



european centre for nature conservation

Climate change and biodiversity in South-East Europe

Impacts and action

Technical background report



REGIONAL ENVIRONMENTAL CENTER

Climate change and biodiversity in South-East Europe – impacts and action

Technical background report

Authors

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Preface

The threat posed by climate change to people, livelihoods and our environment is now widely accepted at both the scientific level and amongst policymakers and, increasingly, politicians and the general public. Nobody can predict the future; however, all the current data and information and a range of sophisticated models suggest that ecosystems, the goods and services that they provide, and the biodiversity that is an integral part of them are becoming increasingly degraded and less able to function. It is also clear that southern Europe will be particularly badly affected both generally and specifically in relation to its biodiversity.

We were therefore particularly pleased to be able to coordinate the interregional project 'Climate change impacts on biodiversity in South-East Europe', of which this technical report is one of the key outputs.

The project is based on the assumption that the impacts of climate change on biodiversity and ecosystem services in South-East Europe will be severe; indeed, these effects are already visible in many places and in many ways. These include increased temperatures, extreme pressure on water resources, a rise in the frequency of severe weather conditions and flooding, increased coastal erosion and more forest fires.

Although our understanding of the complex processes surrounding climate change impacts is still in its early stages, these trends and patterns and their impact on biodiversity are confirmed by scientists and experts in the South-East European region. Whilst there is limited data available in certain parts of the region, we are also beginning to establish where the gaps exist in research and monitoring and can begin to target our efforts in these areas better.

This project, funded by AECID–Agencia Española de Cooperación Internacional para el Desarrollo (Spanish International Cooperation Agency for Development) and implemented by ECNC and REC, has already led to an increased understanding and sharing of expertise about the effects of climate change on biodiversity and ecosystem services. Even better, in terms of added value, it has led to a growing consensus about the urgency of additional policies and measures. For instance, the interregional conference which formed part of this project resulted in a plea for a targeted and concrete action plan for climate change and biodiversity in the region.

This technical report, which draws on the expertise of leading experts in the field of biodiversity and climate change, describes the situation in Albania, Bosnia and Herzegovina, Montenegro, Serbia and Turkey. However, it does more than only describing the situation; it also contains various recommendations and suggested actions for policies and mitigation measures.

This report is complemented by the Conference Proceedings, which summarize the presentations, discussions and outcomes of the interregional conference on climate change impacts on biodiversity in South-East Europe, which took place on 18 and 19 June 2008 in Belgrade, Serbia.

I am very pleased with the way the project increased the expertise, interregional cooperation and also the general levels of awareness about the effects of climate change on biodiversity amongst stakeholders.

As a result of the project I believe that a platform has been created from which actions can be taken that will allow South-East Europe to be better prepared for maintaining the quality of its rich biodiversity, its ecosystems and the vital goods and services that they provide.



Rob Wolters

Executive Director ECNC–European Centre for Nature Conservation

Abbreviations

AECID	Agencia Española de Cooperación Internacional para el Desarrollo
AR4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
BAP	Biodiversity Action Plan
BCCI	Belgrade Climate Change Initiative
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
DNA	Designated National Authority
ECBS	European Community Biodiversity Strategy
ECONET	Ecological network
EPA	Environmental Protection Agency
FNC	First National Communication
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
IWC	International Waterfowl Census
MTE	Ministry of Tourism and Environment
NES	National Energy Strategy
NGO	Non-governmental organization
PEBLDS	Pan-European Biological and Landscape Diversity Strategy
SAR	Species-area relationship
SEA	Strategic Environmental Assessment
SEE	South-East Europe
SNC	Second National Communication
SPI	Standardized Precipitation Index
SRES	Special Report on Emissions Scenarios (IPCC)
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WAIS	West Antarctic Ice Sheet

Summary

Based on past trends, current measurements and models that illustrate future scenarios, it is now widely accepted amongst the scientific community that global temperature is increasing and that the Earth's climate has the potential to change rapidly. Much of this is as a direct result of increasing emissions of greenhouse gases (GHGs) and other human activities, and brings specific challenges for society as a whole. Policymakers and politicians are beginning to respond to this challenge and there is a growing awareness amongst the general public that their livelihoods and the environment around them may be affected. This report describes the impacts of climate change on biodiversity and ecosystem services, with a focus on South-East Europe (SEE); specifically, it contains country assessments of the current knowledge and position in Albania, Bosnia and Herzegovina, Serbia, Montenegro and Turkey. It is a key output of the project: 'Climate change impacts on biodiversity in South-East Europe'. As far as possible it is based on state-of-the-art information on the impacts of climate change on biodiversity and ecosystem services and assessments by the experts of the above-mentioned countries.

Many SEE regions belong to the areas of Europe most vulnerable to climate change, where we can expect the highest future impacts of climate change to ecosystems, with associated impacts on biodiversity. For example:

- southern SEE regions and the SEE parts of the Mediterranean Basin, due to the combined effect of high temperature increases and reduced precipitation in areas already coping with water scarcity;
- mountain areas, where temperatures increase rapidly leading to widespread melting of snow and ice, changing river flows;
- SEE coastal zones and marine nature areas, due to sea-level rise combined with increased risks of severe weather events such as storms;
- densely populated floodplains, due to the increased risk of storm conditions, intense rainfall and flash floods, leading to widespread damage to built-up areas and infrastructure.

For the SEE countries, including Albania, Bosnia and Herzegovina, Montenegro, Serbia and Turkey, the impacts of climate change may include: increased temperatures; a rise in the frequency of extreme weather events; increased coastal erosion, sea-level rise, impacts on marine biodiversity, rising water levels in tidal rivers; increased flooding; severe pressure on water resources; changing agricultural landscapes, including crop failure; changes in habitats and species distribution; increased forest and scrubland fires; increasing problems caused by invasive alien species; and a decrease in the richness of biodiversity. In addition, there will be more problems for local and regional communities that depend on the services provided by ecosystems (in the form of food, drinking water, fuel, building materials or as a harvestable resource) to sustain acceptable living conditions and welfare.

The impacts of climate change on biodiversity will also have direct and indirect economic consequences. Climate change is poised to significantly alter the supply of European ecosystem services over the next century. In the first years of the period 2000 to 2050, it is estimated that each year we are losing ecosystem services with a value equivalent to around EUR 50 billion from land-based ecosystems alone, while cumulative welfare losses could be equivalent to 7% of annual consumption by 2050.

A warmer world will be marked by changes in the timings of seasonal events in nature; many habitats will become less suitable for life, while shifts in suitable climate conditions for individual species will lead to changes in their abundance and range, with direct impacts on ecological connectivity.

It became clear from the discussions and consultations in the SEE region associated with the production of this report, that there is a need to develop a practical and concrete action plan for biodiversity and climate change in SEE. This report represents an important building block for the Action Plan at SEE and national level. Actions proposed at SEE level include to:

- step up regional cooperation between countries in SEE, and the key stakeholders within the countries, ministries and main sectors;
- promote constructive dialogues among relevant stakeholders and joint actions at international, regional and national level for addressing the relationship between climate change and biodiversity;

- increase knowledge and human and financial resources for addressing biodiversity and climate change in SEE; this is seen as a top priority and a vital basis for real actions;
- develop and implement adequate mitigation and adaptation measures and guidelines for addressing the negative impacts of climate change on biodiversity, including adaptive management (strategies) for nature sites;
- prevent damaging of biodiversity from wider climate change mitigation measures;
- implement concrete and far-reaching measures in order to strengthen ecological and landscape resilience in the SEE region, including the concrete establishment and management of protected areas and ecological networks, and of SEE- and Europe-wide climate corridors (to facilitate the movement of wildlife species);
- further develop an active and dedicated network or forum of people and organizations on climate change and biodiversity in the SEE region, while building on the contacts and dialogue established during the conference 'Changing climate, changing biodiversity in South-East Europe'.

Relevant national and international governmental organizations should integrate biodiversity and climate change considerations in their policies, strategies and actions, and ensure that available funds work in favour of (and not against) biodiversity conservation. Non-governmental organizations should as far as possible synchronize their actions and activities on climate change and its impacts on biodiversity and ecosystem services.

Awareness and education actions on climate change, biodiversity and ecosystem services are also of vital importance in order to reach the public, politicians and policymakers, and economic sectors.

At European, regional and national levels action should be taken to fill basic gaps in information and knowledge about climate-related impacts on biodiversity in the SEE region.



A coastal mountain range in Antalya, Turkey. Mountain ecosystems in South-East Europe will be seriously affected by the impacts of climate change.

1 Introduction

The Earth's climate – to the present

A growing amount of scientific evidence indicates changes in the Earth's climate (Stern, 2006). The Synthesis Report of the Fourth Assessment Report (AR4) adopted by the Intergovernmental Panel on Climate Change (IPCC) in 2007 clearly states that warming of the Earth's climate system is unequivocal; it cites observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (AR4 Synthesis Report, 2007). Specifically:

- The global average surface temperature has increased by $0.74^{\circ}\text{C} \pm 0.18^{\circ}\text{C}$ over the 100-year period 1906–2005. Eleven of the last twelve years (1995–2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The linear warming trend over the 50 years from 1956 to 2005 is nearly twice that for the 100 years from 1906 to 2005 (Figure 1). The temperature increase is widespread over the globe and is greater at higher northern latitudes.
- Increases in sea level are also consistent with warming (Figure 1). Global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003 and at an average rate of about 3.1 [2.4 to 3.8] mm per year from 1993 to 2003.
- There is a clear link between warming and observed decreases in snow and ice extent (Figure 1). Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade. Mountain glaciers and snow cover on average have declined in both hemispheres. The maximum areal extent of seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with decreases in spring of up to 15%. Temperatures at the top of the permafrost layer have generally increased since the 1980s in the Arctic by up to 3°C . (IPCC AR4 Synthesis Report, 2007.)

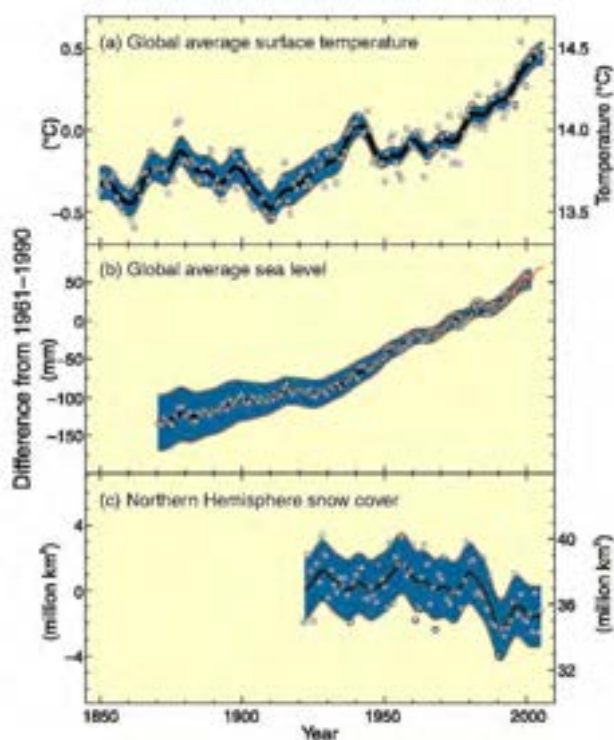


Figure 1: Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March–April. All differences are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from comprehensive analysis of known uncertainties (a and b) and from time series (c). (Source: IPCC AR4 Synthesis Report, 2007)

Increasing trends, from 1900 to 2005, have been observed in precipitation (rainfall) in many large regions. Over this period, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia whereas it declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought is likely to have increased since the 1970s (IPCC AR4 Synthesis Report, 2007).

Certain extreme weather events have changed in frequency and/or intensity over the last 50 years. For example:

- cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent;
- heatwaves have become more frequent over most land areas;
- frequency of the proportion of total rainfall from heavy falls has increased over most areas;
- incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.

There is now widespread awareness and acceptance that the significant problems we are facing due to the changing climate and its associated impacts are largely a direct result of human activity. For instance, the increased 'greenhouse effect', which is a natural process that keeps the Earth's surface around 30°C warmer than it would be otherwise. Without this effect, the Earth would be too cold to support life. The atmosphere is more permeable to incoming solar radiation than outgoing infrared radiation and therefore traps heat (Figure 2).

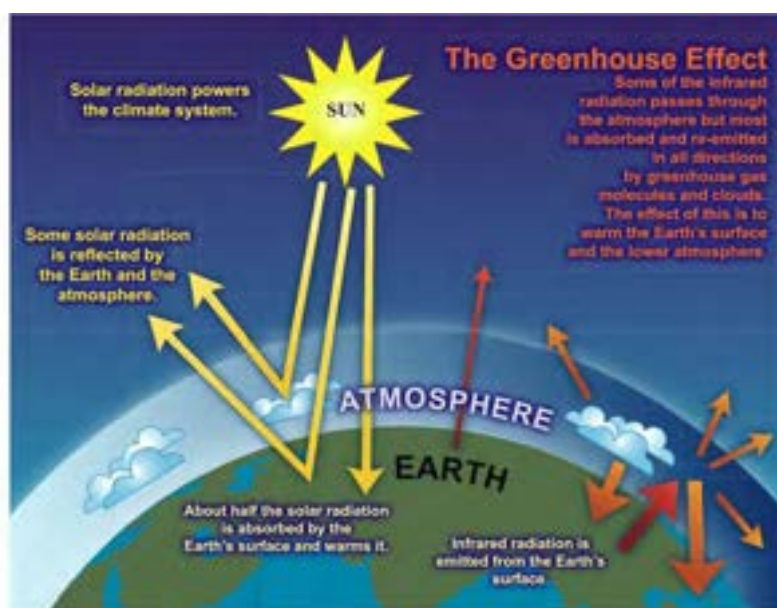


Figure 2: An idealized model of the natural greenhouse effect. (Source: IPCC WG1, 2007)

Certain types of molecules are known that create the heat-trapping effect: like a greenhouse window, such molecules allow sunlight to enter and then prevent heat from leaving the atmosphere (Figure 2). Described generically as 'greenhouse gases' (GHGs), they are mainly made up of water (H₂O) vapour, carbon dioxide (CO₂), but also methane (CH₄), nitrous oxide (NO₂), ozone (O₃) and chlorofluorocarbons (CFCs). Human activities, primarily burning fossil fuels, are increasing the concentrations of these gases, thereby amplifying the natural greenhouse effect (National Academy of Sciences, 2008).

Most climate models show that a doubling of pre-industrial levels of GHGs is very likely to commit the Earth to a rise of between 2–5°C in global mean temperatures. Figure 3 shows atmospheric concentrations of important long-lived GHGs over the last 2,000 years. The exponential increase since 1750, attributed to human activities in the industrial era, indicates that the doubling of pre-industrial levels will be reached between 2030 and 2060. A warming of 5°C on a global scale is comparable to the difference between temperatures during the last ice age and today. Several new studies suggest up to a 20% chance that warming could be greater than 5°C. Such opinion is scientifically well-documented in

the AR4 report. This report is built on scientific progress from the past six years of research (2001–2007) and is based upon large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges.

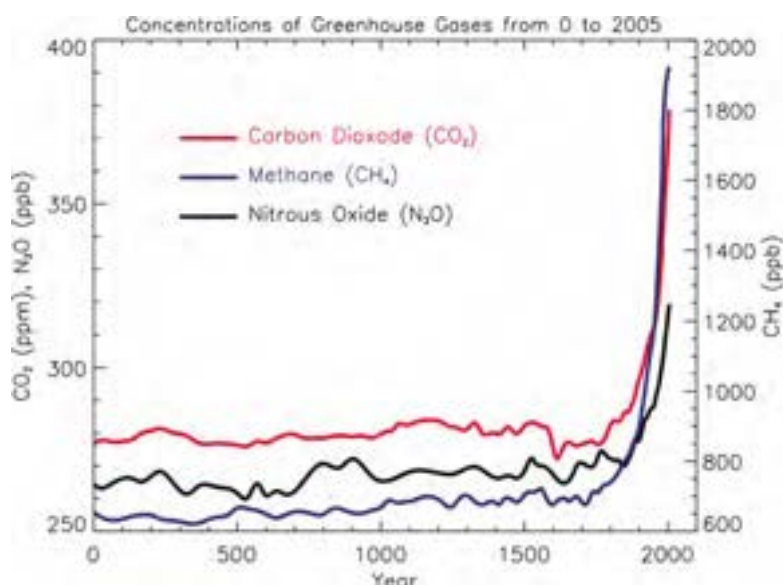


Figure 3: Atmospheric concentrations of important long-lived GHGs over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the GHG per million or billion air molecules, respectively, in an atmospheric sample. (Source: IPCC WG1, 2007)

Future climate change

Using climate models that follow basic physical laws, scientists can now assess the likely range of warming for a given level of GHGs in the atmosphere in the future. If annual emissions continued at today's levels, GHG levels would be close to double pre-industrial levels by the middle of the century. Under such conditions, for the next two decades a warming of about 0.2°C per decade is projected for a range of Special Report on Emissions Scenarios (SRES) emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Anthropogenic warming and sea-level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if GHG concentrations were stabilized.

Projected warming in the 21st century is expected to be greatest over land and at most high northern latitudes and least over the Southern Ocean and parts of the North Atlantic Ocean (IPCC WG1, 2007). Warming itself will cause several other effects:

- changes in rainfall patterns and extreme weather events will lead to more severe impacts on people than that caused by warming alone;
- melting of the Greenland ice sheet as temperatures in excess of 1.9 to 4.6°C warmer than pre-industrial will sustain for millennia;
- weakening of the Atlantic Thermohaline Circulation, partially offsetting warming in both Europe and eastern North America, or in an extreme case causing a significant cooling;
- rising sea levels, with very large increases if the Greenland ice sheet starts to melt irreversibly or the West Antarctic Ice Sheet (WAIS) collapses;
- climate change will affect ecosystems and their biodiversity and human systems – such as agriculture, transport, and health infrastructure – in ways we are only beginning to understand.

In the future, climate change itself could trigger additional increases in GHGs in the atmosphere, further amplifying warming. These potentially powerful feedbacks are less well understood and only beginning to be quantified (Stern, 2006).

The alarm bells are therefore ringing across Europe in relation to the impact of climate change on society, the economy and our environment. Maintaining ecosystems that can function as a resource for biodiversity and a source of tranquil enjoyment, recreation and economic benefit, whilst at the same time providing mitigation and adaptation against climate change is one of the great challenges of the 21st century. Indeed, the effects of climate change in Europe and the Arctic are already significant and measurable. Climate change will heavily affect Europe's natural environment and nearly all sections of society and the economy. Because of the non-linearity of climatic impacts and the sensitivity of ecosystems, even small temperature changes can have very big effects. Figure 4 illustrates what can be expected in Europe by the end of the century, according to the IPCC Special Report on Emissions Scenarios (SRES A2) whereby no action is taken to reduce GHG emissions, so that the global mean temperature increases by about 3.4°C by the 2080s compared to 1990 levels (EC Green Paper, 2007).

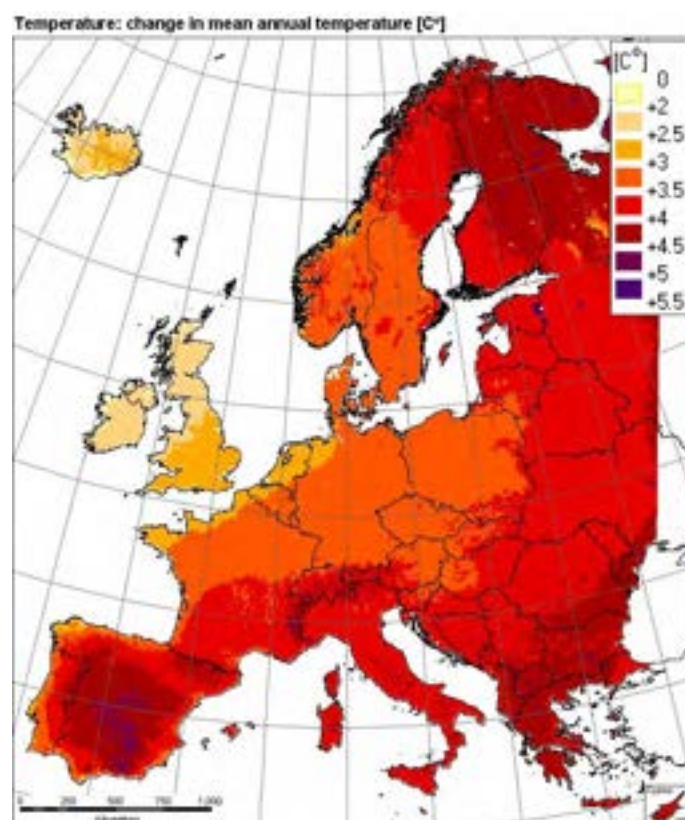


Figure 4: Change in mean annual temperature in Europe; based on IPCC SRES scenario A2. The projected climate impacts are estimated for 2071–2100 relative to 1961–1990. (Source: EC Green Paper, 2007)

2 The impacts of climate change related to biodiversity in SEE

General impacts

As is clear from the 2005 Millennium Ecosystem Assessment, climate change is impacting more and more on biodiversity, both worldwide and in Europe. Scientific research on the possible impact of climate change increasingly provides evidence of considerable consequences for habitats and species. There will be positive and negative impacts of climate change, even within a single region. For example, warmer temperatures may bring longer growing seasons in some regions, benefiting those farmers who can adapt to the new conditions but potentially harming native plant and animal species. Species migrations, extinctions and changes in populations, range and seasonal and reproductive behaviour are among the responses that have been recorded, and these are likely to continue apace as climate continues to change in decades to come. In general, the larger and faster the changes in climate are, the more difficult it will be for human and natural systems to adapt (National Academy of Sciences, 2008).

Figure 5 shows examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. More specific information is now available about the nature of future impacts of climate change to ecosystems and their 'ecosystem services' to society. Those impacts comprise (IPCC AR4 Synthesis Report, 2007):

- the resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insect pests, ocean acidification) and other global change drivers (e.g. land-use change, pollution, fragmentation of natural systems, overexploitation of resources);
- over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change;
- approximately 20 to 30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C (medium confidence);
- for increases in global average temperature exceeding 1.5 to 2.5°C and in associated atmospheric CO₂ concentrations, there are projected to be major changes in ecosystem structure and function, the ecological interactions between species and shifts in their geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

Both ecological theory and conservation history have shown that the modern landscape provides little flexibility for ecosystems to adjust to rapid environmental changes (Walther *et al.*, 2002). Among such changes climate change is considered as the biggest new extinction threat (Thomas *et al.*, 2004).

A significant body of basic research on ecological and physiological processes that are sensitive to climatic variables such as temperature and precipitation is now available. The evidence indicates that the relatively short period of warmer temperatures in the 30 years at the end of the 20th century, has affected the phenology of organisms, the range and distribution of species, and the composition and dynamics of communities. These examples, spanning the previous century and encompassing most major taxa and ecosystems on Earth, provide linkages between recently observed changes in natural systems and 20th century climate change. Those linkages have been confirmed through experimental and observational studies on the behaviour, ecology and physiology of many wild species. Such studies will continue to provide detailed mechanisms by which climatic change affects individual physiology, seasonal timing, population dynamics and geographical distributions. Furthermore, climate change can reinforce already existing detrimental effects of human exploitation and mismanagement and push species and ecosystem tolerances beyond their limits.

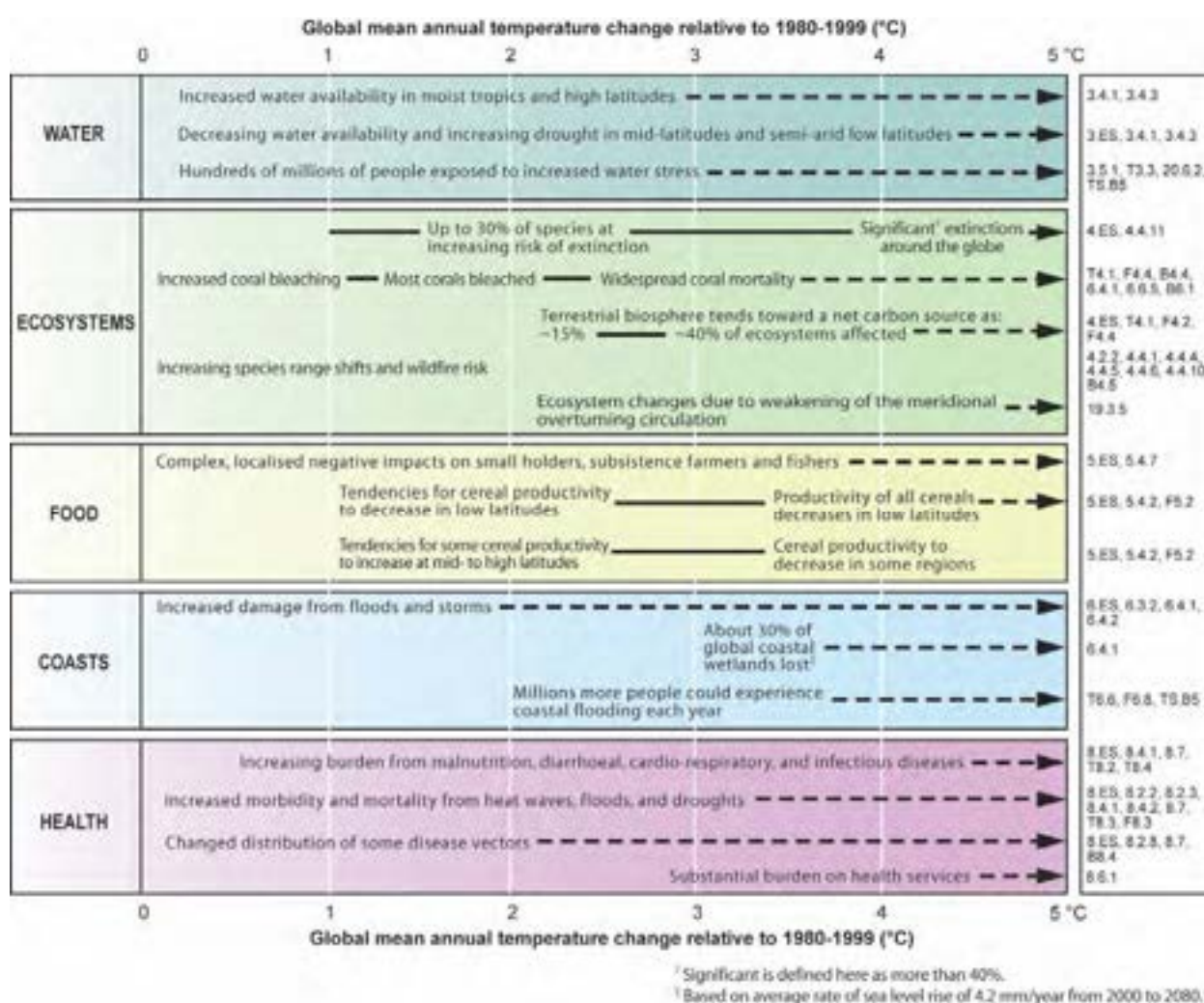


Figure 5: Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Quantitative entries for water stress and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES scenarios A1FI, A2, B1 and B2. Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right-hand column of the Table. Confidence levels for all statements are high.

The complexity of ecological interactions makes it difficult to extrapolate from studies of individuals and populations to the community or ecosystem level. Additional problems are caused by the fact that the most relevant physical and temporal scales of ecological investigation are local and short-term (less than three decades). In contrast, climatology generally encompasses much larger spatial and temporal scales. As a consequence, it remains difficult to link population and community-level dynamics to the global-scale studies of atmospheric and oceanic processes (Walther *et al.*, 2002).

There is not enough research on the impacts of climate change on biodiversity particularly related to the SEE region. On the other hand, the SEE region contains high biodiversity richness, and the climate impact comes on top of the existing threats to biodiversity. Therefore, in the absence of comprehensive data inaction is not an option, and some extrapolation should be done from available European studies. Researchers in the United Kingdom (University of Durham and Royal Society for the Protection of Birds) and the Netherlands (National Institute of Public Health and Environment), respectively, estimated that European birds and plants might have lower than average risks of extinction from climate change. For European birds, they project a 25% extinction rate under the maximum climate change scenario. For

European plants, between 11 and 17% loss is expected under minimum to maximum climate change scenarios that are likely to occur between now and 2050 (Thomas *et al.*, 2004).

The fourth assessment report of the EEA states that by 2100, more than 35% of plant species in northern countries may be invasive and 25% of the plant species in Romania, Bulgaria, Iberian countries and some other Mediterranean countries may have disappeared (Bakkenes *et al.*, 2006).

A complication in Europe is that almost the entire land surface is heavily populated and intensively managed, and the interaction between land use and climate change has so far hardly been studied. Some species, such as the Spanish Imperial Eagle (*Aquila adalberti*), which is largely restricted to natural parks and reserves, will be required to move to new areas – and though it is predicted that it will have a larger climatically suitable area in the future, there may not be large enough undisturbed and protected areas available to support it within its new distribution. Future studies that take account of the availability of natural areas are likely to result in even higher estimates of extinction rate (Thomas *et al.*, 2004).

Many regions of South-East Europe (SEE) are therefore the most vulnerable to climate change in Europe (as defined in EC Green Paper, 2007), where we can expect the highest future impacts of climate change to the ecosystems, and in particular to biodiversity. For example:

- southern SEE regions and the SEE parts of the Mediterranean Basin, due to the combined effect of high temperature increases and reduced precipitation in areas already coping with water scarcity;
- mountain areas, where temperatures increase rapidly leading to widespread melting of snow and ice, changing river flows;
- SEE coastal zones and marine nature areas, due to sea-level rise combined with higher water temperatures and increased risks of storms;
- densely populated floodplains, due to increased risks for storms, intense rainfall and flash floods, leading to widespread damage to built-up areas and infrastructure.

Specific impacts – changes in the timing of seasonal events

Phenology is the study of changes in the timing of seasonal events, such as flowering, migration and hibernation. Some phenological responses are triggered principally by temperature, while others are more responsive to day length. Studies in Europe and North America have therefore revealed phenological trends that very probably reflect responses to recent climate change. Such changes are linked with the growing season and affect ecosystem functioning and productivity. Farming, gardening and forestry, as well as wildlife, are affected; the timing of tilling, sowing and harvesting requires adjustments, and fruit is ripening earlier due to warmer summers (Menzel *et al.*, 2006).

Common changes in the timing of spring activities in relation to plants include earlier shoot and leaf appearance (see, for example, Figure 6) and flowering. Changes in flowering have implications for the timing and intensity of the pollen season; this is showing an advancing trend as many species start to flower earlier. In general, spring activities have occurred progressively earlier since the 1960s. Allied to this, the concentration of pollen in the air is increasing (Nordic Council, 2005). However, geographical differences are evident for both plants and birds, with delayed rather than earlier onset of spring phases in SEE, including a later start to the growing season in the Balkan region (Walther *et al.*, 2002). In recent decades changing phenology has been clearly visible across Europe (Parmesan & Yohe, 2003; Root *et al.*, 2003; Menzel *et al.*, 2006). Early phenological events (i.e. spring) are more variable than later events. For plants:

- 78% of all leaf unfolding, flowering and fruiting records across Europe show an advancing trend and only 3% a significant delay. The average advance of spring/summer phenological events is occurring at a rate of 2.5 days per decade (Menzel *et al.*, 2006);
- the pollen season starts currently on average 10 days earlier and is of longer duration than 50 years ago;
- in Britain, the first flowering date for 385 plant species has advanced by 4.5 days on average during the past decade in comparison with the previous four decades (Fitter & Fitter, 2002); oak leafing has advanced three weeks in the last 50 years (Hopkins *et al.*, 2007) (Figure 6);
- in the Arctic, rapid climate-induced advancement of spring phenomena (e.g. flowering, egg laying) has been observed during the last 10 years. The strong responses of Arctic ecosystems and large

variability within species illustrate how easily biological interactions can be disrupted by climate change (Høye *et al.*, 2007).

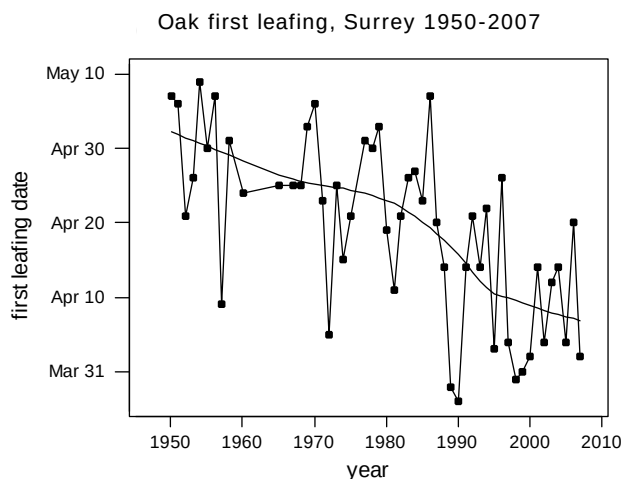


Figure 6: Oak (*Quercus* sp.) leafing date in Surrey, UK (1950–2005). (Source: Nature's Calendar UK, <http://www.naturescalendar.org/uk/climate+change/past.htm>)

It is therefore highly likely that in future phenological changes in plants will alter growing seasons, ecosystem production, population-level interactions and community dynamics (Fitter & Fitter, 2002). The future impacts of climate change on animal phenology are poorly understood, but could include increasing trophic mismatch and disturbance to ecosystem functioning. Different plant species show different responses; for example, annuals and insect-pollinated species are more likely to flower early than perennials and wind-pollinated species (Fitter & Fitter, 2002).

In addition, and in spite of increasing research in these areas, there is a high level of uncertainty around how different plant species will respond when temperature thresholds are reached and whether linear relationships between temperature and growing season will be realized in the future.

Climate warming has affected life cycles of many temperature-sensitive animal species. For example, for both vertebrates and invertebrates, milder springs are allowing earlier onset of breeding and extra generations to emerge during the year. A study in Britain (Crick & Sparks, 1999) analysed 74,258 records for 65 bird species from 1971 to 1995. The study showed significant trends towards earlier (8.8 days on average) laying dates for 20 species (31%), with only one species laying significantly later. The effects, however, are not necessarily uniform. The predicted egg-laying date for the Pied Flycatcher (*Ficedula hypoleuca*), for example, shows significant advancement during the period 1980 to 2004 in western and central Europe, but delays in northern Europe (Figure 7); both are strongly driven by temperature trends (Both & te Marvelde, 2007).

However, changes in the timings of seasonal events could lead to the loss of synchrony between species and the availability of food, and other resources upon which they depend. Some animal species populations will crash if the emergence of vulnerable young does not coincide with their main food source. Conversely, populations will explode if young are not exposed to normal predation pressures; furthermore, the impacts of climate change on ecosystems favour generalists, and as warmer temperatures increase insect survival and reproduction rates, more frequent, severe and unpredictable pest outbreaks may occur with extra generations causing bigger and longer infestations (Cannon, 1998; McKinney & Lockwood, 1999). In temperate regions, milder winters are allowing increased rates of winter survival (Bale *et al.*, 2002) and it has been estimated that, with a 2°C temperature increase, some insects could undergo up to five additional life cycles per season (Yamamura & Kiritani, 1998).



Figure 7: Changes in egg-laying dates (1980 to 2004) of the Pied Flycatcher (*Ficedula hypoleuca*). Dots: weather stations used to calculate local laying date trend (derived from temperature data); triangles: source of Pied Flycatcher laying date time series. Scale: 25 yr temperature trends on which laying date trends were based. (Source: Both & te Marvelde, 2007)

Strong and rapid phenological changes have especially been observed in the high latitudes as a response to warming of the region occurring at twice the global average (Høye *et al.*, 2007). The date of snowmelt in north-east Greenland has advanced by an average of 14.6 days since the mid-1990s, resulting in earlier egg-laying dates for birds in the region.

For animals, the trend towards warmer springs may continue to induce earlier breeding and migration activity. Unpredictable cold snaps are likely to cause high mortality amongst early movers. Meanwhile, species whose life cycles are calibrated according to day length, and which do not respond so readily to changing temperatures, will not be able to exploit earlier spring resources unless they can adapt (Feehan *et al.*, 2008). In general for animals:

- climatic warming has caused advancement in the life cycles of many animal groups. There is a danger that populations will crash if the emergence of vulnerable young is not in synchrony with their main food source. Observed trends include earlier frog spawning, bird nesting and arrival of migrant birds and butterflies. Seasonal advancement is particularly strong and rapid in the Arctic;
- breeding seasons are lengthening, allowing extra generations of temperature-sensitive insects such as butterflies and dragonflies (and potentially insect pests) to be produced during the year;
- the observed trends are set to continue as climate warming increases in the decades to come.

Specific impacts – changes in the distribution of plant and animal species

Warmer temperatures in the last 30 years have significantly influenced seasonal patterns among, particularly, plants but also animals (see above). The rate of climate change in Europe is likely to exceed the adaptive capacity of some wild plant species (IPCC, 2007), whilst others are expected to benefit from changing environmental conditions (e.g. Sobrino Vesperinas *et al.*, 2001). Shifts in suitable climate conditions for individual species will, therefore, potentially lead to changes in their abundance, distribution and range. Thus, with general warming trends, these 'climatic envelopes' become shifted towards the poles or higher altitudes. To the extent that dispersal and resource availability allow, species are expected to track the shifting climate and likewise shift their distributions poleward in latitude and upward in elevation. However, factors affecting species distribution interact in complex ways, and it is not surprising that simple correlations with temperature changes are not always observed (Walther *et al.*, 2002).

Lewis (2006) examined the scientific basis to the claims made by the extinction projections presented by Thomas *et al.* (2004). These projections come from applying a well-known ecological pattern, the species-area relationship (SAR). Figure 8 gives a schematic representation of range reduction under climate change. The outlines represent the climatic envelope suitable for a species to persist currently (stippled) and in a future, warmer world (hatched). The hatched area represents the future distribution of the species with global dispersal. The optimistic, full dispersal scenario is that the new distribution of each species will reflect the spatial extent of its new climatic envelope. The pessimistic, zero dispersal scenario is that species will persist only in areas of overlap between current and predicted future distributions; in cases where there is no overlap these species will become extinct. In reality, the response of most species will lie somewhere between these two extremes, and will depend on the dispersal ability of individual taxa, relative to the speed and magnitude of shifts in their climatic envelope. There are already some clear examples of this.

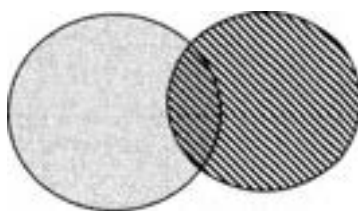


Figure 8: A schematic representation of range reduction under climate change. The outlines represent the climatic envelope suitable for a species to persist currently (stippled) and in a future, warmer world (hatched).

Evidence from glacial and interglacial periods shows that the predominant adaptive response of climate-limited plant species has been to shift distribution, resulting in altitudinal and poleward movements; such as are evident now for instance with Holly (*Ilex aquifolium*), a climate-limited species which has expanded in southern Scandinavia in a manner consistent with increasing winter temperatures (Walther, Berger & Sykes, 2005). Climate change effects have been observed in particular on and around mountain summits, as these ecosystems are very vulnerable (IPCC, 2007).

There has been a general species increase in mountain summit vegetation since the early 20th century. The uphill shift of alpine plants showed an accelerating trend towards the end of the century that is likely linked with the extraordinarily warm conditions of the 1990s (Walther, Beissner & Burga, 2005). Evidence has also emerged showing declines in cold-adapted species as warming conditions and pioneer species drove these from their characteristic niches. In the Swedish Scandes, the treeline of the Scots Pine (*Pinus sylvestris*) rose by 150–200 m as warmer winters significantly lowered mortality and increased rates of establishment. Observations from other continents show that uphill treeline migration is a global phenomenon (Kullman, 2006, 2007); this could become the major threat to biodiversity in high mountains (Pauli *et al.*, 2007).

The northwards and uphill movement of a wide variety of animal species has been observed over recent decades across Europe. These observations are partly attributable to observed changes in climatic conditions, whilst others are triggered more by land-use and other environmental changes. In a study of 57 non-migratory European butterflies, 36 had shifted their ranges to the north by 35–240 km and only two had shifted to the south (Parmesan *et al.*, 1999). The Sooty Copper (*Heodes tityrus*), for example, spread north from Catalonia and by 2006 had established breeding populations on the Baltic coast (Parmesan *et al.*, 1999). In Spain, the habitat of 16 mountain-restricted butterflies has been reduced by about one-third over the last 30 years; lower altitudinal limits rose on average by 212 m – in line with a 1.3°C rise in mean annual temperature (Wilson *et al.*, 2005).

Similarly, the spread of the Comma Butterfly in the Netherlands has been linked to recent climate change patterns (Figure 9).

A recent study of 122 terrestrial bird species indicated that, from around 1985, climatic changes have influenced population trends across Europe (Gregory *et al.*, in press), with impacts becoming stronger through time. The study shows that the populations of 92 species have declined because of climate warming, whereas 30 species have generally increased. In Britain, 275 of 329 animal species analysed over the last 25 years shifted their ranges northwards by 31–60 km, 52 shifted southwards, and two did

not move (UKCIP, 2005; Hickling *et al.*, 2006). However, many species, including butterflies, are failing to move as quickly as might be expected under the current rate of climate change (Warren *et al.*, 2001).

In Germany, the once rare Scarlet Darter Dragonfly (*Crocothemis erythraea*) has spread from the south, paralleling observed changes in climate, and now is found in every federal state (Ott, 2007).



Figure 9: Occurrence of the Comma Butterfly (*Polygonia c-album*) 1975–2000. (Source: Dutch Butterfly Conservation, processed by Netherlands Environmental Assessment Agency for the Environmental Data Compendium)

Other species are decreasing, and both aspects will have impacts on a variety of ecosystems. Projections indicate that by the late 21st century, the potential range of many European plant species may shift several hundred kilometres in a northerly direction. This is several times faster than past rates as estimated from the Quaternary record or from historical data (Huntley, 2007). Due to these range shifts some species will find themselves at the end of their ecological range (e.g. mountain summits), and they face extinction at national, European or sometimes even global levels. The greatest changes have been projected for the endemic plant species in Mediterranean and Eurosiberian regions and many mountain regions (Thuiller *et al.*, 2005). Bakkenes *et al.* (2006) obtained similar results from modelling stable areas of plant species distribution for this century under different climate change scenarios. This study suggests that 10–50% of plant species in European countries are likely to disappear by 2100 from their current location in the absence of climate mitigation. Again, species in South-East and South-West Europe are projected to be worst affected. For Europe as a whole, about 1% of plant species may go extinct because they no longer have a suitable climate niche. This figure will be higher if movement is restricted or if they are out-competed by invasive species.

A similar trend is predicted for animal species. Widespread species may be less vulnerable while threatened endemic species, which are already under pressure, will be at greatest risk (Levinsky *et al.*, 2007). Again, the species richness is likely to decrease most dramatically in the Mediterranean region (but increase towards the north-east and in mountainous areas such as the Alps and Pyrenees). The limited dispersal ability of many Mediterranean reptile and amphibian species is very likely to reduce their range in particular (Hickling *et al.*, 2006; Araújo *et al.*, 2006).

A note on ecological networks and ecological connectivity

There is strong evidence that the distribution of many species has responded to climate change. However, very many species are unable to disperse sufficiently rapidly to adapt to climate change in this way, especially in systems with low connectivity (EPBRS, 2005; Vos, C. in Nieto *et al.*, 2008). Many of the models, which seek to illustrate the movement of plants and animals in response to climate change, are based on a presumption that functioning ecological networks exist between areas of habitat along which species can move. However, the majority of Europe's landscapes are fragmented in one way or another as

a result of agricultural intensification, the modification of watercourses and other water bodies, changing forestry practice, urban sprawl, transport and other infrastructure. In some landscapes ecological connectivity is extremely low. In recognition of this issue, ministers of environment and biodiversity and heads of delegations of the 53 European states met at the Sixth Ministerial Conference 'Environment for Europe' (Belgrade, 2007). They stated collectively that ecological connectivity has a major role to play to combat the growing effects of climate change on pan-European ecosystems. Clearly, the change in distribution, or the inability to migrate to traditional sites, particularly for bird species but also for large mammals using ecological networks which may be fragmented or dysfunctional, will impact on the ability of Europe to meet its targets in relation to halting the loss of biodiversity by 2010 and beyond.

Specific impacts – changes to the composition of plant and animal communities

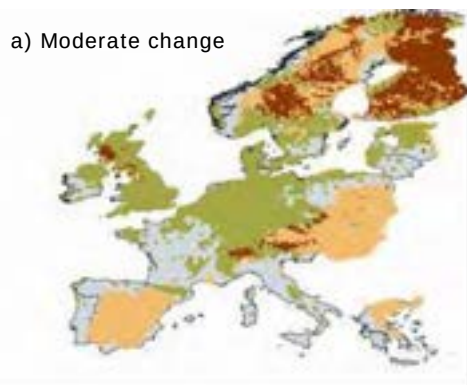
The assemblages of species in ecological communities reflect interactions among organisms as well as between organisms and the abiotic environment. We might expect, therefore, that rapid climatic change or extreme climatic events can alter community composition. Indeed, it is clear that increased temperatures will make some habitats less suitable; the disappearance of some species and the appearance of others (some of them alien to those ecosystems) have been observed.

For many species, an important constraint on successful colonization of new areas is the presence of host plants (Schweiger *et al.*, in press). An additional constraint, particularly for specialized feeders, is the seasonal availability of food supplies. Advancements in spring activity may result in asynchrony between food sources and breeding, causing starvation of young that emerge too early or too late, and the disruption of predator-prey relationships (see also above sections). This so-called trophic mismatch has been demonstrated in various animal groups, including birds (Both *et al.*, 2006), and in some cases is causing crashes or explosions in populations.

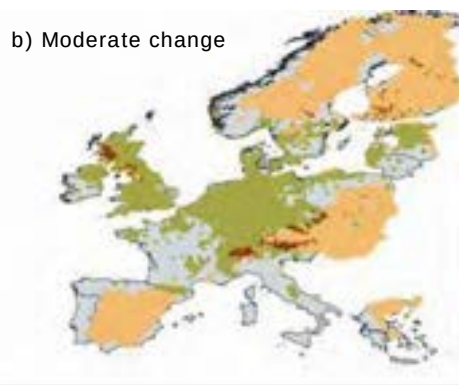
Many butterfly species are moving northward (see above), but often with overall declines in abundance and range size (Warren *et al.*, 2001). Biotic interactions are important factors in explaining the distributions of butterflies, because they are often host-specific. For example, many parts of Europe are climatically suitable for the butterfly *Titania Fritillaria* (*Boloria titania*) (Figure 10) and the species may even be able to migrate quickly in response to climate change. However, an important constraint to range expansion is the presence of its larval host plant American Bistort (*Polygonum bistorta*) (Schweiger *et al.*, in press). Likewise, the current distribution of the Clouded Apollo (*Parnassius mnemosyne*) is not only explained by climate suitability, but also by the presence of its *Corydalis* host plant (Araújo & Luoto, 2007).

The response to climate change of the butterfly *Titania Fritillaria* (*Boloria titania*) and its host plant American Bistort (*Polygonum bistorta*) is likely to lead to a reduction in range overlap and, thus, an uncertain future for this specialist butterfly. Played out on a larger scale, these trophic mismatches benefit generalists at the expense of specialists, putting additional pressures on the capacity of ecosystems to provide certain services and on species of conservation importance (McKinney & Lockwood, 1999; Reid *et al.*, 2005; Biesmeijer *et al.*, 2006).

Unlimited dispersal of *P. bistorta*



No dispersal of *P. bistorta*



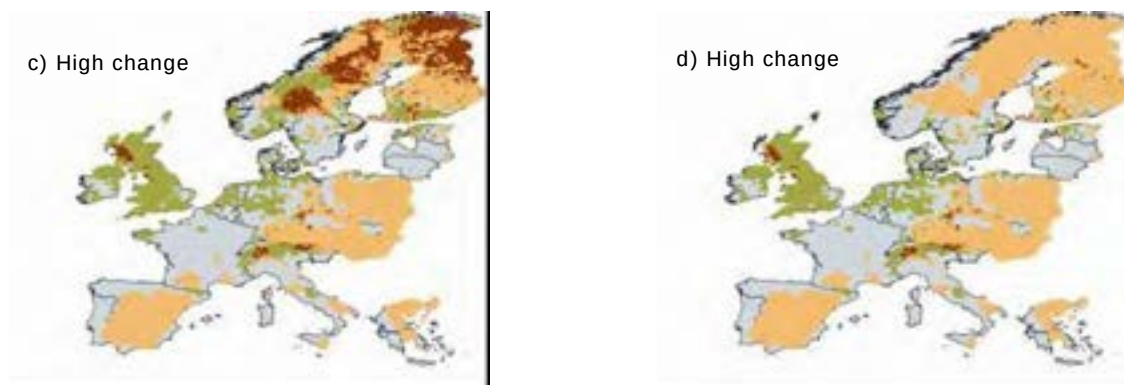


Figure 10: Relationship between projected distribution space of the butterfly Titania Fritillaria (*Polygonum bistorta*) and its host plant American Bistort (*Boloria titania*) for moderate (a, b) and high (c, d) climate change scenarios for 2080 under the assumption of unlimited (a, c) and no (b, d) dispersal of its host plant. (Source: Schweiger *et al.*, in press)

Climate change has also had a disruptive effect on Scottish seabird communities and their food webs. During 2004 and 2005, major population crashes have been observed. In Shetland, over 1,000 Guillemot nests and 24,000 nests of the Arctic Tern were almost entirely deserted, and on the nearby island of Foula, the world's largest colony of Great Skuas saw only a few living chicks. The cause was a drastic reduction in the populations of Sand Eel, their principal food source. The disappearance of the Sand Eel was due, in turn, to the northward movement of cold-water plankton on which these fish feed. The plankton's range had shifted because the waters between Britain and Scandinavia had become too warm for it to survive there. Since 1984, some seabird species around Scotland have decreased by 60–70% (CEH, 2005).

The composition of many plant communities is changing to the extent that completely new assemblages of plants are appearing. The ecological implications of these changes and their impact on biodiversity conservation (in relation to the loss of characteristic and rare species assemblages and habitats) are unpredictable. However, it is clear that some habitats and ecosystems are more vulnerable than others to climate change. Arctic and mountain ecosystems, coastal wetlands and ecosystems in the Mediterranean region are the most vulnerable natural ecosystems in Europe (see, for instance, p. 186 of EEA, 2007.)

With climate change, non-native species from adjacent areas may cross frontiers and become new elements of the biota. Examples include warm-water species that have recently appeared in the Mediterranean and thermophilous plants that spread from gardens into surrounding countryside. A particular threat is therefore posed by 'invasive alien species', which are plant and animal species whose introduction and/or spread outside their natural range or distribution threaten biological diversity (CBD, 2007). This threat is considered one of the major global pressures on biodiversity (Millennium Ecosystem Assessment, 2005). Most recent introductions have been unintentional and, while not all alien species become invasive, an increasing number of them present a threat to native biodiversity. The rising trend indicates that the situation is far from under control, with impacts on biodiversity expected to increase because of the growing number of species involved, and the increasing vulnerability of ecosystems to invasions, which results from fragmentation and climate change.

A list of 'worst invasive alien species' has been drawn up to document those species that have had demonstrated significant negative impacts in the past. The 163 species on the list, of which vascular plants are the biggest taxonomic group with 39 species, have a significant impact on native biodiversity at the genetic, species or ecosystem levels, and may also affect human health, society or the economy. The map below (Figure 11) shows the number of these worst invasive species that have occurred in European countries. These country figures are only very rough indications of the actual impact, which may differ markedly between species and regions.



Changes in plant composition within ecosystems are also likely to affect the services that these systems provide. Alteration to the overall dynamic of ecosystems may reduce their value for biodiversity and nature conservation and the ability of Europe to meet its targets in relation to halting the loss of biodiversity by 2010 and beyond, not least in relation to the favourable status of Natura 2000 sites.

Some of the interactions both between organisms and with their physical habitats (biophysical interactions) result in ecological processes that interact at different scales to deliver 'ecosystem services' or 'natural capital' that have value to people (Parliamentary Office of Science and Technology, 2007). The Millennium Ecosystem Assessment, a project initiated by the United Nations Environment Programme (UNEP) in 2001, set out to assess how human-made changes to ecosystems affected human welfare. The Millennium Ecosystem Assessment (2005) grouped ecosystem services into four broad categories:

- For example, the structures within woodland habitats can slow the passage of water into watercourses, thereby contributing to the ecosystem regulating service of flood protection. The ecological processes that

contribute to ecosystem services, in this case slowing the passage of water, are referred to as ecosystem functions. The habitats and organisms that give rise to the ecological processes are usually described as the ecological assets, and these can be protected to ensure ecosystem services are maintained.

Climate change is poised to significantly alter the supply of European ecosystem services over the next century. While it may result in the enhancement of some ecosystem services, a large portion will be negatively affected through the impact of drought, reduced soil fertility, fire, and other climate change driven factors (Jones-Walters & Nieto, 2007). For instance:

- Changed characteristics of soils due to changes in water regimes and temperatures. Many of the plants, fungi, bacteria and animals which inhabit the soil layers will also alter in composition and the soil fertility will decrease and its function as a growing medium for plants will change.
- Lost or reduced capacity of soils and the habitats they support to trap and sequester carbon.
- Sharp drop in crop yields caused by drought conditions, in some cases made worse by more frequent forest fires; fruit trees and commercial flowers are flowering earlier and may be more susceptible to frosts and other climate-related effects, making farming and horticulture more difficult.
- Rapidly disappearing genetic resources within the wild and traditional breeds of domestic plants and animals.
- Changed landscapes and the characteristic biodiversity within them, many of which contribute to people's health and well-being through opportunities for tranquil enjoyment of the natural environment, and which provide the backdrop for holidays and recreation (which may have human benefits through increased opportunities for recreation, but this will also have to be managed).
- Affected tourist destinations as some areas become too hot for holidays, and snow and ice disappear from mountain ranges, the coastal sedimentation regimes which currently recharge tourist beaches with sand may change and under certain circumstances the beaches may begin to disappear – all with enormous economic consequences.

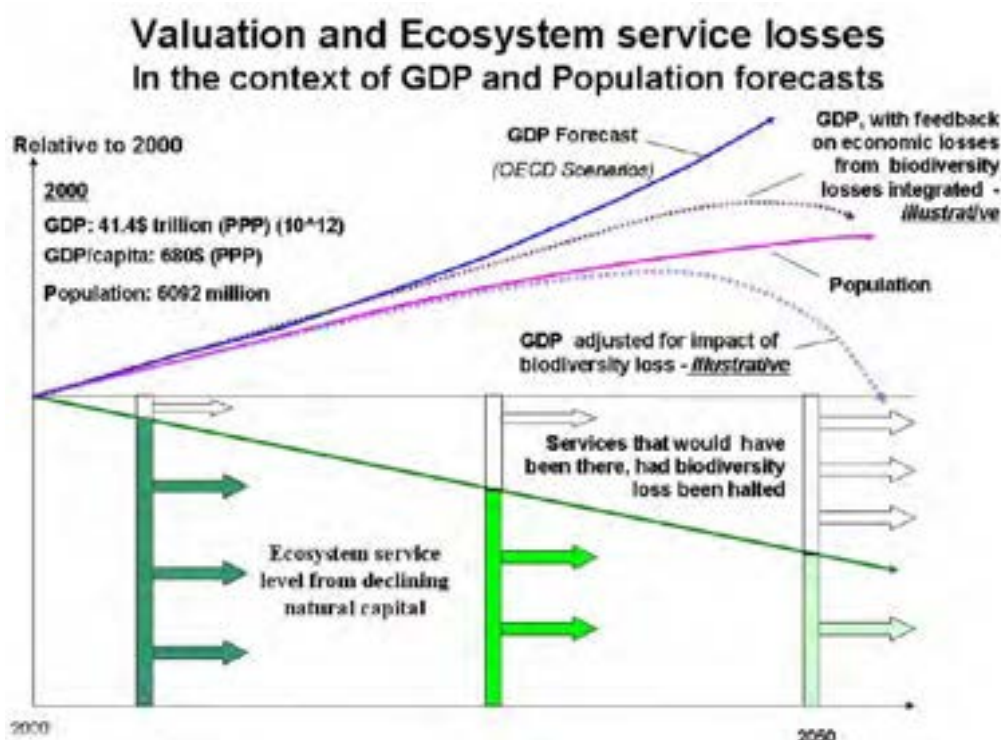


Figure 12: Economic projections, ecosystem service losses and economic consequences. (Source: Braat & ten Brink, 2008)

Currently, we lose biodiversity each year that would have produced ecosystem services (Figure 12) worth around EUR 50 billion per year (taking 2000 as the baseline or point for comparison). Within two years, the losses will be around EUR 100 billion. Within three years, around EUR 150 billion. By 2010, the loss 'grows to' EUR 545 billion in that year compared to 2000, for the land-based ecosystems alone. This is just under 1% of world gross domestic product (GDP) in 2010. However, the world is expected to have lost ecosystem services worth around 7% of world GDP in 2050 due to biodiversity loss between 2000 and 2050 (Braat & ten Brink, 2008).

Specific impacts – impact on potentials for sustainable economic development

Climate change will affect the basic elements of life for people around the world – access to water, food production, health and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms up.

Using the results from formal economic models, *The Stern Review* (Stern, 2006) estimates that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and for ever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action – reducing GHG emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.

As developing countries are especially vulnerable to climate change because of their geographical exposure, low incomes and greater reliance on climate-sensitive sectors such as agriculture (Stern, 2006) expected effects of climate change on sustainable economic development of the SEE region should be taken into serious consideration.

A similar study on the economics of the loss of ecosystems and biodiversity has recently been initiated by Germany and the European Commission. The first results, in the form of an interim report: *The economics of ecosystems & biodiversity* (TEEB, 2008), were presented at the Ninth Conference of the Parties to the Convention on Biological Diversity (CBD), held in Bonn, Germany, in May 2008. This report suggests that, even with a conservative approach, in the first years of the period 2000–2050, it is estimated that each year we are losing ecosystem services with a value equivalent to around EUR 50 billion from land-based ecosystems alone (it has to be noted that this is a welfare loss, not a GDP loss, as a large part of these benefits is currently not included in GDP). Losses of our natural capital stock are felt not only in the year of the loss, but continue over time, and are added to by losses of more biodiversity in subsequent years. These cumulative welfare losses could be equivalent to 7% of annual consumption by 2050 (TEEB, 2008).

3 SEE countries case studies

The following sections present case studies from Albania, Bosnia and Herzegovina, Montenegro, Serbia and Turkey with observed climate changes, direct impacts on biodiversity, country responses to climate changes and, in particular, priorities for action.



Dry forest and shrublands and their associated species (in this case Danford's Rock Lizard, *Anatololacerta danfordi*) will be affected by changing conditions, including increasing dryness and fires.

Please note that each country report is separately referenced at the end of the relevant text.

Albania

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Background

Albania's National Biodiversity reports (1999 and 2007) and State of Environment reports (1995–2005) have shown that as a direct consequence of continuing human activities, many of the natural ecosystems, habitats and species in Albania are already under severe stress.

The main endangered types of ecosystems and habitats in Albania are littoral and coastal ecosystems, such as sand dunes, river deltas, alluvial forests, lagoons and coastal lakes.

Although the known number of species that have become extinct during the last century is not high, the rates of biodiversity loss during the past 50 years are among the highest in Europe (Albania's Biodiversity Strategy and Action Plan, 1999). The insufficient level of knowledge and studies concerning a large number of flora and fauna does not allow for an accurate estimation of biodiversity status in Albania. However, at least two species of plants – Horse Chestnut (*Aesculus hippocastanum*) and Thorny Burnet (*Poterium spinosum*) – and four species of mammals – Mediterranean Monk Seal (*Monachus monachus*), Red Deer (*Cervus elaphus*), Brown Long-Eared Bat (*Plecotus auritus*) and Grey Long-Eared Bat (*Plecotus austriacus*) – are totally extinct, while 17 species of birds no longer nest in Albania.

During the last 25 years, approximately 122 species of vertebrates (27 mammals, 89 birds, and 6 fish) and four species of plants have lost more than 50% of their population. The number of rare and threatened species of plants and animals is high and expected to increase. Today, 36% of the country's vertebrates are included in the Albanian Red Data Book. There is no doubt that we are facing real and serious threats to our biodiversity. These threats are likely to be even more damaging and severe to biodiversity under the influence of climate changes.

Direct impacts on biodiversity

The climate change scenarios for Albania suggest an annual increase of temperature up to 1°C, 1.8°C and 3.6°C, respectively, by 2025, 2050 and 2100 and a decrease in precipitation up to 3.8%, 6.1% and 12.5% by the same time horizons. Cloudiness in comparison with the year 1990 is likely to decrease by 2.6% to 4.6% by 2050 and 2100, respectively. Wind speed, in comparison with the period 1961–1990, is expected to increase from 1.3% up to 2.3% by 2050 and 2100, respectively, especially during summer due to the increase of the land-sea temperature contrast. Evapotranspiration is expected to intensify due to the increase in temperature and wind speed.

Under reduced surface water flow and increased evaporation, the storage of water reservoirs will decrease. The groundwater supply will be affected by decreased percolation of water, due to a decrease in the amount of precipitation, river flow, reductions in snow cover and losses of soil moisture from increased evapotranspiration. Reduction in groundwater supply in combination with the increased salinity of the groundwater will bring a shortage of drinking water of adequate quality. A sea-level rise of 48–61 cm by 2100 would result in direct flooding of coastal areas. Due to the increasing sea level, flooding will be intensified both directly by the sea rise and indirectly by changes in water tables.

In spite of the available provisions and climate change scenarios, Albania, along with many other countries in the region, is facing significant gaps in information and uncertainties related to climate changes and their potential implication for biodiversity and ecosystem services. There is a lack of:

- documentation of impacts that are already occurring in response to existing climate trends;
- understanding of the factors determining the resilience and adaptive capacity of ecosystems, including the roles of habitat extent, connectivity and quality, flow regimes and disturbances;

- understanding of the factors affecting the distribution and abundance of species, particularly those affecting the establishment and death phases of life cycles, and the identification of migration barriers and refugia;
- analyses of the species, habitats and ecosystems most vulnerable to climate changes, including those likely to be negatively affected by species favoured by the changes (such as weeds, feral animals and alien species);
- comprehensive assessment of adaptation options available, including the modifications needed to existing conservation planning and practice (*in-situ* and *ex-situ* conservation);
- analyses of present and future social and economic costs of climate change impacts on biodiversity.

Furthermore, there is a considerable uncertainty about (i) scenarios for emissions; (ii) the implications of emissions for global and regional climate change; (iii) the impacts of increased CO₂ concentrations and changed climate on ecosystems and their constituent species; and (iv) the adaptation options available, and their associated effectiveness and cost.

Regardless of the above information gaps and uncertainties, some major potential impacts of climate change on Albania's landscape and biological diversity can be predicted and they are briefly summarized in the following paragraphs.

Impacts on marine littoral and estuarine systems

It is possible that plankton productivity could become significantly more variable in marine, littoral and estuarine systems, and this change could have knock-on effects on system ecology and productivity.

Impacts on coastal habitats

There is likely to be an increase in coastal erosion, particularly along the sandy coast of the Adriatic Sea, leading to further degradation of sand dunes and coastal wetlands, increased salinity, and reduction of fresh and brackish water habitats and species, including alluvial forests.

Impacts on rangelands/pasturelands

There is likely to be a decrease in rangeland productivity, an increasing risk of degradation, soil erosion, and desertification, an increasing sensitivity to disturbance, a change in ecosystem function, and alteration to plant and animal community composition.

Impacts on forests

Coverage of broadleaf and conifer forests, particularly Beech (*Fagus sylvatica*) and Fir forests (*Abies alba*, *Picea abies*, etc.), will be reduced, being replaced by Mediterranean evergreen shrubs and Oak woodlands. Tree species that produce many small seeds and have a high distribution potential (e.g. *Pinus sp.*) would be able to survive and even to spread further. Changes in vegetation composition in forests, changes in structure, productivity and foliage quality will have knock-on effects to other components of biodiversity. Additionally, probable increases in the frequency and intensity of fires will also have impacts.

Impacts on subalpine/alpine meadows and pastures

Large reductions in snow cover are likely to lead to declines in alpine flora and fauna as a result of changes to habitats, alterations to fire regimes and incursion of feral animals and weeds.

Impacts on ecosystem services

Forest ecosystems provide a wide array of goods and services. Forests are particularly vulnerable to climate change because even a small change in temperature and precipitation can have significant effects on the functioning and composition of forests.

Forests play an important role in regulating the Earth's climate. They are an essential link in the global carbon cycle because they take up CO₂ for their growth. During the last 50–60 years Albania has lost more than 15% of its forest cover, while more than half of the high forest stock has been converted into coppice or shrubland due to overexploitation of timber and firewood. Clear-cutting and illegal harvesting of timber and fuelwood have intensified during the last 15–20 years, leading to forest land degradation, increased risk of fires, soil erosion and landslides and floods. Expected climate changes will accelerate these processes and phenomena and will adversely impact forest management, timber and non-timber forest production and forest biodiversity.

The mountain regions of Albania are already under stress from various human activities, such as illegal and uncontrolled wood cutting, overgrazing, abandonment and/or inappropriate land management, resulting in reduced natural resilience to climate change.

Existing relevant policies at national and subnational levels, including adaptation and mitigation strategies

Acknowledging the global significance of climate change, Albania joined the United Nations Framework Convention on Climate Change (UNFCCC) in January 1995. Committed to playing its role in the implementation of this international convention, Albania has addressed mitigation and adaptation measures through the National Climate Change Strategy, which consists of a set of priorities for action in order to integrate climate change concerns into other economic development plans. This strategy is elaborated in the framework of Albania's First National Communication (FNC). The abatement scenario of emissions foresees the introduction and implementation of different options mainly focused on energy saving and energy efficiency measures. A basket of 25 GHG mitigation measures for the energy and transport sector is proposed in the framework of this study, which are then analysed in terms of cost and benefit. The above measures include thermal insulation in housing, efficient bulbs, solar thermal, Liquefied Petroleum Gas (cooking, heating), fuel switching in industry, etc. More information on the GHG inventory can be found in Albania's FNC report (2002). These measures are addressed in the National Climate Change Action Plan, which is a part of the revised National Environmental Action Plan already adopted by the Government of Albania.

Legal framework related to climate change

With the exception of the laws on ratification of the UNFCCC and the Kyoto Protocol, Albania's Parliament has passed no laws that explicitly address the issue of climate change. Because the energy sector emits a significant share of GHG emissions, it has been the focus of analysis and recommendations for climate change mitigation. In addition, the most relevant laws that relate to climate change are adopted under the energy sector. A legislative framework on energy in Albania comprises a relatively large number of different pieces of legislation at present:

- Law on Energy Efficiency and Renewable Energy Sources (No. 9372 of 27 April 2005);
- Law on Power Sector (No. 9072 of May 2003);
- Law on Electricity (No. 7962 of July 1995);
- Law on Regulation of Power Sector (No. 7970 of July 1995);
- Law on Energy Conservation in Buildings (No. 8937 of September 2002);
- Governmental Decree for Energy Building Code;
- Governmental Decree for Strategy of Energy (No. 424 of June 2003).

Educational and public awareness programmes on climate change

The overall process of preparing the FNC, the Technology Needs Assessment (TNA) and the Second National Communication (SNC) has probably contributed to the enhancement of general awareness and knowledge of climate change related issues in Albania; strengthening the dialogue, information exchange cooperation and partnership with and among all relevant stakeholders, including governmental, non-governmental, academic and private sectors; building national capacities; and providing a permanent mechanism and trained national staff to regularly update different elements of the project, especially the emission inventory.

Public awareness and outreach have been designed as a cross-cutting component during the overall climate change activities carried out by the Climate Change Unit/Programme. A national climate change web page – www.ccalb.org – launched in 2000, is updated monthly. In addition, seminars, training, posters and newspaper articles have been produced and interviews have been given in the media over the years.

A strategy of partnership with governmental institutions, international organizations, academia and NGOs has been implemented and found to be successful. The role of the Project Steering Committee has been critical to the success of this strategy. Among the partners involved under the process, collaboration has been strong and successful with the Ministry of Energy and Industry, National Agency of Energy, Ministry of Agriculture and Food, Polytechnic University of Tirana, Institute of Hydrometeorology, Institute of Biological Research, Institute of Statistics, ECAT–Tirana and Energy and Environment for Sustainable Development (an NGO).

UNEP is currently implementing a project in Albania in support of UNFCCC Article 6, which includes, *inter alia*, assistance to countries to raise public awareness on climate change, to involve local stakeholders in a dialogue on a prospective national climate strategy, to approach various target groups on climate change issues, and to disseminate up-to-date materials on climate change problems. This project aims to enhance the level of public awareness on climate change in Albania in order to enable the country to comply with UNFCCC and Kyoto Protocol provisions and to mainstream climate change issues into national policies and strategies. A country assessment on the level of the awareness of climate change issues will be carried out. This will help the development of a national strategy for outreach. Posters and leaflets will be developed and distributed in the course of this project.

Consideration, listing and prioritization of future policy frameworks, prospects and possible actions

Understanding and managing for climate variability

Climate information, together with an understanding of ecosystem dynamics, should be increasingly brought into management decisions (such as for fire management, culling permits, harvest licences, river flows, visitor numbers). The more we incorporate climate information into management tools now, the better we are likely to manage future climate change.

Mainstreaming climate change into national planning and policy

Albania has made some progress in mainstreaming climate change into the national planning process and programming through mobilization of new resources. Due to such efforts some findings and recommendations from the FNC and TNA have been integrated into the National Energy Strategy (NES) in 2002, as well as into the Energy Efficiency and Renewable Law adopted by Albania's Parliament in 2005.

Despite the progress made in mainstreaming climate change issues, there is a significant need to continue the process of bringing climate change into national planning and policy. In addition to GHG reduction measures, there is a significant need to address adaptation, mainly in the most vulnerable areas of the country and the most vulnerable sectors, such as water resources, agriculture and tourism.

Immediate preservation of components of biodiversity sensitive to climate change

There is evidence suggesting that the rate of climate change will be faster than the rate at which most species can adapt, either by migration or by changing their behaviour, physiology or form. Hence, one short-term goal for management is to ensure the survival of species in spite of additional threats resulting from climate change. A first step is to identify threatening processes and threatened species or communities. If there are insufficient resources for managing problem situations, straightforward guidelines and priorities will be needed.

New measures and actions will be needed to explicitly target climate change. For example, we should assess the possibilities for translocating species, or identify the characteristics of sites that can act as refugia (refuges) from climate change: perhaps specific sites (i.e. protected areas) and more intensively managed areas. For some species, the only practicable preservation options may be in aquaria, zoos and botanical gardens – although issues of genetic diversity, animal welfare and cost-effectiveness are likely to arise.

Facilitating long-term adaptation

Long-term adaptation may be achieved by species in environments where natural adaptation processes (such as migration, selection and change in structure) can take place because there is sufficient connectivity in the landscape and few other threatening processes. Two key components will be:

- improvement in the management of existing nature reserves of high conservation value (protected areas);
- consideration of the effects of climate change when building up a comprehensive, adequate and representative network of protected areas (Ecological Network – ECONET).

The scale of potential climate change poses significant challenges in achieving the ECONET goal. However, there may be some conflict between these and other natural resource management goals. For example, well-connected landscapes (to facilitate natural adaptation) may also allow movement of, and

give refuge to, pest animals and weeds, or provide avenues for fire (thereby threatening other species preservation goals).

Monitoring and research

There is very little information to guide priorities for managing climate change. Focused research is needed, as well as predictions of future impacts, if an active adaptive management approach is to be adopted. Key elements in ecosystems of concern will need to be monitored. Monitoring will be very important for enabling progressive adaptation to climate changes as they occur. Monitoring activities should be undertaken for clearly defined purposes: either to make specific decisions or to learn about the ecosystem or species of concern.

Understanding the balance between mitigation and adaptation

Ideally, decisions on climate change responses should be based on three elements:

- costs and/or benefits of mitigation (short-term responses);
- costs and/or benefits of adaptation (longer-term responses);
- interaction between them.

It is necessary to properly communicate the above-mentioned elements to policymakers. Furthermore, consideration of the balance between mitigation and adaptation measures should cover all sectors likely to be affected (including agriculture, forestry, energy, transport, tourism, human health), of which biodiversity conservation is only a part.

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Bosnia and Herzegovina

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Background

Bosnia and Herzegovina has a particularly rich biodiversity due to its location in three distinct geological and climatic regions: the Mediterranean region, the Eurosiberian–Boreo American region and the Alpine–Nordic region. It is home to a number of endemic species and habitats, and the location of relict centres/refuges of tertiary flora and fauna, preserved today in the specific conditions of palaeo-climate. The diversity of species of plants and animals in Bosnia and Herzegovina is among the highest in Europe. Vascular flora accounts for about 5,000 confirmed taxa of species, subspecies, and varieties and forms. As much as 30% of the total endemic flora of the Balkans (1,800 species) is contained within the flora of Bosnia and Herzegovina. There are still no reliable data on the number of bacteria, blue-green bacteria or blue-green algae, but they are estimated at more than 2,000 species. Lichen and moss are poorly documented, as are fungi, although it is estimated that there are several thousand fungi. Fauna inventories are more advanced and indicate that the animal kingdom is rich and diverse, particularly in comparison with other countries in the Balkans and in Europe. This rich biodiversity is endangered. Today a large number of registered domesticated plants in fruit growing, viniculture, tillage, vegetable growing and horticulture are only preserved in certain parts of the country. Indigenous breeds of cattle, sheep, goats, horses, donkeys and dogs are now decreasing and some are nearing extinction.

Bosnia and Herzegovina has an extremely high level of diversity of biotopes (habitats), i.e. geodiversity. This is contributed to by the specific orography, geological surface, hydrology and eco-climate. Given the area of the country and the number of registered geological rarities, Bosnia and Herzegovina's diversity is among the highest in Europe and worldwide. Even though it is under significant anthropogenic pressure, geodiversity is still locally preserved, and it requires an adequate sustainable management regime. Centuries of coexistence and a broad range of interactivity between biological and geological diversity are best reflected in the extremely high diversity of landscapes in Bosnia and Herzegovina. However, many landscapes are now changed, devastated and degraded through different anthropogenic activities and have been transformed into lower forms of ecological organization (NEAP, 2003).

Direct impacts on biodiversity

Global climate-change impacts on recent biodiversity are well recorded and many studies have been published on this subject. However, there has been a lack of studies that address the climate change problem and its regional and local influences on biodiversity. Unfortunately, Bosnia and Herzegovina did not make its First National Communication (UNFCCC) and it now has to face that problem. The First National Communication (FNC) should be the basis of future research on the influence, vulnerability and adaptation of biodiversity to climate change. Few studies have been published about the influence of climate change on agriculture and forestry in Bosnia and Herzegovina. As far as is known there have not been any studies on the influence of climate change on biodiversity, its sensitivity and adaptation. Neither have any models been created that could be used for evaluating the possible changes to plant and animal communities in Bosnia and Herzegovina. In the biodiversity protection strategy for Bosnia and Herzegovina, the climate change problem and its possible influence on some landscape systems in Bosnia and Herzegovina is highlighted. However, there are no concrete examples given for species or models of areas of change for specific ecosystems, plant and animal communities.

In this context, and based on existing research and available literature, we will evaluate climate change and the potential influence on agro-ecosystems in Bosnia and Herzegovina.

In the SEE region which includes Bosnia and Herzegovina an increase in mean annual air temperature of about 3.5°C can be anticipated by the end of the 21st century (compared with annual average temperatures of the last decade of the previous century). This is based on applying:

- a 'rapid' socio-economic development scenario with a (generally) balanced use of energy sources;

- technological advancement in all forms of production and their extreme consumption of energy;
- projections of future emissions of GHGs.

Such increases in temperature would be followed by a reduction in rainfall at an annual level of 12%, with the greatest reductions of about 16–24% during the spring and summer seasons.

Besides these regional climate changes, caused by global climate change, significant changes could be expected in a local area. In this context, following the scenario of partial application of measures for decreasing the emissions of GHGs, in the territory of Bosnia and Herzegovina, an increase of air temperature of 3–4°C below average by the end of 21st century could be also expected. In the context of those thermal conditions, in next few decades we should anticipate a significant reduction of days with snow, a reduction of rainfall in the warm half of the year, which would result in a reduction of soil humidity and availability of water resources.

The reduction of summer rainfall on the territory of Bosnia and Herzegovina would be around 20% by the end of the century and, in the worst possible scenario (continuing the current practice of emitting GHGs), the increase of air temperature would be even larger and rainfall deficit could reach 40% during the summer.

Based on the research of Predic *et al.* (2001), carried out under the FAO project 'Condition inventory of land resources in the post-war period in Bosnia and Herzegovina', the frequency and extension of the dry period for the climatology station at Banja Luka was confirmed in relation to two periods (1962–1970 and 1992–2000) which on average had an equal quantity of precipitation per year. Land with a water capacity of 50 mm (shallow land) and 100 mm (deep land) was compared. The results pointed to the fact that in the period 1962–1970 dryness appeared three times and in the period 1992–2000 five times. It is, therefore, alarming that in 1998, 1999 and 2000 dryness appeared every year. Shallow land with a water capacity of 50 mm, which is mostly on sand (euteric and distric cambisol), distributed in the Bosnian area of Posavina, will be most affected by the period of dryness.

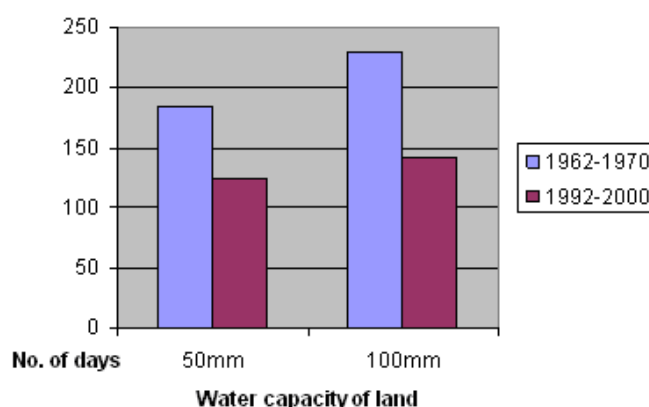


Figure 13: Number of dry days in period 1962–1970 and 1992–2000 for land with 50 mm and 100 mm water capacity.

From Figure 13 it is evident that the number of dry days has increased during the period 1992–2000; in addition, the average precipitation quantity on an annual level has not significantly increased. The precipitation regime is significantly disturbed, meaning that for agro-ecosystems the lack of precipitation is evident in the vegetation period. The increasing trend in relation to the period of dryness continues after 2000 and, as an example, we can highlight the most recent year (2007), which was the warmest year in Bosnia and Herzegovina for the last 100 years. In addition, based on the results set out above, the land with more capacity for water in the same climate conditions also has a shorter period of dryness. The research of Spasova *et al.* (2007) points to the fact that the vegetation period in Bosnia and Herzegovina has increased by a period of one month and also that natural vegetation starts its phenophase development a month earlier, so matching it with spring on the calendar.

The increasing intensity and frequency of dryness, as the precipitation regime changes in the territory of Bosnia and Herzegovina, highlights the necessity for detailed research on climate change and its possible influence, not only on biodiversity but also on food production, water resources and natural ecosystems, which are indirectly related to biodiversity, and likely to require mitigation (or they will have negative consequences).

Impacts on ecosystem services

The areas of Bosnia and Herzegovina that are the most sensitive to global climate change are defined by the strategy for the protection of biodiversity, including an action plan. The sensitive areas exposed to strong pressure of changing climatic conditions are as follows:

- **High-mountainous ecosystems** (higher than 1,600 m above sea level):
 - Bjelasnica, Maglic, Igman, Volujak, Snjeznica, Vlasic.
- **Mountain ecosystems** (from 900 to 1,600 m above sea level):
 - Klekovaca, Vitorog, Jahorina, Romanija, Kozara.
- **Ecosystems of submediterranean forests and underwoods** (from 300 to 800 m above sea level):
 - Eastern and Western Herzegovina.
- **Ecosystems of karst caves, basins and abysses:**
 - Herzegovina region, the best-known is cave Vjetrenica.
- **Ecosystems of highlands** (from 600 to 900 m above sea level):
 - Central, Eastern, North-West and South-Eastern Bosnia.
- **Ecosystems of the peripannonian area** (from 200 to 600 m above sea level):
 - Kozara, Prosara, Motajica, Trebovac, Majevisa.
- **Pannonian ecosystems** (up to 200 m above sea level):
 - Bosnian Posavina – Lijeve polje, Semberija.

High-mountainous and mountain ecosystems, on the basis of research on global climatic changes in Bosnia and Herzegovina, are exposed to the greatest impact. In other words, the areas whose altitude is higher than 1,500 m above sea level have a more rapid increase of average temperature compared with the areas of different altitude. Besides that, extremes in temperature represent the biggest pressure being exerted on the areas, which is particularly visible in the warmer season of the year, leading to melting of snow and drying and, with it, a threat that many glacial and boreal relicts and their habitats will be destroyed. Biodiversity of high-mountainous and mountain areas would be negatively impacted by acid rain, which appears as a result of over-pollution of the atmosphere. Acid rain, to a large extent, changes the pH value of a habitat, especially of the surface layers which are composed of accumulated humus, with which the most intensified processes of decomposition of organic matter are connected and the active part of the rhizosphere. A decrease of the pH value leads to a reduction in the number of basic species, which has an impact on reproduction cycles. In this way it may happen that some stenovalent species and forests disappear, especially those growing on dolomites and dolomitic limestones. In relation to forest ecosystems, the most endangered are the Fir forests, which, taking into account the temperature and humidity, have a very narrow ecological valence. In contrast, the Beech forests have a very broad ecological valence, and it is expected that they will become more prevalent in forests which are composed of a combination of both Beech and Fir.

Ecosystems of submediterranean forests and underwoods, and of karst caves and basins, as a result of global climate changes, will suffer pressure through the soil becoming sour (too acidic).

Peripannonian and hilly ecosystems are the most endangered after high-mountainous and mountain ecosystems. If we take into account the calculated changes of temperature, the greatest pressure would be exerted on the Oak forests (specifically, Cork Oak and English Oak forests). The Cork Oak forests are altitudinally the lowest forests in the territory of Bosnia and Herzegovina; growing between 280 and 860 m; (the altitudinal amplitude is very low – 580 m). The potential of the Cork Oak and English Oak forest to extend into the areas of higher altitude is very limited due to their heavy seed (Burlica & Travar, 2001). In addition, where the increase in temperature is accompanied by an increase in dryness, conditions will be created in which the decay and decomposition of forest ground vegetation slows down. As a consequence, a layer of raw humus would be formed that would lead to a process of subsolation in the soil, and a significant decrease in biodiversity in the lower layers of the vegetation.

Pannonian ecosystems (natural and cultural) are most endangered by floods; this is one of the main factors that can significantly change the quality of a habitat. The floods have a high percentage of nutrients, which increase the nitrification of the soil and underground waters. The resulting changes in pH values cause acidophil plants and pedofauna to disappear. The floods are one of the dominant factors in the expansion of invasive species. In this way, in the area of Bosnian Pannonia, many species of weeds have already become established.

With the aim of preventing flooding along the river Sava, the levees have been raised, which has significantly changed the physiography of the natural surroundings of those areas.

The adaptation of forest ecosystems to rapid climate change is likely to be a key problem in Bosnia and Herzegovina. The implementation of responsive measures in terms of maintaining the forests will, to a certain extent, reduce the social and economic consequences of their decay under the influence of global climate change. Defining the protection measures for forest ecosystems requires more advanced research on the impacts of regional climate change, and an analysis of the social-economic potentials leading from a decay of forests.

Existing relevant policies at national and subnational levels, including adaptation and mitigation strategies

The UNFCCC was ratified by the Government of Bosnia and Herzegovina in 2000 and the country, as a Non-Annex I Party, is fully committed to meeting its requirements; however, further active work on these issues is needed. The Kyoto Protocol was ratified recently (in July 2007) in line with Bosnia and Herzegovina's strategic goals for accession to the European Union. The current climate policy and the existing legal framework in the country are described. In addition to gaps, needs and obstacles, the means to deal with climate change issues from an adaptation point of view are also outlined. However, the First National Communication to UNFCCC for Bosnia and Herzegovina has still not been developed, and adaptation measures for agriculture have not been identified. The awareness of climate change issues in Bosnia and Herzegovina has not been raised to a sufficient level.

It is important to note that there is recognition in the country of the urgent need for undertaking actions for the preparation of the First National Communication Report. Based on recently published regional scientific research results and the IPCC AR4 Reports, the creation of a streamlined and complementary national strategy to address the adaptation problem in the biodiversity sector is also necessary. To start with, local climate change projections should be prepared, the main climate change impact indicators should be identified, and potential future adaptation measures should be drawn up as an initial step towards compliance with UNFCCC and Kyoto Protocol requirements in the fields of adaptation to climate change.

The level of existing capacities can be estimated as low. The activities related to climate change that have been carried out so far are rather fragmented and unsystematic; the preparation of the First National Communication, together with development of the National Strategy and Action Plan for Climate Change related to implementation of UNFCCC and its Kyoto Protocol, as well as National Clean Development Mechanism (CDM) strategy, are of utmost importance. This is because they represent the basis for compliance and continuation of other related activities.

Consideration, listing and prioritization of future policy frameworks, prospects and possible actions

Disadvantages and limitations

- Bosnia and Herzegovina has not implemented the First National Report on Climate Change (FNC).
- Incoherence and lack of harmonization of strategic and development-related documents (in the sectors of forestry, agriculture and water management) in relation to the field of biodiversity management.
- Lack of defined social-related research, with the aim of resolving current problems in the field of biodiversity and implementation of relevant international conventions and directives.
- Very low public awareness of the importance of biological diversity for the purpose of preserving fundamental values of the environment, and especially in regulating climate changes.

- An extremely small number of scientists and experts, as well as of institutions dealing with biodiversity and its maintenance.
- Lack of financial means and funds for scientific research in the field of climate change and biodiversity, as well as the environment as a whole.

Suggested priority tasks

- Implementation of the First National Report on Climate Change (FNC), and within its framework, determining the impact of climate change on biodiversity, as well as adaptation measures.
- Setting a framework which defines long-term activities in relation to solving the problems related to climate change.
- Setting a framework for the adoption of a national strategy for adaptation to climate change, and an overall plan for the implementation of the adaptation measures.
- Defining of measures and activities for alleviating the impact of global climate change on biodiversity and ecosystems in Bosnia and Herzegovina.
- Improvement of knowledge about global climate change, especially about the anthropogenic impacts on global changes, and their potential impact on the biodiversity of Bosnia and Herzegovina.
- Development and conducting of a sensitivity and vulnerability analysis of ecosystems (including agro-ecosystems) and habitats in relation to projected climate change.
- Development of recommendations for monitoring and adaptive measures for conservation and restoration.
- Evaluation of the existing ambient monitoring programme to determine whether additional biodiversity monitoring will be needed as new climate change information emerges.
- Development of scientific tools to evaluate the effects of climate change on local fish and wildlife populations and habitats.
- Analysis of the vulnerability of forest resources to climate change (special attention will be paid to understanding and developing management practices to reduce the risk of forest fires and insect disturbance, as far as possible).
- Extensive educational assistance to small landowners.
- Increased capacity for fire management planning, and sound management of public lands.
- Development of a climate-impacted database and products related to emerging forest practices (e.g. reforestation techniques and pest management) that are considered most adaptive to climate change, as well as information on how to reduce the risks of forest fires and insect damage.
- Provision of outreach and updating of stakeholders from the SEE region and national adaptation teams with relevant information through appropriate seminars and workshops and various media sources about the impact of climate change on forest health and forest biodiversity.

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Montenegro

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Background

Climate change is an additional pressure for biodiversity in Montenegro. For some species and ecosystems it could result in extinction or reduction in the species population size.

The character of Montenegrin biodiversity

Montenegro has a rich and diverse biota, whose value has often been compared with other European states, particularly through the species-area index. The index for Montenegro is 0.837¹ which places this small state at the top of the European biodiversity scale. Montenegro comprises three main ecological subregions: (i) inland mountains, which dominate the territory; (ii) the central lowland plain, characterized by the river Morača, and Skadar Lake; and (iii) the Adriatic coast, which is separated from the rest of the country by the mountains of Orjen, Lovcen and Rumija. The northern mountain ecoregion is biogeographically connected with other mountain habitats in the Dinarides mountain corridor (the wide Dinarides bio-corridor extends from Bosnia and Herzegovina in the west to the 'Green Belt' between Albania and Montenegro in the east). Due to the refugial character of many habitats there is considerable endemism, with dominant mid-European, Iliric, alpine and Mediterranean elements.

Relevant climate issues

Baseline – The climate of Montenegro is influenced by its geographical position and relief. Ranging from 41°52' to 43°32' north latitude and from 18°26' to 19°22' east longitude, Montenegro is in the central part of the moderate warm belt of the Northern Hemisphere and thus has a moderate, warm and pleasant climate. Its geographical position and the vicinity of the sea, morphological profiles and air mass circulations form complex climatic characteristics in the region of Montenegro in terms of high variability over space and time. The warmest months are July and August, while the coldest month is January. Two types of winds are typical, *Bora* and *Sirocco*. The Bora is the predominant wind during the winter with a N–NE direction, high intensity and gusting; especially along the coastal zone and Podgorica–Skadar Basin. The Sirocco, with its S–SE direction, brings warm and humid air producing a high amount of precipitation, especially behind the Bay of Kotor. The largest proportion of precipitation during the colder part of the year is due to the Sirocco. Wind storms affect the coastal zone and Podgorica–Skadar Basin. This occurs frequently as a result of the Bora. During the summer, forest fires affect littoral mountain slopes along the coastal zone and the district between the two cities Podgorica and Cetinje. The rainiest part of Europe is at the littoral mountain chain Krivosije, behind the Bay of Kotor. The annual amount of precipitation is 4,600 mm. The maximum annual amount of precipitation is around 7,000 mm in Crkvice town (940 m asl), representing the European maximum. This high amount of precipitation is due to orographic effects. Important weather systems that determine the weather in Montenegro are the Siberian and Azorean anticyclones, the Genoa cyclone and low air pressure over the Adriatic Sea.

Climate projections – The trend of increase in temperature from the second half of the 20th century has been recorded in most parts of Montenegro. The intensity and frequency of climatic extremes such as droughts, floods, landslides, erosions, heatwaves, extremely high and low temperature, heavy precipitation with short duration, forest fires, conditions appropriate for spreading epidemics, pests and diseases, etc., show the trend of changes. There is a reasonable amount of information on national climate change projections. According to the Third Assessment Report of the IPCC (IPCC, 2001), the southern European region (including Montenegro) will experience severe impacts of climate change until the end of the 21st century. Projected changes are:

- an increase in temperature of 2°C in the winter season;
- an increase in temperature of 2–3°C in the summer season (with projected 0.2°C per decade, the most rapid increase in the last 10,000 years);

¹ According to *The Dobříš Assessment* (1995) and Stevanović *et al.* (1995). Index S/A = log (S) / log (A), i.e. ratio between the vascular plant species number and the state territory.

- a reduction of precipitation of 5–15%, especially in the warmer part of the year, and consequently a reduction of soil humidity of 15–25%.

Direct impacts on biodiversity

Climate change and interactions between species

At present, national statistics and monitoring schemes do not provide adequate data/information about the direct impacts of climate change on biodiversity. However, some indirect linkages between climate change and biodiversity are noted in the following climatically and geographically different regions in the country: (i) Mediterranean: which suffers from summer droughts and excessive winter rainfall; and (ii) Continental: which has a shorter snow duration. In consequence, Mediterranean animal and plant species will become more threatened, particularly those in/near to wetlands/water bodies, as well as species in karstic habitats. It has already been noted that there have been reductions in the populations of some amphibian (newts, frogs) and reptile (lizards, snakes) species that are dependent on surface waters in the karstic area of the country. The phenomenon of 'die-back' of coniferous forest in the continental region, in particular on Durmitor Mountain, has been reported by Šmit (in his works published in the period 1960–1980). In-depth research on the toxic impacts of heavy metals in acid precipitations, such as Fe, Mn, Zn and Cu (also called 'acid rain') on these forests was carried out in the late 1990s (Andjelic, Ph.D. thesis, 1998 – full reference available from country report author). Acid rain was recognized as a key cause of the drying of forests, resulting in deforestation.²

Climate change and food production

Due to various factors (including climate variability, the decline in use of domestic species in (traditional) agricultural practices), new, mostly genetically modified species adapted to all climatic conditions are becoming very common in the main agricultural areas such as the Zeta and Bjelopavlici Valleys. With respect to food production, there are significant trends in relation to changing agricultural land size and in the production/yield of some vegetable crops. In the period 2002–2006, a decrease in the area of agricultural land has been recorded (518,067 hectares in 2002; 517,337 hectares in 2006). However, in the same period 2002–2006, the production/yield of vegetable crops increased, as follows:

- potato yield increased from 101,288 tonnes in 2002 to 132,783 tonnes in 2006;
- onion yield increased from 3,319 tonnes in 2002 to 3,928 tonnes in 2006;
- cabbage yield increased from 26,782 tonnes in 2002 to 31,813 tonnes in 2006.

The annual production (yield) of paper is similar to the production of potatoes in the reporting period. Vineyard productivity shows an increase in both size (3,859 hectares in 2002; 4,188 hectares in 2006) and yield (34,954 tonnes in 2002; 41,726 tonnes in 2006).

It should be mentioned that national monitoring schemes do not provide adequate data collection in relation to the water stress regime in the soil (Standardized Precipitation Index – SPI) for the purpose of estimating impacts of climate change on agriculture.

Climate change and natural resources

Until now, the availability and use of water has been determined by local conditions such as the karstic geology of the terrain, volume of extraction, etc., more than by climate variability. However, national statistics record a significant increase in the capture of water for water supplies from 95,133,000 m³ in 2002 to 101,866,000 m³ in 2006. This change is mostly attributed to the use of underground water.

Forest exploitation shows an ascending trend in the volume of forest felling in the period 2002–2006. While the volume of forest cut in 2002 was 514,708 m³ its value in 2006 was 631,273 m³.

Bearing in mind the local topography of the terrain in Montenegro (mountains intersected by deep canyons, scarce karstic waters), it could be expected that negative trends in exploitation of natural

² Deforestation, i.e. drying of the forests, as a relevant climate change impact is considered in the CBD publication: *Report for experts and government review, prepared by the CBD Ad Hoc Technical Expert Group on Biodiversity and Climate Change* (2003). This issue was also considered in the document *Framework Strategy and Action Plan for Serbia and Montenegro in response to the problem of GHG (greenhouse gases) emissions – Proposal for the discussion* (prepared in 2005 by several authors and supported by Ministry for the Environment and Territory, Italy – Belgrade office), REC and the Special Japanese Fund.

resources, such as use of the land, water extraction and deforestation, could lead to a *change in local climate conditions*. For this phenomenon specific data/information and evidence are missing.

In addition, exploitation of freshwater and marine biological resources has increased in the period 2002–2006. While total marine fish catch in 2002 was 466 tonnes, in 2006 it was 738 tonnes. Freshwater fish catch in 2002 was 296 tonnes, but in 2006 it was 786 tonnes.

Changes in biodiversity distribution and abundance caused by climate change/conditions

Until now, there have been no data which directly addressed changes to or adaptation of biodiversity in relation to its distribution and abundance that can be attributed to climate conditions. Due to the small area of the country the distribution of plant species (vegetation) still follows regional vertical zoning as described in the literature. Specific biodiversity monitoring data (e.g. the International Waterfowl Census (IWC) biodiversity monitoring programme at Skadar Lake) are not tailor-made to link their results and outcomes with changes in climate. For example, the counting of birds (IWC) at Skadar Lake (since the 1990s) has produced specific numerical data that are important for the estimation of global regional bird populations but, unfortunately, cannot be linked with the changes in local or global climate conditions.

Changes in habitats, composition of biocenosis and ecosystems caused by climate change/conditions

As mentioned above, available national statistics and monitoring schemes do not provide adequate data that directly address the consequences of climate change for natural habitats, animal and plant communities (biocenosis) and ecosystems. Existing data on habitat/ecosystem destruction and fragmentation are directly linked to local human activities (urbanization, tourism facilities, infrastructure, etc.).

Changes in water ecosystems (altered waters)

The existing legal and institutional set-up³ provides monitoring of quality (physico-chemical and biological) and quantity (water level, discharge) of marine and fresh waters. However, these data are not sufficient to explain linkages between climate change and changes in altered water regimes. On the other hand, attempts were made in relation to specific geographical areas such as the Tara and Lim River Basins⁴ with regard to flood management.

Impacts on ecosystem services

Changes in the structure and productivity of the ecosystems caused by climate change have not been assessed in Montenegro. However, data on the phenology of fruits and natural trees (Hydrometeorological Institute⁵) indirectly indicate the consequences of climate change on the productivity of certain ecosystems in Montenegro. Available data for 2007/2008 shows that the foliation of some fruit trees and wild trees started a few days earlier than the average. While foliation of selected wild trees⁶ in 2008 started 12.4 days earlier, foliation of selected fruit trees⁷ started 4.6 days earlier than average. An earlier start to foliation is followed by an earlier start to flowering of both selected wild trees and fruit trees. The data for changes in the phenological events mentioned above do not explain the viability or resilience capacity of these natural and agro-ecosystems to climate change impacts.

Existing relevant policies at national and subnational levels, including adaptation and mitigation strategies

Some of the existing legal regulations relevant to climate change are largely harmonized with relevant EU directives, as is the case with the Law on Integrated Pollution Prevention and Control (2005) which, if implemented, would reduce the GHG emissions. The Law on Protection of Air against Pollution (1980) is being updated and a new draft Law on Air Quality has also been prepared; among other issues, the establishment of emission norms has been recommended by EU directives. It is important to mention that the Ministry for Economic Development, with the support of the United Nations Industrial

³ **Laws:** Law on water, Decree on classification and categorization of waters. **Institutions:** Hydrometeorological Institute, PE Centre for Eco-toxicological research.

⁴ Study: Flood management in the Tara and Lim River Basins (WL/Delft Hydraulics, 2004), WB/GEF: Tara and Lim Integrated River Basins Management Project.

⁵ Visit <http://www.meteo.cg.yu/misc.php?text=62&sektor=1> (available in Montenegro's national language).

⁶ Trees: Acacia, Linden, Oak, Maple, Ash, Beech, Poplar, Alder, Black Pine and Maritime Pine.

⁷ Fruit trees: Sour Cherry, Cherry, Olive, Pomegranate, Mandarin, Fig, Plum, Lemon, Apple, Pear, Hazel.

Development Organization (UNIDO), prepared the Draft Energy Strategy. The United Nations Development Programme (UNDP) in Montenegro is supporting the preparation of a pilot Strategic Environmental Assessment (SEA) on the draft Energy Strategy, whose main objective is to assess the environmental and associated socio-economic impacts of the suggested and alternative options given in the Draft Energy Strategy.

In the framework of the Global Environment Facility (GEF)/UNDP 'National Capacity Self-Assessment (NCSA)' project (2006–2007), priority needs for capacity building for implementation of the UN Framework Convention on Climate Change (UNFCCC) have been assessed. Thus, the *Thematic Report for the UNFCCC* emphasizes that the legal framework related to the sectors of energy, heavy industry, agriculture, forestry, transport and waste management is especially important for the fulfilment of Convention requirements. However, the current legislation is insufficient for the implementation of existing and future plans and programmes in the field of climate change. In effect, the existing laws treat climate change in a general manner, while specific issues, such as gas inventories, reporting and allowed GHG emissions, are not sufficiently taken into consideration. In addition, there are no regulations that deal with the creation and operation of the national system for the assessment of anthropogenic GHG emissions, as required by the Convention.

The Law on the Protection of Air against Pollution (1980) contains norms on monitoring and reporting of air quality values (e.g. SO₂, NO_x, CO, suspended particles) which should be harmonized with those of relevant EU directives.

The Energy Law does not deal with the UNFCCC and Kyoto Protocol requirements. In the waste management sector the regulations only touch upon the problems of GHG emission at waste disposal sites and there are no binding regulations. In the agriculture sector Convention-related issues are not included, while the legal framework in forestry deals only with the economic exploitation of forests. In the transport sector no regulation takes environmental issues into consideration.

With regard to the preparation of the strategies and plans required by UNFCCC, the *Framework strategy and Action Plan of Serbia and Montenegro in response to the problem of GHG (greenhouse gases) emissions* (2004/2005) includes the following goals: (i) definition of a framework containing long-term activities to solve climate change problems, especially the mitigation of climate change, and effects of and adaptation to changed climate conditions, all in support of a more efficient implementation of the UNFCCC and the Kyoto Protocol; and (ii) definition of a framework set of measures to solve specific issues in all sectors that are exposed to or contribute to the problem of GHGs. This document can serve as the basis for the formulation of the country's strategy, as well as of the national plans and programmes.

The project 'Assistance for preparation of the *First National Communication* for the implementation of the UNFCCC' is ongoing, funded by the GEF. The *National Communication* will contain, among other things, descriptions of the status of GHG emissions in the country; the institutional structure and its roles and responsibilities; and demographic, geographical, climate and economic data. However, the *National Adaptation Programmes of Actions* (article 4.1) will contain measures to mitigate climate change, but has not yet been developed.

In 2006 the Italian Ministry of Environment, Land and Sea and the Ministry of Tourism and Environment (MTE) of Montenegro established a joint office with the main aim of assessing and preparing CDM projects. It is planned that this office will assist in the formulation of proposals for the preparation of the national plans for adaptation to and mitigation of climate change and identification of various sectors that need intervention. In addition, the Designated National Authority (DNA) has been established. In compliance with DNA guidelines, a future carbon financed project shall be prepared by the national Environmental Protection Agency (EPA). In the ministries relevant to climate change issues (environment, agriculture, forestry, water management, energy, etc.) there are no specialized units dealing with climate change nor plans or budgetary provisions to hire the required specialists to carry out the responsibilities associated with the implementation of UNFCCC compromises. In addition, apart from the UNFCCC Focal Point at the MTE, there are no other employees in State institutions dealing with the fulfilment of Convention requirements.

Some institutions are already involved in or have some capacity to participate in data collection and monitoring. For instance, the Hydrometeorological Institute currently monitors climate data and has some capacity to participate in the fulfilment of requirements related to systematic observation of the climate

system, the assessment of ecosystem vulnerability to climate change and data collection on GHG emissions. The Institute for Forestry, the Bio-Technical Institute and the Institute for Transport at the University of Montenegro have the potential to work in the field of observation and research in climate systems. The Institute for Transport collects data on emissions from transport and has built a substantial database.

In the framework of the plan for the establishment of a national EPA, there is a proposal for the creation of a unit within its administrative structure to deal specifically with climate change issues.

Consideration, listing and prioritization of future policy frameworks, prospects and possible actions

Because there are not enough experts in the area of formulation and implementation of UNFCCC/CDM projects, it is necessary to undertake *additional training of experts* who will work on CDM projects.

The Statistical Office of Montenegro (Monstat) is in charge of collection, maintenance, processing and issuing of statistical information, including environmental data. Only one employee is engaged in gathering and working on the information related to the environment, including climate change. Monstat has no data on carbon dioxide emissions and does not exchange environmental data with international sectoral agencies.

Apart from officially non-verified data on GHGs collected⁸ for 1990, 1998, 2000 and 2003, a reliable *GHG emissions inventory does not exist* and, in addition, there is lack of harmonization of the methods of data collection about GHG emissions. There has been some non-systematic research on the climate system, but there is no exchange of databases in this area. There are no studies on mitigation and adaptation to climate changes. A twin-track approach is needed to pursue mitigation and adaptation through policy instruments intended to deal with climate change. There should also be an examination of whether and how 'business-as-usual' can accept and take part in implementing mitigation and adaptation measures. This could be a good reason for mainstreaming climate change responses into regular development activities undertaken by various public institutions.

The Institute for Transport at the University of Montenegro has a substantial database on emissions from transport, but better cooperation and exchange of information with other institutions needs to be established.

There is an obvious need to *modernize technical equipment* (which is rather old in most institutions) in order to meet UNFCCC reporting requirements, by participating in international programmes, such as the World Climate Programme and the International Geosphere-Biosphere Programme.

It should be noted that the plans of the Ministry for Tourism and Environment to *hire additional professional staff* will be realized in order to increase efficiency in the work concerning issues relating to both climate change and biodiversity conservation. This would increase the number of specialists in the Ministry to three in the field of climate change and four in the area of biodiversity.

Regarding UNFCCC requirements, Montenegro has not adopted any *plan or programme at the national level related to climate change*. Consequently, there is no fund for these purposes. Consequently, climate change and biodiversity conservation issues should be promoted as a high priority in the political agenda and the awareness among decision makers of these issues should be raised.

Because national strategies, policies and plans are still prepared in a traditional way, there is a need to *integrate climate change* issues in the process of their development, emphasizing linkages between changes in biodiversity and changes in climate conditions at national level.

It is recommended that more precise forecasts and projections of climate change in Montenegro based on regional models should be made. A draft GHG inventory has been made, but it is necessary to identify the real status of emissions from agriculture and forests based on IPCC documents. There is a need to develop and implement climate change adaptation plans and to adopt biodiversity-based adaptive and

⁸ Data are provided by a technical assistance project of the Italian Ministry of Environment, Land and Sea to the Montenegro ministry responsible for the environment.

mitigative strategies. Some of the recommendations include: maintaining and restoring native ecosystems, and establishing networks of ecological connectivity between terrestrial, freshwater and marine protected areas taking into account projected climate change impacts. Recommendations in relation to agricultural and forestry ecosystems include: improving energy efficiency; using renewable energy (biogas and biodiesel) and supporting research in the field of renewable energy; effective use of nitrogen fertilizer and controlling the practice of igniting organic residues after the harvest.

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Serbia

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Background

The Republic of Serbia, located in SEE, covers an area of 88,361 km² and includes two provinces: Vojvodina (21,506 km²) and Kosovo and Metohija (10,887 km²), which is currently under the provisional administration of the United Nations. Except for the flat parts of the Pannonian plain in the north, Serbia is situated mostly in the Balkan Peninsula, which is one of the most important centres of biodiversity in Europe.

Serbia's predominantly upland terrain can be divided into a northern region (part of the Pannonian plain intersected by the Danube, Sava, Tisza, Tamis and Begej Rivers, and several lowland shallow lakes and great wetlands) and a more hilly/mountainous region to the south of the Danube and Sava Rivers (comprising the Rhodope, Carpathian, Balkan, Dinaric and Scardo–Pindhic mountain ranges). Forests and woodland cover 28% of Serbia, 40% is arable land and 21% of land is used as permanent pastures.

The greatest part of the territory of Serbia has a moderate-continental climate. The south-western part of the country is on the border of Mediterranean subtropical and moderate-continental climate. Weather conditions have been monitored by the Republic Hydrometeorological Service for more than a century. Data indicate that the mean temperatures are increasing continuously. During the period 1951–2005, the mean annual temperatures fluctuated, but with a rising trend, except for the south-eastern part of the country. After 1990 the increase of annual air temperature has been more pronounced. Data also indicate a decrease in the number of days with snow and snow cover, a decrease of precipitation in the warm half of the year, accompanied by a decrease in runoff, soil moisture and availability of water resources, as well as changes in the frequency and intensity of climate extremes. The expected impact of climate change also includes greater leaching of nutrients from the soil during intense rains, greater erosion and more wildfires. The latest report of the IPCC (IPCC, AR4, 2007) included the region of southern Europe in global regions that are highly sensitive to climate change.

The impacts of a progressively changing climate, such as rising average temperatures and increases in the frequency and severity of extreme events, droughts and floods, are already affecting biodiversity and ecosystems in Serbia. The Regional Centre for Climate Change Monitoring 'Milutin Milankovic' has recently been established within the Republic Hydrometeorological Service. The Centre will enable better links between climate and biodiversity research.

Direct impacts on biodiversity

Most scientists agree that an increase in the concentration of GHGs in the Earth's atmosphere has caused global temperatures to increase, mainly as a result of the impacts of different human activities. Numerous examples have shown that climate change, together with various types of destruction and degradation of natural habitats, is already having harmful impacts on biodiversity on Earth. Climate change is a highly complex problem. Assessing the direct impact of climate change on biodiversity is difficult because climate change effects interact with other stress factors already imposed on the environment.

The Balkan region is characterized by an extraordinary richness of species, comprising areas with numerous refugial habitats of various ages and ecological features. They include important centres of speciation, biodiversity and endemism. For example, the endemic vascular flora of the Balkans is currently estimated between 2,700 and 2,800 taxa at species and subspecies rank (Stevanović *et al.*, 2007). Generally, all high mountains and larger mountain massifs are areas with high biodiversity, mainly due to the existence of different types of ecosystems and zonal biomes. Local biodiversity is influenced by the presence of refugial biotopes within gorges, canyons and relict forests, as well as special categories of open habitats.

The biodiversity of Serbia is extremely high, owing to its biogeographical position (the mountains of the Balkans are designated as one of the six centres of plant diversity in Europe), the openness of the territory to other surrounding regions and the past processes of flora and fauna genesis. The *119 Assessment* (Schulze, L.L. & DevTech Systems, 2002) identified four general categories of threats to biodiversity in Serbia: habitat degradation, illegal extraction or poaching, invasive alien species and pollution. Climate change could bring additional pressures to biodiversity. This is a phenomenon which is currently recognized as important by the academic community and a minor part of the Serbian public. Despite the fact that the number of biodiversity researchers is growing, a complete inventory of biodiversity has not yet been completed. At the present time, a biodiversity inventory is limited to studying the endangered, endemic, rare, relict and internationally significant species (fungi, vascular flora, Nematoda, Arthropoda, fishes, reptiles, birds and mammals). At the same time, estimation of direct impacts of climate change on biodiversity is still in the initial stage.

Climate change is predicted to hit hardest among those species with intrinsically low population numbers, those inhabiting restricted or patchy areas, and those adapted to very specific climatic and habitat conditions. Species which are already endangered due to changes in their habitats in Serbia (e.g. *Bulbocodium versicolor*, *Paeonia tenuifolia*, *Spalax leucodon*, *Spermophilus citellus* and *Falco cherrug*) are therefore particularly vulnerable.

It is projected that by 2050 climate change will cause the extinction of a substantial number of endemic species. The Balkan endemics make up 8.06% of the flora in Serbia, and local endemics make up 1.5% (Stevanović, 1999). Numerous plant and animal species are tertiary, glacial, boreal, xerothermic or steppe relicts, while the gorges and canyons of eastern and western Serbia are the most significant refugial areas of Tertiary vegetation in the Balkans. It is estimated that c. 60% of the endemic plant species in Serbia are endangered for various reasons.

The total number of known species in Serbia is 4,082. As a subset of that total, Serbia has 96 mammals, with 12 identified as threatened species; 238 breeding birds, with five identified as threatened species; 35 reptiles, with one identified as a threatened species; 10 amphibians and 125 fishes, with 10 identified as threatened species. Six hundred plant species and 270 animal species are under various categories of threat in Serbia (Stevanović & Vasić, 1995). Species that are already threatened are particularly vulnerable to the impacts of climate change.

Research topics studied by Serbian scientists can be grouped into: (i) spatial and temporal distributions of taxa; (ii) genetic diversity and viability of populations of species; (iii) physiological tolerance of species; and (iv) ecosystem processes. There are still many gaps in the knowledge relating to the effects of climate change on biodiversity in Serbia. Additional research should be done on the direct effects of GHGs, and on interactions between the effects of climate change and habitat fragmentation.

Changes in the timings of seasonal events, leading to loss of synchrony between species and the availability of food, and other resources upon which they depend

Climate change has led to shifts in phenology in many species, distributed widely across taxonomic groups. The major effect of climate warming on species occupying even a broad climatic range of systems is an increase in the length of the growing season and an altering of the optimal time for life-history transitions such as development, reproduction, dormancy and migration (Bradshaw & Holzapfel, 2008). As a consequence of winter warming within temperate regions, spring arrives earlier and winter arrives later, resulting in an earlier or longer season favourable for growth, development and reproduction. Biotic response to climate change is seen primarily in the northward expansion of species' ranges, the earlier migration and reproduction in the spring, and the later migration or entrance into hibernation in the autumn (Hughes, 2000).

Plant and animal species in Serbia exhibit seasonal patterns in their activities because there is a clear seasonality in the suitability of their environment: there is often only a limited period in the year when conditions are favourable enough to successfully reproduce or grow, but changes in the timings of seasonal events have not been studied in Serbia.

Shifts in suitable climate conditions for individual species leading to change in abundance and range

The abundance, distribution and phenology of a broad range of plant and animal species correlate well with changing patterns of atmospheric temperature, precipitation and other weather variables over recent decades (Root *et al.*, 2003). It has become apparent that many species typical for temperate woodland in

Europe are declining, although the mechanisms responsible have yet to be identified. A number of potential causes have been suggested, including trends in woodland management, interactions between species and climatic change.

It has been shown that weather conditions might influence bird species abundance through their impact on both survival rates and breeding success (Leech & Crick, 2007). In numerous areas in Serbia, fragmentation of ecosystems and natural habitats results in the reduction of the area of activities of individual species. Many areas of particular importance to breeding or wintering birds are currently protected in Serbia.

While generalist species may be able to cope with rapid environmental change, it is likely that species with more specialized ecological niches will face more severe challenges (Huntley *et al.*, 2006). Forest ecosystems are likely to be particularly vulnerable to climate change due both to their complexity and to the time taken for trees to mature.

Environmental factors, influenced by global climate change, determine the distribution and range of species. Ectothermic animal species in particular are expected to shift their distribution northwards. However, in many cases, the adaptability of species under rapidly changing climate conditions is largely unknown (Araújo & Rahbek, 2006).

Changes in the habitats which species occupy

A decline in biodiversity is directly attributed to a substantial loss of natural habitat due to expanding agriculture (particularly on the Pannonian plains) and the drainage of swamps and marshes. Degradation and change of land use in Serbia, especially at the expense of forests, cause huge changes in habitats. Agricultural land occupies about 65% of Serbian territory, which was originally covered with forests, shrubs, steppe vegetation and marshes. The original vegetation was removed to obtain areas for either mountain pastures or lowland arable land. Marshes were drained and steppes were irrigated for agricultural crops. Degradation and loss of forest cover have increased in the past two decades due to illegal forest cutting, uncontrolled livestock grazing and forest fires. Complete destruction of the natural habitats and their replacement by artificial habitats has created unsuitable conditions for the survival of many plant and animal species.

Colonization of habitats by invasive alien species or the introduction of exotics could lead to increased competition for resources, negatively influencing survival and productivity of native species.

Changes to the composition of plant and animal communities

Climate change, together with other negative human impacts, is very likely to affect the diversity of plant and animal communities. The magnitude, extent and duration of the impacts and responses will be location-dependent, and will produce varying outcomes, including local and/or regional extinctions or species loss, genetic adaptations to new environments and alterations in species ranges and distribution.

Forests contain some of the greatest diversity of all ecosystems in terms of species, genetic material and ecological processes. They have an important role to play in providing environmental services, in particular when they are not fragmented. They absorb and retain water, store carbon, protect the soil from wind and water erosion, and are needed for socio-economic services. It is expected that climate change will cause forest ecosystems to change in various ways, such as in animal and plant species distribution and changes in tree physiology and stability.

Tree species composition in many European forests is likely to change significantly (Huntley *et al.*, 1995). For example, Beech (*Fagus sylvatica*) and Scots Pine (*Pinus sylvestris*) are likely to decline at the southern edges of their range in Europe, while climate conditions to the north of the current ranges could become more suitable, leading to northwards range expansions. Increasing drought frequencies during the growing season could also result in higher tree mortality rates.

Freshwater ecosystems in Serbia are characterized by sensitive and changeable physico-chemical features on which the survival of living organisms depends. Large areas besides rivers are especially fragile and are very important for the maintenance of natural heritage and environmental protection. Most of these areas in Serbia are habitats of national and international importance. The Institute for Biological Research in Belgrade participates in the ALARM (Assessing Large Scale Risk for Biodiversity) project, which includes investigation of phytoplankton, phytobenthos, macroinvertebrates, fish and fish

parasites in freshwater ecosystems. The project includes studies on biodiversity, endangered aquatic species and the introduction, distribution and acclimation of invasive species.

Changes to habitats and ecosystems, such as altered water regimes

The alteration of natural water regimes is now recognized as a major contributor to loss of biodiversity and functionality in aquatic and terrestrial ecosystems.

Inland waters have unique natural water and flow regimes influenced by climate, surface runoff, catchment size and geomorphology. Many types of human activities influence water regimes within catchments. Widespread changes of vegetation cover and land uses can affect both surface water and groundwater. Direct interference to a waterway, such as the construction of dams and weirs for water storage and flood protection structures, can modify surface water regimes. Extraction of water for domestic, agricultural, mining or industrial reasons can also have a profound impact on surface and groundwater regimes.

Alteration of natural water regimes can modify the values of inland waters and lead to other land and water problems, including floods and drought-like conditions, waterlogging, eutrophication, acidification and erosion. Widespread land clearance and the replacement of native vegetation with solid surfaces associated with buildings and roads can increase water runoff and reduce recharge to groundwater. Similarly, the replacement of native vegetation with agricultural crops and pastures that use less water leads to a gradual rise in groundwater levels.

Modified water and flow regimes can have significant social, economic and environmental impacts. Too much water can result in flooding of ecosystems, loss of fauna habitat and a favouring of opportunistic weed species. Too little water results in drought-like conditions, often leading to loss of inland waters, degraded ecosystems, limited habitat, acidification and eutrophication problems, and widespread death where species are unable to adapt to modified conditions.

Impacts on ecosystem services

The vulnerability of an ecosystem to climate change depends on the tolerance of its constituent species to change, the degree of change, and other stresses already affecting it. Disturbances such as fires, floods and insect plagues are expected to become more frequent as a result of climate change in Serbia.

Forest ecosystems provide a wide array of goods and services. Forests are particularly vulnerable to climate change because even a small change in temperature and precipitation can have significant effects on the functioning and composition of forests. Many large forest-dwelling animals and nearly 9% of all known tree species are already at some risk of extinction.

Forests play an important role in regulating the Earth's climate. They are an essential link in the global carbon cycle because they take up CO₂ for their growth. In Serbia, a significant share of forest land is currently at a lower intensity than in previous centuries. The project 'The Impact of Climate Change on Forest Biodiversity' has been initiated with the goal of improving the state of forestry in Serbia and sets out to describe the most likely impacts of climate change and its consequences for forest management, timber production and biodiversity, including risk assessment.

Mountain regions are already under stress from various human activities such as overgrazing, abandonment or inappropriate land management, thus reducing their natural resilience to climate change. Mountain species, especially endemic species, have a very limited capacity to move to higher altitudes in response to warming temperatures. In some national parks (Kopaonik, Tara) and a nature park (Stara Planina), the pressure of increased tourism is additionally threatening biodiversity.

Existing relevant policies at national and subnational levels, including adaptation and mitigation strategies

Serbia ratified the UN Convention on Biological Diversity in 2002, but still does not have a National Strategy and Action Plans for the protection of biodiversity. The National Biological Diversity Monitoring System has not yet been developed. This system is necessary for monitoring and summarizing the changes in the biological diversity.

The system of laws and by-laws addressing biodiversity and nature conservation in Serbia is inconsistent and requires revision and adaptation to the EU directives. The legal regulations in the field of biological diversity have already been aligned in certain areas with the relevant EU regulation; it is expected that the alignment will be completed by the end of 2009. Full implementation is expected to take place in 2014.

Serbia ratified the Kyoto Protocol in September 2007. As a Non-Annex I country, it is not legally bound to reduce GHG emissions. At the present time, preparatory activities are being carried out in order to establish an interministerial body in charge of approving climate-friendly projects in the country and for determining and approving projects in the scope of the Flexible Mechanisms of the Kyoto Protocol — the CDM.

An official GHG emissions inventory does not exist in Serbia. This inventory would serve as a basis for formulating programmes and measures that would contribute to addressing the adverse impacts of climate change. In addition, Serbia needs to identify major vulnerabilities and adaptation strategies to global climate change and enhance general awareness and knowledge on climate change related issues in the country.

The ongoing National Environmental Strategy policy objectives for 2005–2009 are to draft the National Action Plan for Combating Climate Change and to implement international agreements dealing with air protection, climate change and protection of the ozone layer. The National Action Plan for effective response measures to climate change should include measures to facilitate adaptation to climate change, as well as measures to abate the increase in GHG emissions.

Consideration, listing and prioritization of future policy frameworks, prospects and possible actions

The nature and level of the impacts of climate change on biodiversity suggest that the issue should be addressed and managed at a national level. The State of Environment reports show that many natural and semi-natural ecosystems in Serbia are already under severe stress as a direct consequence of continuing human activities. The most vulnerable species are those with long generation times, low mobility, highly specific host relationships, small or isolated ranges and low genetic variation. The available information on biodiversity in Serbia, although incomplete, is reliable and quite detailed. However, only a small part of the information has been put into the context of climate change and the required linkages have yet to be made.

A greater amount of information about current and expected impacts of climate change is needed to guide biodiversity conservation programmes and to direct biodiversity research

The existing body of biodiversity research is characterized by a great number of information gaps. They include: documentation of already occurring impacts in response to existing climate trends; an understanding of factors affecting the distribution and abundance of species; analysis of species, ecosystems and regions most vulnerable to climate change; a comprehensive assessment of available adaptation options, including modifications needed for existing conservation planning and practice; analysis of present and future social and economic costs of climate change impacts on biodiversity; an understanding of factors determining the resilience and adaptive capacity of ecosystems.

A priority action should be the establishment of the Biological Diversity Advisory Working Group at the national level

The Biological Diversity Advisory Working Group should enable linkage and cooperation between climate change researchers, biodiversity researchers and policymakers in order to assess the issue of climate change in relation to biodiversity in Serbia. The Group should have the capacity to identify aspects of biodiversity (species, communities and ecosystem services) which are most likely to be affected, the severity of the impacts (alteration of the distribution range of species, replacement of ecosystems, extinction of species) and the rate at which these impacts may occur.

Monitoring activities should be undertaken in order to assist in decision making concerning biodiversity conservation under the impacts of climate change.

Several types of indicator organisms can be used for monitoring. Organisms which have particular life-history traits tightly controlled by temperature may be the best candidates to screen for climate change

impacts. No coordinated monitoring of sensitive species has been undertaken so far. Additionally, there is no analysis demonstrating the change that has already taken place in species which are extensively studied and documented. An excellent model for a national monitoring programme is the set of 34 climatic, environmental and socio-economic indicators of climate impacts selected in the UK under the auspices of the Department of Environment, Transport and Regions (www.nbu.ac.uk/iccuk/). A monitoring programme specific to Serbia should be developed on the basis of existing monitoring programmes in other countries.

A broad range of activities are required for biodiversity conservation under climate change. They might include the following:

Preservation of biodiversity, especially the parts which are highly sensitive to climate change

Actions for preservation of the ecosystems which are highly sensitive to climate change may include the following:

- prevent further forest clearing;
- reduce agricultural land and wherever possible convert it into forest ecosystem;
- prevent loss and fragmentation of habitats;
- establish a connected, comprehensive ecological network of protected areas;
- preserve indigenous biodiversity through the network of protected areas (national parks, strict and special nature reserve, natural parks);
- conserve species ex situ that cannot survive future climate change;
- enable reintroduction of extinct species;
- prevent introduction of new invasive species and suppress the species likely to become invasive under climate change;
- increase resilience and prevent as many species as possible from becoming endangered;
- reduce risks of forest fires, especially in protected areas;
- reduce grazing in sensitive areas; in the case of remaining forest-steppe ecosystems, controlled grazing should be an appropriate measure for maintaining steppe habitats;
- reduce nutrient and sediment flows to rivers and wetlands;
- maintain bio-security.

Facilitation of long-term adaptation

Actions for facilitation of long-term adaptation may include the following:

- increase the connectivity in the landscape;
- rehabilitate degraded habitat, including re-vegetation of cleared land and restoration of streams, rivers and wetlands;
- preserve locations that may become key habitats under future climate change.

Monitoring, research and policy elaboration

Actions for establishing efficient monitoring systems, further research work and relevant policy elaboration may include the following:

- develop criteria for monitoring climate change impacts;
- monitor and assess climate change and biodiversity impacts;
- design adaptation actions to maximize information for future actions;
- ensure that climate change impacts are integrated into existing and future biodiversity conservation programmes;
- increase the priority of climate change in the research funding processes.

Mitigation of climate change and reduction of other pressures on biodiversity

Strategies that mitigate climate change resulting from increasing concentration of GHG emissions should promote sustainable development. To ensure sustainable development, the local management of resources is crucial. Identification and selection of actions to mitigate GHG emissions will be a great challenge because these emissions are strongly tied to human activities. It is necessary that Serbia cooperate through regional and international mechanisms such as the Framework Convention on Climate Change, which recently came into force to tackle the global climate problem.

Most mitigation options suggested so far are varying degrees of those identified by IPCC:
In the short term:

- improved energy efficiency;
- utilization of cleaner energy resources and technologies;
- improved forest management;
- phasing out of CFCs under the Montreal Protocol;
- improved livestock waste management, altered use and formulation of fertilizers, and other changes to agricultural land use, while maintaining food security.

In the long term:

- accelerated and coordinated research programmes;
- development of new technologies;
- review of planning in relevant fields;
- encouragement of beneficial behavioural and structural changes;
- expansion of global observation and monitoring.

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Turkey

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Background

Turkey is situated at the meeting point of the three continents of the Old World and stands as a crossroads between Asia and Europe. The country is located in SEE and South-West Asia, between longitudes 36°N to 42°N and latitudes 26°E to 45°E.

Turkey is a mountainous country in the eastern Mediterranean–Black Sea Basin, straddling the continents of Europe and Asia. It has a surface area of 776,774 km² and 90% of its land mass lies above 250 m altitude. It features a rich variety of climate regimes, land forms and geological features. Its biodiversity reflects this richness, both in terms of the number of species present and in the unique ecological communities they constitute. Approximately 100,000 species of animals, plants, fungi and other organisms are estimated to occur in Turkey (Bilgin, 1994). Among these taxa, high levels of endemism are particularly true for plants, endemic forms making up about one-third of the nearly 10,000 plant species recorded.

The current Mediterranean-type macroclimate of Turkey results from the seasonal alternation between mid-latitude frontal cyclones, associated with polar air masses, during the winter and subtropical high pressure systems, from subsiding maritime and continental tropical air masses during the summer. In addition, the north-western extension of the Asiatic monsoonal circulation causes very dry and hot conditions over the Middle East region, including the southern and central parts of Turkey (Türkeş, 1990). Continental tropical air-streams from the northern African and the Middle East/Arabian regions dominate particularly throughout summer by causing long-lasting warm and dry conditions over Turkey, except in the Black Sea region and the continental north-eastern part of the Anatolian Peninsula (Türkeş, 1998, 1999, 2000, 2003a). In winter, a well-known combination of the mid-latitude cyclone originating in the North-East Atlantic, the Mediterranean cyclone and subtropical dynamic anticyclones from the Azores control the weather and climate in Turkey. In some winter seasons, the very cold, stable and dry high pressure conditions related to the Siberia anticyclone join this average macro-atmospheric circulation pattern over Turkey and its surrounding regions. Turkish precipitation is generally associated with the location, variation and activity of the atmospheric centres of action throughout the year (except summer) over most of Turkey (Kutiel *et al.*, 2001; Türkeş, 1998; Türkeş *et al.*, 2002a; Türkeş & Erat, 2003).

There are also various subclimate types in different parts of the country. Two major factors cause this diversity. First, Turkey is situated in a transition zone that is under the influence of various atmospheric disturbances and weather types originating from polar and tropical regions. The second factor is the complexity of topographical features and rapid elevation changes within short distances.

Land-use patterns are largely responsible for the current land cover, with agricultural fields, rangelands, and forests covering 35%, 28% and 26% of the country, respectively. Soil structure is deep and fertile only in the flat lowlands and soils under significant erosion risk constitute up to 80% of the land surface. Numerous lakes and wetlands with more than a million hectares of surface area are fed by rivers and streams, although many may dry out on a regular basis. A long coastline of 8,333 km stretches along the shores of the Black Sea, Aegean Sea, the Mediterranean, Sea of Marmara and the Turkish Straits.

With a population of more than 70 million, Turkey is one of the most populous countries in Europe and the Middle East. A high proportion of dependent young people and increasing life standards put great demands on the resources of the country.

Global climate predictions indicate that Turkey is likely to be severely affected by climate change, as are other countries in the Mediterranean Basin (IPCC, 2007). Similarly, preliminary research at a regional level has shown that the expected climate change will involve increased annual average temperatures and decreased rainfall, especially in the west and south of the country (Önol & Semazzi, 2006; Demir *et al.*, 2008). In a new study, Demir *et al.* (2008) have made detailed climate projections for Turkey and its

region by using the British Meteorological Office, Hadley Centre for Climate Prediction and Research's Regional Climate Model, PRECIS (Providing REgional Climates for Impacts Studies), running with Hadley Centre's GCM HadAMP3 outputs and reference period (1961–1990). According to the results of simulations found by Demir *et al.* (2008), 5–6°C increases in mean temperatures are projected in Turkey by 2071–2100, except in the coastal regions. Precipitation amounts will continue to decrease from east to westward of the country at a rate of 40%. In winter, there will be marked decreases in precipitation amounts in the western and southern regions characterized by the Mediterranean rainfall regime, while in the summer season this situation will be reversed. Snow depth will lessen in the continental eastern Anatolia Region and the eastern Black Sea subregion. Due to predicted decreases in precipitation and increases in temperature, evaporation will also increase and water deficit during particularly the warm period of the year will be exacerbated. Their combined effect is expected to decrease surface water runoff by up to 50% (DEÜ-SUMER, 2006).

Direct impacts on biodiversity

Climate change may affect particular species in different ways. It may alter their distribution, abundance, behaviour, phenology, morphology and genetic composition. Moreover, climate change may lead to increased pressure from competitors, predators, parasites, diseases and disturbances (Anonymous, 2008). Communities may disappear as they lose their unique species composition or as key ecological processes start to occur in increasingly unusual frequencies or intensities.

Changes in the timings of seasonal events, leading to loss of synchrony between species and the availability of food, and other resources upon which they depend

As a middle latitude country with considerable topographic relief, Turkey is a strongly seasonal land. Its biota follows annual cycles that are tightly linked to seasonality. Many key events in life cycles, such as migration and reproduction, are known to be based on cues provided by the season's progress. For example, the timing of breeding in birds usually coincides with a peak in the availability of food resources to ensure fast growth and survival of offspring. Insect eggs are laid at a time that will ensure that hatching will coincide with the point that the growth of their host plant is fastest (see, for instance, Van Asch & Visser, 2007). Migrants need to arrive at breeding grounds neither too early (because they would still be inhospitable) nor too late (all suitable sites would be occupied by others by then).

It is possible that some species can adapt to seasonal advancement by changing their phenology accordingly. In the UK between 1971 and 1995, 63% of 65 breeding bird species started to nest earlier – by nine days on average for those showing significant trends (Crick *et al.*, 1997). Some Great Tit (*Parus major*) populations appear to track climate change by nesting earlier (Charmantier *et al.*, 2008) while other populations of the same species do not respond in the same way (Visser, in press). In Europe, the migration of birds that winter south of the Sahara has advanced by an average of 2.5 days in the last 40 years, possibly so that they can cross the Sahel before the seasonal dry period. By contrast, migrants wintering north of the Sahara have delayed autumn passage by 3.4 days on average over the same period (Jenni & Kéry, 2003).

However, not all organisms take their cue from climatic variables such as temperature or precipitation; the behaviour of many other species is instead determined by photoperiod, i.e. the day length. Such organisms include many plant and bird species, and such species would not be able to adapt easily to climate change. For example, insect larvae may no longer be available at the time when chicks need the most food to grow. Insect pollinators may already have completed their life cycle when the dependent plant species bloom. A break in the synchrony of resources and the key events in a species' annual cycle may influence not only that species, but also others that are linked to it through the food chain or through competitive interactions. Species that rely on the photoperiod as a phenology timer are therefore more prone to severe mistiming.

Finally, ephemeral species that thrive in suitable but temporary conditions may end up not having a long enough window of opportunity to complete their life cycle. Such species make up a considerable proportion of local biota in the more arid parts of Turkey.

Shifts in suitable climate conditions for individual species leading to change in abundance and range

There is already some evidence elsewhere that species are shifting or expanding their ranges. For example, in the UK, breeding birds extended their ranges north by 19 km on average between 1968 and 1988, in association with increasing temperatures (Thomas & Lennon, 1999). Modelling studies show that the ranges occupied by many species will become unsuitable for them as climate changes. The

environmental space that is suitable for particular species may shift (either in latitude or altitude), contract, or even disappear (Anonymous, 2008).

Many species with northern affinities (i.e. of Eurosiberian extraction) have their southernmost borders in Turkey. A northward shift in this range boundary may lead to such species being removed from the country biota for good. Altitudinal range shifts are possible since Turkey is highly mountainous; however, a reduction in the number of separate populations, in linkages between those populations and probably in total population size would increase the risk of extinction even for species that can escape to higher land. Tertiary relicts, especially those in the south-west (Lycian Peninsula) and south (Amanos Mountains), would suffer most and may become extinct within a century.

Changes in the habitats which species occupy

The impact of climate change on species habitats will be severalfold. First, certain habitat types will end up with a much smaller total area and/or will become further fragmented. The alpine tundra is one such habitat whose current extent will be squeezed by the treeline extending upwards. Another habitat expected to be severely negatively affected is wetlands. Reduced precipitation coupled with higher evapotranspiration and increased water consumption will lead to major – even catastrophic – changes in the nature of freshwater marshes and shallow lakes, including loss of submerged macrophytes, salinization and complete drying out (Beklioglu *et al.*, 2006; Klepper, 2007).

Second, due to a generally drier climate regime, tree cover will regress and be replaced by herbaceous vegetation in certain locations. Steppes and grassland cover will also become sparser, and desert-adapted elements will probably invade the driest and hottest regions. Plants and animals will thus become increasingly sensitive to drought stress.

Changes to the composition of plant and animal communities

Ecosystems can adapt if given enough time, but climate change appears to take place too fast. Indeed, for many species the 'climate space' within which they thrive will move faster than the rate at which they can adapt (Anonymous, 2007). As species move at different rates, the community structure of ecosystems will also become disrupted. Certain species may become extinct simply due to interdependencies within a community. The species most susceptible to extinction will be those with restricted ranges, bounded distributions (on the edges of continents, mountain tops or small islands), specialized habitat requirements, poor dispersal abilities or small populations (Anonymous, 2008).

Species composition can also change due to differential survival and reproduction of species with particular life-history traits over others. In Germany, the proportion of long-distance migrants decreased and the number and proportion of short-distance migrants and residents increased between 1980 and 1992. This may be because increased winter temperatures benefit residents and increase the competitive pressure they impose on long-distance migrants (Lemoine & Bohning-Gaese, 2003). Overall, it is very difficult to predict exactly how communities will be affected due to the complexity of the network of interacting elements in a community, but a reduction of diversity is expected.

Changes to habitats and ecosystems, such as altered water regimes

Observed rapid temperature increases in southern Turkey (Türkeş *et al.*, 2002b; Türkeş & Sümer, 2004), but possibly also elsewhere, will lead to snow and glacier melt and increased seasonal river flows in mountain regions. However, overall water surface runoff is expected to decline. This will cause changes in seasonal water-level fluctuations in wetlands and lakes, possibly disrupting natural processes and habitat loss for certain species. Reduced river flows will also lead to changes of coastline shape through coastal erosion.

Climate change in Turkey is expected to increase the risk of intense rainfall and flash floods (Türkeş, 1994, 1996, 2001, 2003b), in turn causing severe erosion, more frequent and intense fires, and desertification. The innermost and South-Eastern parts of Turkey are already prone to desertification (Türkeş, 1999, 2003a and b), especially due to wind erosion and overgrazing. Climate change could accelerate the pace of this process and increase its extent.

Impacts on ecosystem services

Services provided by terrestrial, freshwater and marine ecosystems have not yet been estimated for Turkey. However, they are known to include provision of energy; regulation of climate, hydrological and nutrient cycles; waste decomposition; purification of water; and crop pollination. Many local and regional

communities depend on the services provided by ecosystems (in the form of food, drinking water, fuel, building materials or as a harvestable resource) to sustain acceptable living conditions and welfare.

Climate change is expected to influence the functioning of ecosystems, and hence the availability of the services they provide to these communities. The result would be rural populations with diminished prosperity and security, especially if the ecosystems responsible have been damaged through fragmentation or overexploitation.

Existing relevant policies at national and subnational levels, including adaptation and mitigation strategies

Climate change scenarios for Turkey are developed under a UNDP-funded project that includes downscaling of global-scale models to regional scale. There are also ongoing or planned national projects on preparedness for drought, on long-term monitoring of forest ecosystems, and on dynamic monitoring of surface water resources. However, there are currently no clear national policies or strategies relevant to loss of biodiversity in the face of climate change. The major official document on the effects of climate change on biodiversity is the *First National Communication* to the UNFCCC (Apak & Ubay, 2007).

Consideration, listing and prioritization of future policy frameworks, prospects and possible actions

Possible actions can be considered under three headings: understanding climate change at the regional level and predicting probable effects and outcomes; monitoring change and improving public awareness; and adapting to change and mitigating.

Possible actions and approaches are listed below in order of perceived priority.

- **Understanding climate change at the regional level and predicting probable effects and outcomes**
 - o Develop and implement downscaled climate change models to assess likely changes.
 - o Assess vulnerability and adaptability through climate change vulnerability analysis, risk assessment and adaptation options.
 - o Conduct long-term research on species adaptability to changing environmental conditions under climatic or human-induced global change.
 - o Assess vulnerability of wetland ecosystems, especially coastal wetlands.
- **Monitoring change and improving public awareness**
 - o Identify and use protected sites as baseline and reference areas to detect trends in the loss of biological diversity, climate change and desertification.
 - o Provide evidence to the general public of climate change impacts and models of possible outcomes.
 - o Make information available to policymakers and use relevant information in policymaking.
 - o Promote the monitoring of mountain areas susceptible to climate change.
- **Adapting to change and mitigating**
 - o Identify capacity-building needs and build capacity where needed.
 - o Incorporate climate change and biodiversity objectives in relevant plans.
 - o Select and improve the protected area network by explicitly incorporating climate change as a factor into systematic conservation planning, establishing biodiversity corridors and increasing their size and diversity.
 - o Undertake assessments of country-specific technology needs for mitigation and adaptation.
 - o Consider climate change in the planning and management of forests, rangelands, wetlands and fisheries.
 - o Conserve and restore ecosystem services in the wider terrestrial and marine environment, maintain resilience of natural systems in general and restore degraded ecosystems.

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SEE countries case studies: conclusions

Based on the extrapolations from available European studies, described in Chapter 2, and on the expert views presented in this chapter, specific impacts of climate change on biodiversity in the SEE region include:

- increased temperatures;
- a rise in the frequency of extreme weather events;
- increased coastal erosion, sea-level rise, impact on marine biodiversity, rising water levels in tidal rivers;
- increased flooding, pressure on water resources;
- changing agricultural landscapes, crop failure;
- changes in habitats and species distribution;
- increasing problems caused by invasive alien species and a decrease in the richness of biodiversity.

In addition, we can expect more problems for local and regional communities that depend on the services provided by ecosystems (in the form of food, drinking water, fuel, building materials or as a harvestable resource) to sustain acceptable living conditions and welfare. Severe economic and financial consequences are to be expected in the near future if climate impacts on biodiversity and ecosystem services are not mitigated.

Impacts of climate change in the SEE region will also jeopardize the implementation of various national and international biodiversity policies, in particular the CBD and European biodiversity 2010 targets of reducing or halting the decline of biodiversity by the year 2010.

Complementary to the Biodiversity Action Plan (BAP) as an internationally recognized programme addressing threatened species and habitats, and designed to protect and restore biological systems, there is clear need to develop action plans that will address interlinkages between biodiversity and climate change. Although the original impetus for BAPs derives from the 1992 CBD, not all of the signatory countries have developed substantive BAP documents. Furthermore, most countries do not yet have action plans to address the impacts of climate change on biodiversity. This is in particular the case in the SEE region, where such plans do not exist at the moment.

In order to combat the negative consequences of climate change on biodiversity in the SEE region, it is important to enforce biodiversity-protection related legislation, reduce sources of harm to biodiversity not linked to climate and efficiently conserve existing biodiversity. There is also a need to further develop strategic policy documents related to biodiversity and climate change.

4 Strategic policy

Strategic policy – biodiversity

According to the fourth edition of the *Global Environment Outlook* (GEO-4, 2007), one of the main reasons for the unprecedented loss of biodiversity is that current policies and economic systems do not incorporate the values of biodiversity effectively in either political or market systems, and many policies that are already in place are yet to be fully implemented. In other words, we cannot protect what we do not know, and we cannot protect what we do not value.

If no major new policy measures are put in place, past trends of biodiversity and ecosystem service loss will continue. In some cases losses will accelerate. In others the ecosystem will be degraded to such an extent that it will not be possible to repair or recover it (GEO-4, 2007).

The most important international framework for biodiversity conservation at a global scale is the CBD. Opened for signature at the Earth Summit in Rio de Janeiro in 1992, the CBD has three main objectives: (i) conservation of biodiversity; (ii) sustainable use of its components; and (iii) equitable sharing of the benefits of genetic resources. With 190 parties, the CBD has near-universal participation among countries which have committed to preserving life on Earth (<http://www.cbd.int/>).

In April 2002, the CBD adopted its Strategic Plan, which includes a commitment of CBD parties to achieve by 2010 a significant reduction in the rate of biodiversity loss at the global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on Earth (Decision VI/26). The target set for 2010 is commonly called the '2010 Biodiversity Target'. This objective has also been endorsed by the World Summit for Sustainable Development, which took place a few months later in Johannesburg, in September 2002. The European Union adopted an even more ambitious commitment at the EU Council in Göteborg in 2001, promising to halt the loss of biodiversity by 2010. At the Fifth Ministerial Conference 'Environment for Europe' in Belgrade (2007), the Ministers of 53 European countries stressed the importance of reaching the 2010 target, of combating climate change and prioritizing the establishment of European ecological networks to increase the resilience of habitats and ecosystems.

Besides the CBD, biodiversity policy in Europe is driven by a number of conventions and directives. These include:

- 1971 Ramsar Convention on the conservation and wise use of wetlands of international importance;
- 1979 Bonn Convention on migratory species;
- 1979 Bern Convention on the conservation of European wildlife and natural habitats;
- 1979 EU Birds Directive;
- 1992 EU Habitats Directive (including the conservation of habitats and wild flora and fauna).

Signatory nations of the above-mentioned conventions have an obligation to protect particular species and habitats. The EU Member States are legally bound to protect species and habitats listed under the EU Habitats and Birds Directives, and to develop Natura 2000 – a European Union-wide network of nature conservation sites, which was initiated through the Habitats Directive. In the framework of the Bern Convention, a biodiversity and climate initiative has been launched, which addresses biodiversity impacts on Europe's natural heritage.

In 1995, in the framework of the Ministerial 'Environment for Europe' process, supported by the United Nations Economic Commission for Europe (UNECE), the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) was endorsed at the Third Ministerial Conference 'Environment for Europe' in Sofia, Bulgaria. PEBLDS initiated a variety of actions, including actions on the establishment of the Pan-European Ecological Network, the development of national biodiversity strategies and action plans, and the European streamlining of biodiversity indicators.

At a strategic policy level, the European Union has taken important steps in response to commitments under the CBD. In 1998, the European Commission adopted a Communication on a European Community Biodiversity Strategy (ECBS). The ECBS has four associated action plans which specify how to implement the strategy in particular areas of European Community activity: conservation of natural resources, fisheries, agriculture, and economic and development cooperation (ECBS, 1998).

In 2006, the EC launched the EC Biodiversity Action Plan, as part of the Communication 'Halting the loss of biodiversity by 2010 – and beyond'. This Communication and its detailed Action Plan set out a detailed agenda for action to halt the loss of biodiversity by 2010. It proposes 10 priority objectives within 4 policy areas, and about 120 actions. One policy area specifically targets biodiversity and climate change, and one objective (objective 9) aims at supporting biodiversity adaptation to climate change.

In order to preserve the biodiversity of European importance in the SEE region, most countries have adopted modern laws on nature conservation in recent years, already taking into account the EU Birds and Habitats Directives. They have become parties to international conventions such as the Convention on Biodiversity, CITES, and Bern. Biodiversity strategies according to the CBD have been developed in all the countries and territories, except Montenegro and Serbia, which are now beginning their preparation. Biodiversity and nature conservation have been integrated into national development strategies and environmental action plans (UNDP, 2007).

In addition to the individual protected areas, the countries in the SEE region have started work on ecological networks such as the Emerald Network, under the auspices of the Bern Convention, and the initial steps towards the Natura 2000 network according to the EU Birds and Habitats Directives (UNDP, 2007). Bulgaria and Romania, as EU Member States, had to develop much more concrete steps.

Although a significant amount of information is available about the quality and quantity of biodiversity in the SEE region, the existing information is not sufficient for effective establishment and management of the Natura 2000 network. More work therefore needs to be done to establish inventories of relevant species and habitats, as well as to transform existing scientific data into policy-relevant information (UNDP, 2007).

The final report on the Economics of Ecosystems and Biodiversity (TEEB), expected for the year 2010, will systematically address a comprehensive range of such policy options for better conserving biodiversity and ecosystem services, and will demonstrate how better policies result from applying and integrating the new economics of ecosystems and biodiversity (TEEB, 2008).

Strategic policy – climate change

Two main types of policy can be used to deal with the impacts of climate change – mitigation and adaptation. **Mitigation policies** attempt to limit further changes in global climate. Mitigation policies either focus on reducing the emission of GHGs through, for example, more efficient energy use or cleaner energy production or on enhancing GHG sinks. However, even with the most optimistic projections of the level of mitigation that can be achieved, there will still be a significant degree of climate change. Therefore, to cope with the current and future change it is necessary to develop **adaptation strategies**, i.e. strategies that optimize the outcome of those changes that occur. With respect to biodiversity conservation, adaptation strategies would be designed to enable the maximum biodiversity resource to persist within the context of a changing climate (Brooker & Young, 2005).

The main international framework for addressing and combating climate change is the UNFCCC⁹ of 1992. With 192 parties, the UNFCCC has near-universal membership and is the parent treaty of the 1997 Kyoto Protocol.¹⁰ The Kyoto Protocol has to date 182 member Parties. Under the Protocol, 37 States, consisting of highly industrialized countries and countries undergoing the process of transition to a market economy, have legally binding emission limitation and reduction commitments. The ultimate objective of both treaties is to stabilize GHG concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

The post-Kyoto climate change discussions started on 2 June 2008 in Bonn, Germany. This was the second major UNFCCC negotiating session in 2008, following UN talks in Bangkok in March and April which set out a work programme for negotiations in 2008 on a strengthened and more effective international climate change deal. The deal is to be clinched in December 2009 in Copenhagen. The deal is also known as the 'post-Kyoto climate change regime'.

⁹ UN Framework Convention on Climate Change: information available at: <http://unfccc.int/2860.php>

¹⁰ Kyoto Protocol: information available at: http://unfccc.int/kyoto_protocol/items/2830.php

All countries in the SEE region are parties to the UNFCCC. Albania, Croatia, FYR Macedonia and Montenegro ratified the Kyoto Protocol between 2004 and 2007, and other countries are in the process of preparing its ratification. Croatia belongs to the group of countries in transition (Annex I of UNFCCC) and the remaining countries are in the group of Non-Annex I countries.

Most SEE countries have prepared their GHG inventories and submitted their FNCs on Climate Change; others are in the process of preparing them. FYR Macedonia and Albania are currently preparing their Second National Communication on Climate Change. Croatia has prepared and submitted its Second, Third and Fourth National Communication of the Republic of Croatia under the UNFCCC and has prepared a draft National Strategy for Implementation of UNFCCC and the Kyoto Protocol (UNDP, 2007).

Although in some SEE countries GHG emissions dropped significantly between 1990 and 2000, recently emissions have been growing in all countries in the region. The countries in the region have started preparing and implementing policies to reduce their emissions. Croatia is encouraging activities and projects dealing with renewable energy sources, energy efficiency, sustainable and environmentally friendly construction and clean transport. Albania is in the process of establishing an energy efficiency centre. All countries are promoting renewable energy sources in their energy policies/strategies or are developing specific plans for the use of renewable sources; yet the use of renewables overall remains at a rather low level. Work on the preparation of CDM projects has been initiated in most countries and is in different stages across the region. In February 2007, the Macedonian Government adopted the National Strategy for CDM for the First Commitment period 2008–2012, developed with the support of UNDP and in collaboration between UNDP, the Ministry of Environment and Physical Planning and REC.

Recognizing the importance of climate change for sustainable development and poverty eradication in the SEE region and the importance of integrating climate change considerations into the development of key economic sectors in SEE countries, the Belgrade SEE Climate Change Initiative was adopted by the Sixth Ministerial Conference 'Environment for Europe' (10–12 October 2007, Belgrade, Serbia). The Belgrade Climate Change Initiative (BCCI) has as its main goal the facilitation of partnership and cooperation between the SEE countries and other countries in the UNECE region in climate change related programmes. The main BCCI policy recommendations are related to: (a) development of the SEE Climate Change Framework Action Plan; (b) establishment of a Subregional, Virtual Climate Change Related Centre in Belgrade for research and systematic observation, education, training, public awareness and capacity building; and (c) developing partnerships.

Work on adaptation strategies should start immediately, focusing primarily on issues of water management (drought and flood risks) and the vulnerability of ecosystems (fire). These strategies need to be integrated into the relevant sectoral strategies such as physical plans, water and forest management plans (UNDP, 2007).

5 Conclusions and recommendations

Conclusions

The expert reports on Albania, Bosnia and Herzegovina, Montenegro, Serbia and Turkey present observed changes: increased temperatures; a rise in the frequency of extreme weather events; increased coastal erosion, sea-level rise, impact on marine biodiversity, rising water levels in tidal rivers; increased flooding, pressure on water resources; changing agricultural landscapes, crop failure; changes in habitats and species distribution; increasing problems caused by invasive alien species and a decrease in the richness of biodiversity. In addition, there will be more problems for local and regional communities that depend on the services provided by ecosystems (in the form of food, drinking water, fuel, building materials or as a harvestable resource) to sustain acceptable living conditions and welfare.

Many SEE regions belong to the most vulnerable areas of Europe to climate change where we can expect the highest future impacts of climate change on the ecosystems, and in particular to biodiversity:

- southern SEE regions and the SEE parts of the Mediterranean Basin, due to the combined effect of high temperature increases and reduced precipitation in areas already coping with water scarcity;
- mountain areas, where temperatures increase rapidly leading to widespread melting of snow and ice, changing river flows;
- SEE coastal zones, due to sea-level rise combined with increased risks of storms;
- densely populated floodplains, due to increased risks of storms, intense rainfall and flash floods leading to widespread damage to built-up areas and infrastructure.

Severe economic and financial consequences are to be expected in the near future if climate impacts on biodiversity and ecosystem services are not mitigated. In the first years of the period 2000–2050, it is estimated that each year we are losing ecosystem services with a value equivalent to around EUR 50 billion from land-based ecosystems alone, while cumulative welfare losses could be equivalent to 7% of annual consumption by 2050.

The impacts of climate change in the SEE region will jeopardize the implementation of various national and international biodiversity policies, in particular the CBD and European biodiversity 2010 targets to reduce or halt the decline of biodiversity by the year 2010.

Recommendations

The following key recommendations for tackling climate change impacts on biodiversity in the SEE region emerged from the expert reports and the presentations and discussions of the conference 'Changing climate, changing biodiversity in South-East Europe' (18–19 June 2008, Belgrade, Serbia):

1. The development of a strong and concrete action plan on climate change and biodiversity for SEE, while building on ongoing initiatives, including the Belgrade Initiative on enhancing SEE regional cooperation in the field of climate change adopted at the Sixth Ministerial UNECE Conference 'Environment for Europe' (October 2007, Belgrade, Serbia) and those of EU, UN and Council of Europe. Governments in the SEE region are encouraged to endorse and further the initiative for an action plan, while seeking support from all relevant stakeholders, including international and national NGOs, scientific and expert institutions, and economic sectors.
2. Regional cooperation between countries and multi-stakeholders in SEE should be stepped up; and within the countries, ministries and other stakeholders should enter into constructive dialogues and joint actions for addressing the relationship between climate change and biodiversity. Involved international NGOs are encouraged to establish synergy between their activities on biodiversity and climate change in the SEE region.
3. Relevant national and international governmental organizations are encouraged to integrate biodiversity and climate change considerations in their policies, strategies and actions, and ensure that available funds work in favour of and do not work against biodiversity conservation.

4. Awareness and education actions on climate change, biodiversity and ecosystem services are of vital importance in order to reach the public, politicians and policymakers, and economic sectors. These actions need to increase and be implemented at regional, national and subnational levels, while adopting a multi-stakeholder approach. At least one concrete and impacting communication and awareness action should be initiated at short notice.
5. At European, regional and national levels actions should be undertaken to fill basic gaps in information and knowledge about the climate impacts on biodiversity in the SEE region, including via focused and extended multidisciplinary research, policy analyses, modelling and scenario building, and adequate biodiversity monitoring at regional, national and subnational levels. These actions should address both terrestrial and marine environments. However, no action should be delayed because of gaps in information and data.
6. Practical capacity building in terms of increasing knowledge and human and financial resources for addressing biodiversity and climate change in SEE is a top priority and a vital basis for real actions.
7. Development and implementation of adequate mitigation and adaptation measures and guidelines for addressing the negative impacts of climate change on biodiversity, including adaptive management (strategies) for nature sites is highly important. Wider climate change mitigation measures should not damage biodiversity.
8. Concrete and far-reaching measures should be implemented in order to strengthen ecological and landscape resilience in the SEE region, including the concrete establishment and management of protected areas and ecological networks, and of SEE- and Europe-wide climate corridors (to encourage animal movement).
9. An active and dedicated network or forum of people and organizations on climate change and biodiversity in the SEE region should be further developed, while building on the contacts and dialogue established during the conference 'Changing climate, changing biodiversity in South-East Europe'.

Specific recommendations

Besides key recommendations, several groups of specific recommendations for tackling climate change impacts on biodiversity in the SEE region were developed as follows:

International, European and regional policy frameworks and actions for addressing climate change and biodiversity in SEE

National and international policies are beginning to tackle the impacts of climate change on biodiversity, but still have large gaps in terms of specific targets and measures. It is therefore recommended that:

- more strategic and operational synergies between national and international policies and actions on climate change and biodiversity for SEE are required in order to combat climate impacts adequately at all geographical levels;
- there is a strong need to improve targeted implementation at national and subnational levels of international conventions related to biodiversity and climate change.

Regional impacts and response to climate change on biodiversity and ecosystem services in SEE

Scientific and field evidence indicate that the effects of climate change on biodiversity and ecosystem services will be severe. However, in most of the target countries of this report, large gaps in knowledge exist. The policy response at SEE regional, national and subnational levels is still in an early phase, although political attention for the issues is rapidly increasing in most countries. Top priority should therefore be given



The traditional breeding and feeding areas of the Eurasian Spoonbill (*Platalea leucorodia*) may be reduced in size or disappear as a result of changing water regimes under altered climatic conditions.

to the exchange of experience and expertise between countries in SEE, increased cooperation between relevant ministries at national level, enhanced synergies between programmes of international organizations, and involvement of all relevant stakeholders, in particular businesses and landowners.

Practical solutions and policy tools

The following actions are recommended:

- awareness raising and communication projects, including conflict-management activities, also at subnational levels;
- adaptation strategies for biodiversity impacts of climate change;
- community programmes, involving local people and entrepreneurs;
- tailor-made capacity-building programmes, including on delivery of biodiversity policy targets and development and implementation of projects;
- integrate, in a down-to-earth and practical way, climate change impacts on biodiversity into sectoral policies, and economic and financial sectors;
- establish lobbies and national biodiversity and climate panels;
- sustainable protected area management;
- control of urbanization and development in coastal areas;
- create lists of species and habitats most vulnerable to climate change in SEE and establish sites to monitor climate change. These sites should include marine areas.

Managing the effects of climate change and increasing the resilience of ecosystems

The following actions are recommended:

- establish multi-stakeholder networks on climate change and biodiversity;
- increase the number of protected areas on land and seas, and improve the management of these areas with new adaptive management techniques;
- prepare for climate change impacts in the preparation or review of management plans for nature sites and national parks, including via the development of new spatial plans for designated sites;
- establish resilient ecological networks, *inter alia* by creating Europe-wide, and SEE-wide and national climate ecological corridors, which will allow species to migrate as a result of climate change impacts; identify potential bottlenecks;
- reconsider the strategies towards native and alien species, and develop coherent actions;
- identify areas of nature restoration, while focusing on ecosystem functions;
- establish concrete capacity-building programmes and learning networks for involving local stakeholders and land users in combating the impacts of climate change on biodiversity;
- implement risk assessment studies, especially for vulnerable areas from a point of view of biodiversity and ecosystem services;
- develop programmes of interdisciplinary research at national and SEE levels.

Identifying solutions to manage and communicate the effects of climate change on biodiversity

The following actions are recommended:

- new and appealing ways and means of bringing the message to the public and key stakeholders should be adopted and implemented, while focusing on the receiver instead of the sender of the message. Short messages should be developed, such as 'Nature is dying – we are part of it!' or 'Will we be climate change refugees?', but also 'You are rich by living close to nature';
- the climate and biodiversity messages should relate to the daily lives of people and businesses, and indicate ways in which they could help to address the problems.

Keeping the momentum alive – follow-up

It is of high importance to keep the momentum alive and follow up activities initiated through the preparation of this report, and in particular through the conference 'Changing climate, changing biodiversity in South-East Europe'.

It is necessary to identify as soon as possible at least five priority projects, amongst them at least one communication and awareness project. The projects could also figure as spearheads in the proposed Action Plan.

Organizing frequent biodiversity and climate change seminars or conferences for the SEE region can significantly contribute to discussion and monitoring the implementation of actions.

This report should be widely communicated, and specifically to all the relevant stakeholders.



The Grey Wolf (*Canis lupus*) is one of a number of large carnivores in South-East Europe whose range and distribution may be affected by climate change.

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