Adapting to climate change

Evidence that the cumulative effects of human activities are changing the world's climate has become all but irrefutable. What will it mean for the world's forests? Grim threat or opportunity for growth? In the absence of certainty, it depends on the point of view.

The question of how forests and forest-dependent people will adapt to climate change is a growing area of research and has been at the heart of a number of recent conferences. One of these, the international conference on Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health: A Review of Science, Policies and Practices (Umeå, Sweden, August 2008), spawned the contents of this special double issue of *Unasylva*. The conference, organized by FAO, the International Union of Forest Research Organizations (IUFRO) and the Swedish University of Agricultural Sciences, brought together over 300 researchers, managers and decision-makers from 50 countries.

This issue includes a varied sample of presentations from the Umeå conference. Interested readers will find other generally more technical offerings, as well as further detail on some of the studies covered here, in upcoming issues of *Forest Ecology and Management* and *Forest Policy and Economics.* Both were planned, in coordination with *Unasylva*, in lieu of published proceedings.

Key issues. The first article, by P. Bernier and D. Schoene, sums up observations from the Umeå conference. After an overview of impacts of climate change (which we take to include climate variability throughout this issue) on forest ecosystems, their goods and services, and people and livelihoods, it appraises measures for planned adaptation of forest management practices. It reviews the role of science in supporting planned adaptation, and the need to modify policies and institutions. The authors stress the need for countries and sectors to tackle this global issue in a collaborative way, and the need to narrow the gap between developed and developing countries in terms of scientific, planning and operational capacity for adaptation.

The second article, developed by B. Osman-Elasha from her keynote presentation, examines the predicted impacts of climate change in Africa and the links between climate change and sustainable development. While the article does not focus on the forest sector *per se*, these links should be considered by anybody concerned with how the forest sector in developing countries will adapt to climate change. Key terms are defined: vulnerability, adaptation, adaptive capacity. The central message is that since climate change is a constraint to development, and sustainable development is a key to capacities for mitigation and adaptation, sustainable development and climate change should be addressed together.

A 13-million hectare outbreak of mountain pine beetle in the province of British Columbia, Canada exemplifies the devastating effects that a warming climate can have for the landscape, forest industry and forest-dependent communities. D. Konkin and K. Hopkins, recapping another Umeå keynote presentation, summarize the challenges faced and lessons learned. The epidemic has increased recognition of the need to develop resilience in ecosystems, people and communities, and has forcibly broadened the thinking and approach of British Columbia's forest managers. In addition to investment in reforestation of affected areas, the government's responses emphasize recovering the economic value of killed trees through rapid harvest for timber, promoting the use of wood in construction, and economic diversification in forest-dependent communities.

Impacts on forest species composition and distribution. The next few articles highlight some efforts to predict effects of climate change on forest ecosystems and the distribution of forest species. M. van Zonneveld and co-authors used climate envelope modelling to predict possible shifts in the distribution of two tropical pine species, *Pinus kesiya* and *Pinus merkusii*, in Southeast Asia; the aim was not only to anticipate impacts, but also to identify opportunities, such as the potential for pine plantations in areas where they were not previously possible.

M. Silveira Wrege *et al.* used climate vulnerability mapping to predict areas in Brazil where climate change might have the greatest effects on *Araucaria angustifolia*, so that these areas can be prioritized for conservation activities.

A short contribution by M. Devall summarizes how global climate change might make rare trees and shrubs – those most in need of conservation efforts – more vulnerable because of their small populations, habitat specialization or limited geographic range. D.I. Nazimova *et al.* analyse 350 years of post-fire succession in the subtaiga forests of southern Siberia, Russian Federation to predict how increased fires (a likely result of climate change) could influence their future composition, since fire is the main factor determining biodiversity, regeneration and dominant tree species in these forests. Adaptive management plans in this zone will thus need to emphasize fire protection.

Impacts on forest health. Changing climate will also influence forests through impacts on other biotic factors such as pests and diseases. Climate change in some areas is already providing insect species with increasingly hospitable habitats, while their movement is further facilitated by wider global commerce. J. Régnière (an Umeå keynote speaker) describes

an approach for predicting distributions of insect pest species under climate change, based on their physiological responses to specific weather factors. He notes that the distribution of most insect species can be expected to shift towards the poles and to higher elevations, with greatest impact in temperate regions – but that shifts in distribution do not necessarily mean that the world will have more pests.

C.D. Allen finds that beyond impacts of expanding human populations and economies, ongoing climatic changes are influencing the condition of forests all over the world. He traces patterns of dieback (tree mortality well above the norm) primarily related to drought and warmer temperatures. Although gaps in knowledge currently limit the conclusions that can be drawn about trends in forest mortality, Allen suggests that many forests and woodlands today may be at increasing risk of climate-induced dieback. An illustrated map supports the case with examples from all forested continents.

What science and policy can do. Can tree improvement programmes offset new forest health problems that may be expected to arise with climate change? Based on a survey of existing programmes to develop pest and disease resistance in trees, A. Yanchuk and G. Allard observe that most progress has been made for only a small number of major commercial species and has taken decades to achieve. The article suggests that in a world with rapidly changing climates, where new insect pest and disease introductions and increased damage from native pests are likely, past approaches may not be fast enough. The authors recommend that research focus on the search for more general forms of resistance against various classes of insects or diseases that could be developed in advance of outbreaks.

G.M. Blate *et al.* offer practical options for adapting forest management goals and practices to expected climate change impacts, as identified for national forests in the United States. They outline short-term adaptations for building resistance and resilience, and longer-term adaptations for managing for change as resilience thresholds are crossed. They stress the need to strengthen the relationship between scientific research and forest management; to assess trade-offs and synergies between mitigation and adaptation options; to use participatory decision-making to embrace all stakeholders' concerns; and to focus on realistic outcomes, confronting what can and cannot be done given limited financial and human resources.

S. Mansourian, A. Belokurov and P.J. Stephenson examine the role of forest protected areas in adapting to climate change, drawing on examples from the global work of the World Wide Fund for Nature (WWF). They summarize a range of management and policy responses for ensuring that forest protected areas continue to support biodiversity conservation in the face of climate change – for example, designing, planning and managing protected areas in landscapes to improve their resilience and species' freedom of movement. The authors stress that in a future in which climate change will add to the pressure on natural resources caused by growing populations, protected areas will be viable only if they are directly relevant to human communities that live in or depend on them

Community adaptation. What can communities do to adapt? B.A. Gyampoh and co-authors surveyed 20 rural communities in Ghana to examine the use of traditional knowledge to cope with impacts of climate change, particularly water shortage. Indigenous people live close to nature and are often the first to note and adapt to its changes. Strategies for adaptation and coping could benefit from combining scientific and indigenous knowledge, especially in developing countries where technology is least developed. The authors call for further study towards integrating indigenous adaptation measures in global adaptation strategies and scientific research.

M. Idinoba *et al.* briefly examine the impacts of climate change for communities that depend on non-wood forest products in West Africa. They cite research in Burkina Faso that has shown reduction in the distribution, availability and productivity of some NWFP species due in part to climate change. The authors describe forest management and conservation practices adopted to reduce vulnerabilities.

The issue finishes with a comprehensive review of ecosystem sensitivities to climate change, its likely future impacts on goods and services and possible adaptation options in a particularly vulnerable ecosystem: mountain forests. Focusing on temperate and Mediterranean mountain forests in Europe, M. Maroschek and co-authors note the importance of choosing suitable species and reproductive material; adapting spacing, tending and thinning schemes for expected future conditions; adopting preventive (e.g. pest monitoring) and remedial (e.g. sanitation felling, pest control) forest protection routines against the possibility of increased disturbances; and supporting adaptive management options by reducing other pressures through integrated environmental management.

In this special issue, even the usual sections on FAO Forestry, World of Forestry and Books highlight the theme of forests and climate change.

Climate change presents a moving target – so it will be necessary to assess risk and reduce vulnerabilities to predicted changes. We hope that the knowledge presented here can help the forest sector prepare for changes to come.