Climate change and forest genetic diversity

Implications for sustainable forest management in Europe

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editors

EXECUTIVE SUMMARY

Opening of the workshop

Ms Sylvie Alexandre (Deputy Director General, Forest and Rural Affairs, Ministry of Agriculture and Fisheries, France) delivered a welcome address on behalf of Mr Dominique Bussereau (then Minister of Agriculture and Fisheries, France). She stressed the commitment of France to the MCPFE work, and highlighted the ongoing work on the conservation and use of forest genetic resources in the country. She then informed the participants of a decision made by the Ministry of Agriculture and Fisheries in 2006 to make its forest genetic resources conservation policy a part of the national strategy for biodiversity. Mr Cyril Van Effenterre (Director, ENGREF) also welcomed the participants to the workshop.

The background and objectives of the workshop were introduced by Dr Jarkko Koskela (EUFORGEN Coordinator, Bioversity International) and Dr Eric Teissier du Cros (former Vice-President, Science, IUFRO). Dr Koskela summarized the EUFORGEN work in promoting conservation and management of forest genetic resources in Europe, and Dr Teissier du Cros highlighted IUFRO activities related to forest genetics and climate change.

The workshop continued with technical presentations by leading experts during three sessions that focused on (1) the regional policy context; (2) climate change and forest trees in Europe; and (3) the role of forest genetic diversity in forest management under climate change. The presentations and subsequent discussions are summarized below.

On the second day of the workshop, the participants formed three working groups to address the following issues: (1) silvicultural practices and forest genetic diversity; (2) forest reproductive materials; and (3) regional and national strategies for forest genetic diversity and climate change. The working groups reported the results of their discussions during a plenary session. The workshop recommendations were then developed and adopted based on the outputs of the working groups. The workshop recommendations are presented at the end of this Executive Summary.

Session 1: Regional policy context

Dr Roman Michalak (MCPFE Liaison Unit Warsaw) described the policy context of the workshop. He pointed out that the potential pressures arising from climate change had already been acknowledged at the first Ministerial Conference on the Protection of Forests in Europe, in Strasbourg in 1990. In 1993, the second Ministerial Confer-

ence, held in Helsinki, called for development of strategies to ensure long-term adaptation of European forests to climate change. The linkage between sustainable forest management and climate change was subsequently taken up at the fourth Ministerial Conference, in Vienna in 2003, where the ministers responsible for forests committed themselves to supporting research on the impacts of climate change on forests, and to develop policies to enhance adaptability of forests to climate change. Dr Michalak also presented briefly some forest-related issues of the United Nations Framework Convention on Climate Change (UNFCCC) and the work of the Intergovernmental Panel on Climate Change (IPCC). He communicated that the fifth Ministerial Conference was planned to be held in Poland in 2007, and that the present workshop was a good opportunity for providing inputs to the preparation of that Conference.

Session 2: Climate change and forest trees in Europe

In his presentation, Dr Antoine Kremer (INRA, France) focused on evolutionary processes, the rate of evolution and responses of forest trees to climate change. There is some evidence, based on long-term empirical data, that climate-change-induced evolution is already taking place and that trees have started to adapt to increasing atmospheric carbon dioxide concentrations, at both individual and population levels. According to Dr Kremer, evolution in forest trees can occur over a few generations or less than 200 hundred years. In some cases, even one generation is enough for local adaptation, as demonstrated by the transfer of a Norway spruce (*Picea abies*) provenance from Germany to Norway as part of a provenance experiment.

Dr Kremer remarked that most climate models predict a dramatic shift in the range of forest trees, but they assume that the climatic envelopes of the species will not change. However, this assumption is unlikely to be valid as the climatic envelopes will probably change due to evolutionary processes. The climatic envelope of a species refers to the range of climatic variation within which the species can persist, provided its non-climatic environmental requirements are met. Dr Kremer concluded that it is unlikely that the widely-occurring tree species will face extinction at species level due to climate change. However, local extinctions of tree populations may occur as a result of fragmentation and lack of reproduction. Human interventions, such as transfer of forest reproductive material, may thus in particular be needed to enhance local adaptation of rare and scattered tree species.

Dr Outi Savolainen (University of Oulu, Finland) emphasized that natural tree populations adapt as a result of selection and migration based on total fitness, not just growth. These processes are likely to be slow in comparison with the rate of the

predicted climate change. She further pointed out that landscapes are very fragmented in most of Europe, making migration of forest trees even more difficult. Dr Savolainen highlighted that climate change will affect tree populations very differently in southern Europe compared with northern Europe. For example, in higher latitudes, Scots pine (*Pinus sylvestris*) populations can migrate northwards under climate change, but at the southern edge of the species' distribution range, the species is likely to withdraw to more suitable sites. Furthermore, large and diverse tree populations have higher probable potential to adapt to new climatic conditions than have fragmented tree populations. She concluded that a cautious transfer of forest reproductive material has a role in facilitating migration of tree species and increasing the intensity of selection. She also stressed the need to integrate ecology and genetics in further experiments, as currently there is limited data available on the fitness of tree species facing simultaneously competition from evolving species.

Session 3: The role of forest genetic diversity in forest management under climate change

Dr Marcus Lindner (European Forest Institute, Finland) pointed out that future climate projections still include a considerable degree of uncertainty and that this creates a big challenge when designing adaptation strategies in forest management. However, what seems more obvious is that the frequency of extreme weather events is increasing and that such events are likely to be the most important drivers of ecosystem change. While the productivity of forests is likely to increase in northern Europe, it is expected to decrease in southern Europe due to more severe drought periods. Subsequently, forest fires will become an even more serious problem in southern Europe. Furthermore, storms may become more frequent also in the northern and central parts of Europe, and new pests and diseases are likely to spread northwards. Dr Lindner highlighted that different tree species respond differently to extreme weather events, such as drought. Overall, mixed forests are likely to withstand better a broad range of climatic conditions, and broadleaved species are more susceptible to disturbances. Dr Lindner concluded that diversification of adaptation strategies leaves more options to cope with uncertain future climatic conditions. No single adaptation strategy is the best one. Thus, he recommended diversifying species, forest types, forest management practices, forest products and services.

Dr Koen Kramer (ALTERRA, Netherlands) focused on the concepts of equilibrium, non-equilibrium and resilience. He noted that traditional thinking is largely based on the concept of equilibrium, i.e. that species coexistence is due to niche differentiation and that species' distribution areas are in equilibrium with climate. Due to climate change, however, species are in disequilibrium with the prevailing climate.

Moreover, the future equilibrium states of species composition in a forest and of species' distribution areas are essentially unknown. Forest management guidelines and policies based on the restoration of a historic pre-disturbance reference are not necessarily still attainable. A non-equilibrium approach is therefore needed, focusing on setting conditions so that the system can adapt to environmental changes. Resilience is then defined as the rate of return to the stable state, i.e. how well a system can absorb disturbances and environmental stress and still persist. Hence, Dr Kramer proposed that the concept of resilience be made operational by quantifying both genetic and ecological aspects of diversity at the stand, landscape and regional scales. He then presented the DYNABEECH project as an example where genetics, ecophysiology and silviculture were successfully integrated to formulate forest management practices that optimize the adaptive capacity, as measure of non-equilibrium resilience, of beech (*Fagus sylvatica*) stands.

Professor Csaba Mátyás (University of West Hungary) reviewed results of various field trials and stressed the need to use quantitative genetic knowledge in forecasting adaptive responses of forest trees to climate change, formulating mitigation strategies and in supporting adaptation of trees by human interventions. He stated that results of field trials show a remarkable range of adaptability in forest trees even to dramatic changes in thermal and moisture conditions. However, he emphasized that there are genetically set limits to adaptation and that some tree populations are seriously threatened by climate change. He emphasized that tree populations at the xeric limits, such as the Mediterranean region and continental Europe, are the most threatened ones. Concerning the role of spontaneous migration in adaptation of forest trees to climate change, Prof. Mátyás expressed his doubt that spontaneous migration could occur in most parts of Europe. This is mainly because fragmented and intensively managed landscapes pose considerable obstacles to migration. He therefore considered that human interference is necessary to facilitate the adaptation of forest trees to climate change. He then recommended the development of flexible pan-European guidelines for the use of forest reproductive material, and the incorporation of climate change and adaptation issues into national forest programmes.

Dr Bo Jellesmark Thorsen (Royal Veterinary and Agricultural University, Denmark) discussed the role of forest genetic diversity in maintaining the supply of numerous benefits derived from forests. In addition to supporting supply of many marketable forest products, forest genetic diversity also contributes indirectly to securing the long-term health of forest ecosystems and the services they provide. He underlined that climate change implies increased uncertainty, which is a key factor in economic considerations. He further highlighted two economic aspects of uncertainty. Firstly,

uncertainty can be perceived as risk and handled by diversification. Secondly, with uncertainty ahead, we may benefit from strategies that retain options open for later adjustment. The time horizon of the implications of the climate change may be of little importance to an individual forest owner, but of great importance for society pursuing sustainable development. He recommended that forest owners and policy-makers pursue flexible strategies and decisions on forest genetic diversity, as these are likely to increase both the private value and social values of the forests. He also emphasized that diversification through increased use of forest genetic diversity is a recommendable risk-reduction strategy for an individual forest owner.

Ms Mari Rusanen (Finnish Forest Research Institute) provided an overview of Finland's National Strategy for Adaptation to Climate Change. The strategy was prepared in a collaborative effort of all relevant sectors and was finalized in 2005. It identifies actions and measures for each sector (including forestry), and also takes into account changes occurring outside Finland (transboundary effects). Furthermore, the strategy places special emphasis on cross-cutting adaptation, such as public sector capabilities (e.g. risk assessments, environmental impact assessment and management systems), observation and warning systems, research and development, communication and information sharing. The strategy highlights the role of the National Forest Programme as a planning and implementation tool for the adoption of specific adaptation measures for the forest sector. Also, it addresses the need to conserve forest genetic resources and the new challenges for tree breeding and seed production. Regarding forest management, the strategy proposes actions such as revision of silvicultural guidelines, rapid harvesting of forests destroyed by storms, control of pests and diseases, and better maintenance of forest roads. Ms Rusanen summarized that the lessons learned were that key elements of the comprehensive strategy involved integration of mitigation and adaptation measures and implementation through specific sectors. The strategy will be reviewed within 6 to 8 years.

Dr François Lefèvre (INRA, France) gave an overview of the institutional framework for the conservation of forest genetic resources in France, and analyzed the effects of climate change on gene conservation strategies. He stated that 11 *in situ* or *ex situ* networks of gene conservation units have been established throughout the country for different tree species. All units are located in public forests and gene conservation is incorporated into the management plans of these forests. Dr Lefèvre observed that there is a need to re-evaluate and improve the existing gene conservation networks in the context of climate change. The objectives of the gene conservation networks should not only focus on genetic diversity per se, but also on plasticity, adaptation and migration potential of tree species. Subsequently, process-based rather than di-

versity-based criteria and indicators should be developed for the management of the gene conservation units. The robustness of the existing gene conservation networks to extreme weather events should be assessed and monitored, as there are already examples of such events destroying particular units. He stressed that there is a need for better coordination between habitat and gene conservation programmes. Gene conservation efforts for several scattered tree species should also be managed on a larger scale than that of the stand.

Working group discussions

Working Group 1: Silvicultural practices and forest genetic diversity

The working group recognized that there is still considerable uncertainty in the future climate projections based on different models. However, it is likely that climate variability and the frequency of extreme weather events will increase, bringing storms and extended drought periods. Furthermore, there may well be combined effects of climate change, pests and diseases on forests. It was also emphasized in the discussion that there are regions where forests are facing high risks (e.g. southern Europe) due to climate change, while forests in other regions are likely to have lower risks. Furthermore, the working group agreed that specific silvicultural and gene conservation measures should be taken to protect species that are endangered or of special interest.

The working group stressed that silviculture should help forest ecosystems to regenerate and thus evolve under climate change. In this regard, an important question is the balance between natural and artificial regeneration, i.e. to what extent promote natural regeneration and when to encourage planting of seedlings, possibly originating from different climatic conditions. The occurrence of frequent natural regeneration is fundamental for continuous natural selection in forest ecosystems, thus maintaining the evolutionary process of forest trees. Artificial regeneration is needed to complement natural regeneration and, in some cases, to accelerate the adaptation of forest trees to climate change. The working group concluded that forest genetics can play an important role in identifying the most feasible regeneration methods in terms of adaptation to climate change.

Working Group 2: Forest reproductive materials

The working group highlighted that knowledge-based use and transfer of well-documented and characterized forest reproductive material can be an effective tool

to ensure that forests are able to cope with climate change. Existing networks of provenance trials of various tree species and the research results already available provide plenty of information and a solid basis for the assessment of provenance regions. The working group recognized that climate change is likely to alter the existing provenance regions in most countries. Consequently, there is a need to revise the delineation of the present provenance regions of forest trees in most countries, and to modify these regions according to the predicted climate change scenarios. The working group also underlined that new strategies and guidelines were needed at pan-European level to support and promote appropriate use of forest reproductive material.

The working group welcomed that most European countries have implemented the EC Regulations on the marketing of forest reproductive material (1999/105/EC) in their legislation, but pointed out that there is still a need to promote the use of high quality and well adapted material. It was noted that long-term economic analyses confirm the benefits of using high quality reproductive material. The working group also urged European countries to keep better records on the transfer and use of forest reproductive material so that the origin of a forest stand could later be verified, even after a long period. This would enable future analyses of the long-term performance and economic aspects of natural versus artificial regeneration under climate change.

Working Group 3: Regional and national strategies for forest genetic diversity and climate change

The working group acknowledged that most European countries have national forest programmes (NFP), national biodiversity action plans (NBAP) or similar processes in place. However, only about one third of the countries have well-established national programmes on forest genetic resources (NPFGR) or related strategies, as revealed by a EUFORGEN survey in 2002. Furthermore, the discussions demonstrated that very few countries have initiated the development of national adaptation strategies (NAS), which aim at increasing the capacity of the whole of society to adapt to climate change. The working group considered NAS as a useful approach to tackle and coordinate mitigation efforts at national level.

The working group welcomed the efforts of the MCPFE process in promoting cross-sectoral coordination and implementation of sustainable forest management through NFP in Europe. It is important to include NAS and climate change considerations in NFP as these remain the mechanism through which various strategies are actually implemented in the forest sector in a country. The working group noted that the

existing examples of NAS highlight the role of forest genetic diversity in mitigating the impacts of climate change. However, in many countries, the linkages between NFP and NPFGR remain weak, and the management of forest genetic resources is not incorporated well enough into NFP. The working group concluded that it is necessary to strengthen the linkage and collaboration between NFP and other relevant national processes, in particular NPFGR and NAS.

Workshop recommendations

Climate change may have substantial impacts on the European forest sector as well as conservation of forest biodiversity. The genetic diversity of forest trees plays a key role in maintaining the resilience of forests to the threats and in taking advantage of the opportunities. The wise use of this genetic diversity also provides flexibility with respect to forest management and adaptation strategies for climate change. The workshop made the following recommendations for further action:

Recommendation 1: Policy-makers in Europe should recognize the importance of forest genetic diversity in mitigating the impacts of climate change on the forest sector by expressing a commitment at pan-European level to incorporate the management of this diversity into national forest programmes and other relevant policies, programmes and strategies.

Recommendation 2: Policy-makers in Europe should promote forest management practices that maintain evolutionary processes of forest trees and support natural regeneration of forests, especially in areas where long-term natural regeneration is self-sustainable despite climate change.

Recommendation 3: Policy-makers in Europe should take into account the potential for accelerating adaptation of forest trees to climate change through tree breeding and transfer of potentially suitable forest reproductive material by endorsing the development of pan-European guidelines for the transfer of forest reproductive material in Europe on the basis of scientific knowledge.

Recommendation 4: The European forest research community should, with the support of policy-makers, carry out more interdisciplinary studies (e.g. tree physiology, forest genetics, pests and diseases, forest management and economics, and modelling) on the impacts of climate change on forests.

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