge is to move towards "win win" or at least "win more and lose less" strategies.

Ecosystem-based approaches, including green infrastructure planning, maintain ecological functions at the landscape scale in combination with multi-functional land uses and contribute to ecosystem resilience. These approaches can be applied to virtually all types of ecosystems, at all scales from local to continental and have the potential to reconcile short and long-term priorities. While contributing to halting the loss and degradation of biodiversity, as well as restoring water cycles, they also enable the functions and services provided by ecosystems to reach a more cost-effective and sometimes more feasible adaptation solution than can be achieved by relying solely on conventional engineered infrastructure or technology-led measures. In addition, these approaches reduce the vulnerability of people and their livelihoods in the face of climate change. They also help to maintain ecosystem services that are important for human well-being and vital to our ability to adapt to the effects of climate change.

Information Box 5: Ecosystem-based adaptation creates benefits for people[41]	
Ecosystem-based adaptation	**Benefit for people**
Restoring fragmented or degraded natural areas	Enhances critical ecosystem services, such as water flow for fisheries provision
Protecting groundwater recharge zones or restoration of floodplains	Secures water resources so that entire communities can cope with drought
Connecting expanses of protected forests, grasslands, reefs or other habitats	Enables biodiversity to move to better or more viable habitats as the climate changes
Protecting or restoring natural infrastructure such as watershed forests, barrier beaches, mangroves and coral reefs	Reduces exposure of Buffers human communities to natural disasters, such as landslides, flooding, storms and wave surges

[41] Adapting to climate change – ecosystem-based approaches for people and nature, The Nature Conservancy June 2009, adapted

There are many low cost co-benefit measures that contribute to greenhouse gas emission reduction, adaptation and the conservation and sustainable use of biodiversity and ecosystem services. Mitigation and adaptation interactions can be positive: for example reforestation and afforestation with native species increases carbon capture and storage, reduces flooding and aids adaptation both by and of biodiversity. The protection, enhancement and restoration of wetlands, salt marsh and grazing marsh may increase local carbon sequestration in the longer term, protect communities from flooding and is beneficial for biodiversity and ecosystem services.

Working with nature, using ecosystem-based approaches provides benefits that most people take for granted. For example, in addition to providing critical habitat for animal and plant species, trees reduce the effects of air pollution by removing nitrogen dioxide, sulphur dioxide, carbon monoxide and ozone, and they sequester and store carbon thus contributing to mitigation. The greening of cities helps us to adapt to climate change by cooling the surrounding area. It also adds to the quality of life by filtering the air, reducing noise and increasing aesthetic appeal thereby adding recreation and construction value.

Floodplains contribute to adaptation and mitigation, provide space for nature conservation and contribute to water purification. The natural role of a floodplain is to carry excess water during periods of heavy runoff. The height of floods is greatly increased by building levees, wetland loss, deforestation, stream canalization and changes in land use. Therefore adaptation to deal with flooding implies – *inter alia* - restoration and maintenance of wetlands and forests. Re-establishing the role of floodplains and low-lying areas along rivers as natural water buffer zones could reduce the risk of serious floods in EU countries and is a cost-effective measure. In addition floodplain forest provides ecosystem services on different scales:
- on a local scale it serves as recreation area for enhancing the quality of life of the local residents and harbours the key species of healthy floodplain ecosystems;
- on a regional or river basin scale, it provides a green corridor to connect ecological networks and increase their coherence; it further serves for timber production, limits pesticides inflow to the river and stops soil erosion;
- on a national it increases flood retention capability;
- and from an international scale perspective it provides all the above services and contributes to carbon sequestration and storage and strengthens resilience to climate change.

Similarly wetlands, such as swamps, marshes, fens and bogs, as well as being important wildlife habitats, also act as massive water filters, purifying water and natural basins that harness rainwater. Species richness usually increases the water storage capacity, because different species occupy various niches and fulfil different functions. Acting like sponges, wetlands absorb precipitation and runoff and slowly release it into the ground or outlet streams. Wetlands do not only store water: restoration of wetlands can contribute to mitigation and enhance the quality of ground and surface water e.g. by removal of nitrogen from agricultural runoff, as well as reduce the impacts of floods. Experience in the control of floods and coastal erosion shows that more natural approaches, which reduce conventional engineering solutions and involve using "natural" areas instead, e.g. riverside farmland used as washlands, may be more cost-effective and bring multiple benefits. Restoration of wetlands would help to address the losses of wetland habitat due to sea-level rise and reduce habitat fragmentation in farmed landscapes.

***Information box 6: Synergies between climate change mitigation and adaptation*[42]**

Mitigation and adaptation can be mutually reinforcing. Increasing the storage of carbon and avoiding its release from forests and soils can have multiple benefits. The Reducing Emissions from Deforestation and Forest Degradation program offers a promising mechanism for simultaneously delivering mitigation, adaptation, and economic benefits while sustaining vital ecosystem services. The basic principle is that countries and those that own and manage forests would be paid to protect and increase the public goods they provide. Similar ideas with regard to carbon sinks in soils are under discussion.

Such measures could be combined with adaptation efforts and produce synergies. Maintaining or increasing forest coverage, avoiding tillage of highly organic soils, or integrating bio-char may lead to improvements in water retention and soil productivity, ultimately promoting the resilience of ecosystems and of the communities that depend on them. Mitigation would go hand in hand with adaptation. A high value would be assigned to the sustainable management of natural resources and potentially also promote the implementation of the conventions on biodiversity and desertification.

But there are also conflicts. Ample experience tells us that without secure rights and proper governance arrangements, the poor and landless risk being forced out when the value of forests and land increases. New opportunities will enrich some while others lose out. If safeguards against such risks are not put in place, new climate policy may further marginalize the poor and vulnerable.

Global megacities (e.g. Rio de Janeiro, Johannesburg, Tokyo, Melbourne, New York, and Jakarta) rely on protected areas to provide residents with drinking water. These sites offer a local alternative to piping water from further afield. Protecting the catchment areas costs less than building filtration plants. Like sponges, forests soak up water and release it slowly, limiting floods when it rains and storing water for dry periods. Watershed and catchment protection near cities is thus smart – economically, ecologically and socially.[43]

Mangrove ecosystems stabilise the coastline; their intertwined root systems help bind soft sediment and shield the land from wind and waves, thus contributing to flood protection. They provide natural protection from tropical storms and hurricanes that can be cheaper and more effective than man-made solutions. Their maintenance and restoration contribute to mitigation and adaptation and lead to the re-establishment of fish stocks, thus improving and sustaining livelihoods of local people.

Climate change policy-makers are increasingly conscious that biodiversity and its ecosystems provide services for other sectors (e.g. pollination, flood mitigation and water quality enhancement) in addition to climate adaptation and mitigation. This presents a good opportunity to improve stewardship of biodiversity and ecosystem services. We now need to acknowledge and use the positive potential of conservation and sustainable use of biodiversity and ecosystem services with regards to other policy areas.

---

[42] Quoted from the Report by the *Commission on Climate Change and Development*. **Closing the Gaps**. 2009. See http://www.ccdcommission.org

[43] *Benedict M.A., McMahon* E.T. edts. **Green infrastructure: linking landscapes and communities**, Island press

Preserving and enhancing the resilience of ecosystems, through conservation and sustainable use of biodiversity, is a vital tool in our efforts to lessen the adverse impacts of climate change. Working with nature rather than against it encourages opportunities for sustainable development involving people and sharing responsibility for a future built on welfare, equity, security, human development and well-being. Therefore the maintenance and restoration of diverse, functioning ecosystems across the wider terrestrial, freshwater and marine environment must be a guiding principle as we move forward to "climate proof" our policies and adapt to climate change.

Information Box 7: Political statements referring to the biodiversity-climate change linkage, co-benefits and synergy

The **Toyako Declaration** (G8 Summit in 2008) underlined the need to promote a co-benefit approach that will lead to a reduction in greenhouse gas emissions as well as to the conservation and sustainable use of biodiversity.

The **Environment Council Conclusions** (20 October 2008) HIGHLIGHTS … the opportunities for co-benefits of actions to mitigate and adapt to climate change, preserving biodiversity and controlling desertification and REAFFIRMS that concerns regarding conservation and sustainable use of biodiversity and ecosystems should be taken into account when formulating and implementing activities aimed at mitigation and adaptation to climate change.

The **Recommendation 135 (2008) of the Bern Convention** calls on Parties to “raise awareness of the link between biodiversity and climate change and emphasise the large potential for synergies when addressing biodiversity loss and climate change in an integrated manner; including socio-economic effect;”

The **Environment Council Conclusions** (4 December 2008) recalled Conclusions of 20 February, 28 June 2007, 3 March 2008 and the Conclusions of the Spring Council of March 2008, which stressed the need to achieve synergies between climate change and biodiversity policies as a way to secure co-benefits.

The **Environment Council Conclusions** (25 June 2009) HIGHLIGHTS the fact that terrestrial and marine ecosystems, which currently absorb roughly half of anthropogenic greenhouse gas emissions, constitute a major buffer against the impacts of climate change, and that continued degradation of these ecosystems reduces their capacity as carbon sinks and to protect against floods and soil erosion, which compromises our efforts to mitigate and our capacity to adapt to climate change; … EMPHASISES the need to pursue a significantly improved understanding of the role of human communities and ecosystems in adaptation measures as well as the possible application of ecosystem-based approaches in this context, with a view to strengthening their resilience and adaptive capacity and generating additional economic and social benefits…; CALLS for greater synergies between measures for climate change mitigation and adaptation and for combating land degradation and desertification, and the conservation ad sustainable use of biodiversity and ecosystems, in order to fully exploit and maximise co-benefits;

The **Aquila Declaration** (G8 Summit 2009) requests to: "significantly increase consideration of the role of ecosystems in adaptation measures, with a view to improving resilience of

ecosystems, reducing vulnerability and underpinning new and sustainable growth models." "…making use of the synergies between climate change and biodiversity policies".

Section 2: The Way Forward

2.1 Use Ecosystem-based Approaches (in adaptation and mitigation) to Achieve Multiple Benefits

Use ecosystem-based approaches to address climate change and biodiversity loss and ecosystem service degradation in an integrated manner and develop strategies that achieve mutually supportive outcomes. This implies addressing the wider ecosystem challenges and potential in the climate change negotiations e.g. by establishing a REDD+ like mechanism, promoting a similar approach for other land use and ecosystems and, by including ecosystem-based approaches[44] as an integral part in the UNFCC Framework for Adaptation Action.

Healthy resilient ecosystems have enormous potential to enable society to mitigate and adapt to climate change. They resist and recover more easily from extreme weather events and provide a wide range of benefits on which people depend (see also Information Box 1). Therefore biodiversity conservation should be an integrated part of mitigation and adaptation efforts.

Mitigation activities can be designed to create synergies with adaptation, the conservation of biological diversity and sustainable development. Activities with negative impacts on biodiversity should be avoided and where necessary remedial measures implemented. While measures with positive outcomes represent opportunities that should be identified and promoted.

[44] The CBD AHTEG on Biodiversity and Climate Change in its "Main messages" of June 2009 suggested the following definition: *"Ecosystem-based adaptation (EbA) may be described as the use of ecosystem management activities to support societal adaptation. EbA identifies and implements a range of strategies for the management, conservation and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to increase the resilience and reduce the vulnerability of ecosystems and people in the face of climate change. …"*

In the revised draft negotiation text of 22 June of the UNFCCC working group on long-term co-operative action (AWG LCA) it reads: *"… necessitating a shared vision for actively promoting sustainable community-based ecosystem management, conservation and restoration activities, where appropriate to support adaptation. …"*

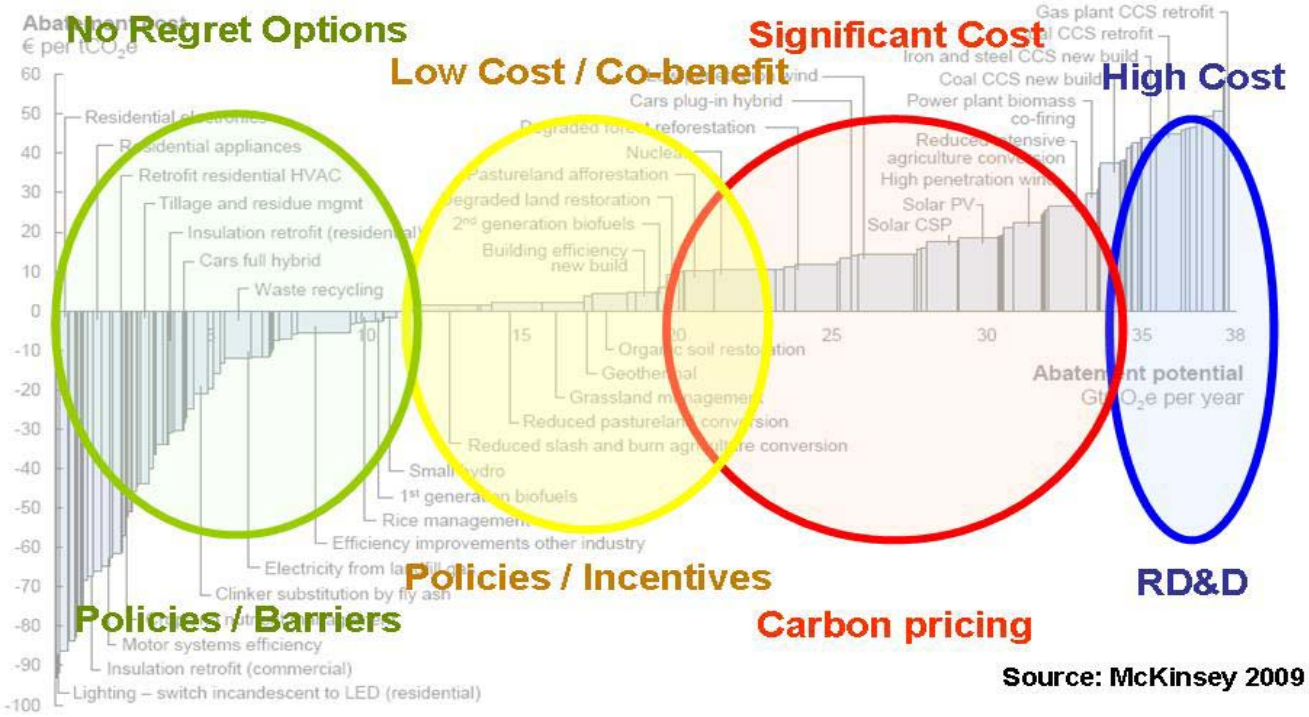

Figure 3: Examples of options for emission reduction; *ecosystem-based approaches, which also contribute to conservation and sustainable use of biodiversity, figure amongst the low cost co-benefit measures. They include appropriate restoration of "degraded" land, forests, organic soils, floodplains and wetlands, reduction in conversion of pastureland, less slash and burn practices, and improved grassland management*[45]*. Equally important, but not included in the figure is maintaining healthy ecosystems, e.g. old-growth forests and peatlands.*

Key to any adaptation and mitigation planning process is the principle of adaptive management, where earlier steps in an iterative and ongoing process inform later steps. Management approaches need to learn from experience and changing conditions, and assess risks to tackle uncertainties. Flexible approaches to policy design are needed that are sensitive to context and uncertainties and are not tied to a single, one-size-fits-all mechanism.

Broadly speaking, climate change mitigation and adaptation requires improved institutional co-ordination, expanded spatial and temporal perspectives, incorporation of climate change scenarios into all planning and action, together with greater effort to address multiple threats and global change drivers simultaneously and in ways that are responsive to and inclusive of human communities. We have to make sure that climate change measures do not come at the expense of biodiversity and ecosystems services.

[45] McKinsey Report 2009, adapted

Assessment of the impacts of policies, development plans and projects that incorporates not only climate change impacts but also those of mitigation and adaptation actions is vital to protect and maintain biodiversity under climate change. Impact assessment procedures should factor in where relevant specific elements related to impacts of climate change (as well as the impacts of mitigation and adaptation) upon biodiversity.

Recommendation Box 1: Integrated and Ecosystem-based Approaches

- Develop a comprehensive policy framework in which the relationship between climate change, biodiversity and ecosystem services is fully recognised and the wider ecosystem challenge of climate change is appropriately addressed.

- Develop and implement mechanisms for "ecosystem proofing" to assess and address the impacts of programmes and projects on biodiversity and ecosystem resilience.

- Maintain and restore areas such as wetlands, floodplains, forests, oceans and seas as carbon and water stores and filters as well as habitat for wildlife.

- Recognise the importance of and implement management for, maintaining and restoring soil carbon and soil processes in land use, especially for agricultural, forested land and peatland.

- Use ecosystem-based approaches to control and adapt to coastal erosion by e.g. using natural processes, natural coastal defences, maintaining sediment flows, protecting mangroves, reefs etc....

- Green the cities to improve the quality of life, both visually and by filtering and cooling the air and shading buildings and surfaces to help cope with heat waves.

- Promote ecosystem-based approaches to adaptation and mitigation with special emphasis in the EU overseas entities and in development co-operation.

All measures to mitigate effects of climate change or to slow down the speed of increase of greenhouse gasses in the earth's atmosphere are valuable. This implies:
- a move away from further release of the remaining Earth's fossil carbon resources for combustion purposes,
- promotion of clean technology and increasing energy efficiency,
- avoiding emissions from ecosystem degradation and loss,
- maintaining and enhancing the capacity of marine and terrestrial ecosystems to sequester and store carbon,
- use of ecosystem-based approaches,
- promotion of sustainable development.

Improvements in institutional mechanisms at the international level are also needed to facilitate the development of integrated approaches. The collaboration between relevant conventions needs to be improved. In spite of several commitments through the cross cutting Joint Liaison group (JLG) and Ad Hoc Technical Expert Groups that carry out valuable work, the three Rio Conventions still work very much in parallel. However, complex challenges such as biodiversity loss and climate change need integrated approaches, which depend on fruitful collaboration.

Emission reduction programmes and the "Clean Development Mechanisms" (CDMs) in the Kyoto Protocol (and, we would hope, in the anticipated new climate agreement) should promote projects that simultaneously address carbon sequestration, biodiversity conservation and human livelihoods, next to projects that deal with emission reduction and carbon sequestration in isolation. However, despite the importance of biodiversity and ecosystem services in the climate system, land-use based mitigation policy has been constrained by a number of issues. These include the uncertainty over the exact role of ecosystems in the climate system, methodological issues such as the lack of accurate carbon accounting and difficulties in estimating emissions "saved" and factoring out natural disturbances from anthropogenic activities. Other specific concerns include issues of permanence, leakage and additionality[46]. These concerns were raised for projects allowed under the CDM, but are less relevant for a potential "Reducing Emissions from Deforestation and Forest Degradation in Developing Countries" (REDD) mechanism, if it is based on national-level accounting. The scale of emissions reduced and particularly biodiversity benefits will be determined by the design of the mechanism. A successful REDD mechanism will have to address the drivers of deforestation and will require effective targets, monitoring and measuring, appropriate financial mechanisms and good governance[47].

At its 6th session in the beginning of June 2009 the Ad Hoc Working Group on Long-term Cooperative Action (AWG-LCA) adopted wording for a REDD+ mechanism. The text added the phrase: *"promoting conservation and the sustainable management of forests, and to enhancing forest carbon stocks".* As part of the negotiation process underway proposals have been put forward to expand the principles agreed for forestry under REDD+ to other ecosystems (also known as REDD+). Extending the principles agreed for REDD+ to other land uses and ecosystems would be a valuable outcome, helping developing countries achieve sustainable development and contributing to the objective in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), *i.e. "stabilization of green house concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."*[48] In view of new evidence that old growth forests remain active as carbon sinks[49] and that deforestation results in huge carbon emissions, particularly in the tropics, and in recognition of the vital role of tropical rainforests in stabilising climate, measures to halt deforestation are urgently needed.

Recommendation Box 2: International Dimension

- Appropriately address biodiversity and ecosystem services in a post-2012 climate agreement by, *inter alia*, the establishment of an environmentally sound REDD+ mechanism and the inclusion of "ecosystem-based adaptation" or alternative wording on ecosystem-based approaches as one of the elements of a future adaptation framework. The principle of

[46] "Permanence" refers to the issue that carbon locked up in biomass and soils may be released at a later date either following human or natural disturbance; "leakage" occurs when emissions reduced in one area, for example through the protection of a section of forest are simply displaced by deforestation nearby; "additionality" refers to a situation in which the emission reductions or carbon savings would have occurred anyway in the absence of mitigation policy.
[47] Eliasch. 2008
[48] Objective UNFCCC Article 2 of the Convention
[49] Lewis et al., 2009

extending REDD+ to other land uses and ecosystems should be discussed at COP 15 with the aim of elaborating concrete proposals at subsequent meetings.

- Add force to the Joint Liaison Group (JLG) enhancing the collaboration between the Ramsar Convention on Wetlands and the three Rio Conventions: Convention on Biological Diversity (CBD), Framework Convention on Climate Change (UNFCCC) and Convention on Combating Desertification (CCD) recalling also CBD COP Decision IX/16 including options for mutually supportive actions addressing climate change within the Rio Conventions.

- Develop and promote projects that simultaneously address carbon sequestration, biodiversity conservation and the improvement of human livelihoods e.g. restoration of wetlands in particular peatland.

- Valorise the interdependency between climate, ecosystem services and biodiversity at CBD COP10 in 2010.

- Consolidate the collaboration between the Conventions and renew Agenda 21, including the financing of its actions at the Rio+20 Summit in 2012.

2.2 Act Now

Take immediate action to conserve and restore terrestrial and marine biodiversity and ecosystem services as these are the basis for cost-effective climate change adaptation and mitigation and can provide multiple economic, social and environmental benefits. It also includes developing and implementing actions to support adaptation of biodiversity to climate change.

One of the key messages of the Climate Change Congress on Global Risks, Challenges & Decisions[50] is that "*Inaction is inexcusable*", moreover that "*a wide range of benefits will flow from a concerted effort to alter our economy now, including … the restoration of ecosystems and revitalisation of ecosystem services*."

Uncertainty about future climate change, its impact on the natural environment and the response of biodiversity, should not limit action to reduce pressures on the environment and to strengthen existing conservation strategies. A key focus is to increase ecosystem resilience i.e. enhancing the ability of ecosystems to absorb and recover from rapid and unpredictable change, and facilitating the movement of species to help them stay within areas of suitable climate conditions, as these shift location with ongoing climate change. This principle has been endorsed in Recommendation 135 (2008) of the Bern Convention[51].

Measures that are wholly positive ("win win win" for each of the three fields: adaptation, mitigation and biodiversity goals), such as protecting and restoring wetlands and floodplains, maintaining and enhancing urban green spaces, protecting old-growth forests are cost

[50] See http://climatecongress.ku.dk/

[51] The action point in Recommendation 135 (2008) of the Bern Convention reads as follows: "Take action now: As uncertainties surrounding the precise nature of future climate change and its impacts on biodiversity should not delay practical conservation action."

effective and represent environmentally sound actions. Such measures should be implemented without any further delay.

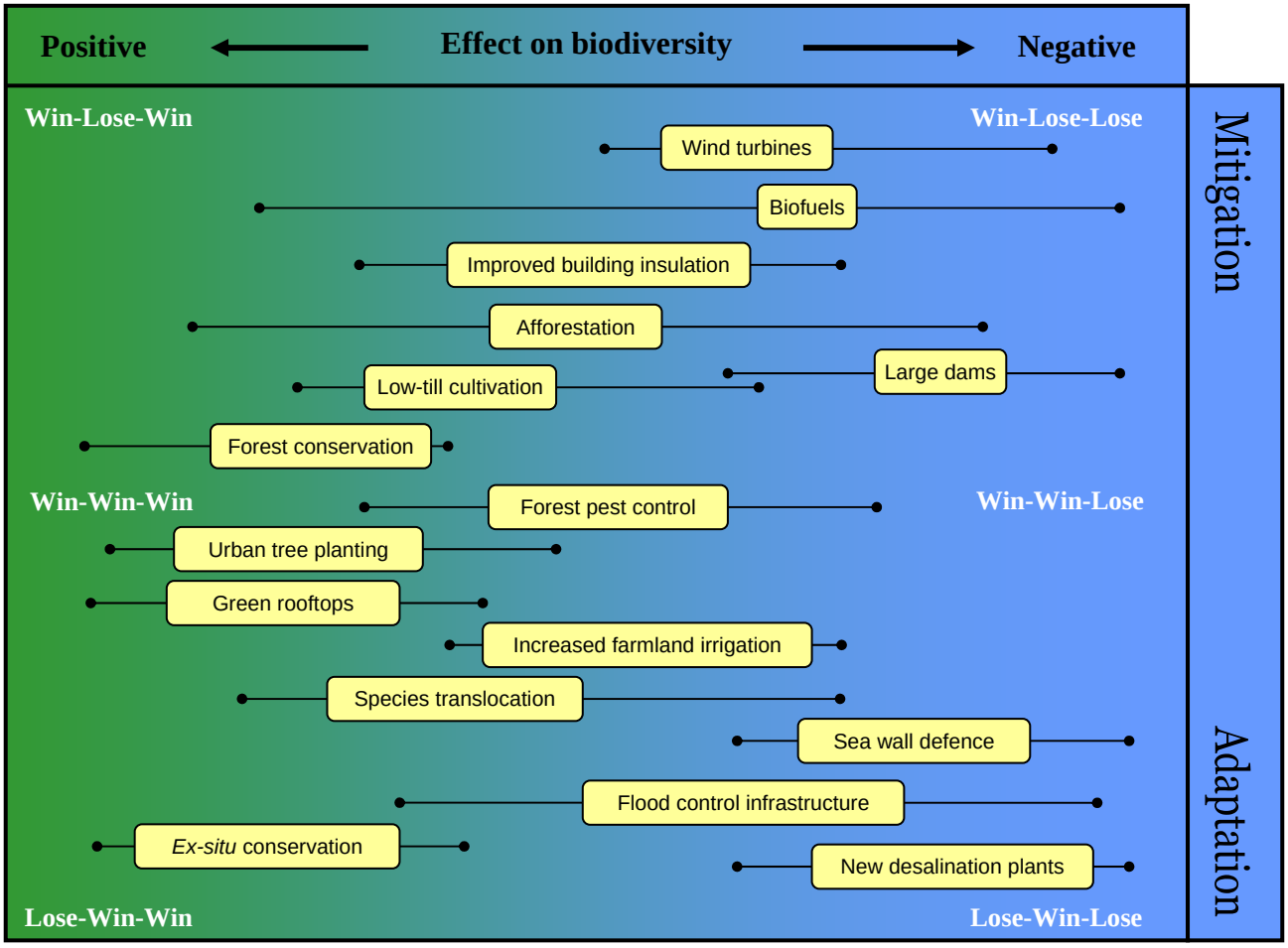

Figure 4: ***Known and potential relationships between mitigation and adaptation measures and their impacts on biodiversity***[52]

Moreover, the impacts of climate change will be exacerbated by stress from other factors. "Therefore, with immediate effect, governments should take steps to improve resilience to existing pressures and reduce those pressures. Such action will, in turn, reduce exposure to the threat posed by climate change"[53]. It is also crucial that climate change adaptation and mitigation is implemented in ways that alleviate pressure rather than putting additional adverse pressure on biodiversity. Reducing other pressures on biodiversity is one key adaptation strategy aimed at increasing resilience to climate change.

[52] From Paterson J. et al, (2008) Mitigation, Adaptation and the Threat to Biodiversity. Conservation Biology, 22, 1352-1355

[53] Quoted from "Climate Change Adaptation and the Transition to a low carbon society" - Joint Science Academies' Statement 2008

Recommendation Box 3: Immediate Action

- Implement "synergy" or "no regret" measures that provide multiple win solutions i.e. adaptation and mitigation measures that benefit (or are neutral to) conservation and the sustainable use of biodiversity and ecosystem services.

- Reduce other pressures on the environment as a means to reduce vulnerability and increase resilience of ecosystems and societies – *inter alia* - by energising the implementation of existing polices and legislation.

Biodiversity policy needs to evolve, supported by comprehensive long-term monitoring, to deliver biodiversity protection and enhance ecosystem resilience under changing climatic conditions. We should make better use of existing relevant legislation such as the Nature Directives, Water Framework Directive, Marine Strategy Framework Directive[54], Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA)[55] etc. The implementation of the Nature Directives should be improved as it provides an essential minimum area for protected species and habitats and the ecosystem functions provided by them. An extension of the network to accommodate the possibility of better dispersal of species and to reduce the risks of habitat fragmentation could be achieved by making best use of Article 3 of the Birds Directive and Articles 5, 10 and 12 of the Habitats Directive. The enhancement of "Green Infrastructure" can also contribute to maintain ecological coherence thus increasing the resilience of ecosystems.[56]

While fully implementing existing instruments, we also have to develop further measures appropriate for protecting biodiversity and increasing resilience not only to climate change, but also to the combination of climate change with other pressures. This will include landscape level protection, improved opportunities for movement of species, and the development of skills and technical adaptation capacity.

Ecosystem resilience can be increased by enhancing the quality of the network. This entails protecting existing habitats from destruction, managing habitats appropriately, reducing external threats (e.g. eutrophication from air and water pollution, disturbance and the spread of invasive species) and, where necessary, creating or restoring habitats to increase the size of core areas and their functional connectivity to enable species to move through the wider environment and establish new populations in more suitable locations. EU overseas entities are home to especially rich biodiversity, particularly vulnerable to climate change. As such, special attention should be given to these territories.

The following adaptation principles are fundamental to conserving biodiversity under changing climatic conditions:

- take action now;
- maintain and increase ecosystem resilience;
- accommodate change;
- develop knowledge and facilitate knowledge transfer;
- use adaptive conservation management.[57]

[54] See information boxes 4 and 5
[55] See http://ec.europa.eu/environment/eia/home.htm
[56] "Towards a green infrastructure for Europe" European Commission workshop 25-26 March 2009, http://www.green-infrastructure-europe.org
[57] Smithers et al., 2008. Defra and part II of the guidance of the Bern Convention Recommendation 135 (2008)

Species may adapt to climate change either through adapting on site, or by dispersing and establishing at new sites or a combination of these. Potential adaptation strategies include:

- create adaptable conservation areas e.g. by management of sites to increase resilience, expansion of sites or identification and designation of new sites;
- ensure sound conservation in the wider environment;
- reduce other sources of harm e.g. invasive species, pollution, inappropriate management;
- connect existing sites through corridors and stepping stones;
- conserve genetic diversity;
- as extreme solutions: develop *ex-situ* conservation or translocate species in order to assist migration; and
- take no action through informed choice; [58]

Adaptation measures for biodiversity can be described as a fourfold process: protect-enlarge-connect-integrate. This process includes: maintenance of genetic and species diversity, protection of habitat heterogeneity and connectivity to maintain migration routes and access to sites which can act as refuges from climatic extremes e.g. drought or flooding; conservation of physical features and the protection of sites from other human pressures; management of entire catchments and the regulation of extraction and water use; appropriate restoration of "degraded" sites; and development and implementation of adaptive management strategies to maintain flexibility. It should also include measures across the wider countryside. Added value is provided by restoration schemes, since they can provide links or corridors between isolated nature reserves or create space in which species may survive. The concept of an ecological network implies measures to conserve the integrity of the natural systems on which species depend. Developing ecological corridors and stepping stones is a strategic and dynamic concept that could provide a framework to help redress habitat fragmentation. The range of policy options to achieve this includes legislation, market-based instruments, guidance, insurance and collective action, as well as use of the planning and development process. Specific measures are listed in Recommendation Box 4.

Recommendation Box 4: Supporting Climate Change Adaptation of Biodiversity

- Enhance the implementation of existing instruments for nature conservation including using related policies e.g. water management and requiring the consideration of climate change impacts. The enlargement of existing sites and networks should be encouraged.

- Apply the ecosystem approach[59] for landscape planning to ensure that ecological function is given due weight alongside conventional socio-economic considerations.

- Protect and appropriately manage existing protected areas and other areas of high ecological value, - *inter alia* - by establishing effective governance mechanisms.

- Decrease fragmentation by road and other human infrastructure.

- Ensure conservation and adaptation needs of biodiversity in the wider countryside, through environmentally friendly land management practices in other land uses e.g. agriculture and

[58] MACIS report adapted
[59] Definition of the "ecosystem approach" see CBD Decisions II/8, IV/1B, V/6, VI/12

forestry and manage the wider landscape facilitating dispersal of species for example by increasing the numbers of hedges, ponds, water-filled ditches, patches of woodland, scrub and extensively managed grasslands and field margins.

- Increase connectivity and landscape permeability to allow dispersal and migration of species through the wider environment by strategic measures which include sustainable use of resources in the wider landscape as well as ecologically functional corridors (e.g. riparian habitats, hedgerows, forest strips) and stepping stones between nature conservation sites to allow dispersal and migration of species.

- Create networks of ecologically connected areas linked within the wider sustainably managed environment to facilitate the movement of species to track suitable climate conditions and habitat through the countryside.

- Co-ordinate actions such as ecological networks regionally, but manage locally in association with local authorities - governmental and non-governmental organisations, – and in dialogue with local stakeholders.

- Take special action for vulnerable species, habitats and ecosystems including pristine forests.

- Promote "green infrastructure" to enhance ecosystem resilience.

- Facilitate migration and adaptation potential by locating nature conservation sites with reference to focal species or community distribution, such as in their core areas or on their extreme boundaries.

- Ensure adaptive management, which by monitoring and responding to changes and activities enables action to be modified on the basis of experience.

- Give special attention to EU overseas entities and adapt recommendations when necessary.

Further suggestions can be found in the Recommendation N° 135 (2008) of the Standing Committee of the Bern Convention[60] on addressing the impacts of climate change on biodiversity.

2.3 Engage Other Sectors

Engage other sectors e.g. agriculture, finance, transport, energy, regional planning, water management, fisheries, forestry, tourism, development policy, health, built environment etc… to increase and maintain ecosystem resilience.

Sectoral policies on territorial and spatial development within Europe relate principally to cohesion and growth, but are also concerned with the quality of life and meeting the challenge of sustainable development. The maintenance and restoration of diverse and functioning ecosystems across the wider terrestrial, freshwater and marine environment need to be guiding principles as we move to make all our policies resilient to and protective against adverse

[60] adopted on 27 November 2008, see http://www.coe.int/t/dg4/cultureheritage/conventions/Bern/Recommendations/Rec135_2008__en.pdf

climate change impacts. Spatial planning policy and measures affecting development are important in providing for the protection and maintenance of biodiversity in a changing climate, as these changes act in addition to other pressures, such as fragmentation of habitats and corridors by transport routes and urban expansion. Spatial planning approaches, promoting green infrastructure, that enable natural processes to take place and increase the resilience of ecosystems, also can lead to other socio-economic benefits. They play a key role in addressing the challenge of nature conservation under changing climatic conditions. Despite the variation between organisations and authorities in competences and responsibilities, ways need to be found to integrate policies across the hierarchy of levels (EU-wide to local) and across sectors – this should be supported by using common targets, indicators and time horizons.

Plans to deal with climate-induced disasters should identify not only the damage to human settlements, but also to the local ecosystems on which they depend. This approach would protect ecosystems both as economic mainstays of local people, and as havens of biodiversity. A review[61] of recent policy development across several policy areas has confirmed that the majority of these still make little reference to climate change, and less to biodiversity, even in sectors that are important in affecting biodiversity and at the same time rely upon ecosystem services.

Biodiversity and ecosystem services are crucial to the alleviation of poverty, as human populations in poor countries depend directly on them. They are integral to key development sectors, such as agriculture, forestry, fisheries and tourism. Sustainable development cannot be achieved if biodiversity is compromised by development efforts. Consequently, mainstreaming biodiversity into development strategies and programmes is essential to poverty alleviation and development. Ecosystem-based approaches, as outlined in section 1.3, are a smart, innovative and simple way of contributing to the objectives of combating climate change, conservation and sustainable use of biodiversity and poverty alleviation.

Biodiversity conservation issues should be incorporated into climate change adaptation and mitigation policies, sectoral policies and sustainable development strategies. In particular conservation and sustainable use of biodiversity needs to be built into the adaptation plans of other sectors. Not only will this will help to deliver nature conservation goals and ensure that natural resources such as water and wetlands, remain available at current and preferably increasing levels, it will also contribute to adaptation and mitigation objectives.

Adaptation in one sector should not compromise the ability of another sector or region to adapt, should not exacerbate the causes or consequences of climate change and should not come at the expense of biodiversity and ecosystem services. Cross-sector integration is important to avoid unintended adverse effects, benefit from synergies and to use the opportunities provided by ecosystem-based approaches. This can often be achieved by open dialogue between sectors and adopting best practices for the implementation of adaptation and mitigation policies.

Multi-functional landscapes appear to provide insurance against an uncertain future for human societies and biodiversity. For example cross compliance and agri-environmental schemes, forestry grant schemes and planning guidance can help to protect biodiversity and increase ecosystem resilience. The maintenance of landscape features would contribute both small

[61] MACIS deliverable 4.1. see http://www.macis-project.net/MACIS-deliverable-4.1.pdf

scale local ecosystem services such as providing shade for farm animals, but also services with wider impact, such as buffering water courses from pollution.

Given the uncertainty surrounding future rates and impacts of climate change, as well as the gaps in knowledge and uncertainty of responses to policy initiatives, a precautionary approach should make use of a variety of policy options including regulation, market based instruments, insurance, soft options, and research and development. These combine top-down and bottom-up approaches and could lead to policy integration.

Recommendation Box 5: Engagement of Other Sectors

- Fully implement the EU Biodiversity Action Plan[62] and integrate aspects of biodiversity and ecosystem services into sectoral policies, including agriculture, regional policy, water management, fisheries, forestry, transport, energy, tourism, development policy, health and built environment. This means ensuring the contribution of ecosystem services is acknowledged and protected. These recommendations are intended to apply to all ecosystems and territories of the EU and thus include the terrestrial, marine and freshwater environments of EU overseas entities. Examples of some pertinent measures[63] are presented below. A thorough analysis of each sector would be useful but goes beyond the scope of this paper.

Sector	***Measure***
Agriculture	- Develop multi-functional, sustainably managed agricultural landscapes. - Increase direct public support for farmers towards biodiversity conservation objectives - inter alia - contributing to climate change adaptation. - Encourage agricultural practices which help to reduce greenhouse gas emissions and maintain and enhance carbon storage in soil. - Promote the use of diverse crops and production systems to increase ecosystem resilience.
Regional Policy	- Promote ecosystem-based approaches to the development and implementation of regional policy. - Develop spatial plans that include clear objectives that support and enhance biodiversity conservation and reduce habitat fragmentation and destruction, e.g. by promoting green infrastructure. - Develop a programme of action to improve landscape permeability for species at risk ideally linked with spatial planning policies. This should help ensure that all land use e.g. forestry, agriculture and urban, include minimum amounts of key habitat features.
Fisheries	- Review impact of policies relating to trade and fisheries - Take measures to prevent over-fishing. - Promote sustainable management of fisheries.

[62] See http://ec.europa.eu/environment/nature/biodiversity/comm2006/index_en.htm

[63] adapted from MACIS deliverable "Policy Analysis for Biodiversity under Climate change" see http://www.macis-project.net/MACIS-deliverable-4.1.pdf

Water management	- Promote ecosystem-based approaches for water purification and storage (e.g. wetlands to abate nutrients). - Apply ecological flood management. - Appropriately address ecosystem issues in the management plans for river basin districts. - Avoid unsustainable water use e.g. by water pricing reform.
Forestry	- Promote sustainable forest management and prevent deforestation and forest degradation.
Transport	- Introduce overarching policies to reduce fragmentation or destruction from development of new transport infrastructure and make use of potential positive connection opportunities. - Review EU and Member State external action on transport including air and shipping and interactions with climate change and implication for biodiversity globally.
Energy	- Introduce policies to stimulate markets where appropriate for energy sources that will restore biodiversity (e.g. coppicing/wood fuel). - Review EU and Member State external action on energy and interactions with climate change and implication for biodiversity globally. - Develop and implement sustainability criteria for biofuels and bio-energy to avoid unfavourable direct and indirect land-use change impacts. - Support appropriate development of renewable energy options. - Promote the use of full cycle valuation when considering energy options.
Development Policy	- Support ecosystem-based approaches by development programmes. - Recognize the conservation of biodiversity and ecosystem services as a means to disaster reduction. - Ensure that development programmes do not negatively impact on biodiversity and ecosystem services. - Promote sustainable forest management and prevent deforestation and forest degradation
Tourism	- Support sustainable eco tourism and encourage "green" supply chains.
Health	- Support creation of green spaces in cities to reduce the urban heat island effect.
Built Environment	- Support creation of green spaces in cities. - Encourage construction of energy saving buildings.

2.4 Communicate and Collaborate

Raise awareness of the linkages between climate change, ecosystem services and biodiversity through communication and education initiatives, make use of local knowledge and build capacity and partnerships to facilitate integration.

To use better the opportunities provided through the link between biodiversity, ecosystem services and climate change it is necessary to raise awareness, involve stakeholders and

citizens and build capacity and partnerships. The responsibility of all stakeholders (authorities, developers and the public) for the protection of biodiversity under a range of pressures, including climate change, must be communicated, facilitated and promoted through education, guidance, incentives, and partnership working. Awareness of the benefits should encourage people to take an increasing interest in the conservation and sustainable use of biodiversity and its role in combating climate change. Farmers, foresters, landowners, schools, community groups and NGOs can play a key role and should engage in project planning and management. Education and training programmes could be linked to the establishment, restoration and management of nature conservation and restoration sites. Bern Convention Recommendation 135 (2008) calls on Parties to "address and communicate, as a matter of urgency, the impacts of climate change on biological diversity and its conservation."

To achieve a coherent network of protected sites with functional healthy ecosystems set within a sustainable countryside, we need a bold partnership of governments and their agencies, planners, businesses (including fishing, agriculture and forestry), landowners and NGOs. Such a partnership will deliver social, economic and environmental benefits, but will require a high degree of coordination across multiple jurisdictions to provide landscape cohesion.

Expertise in climate change and biodiversity needs to be built across agencies and within competent authorities, in order to deliver a coherent cross sectoral response.

To achieve a multiplier effect of useful investments, partners need to be identified and partnerships established. Ideally the wider public should also be involved. We need to develop new modes of governance that enable meaningful stakeholder participation and provide sufficient financial incentives.

Recommendation Box 6: Communication and Collaboration

- Initiate, develop and support programmes and campaigns that raise awareness in all relevant sectors for the link between climate change, ecosystem services and biodiversity and their role in providing societal requirements, e.g. food, fibre, and cost effective adaptation.

- Include issues related to biodiversity, ecosystem services and climate change in school curricula as well as in informal and higher education programmes.

- Develop and facilitate stakeholder participation.

- Build institutional capacity and partnerships at and across all levels to ensure improved understanding and communication between different communities.

2.5 Increase Understanding

Strengthen the knowledge base on the climate change-biodiversity linkage through increased research effort, long-term monitoring, ecosystem assessments, and valuation.

While there is a sufficiently strong knowledge base to enable immediate action, there are many unknowns and uncertainties. One large gap is on how to guarantee the sustainability of

the natural environment. Research aimed at addressing this i.e. stopping biodiversity loss and avoiding the negative consequences of human interference, requires us to considerably improve our understanding of the interactions between the climate, biodiversity, ecosystem services and human activities.

The second most important unknown is to rapidly improve our understanding of the possibilities of compensating for the loss of elements of ecosystems. If it is possible to restore them, then we must urgently discover how, since with rapid climate change such losses are becoming inevitable.

Funding bodies need to co-operate to support these research needs. Other key areas for research include:

- Broaden the knowledge base on current and future carbon storage and emissions by marine and terrestrial ecosystems.

- Further develop knowledge with regards to seas, soil, grasslands and peat lands (e.g. the role of soil micro-organisms in determining the rates of key processes in the carbon cycle).

- Gather information concerning the GHGs balance of seas, grasslands, peatland and wetlands.

- Include seas, peatland, wetlands, grasslands and other ecosystems in global climate models for better predictions of future climate change.

- Investigate the cross sectoral interactions between biodiversity and climate change mitigation and adaptation to identify potential trade offs and synergies.

- Better understand the interactions between climate change and other threats to biodiversity and assess the interactions and possible synergistic effects of climate change with other stress factors such as habitat change, invasive species and pollution.

- Improve knowledge on climate change impacts on species interactions and multiple species responses to climate change and identify their specific role in the response of species to climate change.

- Identify vulnerable habitats and species, i.e. assess the extent to which sensitivity and exposure are likely to result in actual threats taking into account each species' and habitats' adaptive capacity.

- Better understand the mechanisms by which species can adapt with a particular focus on identifying thresholds beyond which recovery or survival will be impossible.

- Step up research on habitat restoration and management for adaptation. A partnership between researchers and land managers would allow to benefit from local knowledge and to apply research results.

For further research needs please refer to the recommendations of the European Platform for Biodiversity Research Strategy (EPBRS)[64] .

[64] See http://www;epbrs.org EPBRS Recommendations (Mythimna 2003, Aviemore 2005)

Monitoring is important to establish whether measures have been appropriately implemented and to ensure that they achieve their objectives. Long-term monitoring is essential and collected data and research results should be widely shared and used. Species distribution models (SDMs) provide a useful first approximation of the potential impact of climate on biodiversity. However, these models are only projections and contain a lot of uncertainties including future climate projections and the actual response of species. Increasingly sophisticated analyses combine outputs from SDMs with knowledge of habitat features, species interactions and species dispersal abilities and requirements to provide a better approximation of likely changes in distribution and abundance. Monitoring habitats, species' abundances and distributions, ecosystem functions and services are nevertheless indispensable processes to verify the direction and the rate of changes, and these should contribute over the longer term to the development of more realistic models via improved baseline data. The influence of climate changes on species' phenology is still poorly understood and needs to be monitored as a prerequisite to detecting the risk of decoupling of species' interaction in time and in space.

A long-term science based monitoring programme is needed, with a comprehensive network of sites across EU Member States to evaluate and test the effectiveness of policy measures. The Long-term Ecological Research Network Europe (LTER Europe)[65], set up in the frame of the EU Network of Excellence ALTER-net[66], could become the core of such a programme and form the European part of the Global Climate Change Adaptation Network planned by UNEP in collaboration with the International LTER.

Recommendation Box 7: Increased Understanding

- Ensure the inclusion of the "biodiversity and climate change" topics into EU and national research portfolios.

- Provide sufficient funding for research on biodiversity and climate change.

- Establish science-policy interfaces to maximise societal benefits of research results (applies to all administrative levels: regional, national, EU and international).

- Ensure durable support for long-term monitoring of biodiversity targeting i.e. the impacts of climate change on biodiversity.

- Encourage and assist existing monitoring networks such as those for birds or butterflies.

- Support LTER Europe as a European contribution to the Global Climate Change Adaptation Network planned by UNEP.

2.6 Ensure Funding

Appropriately address the issue of biodiversity, ecosystem services and climate change in upcoming financial reviews.

[65] See http://www.lter-europe.net/
[66] See http://www.alter-net.info/

The strategic measures that ensure connectivity across the wider landscape described in Recommendation Box 4 need to be supported by action plans and implementation measures which enable timely intervention and have assured funding.

Much greater total societal re-investment is required in the life support system represented by biodiversity and ecosystem services. According to experts' opinion we need to invest at least three times as much in protected areas worldwide and 10 times current levels of total re-investment in natural capital[67]. This means that current re-investment in natural capital is at least an order of magnitude too small to sustain it as our future life support system. A substantial part of this investment needs to be obtained from private firms and individuals.[68] Some land managers (foresters and farmers, etc.) already invest in management of natural resources in their care. A regulatory environment that encourages them to maintain public goods while providing an income for themselves should be set up.

In parallel the redistribution of current funding to shift away from perverse subsidies and from polluting, energy intensive methods towards employment of cleaner technologies and ecosystem-based approaches, should be explored e.g. by including ecosystem-based approaches in currently funded measures for flood control and maintenance of water quality.

Ideally, conservation policies should create positive economic and environmental outcomes for local people to buffer them against the potentially dramatic shifts in livelihoods that will accompany climate change.

Another possibility is the creation of premium credits for providing co-benefits. For example, it has been suggested that the REDD mechanism should include explicit means of rewarding actions that reduce emissions from deforestation and degradation in ways that deliver benefits for biodiversity and ecosystem services. The Global Canopy Programme[69] proposes "Proactive Investment in Natural Capital (PINC)" as a global ecosystem services payment mechanism to complement REDD.

Recommendation Box 8: Ensured Funding

- Examine to what extent existing instruments, such as structural funds and agri-environment measures, can offer appropriate funding, e.g. by explicitly integrating the contribution and co-benefits of land-use practices into climate change adaptation and mitigation.

- Explore how to increase the efficiency of funding instruments.

- Evaluate the success of the "integration" approach and if there is evidence that it is not working, propose a specific funding instrument for biodiversity.[70]

[67] Climate Change Congress, Copenhagen, March 2009; Theme 4: Preparing for impacts: Adapting to the inevitable, Sub-theme 31 "Biodiversity: Enhancement of Resilience or Facilitating Transformation?"
[68] Steffen et al, *"From principles to practice":* National approaches to managing biodiversity under climate change in Australia, spoken paper, Climate Change Congress, Copenhagen, March 2009
[69] See http://www.globalcanopy.org/
[70] "The Message from Athens", http://ec.europa.eu/environment/nature/biodiversity/conference/pdf/message_final.pdf

- Promote investment in ecosystem-based approaches in cooperation with the European Investment Bank and the World Bank.

- Appropriately address biodiversity and ecosystem services in upcoming financial revisions (new financial period).

- Develop premiums within incentive measures for biodiversity co-benefits.

- Explore systems that recognise and generate revenues to pay for ecosystem services such as "Proactive Investment in Natural Capital (PINC)".

Glossary

Agenda 21 was adopted in 1992 at the Earth Summit in Rio de Janeiro, UNCED United Nations Conference on Environment and Development. In the first paragraph of the preamble it reads: "… *However the integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future* …"

Albedo reflection of solar radiation

AHTEG Ad Hoc Technical Expert Group. The group referred to in the document is the AHTEG on Biodiversity and Climate Change under the CBD.

ALARM Integrated Research Project (2004-2009) on "Assessing large scale environmental risks for biodiversity with tested methods, assessed risks caused by climate change, environmental chemicals, biological invasions, pollinator loss and socio-economic aspects. The project, in collaboration with others, produced an *Atlas of Biodiversity Risk*, as well as Climate Atlases for butterflies, amphibians and reptiles. It was funded under the 6th Research Framework Programme.

ALTER-net "A long term biodiversity, ecosystem and awareness research network", a network of excellence supported under the 6th Research Framework Programme.

AR4 IPCC Fourth Assessment Report published in 2007.

AWG-LCA Ad Hoc Working Group on Long-term Cooperative Action. Working Group under the UNFCCC preparing the climate agreement for UNFCCC COP 15 in Copenhagen (December 2009).

Biodiversity is defined by the UN CBD as the variability among living organisms on the genetic, species and ecosystem level from all sources including, inter alia, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part. This includes diversity within species, between species and ecosystems.

Birds' Directive Council Directive 79/409/EEC on the protection of wild birds

CCS Carbon Capture and Storage

CDM Clean Development Mechanism, mechanism under the Kyoto Protocol.

CH_4 Methane, green-house gas stronger than CO_2

CO_2 Carbon dioxide, green-house gas

COP Conference of the Parties

DMS Dimethyl sulphid

EbA (Ecosystem-based Adaptation) use of ecosystem management activities to support societal adaptation. EbA identifies and implements a range of strategies for the management, conservation and restoration of ecosystems to provide services that enable people to adapt to the impact of climate change. It aims to increase the resilience of ecosystems and people in the face of climate change (definition proposed by the CBD AHTEG). In the revised draft negotiation text of 22 June by AWG LCA it reads: "…necessitating a shared vision for actively promoting sustainable community-based ecosystem management, conservation and restoration activities, where appropriate to support adaptation …

ECCP European Climate Change Programme

Ecosystem-based Approaches are approaches that recognise and value natural resources including land, soils, air, water and living resources. They represent potential triple-win measures: they contribute to preserve and restore natural ecosystems, mitigate climate change by conserving or enhancing carbon stocks or by reducing emissions caused by ecosystem degradation and loss and provide cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems like wetlands, mangroves, coral reefs, oyster reefs, and barrier beaches all provide natural shoreline protection from storms and flooding in addition to their many other services. Ecosystem-based approaches are cost-effective, ready now and likely to be more accessible to rural and poor communities, as often they are already used in many places and are underpinned by traditional knowledge. Thus they can align with and enhance poverty alleviation and sustainable development strategies. Using ecosystem-based approaches is to work with nature.

Ecosystem Services are the benefits that people derive from ecosystems. They are usually divided into the following categories (following the Millennium Ecosystem Assessment): Supporting services, which provide the basic infrastructure for life on Earth. These include the formation of soils, the cycling of water and of basic nutrients, and primary production of materials for all the other services.
Regulating services, which maintain the environment in a fit condition for human habitation and society. Key examples are regulating climate, mitigating the effects of pollution and control of flooding. Provisioning services, providing food, clean water, energy, and materials for building, clothing and medicines. Cultural services, which connect people with the environment. People, communities and societies place value including economic value on nature and the environment for their own sake, for recreation, tourism and other activities, or simply find pleasure in it.

EEA European Environment Agency

EPBRS European Platform for Biodiversity Research Strategy

ETS Emissions Trading Scheme

EU BAP Biodiversity Action Plan adopted in 2006 together with the Commission Communication on "Halting Biodiversity Loss by 2010 and Beyond" (COM(2006)216 final)

EU Nature Directives Birds' Directive and Habitats' Directive

GHG green-house gas e.g. CO_2, CH_4, N_2O

Green Infrastructure in this document is used in a wide sense and stands for sustainable landscape management approaches, which enable natural processes to take place and increase the resilience of ecosystems.

Habitats' Directive Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora

IPCC Intergovernmental Panel on Climate Change

IPCC A1F1 IPCC "worst case scenario"

JLG Joint Liaison Group is to enhance the collaboration between the Ramsar Convention on Wetlands and the three Rio Conventions: UNFCCC, CBD and CCD.

LTER Europe "Long term ecological research network" set up under ALTER-net.

MACIS scientific support to policy project on "Minimisation of and adaptation to Climate Change Impacts on Biodiversity" assessed not only the impact of climate change, but also adaptation and mitigation measures in different sectors and their impact on biodiversity. It was funded under the 6th Research Framework Programme

Marine Strategy Framework Directive, Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of environmental policy (Marine Strategy Framework Directive)

Natura 2000 network of protected sites designated under the EU Nature Directives. Natura 2000 is the largest network of protected areas in the world (it comprises currently roughly 25000 sites and covers an area larger than any single EU Member State.)

Natural Capital is an extension of the traditional economic notion of capital. The term was coined to represent the natural assets which are often not included in balance sheets by economists, governments and corporations. Natural capital can be non renewable resources, like fossil fuels and mineral deposits; renewable resources, such as fish or timber; or ecosystem services (for instance the generation of fertile soils, pollination, purification of air and water, flood protection, etc…)

N_2O Nitrous oxide, green-house gas

PINC "Proactive investment in natural capital", a system to recognise and generate revenues to pay for ecosystem services. PINC could become a global ecosystem services payment mechanism to complement REDD.

REDD Reducing emissions from deforestation and forest degradation in developing countries.

REDD+ Reducing emissions from deforestation and forest degradation in developing countries promoting conservation and the sustainable management of forests, and to enhancing carbon stocks. Note that as part of the ongoing negotiation process there have been proposals put forward to expand the principles agreed for forestry to other land uses and ecosystems.

Resilience is the capacity of a system to absorb disturbance.

SDM Species distribution model

TEEB "The Economics of Ecosystems and Biodiversity", joint initiative and study by the European Commission and Germany to draw attention to the global economic benefits of biodiversity and the costs of biodiversity loss and ecosystem degradation.

UN CBD United Nations Convention on Biological Diversity

UN CCD United Nations Convention on Combating Desertification

UNEP United Nations Environment Programme

UNF CCC United Nations Framework Convention on Climate Change.

WFD Water Framework Directive, Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for community action in the field of water policy (EU Water Framework Directive, WFD)

List of Sources

Andersons K., Bows A.; **Reframing the climate change challenge in light of post-2000 emission trends**. Phil.Trans. R.Soc. (2008) 366, 3863-3882

Benedict M.A., McMahon E.T. edts. **Green infrastructure: linking landscapes and communities**, Island press

Bern Convention, 2008**. Recommendation No 135 on addressing the impacts of climate change on biodiversity** (see http://www.coe.int/t/dg4/cultureheritage/conventions/Bern/Recommendations/Rec135_2008__en.pdf)

Berry P. et al, 2008. **Adaptation and mitigation measures and their impact on biodiversity.** MACIS http://www.macis-project.net/MACIS-Deliverable-2.2-2.3-Oct.2008.pdf

Buck, M. 2008. **The main results of the ninth Conference of the Parties to the UN Convention on Biological Diversity**, Journal for European Environmental Planning and Law (JEEPL) 5.3-4 (2008) 249-261

Canadell et al., 2007. **Contributions to accelerating atmospheric CO_2 growth from economic activity, carbon intensity, and efficiency of natural sinks**. PNAS Proceedings of the National Academies of Science, 104 (47): 18866-18870

Caribbean Natural Resources Institute for the Joint Nature Conservation Committee (JNCC) Document Series on **Climate Change in UK Overseas Territories** (see http://www.jncc.gov.uk/page-4362)

CBD AHTEG on Biodiversity and Climate Change. November 2008
Draft findings of the first meeting and **Documents provided for the first meeting of the CBD AHTEG on biodiversity and climate change** (see https://www.cbd.int/doc/?meeting=AHTEG-BDCC-01)

CBD Secretariat. **Integrating Biodiversity into adaptation planning** see CBD website http://adaptation.cbd.int/ including adaptation option see http://adaptation.cbd.int/options.shtml#sec1

CBD Technical Series N° 10, "**Interlinkages between biological diversity and climate change**" (see http://www.cbd.int/doc/publications/cbd-ts-10.pdf)

Climate Action Network, CAN International, 2009. **Position Paper and briefing on the role of ecosystems in adaptation**

Commission on Climate Change and Development, 2009. **Closing the Gaps: Disaster risk reduction and adaptation to climate change in developing countries** http://www.ccdcommission.org

Commissioner Stavros Dimas **"EU Nature Policy – Challenges in a changing world**", SPEECH 08/82 (see http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/08/82&format=HTML&aged=1&language=EN&guiLanguage=en)

*Conference "Beyond Kyoto – addressing the challenges of climate change, 5-6 March 200*9 **The 7 Aarhus Statements on Climate Change.** http://www.klima.au.dk/dk/forside/konferencebeyondkyotoconferen/

Congress Climate Change - Global Risks, Challenges and Decisions, Copenhagen 10-12 March 2009; Key Messages. http://climatecongress.ku.dk/newsroom/congress_key_messages/

ECNC European centre for nature conservation, 2008. **Climate change and biodiversity in South-East Europe,** a concise summary of the scientific and policy context, issues and recommended actions and technical background report

Eggers J. et al, **Is biofuel policy harming biodiversity in Europe ?**, GCB Bioenergy (2009) 1, 18-34

Ekman B., Rockström J. Wijkman A., 2008. **Grasping the climate crisis** – a provocation from the Tällberg Foundation http://www.tallbergfoundation.org/TÄLLBERGINITIATIVES/Publications/Graspingtheclimatecrisis/tabid/555/Default.aspx

Environment Department, The World Bank, June 2009. **Convenient solutions to an inconvenient truth: ecosystem-based approaches to climate change,** http://siteresources.worldbank.org/ENVIRONMENT/Resources/ESW_EcosystemBasedApp.pdf

EU Climate Change Expert Group "EG Science", July 2008. **The 2°C target**. Background on impacts, emission pathways, mitigation options and costs

European Academies Science Advisory Council (EASAC), 2009. **Ecosystem services and biodiversity in Europe** (see http://www.easac.eu/downloaddoc.asp?id=40&page=2&skin=0)

European Commission, 2009. **White Paper "Adapting to climate change: Towards a European Framework for action"** COM(2009) 147 final

European Commission, 2008. **Interim Report on the Economics of Ecosystems and Biodiversity (TEEB)** http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf

European Commission, 2008. **Communication "Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss",** COM (2008) 645 final

European Commission, 2006. **Communication on Halting the Loss of Biodiversity by 2010 – and beyond, Sustaining ecosystem services for human well-being**. COM(2006)216 final

Information on ***European Commission*** **activities and policies on adaptation** http://ec.europa.eu/environment/climat/adaptation/index_en.htm

European Environment Agency (EEA), Joint Research Center JRC, World Health Organization (WHO); September 2008, **Report on "Impacts of Europe's changing climate – 2008 indicator based assessment,** ISSN 175-9177; ISBN 978-92-9167-372-82 http://reports.eea.europa.eu/eea_report_2008_4/en

European Environmental Bureau (EEB), December 2008. **Building Green Infrastructure for Europe** (see http://www.eeb.org/publication/documents/EEB_GreenInfra_FINAL.pdf)

European Environment and Sustainable Development Advisory Council (EEAC), 2005. **Statement on "Biodiversity Conservation and Adaptation to the Impacts of Climate Change" (**see http://www.eeac-net.org/)

Hansen et al. 2003. "**Buying time**"

Heller N.E., Zavaleta E.S. 2009. **Biodiversity management in the face of climate change: A review of 22 years of recommendations**, Biological Conservation 142 (2009) 14-32

HERMES Deep Sea Briefs 2009, **A warning from the deep: climate change reaches the deep ocean; What's it worth? Valuing the deep sea** (see http://www.eu-hermes.net/)

Hopkins, J.J.; Allison, H.M.; Walmsley, C.A.; Gaywood, M.; Thurgate, G., 2007. **Conserving biodiversity in a changing climate - building capacity to adapt.** Defra. http://www.ukbap.org.uk/Library/BRIG/CBCCGuidance.pdf

Huntley, B., 2007. Discussion paper in the frame of the Bern Convention on "**Climatic change and the conservation of European biodiversity: towards the development of adaptation strategies**" (see http://www.coe.int/t/dg4/cultureheritage/conventions/Bern/T-PVS/sc27_inf03_en.pdf)

IUCN, 2009. **Ecosystem-based Adaptation (EbA),** Policy Briefing

Joint Science Academies' Statement on **"Climate Change Adaptation and the Transition to a low Carbon society**", June 2008
(see http://www.lincei.it/files/dichiarazioni/G8+5_Academies_Statement-Climate.pdf)

Kettunen M., Terry A., Tucker G., Jones A., 2007. **Guidance on the maintenance of landscape connectivity features of major importance for wild flora and fauna**

Lenton et al., 2008**. Tipping elements in the Earth's system**, PNAS Vol 105: 1786-1793

McKinsey Report 2009, **Pathways to a low carbon economy,** http://www.mckinsey.com/clientservice/ccsi/pathways_low_carbon_economy.asp

Ministry of Environment and Energy, the National Forest and Nature Agency Denmark, 1995. **Nature Restoration in the European Union**, Proceedings of a Seminar, Denmark, 29-31 May 1995

Ministry for Foreign Affairs of Finland, International Union of Forest Research Organisations, 2009. **Making forests fit for climate change – a global view of climate change impacts on forests and people and options for adaptation**

Mitchell, R.J.; Morecroft, M.D.; Acreman, M; Crick H.Q.P.; Frost, M.; Harley, M.; Maclean, I.M.D.; Mountford, O.; Piper, J.; Pontier, H.; Rehfisch, M.M.; Ross, L.C.; Smithers, R. J;, Stott, A.; Walmsley, C.; Watts, O.; Wilson, E., 2007. **England Biodiversity Strategy: towards adaptation to climate change.** Defra. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13807&FromSearch=Y&Publisher=1&SearchText=towards%20adaptation&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

The Nature Conservancy, 2009. **Adapting to Climate Change – Ecosystem-based Approaches for People and Nature**

Parry, M., Lowe, J. and Hanson, C. (2009). **Overshoot, adapt and recover.** Nature 458 (30), 1102-1103

Paterson, J. et al., 2008. **Mitigation, Adaptation and the Threat to Biodiversity**. Conservation Biology, 22, 1352-1355

Piper J., Wilson E., 2008. **Policy Analysis for Biodiversity under climate change**. MACIS http://www.macis-project.net/MACIS-deliverable-4.1.pdf and **Policy options to prevent minimise negative impacts on biodiversity** http://www.macis-project.net/MACIS-Deliverable-4.2-Oct.2008.pdf

Pullin A.S. et al., 2009. **Conservation Focus on Europe: Major conservation policy issues that need to be informed by conservation science**. Conservation Biology 23 (4), 818-824

Raupach et al, 2007. **Global and regional drivers of accelerating CO_2 emissions.** Proceedings of the National Academy of Sciences 104 (24), 10288-10293.

Reid H., 2006. **Climate Change and Biodiversity in Europe**, Conservation and Society, Pages 84-101, Vol 4, No 1

Report of an international meeting held at the Royal Society, 2007. **"Biodiversity-Climate change interactions: adaptations, mitigation and human livelihoods"** (see http://royalsociety.org/document.asp?tip=0&id=6830)

Royal Society for the Protection of Birds (RSPB), 2009. **Response to the Commission Communication "Towards a comprehensive climate change agreement in Copenhagen",** COM (2009)39

RSPB, BirdLife International. 2008. **Climate Change – wildlife and adaptation; 20 tough questions, 20 rough answers**

Smithers, R.J.; Cowan,C.; Harley, M.; Hopkins, J.J.; Pontier, H.; Watts, O. 2008 **England Biodiversity Strategy climate change adaptation principles - conserving biodiversity in a changing climate.** Defra.
www.defra.gov.uk/wildlife-countryside/pdf/biodiversity/ebs-ccap.pdf

UNEP, June 2009. **The Natural Fix? The role of ecosystems in climate mitigation**.
http://www.unep.org/pdf/BioseqRRA_scr.pdf

Van Minnen et al. 2009. **The importance of three centuries of climate change and land-use change for the global and regional terrestrial carbon cycle**. Climatic Change DOI 10.1007/s 10584-009-9596-0

Vos, C.C et al. 2008. **Adapting landscapes to climate change: identifying climate-proof ecosystem networks and priority adaptation zones**. Journal of Applied Ecology: 45: 1722-1731

World Travel & Tourism Council, 2009. **Leading the challenge on climate change**

Zeitlin, Hale et al., 2009. **Ecosystem-based Adaptation in Marine and Coastal Ecosystems**. Presented at Global Forum on Oceans, Coasts, and Islands for the World Ocean Conference's Global Policy Day (13 May) and Adaptation workshop at the International Marine Conservation Congress (28 May)