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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 2018 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. 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 2016–2017 and 2018–2019 workplans for the implementation of the Convention (ECE/EB.AIR/133/Add.1) and with the activities set out in the informal document submitted to the Executive Body for the Convention at its thirty-seventh session entitled "Draft revised mandates for scientific task forces and centres under the Convention".

The report presents the outcomes of the thirty-fourth meeting of the ICP Forests Task Force (Riga, 23-25 May 2018) and of the activities carried out since the 2017 report (ECE/EB.AIR/GE.1/2017/11−ECE/EB.AIR/WG.1/2017/4). In particular, it draws attention to the finding of ICP Forests that, based on soil solution datasets from an area formerly

heavily loaded with nitrogen (and sulphur) deposition, the ratio of dissolved organic nitrogen to total dissolved nitrogen (DON:TDN) and that of dissolved organic carbon to inorganic nitrate (DOC:NO^3) increased, indicating a general reduction in reactive nitrogen, while biotic response (foliage) lagged behind. Heavy metals emitted in large quantities by oil shell industries in Estonia in the 1980s are still stored in forest ecosystems, especially in the organic layer and in fine roots. Mycorrhizal fungi play an important role in the nutrition and water provision of forest trees. Many species were found to be more heavily dependent on nitrogen deposition than had been presumed. A downward adjustment of critical loads appears appropriate in order to ensure stabilized mycorrhizae in Europe.

I. Introduction

1. The present report describes the outcomes of the activities carried out by the Programme Coordinating Centre of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) during the reporting period (May 2017–May 2018. 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 (Air Convention) and in accordance with the 2016–2017 and 2018–2019 workplans 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, 1.4.1–1.4.1.2 and ECE/EB.AIR/140/Add.1, items 1.1.1.19–1.1.1.24 and 1.1.4.1) and with the activities set out in the informal document submitted to the Executive Body for the Convention at its thirty-seventh session entitled "Draft revised mandates for scientific task forces and centres under the Convention".

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). A total of 42 Parties to the Air Convention participate in ICP Forests activities. In 2017, the lead country appointed Mr. Marco Ferretti (Switzerland) as Chair of ICP Forests.

3. The Seventh ICP Forests Scientific Conference, "European Forests in a changing environment: Air pollution, climate change and forest management", was immediately prior to the thirty-fourth meeting of the Task Force (Riga, 21–23 and 23–25 May 2018, respectively). A compilation of abstracts of all contributions to the Conference was distributed to the participants and is posted on both the ICP Forests website[1] and the Conference website.[2] The main topics of the Conference were:

(a) Changes in ecosystem processes in forests under various management regimes;

(b) Time series of forest ecosystem processes and their interrelationship;

(c) Climate change adaption of forests and their contribution to climate change mitigation; and

(d) Research data management.

There was also a poster session with flash presentations on a broad range of topics.

4. During the meeting, a representative of the Programme Coordinating Centre presented an overview of activities and progress since the thirty-third Meeting of the Task Force (Bucharest, 18–19 May 2017); the draft 2018 technical report of ICP Forests[3] was introduced; two glossy thematic briefs, one on ICP Forests and the other on nitrogen (N) deposition in forests ecosystems across Europe, were introduced; and a forthcoming brief on ozone was announced. A representative of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) summarized the Programme's activities and representatives of the expert panels and committees of ICP Forests reported on their activities. A proposal for minor changes in already submitted data sets in the *Manual on Methods and Criteria for Harmonized*

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[1] Karin Hansen and others, eds., 2018, *European forests in a changing environment: Air pollution, climate change and forest management*. Abstracts of the Seventh ICP Forests Scientific Conference, Riga, Latvia, 22-23 May 2018 (Riga 2018). Available at http://icp-forests.net/page/icp-forests-other-publications.

[2] https://sc2018.thuenen.de.

[3] Alexa Michel and Walter Seidling, eds., *Forest Condition in Europe: 2018 Technical Report of ICP Forests* (Vienna, Austrian Research Centre for Forests, forthcoming).

Sampling, Assessment, Monitoring and Analysis of the Effects of Air Pollution on Forests (ICP Forests Manual) by the PCC was adopted. A representative of the Programme Coordinating Centre reported on ongoing studies using ICP Forests data from internal and external users. In the context of the Working Group on Effects, the Programme Coordinating Centre had contributed to a joint initiative associated with article 9 and annex V of the 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) (the National Emission Ceilings Directive) (article 9 and annex V), for which a guidance document had been drafted, discussed and finalized by the end of 2017. The Centre also commented on the draft template for the reporting of ecosystem monitoring under the Directive. In the future, a representative of ICP Forests will be included in a technical subgroup of the Directive's expert group.

II. Outcomes and deliverables during the reporting period

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

(a) The 2017 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.1/2017/3–ECE/EB.AIR/WG.1/2017/3). 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 annual report of ICP Forests to the EMEP Steering Body and the Working Group on Effects (ECE/EB.AIR/GE.1/2017/11–ECE/EB.AIR/WG.1/2017/4);

(c) The 2017 Technical Report of ICP Forests,[4] including thematic papers on:

(i) Spatial variation of atmospheric deposition in Europe in 2015;

(ii) Trends in foliar nitrogen and phosphorous concentrations and ratios since 2000;

(iii) Tree crown condition in 2016;

(iv) Selected meteorological stress indices for 2013-2015.

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

(e) *ICP Forests Brief #1*;[6]

(f) *ICP Forests Brief #2*;[7]

(g) Abstracts of the Seventh Scientific Conference of ICP Forests.[8]

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[4] Alexa Michel and Walter Seidling, eds., *Forest Condition in Europe: 2017 Technical Report of ICP Forests*, BFW-Dokumentation 24/2017 (Vienna, Austrian Research Centre for Forests, 2017). Available at http://icp-forests.net/page/icp-forests-technical-report.

[5] Walter Seidling, ed., *Forest Conditions: ICP Forests 2017 Executive Report* (Eberswalde, ICP Forests, 2017). Available at http://icp-forests.net/page/icp-forests-executive-report.

[6] Alexa Michel and others, *ICP Forests: A policy-relevant infrastructure for long-term, large-scale assessment and monitoring of forest ecosystems, ICP Forests Brief #1* (Eberswalde, 2018), Available at http://icp-forests.net/page/icp-forests-briefs.

[7] Andreas Schmitz and others, *Status and trends of inorganic nitrogen deposition to forests in Europe, ICP Forests Brief #2.* (Eberswalde, 2018). Available at http://icp-forests.net/page/icp-forests-briefs.

6. A total of 21 scientific papers based on ICP Forests' data and with significant use of its infrastructure were published between May 2017 and May 2018. These publications cover the following fields: mortality and crown condition (4 papers), carbon uptake and carbon cycling (2 papers); atmospheric nitrogen deposition and impacts (2 papers), ozone impacts (3 papers), phenology (2 papers), aspects of diversity (3 papers), heavy metals (1 paper) and various methodological topics (4 papers). Eight more papers were based in part on ICP Forests infrastructure and/or data but were not directly attributed to it.

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

7. In the second half of 2018 and in 2019, ICP Forests will carry out the following activities in accordance with the 2018–2019 workplan for the Convention and with the decisions taken at the thirty-fourth Meeting of the Task Force:

(a) Further collection 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 joint progress report of the International Coordinated Programmes and the Joint Task Force on the Health Aspects of Air Pollution on policy-relevant scientific findings (ECE/EB.AIR/GE.1/2018/3-ECE/EB.AIR/WG.1/2018/3);

(c) Finalization of the draft 2018 Technical Report of ICP Forests;

(d) Finalization of the draft ICP Forests Brief #3 on ozone risks to forest trees and other woody forest vegetation;

(e) Finalization of the draft 2018 Executive Report.

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

8. In an ongoing project carried out by members of ICP Forests and the EMEP Meteorological Synthesizing Centre-West, the sulphur and nitrogen species deposition rates calculated for the 50 x 50 kilometre and 0.1° x 0.1° EMEP grids are compared with the ICP Forests bulk deposition measurements within these EMEP grid cells. Various quality assurance criteria and variables, such as seasons, will also be taken into consideration. The study, which serves as a bridge between the air pollutant emissions and effects communities, will have a considerable impact on the quality assurance procedures of ICP Forests.

9. 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 co-operation" is planned for March or April 2019.

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

10. Most of the countries in South-Eastern Europe, including Turkey, are included in the extensive ICP Forests Level I monitoring of forest ecosystems; the more complex and

[8] See note 1 above.

intensive Level II monitoring is carried out at only a few sites in South-Eastern Europe. None of the countries in the Caucasus or Central Asia is active in ICP Forests monitoring activities.

11. In 2017, a representative of ICP Forests was invited to visit the Weizmann Institute of Science and the Dead-Sea and Arava Science Centre in Israel in order to explore possibilities for monitoring and research in that country. The Israeli scientists were enthusiastic about the potential for membership in ICP Forests but the issue is still under negotiation.

12. Follow-up to the initial contacts with forestry officials in Uzbekistan with a view to membership in ICP Forests proved impossible.

VI. Scientific and technical cooperation with relevant international bodies

13. 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), the Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) and ICP Vegetation have been taken into consideration in reporting by the European Commission (see para. 4 above).

14. A considerable number of ICP Forests sites have been incorporated into the European Long-term Ecosystem Research (LTER) network.[9] ICP Forests has begun to adapt its plot-related metadata so that it can be better integrated into the Dynamic Ecological Information Management System (DEIMS) website and the LTER dataset registry and has exchanged letters of support with the LTER network.

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

15. Between May 2017 and May 2018, 21 papers published by the ICP Forests community (see para. 6 above) have been listed by the Institute for Scientific Information. Some of the conclusions of these papers are particularly relevant to recent environmental policy issues:

(a) Because nitrogen saturation of forest ecosystems can have undesired effects not only for forests and forestry, but also for societal benefits such as drinking water from forested areas, indicators on the nitrogen saturation status of forests are generally of high political relevance. It was theorized that the decreasing inorganic nitrogen (and sulphur) deposition rates of recent decades in large parts of Europe would be followed in most cases by enhanced leaching of DOC and DON that also affects TDN levels. This hypothesis was tested using soil solution and foliage datasets from ICP Forests Level II plots in areas with formerly high deposition rates, such as northern Belgium, in order to determine whether these processes are responding to reduced nitrogen deposition. Since the molar DON:TDN ratio in the organic and mineral soil horizons of all five monitored plots between 2005 and 2014 and the molar DOC: NO_3 ratio also increased between 2002 and 2014 in the organic and mineral soil horizons of three and four plots, respectively, an overall reduction of reactive nitrogen in soil solution may be presumed. During the same time period, the nitrogen:phosphorous (N:P) ratio and the base cations:nitrogen ratio in foliage remained stable. While the results from soil solution confirm improvement in the nitrogen status of

[9] See: www.lter-europe.net.

these forests, the biotic response appears to lag behind. These results show the need for continued intensive monitoring of forest ecosystems since single parameters or ratios do not appear to adequately reflect their tendency to recover from previously-high nitrogen deposition loads;

(b) Heavy metal deposition has been a source of concern for environmental policymakers because these deposits can accumulate in certain ecosystem compartments and food webs and pose a threat to sensitive organisms. Estonia's oil shale industries have exposed its forest ecosystems to significant amounts of chromium, nickel, lead and zinc during the 1980s and, to a lesser extent, even today. While emissions have been greatly reduced over the past 20 years, storage and probable mobility within ecosystems must be monitored. To that end, the levels of six heavy metals (cadmium (Cd), copper (Cu), chromium (Cr), nickel (Ni), lead (Pb) and zinc (Zn)) were studied in the living needles, litterfall, fine roots, organic forest soil horizon and, in part, the mycelia of Scots pine and Norway spruce stands at Estonian ICP Forests and ICP Integrated Monitoring sites. Root uptake, translocation and accumulation were also calculated. While there was a high degree of element- and compartment-specific variability, some patterns were identified: the highest concentrations of Cd, Pb, Cr (the contaminant-heavy metals) and Ni were invariably found in organic soil horizons and the highest concentrations of Zn and Cu (biogenic heavy metals) were found primarily in fine roots. Soil type appears to modify the distribution of heavy metals and the translocation pattern within tree species although distinct geographic patterns could not be corroborated. In that regard, the role of mycorrhizae seems particularly important in the case of Ni, Cr, Cu and Zn as their concentrations are several times higher than in other compartments, including fine roots;

(c) Mycorrhizal fungi play a key role in the carbon and nitrogen cycling of forest ecosystems because they mediate the interface between plants and soil. In the past, the hidden nature of this life form has prevented its occurrence from being studied on a wider scale. Close cooperation between Imperial College London and ICP Forests partners made it possible to combine an extensive DNA sequencing approach with data from transcontinental monitoring, making comprehensive statistical evaluation possible. Through an ordination approach, nitrogen deposition was identified as one of five key variables driving mycorrhiza identity across Europe, together with other biotic and abiotic drivers such as forest floor pH, mean annual air temperature, potassium throughfall deposition and foliar N:P ratio. Ordination of individual operational taxonomic units of fungi (47 per cent of which were equivalent to species and 90 per cent to genera) showed a throughfall deposition threshold of 5.8 kilograms (kg) of nitrogen per hectare per year (N ha^{-1} yr^{-1}) for N-sensitive taxa. Most of these N-sensitive species grow on conifers. Initial signs of response are seen even at deposition values below 5 kg N ha^{-1} yr^{-1}. The study recommends a downward adjustment of critical loads for eutrophying nitrogen in order to keep the balance between mycorrhizal fungi and forest trees stable.

VIII. Publications

16. For a full list of all 20 ICP Forests publications and references for the present report, please refer to the 2018 ICP Forests Technical Report or visit the ICP Forests website.[10]

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