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RECENT RESULTS AND UPDATING OF SCIENTIFIC AND TECHNICAL KNOWLEDGE

2009 RESULTS OF MONITORING FOREST CONDITION IN EUROPE

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

I. INTRODUCTION

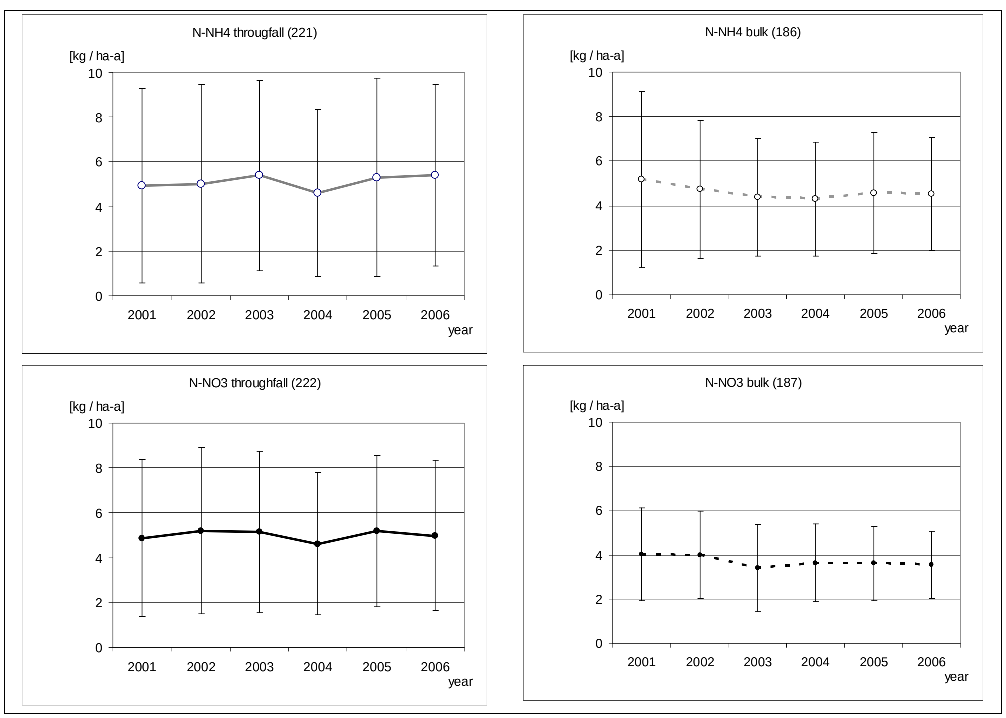
1. In 2009, the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) continued its large-scale and intensive monitoring of forest condition. Results are available for 5,002 level I plots (2008 assessment) and 308 level II plots (2006 assessment). The parameters monitored included crown condition, foliar chemistry, soil and soil solution chemistry, tree growth, ground vegetation, atmospheric deposition, ambient air quality, meteorology, phenology and litterfall (Lorenz et al. 2009, Fischer et al. 2009). The results are presented here in accordance with item 3.4 of the 2009 workplan for the implementation of the Convention (ECE/EB.AIR/96/Add.2), adopted by the Executive Body at its twenty-sixth session in December 2008.

II. SPATIAL AND TEMPORAL VARIATION OF DEPOSITION

2. Bulk deposition and throughfall deposition data were available from approximately 500 level II plots since the second half of the 1990s. The recent analysis covered sites which had been operational for the whole period 2001–2006, allowing a maximum of one month of missing data per year. Deposition for the missing periods was calculated from the average daily deposition of the remainder of the year. To take into account the variability of deposition, the plotwise mean deposition for a three-year period (2004–2006) instead of a single year was evaluated. The slopes of linear regressions over three years for each plot were calculated and tested for significance to quantify temporal developments.

3. Mean nitrogen (N) throughfall deposition ranged from 8.9 to 10.2 kg ha^{-1} a^{-1} for about 220 plots in Europe (figure 1). Mean annual values fluctuated. Ammonium (NH_4) throughfall deposition ranged from 4.6 to 5.4 kg ha^{-1} a^{-1}. Nitrate (NO_3) throughfall deposition ranged from 4.6 to 5.2 kg ha^{-1} a^{-1}. The plotwise evaluations showed that 90 per cent of the plots did not show any significant changes in N throughfall deposition. The shares of plots with increasing deposition were slightly higher than the shares with a decrease (5.0 per cent for NH_4 and 4.5 per cent for NO_3). Depositions were mostly higher on plots in Central Europe than in the Alpine, North and South European regions.

Figure 1. Annual mean bulk and throughfall deposition of sulphate (S-SO_4), nitrate (N-NO_3) and ammonium (N-NH_4) for the period 2001–2006



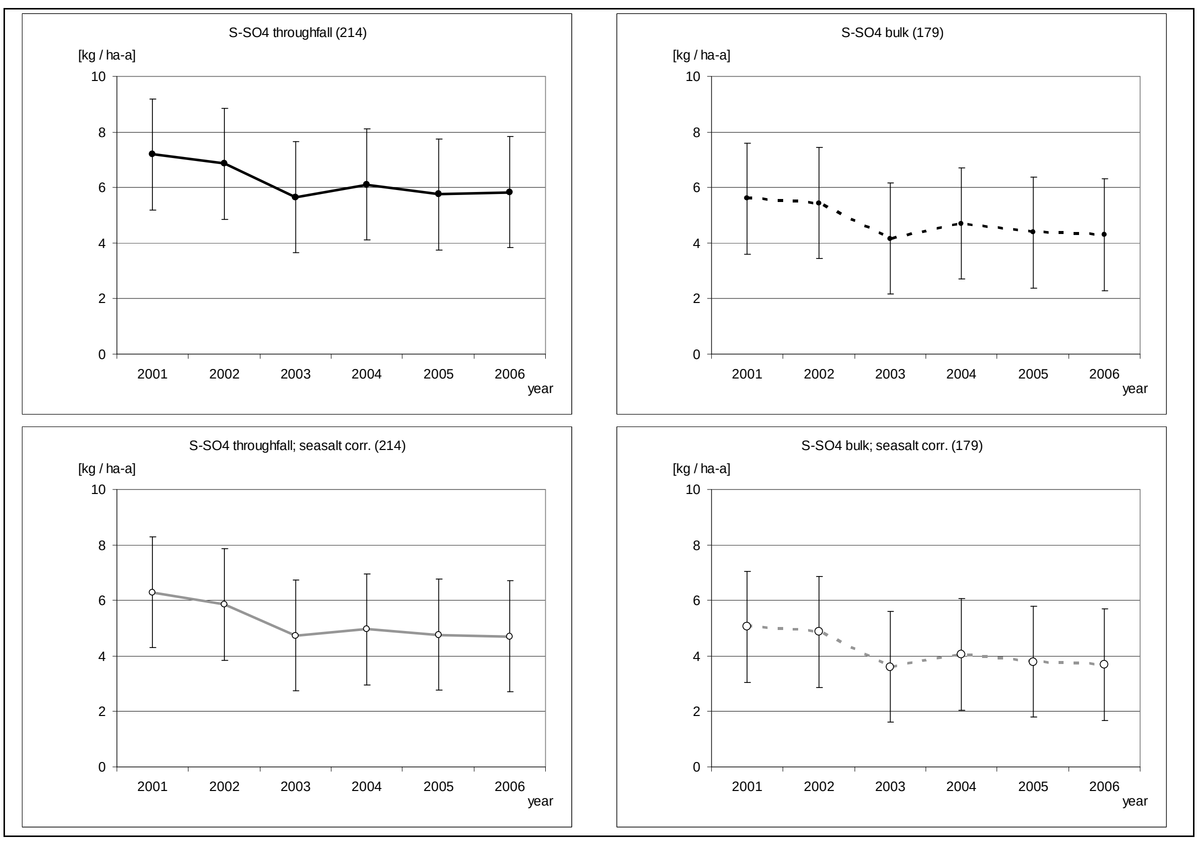
Note: The numbers of plots appear in brackets.

4. Mean bulk NH_4 deposition for 186 plots varied from 4.3 to 5.2 kg N ha^{-1} a^{-1}. An overall decrease was observed for 4 per cent of the plots, whereas an increase was observed on 3 per cent of the plots. Mean bulk NO_3 inputs decreased from 4.0 to 3.5 kg N ha^{-1} a^{-1}. A significant decrease was observed on 8 per cent of the plots. A significant increase was observed on 2 per cent of the plots.

5. Mean throughfall sulphate (SO_4) inputs decreased from 7.2 to 5.8 kg ha^{-1} a^{-1} (figure 2). 9 per cent of the plots showed significantly decreasing sulphur (S) inputs, whereas increases were not detected on any plots. Comparatively low SO_4 throughfall deposition was measured on plots in the Alpine region, Scandinavia and the Iberian Peninsula. Mean bulk SO_4 deposition decreased from 5.6 to 4.6 kg S ha^{-1} a^{-1}.

6. Total mean SO_4 inputs were reduced by those shares originating from sea salt to quantify inputs of anthropogenic origin. Sea salt correction mostly affected plots close to coastal areas. The mean sea salt corrected throughfall SO_4 inputs decreased from 6.3 to 4.7 kg ha^{-1} a^{-1} (figure 2). Sea salt corrected mean bulk SO_4 deposition decreased from 5.1 kg to 3.7 kg S ha^{-1} a^{-1}.

Figure 2. Annual mean bulk and throughfall deposition of sulphate (S-SO_4) with standard deviation for the period 2001–2006



Note: The numbers of plots appear in brackets.

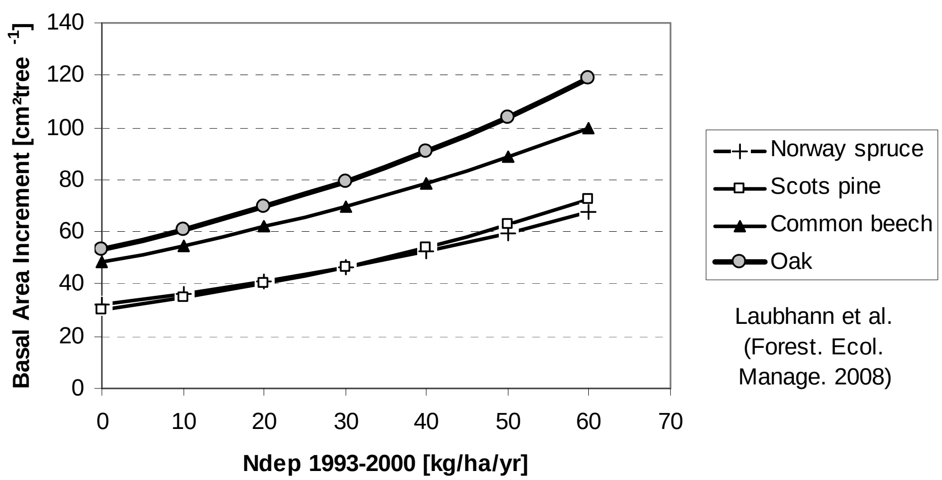
III. EFFECTS OF DEPOSITION AND TEMPERATURE ON FOREST TREE GROWTH

7. The impact of N and S deposition as well as other environmental influences on forest tree growth in terms of basal area increment was evaluated. Data from 382 level II plots in 18 countries for the period 1995–2000 were used. Evaluations focused on *Pinus sylvestris*, *Picea abies*, *Fagus sylvatica* and *Quercus robur* and *petraea*. An individual tree growth model was used to explain basal area increment. It included variables on tree size (diameter at breast height), tree competition (basal area of large trees and stand density index), site factors (soil carbon-to-nitrogen ratio, temperature), and environmental factors (e.g. temperature change compared to the long-term average, N and S deposition).

8. Mean annual temperature was positively related to the growth of *Quercus* species and *Pinus sylvestris*. For *Fagus sylvatica*, the difference between the long-term yearly mean temperature and the yearly mean temperature was significantly related to tree growth. This positive relation of temperature with growth could be seen as indirect response to climate change. The basal area increment of *Picea abies* showed no response to temperature.

9. The only factor on environmental change affecting growth of all four species was N deposition (figure 3). The increase in growth by one additional kg N deposition per hectare varied between 1.2 per cent and 1.5 per cent, depending on tree species, when all other influencing factors were constant. On soils that were already well supplied with N the effect was smaller. There were no negative effects of S and acid deposition on forest growth. It was assumed that such negative effects were outweighed by the positive effect of N deposition because of a co-linearity between these variables.

Figure 3. Basal area increment as a function of N deposition as obtained in the individual tree growth model for four tree species



IV. CROWN CONDITION

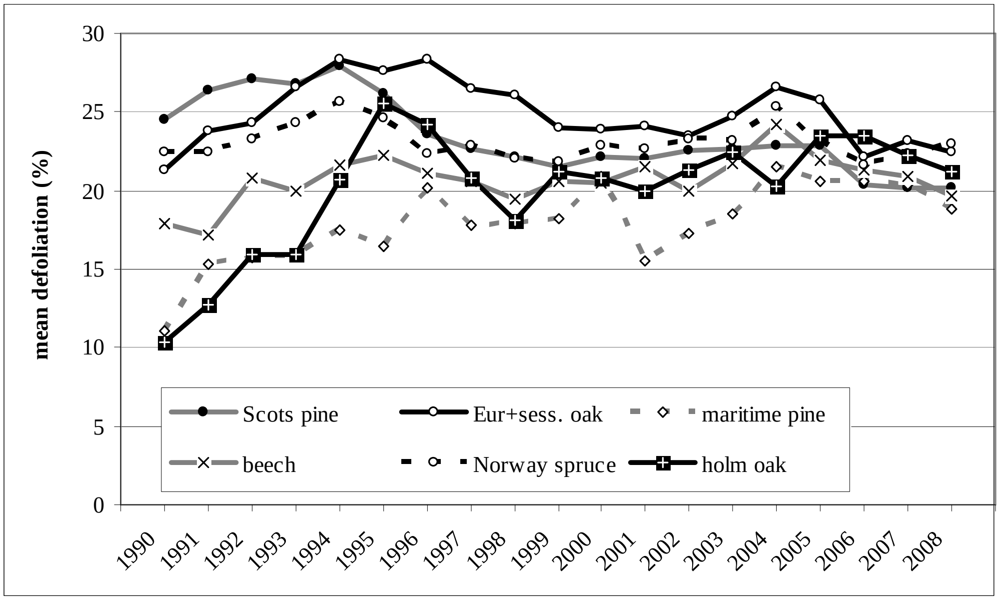
10. The influence of air pollution on forests in Europe has to be evaluated together with the general health status of forests and additional stress factors, because forests are complex ecosystems and different stressors interact. Forest health is monitored over large areas by a survey of tree crown defoliation. Trees that are fully foliated are classified as undamaged in the defoliation survey. Defoliation percentage denotes the proportion of needle or leaf loss in comparison to a fully foliated reference tree.

11. The transnational crown condition survey in 2008 comprised 5,002 plots in 25 countries, with 111,560 trees assessed. 21.1 per cent had a needle or leaf loss of more than 25 per cent and thus were classified as damaged or dead. In 2007, the respective share was 21.8 per cent. Of the most frequent tree species, European and sessile oak had the highest share (34.2 per cent) of damaged and dead trees in 2008.

12. The long-term development of defoliation was calculated from the monitoring results of those countries which have been submitting data since 1990 every year without interruption (figure 4). Of the main tree species, *Pinus sylvestris* showed a clearly decreasing defoliation. *Pinus sylvestris* showed no rise in defoliation even after the dry summer of the year 2003, as it is less susceptible to drought. For the mean of all plots assessed, defoliation of *Picea abies* has been fluctuating in the observation period. There was a peak in mean defoliation in the mid-1990s and after the dry and hot summer in 2003. *Fagus sylvatica* showed a constant increase in mean defoliation from the end of the 1990s until 2004. This peak has been described as a response to the drought in Central Europe in 2003. Since then, a constant recuperation has been observed. The development of *Quercus robur* and *Quercus petraea* resembled the crown condition of *Fagus sylvatica*. However, in almost all years the deciduous oak species showed the highest level of defoliation among the main tree species. *Quercus ilex* was characterized by peaks in mean plot defoliation in 1995 and 2005/2006. In the last two years, mean defoliation decreased. This development mainly reflected the situation in Spain where most of the observed trees are located. With some fluctuations defoliation of *Pinus pinaster* showed an increase until 2004. Since then, a slight recuperation has been observed.

13. Previous studies (e.g. Lorenz et al. 2003) have shown that the variation in defoliation was mainly explained by tree age, weather extremes and biotic factors. Air pollution was found to correlate partly with defoliation. The crown condition survey was deemed a valuable early warning system for many stress factors for forest health.

Figure 4. Percentage of damaged trees of all tree species and mean defoliation for the most frequent tree species



Note: The data include only countries with continuous data submission.

V. CONCLUSIONS

14. Over more than 20 years, ICP Forests, in close cooperation with the European Commission, has established a unique monitoring system that combines both a harmonized and regular inventory and an intensive monitoring approach. Whereas the inventory provided representative information on the condition of forests in Europe, intensive monitoring enabled the investigation of the complex relations between deposition fluxes and ecosystem responses. ICP Forests provided a combination of monitoring, early warning system and analyses of cause-effect relationships.

15. The intensive monitoring provided data for atmospheric deposition and for more complex studies on ecosystem responses. The sum of NO_3 and NH_4 deposition was above deposition of SO_4 for both, bulk and throughfall inputs for the period 2001–2006. SO_4 originating from sea salt spray was estimated to account for approximately one kg per hectare (mean of all evaluated plots). This indicated that the main proportion of the SO_4 inputs was of anthropogenic origin. Mean SO_4 deposition showed a decrease in the observation period and there were hardly any plots with increasing S inputs. There were no clear temporal trends for N compounds.

16. Effects of N deposition on forest ecosystems remained in the focus of the monitoring activities. Individual tree models taking into account tree size and competition, as well as site and environmental factors were applied to level II growth data. The results revealed growth accelerating effects of N deposition for all main tree species evaluated. One kg of N inputs was

linked to a basal area growth increase of 1.2 per cent to 1.5 per cent. There were no such relations to SO_4 inputs or acidity deposition. However, it was assumed that these effects were disguised by the stronger N effects.

VI. REFERENCES[1]

Fischer R, Lorenz M, Köhl M, Becher G, Granke O, Bobrinsky A, Braslavskaya T, Chirici G, De Vries W, Dobbertin M, Kraft P, Laubhann, Lukina N, Nagel HD, Reinds GJ, Sterba H, Solberg S, Stofer S, Seidling W (2009) The condition of forests in Europe; Executive report 2008.

Laubhann D, Sterba H, Reinds GJ, De Vries W (2008) The impact of atmospheric deposition and climate on forest growth in European monitoring plots: An individual tree growth model. *Forest Ecol. Manage.* (2008), doi:10.1016/j.foreco.2008.09.050

Lorenz M, Fischer R, Becher G, Iost S, Mues V, Granke O, Braslavskaya T, Bobrinsky A, Clarke N, Lachmanová N, Lukina N, Schimming C (2009) Forest condition in Europe; 2009 technical report of ICP Forests. Institute of World Forestry, Hamburg, 83 pp. + annexes.

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[1] The references have been reproduced as received by the secretariat.