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Managing forests for adaptation to climate change

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ABSTRACT

There is now an overwhelming body of evidence indicating that our climate is changing at an alarming rate. It will force us to re-visit how we manage our natural resources, including forests. The various climate scenarios predict an average temperature rise of several °C over the 21st century, and changes of similar magnitude can be expected in other climatic variables. Such a drastic change in climate will be very hard to tolerate for any ecosystem. It is also predicted that the frequency of extreme weather events (like storms, droughts or extreme precipitation) will increase, which is also likely to adversely impact on forests. Species can adapt to the changing climate through phenotypic plasticity, adaptive evolution and migration to more suitable sites. The following recommendations can be made regarding the use and management of forests, to enhance their capacity to adapt:

- Nature reserves should be sufficiently large and should include a full range of forest types
- Avoid fragmentation and/or establish connectivity, minimise road network
- Protect climatic refugia and migration corridors
- Protect primary forests
- Provide buffer zones
- Practice low-intensity forestry and avoid plantations
- Maintain genetic diversity at all levels
- Monitor changes
- Identify and protect functional groups

Forest/timber users should be accommodated without compromising the adaptive capacity of forests.

Key words: diversity, connectivity, migration, reserves, monitoring

INTRODUCTION

There is a rapidly growing body of evidence indicating that our climate is changing at an alarming rate. What was once mostly a subject of scientific discourse has now become a major item on the global political agenda, and is featured regularly in the mass media. Climate change will have profound implications on our entire lives. It will also force us to re-visit how we manage our natural resources, and forests are no exception.

Forests have received considerable attention in the climate-change discussions. However, there is barely any indication that the predictions are taken to heart, and our approach to forest management has so far remained largely "business as usual". Although climate change has made it to the top of the agenda in the various forest policy fora (*e.g.*, UNFF, MCPFE or national policies), the issue is primarily used to highlight the role of forests as potential providers of "renewable", "carbon-neutral" energy, and as carbon sinks. There are effective policy frameworks (most notably the Kyoto Protocol) that bind countries to reduce net greenhouse gas emissions, and there are financial mechanisms that make such efforts worth-while. This encourages investment into renewable energy and carbon sinks. Unfortunately, much less attention has been given to (and money invested into) the ability of forests to withstand the predicted changes in climate, although it fundamentally affects their long-term potential as carbon sinks, or as sources of biomass (not to mention their other, no less important functions).

This paper first provides a summary of the predicted changes in climate that are most likely to affect European forests, and their likely impacts. Then it highlights the most important measures countries and forest managers can implement to enhance the resilience and/or resistance of forests and to increase their capacity to adapt to the changing climate. Finally, recommendations are proposed for the "sound use of wood" in the context of climate change.

CLIMATE CHANGE AND ITS IMPACTS ON FORESTS

"An increasing body of observations gives a collective picture of a warming world and other changes in the climate system" (IPCC 2001a).

As climate change is a global phenomenon which cannot be substantiated with controlled trials, most of the evidence is indirect. However, a consistent pattern of observations together with ever more powerful global climate models indicate that our climate has discernibly changed over the past decades, and it is likely to change at a faster rate in the 21st century.

Projected changes in the environment

Below are a few highlights of the most likely climate change scenarios for Europe, based on the reports by the IPCC (1998, 2001b).

Temperature

Mean temperatures are generally expected to increase ("global warming"), although there might be regional exceptions. In Europe, annual temperatures are expected to grow at a rate of 0.1 to 0.4 °C/decade in the first half of the century. Warming is predicted on the whole continent in all seasons.

As with most other climate parameters, it is likely that changing averages will be accompanied by changes in patterns (unseasonable/extreme weather events). Winters currently considered "cold" (occurring once in ten years in the past) are likely to become less frequent, and disappear entirely by the end of the century. In contrast, hot summers are likely to become much more frequent.

Precipitation

Annual precipitation is expected to increase in northern Europe (1-2% per decade) and decrease across southern Europe. No (or uncertain) changes are predicted in central Europe. There is a marked contrast between winter and summer patterns of predicted precipitation change.

Extreme weather events

It is very likely that frequencies and intensities of summer heat waves will increase throughout Europe. The frequency of intense precipitation events is likely to increase (especially in winter), and the frequency/severity of summer droughts is likely to increase in central and southern Europe. It is possible that the frequency of gale-strength wind will increase.

Increasing concentration of CO_2

Climate change is largely driven by the release of greenhouse gases into the atmosphere, most important of which being carbon-dioxide. The concentration of atmospheric CO_2 has been increasing at an accelerating rate since the industrial revolution. This trend may be slowed down by efforts to curb emissions. However, even with a full implementation of the Kyoto Protocol, CO_2 emissions are likely to keep increasing until at least the middle of the 21st century, and atmospheric concentrations are likely to keep increasing throughout the century.

Likely impacts on forests

Fossil records indicate that there have been significant changes in the earth's climate in the past, and that ecosystems and species responded in a variety of ways. Changes in climate were likely to be major drivers of speciation as well as extinction. These are natural processes which, in and by themselves, would be no reason for concern.

However, the on-going, human induced climate change is different from past climate shifts in several respects, and should be a major cause for concern. The most important reasons are the following:

- The rate of change in the climate appears to be higher than most (or any) previous changes in the Quaternary period. This, in and by itself, would put species, functional groups and ecosystems under considerable stress.
- Unlike during past climate changes, the landscape is no longer pristine, which is particularly true for Europe. Ecosystems tend to be highly fragmented and altered by past and present human activity. In addition, there is an abundance of invasive introduced species which encroach on the habitat of native communities. All these factors make adaptation more difficult. Climate change will constitute still another stress factor impacting on forests which are already under suffering from a variety of pressures.
- Most ecosystems serve basic, often multiple human needs. Large-scale losses and damages to forest may cause such a deterioration of economic, environmental and social services that we cannot afford.

The most likely impacts on forests are the following:

Shifting range boundaries

Optimum ranges of species/communities will shift. In Europe, climatic zones are likely to shift towards the north and, in the mountains, to higher elevations (potentially elevating the tree line). This may naturally follow the changing climate under some circumstances, but their ability to do so can be seriously limited by land use, management interventions, natural dispersal rates and other factors (e.g. soil conditions). Due to their long life cycles and often slow dispersal speeds, (not to mention conservative management practices), forests are likely to complete their life-cycles (perhaps even for several generations) even if their environmental conditions exceed their historic range of variability. However, these forests are going to be under considerable stress, which is likely to make them more vulnerable and will lead to their decline.

Changes in phenology

Changes in the timing of some biological processes are among the most easily detectable effects of climate change. In Europe, a general lengthening of the growing season has been detected, and is likely to continue. This manifests itself in earlier bud break and flowering, and a later occurrence of the first frosts. At the same time, it also leads to higher evapotranspiration, potentially contributing to water scarcity. As different species use different environmental signals (heat, light, etc.) to time their life processes, changes in phenology may lead to the disruption of some functional groups (i.e., inter-species relationships like between plants and their pollinators, seed dispersers or parasites) with potentially serious consequences.

Changes in forest growth.

It is likely that forest productivity will increase, at least on the short run, in most of Europe. This is due primarily to the longer growing season, increased CO_2 concentrations (fertilisation effect). Factors unrelated to climate change, such as increased nitrogen deposition, are also likely to promote growth. Forest inventory data in Europe do indicate an increased growth rate, although the attribution of this to climate change and other factors is not yet possible. Increased growth is going to lead to increased evapotranspiration, which will contribute to water scarcity unless changes in precipitation make up the difference.

Carbon balance

Although increased growth suggests that forests are going to be more effective carbon sinks, it is not necessarily the case. Higher temperatures are likely to cause higher respiratory losses. The loss of soil carbon, especially in northern latitudes, can turn the overall carbon balance negative. While Europe's forests act as a net sink of carbon, models suggest that they will become a net source by the middle of the 21st century.

Increased incidents of calamities

As it has been mentioned, most climate models agree that an increase in the frequency/severity of extreme weather events can be expected. This is likely to translate into more frequent and/or more serious damages to forests. Such events include storm damage, fire (due to higher temperatures and drought), snow/ice damage, etc. Climate change may indirectly contribute to pest outbreaks in various ways. For example, higher winter temperatures may allow certain pests to survive winter in higher numbers, thus becoming more damaging. In addition, changing climatic conditions may lead to the migration of pests/pathogens to new areas.

Adaptation mechanisms

During past climatic changes, species adapted by physiological acclimation (phenotypic plasticity), evolution (micro-evolution) and/or migration to suitable habitats. Those species that could not adapt began to decline, eventually leading to their extinction.

Physiological acclimation

All species have a certain amount of physiological plasticity, allowing them to tolerate a range of environmental conditions. Trees, as they are long-living organisms, tend to have a relatively high plasticity, and can tolerate considerable changes in the environment. However, when environmental changes consistently exceed the range of historic variability, individuals eventually succumb to persistent stress.

In-situ evolution

Evolution is a typically slow process (requires many life cycles to be completed under a consistent selection pressure). There are many examples indicating that evolutionary changes have already been caused by climate change (and other human-induced environmental change), but most of these are from species of short life cycles (mostly invertebrates). This kind of adaptation requires viable populations with adequate genetic diversity. Rapid *in situ* evolution is likely to lead to losses of genetic diversity in the populations: while some traits are enhanced, others disappear. On a longer temporal scale, climate change can contribute to genetic diversity and can drive speciation (through the divergence of populations).

Migration

Paleological records indicate that during past changes in climate, most species adapted by migration, with little or no sign of evolutionary change. Whether or not migration is a successful adaptation response depends largely on the speed at which species are able to expand their ranges.

Migration requires freedom of movement along ecological gradients. It can also be a slow process, which is especially true for some tree species which are slow to mature and have low dispersal rates. The speed of migration of tree species after the last glaciation has been estimated to range from a few dozen to a few thousand meters per year. Functional groups of species have to migrate together, so factors limiting the migration of one species may impede the migration of others.

Refugia

Refugia are areas where the special microclimate and/or other environmental factors (like hydrology) allow species and communities survive extended periods of otherwise unfavourable macroclimatic changes. Refugia are crucial for the survival of species and they were important sources of re-colonisation after the reversals of climatic changes.

IMPLICATIONS FOR THE USE OF FORESTS AND THE USE OF (HARVESTED) WOOD

The above factors have implications on how we should manage and use our forest resource. The most important conclusions relate to the management and use of forests, but some recommendations can also be formulated for the wood processing sector and downstream activities.

Management measures favouring adaptation

Although our predictions about the future trends in climate change, especially its manifestations in given geographical areas, contain a lot of uncertainty, there are a number of land use and management principles which, when properly implemented, are likely to help ecosystems adapt to the changing climate. Most of these measures are such that would be beneficial without regard to climate change. The following is the summary of the land use and forest management guidelines (after Noss, 2000).

Nature reserves should be sufficiently large and should include a full range of forest types

Perhaps the oldest approach to nature conservation is the creation of reserves, where species and communities can be preserved, maintained and monitored. Climate change adds another strong argument for the creation and maintenance of a reserve network. Since it is poorly understood which species/communities are going to be most affected, and how they are likely to shift along environmental gradients, reserve networks should include all representative habitat types, preferably in reasonably large, contiguous areas along ecological gradients.

Avoid fragmentation and/or re-establish connectivity, minimise road network

Fragmentation is likely to hinder adaptation in various ways. First, large populations are broken up into smaller ones, which are more vulnerable to adverse impacts. Second, fragmentation increases the influence of the edge effect, and reduces the area typical of the interior of mature forest. Excessive fragmentation can lead to total disappearance of the interior zone. Last, but not least, fragmentation poses one of the most important obstacles to the migration of species.

When forest communities are already fragmented, connectivity has to be re-established by appropriate land-use planning and restoration measures.

Road networks are increasingly considered as major threats to biodiversity. Not only can they provide significant barriers to less mobile organisms, but they also facilitate the invasion of natural areas by exotic species (a problem that is likely to increase with climate change). Unused/unnecessary roads should be decommissioned and reclaimed, while the necessary road infrastructure should be developed in a way that it does not cause undue disturbance. There are a number of measures that can effectively reduce the impacts of roads (*e.g.*, installation of wildlife crossings or closing roads to public transport)

Protect climatic refugia and migration corridors

Researchers have long recognised the importance of climatic refugia, areas were species/communities survived past changes in climate. These areas tend to have special microclimatic or other environmental features which largely override macroclimatic conditions. Despite our limited understanding of the functioning of refugia and the lack of certainty about their effectiveness in the future, it is safe to assume that these areas can again play an important role in the survival of species/communities, and conservation efforts should pay special attention to these areas. Refugia can be identified (and should be protected) at various scales, from special micro-habitats (like cave entrances) to extensive regions (like whole mountain ranges).

Similarly to refugia, migration corridors were also instrumental in the adaptation (migration) of species in the past, and they also need special protection in the future. These include river valleys, mountain chains and other geographical features. Disruption of these may seriously impede the migration of various organisms.

Protect primary forests

Apart from their obvious role in harbouring biodiversity, mature primary forests are also considered to have a considerable resistance to climate change. Sufficiently large tracts of undisturbed old-growth forests are likely to persist under a changing climate, changing much slower than younger/disturbed communities of the same species.

Provide buffer zones

The importance of buffer zones around protected areas has long been recognised. Their role is even more important in light of the changing climate. Whenever possible, reserves should be surrounded by buffer zones that allow populations to change boundaries. If critical elements of biodiversity are monitored, the zoning of the reserve and its protection zones can be periodically reviewed.

Practice low-intensity forestry and avoid conversion to plantations

Close-to nature forest management is likely to lead to higher stability by limiting soil disturbance, by limiting the size of canopy openings (maintaining more favourable microclimatic conditions within the forest) and maintaining a higher diversity of not only tree species, but also of associated organisms. The conversion of (semi-)natural forests to plantations (even-aged monocultures) should be strongly discouraged. Whenever possible, plantations and other species-poor, degraded communities should be rehabilitated

Maintain genetic diversity at all levels

A diverse gene pool makes it more likely that traits and genotypes that are well suited to the new environment are represented in sufficient quantities. Adaptation mechanisms like micro-evolution and speciation are fundamentally dependent on the genetic variation within populations. Breeding programmes that limit genetic variation, and favour only a few traits that are considered commercially desirable should be discouraged.

Monitor changes

Climate induced changes in ecosystems are already noticeable. Although variations in the distribution or phenology of individual species cannot be attributed to climate change with 100% certainty, there are indications of consistent shifts in species ranges and changes in phenology across a number of taxa. Recently published reports analysing the results of hundreds of studies on a number of taxa concluded with a high degree of confidence that climate change is already affecting living systems (Parmesan *et al.* 2003 and Root *et al.* 2003). They found that observed changes are rather consistent with predictions from climate models.

Relevant changes in natural systems therefore can and should be monitored, and the results should be used in decision making.

Identify and protect functional groups

Functional groups, and keystone species within them, are essential elements in the resistance and resilience of forests to climate change. Our knowledge of these, however, is rather limited, mostly because they could be taken for granted. It is, however, very likely that some functional groups will be disrupted by climate change, leading to unpredictable effects. Efforts should be made to identify and protect these functional groups.

Implications on the use of wood

As it has been indicated in this paper, climate change is likely to have a potentially serious impact on forests, and the long-term security of our forest resource depends on the ability of the forests to adapt to the changing conditions. The adaptation measures listed in the previous section should be given priority during decision making, and that has implications also for the utilisation of wood.

From the earliest days of the profession, foresters had the mandate to produce the kind of wood that was needed by the users (industry, agriculture, etc.). For example, when before industry learned how to process beech, it was considered to be just a little better than a weed, and much beech forest has been replaced by conifers. Today beech is one of the more valuable hardwood species. Similar stories can be told about other species during different times.

Wood technology has made considerable progress in the past decades in exploring new processing methods. Particle boards, composites, finger-jointing, various biomass applications and other technologies all resulted in more opportunities for providing new uses to previously under-utilised sortiments.

This should be continued, and there should be systematic efforts aiming at finding ways for the economically viable utilisation of native tree species. Beyond technological advances, this should also include marketing efforts to change the consumption habits of end users. A more adaptive timber industry, capable of accommodating a variety of species, quality and size classes can provide a market for previously less-favoured species, and can make the diversification and restoration of forests economically more attractive to forest owners and managers. This is likely to require targeted research, and the involvement of the public sector.

CONCLUSION

Climate change is a potential threat to the long-term health of forests and to the resource security of the wood-based industries. Land use and management measures can reduce these risks by helping forests to adapt to the changing conditions. The recommended measures do not differ significantly from sound forest management under a more static climate, but there is an increased emphasis on refugia and connectivity. On the basis of precautionary principle, these adaptation measures should be given priority in forest management, and other uses of forest should try to accommodate these needs.

REFERENCES

IPCC, 1998. The Regional Impacts of Climate Change: An Assessment of Vulnerability. Special Report of IPCC Working Group II [Watson, R.T., M.C. Zinyowera and R.H. Moss (eds.)]. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

IPCC, 2001a. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [Houghton, J.T, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K.Maskell and C.A. Johnson (eds.)]. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

IPCC, 2001b. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [McCarthy, J.J, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds.)]. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

Noss, R.F., 2000. Managing forests for resistance and resilience to climate change. A report to World Wildlife Fund U.S.

Parmesan, C. and G. Yohe, 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:2, 37-42.

Root, T.L., J.T. Price, K.R. Hall, S.H. Schneider, C. Rosenzweig and J.A. Pounds, 2003. Fingerprints of global warming on wild animals and plants. Nature 421:2, 57-60.

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