10 messages for 2010
Climate change and biodiversity

European Environment Agency

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This document is the 1st in a series of assessments under the title '10 messages for 2010'. Each message provides a short assessment focusing on a specific ecosystem or issue related to biodiversity in Europe. The remaining messages will be published at various intervals throughout 2010. More detailed information on the published and upcoming messages can be found at www.eea.europa.eu/publications/10-messages-for-2010.

European Environment Agency

Cover design: EEA
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Layout: Pia Schmidt/EEA

Luxembourg: Office for Official Publications of the European Union, 2010

ISBN 978-92-9213-150-0
doi:10.2800/57180

Acknowledgments
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Valuable comments were received from the Eionet National Reference Centre (NRC) for Biodiversity; from members of the SEBI Expert Group on Indicators on Climate Change and Biodiversity; from Elena Cebrian Calvo, Rania Spyropoulou, Josef Herkendell, Ivone Pereira Martins at EEA and Anne Teller and Karin Zaunberger at DG Environment of the European Commission.

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Climate change and biodiversity

Key message

The variety of life underpins our social and economic wellbeing and will be increasingly an indispensible resource in the battle against climate change. However, our consumption and production patterns are depriving ecosystems of their capacity to withstand climate change and deliver the services we need from them.

As we understand more about the ways that climate change is impacting biodiversity, it becomes clear that we cannot tackle the two crises separately. Their interdependence requires us to address them together.

1 Europe's climate is changing rapidly

On average, global temperatures on land have risen by 0.8 °C compared with pre-industrial times. European land areas have warmed up more rapidly, however, increasing by more than 1.2 °C so far (IPCC, 2007), with a further increase of 1.0–5.5 °C expected by the end of the 21st century (Christensen *et al.*, 2007).

Already southern Europe has experienced extremely dry weather conditions, with rainfall decreasing by up to 20 % during the 20th century. In northern European countries, meanwhile, precipitation increased by 10–40 %. The frequency of extreme weather conditions is expected to increase (EEA-JRC-WHO, 2008).

Regional average sea levels have risen by between 0.3 mm/year and 2.8 mm/year during the 20th century, with the global average increasing 1.7 mm/year (Church and White, 2006).

Europe's snow cover has decreased by 1.3 % per decade during the past 40 years. And the average duration of ice cover on lakes and rivers in the northern hemisphere has been decreasing at a rate of 12 days per hundred years (EEA-JRC-WHO, 2008).

In accordance with the observed changes in precipitation and temperature there is some evidence of climate-induced changes in annual river flow and the seasonality of flow in Europe during the 20th century, with an average increase in the north (Lindström and Bergström, 2004; Milly *et al.*, 2005) and a decrease in the south (Milly *et al.*, 2005). However, these changes are also influenced by human interventions in the catchment, such as groundwater abstraction, irrigation, river regulation, land-use changes and urbanisation.

Climate change has increased the frequency or severity of droughts in some regions, although there is no overall trend for Europe as a whole.

2 Climate change affects species in numerous ways

Climate change impacts biodiversity through a complex interaction of species and their habitats. Both the structure of habitats and their ecological functions will change in a new climate regime. But the movement of species into or out of a community will also affect both the physical elements of the ecosystem and other species.

Changes to local conditions and resources will thus influence a species' ability to survive. And if a species can no longer survive in an ecosystem, it has two choices. If it can disperse rapidly enough and an accessible and suitable alternative habitat exists, it can relocate. Or it can gradually disappear in different locations and eventually go extinct.

Photo: © Pia Schmidt

Whether directly or indirectly, climate change can produce a variety of effects on populations, including:

- distribution changes: due to habitat loss;
- range changes: either contraction and expansion, relating to their dispersal ability;
- phenological changes: changes in timing of life stages;
- ecological changes: mismatching of species life-cycle events and food sources, decoupled predator–prey relationships, new invasions and spread of already established invasive alien species.

Under a new climatic regime, therefore, individuals of some species may be able to colonise new, more suitable areas. But a variety of factors could limit the availability or accessibility of such areas, including land-use changes and fragmentation, hydrological changes and nitrification, and sea-level rise (for example, Terry *et al.*, 2007).

New species assemblages and changes in the relative abundance of populations are expected in some ecosystems. Changes in species composition, habitat structure and ecosystem functioning will be noticed and, in combination, may affect the resilience of ecosystems and the services they deliver to humanity.

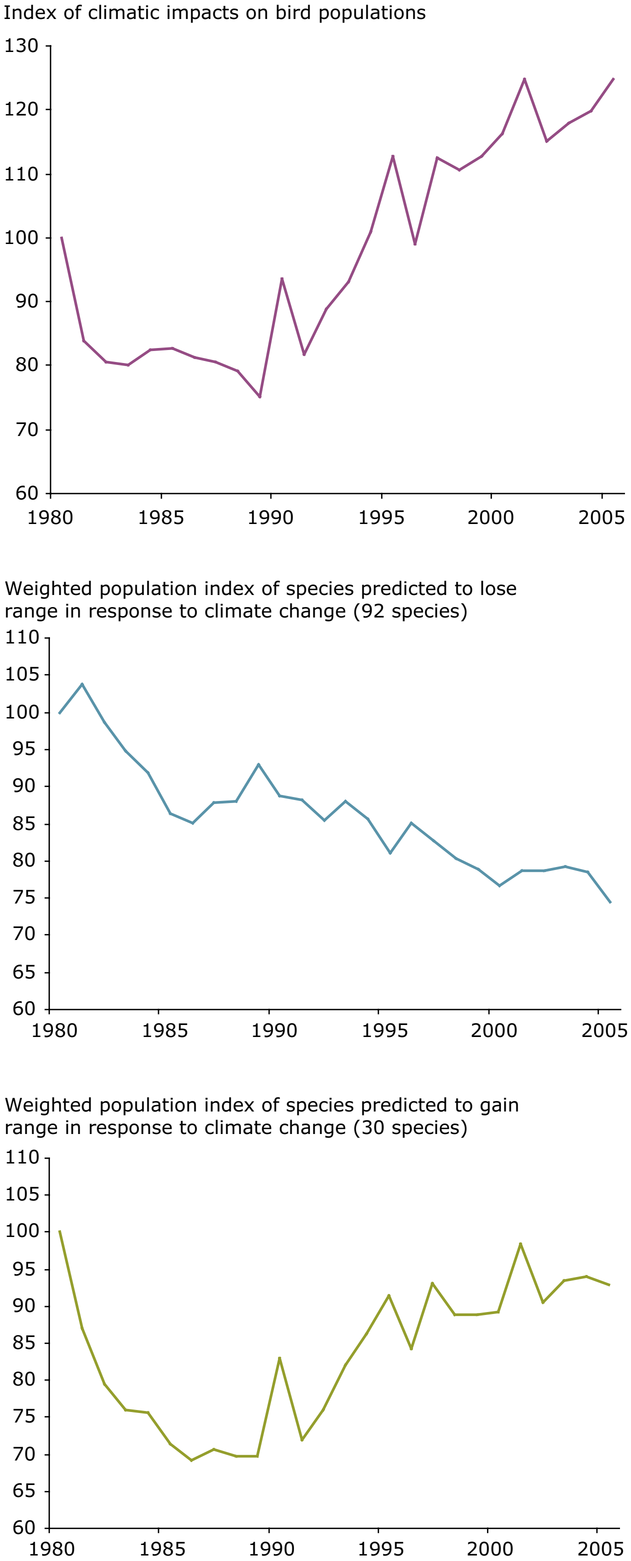
3 There is now detectable evidence that climate change is having a real impact on European species

There is growing scientific consensus that climate-induced changes in biodiversity and ecosystem services are occurring. This helps to increase awareness of current and projected impacts. Measuring and observing climate change's impacts on biodiversity at the continental scale will be a significant challenge. But such evidence will be very valuable, enhancing the usefulness of existing indicators based on limited monitoring programmes and enabling projections of species and habitat distributions in future climatic envelopes.

An indicator based on observed populations of 122 common bird species across 18 European countries alongside climatic envelopes shows that rapid climate change in Europe in the past 20 years has strongly impacted these bird populations. Three-quarters of the populations declined as a result of climate change, whereas one-quarter benefitted (Figure 1).

Regular monitoring of butterflies in three countries (Finland, the Netherlands and the United Kingdom) and one region (Catalonia), and analysis of butterfly climatic envelopes, reveals

Figure 1 Climate change impact indicator of European bird populations



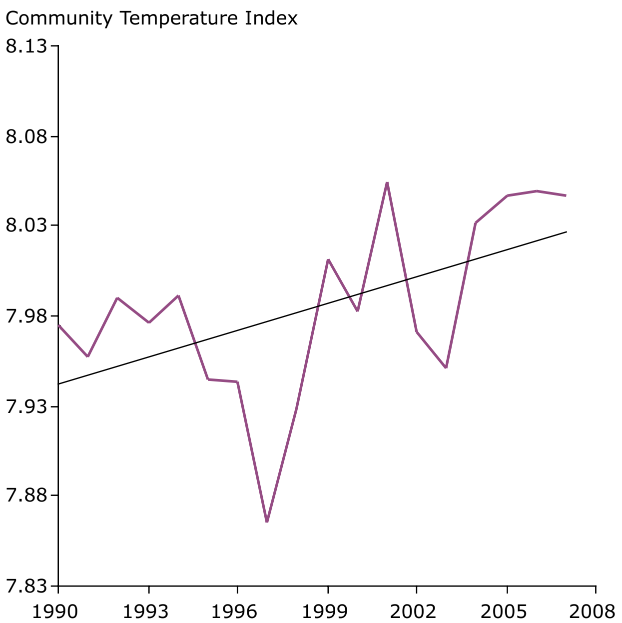
Source: Adapted from Gregory *et al.*, 2009.

changes in butterfly communities during the period 1990–2005, with a significant trend towards a higher proportion of 'warm' species relative to 'cool' species. This trend is expressed though the Community Temperature Index (CTI). The higher the CTI, the greater the proportion of 'warm' species (Figure 2).

Climate change is also having an impact on plant species. Alpine plants represent a large proportion of Europe's native plant diversity: about 20 % of all native vascular plants occur primarily within the Alpine altitudinal belt, which covers only 3 % of the continent (Väre *et al.*, 2003). Alpine plants are a sensitive and vulnerable indicator group of global warming impacts because at high altitude, where very little or no land use occurs, climate change is a major driver of observed adjustments in species composition.

Observations on Mount Schrankogel/Stubaier Alps (Tyrol, Austria) (Pauli *et al.*, 2007) taken during 1994–2004 as part of the GLORIA observation network ([1]), clearly show a shift of plants towards higher altitudes. The populations of subnival and nival species, dwelling near a mountain's peak and therefore unable to move further upwards, were declining.

Figure 2 Community Temperature Index of butterflies



Source: van Swaay *et al.*, 2008.

([1]) Available at www.gloria.ac.at.

Table 1 Habitats and species negatively affected by climate change in at least one EU Member State *

Habitat type group	% of habitat types noted as affected by climate change	Out of (no. of habitat types)	Species group	% of species noted as affected by climate change	Out of (no. of species
Bogs, mires and fens	50	12	Amphibians	45	51
Dunes	29	21	Arthropods	29	118
Forests	22	72	Mammals	26	125
Heaths	20	10	Non-vascular plants	21	38
Sclerophyllous scrub	15	13	Molluscs	17	35
Coastal	14	28	Reptiles	13	87
Rocky habitats	14	14	Fish	4	100
Grasslands	10	29	Vascular plants	3	602
Freshwater	5	19			
All habitats	19	218	All species	12	1 158 **

Note: (*) The table sets out the proportion of habitat types and species groups listed in the Habitat Directive for which at least one Member State identified climate change as a reason for unfavourable trends in the area covered or the natural range.

(**) In addition to these species groups, two species from the 'others' category were noted as affected by climate change: the red coral (*Corallium rubrum*) and the medicinal leech (*Hirudo medicinalis*).

Source: ETC/BD, 2009.

An upward shift of vegetation zones induced by a 3 °C warming (approximately 460 m of vertical distance when assuming a temperature lapse rate of 0.65 °C per 100 m) would therefore be associated with drastic biodiversity losses in the longer term, when many present day Alpine areas would be converted into montane and subalpine forests. Endemic species are often restricted to high elevations and thus may be particularly vulnerable to warming-induced impacts.

Photo: © Pia Schmidt

4 Protected species and habitat types are also vulnerable to climate change

The EC Habitats Directive calls for the regular assessment and reporting of the conservation status of the 1 500 species and habitats of special European interest listed in the Directive's Annexes I, II, IV and V. Such assessments highlight the main threats to these habitats and species.

In 2008, the first reports by countries pursuant to the Directive showed that 19 % of habitats and 12 % of species of European interest are potentially threatened by climate change over their natural European range.

Bogs, mires and fens are the most vulnerable habitat types, with up to 50 % negatively affected. This is particularly troubling because bogs and mires are extremely important carbon stores and their degradation releases greenhouse gases into the atmosphere.

Of the species groups, amphibians are worst affected with 45 % of species negatively affected by climate change (Table 1).

Habitats and species protected by the Habitats Directive are distributed widely across Europe. Creating 'green infrastructure' — defined as 'sustainable landscape management approaches, which enable natural processes to take place and increase the resilience of ecosystems' (EU WG, 2009) — is a way to maintain or restore a mosaic environment, enabling them to maintain their distributions.

Avoiding regional and local species extinctions will require efforts to restore semi-natural habitat types and habitats of protected species, and to manage Natura 2000 sites and the wider countryside appropriately.

Photo: © Pia Schmidt

5 An ecosystem-based approach to managing land and sea is crucial to mitigate climate change and help human societies adapt to its impacts

There is now increasing evidence that healthy ecosystems can significantly mitigate the effects of climate change and help human societies adapt. Biodiversity and ecosystems provide shade, fresh air and water; reduce wind speed, erosion and water flow; regulate the nitrogen and carbon cycles; and provide a genetic resource for environmental adaptation.

A recent discussion paper by the European Commission, entitled 'Towards a strategy on climate change, ecosystem services and biodiversity' (EU WG, 2009), neatly summarises these complex relationships:

- Changes in the structure, function and composition of ecosystems impact the overall health of our environment.
- Terrestrial and marine ecosystems currently absorb around half of anthropogenic CO_2 emissions, which makes them invaluable for their carbon capture and storage capacity. Degrading or destroying ecosystems can release significant volumes of greenhouse gases, and sea acidification may lead to degradation of

Table 2 Characteristics and role of selected European ecosystems in the carbon balance

	Vegetation growth	Vegetation decom-position	Carbon source or sink	Current carbon storage(t/ha) approximately	Where majority of carbon is stored
Tundra	Slow	Slow	Sink	260	Permafrost
Boreal forest	Slow	Slow	Sink	Soil: 120–340 Vegetation: 60–90	Soil
Temperate forest	Fast	Fast	Sink	160–320	Biomass above and below ground
Peatlands	Slow	Slow	Sink	1 450	Soil
Oceans and coasts	Plankton: fast	Fast	Sink	Surface: 1020 Gt C; Deep ocean: 39 000	Deep ocean

Source: Adapted from Trumper *et al.*, 2009.

The changing climate directly impacts quality of life

In Europe, climate change will have severe effects on more than 830 million humans, who depend on ecosystem services and habitats primarily provided by managed landscapes. Reduced provision of ecosystem services can be expected for all land uses: agriculture, forestry, fisheries, infrastructure, urban agglomerations and tourism.

Europe can expect a decline in potentially arable land, in Mediterranean forest areas and in the terrestrial carbon sink and soil fertility. More river basins will exhibit water scarcity. And the management of the coastal zones and sea fisheries, mountain regions and urban and periurban areas will suffer (Jones-Walters and Nieto, 2007).

Extreme weather events, such as heatwaves or snowstorms have direct health effects on humans and indirect costs for the economy. For instance, a series of major windstorm catastrophes caused losses of EUR 17.8 billion in central Europe during 1990–2007 and flood catastrophes in central Europe in 1993–2006 caused overall losses of up to EUR 85.8 billion (Munich Re, 2008). Total losses were more than EUR 100 billion, or EUR 208 for every citizen of the EU-27.

calcium in organisms like coral colonies. There is growing evidence that the capacity of the Earth's carbon sinks is decreasing due to both global warming and ecosystem degradation caused by other stress factors.

- Degrading ecosystems, combined with climate change, significantly reduces their resilience and ability to respond to future stresses.

Recent reviews (Luyssaert *et al.*, 2008; Richardson *et al.*, 2009; Trumper *et al.*, 2009) show the crucial role of undisturbed ecosystems in the carbon balance and their potential in mitigating greenhouse gas effects. They also indicate how some ecosystems can turn into negative carbon sinks if degraded (Table 2).

Maintaining ecosystems is therefore vitally important for climate change mitigation and adaptation. This applies at all scales, ranging from the global to the continental, national, regional, and local levels (for example, Berry *et al.*, 2008). And it is especially important for more vulnerable groups of people and species.

6 From political awareness to action

Encouragingly, the importance of biodiversity for climate change mitigation and adaptation has recently been recognised at the highest policy levels:

In March 2009, a high-level working group on the future of global targets for biodiversity emphasised that whereas healthy ecosystems store carbon, if degraded or destroyed they release it as carbon dioxide. Linking the biodiversity and climate change agendas should therefore be a priority for any biodiversity policy framework *post*-2010 (CBD, 2009a).

In the same vein, the European Commission's high-level conference, 'Biodiversity protection — beyond 2010, Priorities and options for future EU policy', held in April 2009, noted that we cannot solve biodiversity loss without addressing climate change and vice versa (EC, 2009b).

We therefore need to look for a 'triple win': protecting and restoring ecosystems and thereby both mitigating climate change and adapting to its effects. This presupposes that climate measures are fully compatible with policies for the protection of biodiversity (EC, 2009c).

In the Siracusa Charter on Biodiversity, environment ministers from G8 countries and elsewhere expressed their grave concern that biodiversity loss will diminish food and water supplies, hinder efforts to mitigate and adapt to climate change, and undermine global economic processes (G8, 2009).

This political awareness has resulted in concrete proposals for action. Key examples at the European level include the European Commission's 2006 Biodiversity Action Plan. It emphasises the importance of maintaining and restoring ecosystem integrity and developing a 'green infrastructure' (EC, 2008).

The Commission's 2009 White Paper 'Adapting to climate change: Towards a European framework for action' (EC, 2009a), specifically calls for efforts to increase the resilience of biodiversity and ecosystems. It lists concrete ideas for action such as climate-proofing river basin management plans (RBMP), exploring ways to boost ecosystem water storage capacity, and drafting guidelines on managing climate change's impact on Natura 2000 sites.

The Convention on Biological Diversity's Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate change has concluded that the role of biodiversity and associated ecosystem services should be recognised through the adoption of ecosystem-based adaptation management. Such approaches can deliver multiple benefits for biodiversity and society, including improved flood control, enhanced carbon sequestration and storage, and support for local livelihoods (CBD, 2009b).

It is now essential that political awareness of the interdependence of climate change and biodiversity protection be translated into concrete action at global, regional and national levels.

In its conclusions of 26 March 2010 (EC, 2010a), the European Council elaborated plans to refocus efforts on climate change after COP15 in Copenhagen. In doing so, it stressed the urgent need to reverse continuing trends of biodiversity loss and ecosystem degradation and its commitment to the long-term biodiversity 2050 vision and 2020 target, as set out in the Environment Council's conclusions of 15 February 2010 (EC, 2010b).

Implementing and maximising synergies between the two fields calls for three sets of actions (EU WG, 2009; The Nature Conservancy, 2009):

- **Maintaining and restoring the biodiversity and ecosystems** that underpin our resilience and ability to mitigate and adapt to climate change. This includes building up our 'green infrastructure'.
- **Developing a policy framework** that recognises the interdependence of climate change, biodiversity and ecosystem services. Such a framework should facilitate cross-sectoral interaction, drawing in areas such as agriculture, forestry and business, and also support further research.
- **Use this cross-sectoral framework to design and implement concrete ecosystem-based actions**. Examples include developing soft coastal defences, and maintaining and restoring floodplains, vegetation cover and green infrastructure.

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TH-30-10-531-EN-N
doi:10.2800/57180

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ISBN 978-92-9213-108-1

Publications Office

European Environment Agency