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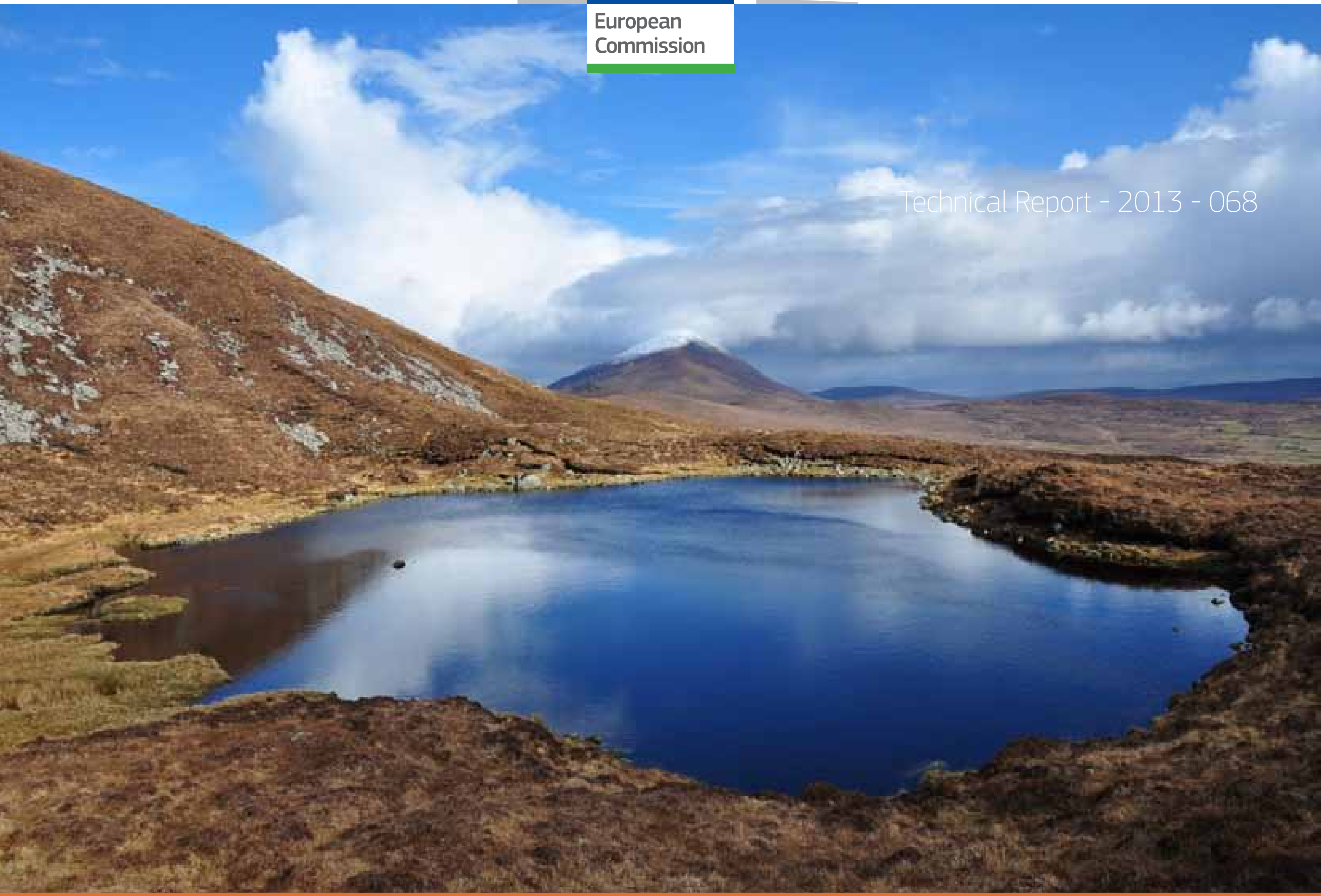

Technical Report - 2013 - 068

Guidelines on Climate Change and Natura 2000

Dealing with the impact of climate change
On the management of the Natura 2000 Network of areas of high biodiversity value

Environment

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://ec.europa.eu).

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Photo cover/ illustration: Micheal O'Briain

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Purpose of this Guidance

Background

There is mounting evidence of the impacts of climate change and the need for the European Union to take integrated action to mitigate and adapt to climate change. This has not only economic and social implications but is also of major importance for the environment, including biodiversity.

The EU biodiversity strategy, 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020', underlines the importance of addressing climate change in the EU. Central to achieving the EU 2020 biodiversity targets is the effective management of areas of high biodiversity value, protected in the Natura 2000 network designated under the Habitats and Birds Directives. Sites in the network provide space for nature, but they must be protected and enhanced as part of the broader issue of managing the entirety of Europe's green infrastructure. These sites are also central to ensuring that biodiversity is able to adapt to a changing environment, particularly as a result of climate change. Over time, the species and habitats present at any individual site may change, but the suite of sites in both the terrestrial and marine environment will remain essential safe havens for Europe's biodiversity. However, the issue of climate change has not yet been adequately considered within the framework of management and restoration of Natura 2000.

In delivery of the EU Biodiversity Strategy the Commission has published a Communication on Green Infrastructure (**(COM(2013) 249 final)**), which provides an enabling framework for nature-based solutions. This guidance sets out an important part of Green Infrastructure; to enhance the role of nature based adaptation for the coherence of the Natura 2000 network.

The need for this guidance was recognised as a follow-up action to the European Commission's White paper on Adapting to Climate Change – a European Framework for Action (COM(2009) 147) and it is also explicitly referred to in the Commission's Communication on an EU Strategy on adaptation to climate change (COM(2013) 216) in the context of mainstreaming adaptation measures into EU policies and programmes.

Purpose of the Guidance Document

These guidelines are primarily aimed at Natura 2000 site managers and policy makers. The purpose is to underline benefits from Natura 2000 sites in mitigating the impacts of climate change, reducing vulnerability and increasing resilience, and how adaptation of management for species and habitats protected by Natura 2000 can be used to tackle the effects of climate change.

In focusing on what needs to be done, the guidelines identify opportunities for sensible adaptive planning. Often, this will involve integrated action between environmental and other sectors in order to realise multiple, and multiplier, benefits for nature and society. Looking to achieve better knowledge, implementation of the types of actions described in the guidelines will generate new evidence and build experience. Developing practical know-how is essential to increase the effectiveness of responses to climate change, assisting the review and refinement of practical ways to address climate change in future.

How to use the guidance document

Knowing precisely what to do and why to do in the context of climate change is challenging and complex. Therefore, a decision framework (see figure 1) is included in the guidelines to facilitate decision-making and assist Natura 2000 site managers, policy makers and others, whose actions impact on nature, in their choices about the types of possible measures. The decision framework consists of a list of questions to be addressed in deciding which actions are required:

- What are the (predicted) effects of climate change in my country, region or site?

- How do Natura 2000 sites assist in mitigating or adapting the region to the (predicted) effects of climate change?
- How vulnerable are the Natura 2000 species and habitats (in my site, region or country) to the (predicted) effects of climate change?
- How can the vulnerability to climate change be managed? (e.g. which impacts can we address through particular measures)
- What are the possible mitigation measures (e.g. reduction of greenhouse gas emissions or increase of carbon storage) on and around sites and at Natura 2000 network level?
- What are the possible adaptation measures on and around sites and at Natura 2000 network level?
- Which actions do we need to take?
- Who should take the actions?
- What resources do we need?
- What is the timing of the various measures over short, medium and long-terms?

Structure and contents

The structure of the guidelines follows the questions that need to be addressed. The guidance is organised in 7 main sections:

<u>Chapter 1</u> provides a general introduction on climate change and Natura 2000

<u>Chapter 2</u> describes how Natura 2000 can provide natural solutions for mitigating and adapting to climate change

<u>Chapter 3</u> describes the risks from climate change to species and habitat types protected by Natura 2000

<u>Chapter 4</u> introduces the concept of adaptive management and considers how to manage climate impacts at different scales

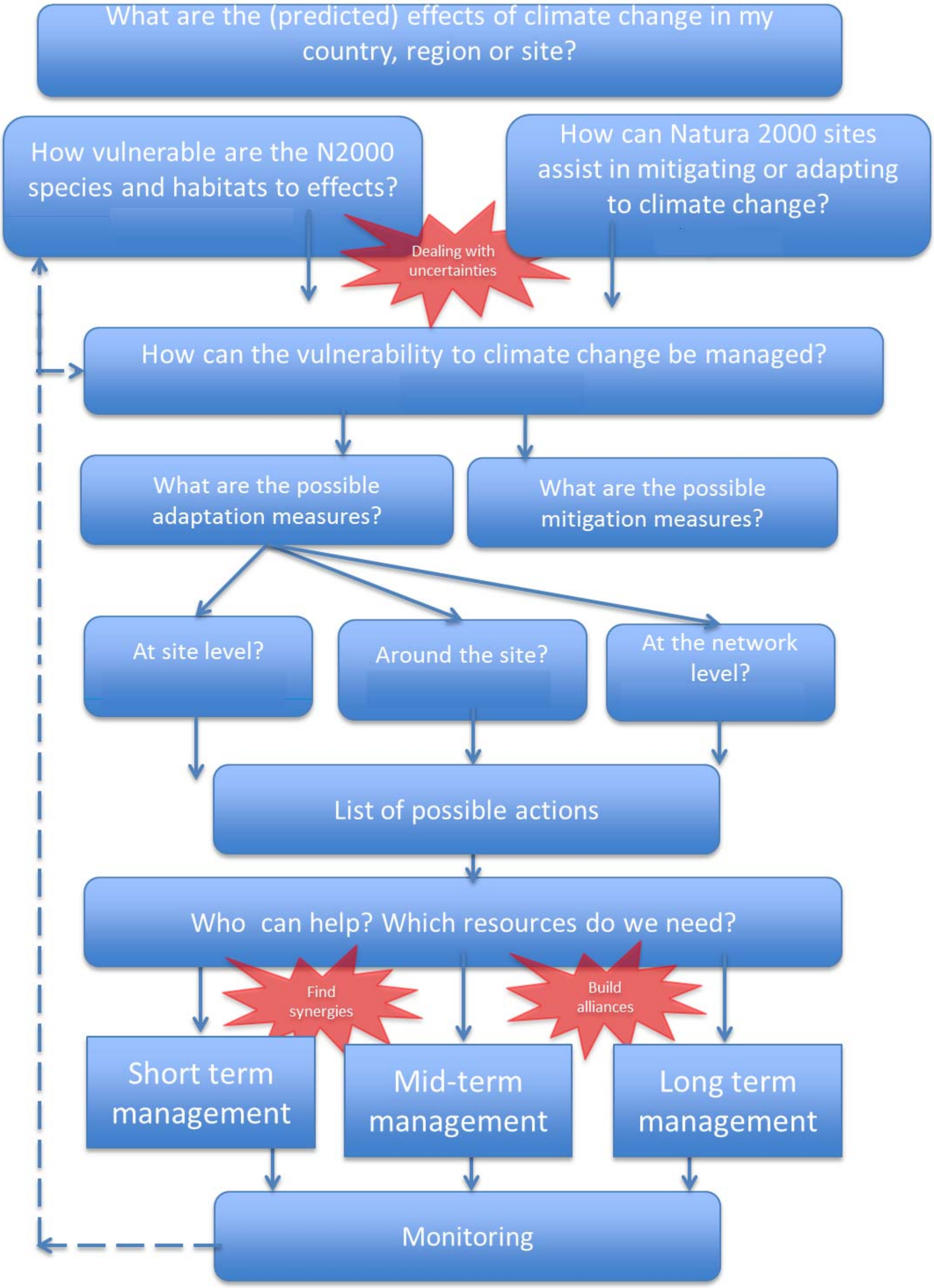
<u>Chapter 5</u> examines in more detail adaptation measures for the Natura 2000 network

<u>Chapter 6</u> explains how to apply the decision making framework in the process of identifying climate change impacts on Natura 2000 sites or at network level and on how to identify appropriate adaptation (and mitigation) measures.

<u>Chapter 7</u> concludes the guidance with core advice and summary recommendations for both site managers and policy makers

The guide is supported by a series of case studies as well as a supplement (available at http://ec.europa.eu/environment/nature/climatechange/pdf/N2_CC_guidelines_supplement.pdf) that describes the methodology used to assess sensitivity and vulnerability of Natura 2000 species and habitats to climate change. Furthermore, the guidelines refer to other European information sources available that can be used to further assess the expected impacts of climate change for specific sites, as well as published handbooks on specific measures.

Figure 1. The decision framework used to structure the guidelines.



Limitations of the document

This guidance document is intended to be bound by, and faithful to, the text of the Birds and Habitats Directives and to the wider principles underpinning EU policy on the environment and renewable energies. It is not legislative in character, it does not make new rules but rather provides further guidance on the application of those that already exist. As such, it reflects only the views of the Commission services and is not of a legally binding nature. It rests with the EU Court of Justice to provide definitive interpretation of a Directive. Wherever relevant, existing case law has been included when clear positions have already been taken by the Court.

The document also does not replace the Commission's existing general interpretative and methodological guidance documents on the provisions of Article 6 of the Habitats Directive[1]. Instead, it seeks to clarify specific aspects of these provisions and place them in the context of wind farm development in particular. The present guide is therefore best read in conjunction with the existing general guidance and the two Directives.

Finally, the guidance recognises that the two nature Directives are enshrined in the principle of subsidiarity and it is for Member States to determine the procedural requirements arising from the Directives. The good practice procedures and proposed methodologies described in this document are not prescriptive in their intent, rather they aim to offer useful advice, ideas and suggestions based on an extensive review of existing experiences and good practices across the EU and beyond. For further reading, references to various national guidance documents and other sources of information are provided in the annexes.

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1 "Managing Natura 2000 sites. The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC". "Assessments of plans and projects significantly affecting Natura 2000 sites. Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC". "Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC". http://ec.europa.eu/environment/nature/natura2000/management/guidance_en.htm

1 Climate change, nature and Natura 2000

1.1 Climate change in Europe

Climate change leads to increasing temperatures, shifting seasons, changing precipitation patterns, the potential increase of weather extremes and sea level rise. To assess the vulnerability of the Natura 2000 network to these different aspects of climate change and develop possible adaptation strategies, it is necessary to understand how the climate in Europe will change in the 21st century. However, many uncertainties exist in predicting future climate. These uncertainties stem from incomplete understanding about how the earth's climatic system works, but also from future socio-economic developments and their impacts on the climate (EEA-JRC-WHO, 2008). The Intergovernmental Panel on Climate Change tackled this problem by developing different scenarios to give an impression of the range of possible future climates. Figure 2 shows the large differences that exist in predicted global temperature increase between these scenarios. The observed rate of temperature increase in the last decades matches and even exceeds the higher scenarios (Berry et al, 2009).

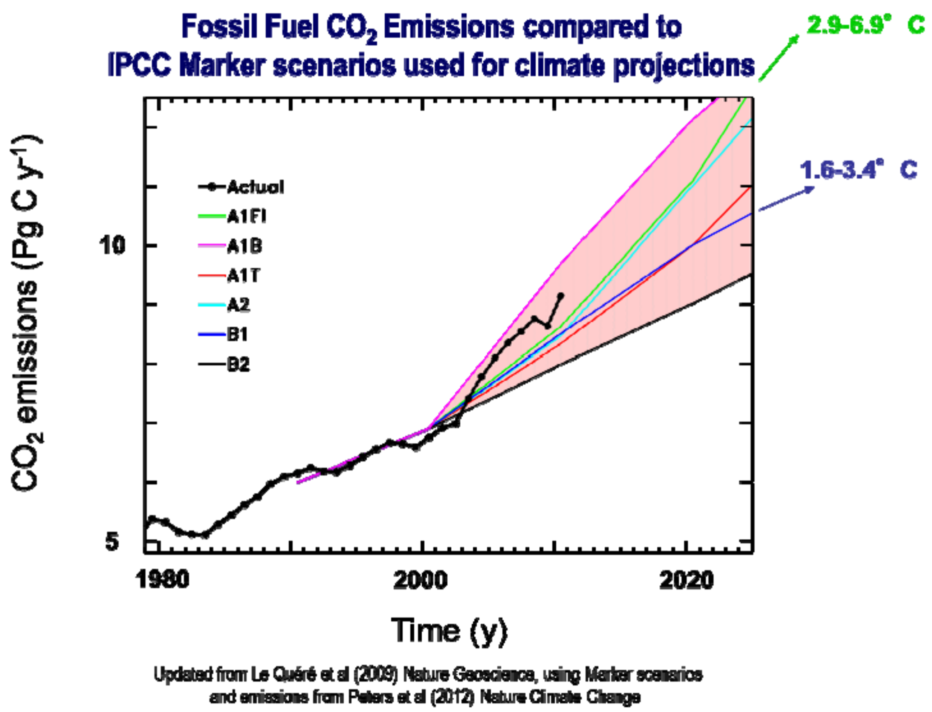

Figure 2. Temperature projections to the year 2025, based on a range of emission scenarios and global climate models. Scenarios that assume the highest growth in greenhouse gas emissions provide the estimates in the top end of the temperature range. The average rate of increase of CO2 emissions since 2000 has been around 3% per year, tracking the highest IPCC emission scenarios used. The increase in emissions in 2010 was 5.9%, the highest total annual growth recorded. Source: Le Quére, 2011.

Although current and projected impacts vary considerably across Europe, it is clear that climate change in Europe is already occurring and that this will continue to have far-reaching consequences for human wellbeing and natural systems. The most vulnerable regions in Europe are the Mediterranean, North-western Europe, the Arctic and Alpine regions: increased and more severe droughts, forest fires and heat waves will lead to a higher pressure on Mediterranean species and habitats; sea-level rise and an increased risk of storms are expected to have a high impact on coastal areas in North-western Europe; temperature increases, leading to reduced periods of snow cover, melting of glaciers and loss of permafrost, are expected in the Arctic and in mountain areas. Figure 3 summarises the main impacts of climate change in the different bio-geographical regions of Europe (EEA, 2010).

Besides the direct effects of climate change, there will also be socio-economic impacts and, particularly land use changes as society adapts to climate change. Within these guidelines, we focus on the direct effects of climate change, as the accompanying human-driven processes are highly uncertain. Nevertheless, all readers should be aware of the pressures resulting from land use changes resulting from climate change adaptation measures on the Nature 2000 species and sites and include this into measures of any kind. It is essential that nature is seen an essential part of the solution, without which we will not be able to tackle climate change and its impacts.

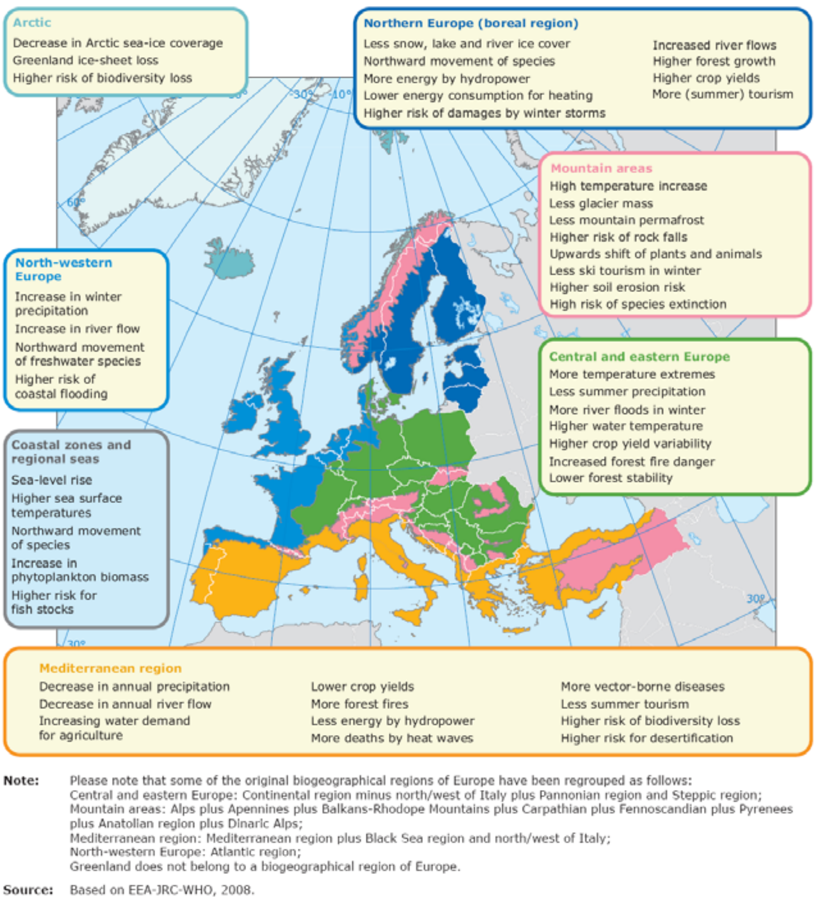

Figure 3. Main impacts and effects of climate change in the different bio-geographical regions of Europe (Source EEA, 2010).

1.2 Natura 2000 - an important resource

Natura 2000 sites are areas of high biodiversity value and a key element of natural capital. Currently, the Natura 2000 network consists of over 26,000 sites, together covering about 18 % of terrestrial environment of the European Union's territory as well as significant areas of the marine environment (EEA, 2009; Natura 2000 barometer June 2011). It encapsulates a broad variety of valuable habitats, from marine and coastal wetlands, Mediterranean shrub lands, forests, to Alpine meadows. The Natura 2000 network covers approximately 30% of forested area in the EU, 45% of Europe's mountainous areas and a substantial part of its wetlands and peatlands. Furthermore, approximately 15% of the coastal zone (landwards and seawards) of Europe is part of the Natura 2000 network (see figure 4). Besides protecting habitats and species of European primary importance, the Natura 2000 network also holds a large proportion of Europe's natural and semi-natural ecosystems that provide a wide variety of ecosystem services.

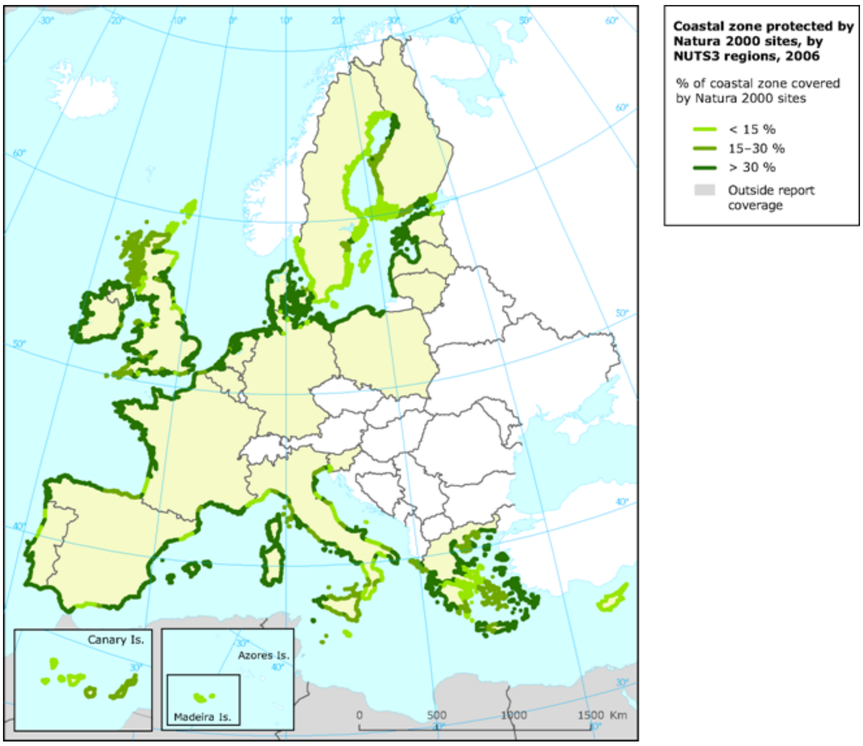

Figure 4. Percentage of coastal zones protected by Natura 2000 (EEA, 2006)

2 Natura 2000 sites: offering solutions to climate change

Natura 2000 sites provide natural solutions for mitigating and adapting to climate change (UNEP, 2009; WWF, 2010). Ecosystems perform important services for society, such as climate regulation, carbon sequestration and storage, flood protection, water purification, water provision and soil erosion prevention. For example, afforestation, apart from carbon sequestration, has other multiple benefits for society - forests temper high temperatures (also in and around cities), retain and gradually release water and, thereby, reduce droughts and floods, and fix soils to prevent erosion. To safeguard these kinds of services for society, resilient ecosystems are needed that are able to cope with impacts of climate change. We can work with nature rather than against it through the development and use of ecosystem-based approaches to mitigation and adaptation (e.g. Cowan et al. 2010). Natura 2000 sites can be managed in ways that increase their mitigation or adaptation role, whilst, at the same time, deliver Natura 2000 objectives: especially projects, in which restoration is undertaken are able to contribute to an increase in biodiversity value and, at the same time, increase opportunities for climate change adaptation (see example 1, 2).

Natura 2000 sites can specifically contribute to managing climate change by (see also figure 5):

- *Providing natural storage capacity for carbon*. Sustainable use and management of Natura 2000 sites will prevent the loss of carbon that is already present in vegetation and soils. Especially peat lands and forests have a high storage capacity for carbon. As stated above, this is particularly significant - the current network of Natura 2000 sites covers almost 30% of the European forest area and a large proportion of the European peat lands. Ten Brink et al (2011) estimate that the total carbon stock currently stored in the Natura 2000 network is around 9.6 billion tones, equivalent to 35 billion tonnes CO2.
- *Increasing capture of carbon dioxide in natural ecosystems.* Restoration activities of different habitat types (e.g. peat lands and forest habitats) in Natura 2000 sites leads to an increased capture of carbon dioxide and reduced CO_2 emissions (see example 1, Case Study

Anderstorp Store Moss). A policy targeted at improving the conservation status of the network might generate a gain in the carbon stock ranging from 1.7-2.8 % (Ten Brink et al, 2011).

- *Reducing the risks of and impacts from extreme events.* Natural management of forests in Natura 2000 areas, with a high diversity of tree species and age structure, reduces the impact of fires. Good management can avoid build-up of fuel load and thus reduce the risk of uncontrolled fires (see example 2). The natural vegetation in Natura 2000 sites can reduce run-off during periods of heavy rain. Natural meandering rivers with functioning floodplains avoid water rushing downstream, and protect human settlements from flash floods. Also, in terms of flood risks, Natura 2000 sites can provide temporary space for floodwaters. Although the contribution of Natura 2000 sites is widely acknowledged, no precise estimate can be given of the role and benefits of the Natura 2000 network for reducing the occurrence of extreme events (Ten Brink et al, 2011).
- *Reduce impacts of sea level rise.* Many Natura 2000 are located along the coast or river estuaries and form natural coastal defences. Coastal defence no longer relies solely on hard coastal defence structures, but is also using soft engineering techniques, such as beach nourishment, to replicate the characteristics of natural dune forming processes. Also, realignment management is considered a useful strategy to reduce the impacts of sea level rise and, at the same time, yield benefits for biodiversity (see example 3).

The report, 'Assessment of the potential of ecosystem-based approaches to climate change and mitigation in Europe', provides several further good examples (Naumann et al, 2011).

How can Natura 2000 sites assist in mitigating or adapting to climate change?

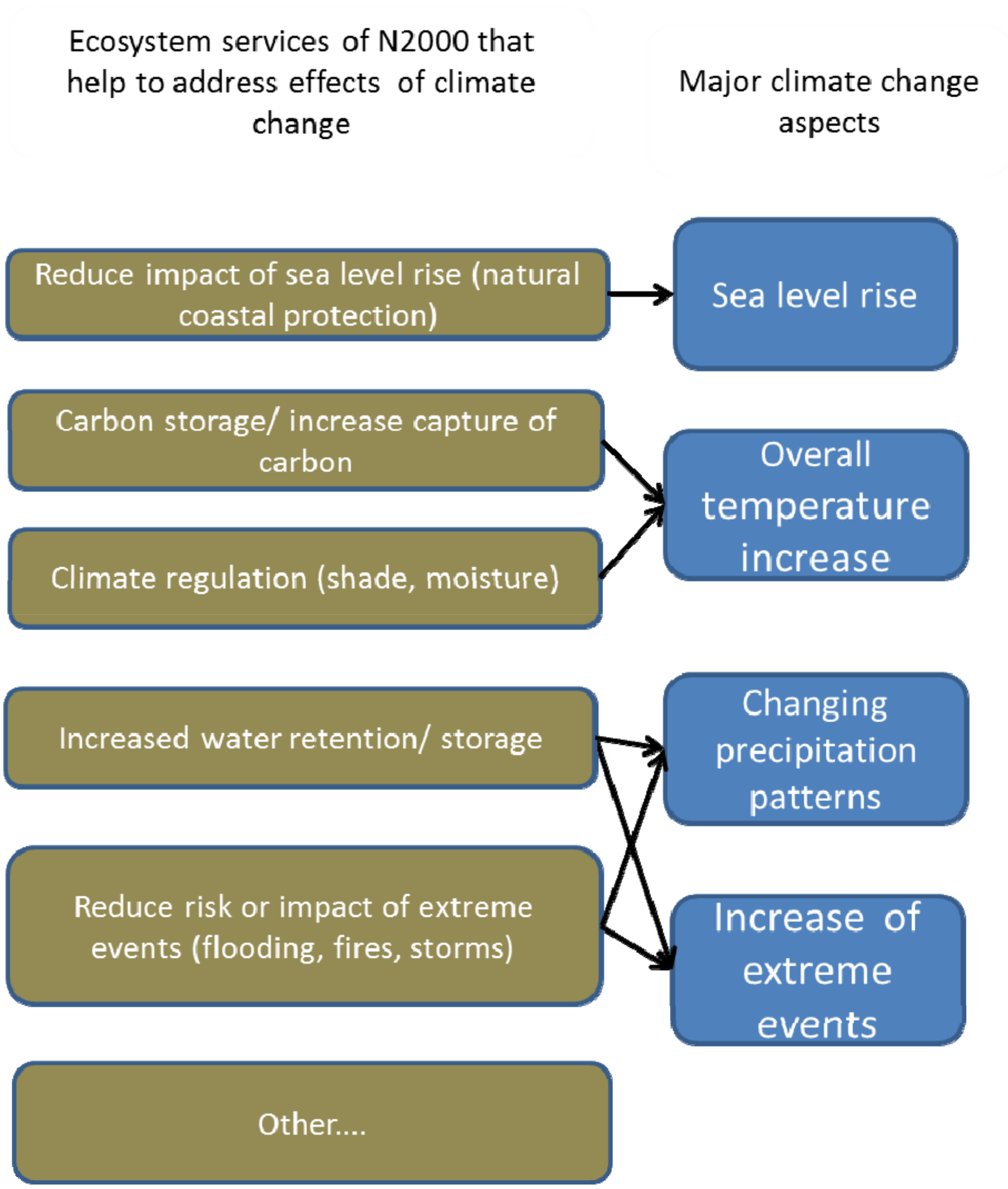

Figure 5. Major ecosystem services of Natura 2000 sites. The arrows indicate how different services can help to reduce climate change.

Example 1: Restoring Peat lands in Scotland – Climate Change Mitigation with Economic and Biodiversity Benefits (UK).

Peat lands and other carbon-rich soils cover about 65% of Scotland. It is estimated that the stock of carbon in peat and organo-mineral soils of Scotland totals 2735 MtC.
Since the mid–90s, several on-going peat land restoration projects in Scotland have been initiated, funded, amongst others, by LIFE. The Scottish government is actively promoting peat land conservation as a means to mitigating climate change. Furthermore, "Carbon Conservation Scotland projects", have been identified and are promoted to the general public as an easy way to contribute towards reducing the impact of the emission of CO_2 from travelling. One of the areas profiting from this carbon emission compensation scheme is Arran's Northern mountain range, which includes a wide diversity of habitats, including blanket bog. Much of this area is encompassed within the Arran Northern Mountains SSSI and Arran Moors SPA.
Source: Environment & Rural Affairs Department, 2007.
http://www.cndoscotland.com/

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Example 2: Adaption of Mediterranean Forest to climate change - fire prevention in Natura 2000 sites (Portugal).

Climate change has considerable impacts on Mediterranean forests and on associated ecosystem services. Therefore, adaptation measures are needed, in particular, to decrease threats from forest fires. Currently, many southern European countries take adaptation measures - these include:

- Changing forest management: increase species diversity; plant trees that are better adapted to the predicted climate changes; change silvicultural practices; change soil management practices to enhance water storage capacity and soil carbon storage.
- Landscape level measures: plan for 'fire-smart' landscapes; diversify habitat types, forest types and land uses; maintain/restore connectivity; protect 'refugial' areas in heterogeneous landscapes.

An example of such a plan has been developed in a LIFE funded project Nortenatur. In 2003, a devastating fire destroyed vast areas of Quercus forests in Alentejo in Portugal. An absence of management of the forest areas was identified as the main cause of the fire propagation. The three involved municipalities to which the Natura 2000 site of S. Mamede Site Nisa / Lage Plate, belongs, together with the ICN, FLORASUL, and Universidade de Évora, identified critical areas in terms of fire risk for natural habitats and surrounding areas.. A plan was developed to take measures to reduce the occurrence of forest fires and to minimise the area/ areas affected by them.

Source: Regato & Pedro. 2008.
LIFE project Pronatur
(www.nortenatur.cimaa.pt)

Climate change will also lead to changing demands for ecosystems services by society, including, for example, increased need for local climate regulation or increased need for flood protection. Proper management of existing natural areas and creation of new natural areas can offer natural solutions for these new societal demands.

There are many opportunities for forging links between building resilient ecosystems and helping society to contribute to mitigation and adaptation to climate change. Site managers, acting with others, are ideally placed to increase social support for nature conservation by showing that Natura 2000 sites are relevant and deliver mutual gains for society and biodiversity and ecosystems. Site managers should not only assess the impacts of climate change on biodiversity, but also review the impacts of climate change on wider society – for example, their site may well provide a solution to adapt to or mitigate climate change. Knowing which services a site may offer to mitigate or adapt to climate change will help to identify the partners needed in order to find integrated solutions.

Figure 6 provides an overview of potentially positive relationships between mitigation and adaptation measures and their impacts on biodiversity (Paterson et al., 2008), including their usefulness for society. The most positive measures ("win win win" for 'adaptation', 'mitigation' and 'biodiversity' goals), such as protecting and restoring wetlands and floodplains or protecting old-growth forests, are the most environmentally sustainable actions to take. Similarly, the potentially negative consequences of not taking effective mitigation and adaptation measures also emphasise the need for 'biodiversity inclusive' thinking in many sectors of society. It is increasingly necessary for site managers ***and*** policy makers, across diverse sectors, to convince others to work together ***for and with nature***, rather than against it to mutually realise sustainable cross-sectoral solutions. Examples 1, 2, 3 & 4 provide examples of how resilient ecosystems create multiple benefits for society and biodiversity.

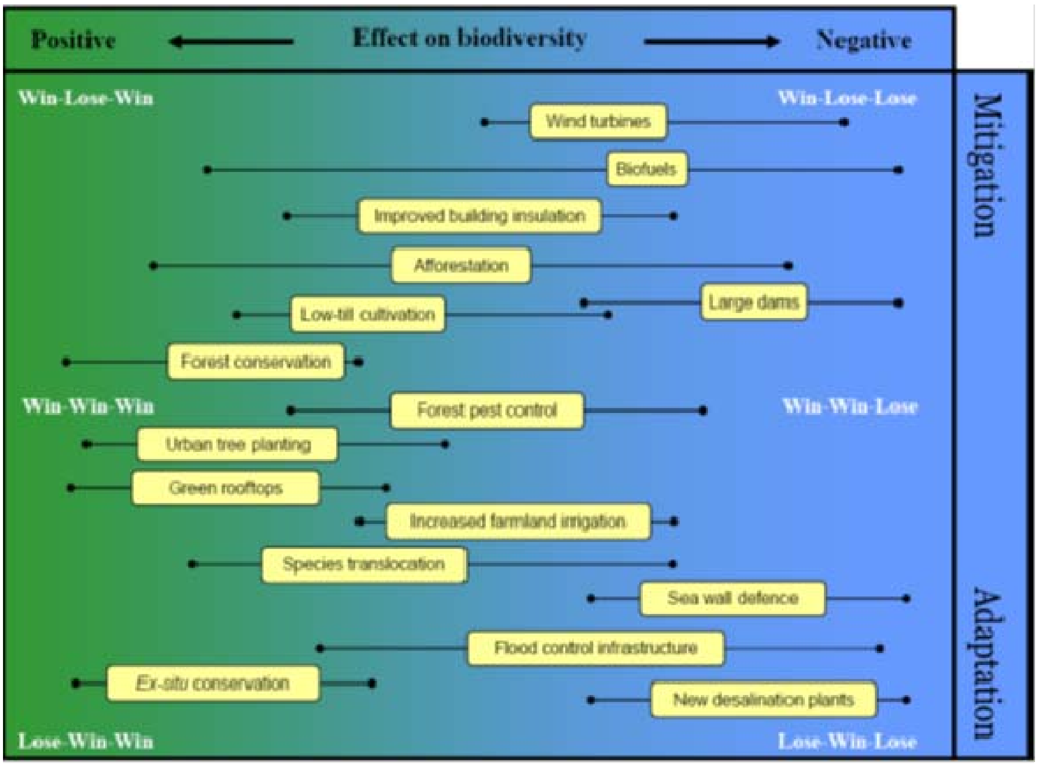


Figure 6. Known and potential relationships between mitigation and adaptation measures and their impacts on biodiversity (From Berry (2009)).

Example 3: Wallasea Island Wild Coast Project – Benefits for biodiversity, flood defence and recreation (UK)

The aim of this project is to create a sustainable multifunctional wetland (700 ha.) providing wildlife habitat, flood protection and recreation. In the past the area consisted of salt marshlands, which were slowly enclosed by sea defences. From 1930, the area was drained and converted into arable land. By breaching the seawall the arable land will be converted towards intertidal marshland.

The newly created coastal habitat will help to offset past and predicted future losses of coastal habitat, and address future flood protection risks. It will also have the potential to act as a carbon sink. Without this intervention, natural breaching of the existing flood defences during storms is predicted to lead to significant flooding of the island, and increased stress on coastal defences elsewhere on the adjacent estuary (Watts, 2010a).

Photo: Courtesy O.Watts.(Watts, 2010a)

Example 4: Increase natural water retention, avoid flood protection & conserve biodiversity - Tisza River

In 1998- 2001 severe floods occurred along the Tisza river. As a result several programmes and projects, including EU funded LIFE projects, were developed to decrease the flood risks. The majority of these programs and projects combined measures aimed at the improvement of infrastructure, the development of new reservoirs and river restoration along the banks of the Tisza river.

The recently approved Integrated Tisza River Basin Management Plan developed under the Water Framework Directive also underlines the need for an integrated approach towards flood protection . It foresees the reconnection and restoration of floodplains/wetlands in the entire Tisza River Basin (ICPDR, 2011).

3 Climate change, biodiversity and Natura 2000 species and habitats

3.1 Climate change and biodiversity

How does climate change impact species and habitats?

Climate change has both direct and indirect impacts on species and ecosystems (see Figure 7) (Berry 2008, Sajwaj et al. 2009; Vos et al 2011). *Direct* impacts on species include, for instance, changes of plant and animal life cycle events (the start/end of growing seasons or breeding seasons may alter), and that co-dependencies across and between species may change (predator-prey interactions or symbiotic relationships). Also, increased temperatures and higher CO_2 levels impact the physiology of species with increased levels of photosynthesis and respiration. Other impacts of climate change for species are *indirect*, through changes in the abiotic conditions of habitats: these include, changes in the ground or surface water tables or increased erosion. As a result of climate change, the area where species find suitable climate conditions may change.

Impacts of climate change will often interact with already existing pressures: for example, eutrophication may be enhanced by increased fluctuations in water tables. Changes in geographical distribution of species as a response to climate change will be limited by habitat fragmentation and the availability of habitat in new areas that are climatically suitable. All these separate impacts will lead to changes in the species composition and functioning of ecosystems and eventually to species loss. Furthermore, changes in the use of land and resources as society adapts to climate change may be of greater concern than the direct impacts and indirect impacts mentioned, due to their scale, scope and speed.

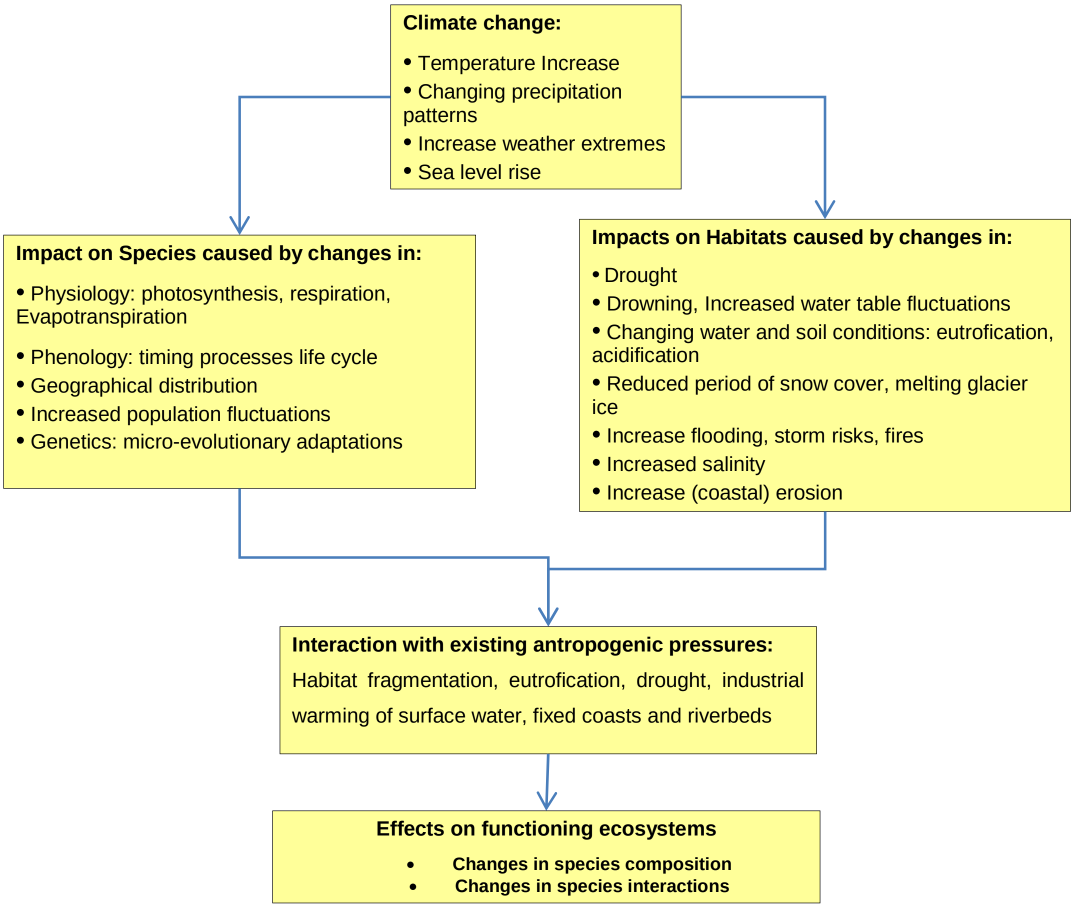


Figure 7. Overview of the selected impacts of climate change on biodiversity (Vos et al, 2010)

What determines if species or habitats are vulnerable to climate change?

The overall vulnerability of species or habitats to climate change depends on three important factors (IPCC, 2007):

1. *Exposure*. How severe is the climate change in the area where the species or habitat is located? For example, local differences in rainfall patterns will determine how much water will enter river systems and the capacity of the river systems to handle extreme water discharge.
2. *Sensitivity*. How sensitive is the species or habitat to the change? Some species are better able to withstand (periods of) cold or heat than others. Also, some species depend on just one or a few other organisms (plants and/or animals)

for food or reproduction, while others are 'generalists', which makes them less sensitive to impacts of climate change.

3. *Adaptive capacity*. Can the species or habitat adapt to the new climatic situation? Large heterogeneous riverine habitats have a high adaptive capacity as they are better adjusted to absorb periodic floods and will recover faster after an extreme event. The local landscape surrounding a Natura 2000 site might limit adaptive capacities of ecosystems - for instance, species with a small dispersal capacity are less able to move and colonize new suitable areas; another example is coastal habitats that may be lost because of sea level rise when the surrounding landscape puts constraints on the inland displacement of the system; alternatively, the adaptive capacity of the system might be blocked because of coastal defences or urbanization, so-called 'coastal squeeze'.

(See Figure 8 for an example and Annex 2 on definitions of exposure, sensitivity, and adaptation.)

How species and ecosystems in a specific Natura 2000 site respond to climate change depends on the species or ecosystem in question, the geographical location of the site in Europe and the land use in the surrounding landscape. As a result, an assessment is complex and, to some extent, unpredictable. However, it is possible to indicate which species and habitats are relatively vulnerable for a changing climate due to their sensitivity, differences in exposure, or constraints in their adaptive capacity.

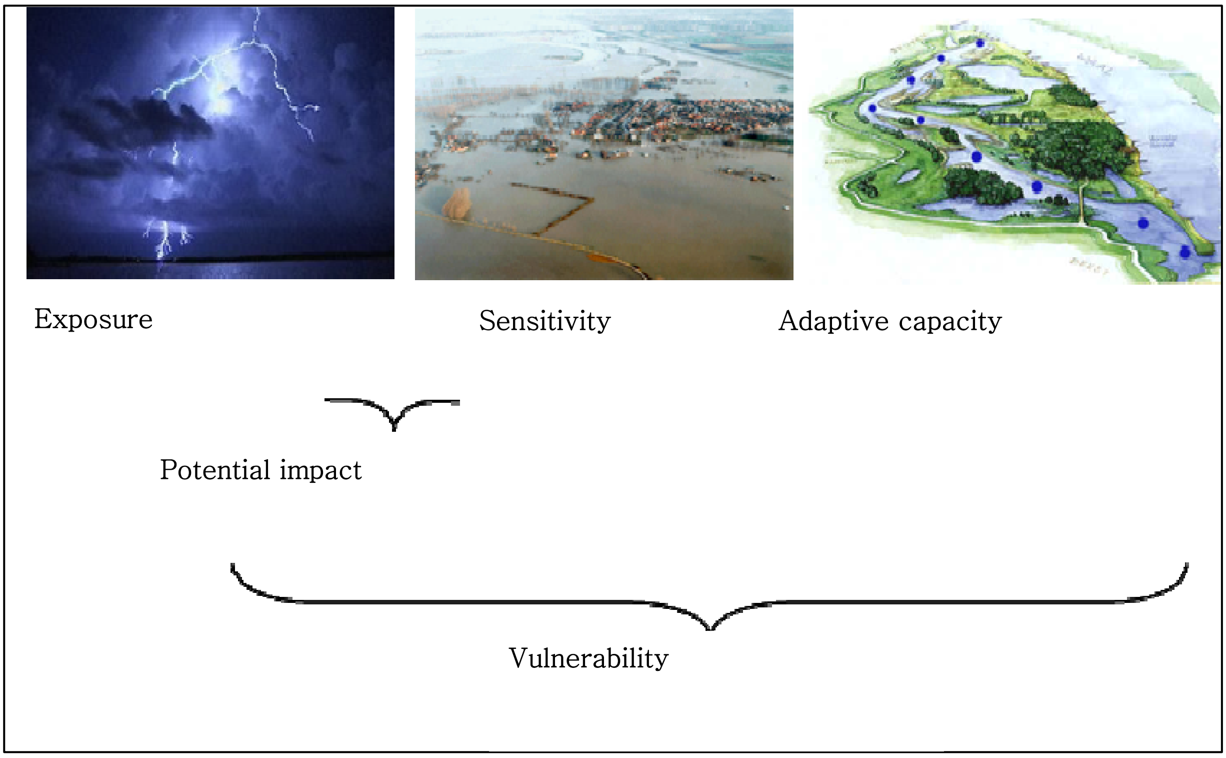


Figure 8. An example of the 3 components that determine the vulnerability to climate change of species and habitats and the role of adaptive capacity (visualization IPCC principles by J. Veraart) - large heterogeneous riverine habitats have a high adaptive capacity as they are better adjusted to absorb periodic floods and will recover quicker after an extreme event. At the same time, they perform an important role for society as they protect the hinterland from flooding.

What are the main effects for habitats?

Combined effects of temperature rise and increased CO_2 levels primarily impact habitats by changing abiotic conditions (IPCC, 2001): this results in processes that affect the quality of habitats and might eventually lead to loss of habitats. Other effects previously reported include: acidification of oceanic habitats, reduction of snow cover and melting of glaciers (IPCC, 2001; Hofmann & Schellnhuber, 2010; Keller et al, 2005); sea-level rise, combined with higher frequency of storms leading to the loss of coastal habitat through flooding and erosion; low-lying coastal land and estuaries being impacted by inundation and salt water intrusion; decrease in annual rainfall potentially leading to dropping water levels in rivers, streams and lakes and even periodical drying out; suitable conditions for bogs declining because of prolonged periods of drought and increased dynamics in precipitation patterns (Casparie & Streefkerk 1992).

The assessment of the vulnerability of habitats for climate change is complex. The vulnerability of habitat types depends on the geographical location and habitats vary in recovery time. A habitat consists of a range of species, which respond differently to changes in abiotic conditions or extreme events, such as fires, floods and storms. As a result, competition and interactions among species can change, leading to a change in structure, or composition, but not necessarily lead to a deterioration of the habitat. In the case of extreme events, often the structure, species composition and dominance of species will change, but the system will recover and return to an equally valuable comparable state[2]. Figure 9 provides an overview of the number of habitats, which are vulnerable to the different aspects of climate change.

In case of changing abiotic conditions, the changed habitat, as a response to climate change, might be better adjusted to the future climate. Change is then part of the adaptive capacity of the system: furthermore, climate change might enhance already existing pressures, such as for instance eutrophication.

Apart from changes within the habitats, an important issue is the spatial shift of habitats due to climate change. Extreme events can degrade habitats at fixed sites but also will create new habitats at new sites. Often habitat boundaries are fixed as a result of the surrounding land use: however, if the surroundings would allow, spatial shifts can be taken into account as an adaptation measure.

[2] provided changing climate and anthropogenic pressures allow for this to happen

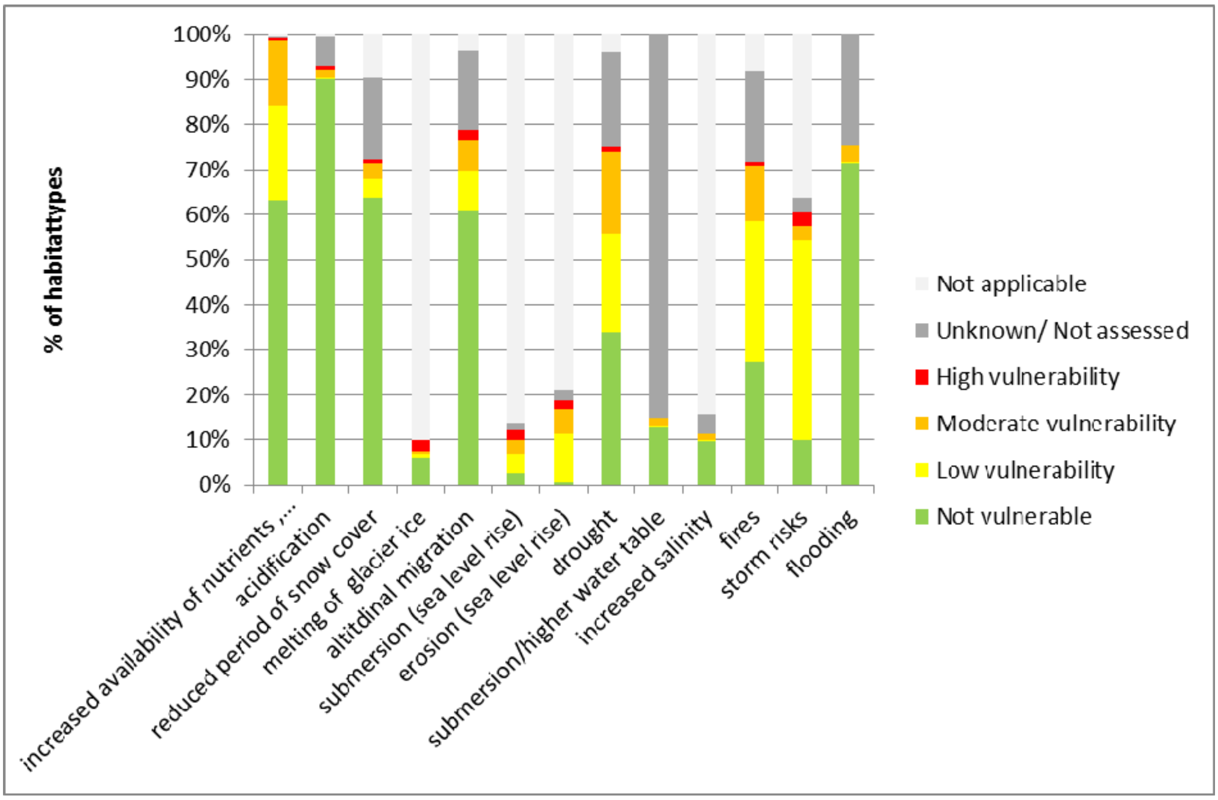


Figure 9. Vulnerability of different Natura 2000 habitats for various climate change induced pressures – sea lever rise, fires, drought and increased availability of nutrients are expected to impact the highest number of habitat (for method and data see *Supplement to the Guidelines).*

What are the main effects for species?

A well-documented impact of climate change is the shifting of suitable climate zones for species towards the north (or south in the southern hemisphere), to higher altitudinal levels or upstream in rivers, as a result of temperature increase and changing precipitation patterns. Changes in species distributions have already been reported for many species from various taxa (e.g. Parmesan and Yohe 2003; Root et al 2003). Projections based on bio-climate envelope modelling (e.g. Harrison et al. 2006) under different climate change scenarios predict further shifts of at least several hundreds of kilometres for many species in the 21st century (Figure 10); the average shift in potential future range for all European breeding birds is approximately 550 km for a 3°C rise in average global temperature (Huntley et al, 2007). Some species might benefit from climate change, if their suitable climate zone increases because of climate change, and if suitable habitat (including biotic and abiotic elements), are both available in these new areas of climatic suitability, and if species are able to reach them.

Furthermore, climate change is also expected to affect relationships between species (e.g. mutualism, predator-prey, parasite host, new pathogens and invasives) and changes in competitive ability. Also, physiological stress can lead to mortality and greater susceptibility of diseases (see also example 11).

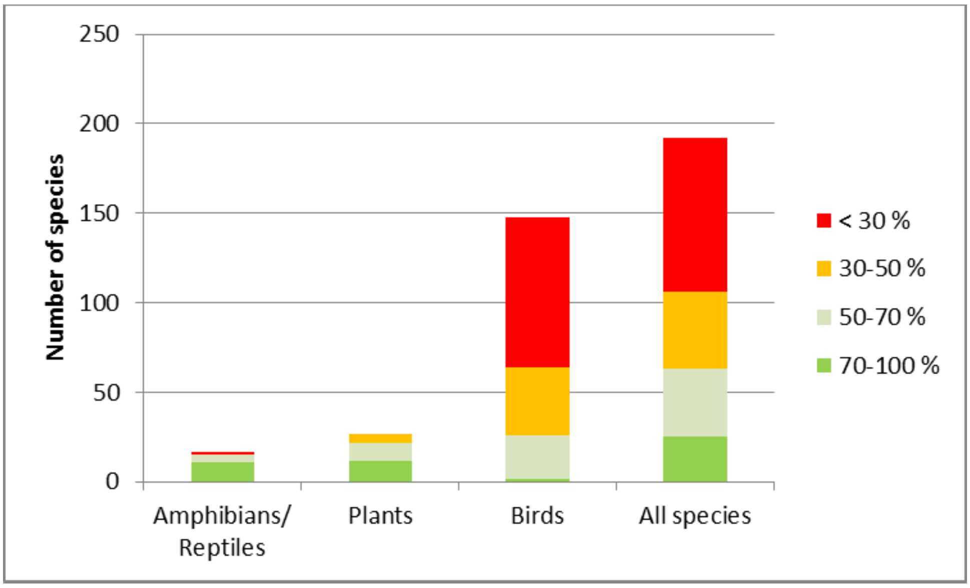


Figure 10. Number of Natura 2000 species that are expected to experience major shifts in climate zone (Sajwaj et al, 2009). Around 60% of all reviewed bird species are expected to experience major shifts in climate zone. For other groups less or no information is available.

In several regions of the world, indications of changes in heat waves, droughts and floods have been observed (IPCC 2001). Secondary effects of extreme weather events include altered fire and flooding regimes. Much less is known of the impacts of increased weather variability on species, although indications are growing that large scale synchronised disturbances, such as flooding or periods of extreme drought, increase population fluctuations and cause extinctions of especially small populations (e.g. Piessens et al. 2009; Verboom et al. 2010).

Figure 11 provides an overview of several of the effects for species.

Species' traits might limit autonomous adaptation responses, thus adding to the vulnerability of specific species (Foden et al, 2008). For instance, a limited dispersal capacity might put a constraint on adaptation, as it would reduce the ability of a species to adjust its distribution to its shifting suitable climate zone. Several other traits, such as a low reproduction capacity, might also put constraints on the ability of species to adapt to climate change or the ability to recover from population declines caused by weather extremes.

How do the areas surrounding Natura 2000 sites influence possible adaptation?
The land use surrounding a Natura 2000 site might limit the adaptation possibilities of species and habitats. For instance, species that are restricted to islands or depend on habitat that is highly fragmented, will find it difficult or even impossible to adjust their distribution to shifting climatic zones or recover after weather extremes. Coastal habitats might experience limitations as they are unable to move inland due to infrastructural barriers.

It is therefore increasingly important that the surrounding landscape is included in an assessment of the vulnerability to climate change of species and habitats of a Natura 2000 site. Is the Natura 2000 site embedded in a landscape with many natural and semi-natural elements and is exchange of species possible between the Natura 2000 site, its surrounding areas and other (Natura 2000) sites? (see the case of Prepirineu Central Català - Spain). In case of extreme events, such as flooding, storms and fires, are there refuge areas nearby that are reachable? And more importantly, can the landscape around the Natura 2000 site be developed to improve adaptation of Natura 2000 species and habitats to climate change?
For species to respond to the effects of climate change, it is vital that existing Natura 2000 sites are well embedded in a well-connected system of habitats, increasingly referred to as Green Infrastructure (see textbox chapter 5.3).

What are the main impacts of climate change on Natura 2000 habitats and species, which can be addressed by management?

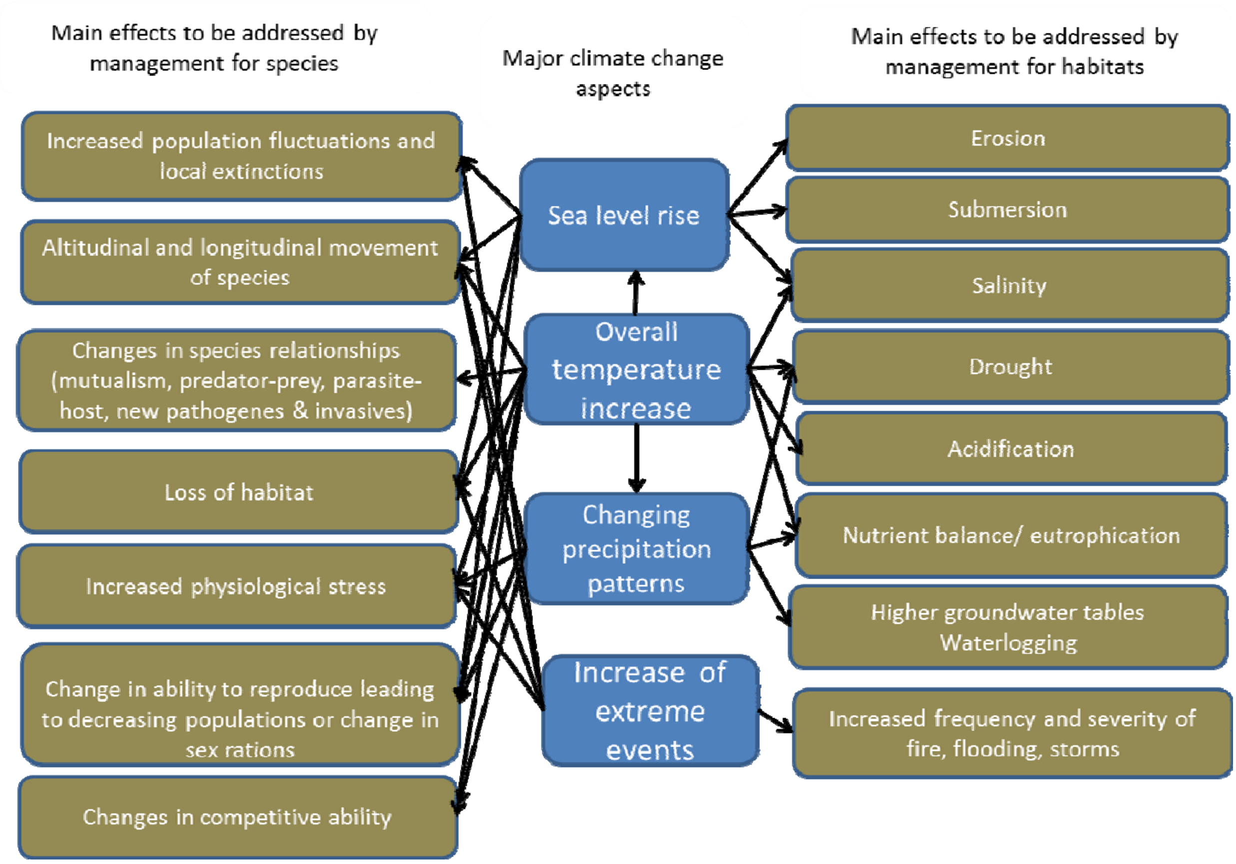


Figure 11. Major climate change aspects and their effect and impact on biodiversity (effects on species adapted from Foden et al, 2008, as some effects not directly related to management were excluded). Arrows indicate cause and effect relations.

3.2 Natura 2000 species and habitats and climate change

What are the known or expected impacts for Natura 2000 species and habitats?
Whilst compiling these guidelines, different information sources regarding the vulnerability of species and habitats of Natura 2000 were gathered. Building on a previous method to assess vulnerability of species developed by Sajwaj et al. (2009), a complementary assessment of the vulnerability for species was made (see Guidelines Supplement). For habitats, a method was developed in preparation of these guidelines (see Guidelines part II- explanatory note). For a few Natura 2000 habitats, scientific literature exists on the current or predicted effects of climate change (e.g. Posidonia beds, Palsa mires, Raised bogs, Machairs, European dry heaths, Vegetated sea cliffs of the Atlantic and Baltic coasts, Mudflats and sandflats not covered by sea water at low tide; Tetraclinis articulata forests, Western Taiga; Bushes with Pinus mugo and Rhododendron hirsutum; Reefs and Macaronesian laurel forests see examples 5 & 6). For other habitats, more generic knowledge is available on the expected impacts of climate change.

Overall, of all the Natura 2000 habitats, the most vulnerable habitat groups are the coastal habitats, fresh water habitats, bogs, mires and fens, and alpine habitats (see figure 12). However, in almost every habitat group, there are habitats present that are very vulnerable to climate change. Also, the negative effects of climate change are not only impacting on habitats, which at present already have an unfavourable conservation status, but are also likely to cause habitats, which at present are in a favourable conservation status, to deteriorate.

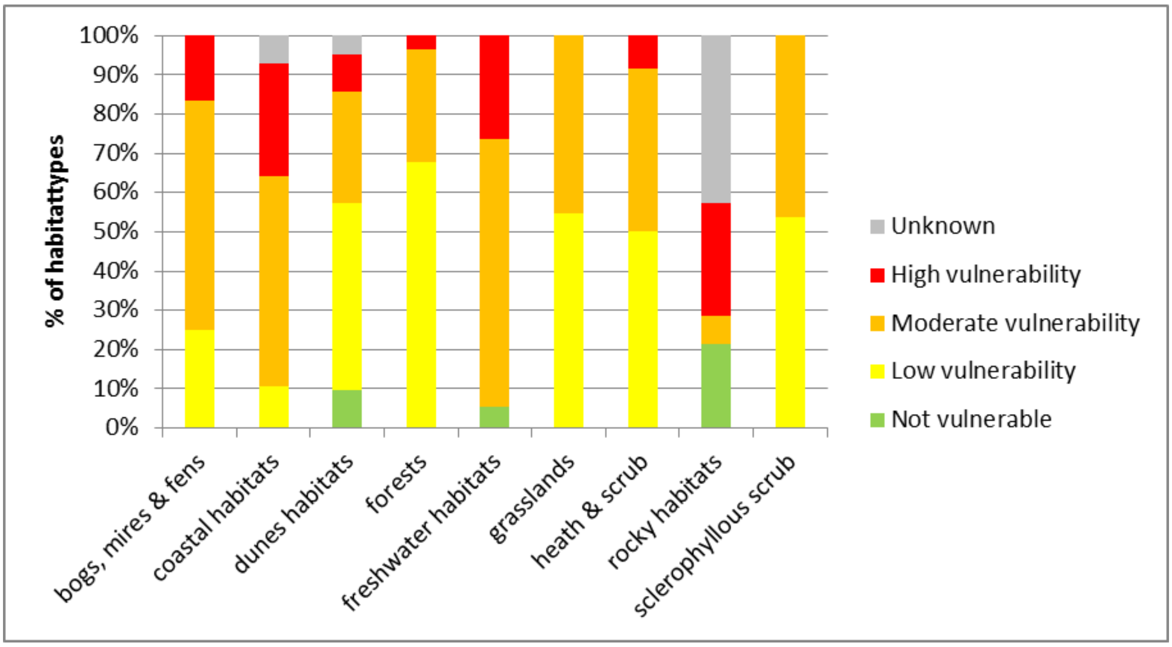


Figure 12. Assessment of vulnerability to climate change based on the highest score for one of the pressures resulting from climate change (e.g. erosion due to sea level rise, drought). For description of method see Supplement to the Guidelines.

Of all Natura 2000 species, amphibians and fish are considered to be most vulnerable to climate change (figure 13), however large differences exist (see examples 7 & 8). For many invertebrates (with the exception of butterflies[3]), not much is known about their response to climate change due to limited knowledge about their ecology or their present distribution. As with habitats, the effects of climate change are not only likely to impact on species already in an unfavourable conservation status, but will also affect species which are currently in a favourable conservation status. The Mediterranean and the Alpine regions show the highest number of vulnerable species.

[3] Settele, J., Kudrna, O., Harpke, A., Kuhn, I., van Sway, C., Verovnik, R., Warren, M., Wiemers, M., Hanspach, J., Hickler, T., Kuhn, E., van Halder, I., Veling, K., Vliegnethart, A., Wynhoff, I. & Schweiger, O. (2008). Climatic risk atlas of European butterflies. Pensoft, Sofia.

Example 5 : Sensitivity of Palsa mires to climate change (Sweden)

Palsas are peat mounds with a perennially frozen core of peat and ice and, often, also mineral soil. Formation of the mounds is a cyclic process and highly dependent on climatic factors and the insulation properties of the peat. The peat prevents the summer heat penetrating into the frozen core of the mound. In Laivadalen – the southernmost area of occurance of palsa mire in Sweden a study was undertaken to assess the development of the palsa mires. In the period between 1960-1997, a decrease of around 50% in the area of palsas occurred and no new palsas seem to have developed during this period. Evidence suggests that the present decay of palsas could be the result of the 1 to 1.5 C increase in mean annual temperature in northern Sweden during the last 100 years, in combination with an increase in snowfall.
Given the southern location of the Palsa bog Laivadalen at the fringe of the permafrost boundary, it is very sensitive to changes in climatic environment.

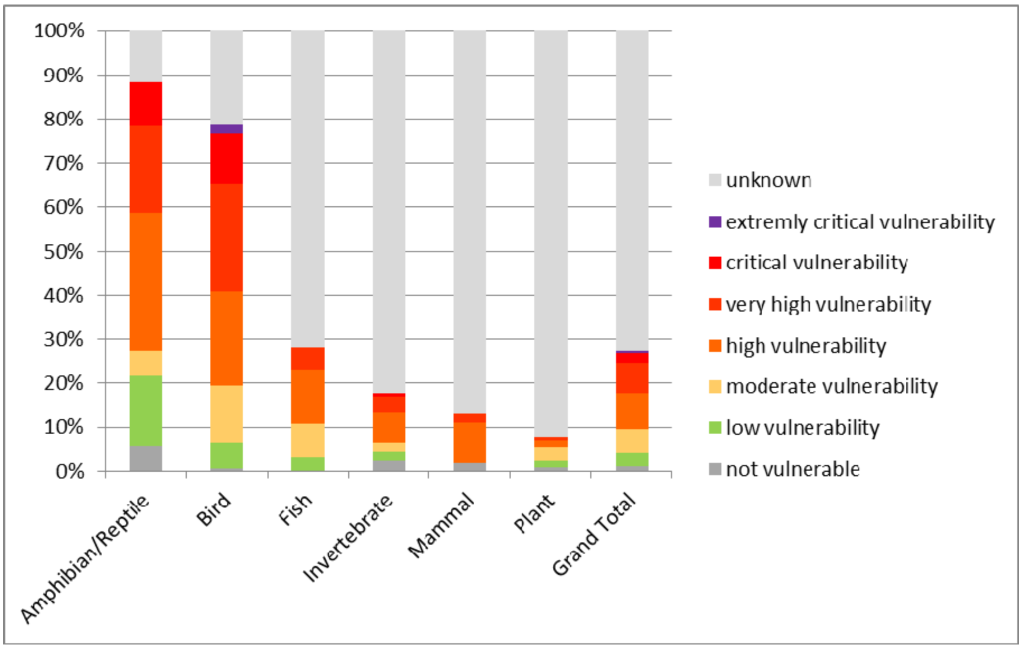
Zuidhoff& Kolstrup, 2000.

Example 6 : Sensitivity of Macaronesian Laurel forests of Tenerife to climate change

The occurrence of Laurel forest on Tenerife is depended on frequent cloud formation during the dry season. These clouds develop daily when the trade winds blowing over the ocean are forced to ascend as they encounter the formidable topographic barrier of the 3718 m high volcano Pico del Teide and the Anaga mountain range (maximum elevation: 1024 m).

As climate change may also affect the trade winds and the related formation of the clouds, the vulnerability of these forests to changing climate was assessed. The Canary Islands are located on the Northern poleward edge of the Hadley Circulation.
Using different scenarios for climate change models, predicted overall a down ward shift of the area climatically suitable for laurel forests. Whether this down ward shift actually will occur depends not only on the actual change in climate but also on soil characteristics and, crucially, competing land-use practices.

Sperling et al, 2004.



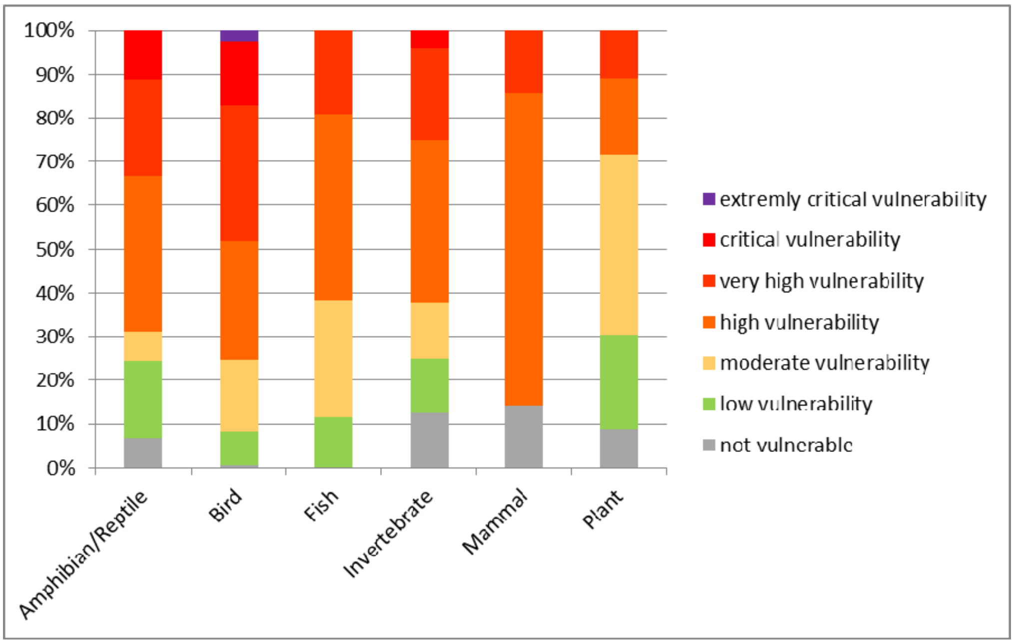


Figure 13. Assessment of vulnerability of Natura 2000 species to climate change based on the highest vulnerability score for one of the pressures resulting from climate change (see Supplement to the Guidelines for method). Figure above includes the number of species for which no information is available, figure below excluding them.

Example 7 : Vulnerability of the Saker falcon (*Falco cherrug*) to climate change

One of the species assessed in The Climatic Atlas of Europe is the Saker Falcon (*Falco cherrug*). Currently, the bird occurs in South-Eastern Europe (Bulgaria, Slovakia and Hungary). Simulation of the potential late 21st century distribution shows a distinctive move towards Northern parts of Europe. Based on the Climatic Atlas, its suitable range would move to Poland, the Baltic States and the southern part of Finland. At the same time, Bulgaria will become less suitable for the species. However, it is questionable whether the Saker Falcon will be able to move northwards. Its key prey species are rodents (especially ground squirrels Citellus). If the species is unable to find new food sources, the chances are high that the species' range will severely decrease.

Example 8 : Vulnerability of reptiles to climate change

Shifts of suitable climate zones are predicted for many species. The European rat snake (Elaphe situla) might gain from the changing climate as the projected suitable climate zone after climate change is considerably larger than the present distribution and, to a large extent, overlaps with its present distribution. Whether the rat snake will actually be able to expand in this new suitable climate zone depends on the availability of suitable habitats within reachable distance of its present distribution. In contrast, for Schreiber's green lizard (Lacerta Schreiberi), the impacts of climate change are very negative. This species already has a very restricted distribution and will lose most of its suitable climate zone after climate change.

Schreiber's green lizard (Courtesy P. Opdam).

4 Managing climate change impacts

4.1 Taking stock of actions required – different levels, different contexts

Although many Natura 2000 sites, their habitats and species are undoubtedly being impacted by climate change, or are likely to be in the future, it is possible to change management regimes and policies to at least partially mitigate or adapt to impacts. In fact, Natura 2000 sites and their ecosystems are an essential part of necessary responses to climate change, required to safeguard wider society. Natura 2000 sites are designated for their precious biodiversity features and, increasingly, it is recognised that the natural ecosystem services such sites provide are, in fact, essential to humans - for example, flood plains act as natural defences and help to protect coastlines against storm damage (see chapter 3).

However, the current reality is that many site managers are uncertain about how to manage, what to manage and how to adapt to the impacts of climate change: also, the benefits of Natura 2000 and ecosystem services are not known widely enough. The integration of climate change into site management plans, from either mitigation or adaptation perspectives, is highly variable. In many European site management organisations, climate change is not yet specifically defined in ways which could make it a 'manageable priority' – whilst it is widely recognised as an issue, the impacts on sites and the operational responses required are not yet clear. Although several site management organisations are developing exemplary work, many others are genuinely struggling with what climate change will mean: especially, those with limited resources are unable to adequately fulfil their key role in contributing to adaptive climate change management.

In addition, there is a general awareness, especially amongst site managers, that they do not 'hold all the cards': they can only be part of the solutions. A common perception is that effective management actions will be meaningless unless they are seen as being part of more integrated solutions: joined-up approaches are required in environmental and other sectoral policy and political frameworks. Also, policy makers are searching for answers and there are critical questions, which require their attention - what are the expected impacts of climate change for the country or region? Which policy frameworks are needed to ensure that all involved parties can play their role in adapting and mitigating to climate change? The emerging Biogeographical Seminar Process, being developed by the European Commission in partnership with Member States and other actors, will certainly establish an important framework to explore answers to such questions: a central objective of the Process is to support Member States within biogeographical regions to work together and, where necessary, pool resources, to improve the conservation status of specific, common Natura 2000 habitats. Climate change in particular is a recognised factor to be addressed. Site managers and policy makers will have important opportunities working through the Process to contribute to developing workable solutions for climate change issues affecting their Natura 2000 sites.

4.2 Adaptive management - what it is and how it works

When talking about adaptive management, a wide variety of terminology exists, which can be confusing – apart from ‘adaptive’ management, the terms ‘adaptable’ and ‘adaptation’ management, for example, may also be encountered; also, adaptive management (AM) is also known as ‘adaptive resource management’ (ARM). Whilst acknowledging this and the various distinguishing characteristics involved, for the purposes of these guidelines, when referring to adaptive management, we are talking about a structured, iterative process of optimal management decision-making in the face of uncertainty, based on system monitoring. As an approach, adaptive management builds in steps to assess progress towards achieving specified conservation goals and targets through monitoring actions, to see whether or not management actions are achieving species and/ or habitat targets. As adaptive management is based on a learning process, it aims to improve management outcomes, by continuously adapting approaches, actions and measures on the basis of lessons learned.

The challenge in using an adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best, short-term outcomes based on current knowledge (Allen & Stankey, 2009). Different handbooks for adaptive management exist, but in most of the adaptive management cycles, the following 6 steps are identified (see also figure 14):

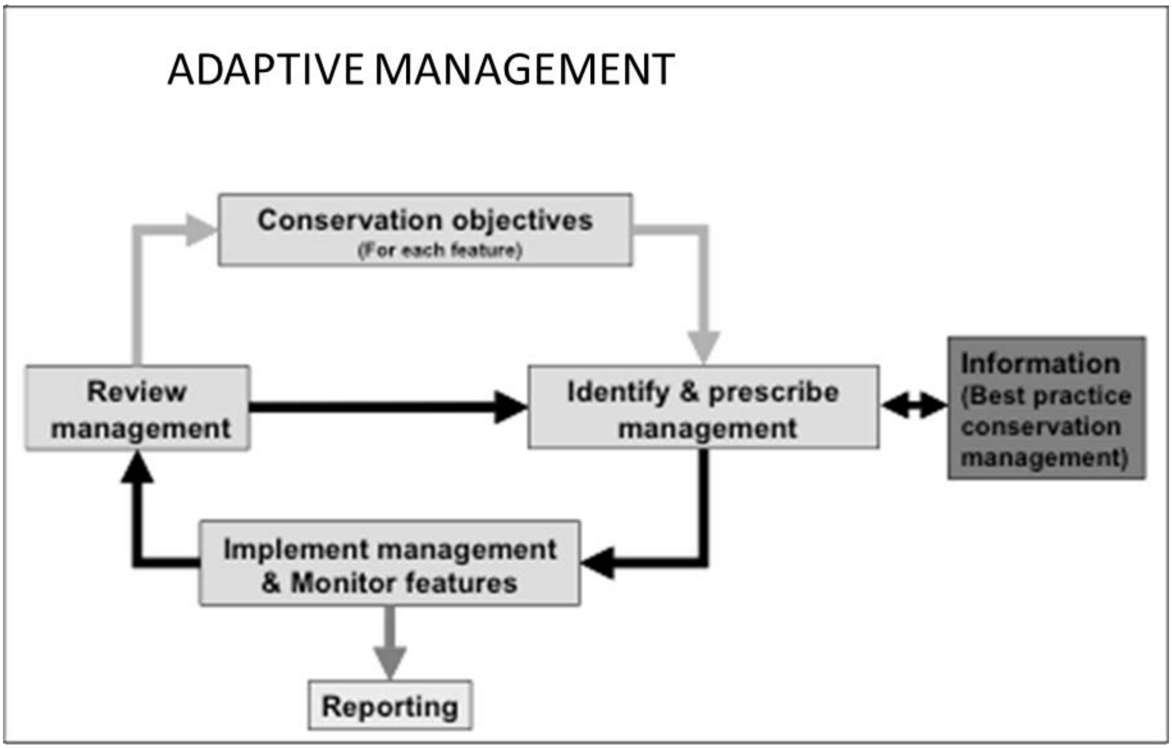
1. Determine the conservation objectives and assess existing problems
2. Design solutions
3. Implement measures
4. Monitor
5. Evaluate effect of measures
6. Adapt solutions and measures

As the impacts of climate change become better known and predictable over time, adaptive management is increasingly seen as an essential, practical tool to integrate climate adaptation measures in management of and planning for all protected areas, including Natura 2000 sites. By monitoring to assess the effectiveness of management actions and progress towards achieving defined conservation goals, it can help to identify whether or not other measures are needed at different management levels and the site management level in particular. Moreover, it also is a practical tool because it enables a flexible and responsive approach for issues other than climate change (e.g. land use change, land ownership change, environmental impacts). Climate changes, as well as other issues, necessarily involve building greater understanding of the impacts to gain knowledge about how to take effective management action: by systematically and routinely assessing progress against conservation objectives, gathering and assessing data, monitoring and measuring impacts, it becomes possible to learn about what does and does not work. Above all, the main benefit of adaptive management is that it positively fosters the development of appropriate actions and flexible management, based on the best, currently available information and assessments of the effectiveness of actions in achieving objectives – it provides a framework for proactive management on the basis of what is known now, that can be adapted in future as more becomes known.

The resource implications for the measures required to adapt to climate change will vary according to the nature of the sites, the anticipated problems to be addressed and also the expected impacts of climate change. However, the cost of not developing effective adaptive management plans as part of a wider adaptation management strategy is likely to be more significant, not just for nature, but also for people and society generally. The need to ensure, as best as possible, that time, energy and site management practices are fully developed to effectively manage (adapt or mitigate as appropriate) for the impacts of climate change and safeguard biodiversity, is urgent. No-regret (synergy) measures should be implemented without any further delay.

Applying the first steps of an adaptive management process is a good way to start changing management to take into account climate change (see figure 14). Chapter 7 describes the decision framework (used to structure these guidelines) and sets out steps to review issues related to climate change: essentially, it encourages systematic and routine review as an integral part of the first 2 steps of adaptive management planning – these are: assessing the problem and designing solutions.

Figure 14. A schematic overview of the different steps of adaptive management



To make the impacts of climate change on biodiversity and ecosystems manageable for site managers, the scale of tasks and possible options for adaptive management action need to be broken down. A best practice example of how adaptive management has been developed and applied as an approach is seen in the Bosherston Lakes Case study, Wales (see example 9) - here, a practical adaptive management approach is applied, which involves distinguishing actions, tasks and possible management options in three phases:

- Short-term actions - to enhance current conservation priority interests by reducing other sources of (existing or potential) harm – a risk assessment and management approach – for example, measures to improve water quality and reduce eutrophication can be a priority;
- Mid-term actions - activities that will increase the resilience of ecosystems to future change – for example, timely management of alien species / raising water

levels in the spring to avoid drought in the summer/ developing natural coastal protection infrastructures – e.g. maintaining coastal dams or developing a surge management plan to manage ingress of sea water at times of high risk;

- Long-term actions – depending on the site, for example, a potential managed transition from freshwater lake to brackish lagoon could be considered as part of an appropriate long term strategy for management of a site where sea-level rises (and associated impacts) are likely.

4.3 Adaptation and Mitigation measures for climate change at different levels

Despite existing knowledge gaps about the impacts of climate change on nature and biodiversity conservation, much is known about measures that can be effective to reduce the effects of climate change. In the last few years, several overviews have been published on adaptation and mitigation for climate change (Berry et al, 2008; Heller & Zavelat, 2009; Harley & Hodgson, 2008). Mitigation and adaptation both aim to reduce vulnerability to climate change. For mitigation, this shall be mainly achieved through a net reduction in greenhouse gas emissions. This reduction can be achieved by an increased uptake or storage of greenhouse gas, but it is also necessary to avoid loss of storage capacity (e.g. by avoiding loss of peat lands). This can lead to a reduction in the magnitude and rate of projected climate changes and, thus, vulnerability through decreased exposure. Adaptation measures are aimed at, either mitigation of the impacts of different aspects of climate change (sea level rise, changes in temperature, changing precipitation patterns, extreme events, etc.), or at enhancing the ability of ecosystems and species to adapt to climate change.

Adaptation measures for conservation proposed to-date range from site-specific management measures to European-wide, or even global, policy initiatives. The measures vary from short-term and longer-term measures, and range from low cost to more expensive measures: these differ in terms of result, impact and priority. Successful mitigation and adaptation to climate change requires action at different levels:

Adaptive Management at site level

Site-level adaptation and/or mitigation measures are, at least in theory, familiar, but practical adaptive management planning and implementation approaches are often lacking. Translating known and 'reasonable-to-expect' impacts of climate change in specific sites into actual practical management actions is something that site managers should address. All site managers should be prepared to think about climate change and the types of measures that could be usefully applied to address both known and 'reasonable to expect' impacts. Whilst it is not possible within these guidelines to specify measures for specific impacts on sites, it is strongly recommended that site managers at least think about how to incorporate reasonable adaptation principles into their management regimes. Doing so will enable more adaptive responses to climate change. Various adaptation principles have been well described in various sources – these include (Smithers et al, 2008; Watts, 2010b):

- Being prepared to identify and accommodate change;
- Taking stock of what is known and not known, develop knowledge and plan strategically;
- Taking actions to maintain and increase ecological resilience;
- Seeking, wherever possible, to integrate actions across all sectors.

By following such principles, all site managers, to varying degrees and according to the needs of their sites, will be better able to seek to develop adaptive management measures which enable action to be taken now on known climate change impacts already evidenced or likely to occur. Guidance about adaptation measures is provided in Chapter 5 of the guidelines.

At a basic level, it is necessary to change site management approaches in response to changing environments and to develop increasingly adaptive attitudes and responses. The improvement of management regimes in response to climate change impacts begins with a site-specific, integrated management approach, addressed by adaptive management planning (chapter 5.2). Knowing what measures can work in what situations is essential, and ways forward for the actual management of sites can be extracted from those known measures. Possible measures at site level are elaborated in chapter 6.2 and site managers in particular will be able to consider these as appropriate for application in the context of their own sites.

Adaptive Management of the surrounding area

Also, around Natura 2000 sites, measures can be taken to minimise the effects of climate change for the protected area. The challenge is to ensure that the management of protected areas becomes integrated in ways which are directly related to and meaningful for other stakeholders in their surroundings – this will avoid protected areas and their surroundings being managed and planned as separate entities. A dialogue between those responsible for protected areas management and those responsible for managing the surrounding areas is needed. Enabling other stakeholders to understand how Natura 2000 sites play a crucial role in a connected landscape and the wider benefit this can bring will help to find integrated solutions – however, this process is not without difficulties. At regional level in particular, spatial planning plays a crucial role (see paragraph 6.4.1). Also, to safeguard and further develop Green Infrastructure in the wider landscape, spatial planning is an essential tool.

Adaptive planning and management at biogeographic region and network levels

At present, species often occupy isolated habitat remnants and many have become increasingly vulnerable, as they are unable to disperse or migrate. On top of existing on-site pressures, climate change pushes species to move (mostly) northwards and upwards. Consequently, the need to facilitate mobility and to reconnect habitats grows. Of course, to be effective, measures must take into account established mobility patterns, the capacities of specific species to disperse and how these species will be impacted upon by climate change. Therefore, management measures, which specifically seek to take into account ecological connections around and between sites - including, for example, maintenance or development of corridors and stepping stones, reducing the barrier effect of roads and railways by development of tunnels or green bridges, creation of new areas, or just generally through actions which stimulate appropriate management of the wider landscape - are to be positively encouraged. This will involve developing collaboration with multiple stakeholders on and around sites, as well as sharing information and experience with site managers on sites elsewhere in the Natura 2000 Network. Especially when multiple administrative structures, diverse land uses and multiple sectoral agencies would be involved, there can be a need for extensive cooperation to find the best routes and opportunities for measures. The new Biogeographical Seminar Process aims to provide a useful framework for information exchange and increased cooperation at biogeographical network level, and, in particular, it seeks to foster inter Member State joint working for Natura 2000.

Although still at an early stage of development, the new process for protecting and promoting the favourable conservation status of species and habitats on a biogeographical level[4] holds significant promise. It specifically provides a series of expert meetings, workshops and seminars within each Biogeographical Region and positively encourages all Member States within each Region to work closely together to develop their nature conservation actions and, especially, their planned activities for priority Natura 2000 species and Habitats. As many species' ranges are limited to specific (biogeographical) regions and as more information on the conservation of these species becomes available, there will be increasing opportunity to enhance the conservation statuses of species: although the quality of and importance attached to monitoring by Member States is currently highly variable, it is reasonable to expect that new knowledge will also become available through the Article 17 monitoring and reporting process and that, for example, this will help to improve transboundary Natura 2000 management at biogeographical level. To achieve this, it will be necessary to ensure coherence in management, monitoring, financing and reporting to establish Natura 2000 as a coherent ecological network. Also, specifically, in formulating responses to climate change, it will be necessary to ensure attention is given to the following questions in particular - what will be the consequences of

[4] Biogeographical regions have their own characteristic blend of vegetation types, climate and geology. There are nine terrestrial biogeographical regions in the EU: the Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesia, Mediterranean, Pannonian and Steppic regions. Natura 2000 sites designated under the EU Habitats Directive (i.e. Special Areas of Conservation, SACs), were selected according to biogeographic regions so that species and habitats could be conserved that were important or characteristic within a particular natural area, irrespective of political or administrative boundaries.

climate change at the specific biogeographical level? Which measures need to be taken and by whom?

Developing adaptation strategies at policy level

Adapting to climate change also requires a review of other policies and strategic frameworks in terms of how they could be developed and utilised as part of the integrated solutions that will be increasingly required for climate change management. A wide range of policies and strategic frameworks is potentially implicated and would require to be reviewed in order to generate and realise greater synergies and integrated collaborative approaches. This revision is not only required in order to 'climate proof' biodiversity and other sectors – for example, policy adjustments for climate change are likely to become increasingly necessary for those involved with water management, urban development and spatial planning, as well as agriculture, to name but a few - crucially, it will become increasingly necessary for policy-makers in such fields to see nature and its management as an integral part of the solution to problems they may face from climate change. In this regard, the current reform of the Common Agricultural Policy, the development of River Basin Management Plans under the Water Framework Directive and also, for example, EC plans to develop policy for Green Infrastructure and Invasive Species, provide an opportunity to incorporate concerns about climate change and its impacts across environment and other sectors. The "development and use of ecosystem-based approaches to climate change adaptation and mitigation" has been recommended in consecutive Environment Council Conclusions.[5] Furthermore, DG Environment has prepared practical guidance and recommendations to foster greater integration of climate change and biodiversity into EIA and SEA procedures. The final output is a set of two guidance documents – one for EIA and one for SEA – to assist authorities, practitioners and stakeholders across the EU Member States to effectively consider climate change and biodiversity in the assessments.

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[5] (22/12/09 on International Biodiversity, 14/10/10 on International Biodiversity, 14/03/11 Follow-up to UNFCCC COP16 in Cancun).

Specifically, in terms of adaptation of biodiversity to climate change the following policies are relevant and might be reviewed to assess how well they consider climate change:

- Revising existing biodiversity strategies for relocation of species (see chapter 5?.4) and habitats;
- Review existing policies for combating invasive species and diseases;
- Incorporate green infrastructure concepts in spatial planning policies (see chapter 5?.4);
- Review existing fire prevention, management plans and policies;
- Review the EIA and SEA procedure to take into account climate change

Example 9: Addressing the threat of climate change – The Bosherston Lakes

The Bosherston Lakes SAC is a very shallow, artificially created lake system adjacent to the Pembrokeshire coast in Wales. The internationally important stonewort (Chara spp.) vegetation for which these lakes are notified is in an unfavourable condition due to eutrophication and insufficient Chara cover despite ongoing management within the lake and the wider catchment. Some stakeholders involved in management have suggested that the SAC may not be viable as freshwater lakes in future, due to sea-level rise. Owing to the perceived vulnerability of the site to sea-level rise and hydrological change, research was undertaken to assess the risk and develop an approach to future management (HOLMAN et al. 2009).

A substantial number of potential climate change impacts were identified, including an increased risk of saline incursion, lower summer water levels, higher water temperatures, increased winter flushing, increased sediment load and increased visitor pressure. However, the modelling and monitoring data analysis for the Bosherston Lakes suggests that no immediate or dramatic change to site management is required at present and that, over the next 50 years, climate change will largely increase pre-existing pressures on the site - such as droughts, sediment input and eutrophication - rather than introduce new pressures. However, given the potential risks of climate change on different timescales, a phased adaptive management approach to adaptation is required:

- In the short-term, further actions to reduce non-climate sources of harm e.g. continuation of extensive catchment and in-lake works to improve the water quality and reduce eutrophication were identified as the priority.
- In the medium-term, measures that will increase the resilience of the lake ecosystem will be required, such as an alien species

management warning system or raising spring lake water levels to reduce the risk of summer drought impacts. Improvements to the coastal protection infrastructure, such as ensuring maintenance of the coastal dam and developing a surge management plan to block seawater ingress at times of high risk, will reduce the likelihood of impacts.

• In the long-term, probably beyond the next 50 years, a managed transition from freshwater lake to brackish lagoon may need to be considered in part of the site, but the necessity for this should be reviewed as new evidence relating to sea-level rise and its likely impacts becomes available.

There was a risk that climate change would be seen as justification for abandoning or radically altering the management of Bosherston Lakes, despite the lack of any analytical evidence to justify this. The research emphasises the need for further work to reduce nutrient enrichment and monitor any evidence of saline intrusion, rather than a dramatic change in conservation management planning. Uncertainty, in terms of sea-level rise and its impacts, makes an adaptive, phased approach to management actions an effective way of reducing both risks and costs.

Photo: Courtesy CCW

5 Adaptation measures for the Natura 2000 network

5.1 Introduction

A broad variety of measures are suggested as being suitable for adaptive management in Natura 2000 sites – these are useful to enable biodiversity generally to better adapt to climate change, as it occurs, and also will enable the surrounding area to become more resilient. For the purpose of these guidelines, all measures mentioned in publications or used by site managers are clustered within 6 main categories based on the overall aim of the measure – these are:

1. To reduce existing pressures;
2. To ensure ecosystem heterogeneity;
3. To increase connectivity;
4. To ensure abiotic conditions;
5. To manage impacts of extreme events; and,
6. Other measures.

Figure 15 provides an overview of the relation between the impacts of climate change, as described in chapter 4, and the main categories of measures discerned.

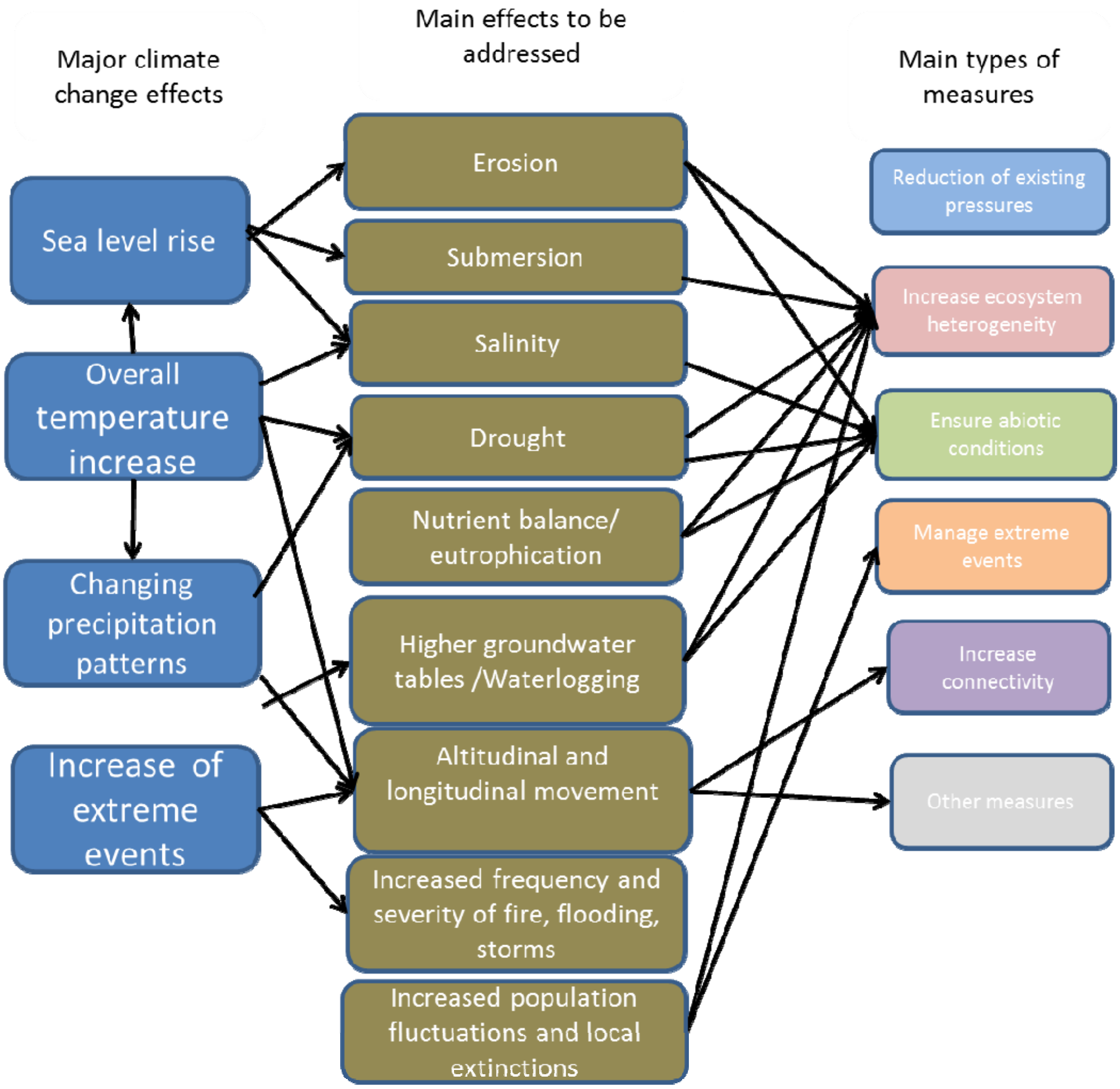


Figure 15. The relation between 4 aspects of climate change, the impacts for species and habitats and the main categories of measures

In these guidelines, a balance has been sought between providing an overview of the types of possible measures and listing all possible management measures for adaptation. This resulted in a description of the main categories of measures and, for each category, a few examples of possible measures are provided. Furthermore, where there are specialised handbooks available, which provide advice on several of the measures proposed, reference is included in the relevant section of the guidelines. At the end of Chapter 6, a more detailed overview is provided of the different measures and their applicability to different levels (on site, around site, network level, figure 20). In Annex 1, a figure is presented that relates the different measures to the examples provided in the case studies and text boxes throughout these guidelines.

In the next two paragraphs, measures are described, which can be taken within or around the site, and on the network level.

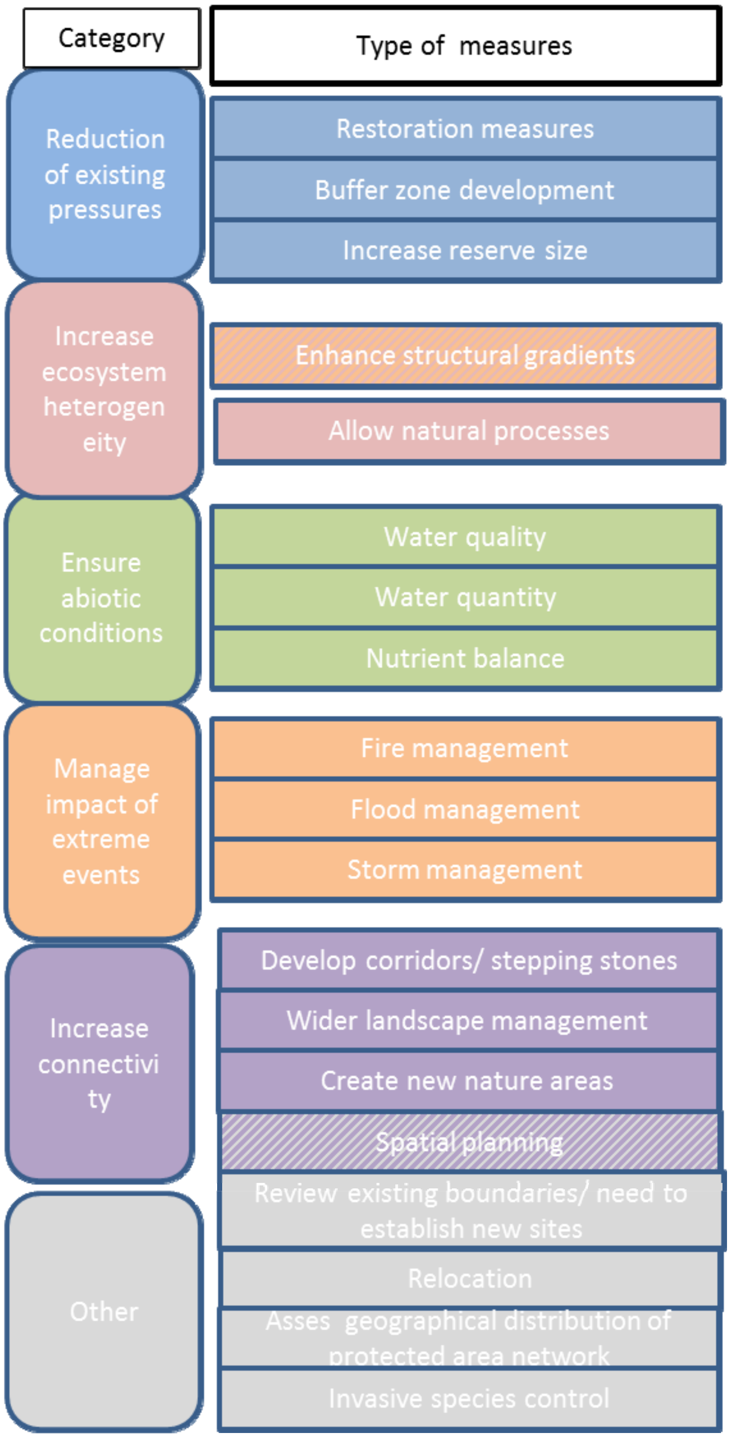


Figure 16. The main categories of measures and the various measures falling into the different categories.

5.2 Measures in Natura 2000 sites and its surroundings

An individual site manager takes measures at site level. However, the size of Natura 2000 sites varies considerably, from 1 hectare to 550.000 hectares. Depending on the pressures that impact species and habitats, the location where the measures need to be taken varies. For small sites, measures taken at site level often may not be sufficient, as the condition of the site depends to a large extent on land use in the surrounding area. In large areas, existing land use within and around the site might impede certain measures. Therefore, depending on on- and off-site pressures and the size of an individual Natura 2000 site, the relevance of the following categories of measures will vary.

Category 1 measures: Reduce existing pressures

As part of everyday management, site-managers are often already aware of the current pressures impacting on the site. Measures to alleviate existing pressures and improve the general conservation status of a species or habitat, by ensuring the suited conditions at the Natura 2000 site, are 'no regret measures', as they will contribute to more robust ecosystems. If species populations and habitats are in a good conservation status to start with, they are better capable of adapting to climate change. Healthy populations are more capable of recovery after extreme events and also produce more young that could disperse to new suitable areas.

Measures which can be considered within or around the site that contribute in reducing existing pressures are:

- Restoration activities (see example 10 Voornes Duin, Case Study Anderstorp Store moss)
- Increase the size of the protected area to minimise negative influences.
- Development of buffer zones around the site.
- Control of invasive and expanding species and diseases (see example 14 & case study Krkonoše National Park).
- Defragmentation of infrastructure in or between protected areas by construction of eco-tunnels or 'green bridges'.
- Reduce or eliminate external sources of, for example, pollution or disturbance (see example 11)

Example 10: Reduce existing pressures – restoration activities Voornes Duin (Netherlands)

Due to nitrogen deposition and a lack of natural dynamics the vegetation of the dune ridge and valleys became overgrown by shrubs. Several restoration measures, most of them within an EU funded LIFE project, were and are being taken. Shrubs and nutrient rich top-soil are removed and the dunes nearest to the coast are sprayed with calcium/lime-rich sand. The mosaic of the open dunes, including rare habitats, such as primary dunes, gray dunes and dune valleys, have thus been restored. Already, sand spray is increasing and is expected to improve the quality of several habitat types on the short-term. Moreover, the measures are protective against rising sea levels in the future. The inland natural areas, such as the freshwater dune valleys, but also agricultural and urban areas, will therefore be sheltered for rising seas and storms.

Source Natuurmonumenten (Photo courtesy Peter Schut)

Example 11: Reduce existing pressures – Loggerhead sea turtles (Greece)

As a consequence of climate change, Southern Greece will face a higher incidence of heat waves and droughts. As the air temperature during the time of incubation determines whether Loggerhead sea turtles become male or female, it is foreseen that the increasing average temperature will increase the amount of females hatching from the eggs. In terms of reproduction, this could obviously be serious for this species. On top of this pressure, the nesting grounds, which are on the beach, will be threatened by rising sea levels and in particular by an increased chance of storms and floods. Currently, it remains hard to define a set of necessary adaptation measures. However, for an increased, sustainable survival of the Loggerhead sea turtles, it is first required to remove any already existing pressures. Tourists cause much disturbance to the (egg laying) turtles. Therefore, beaches are inspected continuously to detect any turtle activity and to safeguard the opportunity for turtles to lay eggs, by removing obstacles (and prevention of disturbance). If necessary, nests can be relocated.
In the meantime, it is important to continue to monitor the Loggerhead sea turtles. By doing that, the potential risks from climate change will be understood and identified in such a way that adaptation measures can hopefully be defined (Giannakopoulos, 2011).

Nest of sea turtle (Courtesy Katelios Group)

Category 2 measures: Enhance ecosystem heterogeneity

Measures included in this category are not specifically taken to protect one species or habitat type. Their aim is to improve the overall resilience of the ecosystems. The following measures can be considered in and around the site:

- *Enhance structural gradients in and around Natura 2000 sites.*

Through pro-active management, variation in structure of vegetation in and around the site can be increased. This might alleviate the influence of increasing temperatures by providing shade and shelter (see example 13). Also, the terrain morphology can be increased. In heterogeneous habitats, some parts may allow a positive growth rate in very dry years, whereas other parts may be optimal during wet years.

- *Facilitate ecosystem change by accommodating dynamic natural landscape forming processes*

By allowing natural dynamics that are characteristic for current and future climate, ecosystems will change and be able to better adapt to new conditions. Examples include steps to better accommodate natural landscape forming processes e.g. sedimentation, marshland development, meandering of rivers and freshwater-salt water gradients. Facilitating natural processes will also enhance heterogeneity (see the above mentioned strategy). Which measures are applicable at site level depends on the habitat types and species, as well as the local context of the site.

Category 3 measures: Ensure required abiotic conditions

Without adequate management, climate change is expected to change the abiotic conditions of certain sites. Maintaining the hydrological integrity of a site is often key to delivering species and habitat objectives, and this will become increasingly difficult on many sites, where increasing climate change is coupled with increasing human demand for water (which may also be linked to climate change). In some areas, increased water scarcity and drought are expected and, as a secondary effect, this may lead to increased levels of nutrients (especially nitrogen) and pollutants. In other areas, an increase in rainfall is expected. Also some sites are expected to have to deal with increased

winter rainfall and a reduction of summer rainfall. As part of adapting management for climate change, a hydrological plan can be developed to cope with the expected changes in rainfall.
Furthermore, higher temperatures in combination with more rainfall might lead to an increase in biomass. Additionally, a prolonged growing season might lead to an increase in biomass.

Many technical measures exist to ensure adequate water quality, water quantity or nutrient balance for Natura 2000 sites. These focus on:

- Increasing water retention within the site by, for example, adapting the existing drainage system, restore meanders of rivers and streams or reforestation.
- Ensuring adequate water supply in times of drought through the development of water retention basins and/ or irrigation systems (see example 12).
- Ensuring water drainage from the site during excessive periods of rainfalls.
- Periodic mowing of vegetation or removal of the topsoil to avoid nutrient enrichment of the site. Climate change will lead to earlier mowing dates and possibly an increase in the number of cuts.

Example 12: Ensure abiotic conditions – The Great Fen (UK)

A prominent example of ensuring water quantity is the Great Fen project. Changing rainfall patterns potentially affect natural sites (water based ecosystems in particular). By taking pro-active measures to increase water storage capacity, on the one hand, Natural England is tackling droughts, and, on the other hand, taking steps to prevent water overflowing into surrounding agricultural and urban areas.

By increasing storage capacity, Natural England ensures sufficient water supplies to maintain wetland habitats. Water dependent species, such as the otter, will therefore be safeguarded from droughts and protected against starvation.

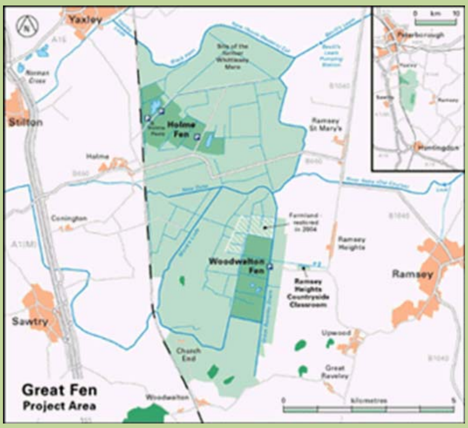


Photo: Courtesy Natural England

Example 13: Ecosystem heterogeneity – increasing shade along streams (Spain)

Climate change is expected to increase the overall water temperatures of streams– re-vegetation in and in areas around streams to increase shade is an important adaptation measures. The time required for "thermal recovery" depends on stream characteristics, local topography, and also factors that affect riparian species composition and their rates of growth. Re-vegetation also brings the allochthonous food source back to the stream ecosystem. Tree roots make banks stable and offer long-term protection against erosion. In general, recovery of stream shade (and therefore temperature) is expected within decades, and is accelerated by deliberate planting: it is most effective and fast in small streams in which stress from sunlight exposure is greatest. However, full recovery of stream and riparian function may take centuries. Re-vegetation of riparian areas was a main measure in 17% of 60 Spanish restoration projects.

Category 4 measures: Management of disturbances and extreme events

Projections indicate are that climate change may increase the frequency of fires, storms and floods. Although many ecosystems are adapted to periodic disturbances, the frequency and the scale of events might pose a threat. Management of extreme events either focuses on reducing the change that they may cause if they should occur, or handling the severity of their impact when they do.

- *Fire management* - The aim of these measures is to minimise the occurrence or the impact of uncontrolled fires. The development of fire buffer zones within a site is an example of such a measure, but preventive burning can also help to reduce the occurrence and impact of uncontrolled fires by simply reducing the availability of fuel. In areas with a high risk of fires, fire management of Natura 2000 sites is often a part of regional fire prevention and management plans. The FAO's handbook on Forest Fire Protection provides a large number of technical measures to reduce the occurrence and impact of fires.
- *Disturbance management – storms.* This type of measure is relevant for two very different ecosystems e.g. coastal habitats and forests. Typical measures include minimising large-scale forest damage by ensuring diversity in age stand and species composition. Storm risk for coastal systems is usually undertaken as part of the overall measures for coastal protection e.g. technical measures, such as the development of dams, or sand suppletion are relevant. A completely different approach is to retreat coastal defence structure and thus create a zone for natural coastal protection (see example 3, Wallasea Island Wild Coast).
- *Flood management.* In general, the majority of these measures are technical, taken from the perspective of overall flood protection of the area. However, measures within the site might consist of ensuring the availability of sufficient refuge areas during floods. (See case study example Cors Fochno SAC)

Category 5 measures: Connectivity measures

Although the majority of these measures are taken at the network level, for large Natura 2000 sites connectivity within the site might need to be improved in the light of climate change. Issues that need to be reviewed include, whether altitudinal ('up the mountain') or upstream movements for species within the site are possible, or if refuge areas are reachable in case of fires or floods.

Category 6 measures: Other measures

This group contains two types of measures applicable at site level;

- *Relocation of species*

Climate change might result in some Natura 2000 areas becoming unsuitable for certain species. Relocation of individual species or populations would be an option to avoid extinction. However, as relocation measures within specific sites are usually embedded in a national programme on relocation, this measure is described more fully in paragraph 6.4.

Obviously, species expanding their range as a natural response to climate change should not be considered as alien species. Even if these new species outcompete presently occurring species, this could be because they are better adjusted to new climatic conditions. Acceptance of new species compositions and thorough consideration of the need for species-specific measures are part of coping with climate change.

- *Control of invasive alien species*

Some alien invasive species will benefit from climate change either by inhabiting new, formerly unsuitable, areas, or through an increased capacity to compete with native species and communities. Depending on the type of alien species, different approaches need to be taken – for example, alien invasive plants can be controlled by biological, chemical, and/or mechanical methods. The European Network of Invasive Alien species provides detailed information on many of the invasive alien species and advises about measures on how to eradicate them (http://www.nobanis.org/Factsheets.asp). The Commission is currently developing a dedicated legislative instrument on invasive alien species, including measures to tackle priority invasive alien species.

In addition to providing benefits to alien invasive species, shifting climate zones can also lead to a change in competition between species. This might lead to an expansion of unwanted dominant species (often trees or shrubs) in Natura 2000 habitats (see example 14: Krkonoše mountains).

- *Consider, where possible, whether or not the designated site can be enhanced beyond its existing boundaries or if there is a need to establish new areas.*

In some sites, adaptation might lead to the need to take into account an immediately surrounding area and consider how that could be specifically incorporated into existing management regimes to benefit the existing Natura 2000 site and biodiversity in the area more widely. For example, in the case of sea level rise, allowing habitats to move inland is a good strategy for natural coastal defense. For some species and habitats, although their current sites may become less suitable, other Natura 2000 sites might provide new habitat. However, if research shows that the new habitat is outside the current Natura 2000 network, exceptionally, it may become desirable to create new protected areas beyond the original Natura 2000 site, but based on the core designation features as these evolve (see example 15).

Example 14: Control of expanding species– Krkonoše National Park (Czech Republic)

Mountainous habitats are amongst the most vulnerable ones because upward moving species threaten the ones on the highest altitudes, which have nowhere else to go. In the Krkonoše Mountains the Arcto-alpine tundra ecosystem at the top of the mountain summits are geographically isolated. Current management actions aim to reduce the occurrence of mountain pine (*Pinus mugo*) at the top of the mountain summits. But climate change will probably increase the colonisation rate of *Pinus mugo* into the arcto-alpine system. So the current strategy to combat *Pinus mugo* could well be a fight in a battle already lost.

Nevertheless, for now, although it remains unknown whether in the longer term these actions will actually sustain the vulnerable habitats or not, this is at present the best strategy.

Photo: Courtesy Krkonoše National Park

5.3 Measures on the network level

Besides the measures suggested in and around the Natura 2000 site, larger scale (network level) adaptation measures are also proposed. Measures on the network level are important to enable species to disperse from present to future suitable climate zones. For species to expand their range, it is vital that existing habitat networks are well connected with neighbouring areas, which will become suitable due to climate change. Facilitating range shifts will require well connected, green infrastructure over large distances, as the suitable climate zones for many species are predicted to move several hundreds of kilometers (see chapter 4 & example 7). This seeks international cooperation to find the best routes and opportunities for implementation of cross border measures (Vos et al. 2010). In textbox 1, the concept of Green infrastructure is further elaborated. More information on the efficiency of the different elements of Green Infrastructure can be found in Mazza et al, 2011.

The overall aim of all measures at the network level is to facilitate movement of species between different Natura 2000 sites, as well as between Natura 2000 and suitable habitat in the surrounding of the Natura 2000 sites. Which measures are needed, depends to a large extent on the land cover (e.g. forest, grasslands) and the land use intensity within the landscape that surrounds the Natura 2000 site and the ecological requirements of the species. The following types of measures can be considered.

- *Improve connectivity by development of stepping-stones and corridors.*

  In intensively used agricultural areas, the wider landscape is often not suitable for the dispersal or migration of species. Small, natural landscape elements within the agricultural landscape - such as tree lines, hedgerows, road/waterway verges, ponds, small woods etc. - provide more suitable areas for dispersal and migration of species. There is even mounting evidence that these natural elements in the landscape surrounding the Natura 2000 site are required to support the biodiversity of the protected areas (Grashof-Bokdam et al, 2009). However, often these natural landscape 'routes' are scattered and of poor quality from a biodiversity perspective. By taking into account species' requirements concerning the robustness and quality of corridors and stepping stones, the connectivity of the Natura 2000 network can be enhanced[6]. For improved connectivity for Natura 2000 sites along or incorporating rivers and streams, the development of river basin management plans (as requested by the Water Framework Directive) offers good opportunities to strengthen the connectivity of river and stream habitats.

- *Implementation of appropriate management of the wider landscape and development of a green infrastructure.*

In more extensively used landscapes, or landscapes that already have a high amount of green infrastructure, the main challenges are to ensure that current management is maintained and that developments do not reduce the amount and quality of the existing green infrastructure. Agri-environmental measures can be good instruments to ensure this management. However, the use of such measures is only effective if a sufficient amount of green infrastructure is developed in the landscape between Natura 2000 sites. Also, other policies, in areas such as spatial planning, or River Basin Management Plans, can be instrumental in improving the management of the wider landscape and development of green infrastructure.

- *Implementation of measures to reduce the barrier effects of roads, railways and technical objects in rivers and streams to facilitate species spatial responses to climate change.*

Man-made infrastructure inhibits the dispersal and migration of species. Technical solutions exist to make new infrastructure more passable for many species or to change existing infrastructure. The book, 'Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions', provides an overview of these measures for road and railways and provides information for which species the measures will be effective.

- *Creation of new areas in order to minimize the occurrence of large spatial gaps in the network.*

For many species, there might be large gaps in the network of suitable areas. Therefore, it might be necessary to link habitat networks, which are currently separated, through the creation of new habitat patches. The need for such measures is

[6] The need to improve the ecological coherence is stated in Article 10 of the Habitats Directive

further explained and illustrated in figure 17. An example is provided for the Tertaclinis forest habitat type. (See example 15).

Textbox 1. The concept of Green Infrastructure.

The concept of Green Infrastructure (Benedict & McMahon 2002) emphasises the importance of ensuring the provision of ecosystem goods and services for society and the value of functionally and spatially connected, healthy ecosystems. Increasingly, it is recognised that Green Infrastructure could contribute to the functional connectivity of the Natura 2000 network by improving landscape permeability and thus could also add to the resilience of ecological networks to climate change (Heller & Zavaleta 2009). In return, resilient ecosystems provide many benefits to society.

The Commission's Communication on Green Infrastructure **(COM(2013) 249 final)**[7], explains its principles and promotes investments within and outside Natura 2000 and other protected areas. It defines Green Infrastructure as "a strategically planned network of natural and semi-natural areas but also other environmental features designed and managed so as to deliver a wide range of ecosystem services.

Green infrastructure describes all elements of an interconnected network of green spaces that conserves natural ecosystem values and functions and provides associated benefits to human populations. It ensures efficient and sustainable use of land by integrating interacting functions or activities on the same piece of land. By giving back space to ecosystems, green infrastructure can maintain and create landscape features, which guarantee that ecosystems continue to deliver services such as clean water, productive soils and attractive recreational areas. It therefore supports economies and societies and makes an essential contribution to natural mitigation of and adaptation to climate change (Lucius et al. 2011).

Such a broad, multifunctional definition has the advantage that many coalitions can be found with other land uses and functions, such as agriculture, forestry and water management. Also the multifunctional nature of green infrastructure provides multiple benefits for society, e.g. biodiversity, climate change mitigation and adaptation, water management, pest control, etc., which will help the support for and implementation of green infrastructure.

[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52013DC0249:EN:NOT

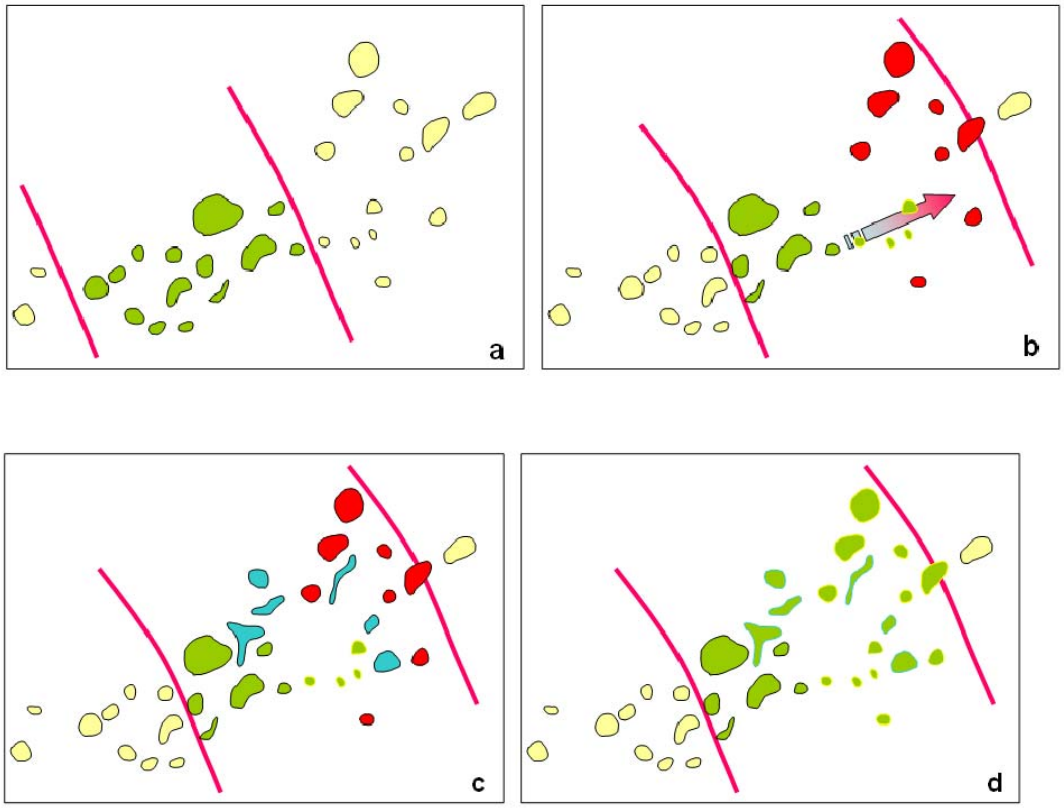


Figure 17. Creation of new areas by closing spatial gaps. At present for species x all the suitable habitat in the suitable climatic zone is occupied (green areas in frame a). In the future (frame b) the suitable climate zone has shifted because of climate change. Although the climate has become suitable in the red areas, they are not colonized, because the species is not able to reach the new areas (gap in the network is too large for species x (bottleneck in the network at arrow). By creating new habitat areas (blue areas in figure c) the species is able to colonize all suitable habitat patches of the network within the suitable climate zone (figure d).

Connectivity is not only improved by taking measures at the network level, as measures at the site level can also help. Enlarging existing areas and improving abiotic conditions are measures to increase the population sizes of species. These measures will also contribute to the connectivity within the total network of suitable areas, as more individuals will disperse from larger populations and this will improve the colonization rate of new areas. Figure 18 provides an overview of the different contributions that different green infrastructure elements can make to improve the overall cohesion of the landscape (Opdam et al. 2003). The roles that different green infrastructure elements can play are indicated for existing areas, stepping-stones, linear features and new (restoration) areas.

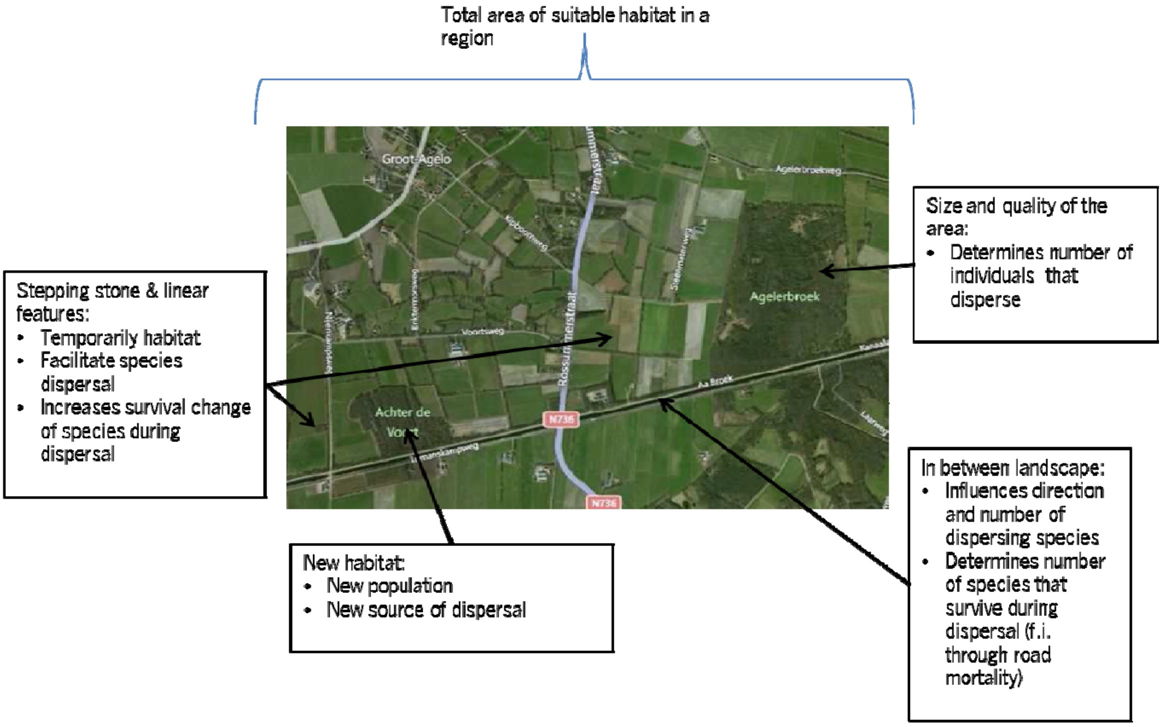


Figure 18. Spatial cohesion of the network is determined by the total area of suitable habitat, the quality, size and shape of habitat patches, the number of stepping stones and linear landscape features and landscape permeability.

Facilitating range shifts is not only beneficial for the protection of individual species, but also important in order to maintain a high level of functional biodiversity in ecosystems: this compensates, for example, for unavoidable species losses at the contracting sides of species' ranges. Evidence is growing that a high level of biodiversity is an important prerequisite for the adaptive capacity of ecosystems and for the sustainable provision of ecosystem services (e.g. Hooper et al. 2005; Johnson et al. 1996).

Example 15 : Reviewing the need for new protected areas

The Natura 2000 *Tetraclinis articulate* forest type in restricted to South-eastern Spain and Malta.

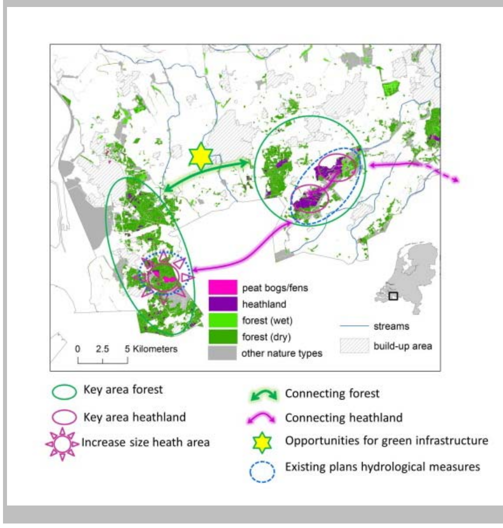
A study reviewed the possible impacts of climate change for this forest type by analysing the change in distribution of this forest type under two scenarios (A2 and B2). Under one of the scenarios (B2) the existing network of reserves will most likely be sufficient to protect the species. Under this scenario the potential area for the forest type is expending and the present and future potential habitats partially overlap and most of the reserves are sufficiently close to allow the migration of the species by means of short-distance dispersal. Under the other scenario (A2) scenario, a loss of the present coastal habitat would occur. Although two existing reserves in the interior would be suitable, the probability of natural colonisation is low due. The species *Tertaclinis articulate* has a low dispersal capability and the present and future potential distribution areas are not overlapping.

Esteve-Selma et al, 2010.

Example 16 : Climate change: Redesigning the ecological network in the Province of North-Brabant (Netherlands)

Since 1990 the Province of North-Brabant (Netherlands) has developed a regional ecological network, which is part of the national ecological network. The Natura 2000 areas are embedded in this network. As part of a larger program to adapt regional policies to climate change, the Province has analysed the main impacts of climate change on nature. Priority zones were indicated where adaptation measures are expected to be most urgent and/or effective to increase the resilience of the ecological network. The main adaptation measures are: increasing connectivity, enlarging existing nature areas, increasing heterogeneity and reducing existing pressures (eutrophication & drought).

Geertsema et al. 2012



5.4 Measures at the policy level

5.4.1 The role of spatial planning

Spatial planning has an important role in mitigation and adaptation to climate change for many sectors (Wilson & Piper 2010). Spatial planning is a vital element in improving the Natura 2000 network's capacities to cope with the impacts of climate change (see example 16). By means of intelligent spatial planning, Natura 2000 sites and their ecological links can be integrated to improve connectivity. Spatial planners at all levels need to consider the options for adapting their existing plans to climate change.

Spatial planning is presently developed mostly at regional and local levels, which impedes effective coordination on development of climate zones that cross administrative borders. Networks need to be improved and linked over large, international transboundary distances. In this respect, the identification of international climate adaptation zones (Vos et al., 2010) may be helpful. Climate adaptation zones are defined as key zones for adaptation measures on the ecological network level to enhance the adaptive capacity to climate change and in which activities that have a negative impact on the functioning of the ecological network can be avoided or mitigated. Within the climate change adaptation zone, no actions that irreversibly block future adaptation of the Natura 2000 network, such as urbanisation and/or road construction, are taken. Inside the zone it remains possible, if not to say essentially important, to adjust measures in future in order to sustain the adaptive capacity of the zone.

As there are indications that a high level of biodiversity is an important prerequisite for the adaptive capacity of ecosystems (e.g. Hooper et al. 2005; Johnson et al. 1996), it is vitally essential that networks are integrated in spatial planning at such a level that range shifts of individual species are facilitated. Subsequently unavoidable losses of species are compensated by newly arriving species, so that the function and the adaptive capacity of the system is maintained. Despite the fact that the composition of biodiversity will then have changed, the resilience of the ecosystem is expected to be preserved, not to say ensured. In addition, a resilient ecosystem is not only beneficial to the system itself, but also is highly functional for others - for instance, functional biodiversity could ease control of pests (e.g. to protect croplands and forests), it makes an area recreationally attractive and a resilient ecosystem is secured to provide effective adaptation to the weather extremes in urban areas.

5.4.2 Relocation of species as an adaptive strategy

For many species, the area which they inhabit is changing. Many species are able to respond to this, by moving on to suitable habitats. However, partly due to the fragmented landscapes through which migration often is impossible, and partly due to dispersal capacity, many species are unlikely to succeed. Their suitable habitats move towards the poles or higher altitudes or upstream and as the changes are happening faster than they can move some are threatened by extinction.

In order to preserve the most vulnerable species, management strategies or options aiming at moving species to new, suitable sites can be considered as a “last resort” option. Before relocation of species is launched, it is essential to gain understanding about whether or not this human assistance has a chance of succeeding; also, the likely effectiveness of other conservation measures, such as increasing connectivity and green infrastructure, need to be understood in order to facilitate the required movements. Using international terminology (IUCN 1998), three management options can be mentioned, which focus on the reinforcement or expansion of a species range:

- **Re-introduction**: an attempt to establish a species in an area which was once part of its historical range, but from which it has been or become extinct;
- **Translocation**: deliberate and mediated movement of wild individuals or populations from one part of their range to another;
- **Conservation/Benign Introductions (IUCN 1999) or assisted migrations**: attempt to establish a species, for the purpose of conservation, outside its recorded distribution range, but within an appropriate and eco-

geographical area (all definitions see IUCN, 1998). This management option can be described as to physically move a species to new suitable habitat outside its original range.

Re-introductions and translocations are well studied and guidelines have been produced by IUCN (IUCN, 1998). Many such projects are linked to a breeding program (in situ or ex situ). Such experimental populations can also be essential to the continued existence of the species, introducing specimens into new suitable habitats.
Selection of species, candidate sites and the technical possibilities of relocations are all debated with regard to assisted migrations. An important element of the decision making process is an analysis of the ecological uncertainties and risks, the legal framework, an assessment of the essence of such an assisted migration, the economic and technical feasibility and likely social acceptance (Piper & Wilson, 2008; McLachlan et al., 2007; Hunter, 2007) before relocation is actually carried out.

Hoegh-Guldberg et al (2008) developed a very useful decision tree to assess whether relocation as a response to climate change could be an option (see figure 19). Although controversial, assisted migration can be reviewed as a last resort option for some species to adapt to climate change (see example 17).

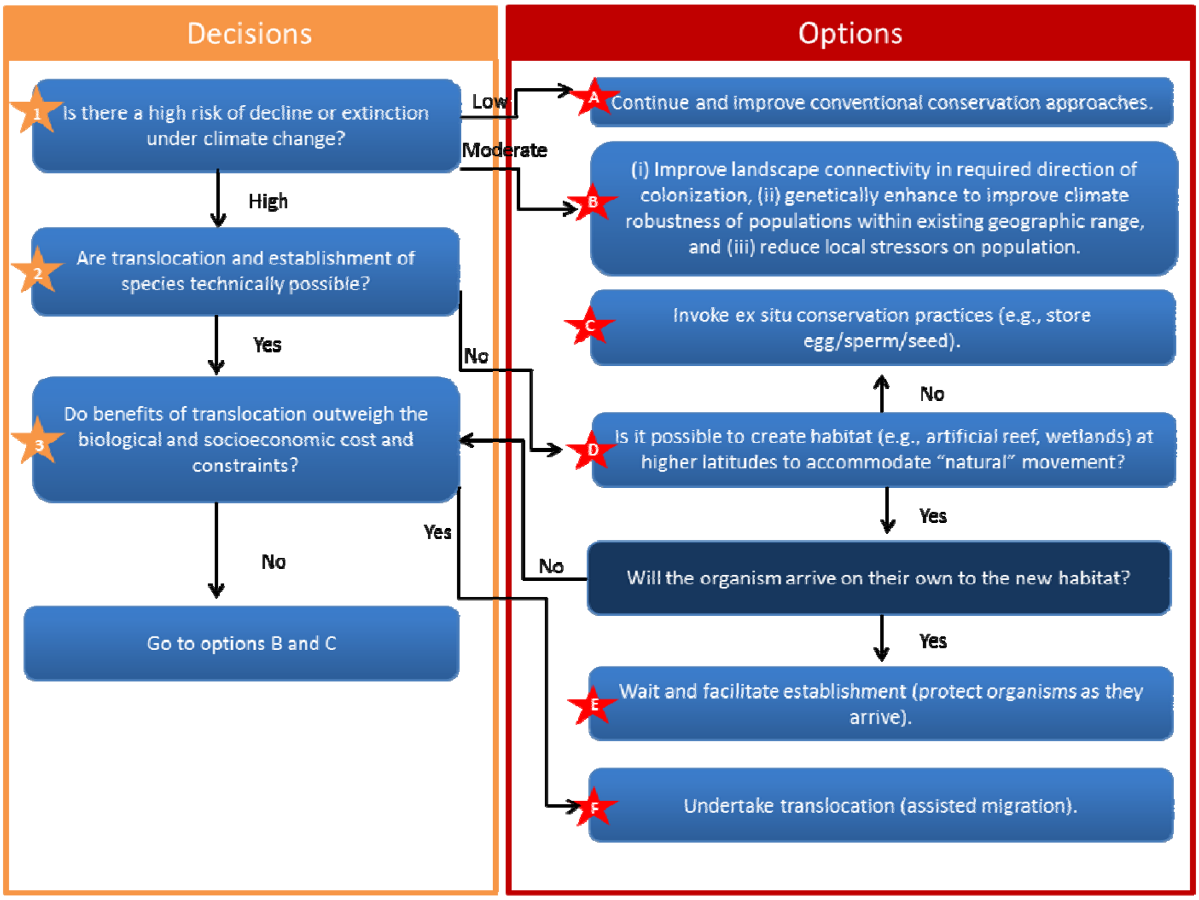
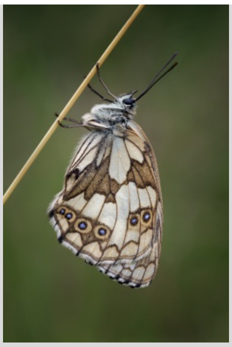


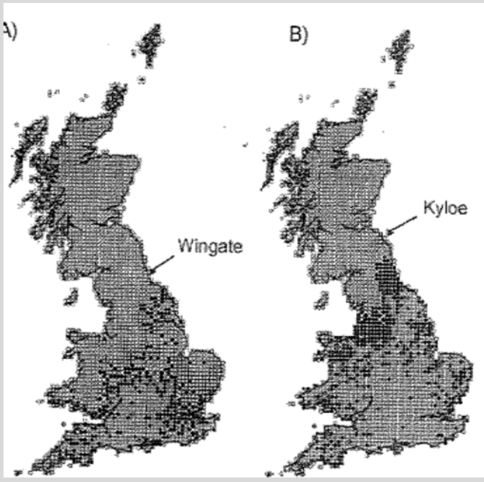
Figure 19. Decision tree developed by Hoegh-Guldberg et al (2008) to assess the need for relocation as a strategy to climate change.

Example 17: Successful relocation of butterflies (UK)

In the United Kingdom, butterfly species have been relocated successfully. The Marbled white (*Melanargia galathea*), Small skipper (*Thymelicus sylvestris*) (Willis *et al.*, 2009; see fig. 4.1) and the Virginia round leaf birch (*Betula uber*) (Shirey & Lamberti, 2010) were assisted in the colonisation of suitable habitats. Before the relocation actually happened, scientists and nature conservationists joint forces to combine the good understanding of the butterflies' ecologies and monitoring data with modelling outcomes, in order to assess whether or not the relocation could be successful.

Recent range expansion for (A) M.galathea and (B) T. sylvestris in the UK at a 10km grid resolution. Black circles represent grid squares newly occupied in 1995-1999. Sites of introduction at Wingate Quarry Co for M.galathea and Kyloe Quarry for T. sylvestris.





Map: Courtesy Willis et al, 2009
Photo: Shutterstock

During the initial phase of an assisted colonisation project, it is highly recommended, not to say essentially required, to strictly follow a set of guidelines. These guidelines should be developed by governments in cooperation with nature conservation organisations, preferably with an international scope, and should at least address the following topics:

- Experiences with other assisted colonisation projects;
- Knowledge on life-history traits and ecological preferences of the respective species;
- Current habitat range of the selected species or comparable species and their life-history characteristics;
- Modelling work on the (natural) dynamics of the species under climate change;
- Community interactions;
- Dispersal capacity and possible obstacles in migration routes;
- Genetic diversity;
- Monitoring the assisted colonisation.

Currently however, guidelines that address the legal introduction of a threatened species into a new environment are still lacking (McLachlan et al., 2007, Shirey & Lamberti, 2010, Camacho, 2010).

Category	Type of measures	On site	Around site	Network level
Reduction of existing pressures	Restoration measures	X	X	
	Buffer zone development		X	
	Increase reserve size		X	
Increase ecosystem heterogeneity	Enhance structural gradients	X	X	
	Allow natural processes	X	X	
Ensure abiotic conditions	Water quality	X	X	
	Water quantity	X	X	
	Nutrient balance	X		
Manage impact of extreme events	Fire management	X	X	
	Flood management	X	X	
	Storm management	X	X	
Increase connectivity	Develop corridors/ stepping stones	X	X	X
	Wider landscape management		X	X
	Create new nature areas		X	X
	Spatial planning		X	X
Other	Review existing boundaries/ need to establish new sites		X	
	Relocation			X
	Asses geographical distribution of protected area network			X
	Invasive species control	X	X	X

Figure 20. Location of the various measures in site, around or at network level.

6 The decision framework

6.1 How to use the decision framework?

The decision framework is basically a set of questions, which systematically addresses the issues site managers and policy makers can consider while addressing the issue of Natura 2000 network and climate change (see figure 21). The questions in the decision framework are explained in this chapter. The questions and brief explanation below will guide you through the process of identifying climate change impacts on your site or the network and how to designate the appropriate adaptation (and mitigation) measures.

What are the (potential) effects of climate change in my site, region or country? How severe a change is expected in my site, region or country? What is the time frame of the expected change?
European-wide maps, as well as national sources, are available that provide (in more or less detail) spatial projections for expected changes in climate (e.g. EEA, 2004, Ciscar et al., 2009, see also the Clearing House Mechanism on climate change impacts, vulnerability and adaptation). In addition to the base information of changes in seasonal climatic conditions, information sources to look out for are the increase in occurrence of fires, storms and floods, expected increase of drought and water scarcity, river flow changes and expected sea level rise. This information will allow you to better assess if and how your site can contribute to the adaptation of some of the expected climate change impacts, which will affect other sectors.

The information sources on climate change that are available (at European, national and regional scales) provide an estimation of the timeframe in which the changes in climate can be expected: these change according to different greenhouse gas emissions scenarios. This information will allow you to better assess the severity of the expected impacts and help you to prioritise the most important effects to tackle.

In addition to looking for information on the overall impacts of climate change it is also useful to consider how the surrounding land use of the site/region might alter as a result of climate change and whether this will have impact on the Natura 2000 site.

How can Natura 2000 sites assist in mitigating or adapting the region to climate change?

Natura 2000 provides various natural solutions to climate change. Based on available information on the expected effects and the main impacts for society, the contribution of the Natura 2000 site or network for climate change can be determined. Figure 5 highlights the most important ways in which sites can assist in mitigating and adapting to climate change. Based on the type of ecosystem and the specific location of your site it could offer various options, for instance:

- Reduction of impact of sea level rise (for coastal areas).
- Carbon storage and increase capture of carbon (all ecosystems but especially peat lands and forests)
- Climate regulation (all areas but especially relevant for areas located near urban areas)
- Increased water retention / storage (Riverine Natura 2000 sites or areas prone to flooding)
- Reduce risk of extreme events

How vulnerable are Natura 2000 species and habitats to the potential effects of climate change?

As part of the development of these guidelines, a supplement is developed that contains a look-up table. All Natura 2000 species and habitats are listed with an indication of the vulnerability, adaptation potential and vulnerability to climate change is given, based on available scientific information as well as on expert judgement. For two species groups butterflies and birds, climate change atlases are available that depict for each species the expected range shift in Europe (Huntley *et al.*, 2007; Settele *et al.*, 2008)[8]. Provided that the limitations of this information are

[8] Also for plants and amphibians and reptiles climate envelopes have been developed. However they are at present not yet published.

fully understood, it will help to assess whether your site, region or area is located in an area for which a range shift for these species groups can be expected or not.
Additionally, if national information of the expected impacts for species and habitats is available, it should certainly be employed. A good way to quickly combine all available knowledge is to organise a workshop (with stakeholders and experts) to address the impacts of climate change on your site. Figure 15 provides an overview of the effects of climate change that you might need to address. Figure 16 provides an overview of the various measures you might consider. The main categories of measures are:

- Reduce existing pressures
- Increase ecosystem heterogeneity
- Ensure abiotic conditions
- Manage impact of extreme events
- Increase connectivity
- Others (spatial planning, policy and relocation)

What potential does the location of the site(s) provide for species and habitats to adjust to climate change?
As each Natura 2000 site is different, an assessment of the local context is required.

- For extreme events: are refuge areas for species available?
- For altitudinal ('up the mountain') and longitudinal movement of species: is the area embedded in a network of green infrastructure?
- For sea level rise: Are there coastal defenses, roads or urban areas in the vicinity or coastal barriers that prevent habitats from moving inland?
- What potential is there for introducing buffer zones/site extensions and developing cross-sectoral adaptation plans with neighbours and in the surrounding landscape?

In a joint effort with experts to answer the questions above, a provisional list of the impacts should be produced, including the knowledge-gaps. Then adaptation and mitigation measures are explored and if possible prioritised.

Managers and policy makers might have difficulty in deciding if and which measures to take in order to adapt the Natura 2000 network to climate change. Overall, reducing existing pressures is a **no-regret** measure to ensure that species and habitats are better capable to cope with climate change. Furthermore the threat posed by the impacts of climate change for species and habitats needs to be compared to other existing threats. If the impacts of climate change are low compared to other threats dealing with the other threats should have a higher priority.

Whether or not to take measures to adapt the Natura 2000 network to climate change requires balancing the threats posed by climate change to the conservation status of the species and habitats and the costs of adaptation measures taking also into account the expected success.

To conclude, it needs to be emphasised that there will always be (to varying degrees) uncertainties in the assessment of climate change impacts that you will have to deal with: therefore, it is absolutely essential not to solely focus on a (few) single expected impact(s) or a set of limited actions - it might turn out that they do not become true; alternatively, other impacts, that were not taken into account, may occur (Smithers *et al.*, 2008). The key point is that uncertainty needs to be addressed both for the impact of climate change on Natura 2000 species and habitats, as well as in respect of the impacts of climate change for society in general, and to consider likely consequences through pro-active, adaptive site management.

How can the vulnerability to climate change be managed?

Once the main impacts have been determined, we can begin with formulating measures to mitigate or adapt to climate change.

What are the possible adaptation measures for each impact?

Based on the identified impacts, the required and desired measures to address the impacts of climate change can be identified (by using figures 15 and 16 in Chapter 5?). For instance, if one of the identified climate change impacts is temperature increase and a consequence of that is drought, a possible type of measure is to increase ecosystem heterogeneity. Specific adaptation measures should then concentrate on, for example, enhancing vegetation structure within the site and strengthening natural processes in and around the site. These measures aim to reduce the impact of a drought on species and habitats as much as possible.

Apart from the measures mentioned in these guidelines, of course it remains important to think of any additional adaptation measures, which might be relevant, based on national, regional and/or local knowledge.

Which group of measures or which specific measure is most relevant to my site/ region/ country and at which level does it need to be implemented?
By combining your knowledge of the site, region or country, the information provided in these guidelines and available in European and national handbooks, the relevance and applicability of the various measures needs to be reviewed.

Based on the outcomes of the questions above, a provisional listing of the measures which may help to address climate change can be prepared and implemented, according to an assessment of priority and predicted benefit.

Who and what resources are needed?

For each of the identified measures, it will be useful to identify the relevant stakeholders that you may want to involve in the process of developing adaptation measures: certainly, some of the stakeholders will gain benefits (ecosystem services) from the adaptation measures and therefore may be willing to work with you. Particularly, a key point to make to engage stakeholders is by explaining the role that ecosystem services will have to mitigate climate change or address impacts of climate change, and the benefits they have for other sectors and the wider society. Also, it is necessary to find out which (human) resources you need for the different measures.
Integrating ecosystem services in the adaptation of site management will provide arguments to carry out certain measures. By working together with stakeholders that are not directly linked with nature conservation, determining which measures in response to climate change should be taken, synergies can be found, increasing the opportunities for sustainable adaptation and cross-sectoral ‘win-win’ outcomes.

Based on the outcomes of the questions above, a provisional listing of the measures at different levels, time frame (short, medium, long term) resources and strategic alliances can be developed.

Monitoring measures and their effects

Adaptive management includes reviewing the effect of management measures taken. Harley & Van Minnen (2010) propose which kind of indicators can be used for the monitoring process, which will provide essential knowledge about impacts and help to shape adaptive management measure outcomes. Not only the effectiveness of the measures taken is assessed, but also to what extent adaptation policies are effective: this is a key step to determine what works and to facilitate the implementation of climate change adaptation measures. The principle objective of adaptation indicators is to monitor the implementation of adaptation policies and measures and to show whether vulnerability of habitats and species can be reduced effectively through adaptation actions.

Harley & Van Minnen (2010) make a distinction between process-based indicators and outcome-based indicators. For policy-makers the following (exemplary) indicator aims are proposed to ensure that:

- Existing relationships are being strengthened and new partnerships built;
- Awareness of the benefits that biodiversity provides and its role in adaptation is increasing;
- Best practice is being communicated and information exchanged on successful adaptation.

For site managers, other process-based and outcome-based indicators can be appropriate, for example:

- Vulnerability assessments of biodiversity and ecosystems are being undertaken;
- New approaches are being piloted;
- Adaptation actions are being continuously monitored and re-assessed;

- Other sources of stress and harm are being reduced;
- Buffer zones are being established around conservation areas;
- Networks of interconnected protected areas and intervening habitat mosaics are being established.

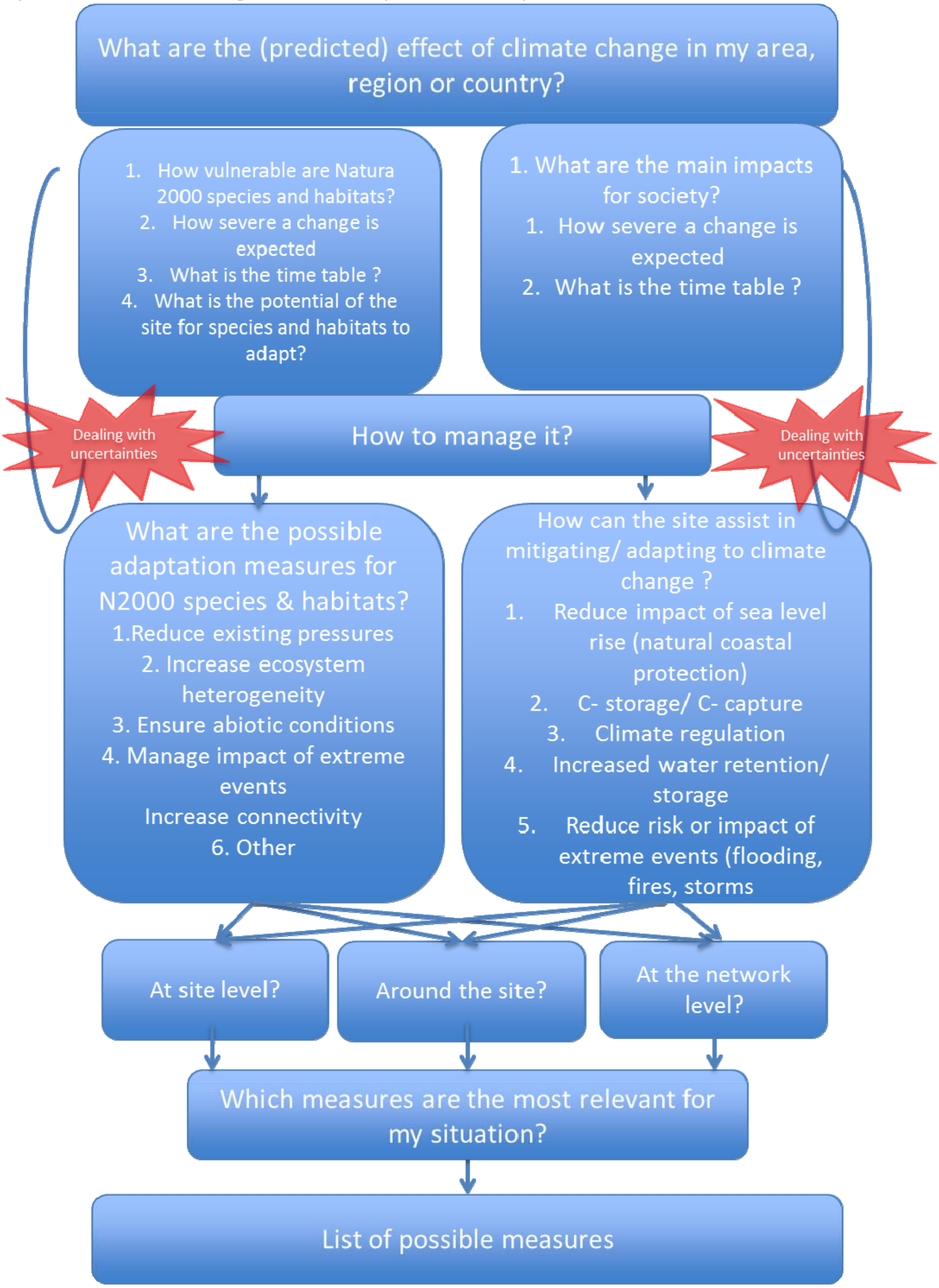
In addition to these, it remains essential that site managers continue to monitor on-site effects - How do (populations of) species and habitats for instance develop? Is their quality (determined by quality/biodiversity indicators and trends) increasing or decreasing? How does the quality relate to the management measure, the time scale and the execution of the measure, and as a consequence of that, is continuation of the management appropriate or should adjustment be considered?

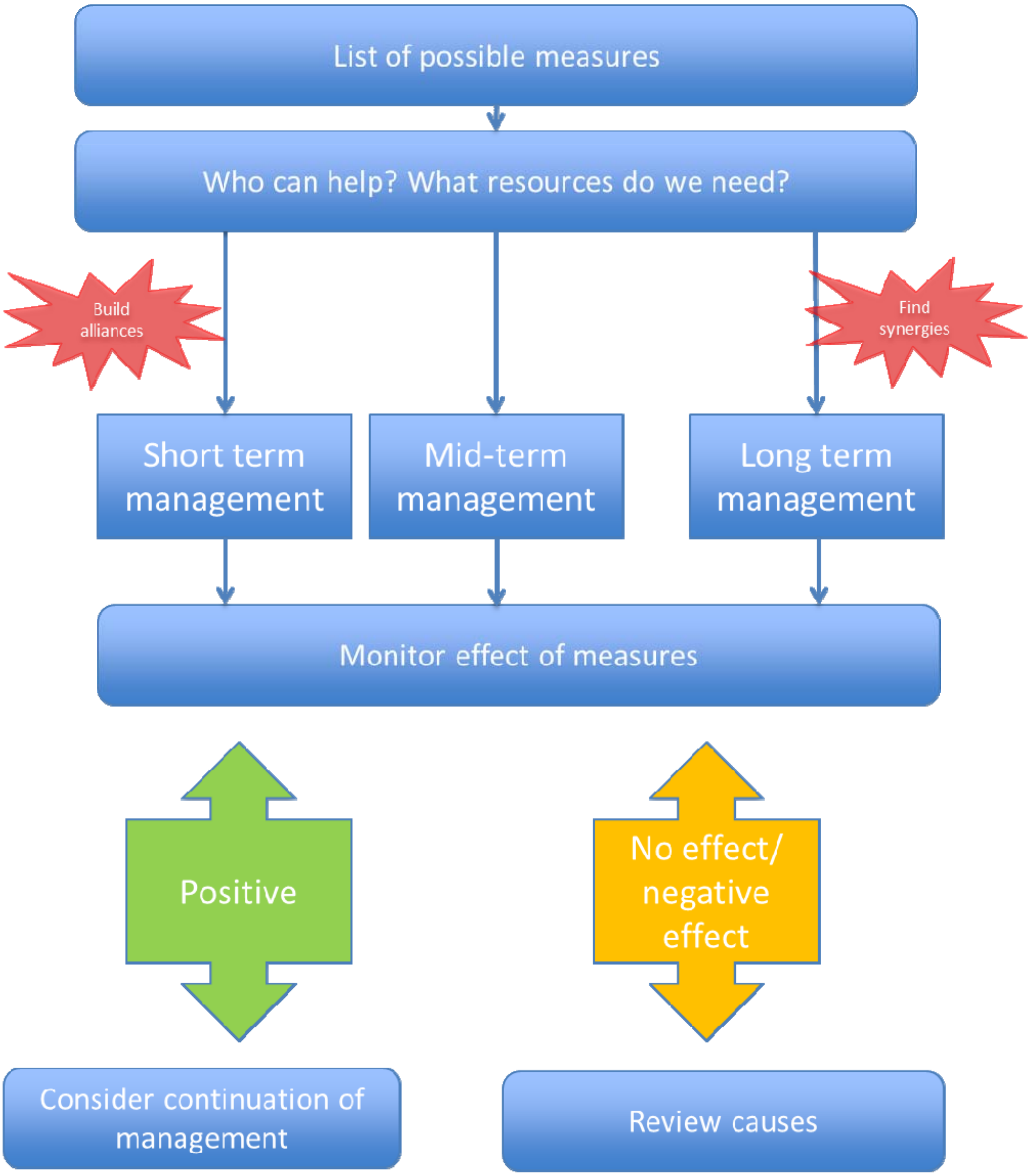
That said, dealing with climate change can be difficult and complex. This gives rise to a fundamental question when an adaptation measure turns out to be unsuccessful: is the impact of climate change in the area so large that it cannot be managed? A clear answer to this question does not exist. However, a degree of caution is sensible – before ascribing the lack of success of measures to the degree of climate change, it is good to consider the following:

- ➔ Are there climatic data (temperature, precipitation, recorded weather extremes) that quantify and prove a (large) change in climate in the region?
- ➔ Are species or habitats in nearby Natura 2000 sites or protected areas also in decline?
- ➔ Are there other indications of biodiversity responding to climate change - for example, are species/ habitats with comparable climate preferences also declining? Are new species entering the area?
- ➔ Have all other, non-climate pressures, been addressed (successfully)?
- ➔ Is more time needed for your management to have effect?

If there are clear indications that the effects of climate change are indeed a main cause of decline and that no further measures will be able to alleviate them, it might be necessary to reconsider the conservation objectives and priorities for the site. Conservation targets need to be regularly reviewed to ensure resources are directed towards conservation priorities as some species increase, others decline and habitats change in character as a result of climatic changes (Smithers et al., 2008).

Figure 21 . Schematic representation of the decision framework




List of possible measures
Who can help? What resources do we need?
Build alliances
Find synergies
Short term management
Mid-term management
Long term management
Monitor effect of measures
Positive
No effect/ negative effect
Consider continuation of management
Review causes

6.2 An example of the application of the decision framework

In this paragraph a simplified example of a filled-in decision framework is presented (figure 22). It is largely based on the Natura 2000 site, Voornes Duin, a Dutch Natura 2000 site along the coast. The area has been designated for its dunes, dune valleys, forests and shrubs and for three particular Natura 2000 species (amongst others):

- H2120 Shifting dunes along the shoreline with Ammophila arenaria ("white dunes")
- H2130 Fixed coastal dunes with herbaceous vegetation ("grey dunes")
- H2160 Dunes with Hippophaë rhamnoides
- H2170 Dunes with Salix repens ssp. argentea (Salicion arenariae)
- H2180 Wooded dunes of the Atlantic, Continental and Boreal region
- H2190 Humid dune slacks
- H1340 Root vole (*Microtus oeconomus*)

In the more Northern dunes areas of the Netherlands, the Hen harrier (*Circus cyaneus*) also occurs and is included in this example to illustrate the use of climate atlases.

How vulnerable are the species and habitats in my area, region or country?

1. Coastal erosion is slowly growing and expected to become rather severe in a period of 25 years. This will lead to high erosion rates of the white and grey dunes. An increased occurrence of storms is not expected, but an increase in severity is.
2. Sea level rise increases the influence of salt water on groundwater. The humid dune valleys in the area are relatively sensitive to an increase in salinity in groundwater. The species composition could change. Already now a high level of nitrogen deposition is affecting nutrient poor dune grasslands.
3. The area is protected for the Hen harrier (*Circus cyaneus*), although the potential distribution is predicted to move northwards, the area still falls in the predicted potential distribution range.
4. Overall precipitation will decrease –leading to a loss of wet grasslands /reed beds possible affecting the Root vole (*Microtus oeconomus*)

How can N2000 assist in mitigating/adapting to climate change?

- Act as natural coastal defense for the urban areas in the hinterland
- Ensure regional climate regulation for the nearby large cities

Dealing with uncertainties:

1. What if the sea level rise is less or higher then predicted- will it also affect dune valleys and forest?
2. Will other vole species enter the area and outcompete the Root vole in the areas that have become drier?
3. Will a changed water management regime to reduce salinization affect the dune valleys?

What are the possible measures for N2000 species & habitats?

1. Reduction of existing pressures: restoration measures (removal of enriched top soil: e.g. shrubs), reduce nitrogen deposition caused by activities in surrounding areas (mainly traffic and harbor industries)
2. Increase ecosystem heterogeneity: improving/restoring natural dynamics of the systems (removal of shrubs to increase sand drift and beach nourishment)
3. Manage impacts of increased severity of storms: ensure (re)formation of the dunes after storms and floods (beach nourishment)
4. Ensure abiotic conditions: more information needed on local hydrology
5. Increase connectivity between small habitats and larger habitats of Root vole

1. Manage impacts of extreme events: ensure the protective capacity of the dunes to sea level rise, storms and floods (beach nourishment)

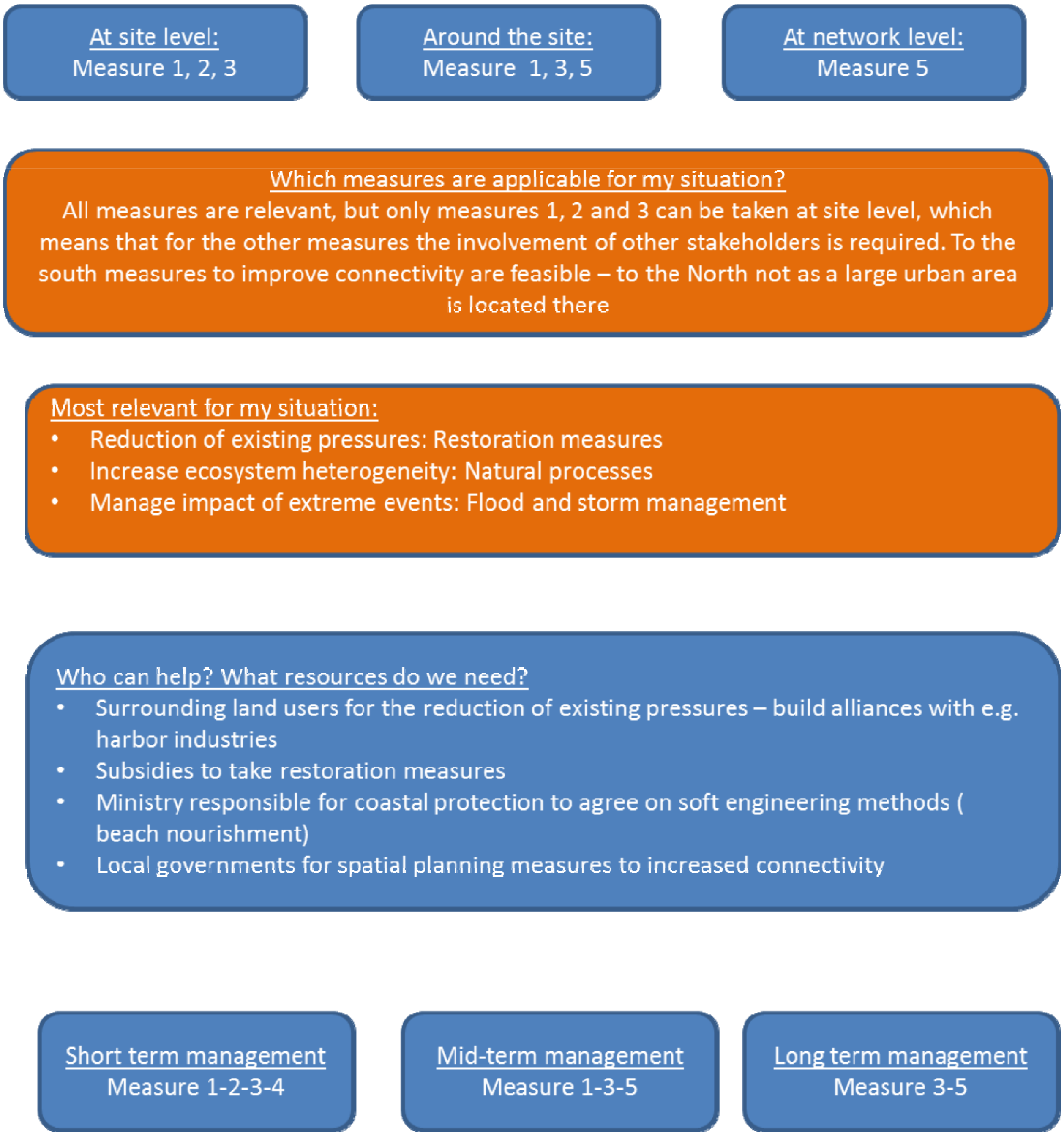


Figure 22. A simplified example developed by using the decision framework

7 Core Advice & Summary Recommendations

The main purpose of these guidelines is to describe the benefits available from Natura 2000 sites in dealing with the impacts of climate change and how adaptation of management for species and habitats protected by Natura 2000 can be used to tackle the effects of climate change. In particular, they highlight the need for increasingly adaptive management to realise the full potential of nature as part of the solutions to climate change. Adaptive management is important not only to ensure that habitats, plant and animal species across Europe can respond to climate change, also for society. The guidelines focus on providing practical advice about key principles involved to develop adaptive management for climate change. They also identify the need for greater integration and cross-sectoral working: the involvement of multiple stakeholders, active within and around Natura 2000 sites, is required to safeguard biodiversity and respond to climate change.

Natura 2000 – part of the solution to climate change

The Natura 2000 sites and the natural resources they contain, have a crucial role to play in mitigating and adapting to climate change. As repositories of Europe's most precious biodiversity, it is essential that Natura 2000 sites are managed for their intrinsic value and also for the value of the key ecosystem services they provide for society. Increasingly, as the impacts of climate change become known, it will be necessary to ensure that Natura 2000 sites, and indeed all protected areas, are capably managed in ways that allow for adaptation to and mitigation of climate change.

From the research conducted and referred to in these guidelines, and the case study examples provided, it is clear that there is continuing uncertainty about the practical responses required for climate change. Part of this stems from the fact that, despite a wealth of scientific research and growing knowledge about how climate is changing, it is difficult to translate this into applied practical management of its impacts. There is an urgent need to bridge the gap between the growing scientific knowledge and its practical application in the field.

Within the scope of this project, the case studies gathered provide good evidence of pragmatic management actions being developed and applied to address climate change: however, they are not common. From the consultation and information gathering process involved in preparing the guidelines, it appears that there is wide diversity and a discernable lack of confidence in terms of knowing what to do at site level. This is even more evident in terms of management for climate change at network level: ecological connections between sites and in their surrounding areas generally receive little attention. In this respect in particular, the emerging Biogeographic Regional Process holds promise, as it is designed to provide a framework for cooperation between Member States on Natura 2000 priority habitats and species at biogeographic regional level. Also, it will establish useful mechanisms to capitalise on national studies and EU level research on climate change, especially in sharing information and building knowledge about impacts on priority species and habitats. In addition, the Prioritised Action Frameworks (PAFs), are expected to be developed by Member States by the end of 2012: this will involve specification of how Natura 2000 and nature conservation priorities generally will be funded at Member State level using not only financial mechanisms in place for nature. The aim is to create integrated funding packages, where nature conservation funds is used to trigger and secure contributions from non-environment sectors, such as agriculture and rural development funds. This development further underlines the growing push for integrated solutions that yield multiple benefits for nature, economy and society: also, it will serve to embed nature and ecosystems in terms of their key contribution to future sustainable development and as part of the solution to barriers to that, including from climate change.

It is clear that there is a need for increasingly adaptive approaches to be developed and applied in greater numbers of Natura 2000 sites, especially as this will enable the natural resources they contain to be harnessed as part of the solutions for climate change. Effective monitoring practices are an integral feature of adaptive management – as an approach, it specifically requires, the effectiveness of actions in managing the impacts of climate change to be routinely and systematically evaluated, so that continuous improvements can be developed, adapted and applied.

There is much to learn about how to manage climate change and the Natura 2000 network of practitioners will have an essential role to play, enabling real progress to be achieved through sharing experiences about what works and what does not through development of adaptive approaches.

The case for greater and improved integration

The impacts of climate change are complex and multi-faceted: they do not affect one sector in isolation and climate change will have implications across society. Given the adaptation services natural areas can provide to other sectors, there is a growing need to act in coordination with stakeholders in multiple sectors: the effective management of climate change impacts will require greater attention and inputs, not just from the nature conservation community. Equally, the scale of the impacts associated with climate change requires more integrated solutions that involve cross-sectoral collaboration and an engaged public, as well as skilled nature conservation professionals. As knowledge grows and experience increases, it will become increasingly possible to demonstrate how nature, when managed adaptively, can provide part of the responses required for climate change. Also, positive results and best practice examples will help to communicate the need for urgent action on climate change and show what can actually be achieved. The case for urgent action on climate change needs to be made well and to be appropriately and widely communicated. Importantly, especially in terms of reaching out to engage the public, it is necessary to avoid jargon and use real-life examples. Increased practical experience can be used to generate evidence to convince other sectors and the public that they have a stake and that nature has a role to play.

Core Advice for Site Managers

Although the scale of the problems associated with climate change can be daunting, these guidelines show that it is necessary and also possible to take action now: even if at first sight the impacts of climate change may be uncertain, there are useful steps, which can be applied in and around Natura 2000 sites, as well as at network level. Chief amongst these is to recognise climate change as an issue and develop an adaptive management approach (as appropriate) for your site. The decision framework provided in Chapter 6 is offered to structure the development of an adaptive management process and can be applied in different types of Natura 2000 sites. Essentially, it advocates integration of monitoring as a core part of an adaptive management planning process - adaptive management of Natura 2000 sites and all protected areas require monitoring of the actual effects of climate change, as well as evaluation of the effectiveness of measures developed to address its impacts.

The extent to which climate change and its impacts affect individual Natura 2000 sites is highly variable. Climate change can result to threats and opportunities. It is important to accept that, despite the best management, some species and habitats might disappear; equally though, other sites may see biodiversity gains. However, the scope of these guidelines is not to develop specific advice for specific sites. The advice presented in the guidelines needs to be reflected upon and applied according to the features and condition of individual Natura 2000 sites, their position as part of a connected ecological landscape and the role that their natural resources can play for society.

That said, what emerges from the research and case studies presented herein is that developing and applying adaptive management as an approach is worthwhile for all sites, especially in response to climate change and its impacts. The following is a summary of key practical steps described in the guidelines, which, when implemented according to need, will enhance and improve management generally and, specifically, enable climate change to be included as a core issue within adaptive approaches:

- **Continue to take all necessary measures that aim to reduce existing pressures on Natura 2000 sites, as they have a key role to play in lessening the impacts of climate change to biodiversity.** Also, in taking steps to enhance site resilience, it is vitally important to consider each individual Natura 2000 site's position in the context of the Natura 2000 network and also its surrounding area. There are management actions, which may be required or will be appropriate to increase the ecological resilience of biodiversity on your site, as well the surrounding area or indeed other Natura 2000 sites. This is perhaps most obvious when thinking about flyways for birds and migration routes for other species; however, it is also appropriate to think about the ecological connections that exist for wider biodiversity and the benefits this can bring for wider society. Acting in a joined-up way and developing management measures which take ecological connections into account will be useful to make biodiversity on your site and in general terms more resilient.

- **Take stock of what is known and where it would be useful to gather more information or gain knowledge.** A reasonable assessment can be made about how a site is or is likely to be affected by climate change, especially if a multi-disciplinary team is involved – as a first step, for example, organise a (local) workshop to share information and experience and discuss the management implications of climate change impacts and potential measures which can be applied.
- **Aim to define climate change in terms of the scale and scope of current and/ or likely impacts and use this to develop adaptive management plans.** In recognising that climate change is an issue, even if it is not yet evident on individual sites, it is still desirable to prepare and develop reasonable adaptive management strategies and actions. Often a site management plan is devised for a period of between five and ten years, yet the impacts of climate change can occur over a much longer timescale. However, by developing a phased, adaptive approach and identifying management measures, which require to be implemented in the short, medium and long-terms, sites will be better managed specifically to cope with climate change now and in future. Also, an adaptive approach can help to demonstrate a site's connectedness with the surrounding landscape and wider society, by making clear the contribution that their natural resources can make to climate change impacts can be specifically recognised. The ways in which a site is managed has implications and (potential) benefits for neighbouring areas and other Natura 2000 sites.

- **Routinely assess the vulnerability of site features in terms of exposure to and vulnerability for climate change impacts.** This will enable the adaptive capacity of species and habitats at the site level to be measured – whilst every site will be different and data may not be fully available, this is an essential and iterative step to the development of appropriate management strategies to adapt the site to climate change.
- **Seek information and experience from others to inform possible measures and tools that could be useful for your site**. Managers and other experts may already have experience of dealing with climate change in sites similar to yours; this is a key resource which should be used to think about ways to manage features and conditions on your site.
- **Be open to and, where appropriate, seek out, opportunities to work in partnership with stakeholders in other sectors.** Take inclusive actions and develop integrated approaches to explore whether or not there are mutually beneficial measures. There are often mutual gains to be realised for nature and other sectors' priorities when synergies can be found and alliances built.
- **Encourage a process of participation of the local population and undertake the necessary communication actions in order to ensure the necessary understanding and support for the foreseen measures".**

Core advice for policy makers

As the research conducted and referred to, and, as several case studies gathered for the guidelines show, it is clear that improved and more sophisticated integration between environmental and other sectors will be required to address climate change - for example, transport, agriculture, spatial planning, as well as local government structures with primary responsibilities for people's social and economic well-being. This is perhaps most obvious in coastal areas – natural coastal defences, as opposed to build structures, are a valid consideration as they are likely to be more sustainable and more cost efficient in the longer term: vitally, natural coastal defences, such as dune systems, can adapt in response to a changing climate.

As more becomes known about climate change and as experience is gained, it is clear that improved, integrated approaches will become increasingly important across much wider areas and a diverse range of Natura 2000 site locations. In this, the key message is that nature holds core resources, which can be harnessed as part of the responses required for climate change. Healthy and more resilient biodiversity is intrinsically better able to adapt to climate change: in economic terms though, it can also be viewed as a worthwhile investment and cost-efficient option in place of, or in combination with, man-made responses to climate change.

Policy makers should have a clear idea of the socio-economic context in which the adaptation/mitigation measures will be implemented as well as of their impact and benefits. Such an assessment should also be used for better targeting both the foreseen measures and the communication actions towards the local population and stakeholders

- **For policy makers, in all sectors, especially working at regional and national levels, there are valuable opportunities emerging to develop increasing cooperation and collaborative responses to climate change that also achieve gains for nature.** For example, the Biogeographic Regional Process provides a framework for collaboration between Members States to support implementation of Natura 2000: specifically, this process identifies climate change as an issue and encourages sharing of information, experience and resources to build knowledge and invites holistic responses and joined-up action.
- **Facilitate public private partnerships (PPPs)**. Commercial organisations have much to gain from embracing nature conservation priorities and have valuable resources to be included as part of collaborative solutions to climate change.
- **Ensure that the needs of nature are considered as an integral part of the adaptation of all relevant cross-sectoral policies.** Nature is essential to mitigate the impacts of climate change and has a major role in developing sustainable adaptation for many sectors.

- **Ensure that individual Natura 2000 sites and the Natura 2000 network become embedded in coherent green infrastructures.** This will enable nature to become part of the solutions required for climate change, benefitting biodiversity, people and society.
- **Build in the need to monitor for the impacts of climate change on biodiversity in non-environment sectors** – for example, how is climate change affecting crop yields, river way transportation arteries, people's health, business re-locations?
- **Develop international/transboundary climate zones that facilitate long distance movements of species -** adapt policies to ensure that climate change and its likely impacts are taken into account and considered wherever appropriate. This is likely to involve thoroughly reviewing existing policies and strategic frameworks to incorporate the contributions available from Natura 2000 to being a vital part of solutions to and required for the negative impacts of climate change on, for example, social issues in relation to urban areas.
- **Ensure that climate change, biodiversity and Natura 2000 are embedded in communication actions towards the local population and stakeholders and that adaptation/mitigation measures are included in this communication framework, in order to gain the necessary understanding, participation and support"**.

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Annex 1. Overview of different adaptation measures and the examples provided in this guideline

Category	Type of measures	Examples of specific measures
Reduction of existing pressures	Restoration measures	Ex. 7/ CS Voorne Duin: removal of shrubs and topsoil CS Anderstorp Store Mosse: mires & wetlands restoration
	Buffer zone development	
	Increase reserve size	Ex. 8/ CS Great Fen: increase of reserve size
Increase ecosystem heterogeneity	Enhance structural gradients	Ex. 12 Stream restoration , CS Spain, CS Great Fen: increase variationin structure
	Allow natural processes	Ex. 7 /CS: Voornse Duin: increase sand drift through sand supletion
Ensure abiotic conditions	Water quality	CS Bosherston Lake: improve water quality
	Water quantity	Ex. 11, CS Great Fen/ CS Bosherston Lakes protection against drought
	Nutrient balance	CS Great Fen: earlier mowing dates
Manage impact of extreme events	Fire management	Ex 2: Adaption of Med. Forests, CS Spain: restoration wetlands areas
	Flood management	Ex. 4, Cs Bosherston Lakes: avoidance of occurrence of impact of sea level rise
	Storm management	Ex. 3, CS Bosherton Lakes
Increase connectivity	Develop corridors/ stepping stones	Ex. 14: Province of North-Brabant, CS Bosherston Lakes
	Wider landscape management	CS Bosherton Lakes
	Create new nature areas	Ex. 4: Tisza river, Cs Bosherston Lakes
	Spatial planning	Ex. 14: Province of North-Brabant
Other	Review existing boundaries/ need to establish new sites	Ex. 13: Tetraclinis forests
	Relocation	Ex 15: Relocation of butterflies
	Asses geographical distribution of protected area network	
	Invasive/ exp. species control	Ex.10: Krkonose National Park

Annex 2 Definitions of frequently used climate change related terms in these guidelines

For a more extensive dictionary on climate change related terms we refer to the IPCC dictionary on line (http://www.ipcc.ch/ipccreports/tar/wg1/518.htm)

Adaptation

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (Glossary, IPCC, 2007)

Adaptation measures

Adaptation measures are aimed at, either mitigation of the impacts of different aspects of climate change (sea level rise, temperature, changing precipitation patterns, extreme events), or, at enhancing the ability of ecosystems and species to adapt to climate change.

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities or to cope with the consequences (Appendix 1, IPCC 2007).

Climate change

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC on line dictionary).

Ecosystem resilience

The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Mazza et al, 2011).

Mitigation measures

Mitigation measures lead to a net reduction in greenhouse gas emissions, uptake of storage and avoidance of loss of storage or greenhouse gas emissions. These measures should lead to a reduction in the magnitude and rate of the projected climate changes and thus vulnerability through decreasing exposure (Berry, 2008).

Vulnerability

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including variability and extremes. Vulnerability is a function of character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (Appendix 1, IPCC 2007):

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