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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 2017 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) sets out the results of activities undertaken since the previous report. The activities and the report on them have been delivered in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution, as set out in the 2016-2017 workplan for the implementation of the Convention (ECE/EB.AIR/133/Add.1, items 1.1.1.7, 1.1.1.10, 1.1.1.24, 1.4.1 and 1.4.2) and the informal document approved by the Executive Body at its thirty-fourth session, “Basic and multi-year activities in the 2016-2017 period” (items 1.1.1-1.1.3, 1.1.6, 1.1.7, 1.2.2 and 1.8.1-1.8.3).

The report of ICP Forests presents the results of its thirty-third Task Force meeting (Bucharest, 18-19 May 2017) and activities undertaken since its 2016 report (ECE/EB.AIR/GE.1/2016/11−ECE/EB.AIR/WG.1/2016/4). In particular, it notes the

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findings of ICP Forests on ozone symptoms in forests, the deposition of air pollutants, defoliation and the results from ring tests as part of the quality assurance efforts. In addition, the document highlights a considerable number of scientific papers by the ICP Forests community, in particular those on dissolved organic carbon formation in soil solution and carbon stocks and fluxes in forest soils, major ecosystem processes in a long-term perspective, the response of ground vegetation to nitrogen inputs and tree crown response as an indicator for climate change effects.

I. Introduction

1. The present report describes the results of the activities undertaken by the Programme Coordinating Centre of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) between May 2016 and May 2017 (the reporting period). The activities and the report on them are in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution, as set out in both the 2014-2015 and 2016-2017 workplans for the implementation of the Convention (ECE/EB.AIR/122/Add.2, and ECE/EB.AIR/133/Add.1 items 1.1.1.7, 1.1.1.10, 1.1.1.24, 1.4.1 and 1.4.2) and the informal document approved by the Executive Body at its thirty-fourth session, “Basic and multi-year activities in the 2016-2017 period” (items 1.1.1-1.1.3, 1.1.6, 1.1.7, 1.2.2 and 1.8.1-1.8.3).

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). Forty-two Parties to the Convention participate in the activities of ICP Forests. The lead country appointed Mr. Marco Ferretti as the new Chair of ICP Forests effective since 19 January 2017.

3. The Sixth Scientific Conference of ICP Forests, “Air pollution, climate change and forest ecosystems: evidence for effects, adaptation, and mitigation”, was held back to back with the thirty-third meeting of the ICP Forests Task Force in Bucharest on 17 May 2017. A book of abstracts containing all the contributions to the scientific conference was distributed among the participants and is available from the ICP Forests website.[1] The main topics of the conference were (a) atmospheric chemistry and related ecosystem processes; and (b) response of forest vegetation: indicators, assessment and monitoring. There was also a poster session at which flash presentations were made on a broad range of themes.

4. During the Task Force meeting, a representative of the Programme Coordinating Centre presented an overview of activities and progress made since the thirty-second Task Force meeting (Luxembourg, 11-13 May 2016). The draft of the 2017 Technical Report of ICP Forests[2] was presented along with a draft prototype of a glossy thematic brief on results from nitrogen deposition measurements of ICP Forests. The Chair of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) presented the activities of that cooperative programme. Representatives of the expert panels and committees — working groups under ICP Forests — reported on their activities. The remaining parts I and II of the “Manual on Methods and Criteria for Harmonized Sampling, Assessment, Monitoring and Analysis of the Effects of Air Pollution on Forests” (ICP Forests Manual) were adopted and will be published following a revision process in 2017. A representative of the Programme Coordinating Centre reported further about ongoing studies with data from the ICP Forests programme by internal and external users. The Programme Coordinating Centre had contributed to the joint initiative through the centres under the Working Group on Effects, in response to the process promoted by European Commission to further implement an

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[1] Walter Seidling and Marco Ferretti, eds., *Abstracts of the Sixth ICP Forests Scientific Conference, Bucharest, 16-17 May 2017* (Bucharest, National Institute for Research and Development in Forestry, 2017). Available from http://icp-forests.net/page/icp-forests-other-publications.

[2] Alexa Michel and Walter Seidling, eds., *Forest Condition in Europe: 2017 Technical Report of ICP Forests*, BFW-Dokumentation (Vienna, Austrian Research Centre for Forests, forthcoming).

effects-related part of the European Union National Emission Ceilings Directive (article 9 and annex V).[3]

II. Outcomes and deliverables in the reporting period

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

(a) The 2016 joint progress report 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.1/2016/3–ECE/EB.AIR/WG.1/2016/3). This report contained information on the data gathered and recorded by ICP Forests on 13 domains covering the most relevant compartments of forest ecosystems in Europe;

(b) The annual report of ICP Forests to the EMEP Steering Body and the Working Group on Effects (ECE/EB.AIR/GE.1/2016/11–ECE/EB.AIR/WG.1/2016/4);

(c) The 2016 Technical Report of ICP Forests,[4] including thematic papers on:

(i) The monitoring and research infrastructure of ICP Forests;

(ii) Tree crown condition and damage causes;

(iii) Spatial variation of deposition in Europe 2014;

(iv) Spatial and temporal distribution of ozone symptoms across Europe from 2002 to 2014;

(v) Ring tests as main parts of the quality assurance and control programme for the comparability of analytical data within the ICP Forests monitoring programme;

(vi) The ICP Forests Level I Biodiversity data: A harmonized data source and baseline for plant species and structural diversity on European forest ecosystems.

(d) The 2016 Executive Report of ICP Forests (glossy brochure)[5],

(e) The book of abstracts of the Sixth Scientific Conference of ICP Forests.

6. In total, 24 scientific papers were published between May 2016 and May 2017 based on ICP Forests data or with a considerable use of the ICP Forests infrastructure. The publications cover the following fields: the carbon cycle and dissolved organic carbon in forest soils (6 papers); atmospheric deposition (4 papers); other soil-related papers (2 papers); climate and tree performance (5 papers); ground vegetation change and diversity (2 papers); ozone-related (1 paper); and methodological (4 papers).

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[3] 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, 2016 O.J. (L 344).

[4] Alexa Michel and Walter Seidling, eds., *Forest Condition in Europe: 2016 Technical Report of ICP Forests*, BFW-Dokumentation 23/2016 (Vienna, Austrian Research Centre for Forests, 2016). Available from http://icp-forests.net/page/icp-forests-technical-report.

[5] Walter Seidling, ed., *Forest Conditions: ICP Forests 2016 Executive Report* (Eberswalde, Germany, ICP Forests, 2016).

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

7. In the second half of 2017 and in 2018 ICP Forests is going to carry out the following activities, in accordance with the tasks set out for it in the 2016-2017 workplan for the Convention and the decisions taken at the ICP Forests Task Force meetings:

(a) Continuation of data collection activities on the condition and development of forest ecosystems and efforts to improve the data quality and the data management system;

(b) Further implementation and further development of the guidelines of the ICP Forests Manual for assessing, evaluating and reporting of air pollution effects on forests (pending part of the 2016 update).

IV. Cooperation with other groups, task forces or subsidiary bodies, notably with regard to synergies and possible joint approaches of activities

8. In an ongoing project by members of ICP Forests and the EMEP Meteorological Synthesizing Centre-West, the main deposition estimates are made for sulphur and nitrogen species calculated for the 50 x 50 kilometre EMEP grid and for the new 0.1^{o} by 0.1^{o} grid, on one side, and the ICP Forests bulk deposition measurements within these EMEP cells, on the other. Various quality assurance criteria and co-variables such as seasons are taken into consideration. The project will have a considerable impact on the quality assurance procedures of ICP Forests. The study also bridges the air pollutant emissions and effects communities.

9. A joint evaluation of plot-related data from both ICP Integrated Modelling and ICP Forests has been initiated; however, owing to limited personnel resources the progress is slow.

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

10. The countries in South-Eastern Europe including Turkey are integrated mainly in the extensive ICP Forests Level I monitoring of forest ecosystems. The more complex and intensive Level II monitoring of forest ecosystems is performed in South-Eastern Europe at a few sites only. No country in the Caucasus or Central Asia is active in ICP Forests monitoring activities.

VI. Scientific and technical cooperation activities with relevant international bodies

11. Monitoring activities of ICP Forests, together with those of the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes Waters, the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops and ICP Integrated Monitoring, have been taken into consideration by the European Commission within the context of the proposal for a

directive of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants and amending Directive 2003/35/EC.[6] Under article 9 of the proposed directive, European Union member states are recommended to monitor, where practicable, the adverse impacts of air pollution upon terrestrial ecosystems. The associated annex V lists under paragraph 2 (b) (i)-(iv) parameters obligatorily measured within the ICP Forests monitoring programme. Under paragraph 3 the methodologies developed under the Convention and laid down in manuals of its ICPs are explicitly mentioned (see ECE/EB.AIR/WG.1/2008/16/Rev.1). ICP Forests contributed to the presentation of the Chair of the Working Group on Effects at a meeting in Brussels on 3 and 4 April 2017 to demonstrate the ICP Forests monitoring as a substantial option for effects-related monitoring according to article 9 and annex V of Directive 2016/2284, the new European Union directive on national emission ceilings (see para. 4 above).

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

12. The ICP Forests community published between May 2016 and May 2017 a total of 24 scientific papers listed by the Institute for Scientific Information- . Nine[7] of them are highlighted as relevant for environmental policy issues:

(a) A very comprehensive study using Spanish Level I and Level II monitoring data together with data from the Spanish and the Catalonian national forest inventories, focused mainly on foliar nitrogen (N), phosphorous (P) and potassium (K) element concentrations and their ratios as response variables with a broad variety of statistical approaches. Besides distinct effects from species and higher phylogenetic clades on foliar element concentrations and ratios, meteorological conditions and N deposition were found to influence foliar N and also P concentration as well as N:P ratios. Both high foliar N and relative low foliar P concentrations are significantly fostered by N deposition;

(b) A comprehensive study on the formation of dissolved organic carbon (DOC) in soil solution relies on unique long-term (two decades) deposition and soil water data sets from the ICP Forests Level II network and a network on grassland, both from the United Kingdom of Great Britain and Northern Ireland. Declines in sulphur deposition coincided with plot-specifically modified decreases in soil water from different depths. While deposition of oxidized and reduced nitrogen declined especially before 2000, nitrate trends in soil solution are less clear. A marked but complex influence of deposition on soil solution chemistry was found, for instance a pronounced decrease in aluminium especially in the more acidic soils (pH < 5). DOC concentrations increased on all sites, especially at shallow soil depths. This indicates a clear production of DOC in the organic superficial horizons. Corresponding patterns of DOC dynamics in soil water and in acidifying components of deposition, especially sulphate, strongly support a close causal mechanism for DOC increase in soil solution, especially pronounced in acid-sensitive soils. In a parallel modelling study the strong influence of the soil acidity status on DOC formation in soil solution and hence the decreasing sulphur input could be reproduced. Under oligotrophic conditions nitrogen input could enhance DOC production, while climatic factors were of subordinate influence;

(c) A European-wide statistical analysis based on 97 plots from the Level II network of ICP Forests also contributed to an understanding of DOC trends in forest soil solution and its possible drivers. While there was an overall increase of DOC concentration in soil solution, at plot level for 40 per cent, no significant trend was found, 35 per cent

[6] European Commission, document COM(2013)920 final, 2013/0443 (COD).
[7] In the seven sections that follow, twice two papers on related subjects were considered together.

showed an increase and 25 per cent a decrease. This indicates interactions between local and regional control factors and makes a single mechanism across Europe improbable. A coincidence between increasing DOC trends and decreasing sulphate was especially found for areas with low to medium nitrogen deposition. This result is in accordance with findings from analyses of freshwater bodies with increasing DOC loads gained in areas with low nitrogen deposition, like Scandinavia;

(d) Changes of soil organic carbon are a major issue for reporting carbon stock and fluxes. Intensive ICP Forests monitoring plots in France allowed a detailed quantification of carbon (C) stocks and fluxes and — owing to its constant measurement — a better understanding of factors driving C turnover in forest soils. As result an overall increase of 0.35 megagrams (metric tons) of C per hectare per year was found,[8] most of it accumulating in the organic soil layer. Fourteen per cent of this rate could be statistically explained, mainly with stand structural features. Younger and uneven-aged stands tend to have higher turnover or C rates than older respectively even-age stands (not to be mixed up with C stocks being generally higher in older stands and higher in pine and spruce than in broadleaved stands). At the same time, climate change and lower foliar nitrogen concentrations may both reduce litter decay rates and enhance C sequestration;

(e) An ecosystem-related study underlines the high value of long data series by analysing soil, deposition, foliar and defoliation data from two plots in the Solling mountain ranges, where monitoring started in the 1960s. Generally higher inputs of air pollutants in spruce compared with beech stands under comparable natural conditions were found. The highest sulphur inputs occurred around 1980 and nitrogen inputs were also considerably higher in the 1970s and 1980s than today. As an indication of nitrogen saturation, considerable amounts of nitrate were leached in intervals from the spruce ecosystems since the 1970s, while nitrate has been leached from the beech stand only after 2000. Beech and spruce foliage revealed a significant decrease of potassium over the decades, whereas the foliar base cation to nitrogen ratio only declined in spruce. Defoliation, estimated since the 1980s was constantly on a comparatively high level of approximately 30 per cent for both tree species, while adjacent limed stands show lower defoliation. The reduction of sulphur and, to a lesser extent, nitrogen deposition reflect efforts of international clean air policies under the Convention; however, critical loads for acidity and eutrophying nitrogen are still exceeded. Owing to the remobilization of sulphur from the soils, leaching of base cations is still ongoing and only on the beech plot some indications of recovery from acidification are visible, rendering further monitoring indispensable;

(f) The composition of ground vegetation and its change from European-wide ICP Forests Level II sites between 1995 and 2006 were analysed. Data on soil chemistry, climate, tree species composition, and stand age were used as explanatory variables along with interpolated deposition estimates of sulphate, nitrate and ammonia. Spatial variation is mainly determined by the “traditional” factors related to soil type and climate. Nevertheless, a significant part of the floristic composition could be ascribed to atmospheric nitrate deposition. Interestingly, floristic changes in time were also correlated to nitrate deposition; however, this could not be shown for any single species. In an approach in Czechia coincidences between the occurrence of selected nitrophilous species and mainly the C/nitrogen ratio in soil were detected and — less distinct — total nitrogen concentration in upper mineral soil;

(g) Tree crown defoliation annually estimated at ICP Forests plots in Spain was compared with annual weather data and with tree ring data. For all investigated oak and

[8] See 2017 Technical Report of ICP Forests (forthcoming).

pine species defoliation was positively correlated with air temperature in April. Warm and dry weather conditions during spring until early summer fostered leaf shedding. This was more distinct for species growing on xeric sites (e.g., *Quercus ilex* and *Pinus pinaster*) than for species preferring mesic sites (*Quercus robur* and *Pinus nigra*). For all species, radial increment of the stems was negatively correlated with defoliation, indicating reduced tree growth in years with both less foliage and warm spells during spring. As also a plausible relationship between defoliation and the North Atlantic Oscillation system could be detected, defoliation appears to be an indicator of climatic stress and climate change effects.

VIII. Publications

13. For a full list of ICP Forests publications and references for the present report, please refer to the 2016 and 2017 Technical Reports of ICP Forests or visit the ICP Forests website.