Air Pollution and Climate Change at Contrasting Altitude and Latitude

Report from the 23rd IUFRO Conference for Specialists in Air Pollution and Climate Change Effects on Forest Ecosystems, 7-12 September 2008, Murten, Switzerland by M. Schaub[1], R. Matyssek[2], G. Wieser[3], E. Paoletti[4] -
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Summary

The regional specificities of tree and ecosystem responsiveness to anthropogenic stressors such as elevated CO_2 and O_3 regimes, enhanced nitrogen deposition and scenarios of climate change, as represented through altered seasonal temperature and moisture regimes were emphasized. Based on the current knowledge on this issue, there is consensus that under predicted climate change, i.e. altered seasonal temperature and water regimes, air pollution may become more harmful to vegetation. The combined effects from seasonal variability of environmental pollution, elevated CO_2, altered nutrient and water availability are the key issues in respect to future forest ecosystem risk assessment.

Dr. Thomas Wohlgemuth (WSL) presents the rain shelter experimental research facility located in the central-alpine region of the canton of Valais, Switzerland. Photo: P. Bleuler, WSL.

Background information

The focus of the conference was on sharing information on impacts and interactions of air pollutants and climate change on the tree and forest ecosystem performance across latitudinal and altitudinal ranges. According to the structure of the IUFRO Research Group 7.01.00 'Impacts of Air Pollution and Climate Change on Forest Ecosystems', the main topics were on:
(1) mechanisms of action and indicator development,
(2) atmospheric deposition, soils and nutrient cycles,
(3) concept and application of critical loads for forests,
(4) integrated effects of multiple stresses,
(5) genetic aspects,
(6) detection, monitoring and evaluation, and
(7) risk assessment and modeling.

Key conclusions and future research needs

Tropospheric ozone (O_3) is still considered to be the most important air pollutant and is expected to increase in future, in particular due to the progressing industrialization of Asia and South America and due to climate warming. While climate change scenarios predict increasing drought episodes (reducing ozone risk on vegetation), increasing ozone concentrations will affect areas with sufficient water availability even more and ozone exposure will impair stomatal regulation and thus the control of tree water loss.

Interactions of ozone, biotic infections, climatic and edaphic factors are still poorly understood. More long-term investigations of those very interactions are

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needed while applying multifactorial experimental set ups under natural or close to natural conditions.

Most recent findings demonstrate that **elevated atmospheric carbon dioxide** (CO_2) is unlikely to cause a sustained increase of carbon storage in biomass, but may enhance the carbon turnover. However, the carbon-cycle is nested in a multitude of feedback loops and influenced by further factors such as nutrient and water availability. Those results demonstrate the importance of simultaneous investigations of the carbon, water and nutrient cycles under natural forest condition. The ignorance of single influence parameters, measured over short time periods may lead to wrong conclusions about the combined air pollution and climate change affects on forest ecosystems.

At present, there are well established relationships between the exceedance of **critical loads**, and ecosystem degradation. However, ecological interactions between critical loads and other environmental stresses such as increased CO_2 and ozone, insects, pathogens, fire, drought, flooding, wind, and extreme temperatures as well as ecosystem management are still poorly understood. In a multiple-stress environment such as forest ecosystems, critical loads effects are connected to effects of climate change. For example, climate change scenarios suggest an increase of sea-salt deposition, runoff, weathering rates, soil decomposition, Nmineralization, organic acids, N- and base cation -uptake. In particular, a change in temperature and precipitation regimes will change catchments' hydrology and affect element leaching. In respect to **integrated effects of multiple stressors**, there is sound evidence that the focus of future research has to be on interacting effects and not on a single environment parameter (as a potential stressor) due to antagonistic and synergistic reactions of forest trees and ecosystem compartments. The discussions on **genetic aspects** revealed that the major future challenge is the better understanding of how genes determine adaptation and survival of tree populations. For the realization, appropriate methods of monitoring genetic traits are required, and the functional characterization of transcripts at a large scale. The increase of knowledge in the fields of genomics and transcriptomics is essential but information on the genomes of tree species (even in case of poplar trees) is still a major draw back and thus a challenge and a determinant for future research topics.

Monitoring, detection and **evaluation** are not only essential to document current status and changes in forest health under changing climate but also of great importance to political decision making regarding forest condition issues. Regional specifications of tree and ecosystem responsiveness to anthropogenic stressors such as elevated CO_2 and O_3 regimes, enhanced nitrogen deposition and scenarios of climate change, as represented through altered seasonal temperature and moisture regimes were emphasized. Due to many overlaps of regional pollution and climate change and their interaction with changes in forest ecosystems, these environmental problems remain of great relevance. However, uncertainties lie in their combined effects on forest ecosystems which may significantly differ from a sum of separate effects. The main reason for this uncertainty lies in the fact that these interactions can only be detected when data of **long-term monitoring** become available, in particular for variables which change slowly. It has been demonstrated that short time series over roughly 10 years could easily be misinterpreted in the context of global climate change. Only long-term measurements will allow us to accurately detect how ecosystems may respond to climate change, and whether there are measurable effects of nitrogen deposition and pollutant fluxes, combined as well as separately.

Risk can be defined as the potential of an adverse effect and can only be addressed if assessed. The issue of **risk assessment** is gaining increasing interest especially in the light of the current focus on climate impacts on ecosystems functions. A thorough understanding of the single processes and the interactions between processes is highly needed to describe current and future mechanisms and assess levels and areas of risk. Both, statistical models or process based models allow for integration of the knowledge acquired from detailed experimental data and monitoring data.