Biodiversity and climate change in the European Union

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Introduction

Biodiversity & ecosystem services and climate change are closely linked. The impacts of climate change on biodiversity present new challenges for nature conservation. Adaptation measures will be necessary to ensure the achievement of nature conservation objectives under changing climatic conditions. At the same time, nature conservation contributes to maintaining healthy ecosystems essential for any strategy for mitigation and adaptation to climate change.

If the loss of biodiversity continues – or accelerates – it will compromise the achievement of the climate change goals. Urgent action now to halt the further biodiversity loss and degradation will help to maintain provision of ecosystem services and future options for reducing the extent of climate change and managing its impacts. Healthy ecosystems are a precondition for stabilising the climate system. Therefore maintenance and restoration of biodiversity and healthy ecosystems represent our life insurance for the future.

Links between biodiversity, ecosystems and climate

There are many important links between ecosystems and climate system of the Earth. Ecosystems play a key role in regulating climate via physical, biological and chemical processes that control fluxes of energy, water and atmospheric constituents including the greenhouse gases. To a large extent, climate may be seen as a product of living systems organised in ecosystems, obviously dependent on physical-chemical conditions. At the same time, stability of physical and chemical conditions is regulated by ecosystems through many natural processes.

Photosynthesis is a principal process enabling capture and store solar energy and enabling creation of biogenic energy reserves using carbon dioxide as a "raw material". It is important to remind, that all fossil reserves of energy are of biotic origin as well. In normal conditions, carbon cycles are largely in dynamic equilibrium, *i.e.* amounts of carbon used for photosynthesis are balanced with carbon released from processes utilising carbon as an energy source. The dramatic increase in utilisation of fossil reserves by humans may lead to conflict with overall capacity of ecosystems to assimilate the released carbon dioxide. Naturally, ecosystems may adapt to such development and increase uptake. This nevertheless depends on possibility of natural processes to proceed, and on the availability of species to enable establishing new equilibriums.

There is growing evidence showing, that for functional ecosystems the presence of their individual components – biological species, or more generally biodiversity – is essential. Some ecosystem functions are directly useful for humans – these are called ecosystem services (MA 2005). Understanding ecosystem services is evolving, and depends on the perception of human society. Usually, general ecosystem function is recognized as ecosystem service only at the moment, when its absence visibly influences people. Therefore, provisioning services in terms of food, medicine and shelter have been recognized since the beginning of mankind, while the capacity to provide drinkable water has been acknowledged in

In the uncertain face of climate change, European coastal zone should be managed in a sustainable way: the Newborough Warren National Nature Reserve in Wales. ***© J. Plesník***

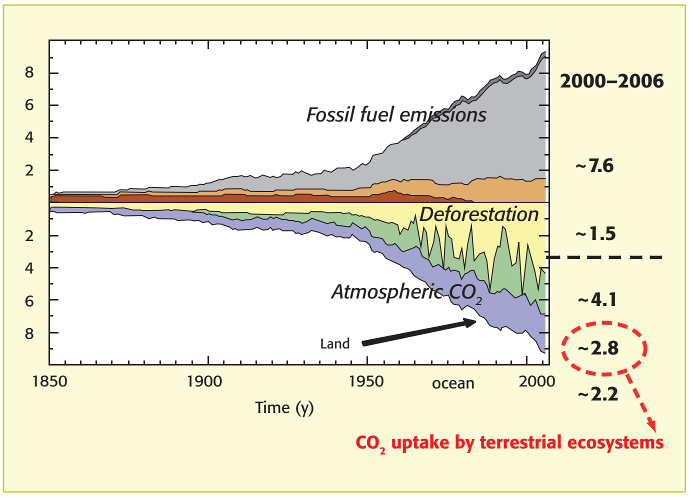

Fig. 1 Global budgeting of CO_2, showing the essential role of ecosystems in sequestration of human-induced CO_2 emissions (Canadell et al. 2007, Le Quéré unpubl.).

Peatlands are the most efficient terrestrial ecosystems in storing atmospheric carbon (the Jizera Mts.). © P. Holub

some parts of the world much later, and the regulating services in particular the capacity to regulate climate by carbon sequestration have been understood as important ecosystem service only in a few recent decades. In the future, potentially further ecosystem function will be recognised as vital services for humanity. Therefore, healthy and functional ecosystems supported by species diversity are to be seen as principal insurance of human well-being and even existence (European Communities 2008).

Ecosystems regulate climate not only by carbon storage and sequestration, but they also play an essential role in the cycling of all important nutrients (including *e.g.* nitrogen), which interfere in global warming. In addition, ecosystems are crucial for the hydrological cycles and contribute to water regulation and purification. Due to very high heat capacity of water, water passage through ecosystems (*e.g.* evapotranspiration) may principally influence temperatures and humidity at global, regional or local scale (global climate, mesoclimate, and microclimate).

Healthy ecosystems are able to accommodate to certain extent changes or fluctuations in conditions. They operate as a natural air-conditioning system of the planet. This ability is again dependent on the state of ecosystems. Biodiversity rich ecosystems are in principle more healthy and could operate in broader set of external conditions (Miko 2007).

Ecological theory recognises five types of stability, among them also resistance and resilience. Resistance is ability to sustain changes without visible changes. Dramatic changes in global ecosystem conditions introduced by humans exceed often this level. Therefore, resilience, the second element of stability is essential. It is the ability of ecosystem to survive and keep its functions after disturbation and restore them after shifts and changes. However, if intensity of disturbation goes beyond the resilience capacity, the ecosystem collapses and undergoes irreversible change. Its original functions or services are altered or lost (Holling 1973, Gundersson 2000, Webb 2007).

Present level of ecosystem services for humans is invaluable. Terrestrial and marine ecosystems currently absorb roughly half of the anthropogenic CO_2 emissions. This is an important 'free' ecosystem service. However, growing evidence suggests that the capacity of the Earth's carbon sinks is weakening due to the continuous ecosystem degradation. In this context, deforestation and forest degradation play a key role. Deforestation accounts for some 20 % of global carbon dioxide (CO_2) emissions (Metz *et al.* 2007). This is more than the total EU greenhouse gas emissions. Reducing emissions from deforestation will therefore be essential in order to achieve our objective of limiting global warming to 2 °C. It is a cost-effective way to combat climate change, which clearly benefits biodiversity conservation and the livelihoods of the poor (Commission of the European Communities 2008a).

Why is climate change a problem?

In the Earth's history, many dramatic climate changes have occurred. Ecosystems always reacted and survived – adapted to new conditions. So, where is a problem? Changes led to the chain of evolution. Many species did not survive, new had to evolve. Conditions in different parts of world changed so that original species had to move. Transposed to our presence, well described changes may occur. Delivery of food, water, local temperatures and vegetation may change. As the modern human society has been developing under more-less stable climatic conditions, such changes may have undesirable effects.

Another acute problem is the speed of the process. Relatively slow changes allow for step-by-step adaptation of ecosystems, so despite change in their composition and structure, the principal functions may be kept. Nevertheless, this "acceptable" scenario has two principal drawbacks with regards to the challenge we are facing now. First, changes of conditions seem to be much faster as in normal planetary fluctuations. At least some species will not be able to cope with that rate, and will be unable move to find its "new home". Second, those species capable to migrate fast may have difficulties to find suitable places to live. Humans changed the landscape heavily, and created plenty of barriers. Big blocks of the terrestrial surface are "occupied" by human's activities and do not allow for establishment of new ecosystems. Summing up, land is not permeable enough and does provide only limited "space for nature".

The already ongoing and often visible climate change impacts on biodiversity and ecosystems are complex. From a human perspective key properties of ecosystems that are or will be affected by climate change are the values and services they provide to people. These include provisioning services such as for example timber production, where the response depends on population characteristics as well as local conditions and may include large production losses. The impact on coral reefs threatens the vital ecosystem services these systems provide through fisheries and coastal protection (Lesser 2007). Climate change also affects the ability of terrestrial ecosystems to regulate water flows, and critically reduces the ability of many different ecosystems to sequester and/or store carbon which can feedback to climate change. Climate change is disrupting species interactions and other ecological relationships. For example temperature changes lead to earlier spring flowering, which comes to early for the pollinating insects. These impacts also threaten managed ecosystems on which many sectors depend, including agriculture, forestry, fishery, tourism, industry and others.

Biodiversity loss, ecosystem degradation and consequent changes in ecosystem services lead to a decline in human well-being. For example, the loss of reef protection against storm surge, together with sea level rise, will create socio-economic catastrophes in low islands and coastlines. The loss of reefs also leads to economic loss in the tourism sector which often constitutes an important source of income at these sites.

Threats: drivers, non-linearity and thresholds

The drivers include temperature increases, shift of climatic zones, melting of snow and ice, sea level rise, precipitation changes, droughts, floods and other extreme weather events. Increased winter precipitation could favour certain habitats such as wet heath, but this effect is likely to be counter-balanced by more summer droughts. The Arctic is witnessing reductions in perennial sea ice which is thinning and being replaced by seasonal ice. Tundra habitats are expected to become highly fragmented and reduced. Area to move is limited, for example by the Arctic Ocean. On its southern border, tundra will be replaced by coniferous boreal forest and scrublands. This reduction in tundra and permafrost is also expected to reduce the so called albedo, the reflectance of solar radiation. Warming will also most probably release carbon stored in the permafrost.

At the extreme of the altitudinal gradient, mountains have been identified as being very vulnerable to climate change. The Alps will experience warmer and wetter winters and dryer summers. The snow pack on mountains is close to its melting point and therefore particularly sensitive to temperature change. The Mediterranean will suffer from water scarcity and heat stress. Droughts will increase the incidence of wildfires (Parry *et al.* 2007).

Climate change and its consequences present one of the most important threats to biodiversity including ecosystems and their functions and services. The current stress is far beyond the levels imposed by global climatic changes occurring in the evolutionary past. Natural systems are vulnerable to such changes due to their sometimes limited adaptive capacity. Climate change will act upon and often aggravate the impact of other pressures on biodiversity and ecosystems such as habitat fragmentation, degradation and loss, invasive alien species, pollution and overexploitation. Ecosystem functions are not linear and there is a risk that continuing pressures will lead towards trespassing critical thresholds. Continuing, accelerating loss of biodiversity will compromise the long term ability of ecosystems to regulate climate, may accelerate and amplify climate warming and could lead to additional, unforeseen and potentially irreversible shifts in the Earth system. Although our detailed knowledge is limited, there is certainty about the existence of multiple positive and negative feedbacks between ecosystems and climate. These feedbacks are generally non-linear and have the potential to produce large undesirable results, particularly at the regional level (Groffman *et al.* 2006).

More than 2,500 scientists who came together in March 2009 in a worldwide congress on climate change in Copenhagen state that *"Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised. For many key parameters, the climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived"* (Anonymous 2009a).

Opportunity

As shown above, there is close mutual influence between climate (change) and biodiversity (ecosystems). It is therefore not exaggerated to say that it is impossible to tackle biodiversity loss without solving climate change as well as it is impossible to solve climate change without tackling biodiversity and ecosystem health. Maintaining and restoring ecosystems and their functions (services) are often our most powerful, spatial and by far the cheapest way to combat climate change (Campbell *et al.* 2008, 2009). However, these mechanisms are endangered by plenty of other drivers, mostly directly or indirectly linked to human activity. It is therefore of our own interest to address these drivers, reduce environmental pressures, increase ecosystem resilience, landscape permeability and reserve necessary space for nature and natural processes. This approach is a prerogative for resolving the rest of problems by technology and innovation. Without vital support by ecosystems our efforts to mitigate and adapt to climate change may prove to be inefficient or not sufficient.

Ecosystem based adaptation provides multiple services and promotes synergies. Healthy ecosystems can go a long way towards adapting to and mitigating the impact of extreme

The Predatory Bush Cricket (Saga pedo) inhabits the warmest region in the Czech Republic. ***© J. Hlásek***

The Bog Bilberry (Vaccinium uliginosum) distribution is projected to shift to the north. ***© J. Hlásek***

events such as floods, droughts and hurricanes, while providing also other services essential for human livelihoods. Protecting upper-catchment forests and restoring wetlands, for example, can reduce the risks from climate related floods and droughts, thereby protecting people's well-being and helping to minimize the loss of life and properties and other assets. These investments are likely to be highly cost-effective relative to structural alternatives such as dams and dikes.

Response of Europe

Climate change is addressed directly and indirectly in EU biodiversity policy, which contributes to all three ecosystems mentioned elements: space for nature, ecosystem integrity and resilience and landscape permeability and connectivity. Some of the provisions are already implemented, some are in progress and some were formulated recently as a direct response to the problems of climate change.

Regarding appropriate "space for nature", Europe has built up a vast network of over 26,000 protected areas covering all the Member States and representing more than 20 % of total EU territory. These sites, known as the Natura 2000 network are the largest network of protected areas in the world. The ecological coherence of the Natura 2000 network, as well as habitat quality, is essential for the long-term survival of many species and habitats.

The article 10 of the Habitats Directive (Council of Ministers of the European Communities 1992) implies improving the ecological coherence of the Natura 2000 network, which is the EU-wide network of nature conservation areas set up to ensure the survival of Europe's most valuable species and habitats. The Natura 2000 offers protection to over 1,000 rare and threatened species and 200 habitat types across 27 Member States. It is based on the principle that man is part of the landscape. The network consists of living landscape in which farming, fishing, forestry and hunting can continue in a sustainable manner without undermining the ecological value of the site. Thus it attempts to deliver best balance between economic development and biodiversity conservation.

The more recent European Commission's *Communication on Halting the Loss of Biodiversity* (Commission of the European Communities 2006) includes four policy areas, one of which is biodiversity and climate change, with the objective to support biodiversity adaptation to climate change.

The discussion on reduction of emissions from deforestation and forest degradation (REDD) recognizes that incentives to counterbalance the economic drivers of deforestation are necessary. Deforestation is one of the main causes of global biodiversity loss and a significant source of greenhouse gas emissions. The European Commission proposes to test two instruments for combating deforestation and forest degradation (Commission of the European Communities 2008b):

(i) establishing a new instrument to generate significant funding to tackle deforestation and forest degradation, the Global Forest Carbon Mechanism;

(ii) testing the inclusion of deforestation in carbon markets.

Finally, in its White Paper on Adaptation (Commission of the European Communities 2009) the Commission puts forward for EU and Member States to "*explore the possibilities to improve policies and develop measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming*".

Efficiency and final effect of all existing and proposed measures will nevertheless highly depend on proper implementation and wise approach in balancing use of natural processes on one side and technology and technical innovation on the other side. Wasting natural potential of ecosystems not only may lead to failure in addressing climate change, but may principally undermine future prospects for human well-being in general.

Key messages

In conclusion, relation of ecosystems, biodiversity and climate change may be summarized in the following key messages:

- Biodiversity, ecosystems and climate are closely mutually interlinked, depend on each other. Effects of climate change on biodiversity have been occurring and observable. Therefore, it is important to react quickly, inaction is inexcusable and unacceptable (*cf.* key message 5 of the Global Change Congress, Anonymous 2009a).
- Climate change adds an additional threat to biodiversity and ecosystems and interacts with existing pressures such as overexploitation, pollution, invasive alien species, habitat fragmentation, degradation and loss.
- Biodiversity and ecosystems need to be an integrated part of the general mitigation and adaptation efforts (*cf.* 7 Aarhus Statements on Climate Change, Anonymous 2009b).
- We cannot solve climate change without addressing biodiversity and ecosystem services. Fostering co-benefits which con-

The Apollo (Parnassius apollo) may lose 78 % of its climatic niche in Europe by 2080. **© L. Havel**

The Dwarf Alpenrose (Rhodothamnus chamaecistus) is endemic to the Eastern Alps. **© J. Čeřovský**

tribute to both emission reduction and to the conservation and sustainable use of biodiversity will help us to make sure that we do not compromise the ecosystem services we depend on, including climate regulation.

- Measures such as nature conservation efforts and protected areas, including the European Community's Natura 2000 network management, are to be seen as central elements for combating climate change, which need to be stepped up. Natural processes should be employed as much as possible in relation to carbon and water cycles, flood protection, soil protection, *etc.*
- Combating climate change and biodiversity and ecosystem conservation and sustainable use cannot be successful without real integration into agriculture, forestry, fisheries and energy policies and economic development programmes, policies and practices.

Regions in South Europe are projected to be particularly vulnerable to reductions in water resources due to climate: the Cabañeros National Park in Spain.

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