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Progress in activities in 2014 and further development of effects-oriented activities

Effects of air pollution on natural vegetation and crops

Report by the Programme Coordinating Centre of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

Summary

The present report is being submitted for the consideration of the Working Group on Effects in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2014–2015 workplan for the implementation of the Convention (ECE/EB.AIR/122/Add.2 items 1.1.10 and 1.1.17–1.1.19).

The report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops presents the results of an evaluation of effects of air pollutants on (semi-)natural vegetation and crops,[1] further development of the flux-based approach for setting critical levels of ground-level ozone for vegetation and progress in the preparations for the European moss survey 2015/16 on heavy metals, nitrogen and persistent organic pollutants. In addition, the results of the workplan items common to all the International Cooperative Programmes under the Convention are presented.

[1] Results on the deposition of air pollutants and their impacts on vegetation in Eastern and South-Eastern Europe, the Caucasus and South-East and Central Asia are reported in more detail in document ECE/EB.AIR/WG.1/2014/13.

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I. Introduction

1. The present report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) is being submitted for the consideration of the Working Group on Effects in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2014–2015 workplan for the implementation of the Convention (ECE/EB.AIR/122/Add.2 items 1.1.10 and 1.1.17–1.1.19). The report presents the results of an evaluation of effects of air pollutants on (semi-)natural vegetation and crops,[2] further development of the flux-based approach for setting critical levels of ground-level ozone for vegetation and progress in the preparations for the European moss survey 2015/16 on heavy metals, nitrogen and persistent organic pollutants. The results of the workplan items common to all the International Cooperative Programmes under the Convention are also presented.[3] The lead country for ICP Vegetation is the United Kingdom of Great Britain and Northern Ireland, with the Programme Coordination Centre at the Institute of Ecology and Hydrology in Bangor. ICP Vegetation has over 200 participants in more than 40 countries, including countries that are not Parties to the Convention.

II. Workplan items common to all International Cooperative Programmes

A. Setting priorities for monitoring and collection of other data in view of policy needs and financial constraints (workplan item 1.1.1)

2. The priorities for monitoring and collection of other data in view of policy needs and financial constraints will be described in an informal document (in preparation) for the thirty-third session of the Working Group on Effects, to be collated by the Convention secretariat.

B. Further implementation of the Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects (workplan item 1.1.10 (a))

3. The table below provides a general overview of the monitoring and modelling effects reported by ICP Vegetation, according to the Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects (ECE/EB.AIR/2008/11).[4]

[2] Results on the deposition of air pollutants and their impacts on vegetation in Eastern and South-Eastern Europe, the Caucasus and South-East and Central Asia are reported in more detail in document ECE/EB.AIR/WG.1/2014/13.

[3] For a list of ICP Vegetation publications and references for the present report, please visit the ICP Vegetation website (http://icpvegetation.ceh.ac.uk/publications/index.html).

[4] The Guidelines were adopted by the Executive Body at its twenty-sixth session (ECE/EB.AIR/96/Add.1–ECE/EB.AIR/WG.1/2008/16/Rev.1, decision 2008/1).

A general overview of monitoring and modelling effects reported by ICP Vegetation

Parameter	*Ozone*	*Heavy metals*	*Nitrogen*	*Persistent organic pollutants*
Growth and yield reduction	X			
Leaf and foliar damage	X			
Exceedance of critical levels	X			
Climatic factors	X			
Concentrations in mosses		X	X	X

C. Enhanced involvement of countries in Eastern and South-Eastern Europe, the Caucasus and Central Asia, and cooperation with activities outside the Convention (workplan item 1.1.10 (b))

4. In 2014, ICP Vegetation transferred the coordination of the European moss survey (i.e., monitoring heavy metals, nitrogen and persistent organic pollutant (POP) concentrations in mosses every five years) to the Russian Federation. The new Moss Survey Coordination Centre, at the Institute for Joint Nuclear Research in Dubna, is negotiating for or has reached agreement on the participation of countries in Eastern Europe, the Caucasus and Central Asia (including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, the Republic of Moldova, the Russian Federation and Uzbekistan) and selected Asian countries (China, India, Mongolia, Pakistan, Republic of Korea, Thailand and Viet Nam) for the next survey in 2015/16. The updated Moss Monitoring Manual[5] was translated into Russian (see also para. 13). In addition, a glossy leaflet on ozone injury symptoms on leaves of vegetation (see also para. 9) was also translated into Russian.

5. ICP Vegetation published a report on *Air pollution: Deposition to and impacts on vegetation in (South-)East Europe, Caucasus, Central Asia (EECCA/SEE) and South-East Asia*; a country report was included for the Russian Federation and various countries in South-Eastern Europe (Albania, Croatia, Greece, Romania, Serbia, Slovenia and the former Yugoslav Republic of Macedonia).[6] This report was translated into Russian (for further details see ECE/EB.AIR/WG.1/2014/13).

D. Cooperation with programmes and activities outside the region (workplan item 1.1.10 (c))

6. ICP Vegetation co-organized the Ozone and Plants Conference in Beijing, China, in May 2014, in collaboration with the Chinese Academy of Sciences and the International Union of Forest Research Organizations (IUFRO). One session at the conference was organized in collaboration with the Task Force on Hemispheric Transport of Air Pollution (see also para. 25).

[5] Online publication available from http://icpvegetation.ceh.ac.uk/manuals/moss_survey.html.

[6] Available from http://icpvegetation.ceh.ac.uk/publications/thematic.html.

E. Contribution to a joint annual report by the Working Group on Effects on recent scientific findings and their implications for policy for consideration by the Executive Body (workplan item 1.1.11)

7. ICP Vegetation contributed to the joint report of the Working Group on Effects with clear policy-relevant messages and recommendations to the Working Group on Strategies and Review and to the Executive Body (see ECE/EB.AIR/WG.1/2014/3).

III. Workplan items specific to the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

A. Evaluation of effects on (semi-)natural vegetation and crops due to air pollution (workplan item 1.1.17)

8. Further supporting evidence for ozone impacts on vegetation (1.1.17 (a)) was evaluated, including the results of the ozone biomonitoring study with bean, showing, for example, strong ozone-induced leaf injury in Beijing, China. These data were reviewed at the ozone workshop and the ICP Vegetation Task Force meeting and included in the review of ozone dose-response relationships as described in workplan item 1.1.18 (see para. 11).

9. A web-based smart-phone application (App) was developed for the recording of visible leaf injury on vegetation caused by ambient ozone (workplan item 1.1.17 (a)). This App is currently being tested by ozone experts and will be released to the wider general public in 2015. Users are guided through a set of questions and will be asked to record the date and location of observed ozone-induced leaf injury on plant species. The data will be used to provide further field-based evidence of ozone impacts on vegetation. The launch of the App was accompanied with a glossy leaflet on symptoms of ozone leaf injury on vegetation, produced in collaboration with the Expert Panel on Ambient Air Quality of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). This leaflet is also available in Russian.[7]

10. The report on *Air pollution: Deposition to and impacts on vegetation in (South-) East Europe, Caucasus, Central Asia (EECCA/SEE) and South-East Asia* (workplan item 1.1.17 (c)) highlights the lack of monitoring stations for air pollutant concentrations and deposition in these regions in comparison with other regions in Europe (especially Northern, Western and Central Europe). In the same regions, there is also a lack of a coordinated network for monitoring air pollutant impacts on vegetation. Further details are provided in document ECE/EB.AIR/WG.1/2014/13.

B. Further development of the flux-based approach for setting critical levels of ground-level ozone for vegetation (workplan item 1.1.18)

11. After a review of new knowledge on ozone dose-response functions for vegetation and further developments of the flux-based approach, the ICP Vegetation Task Force endorsed the existing critical levels for vegetation and recommended not to change them. A new flux-effect relationship for crops for use in integrated assessment modelling only (for effects of ozone on wheat, 90-day exposure period) was agreed with a critical level of

[7] Ibid.

8 millimoles per square metre (mmol m^{-2}). This response function and associated critical level are for integrated assessment modelling only at the European scale. It is provided for use in scenario analysis and optimization runs within the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model[8] to provide an indication of potential effects on wheat yield under non-limiting water availability. The generic crop flux model provides an estimation of the worst case for damage for crops with adequate water supply (either rain-fed or irrigated). Reductions in ozone flux associated with dry soils such as those found in the Mediterranean areas are not included in this model and thus effects may be overestimated where irrigation is not used in these areas. Further details are provided in document ECE/EB.AIR/WG.1/2014/3.

12. Parameterizations of the ozone flux model were agreed for the crops species grapevine, maize, soybean and sunflower and for the tree species poplar. Chapter 3 (Mapping critical levels for vegetation) of the *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends*[9] (Modelling and Mapping Manual) was updated to include the changes mentioned (i.e., in paras. 11 and 12).

C. Progress in preparations for the European moss survey 2015/16 on heavy metals, nitrogen and persistent organic pollutants (workplan item 1.1.19)

13. Following the establishment of the new Moss survey Coordination Centre in the Russian Federation, the moss monitoring manual for use in the 2015/16 survey was reviewed, updated and translated into Russian.

IV. Results/impact achieved of the activities carried out

14. The ozone flux-based methodology for assessing risk for vegetation is now included in the GAINS model. A new flux-effect relationship for crops for use in integrated assessment modelling only and an associated critical level was defined. Chapter 3 (Mapping critical levels for vegetation) of the Modelling and Mapping Manual was updated to include new findings. Collaboration with the scientific ozone community in Asia and the Task Force on Hemispheric Transport of Air Pollution was enhanced at the Ozone and Plants Conference in China. Links between European and American scientists studying and modelling the impacts of ozone on vegetation, in particular, were enhanced at the Ninth Air Pollution and Global Change Symposium. For many other results it is too early to say what their impact will be in the near future.

V. Expected outcomes/deliverables over the next period and in the longer term

15. Over the next period and in the longer term, ICP Vegetation will report on:

(a) Supporting evidence for ozone impacts on vegetation (workplan item 1.1.17 (a));

[8] See http://gains.iiasa.ac.at/models/.

[9] Germany, Federal Environmental Agency (Berlin: December 2004). Available from http://www.icpmapping.org/Mapping_Manual.

(b) Interacting effects of co-occurring pollutants (ozone and nitrogen) and climatic stresses on vegetation (item 1.1.17 (b));

(c) Implications of rising background ozone for vegetation in Europe (item 1.1.17 (d));

(d) Updating of Chapter 3 of the Modelling and Mapping Manual, with an ozone critical levels workshop planned for 2016 (item 1.1.18);

(e) The 2015/16 European moss survey on heavy metals, nitrogen and POPs (item 1.1.19).

VI. Policy-relevant issues, findings and recommendations

16. A new flux-effect relationship was developed for ozone impacts on crops for use in integrated assessment modelling (IAM) at the European scale only**.** The new terminology for the simplified generic ozone flux is Phytotoxic Ozone Dose (POD) above an ozone flux threshold of 3 nanomoles per square meter (nmol m^{-2} s^{-1}; POD_3IAM). POD_3IAM has a 90-day accumulation period and the effect for impacts on crops is based on wheat yield, with a critical level of 8 mmol m^{-2}.

17. The smart-phone App developed for recording incidences of ozone-induced leaf damage on vegetation will allow further collation of field-based evidence of ozone impacts on vegetation and the analysis of spatial patterns, in principal across the globe. Ozone experts across the globe are encouraged to test the App by recording incidences of ozone-induced leaf damage.

18. The transfer of the coordination of the European moss survey to the Russian Federation aims to enhance participation by countries in Eastern Europe, the Caucasus and Central Asia, and potentially other Asian countries.

19. There is a lack of monitoring stations for air pollutant concentrations and deposition and monitoring sites for air pollutants impacts on vegetation in countries of Eastern Europe, the Caucasus and Central Asia and in South-East Asia. In the United Nations Economic Commission for Europe (ECE) region, the area at highest risk from both ozone and heavy metal pollution is Eastern and South-Eastern Europe. Parties in Eastern and South-Europe, the Caucasus and Central Asia should stimulate and finance the participation of national experts in ICP Vegetation.

VII. Issues for the attention and advice of other groups, task forces or subsidiary bodies, notably with regard to synergies and possible joint approaches or activities

20. ICP Vegetation identified the following groups, task forces or subsidiary bodies as partners for cooperation in specific areas, notably with regard to finding synergies and possible joint approaches or activities:

(a) The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)/Working Group on Effects: joint assessment report scheduled for publication in 2016;

(b) The Task Force on Integrated Assessment Modelling/Centre for Integrated Assessment Modelling:

(i) Application and further development of the ozone flux-based approach in the GAINS model;

(ii) Further development of methodologies for the valuation of ecosystem services and biodiversity;

(c) The Task Force on Integrated Assessment Modelling/Centre for Integrated Assessment Modelling, International Cooperative Programme on Modelling and Mapping Critical Loads and Levels and Air Pollution Effects (ICP Modelling and Mapping), Risks and Trends, ICP Forests, the Task Force on Reactive Nitrogen, EMEP/Meteorological Synthesizing Centre-West: Impacts of ozone and nitrogen on vegetation in a future climate will be further investigated in the framework of the European Union (EU) project, Effects of Climate Change on Air Pollution and Response Strategies for European Ecosystems (ECLAIRE);[10]

(d) Task Force on Hemispheric Transport of Air Pollution: The hemispheric nature of ozone pollution requires further collaboration with the Task Force regarding impact assessments on vegetation and feedbacks to the climate, applying agreed air pollution abatement and climate scenarios globally;

(e) EMEP/Meteorological Synthesizing Centre-West: Mapping of the risk of ozone impacts on vegetation under different air pollution and climate scenarios in the extended EMEP domain;

(f) EMEP/Meteorological Synthesizing Centre-East: Further investigate the relationship between heavy metal and POPs concentration in mosses and their modelled atmospheric deposition. Compare spatial patterns and temporal trends in modelled deposition and moss concentrations;

(g) ICP Modelling and Mapping: Joint sessions on ozone and nitrogen impacts on vegetation at each other's Task Force meetings;

(h) ICP Forests: Further development of ozone critical levels for vegetation, the recording and analysis of visible leaf injury due to ozone, and providing field-based evidence of ozone impacts on forests through epidemiological studies. Proposals are being developed for collaboration in the EU Horizon 2020 Framework Programme for Research and Innovation[11] and the EU funding instrument for the environment and climate action LIFE+ programme.[12]

VIII. Recommendations to further strengthen implementation and ratification of the Protocols in Eastern Europe, the Caucasus and Central Asia, as well as South-Eastern Europe

21. To further strengthen implementation and ratification of the protocols to the Convention in Eastern Europe, the Caucasus and Central Asia, as well as South-Eastern Europe, further evidence of air pollution deposition to and impacts on vegetation in countries of the subregion should be sought through increased participation in the work of ICP Vegetation. The latter might be achieved by: (a) establishment of the Moss Survey Coordination Centre in the Russian Federation; (b) knowledge transfer through the publication of reports, the Modelling and Mapping Manual and leaflets in Russian; (c) organization of the twenty-ninth ICP Vegetation Task Force meeting in the Russian Federation (tentatively, in 2016); (d) encouraging countries of the subregion to identify and support the participation of ozone experts in ICP Vegetation.

[10] See http://www.eclaire-fp7.eu/.

[11] See http://ec.europa.eu/programmes/horizon2020/.

[12] See http://ec.europa.eu/environment/life/about/beyond2013.htm.

IX. Scientific and technical cooperation with relevant international bodies

22. As mentioned previously, ICP Vegetation co-organized the Ozone and Plants Conference in Beijing in May 2014, in collaboration with the Chinese Academy of Sciences and IUFRO, and will continue collaboration with these organizations in the future.

X. Scientific findings: highlights

23. Scientific findings of ICP Vegetation are summarized in document ECE/EB.AIR/WG.1/2014/3 and in section VI above.

XI. Meetings

24. The twenty-seventh meeting of the Programme Task Force was held in Paris, France from 28 to 30 January 2014. The meeting was hosted by the French Environment and Energy Management Agency, in collaboration with the Institute of Technology for Life, Food and Environmental Sciences, the National Institute for Agricultural Research, the Muséum national d'histoire naturelle and Université Paris-Est Creteil. The meeting was attended by 84 experts from 22 countries, including 19 Parties to the Convention and guests from Algeria, Egypt and Japan. The first day of the meeting included a one-day workshop on the quantification of ozone impacts on vegetation, including a review of existing dose-response relationships for ozone impacts and ozone critical levels for vegetation.

25. The Ozone and Plants Conference in Beijing, China, was co-organized by ICP Vegetation in May 2014. One session at the Conference was organized in collaboration with the Task Force on Hemispheric Transport of Air Pollution to discuss atmospheric chemistry and exchanges with the biosphere in global and regional modelling. An outline of ozone impacts on vegetation for inclusion in the next hemispheric transport of air pollution assessment was discussed with the Task Force's co-Chairs.

26. The Chair and members of ICP Vegetation attended the Ninth Air Pollution and Global Change Symposium in Monterey, United States of America, in June 2014. Links between European and American scientists studying and modelling the impacts of particularly ozone on vegetation were enhanced at this meeting.

XII. Additional comments and lessons learned

27. There is a need to: (a) collate further field-based evidence of ozone impacts on vegetation, especially for areas where information is scarce; (b) develop flux-effect relationships for Asian crop cultivars and other vegetation under Asian climatic conditions; (c) breed more ozone-tolerant cultivars in crop breeding programmes; (d) further assess the impacts of ozone and nitrogen on vegetation in a changing climate (i.e., interactions with elevated carbon dioxide and temperature, more drought events); (e) continue to communicate the threat of ozone pollution to food production, carbon sequestration and other ecosystem services to stakeholders, including farmers, crop breeders and policymakers; and (f) develop global air pollution abatement policies to reduce the levels of ground-level ozone.