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Working Group on Effects

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Recent results and updating of scientific and technical knowledge

Effects of air pollution on forests

Report by the Programme Coordinating Centre of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

I. Introduction

1. In 2010, the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) continued its large-scale and intensive monitoring of forest condition. Results were available for 6,791 level I plots (2009 assessment) and 462 level II plots (2007 assessment). The parameters monitored included crown condition, foliar chemistry, soil solution chemistry, tree growth, ground vegetation, atmospheric deposition, ambient air quality, ozone injury, meteorology, phenology and litterfall. The results are presented here in accordance with item 3.4 of the 2010 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/99/Add.2), adopted by the Convention's Executive Body at its twenty-seventh session in December 2009.

II. Workplan items common to all programmes

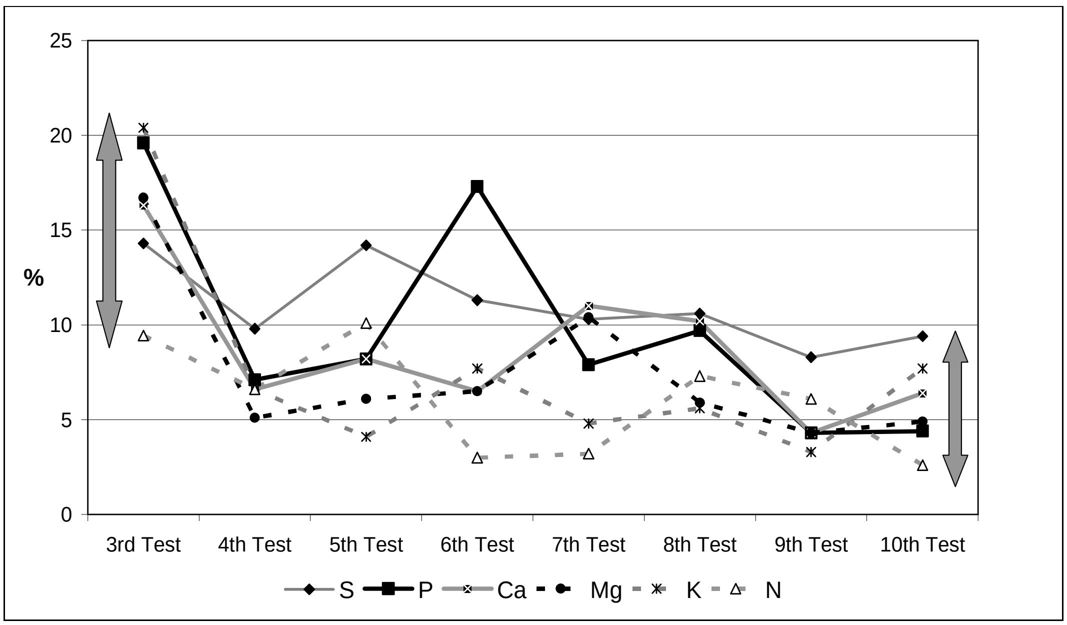
A. Targets and ex post application

2. No harmonized data on concentrations and depositions were available for ex post analyses.

B. Robustness

3. ICP Forests regularly carries out laboratory intercomparison exercises (ringtests) in order to ensure and improve the quality of the data. Results showed that, despite the participation of laboratories from across Europe, data quality was good and had improved in recent years. Results from the soil and precipitation water ringtests in the years 2000 and 2005 showed that 90 per cent of the participating laboratories had improved their results. For foliar analyses, laboratory ringtests have been carried out annually. During the past eight years, the percentage of non-tolerable deviations from standard measurement values in the foliar ringtests decreased from 10–20 per cent to 3–10 per cent for the different parameters (see figure 1).

Figure 1
Decreasing percentage of non-tolerable results in the foliar chemistry ringtests of ICP Forests for the period 2001–2008



C. Links with biodiversity

4. A statistical model based on 477 plots with complete sets of ground vegetation and soil surveys and general plot data together with modelled deposition data from the Convention's Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) explained the 12.5 per cent variance in ground vegetation species composition. A similar analysis based solely on 181 plots with measured deposition data yielded comparable results, but with 19.23 per cent of explained variance. Tree layer, soil, and climate were the most important explanatory variables. There was also a small, but highly significant effect of deposition. In addition to nitrogen inputs, deposition of base cations also contributed to the explanation of ground vegetation species composition in this model (figure 2).

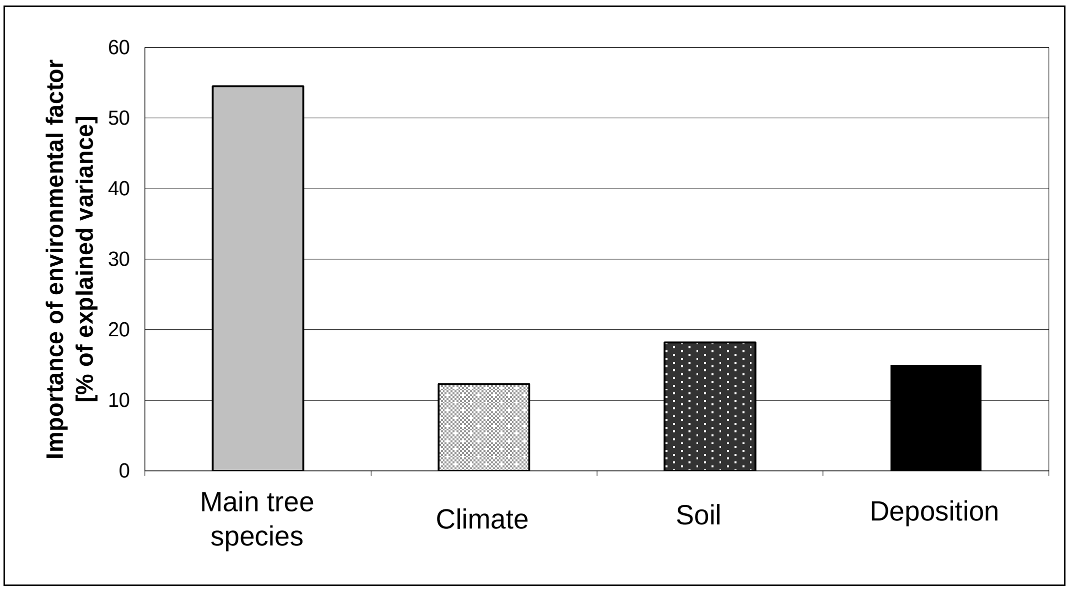
5. Changes in ground vegetation species composition were evaluated based on differences in plot-specific mean Ellenberg indicators. Differences in mean Ellenberg

nutrient indicators on 122 plots were significant, thus indicating a statistically significant shift in ground vegetation species composition towards more nitrophilous site conditions. Differences in other indicators were not significant. Therefore, ground vegetation at present did not indicate changes in, e.g., temperature or soil moisture. The time interval examined was, however, very short and with an increasing length of the time series more ecological trends might become obvious.

6. Differences in mean Ellenberg indicators for nitrogen were related to environmental influences. In these evaluations there was an even stronger effect of nitrogen deposition, suggesting that nitrogen deposition did not only affect present species composition in ground vegetation, but also triggered ongoing shifts in ground vegetation species composition.

Figure 2

Percentage of explained variance for different groups of variables in a model explaining the composition of forest ground vegetation composition with 181 plots and 114 species



D. Trends in selected monitored/modelled parameters

7. The trends for acidification and nitrogen are presented in chapters III and IV.

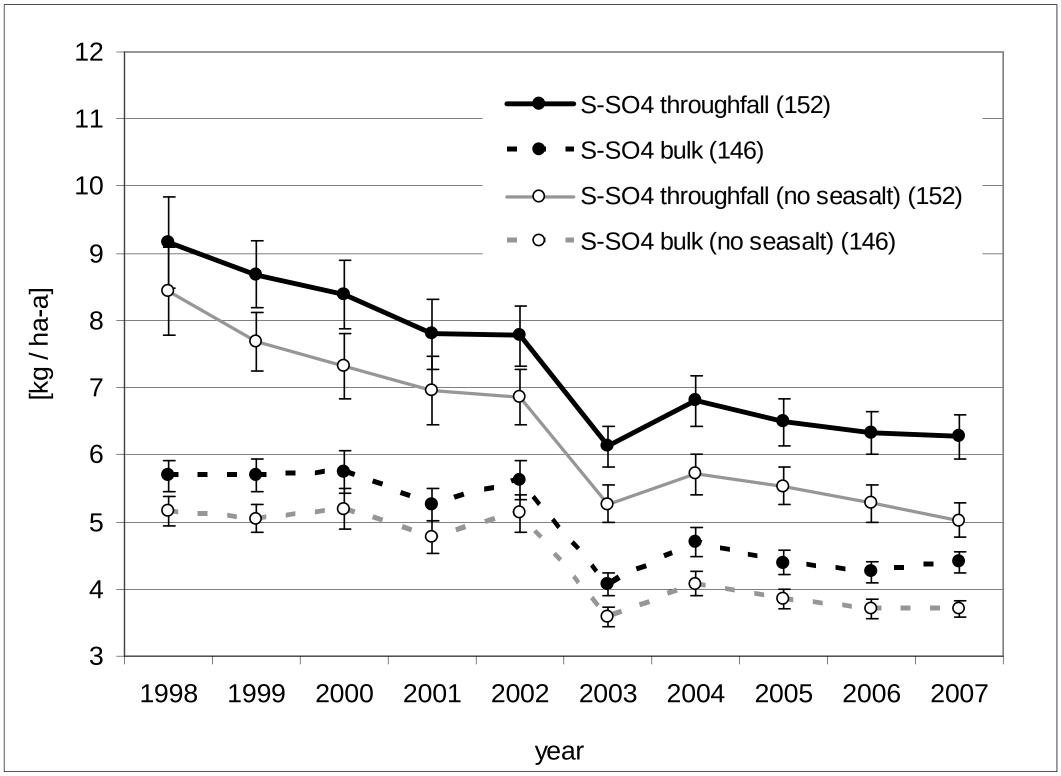
III. Acidification

8. Continuous measurements of bulk and throughfall deposition were available from approximately 150 level II plots since the second half of the 1990s. Mean throughfall sulphate inputs on 152 plots had decreased from 9.2 to 6.3 kg ha^{-1} $year^{-1}$ for the period 1998–2007 (figure 3). Fifty per cent of the plots showed significantly decreasing sulphur (S) inputs, whereas on only one of the plots an increase was observed. Comparatively low sulphate throughfall deposition was measured on plots in the alpine region, in Scandinavia and on the Iberian Peninsula. Mean bulk sulphate deposition, expressed in mass of sulphur, decreased from 5.7 kg in 1998 to 4.4 kg ha^{-1} $year^{-1}$ in 2007 on 146 plots.

9. In order to quantify sulphate inputs of anthropogenic origin, total mean sulphate inputs were corrected for those shares originating from sea salt. In throughfall deposition approximately 1 kg S ha^{-1} $year^{-1}$ could be attributed to inputs from seawater ions, indicating that the major share of the atmospheric inputs was of anthropogenic origin.

Figure 3

Annual mean bulk and throughfall deposition of sulphate (expressed as mass of sulphur) with standard errors for the period 1998–2007 (number of plots in brackets)

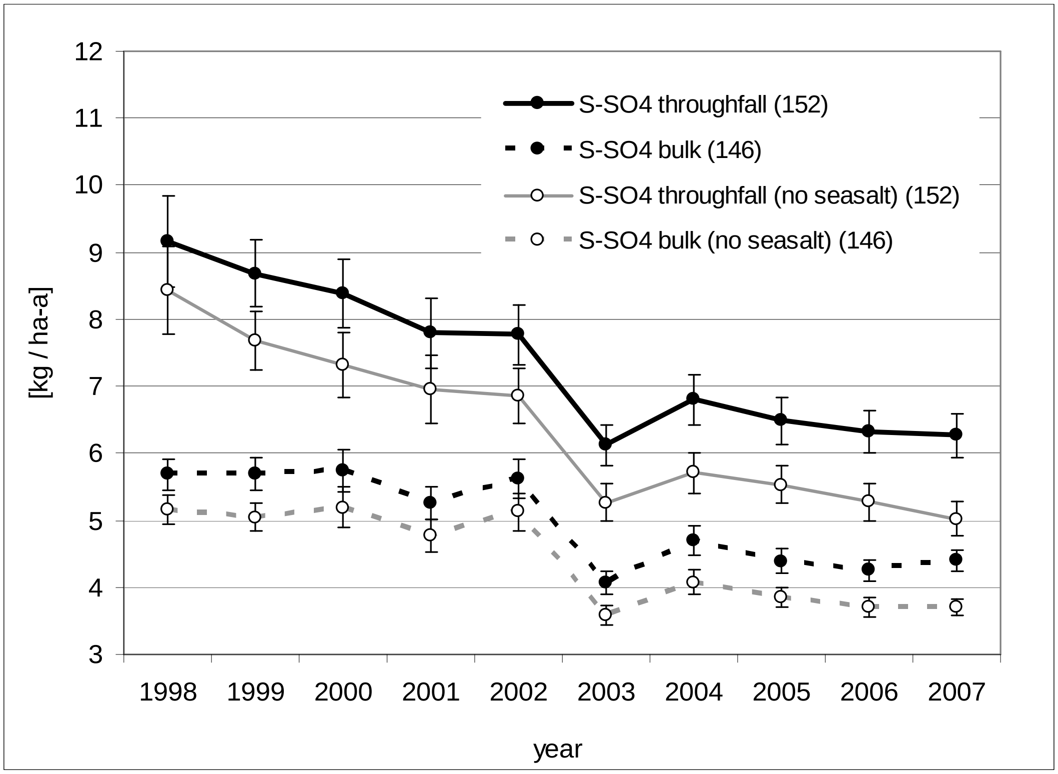


IV. Nutrient nitrogen

10. Mean ammonium throughfall deposition (N-NH_4) varied between 5.3 and 6.5 kg ha-^{1} $year^{-1}$ measured in 1998 to 2007 for 158 plots in Europe (see figure 4). Mean ammonium bulk deposition decreased from 5.3 to 4.1 kg ha^{-1} $year^{-1}$ in the years 1998 to 2007. Lowest mean deposition was measured in the year 2003 (3.8 kg) when inputs were specifically low due to low precipitation quantities. Nitrate throughfall deposition fluctuated between 5.6 and 6.8 kg N ha^{-1} $year^{-1}$. Nitrate bulk deposition, which is not influenced by canopy interaction processes, showed a slight decreased from 4.3 kg in the year 2000 to 3.2 kg in 2003 and again increased to 3.6 kg N ha^{-1} $year^{-1}$ in 2007. Within plotwise evaluations, around 80 per cent of the plots did not show any significant changes in nitrogen deposition. The share of plots with decreasing nitrogen deposition was between 10 per cent for ammonium throughfall and 19 per cent for ammonium bulk deposition. Increasing nitrogen deposition was still observed in Europe, but on less than 6 per cent of the plots. Depositions were mostly higher on plots in central Europe than in alpine, northern and southern European regions.

Figure 4

Annual mean bulk and throughfall deposition of nitrate and ammonium, expressed as N, with standard errors for the period 1998–2007 (number of plots in brackets)

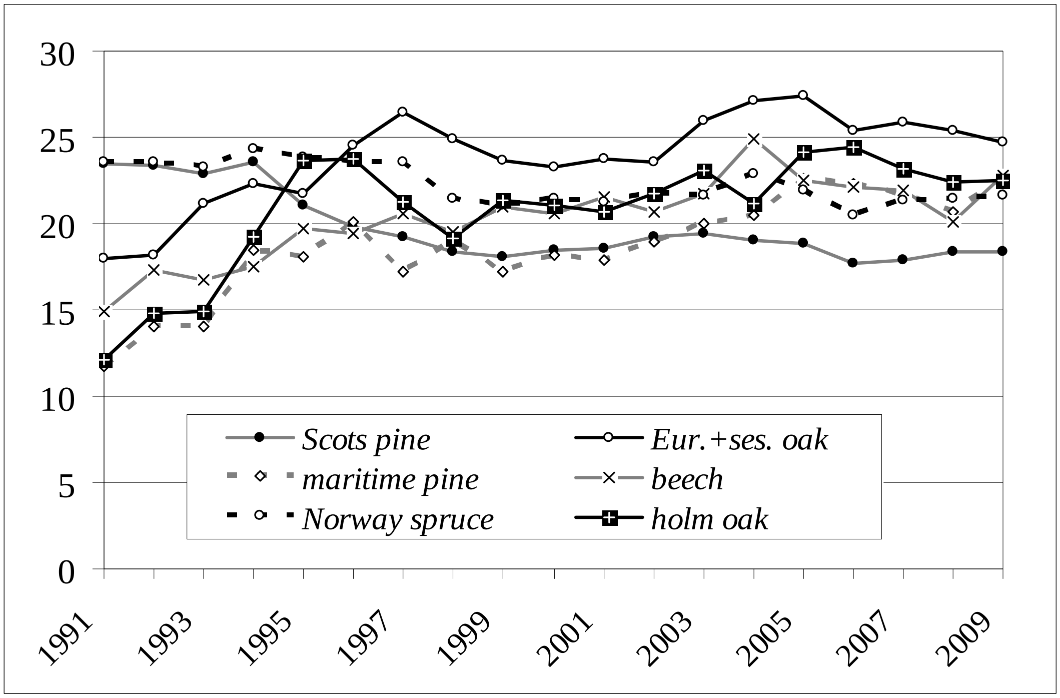


V. Cross-cutting issues

11. Forest health has been monitored by surveys of tree crown defoliation. Trees that were fully foliated were classified as undamaged in the defoliation survey. The transnational crown condition survey in 2009 comprised 6,791 plots in 28 countries, with 126,764 trees assessed. Of those, 21.1 per cent had a needle or leaf loss of more than 25 per cent and were thus classified as damaged or dead. Compared to the 2008 survey, that share remained unchanged. Of the most frequent tree species, European and sessile oak had the highest share of damaged and dead trees, (32.2 per cent in 2009). Over the past 18 years the development of crown condition has shown a clear improvement for Norway spruce and a slight improvement for Scots pine. European and sessile oak showed the highest mean defoliation during the past decade. Defoliation peaked after the extremely dry and warm summer in 2003 and had only been recuperating slowly since 2007. Mean defoliation of common beech was also characterized by a clear peak in 2004 (figure 5).

Figure 5

Percentage of damaged trees of all tree species and mean defoliation for the most frequent tree species (data include only countries with continuous data submission)



12. Soil solution data from up to 160 ICP Forests level II plots with continuous measurements for at least four years up to 2006 were used to compare base cation to aluminium (BC/Al) ratios to critical limits. BC/Al ratios allowed for determining thresholds below which harmful effects from soil acidification were not expected for the vegetation. Soil acidification remained a possible threat to forest vegetation in parts of Europe. On only 46.2 per cent of the plots critical BC/Al limits had not been exceeded. On 13.6 per cent they had exceeded in 5 per cent or less of the measurements. On around one quarter of the samplers there was an exceedance of the critical BC/Al ratio in more than 25 per cent of the measurements (figure 6). Neither pH nor BC/Al ratios in the soil solution of intensive monitoring plots showed distinct changes over time. The distribution of both indicators remained relatively unchanged in the years from 2000 to 2006. The unchanged soil acidification on many plots constituted a risk for forest ecosystem stability.

Figure 6

Percentage of critical BC/Al limit exceedance with 396 samplers in different soil depths on 160 plots in 2006