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Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

Working Group on Effects

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Progress in activities in 2019 and further development of effects-oriented activities

Effects of air pollution on forests

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

Summary

The present report by the Programme Coordinating Centre of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) describes the outcomes of activities carried out since the previous report (ECE/EB.AIR/GE.1/2018/11–ECE/EB.AIR/WG.1/2018/4) and presents the outcomes of the thirty-fifth meeting of the ICP Forests Task Force (Ankara, 13 and 14 June 2019). The activities have been carried out and the report prepared at the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution, and in accordance with the 2018–2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1).

Despite the reduction in ozone concentrations, ozone levels still exceed the threshold value for adverse effects in 13 out of 15 countries. Direct effects of ozone exposure are apparent in terms of visible foliar symptoms and have been observed on woody plant species right across Europe. However, the relationship between ozone exposure and visible symptoms is not straightforward but depends on species-specific sensitivity, nutrition, water availability and climate.

Regional patterns in throughfall deposition were identified based on the analysis of ICP Forests monitoring data. In the case of nitrate, high throughfall deposition was mainly found in Austria, Belgium (Flanders), Czechia, Germany and Switzerland, while values below 4 kg of nitrogen per hectare per year (N ha^{-1} y^{-1}), were mainly found in Bulgaria, Estonia, Finland, Hungary, Latvia, Norway, Romania and Sweden.

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In contrast to the case of nitrate, the area of high ammonium throughfall deposition includes not only Belgium (Flanders), Czechia, Germany, and Switzerland but also northern Italy, the south-east of the United Kingdom of Great Britain and Northern Ireland, southern Romania and western Poland. Values below 4 kg N ha^{-1} y^{-1} were found again in Bulgaria, Estonia, Finland, Latvia, Norway and Sweden, but also in parts of Austria, France and Slovakia.

I. Introduction

1. The present report of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) is submitted at the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution (Air Convention) and in accordance with the 2018–2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1, items 1.1.1.19–1.1.1.24, 1.1.4.1 and 1.4.3).

2. Germany is the lead country of ICP Forests, and its Programme Coordinating Centre is hosted by the Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries) under the Federal Ministry of Food and Agriculture. A total of 42 Parties to the Air Convention participate in ICP Forests activities.

3. The Eighth ICP Forests Scientific Conference, "Trends and events - Drought, extreme climate and air pollution in European forests," was held immediately prior to the thirty-fifth meeting of the Task Force (Ankara, 11–13 June 2019 and 13 and 14 June 2019, respectively). A compilation of abstracts of all contributions to the Conference was distributed to the participants and has been posted on both the ICP Forests website[1] and the Conference website.[2]
The main topics of the Conference were:

(a) Effects of drought and other extreme weather events on processes and forest ecosystem functioning;

(b) Long-term trends in forest ecosystem processes as affected by drought or other extreme weather events;

(c) Air pollution effects on forest ecosystem functioning under extreme and/or prolonged unfavourable climate and weather.

II. Outcomes and deliverables during the reporting period

4. During the reporting period, ICP Forests produced or contributed to the following publications and reports:

(a) The 2018 joint progress report on policy-relevant scientific findings of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the Working Group on Effects (ECE/EB.AIR/GE.1/2018/3–ECE/EB.AIR/WG.1/2018/3). This report contains information on the data gathered and recorded by ICP Forests in 13 domains covering the most relevant aspects of forest ecosystems in Europe;

(b) The 2018 progress report of the Programme Coordinating Centre of ICP Forests to the EMEP Steering Body and the Working Group on Effects (ECE/EB.AIR/GE.1/2018/11–ECE/EB.AIR/WG.1/2018/4);

(c) The 2018 Technical Report of ICP Forests,[3] including thematic papers on:

(i) Atmospheric deposition in European forests in 2016;

(ii) Homogenizing the volume calculation within the tree growth survey;

(iii) Tree crown condition in 2017.

(d) The 2018 Executive Report of ICP Forests (glossy brochure);[4]

[1] Marcus Schaub and others, eds., 2019, *Trends and events – Drought, extreme climate and air pollution in European forests. Eighth ICP Forests Scientific Conference, 11–13 June 2019, Ankara, Turkey. Proceedings*. Available at www.icp-forests.org/pdf/SC2019_proceedings.pdf.

[2] See https://sc2019.thuenen.de.

[3] Alexa Michel, Walter Seidling and Anne-Katrin Prescher, eds., *Forest Condition in Europe: 2018 Technical Report of ICP Forests*, BFW-Dokumentation 25/2018 (Vienna, Austrian Research Centre for Forests, 2018). Available at http://icp-forests.net/page/icp-forests-technical-report.

(e) ICP Forests Brief No. 3: Ozone concentrations are decreasing, but exposure remains high in European forests;[5]

(f) Proceedings of the Eighth Scientific Conference of ICP Forests.[6]

5. A total of 34 scientific papers based on ICP Forests data and with significant use of its infrastructure were published in international peer-reviewed journals in 2018. These publications cover the following fields: fructification and tree growth (4 papers); soil and soil solution (4 papers); ozone impacts (4 papers); atmospheric deposition (3 papers); forest biodiversity (3 papers); nutrient cycling (3 papers); tree condition (3 papers); climate and carbon (2 papers); heavy metals (1 paper); tree mortality (1 paper); and various methodological topics (6 papers).

III. Expected outcomes and deliverables for the next reporting period and in the longer term

6. In the second half of 2019 and in 2020, ICP Forests will carry out the following activities, in accordance with the 2018–2019 workplan and the 2020−2021 workplan (to be adopted by the Working Group on Effects and the Executive Body) for the Convention and with the decisions taken at the thirty-fifth meeting of the Task Force:

(a) Further acquisition of data on the condition and development of forest ecosystems and efforts to improve data quality and the data management system;

(b) Contribution to the 2019 joint progress report on policy-relevant scientific findings of the of the Steering Body to the EMEP and the Working Group on Effects (ECE/EB.AIR/GE.1/2019/3–ECE/EB.AIR/WG.1/2019/3);

(c) Finalization of the draft 2019 Technical Report of ICP Forests;

(d) Finalization of the draft ICP Forests Brief No. 4: Tree nutrition is increasingly imbalanced in European forests.

IV. Cooperation with other groups, task forces and subsidiary bodies, including with regard to synergies and possible joint activities

7. A joint ICP Forests/International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) expert workshop on the theme, “Assessing and estimating ozone impacts on forest vegetation – opportunities for improved cooperation” was held at the Swiss Federal Institute for Forest, Snow and Landscape Research at Birmensdorf, Switzerland, on 12 April 2019, with 17 participants from nine countries. Work is ongoing to prepare a workshop report and a proposal for a special issue in the journal *Forests* on impacts of ground-level ozone pollution on forests: assessment of the influence of European air pollution policy on forest ecosystems.

8. In line with the 2018−2019 workplan, several task forces and International Cooperative Programmes under the Working Group on Effects, including ICP Forests, have implemented a new Working Group on Effects website,[7] to be used as an official portal for an overview of effects-related information, including available data and interactive maps, with links to individual ICP/Task Force websites.

[4] Walter Seidling, ed., *Forest Conditions: ICP Forests 2018 Executive Report* (Eberswalde, Germany, ICP Forests, 2018). Available at http://icp-forests.net/page/icp-forests-executive-report.

[5] Marcus Schaub and others, *Ozone concentrations are decreasing but exposure remains high in European forests, ICP Forests Brief No. 3* (Eberswalde, Germany, ICP Forests, 2019), available at: http://icp-forests.net/page/icp-forests-briefs.

[6] See footnote 1.

[7] See http://unece-wge.org.

9. The data infrastructure developer of ICP Forests met with the new coordinating team of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) in February 2019 to exchange data management experiences.

V. Strengthening the involvement of countries of Eastern and South-Eastern Europe, the Caucasus and Central Asia

10. Most of the countries of South-Eastern Europe, including Turkey, are included in the extensive ICP Forests Level I monitoring of forest ecosystems. The more complex and intensive Level II monitoring is carried out at only a few sites in South-Eastern Europe. None of the countries of the Caucasus or Central Asia is active in ICP Forests monitoring activities.

VI. Scientific and technical cooperation with relevant international bodies

11. Monitoring activities of ICP Forests, the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters), ICP Integrated Monitoring and ICP Vegetation have been taken into consideration in reporting by the European Commission.

12. Based on the cooperation started in 2018, a meeting of the data infrastructure developers of ICP Forests and Long-Term Ecosystem Research took place. During the meeting, a technical concept was defined to integrate ICP Forests plots into the Dynamic Ecological Information Management System - Site and dataset registry of Long-term Ecosystem Research as a "partner network". The realization of the concept is planned for 2020.

13. By July 2018, under the National Emission Ceiling Directive,[8] the European Union member States were obliged to report the location of the sites and the associated indicators used for monitoring air pollution impacts. At least 3,157 sites using ICP Forests protocols have been reported.

14. ICP Forests took part in the European Environment Information and Observation Network National Reference Centres Forests meeting (Copenhagen, 17 and 18 September 2018). As one outcome of the meeting, the European Environment Agency will draft a forest road map of the Agency work on forests towards 2025.

15. A joint ICP Forests/Acid Deposition Monitoring Network in East Asia workshop is planned for November 2019 in Niigata, Japan. The workshop is tentatively entitled "Regional impact assessment of atmospheric deposition and air pollution on forest ecosystems" and aims to exchange information on the current condition of atmospheric deposition/air pollution and the impact on forest ecosystems, and to discuss scientific cooperation between the two networks.

VII. Highlights of the scientific findings: policy-relevant issues

16. In 2018, 34 papers and 1 ICP Forests brief were published by the ICP Forests community. Some of the conclusions of these publications are particularly relevant to recent environmental policy issues:

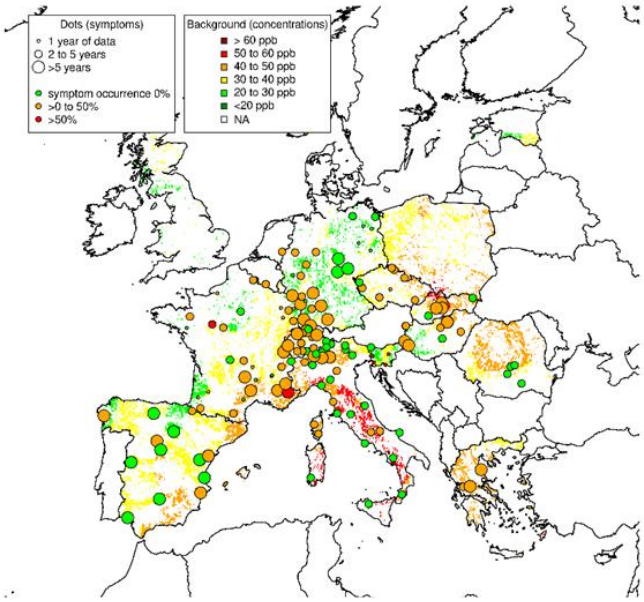
(a) During the period 2000–2014, ozone concentrations decreased significantly at ICP Forests sites by 0.63 part per billion (ppb) per year. The long-term mean ozone concentration in the growing season (April–September) during that period was 36.2 ppb.

[8] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, Official Journal of the European Union, L 344, 2016, pp. 1–31.

Values ranged from 14.5 ppb to 70.1 ppb, showing a marked north-south gradient across Europe, with the highest concentrations in Czechia, Greece, Italy, Romania, Slovakia and southern Switzerland. Despite the reduction in ozone concentrations, ozone levels still exceed the threshold value for adverse effects in 13 out of 15 countries. Direct effects of ozone exposure are apparent in terms of visible foliar symptoms and have been observed on woody plant species across Europe. However, the relationship between ozone exposure and visible symptoms is not straightforward, as it depends on species-specific sensitivity, nutrition, water availability and climate, as figure I demonstrates.

Figure I

Spatial distribution of April–September mean ozone concentrations interpolated from 18,464 passive samplers on 206 plots in 15 countries for the period 2000−2014 (background colour) and occurrence of ozone-induced foliar symptoms on 155 plots in 11 countries for the period 2002−2014 (coloured dots)[9]



(b) French data on ozone visible symptoms from 2013 to 2015 show that leaf damage was found at most of the 15 sites studied in 2015, a year featuring higher temperatures and higher ozone concentration levels compared to 2013 and 2014.[10] Even fir trees, which are regarded as not being particularly sensitive to ozone, showed foliar symptoms in that year. High quality and internationally comparability in the data is indicated by the analysis of the last six intercalibration courses on ozone symptoms assessment, as, during the field campaigns, the frequency of operators meeting the data quality was 78 per cent on average (required data quality limit = 70 per cent).[11] The indirect effects on tree vitality and growth are much less clear. The above-mentioned French study, as well as a study from northern Italy,[12] found no significant correlation between ozone and

[9] Marcus Schaub and others, *Ozone concentrations are decreasing but exposure remains high in European forests, ICP Forests Brief No. 3* (Eberswalde, Germany, ICP Forests, 2019), available at: http://icp-forests.net/page/icp-forests-briefs.

[10] Ciriani M-L, Dalstein L (2018) Forest Health Monitoring Highlights Progress in Forest Deterioration in France. Water Air Soil Pollut 229:. doi: 10.1007/s11270-018-3922-y.

[11] *Elena Gottardini, Vicent Calatayud, Stefano Corradini, Diana Pitar, Pierre Vollenweider, Marco Ferretti, Marcus Schaub* (2019) Activities to improve data quality in ozone symptom assessment within the Expert Panel on Ambient Air Quality. In: Alexa Michel, Anne-Katrin Prescher, Kai Schwärzel, eds., *Forest Condition in Europe: 2019 Technical Report of ICP Forests*, BFW-Dokumentation 27/2019 (Vienna, Austrian Research Centre for Forests, 2019). Available at: http://icp-forests.net/page/icp-forests-technical-report.

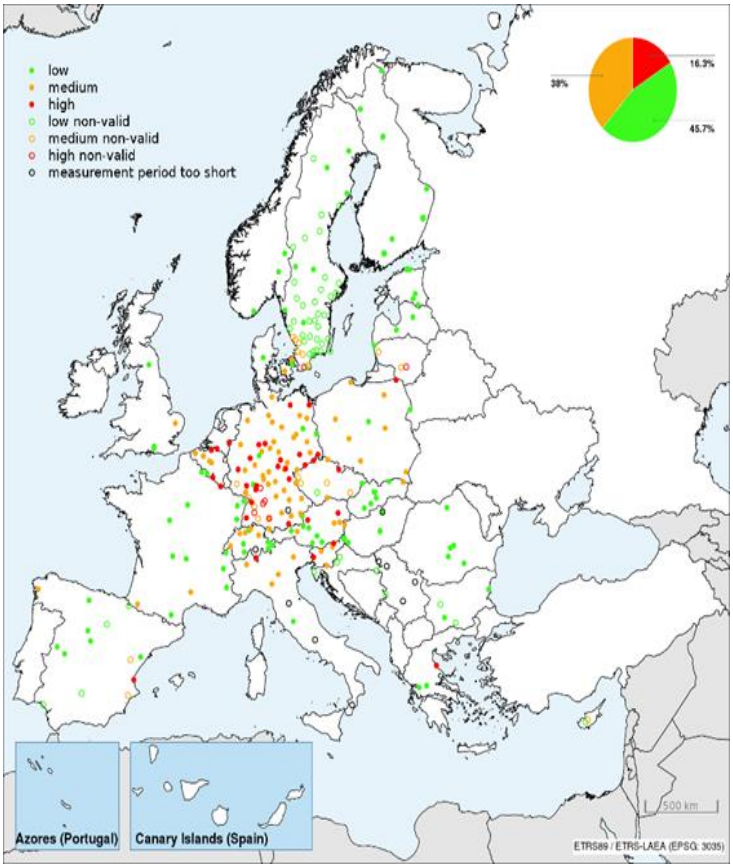
[12] Ferretti M, Bacaro G, Brunialti G, Confalonieri M, Cristofolini F, Cristofori A, Frati L, Finco A, Gerosa G, Maccherini S, Gottardini E (2018) Scarce evidence of ozone effect on recent health and productivity of alpine forests—a case study in Trentino, N. Italy. Environ Sci Pollut Res. doi: 10.1007/s11356-018-1195-z.

defoliation at the respective sites. Further, in northern Italy, the recent status and trends in tree growth (in terms of basal area increment) could be correlated neither to ozone concentrations nor to ozone flux;

(c) The maps presented in figures II and III[13] show the spatial distribution of yearly throughfall deposition of nitrate and ammonium collected in 248 ICP Forests Level II plots and 49 Swedish Throughfall Monitoring Network plots across Europe in 2017. The uneven distribution of emission sources and receptors and the complex orography of part of Europe result in a marked spatial variability of atmospheric deposition, as can be seen in figures II and III. However, on a broader scale, regional patterns in throughfall deposition arise. In the case of nitrate, high throughfall deposition was mainly found in Austria, Belgium (Flanders), Czechia, Germany and Switzerland, while values below 4 kg of nitrogen per hectare per year (N ha^{-1} y^{-1}) were mainly found in Bulgaria, Estonia, Finland, Hungary, Latvia, Norway, Romania and Sweden (see figure II). In contrast to the case of nitrate, the area of high ammonium throughfall deposition includes not only Belgium (Flanders), Czechia, Germany, and Switzerland but also northern Italy, the south-east of the United Kingdom of Great Britain and Northern Ireland, southern Romania and western Poland (see figure III). Values below 4 kg N ha^{-1} y^{-1} were found again in Bulgaria, Estonia, Finland, Latvia, Norway and Sweden, but also in parts of Austria, France and Slovakia. Note that the total nitrate and ammonia deposition to the forest can be higher than the throughfall deposition, due to canopy exchange processes. Nitrogen compounds have two effects on the ecosystems: they are important plant nutrients with strong effects on plant metabolism, all forest processes and biodiversity, but they can also reinforce soil acidification.

Figure II

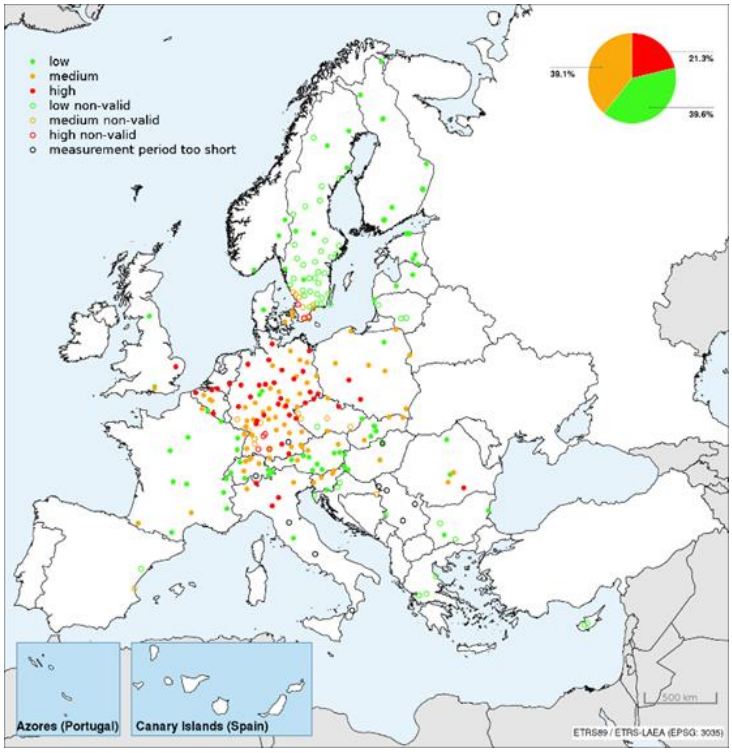
Throughfall deposition of nitrate in kilograms of nitrogen per hectare per year (kg N ha^{-1} yr^{-1}) measured in 2017 on ICP Forests Level II plots and Swedish Throughfall Monitoring Network plots



[13] Alexa Michel, Anne-Katrin Prescher, Kai Schwärzel, eds., *Forest Condition in Europe: 2019 Technical Report of ICP Forests*, BFW-Dokumentation 27/2019 (Vienna, Austrian Research Centre for Forests, 2019). Available at http://icp-forests.net/page/icp-forests-technical-report.

Figure III

Throughfall deposition of ammonium in kilograms of nitrogen per hectare per year (kg N ha^{-1} yr^{-1}) measured in 2017 on ICP Forests Level II plots and Swedish Throughfall Monitoring Network plots



(d) It is a well-known fact that enhanced deposition of nitrogen, atmospheric carbon dioxide enrichment, warmer temperatures and longer growing seasons have stimulated tree growth in many parts of Europe. These increases in tree growth lead to increasing nutrient demand. The question of whether and to what extent nitrogen excess results in nutrients imbalances is currently under investigation. To this end, the ICP Forests long-term data set (469 plots from 26 countries) on nutrient contents of tree foliage is analysed.

VIII. Publications

17. For a full list of all 34 ICP Forests publications using ICP Forests data or the ICP Forests infrastructure in peer-reviewed journals and references for the present report, please refer to the 2019 ICP Forests Technical Report or visit the ICP Forests website.[14]

[14] http://icp-forests.net/page/publications.