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Working Group on Effects

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Recent results and updating of scientific and technical knowledge

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 report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops contained herein presents recent results on the effects of ozone on vegetation, and progress with the European moss survey on heavy metals, nitrogen and persistent organic pollutants.

The 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 2012–2013 workplan for the implementation of the Convention (ECE/EB.AIR/109/Add.2, items 3.1 (c) and 3.5).

I. Introduction

1. Recent results on the effects of ozone on vegetation, and progress with the European moss survey on heavy metals, nitrogen and persistent organic pollutants (POPs) are presented here in accordance with items 3.1 (c) and 3.5 of the 2012–2013 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR.109/Add.2), adopted by the Executive Body for the Convention at its twenty-ninth session in December 2011.

II. Workplan items common to all programmes

A. Further implementation of the Guidelines

2. Table 1 below provides an overview of the monitoring and modelling effects reported by the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation), according to the Guidelines for reporting on the monitoring and modelling of air pollution effects (ECE/EB.AIR/2008/11).[1]

Table 1
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 critical levels	X			
Climatic factors	X			
Concentrations in mosses		X	X	X

B. Final version of the report on impact analysis by the Working Group on Effects

3. With reference to the results reported in the 2012 impact assessment report by the Working Group on Effects (ECE/EB.AIR/WG.1/2012/13), the ICP Vegetation Coordination Centre, in collaboration with the other ICPs and the Joint Task Force on the Health Effects of Air Pollution (Task Force on Health), produced a glossy brochure on "Impacts of air pollution on human health, ecosystems and cultural heritage",[2] summarizing the results, conclusions and recommendations of the impact analysis conducted by the Working Group on Effects.

[1] The Guidelines were adopted by the Executive Body at its twenty-eighth session (ECE/EB.AIR/96/Add.1, decision 2008/1) .
[2] The brochure is available in English, French and Russian from the Coordinating Centre's website (http://icpvegetation.ceh.ac.uk/publications/wge_documents.html).

C. Report on enhancing involvement of countries in Eastern Europe, the Caucasus, Central Asia and South-Eastern Europe and on cooperation with activities outside the Convention

4. Working with the lead participant of the European moss survey in the Russian Federation, ICP Vegetation is actively encouraging the participation of more countries from Eastern Europe, the Caucasus, Central Asia and South-Eastern Europe. For example, Albania took part for the first time in the moss survey in 2010/11 and attended the ICP Vegetation Task Force meeting for the first time in 2012. Every year ICP Vegetation tries to find funds for experts in countries of the subregion to participate in its annual Task Force meeting. In 2012, a short leaflet was produced on the results of the 2005/06 European moss survey, which will be translated into Russian for distribution in countries in Eastern Europe, the Caucasus, Central Asia and South-Eastern Europe. In collaboration with the other ICPs and the Task Force on Health, the ICP Vegetation Programme Coordination Centre produced a glossy brochure on the impact analysis by the Working Group on Effects (see item B above). The brochure was translated into Russian and widely distributed within the effects community working under the Convention and by contacts in countries in Eastern Europe, the Caucasus and Central Asia.

5. Via the Stockholm Environment Institute in York (United Kingdom of Great Britain and Northern Ireland), which hosts the secretariat of the Global Atmospheric Pollution Forum, ICP Vegetation has been enhancing collaboration with South Asia, particularly with Malé Declaration countries. For example, ICP Vegetation produced a position paper on outreach activities with the Malé Declaration, which was presented at the Task Force meeting for the future development of the Malé Declaration in August 2012. Furthermore, ICP Vegetation has developed collaboration with experts in Egypt, South Africa, Cuba and Japan, who have attended recent Task Force meetings. Further collaboration, however, is often hindered by a lack of funds.

D. Report on impacts on biodiversity and ecosystems services

6. In collaboration with other ICPs, ICP Vegetation will report on impacts on biodiversity and ecosystem services in 2013.

III. Nutrient nitrogen

7. Fourteen countries participating in the European moss survey 2010/11 have submitted or will submit data on the nitrogen concentration in mosses. The results will be reported in 2013.

8. A review of the scientific literature showed that little is known about the relationship between nitrogen concentrations in terrestrial mosses and the impacts of nitrogen on terrestrial ecosystems. The nitrogen concentration in the moss species used in the European moss survey tends to be a good indicator of total atmospheric nitrogen deposition up to a deposition flux of circa 15 kilograms per hectare per year. Above this level, the nitrogen concentration in mosses tends to saturate, although the level at which saturation occurs varies between countries. Empirical critical loads have been defined for various habitats (see ECE/EB.AIR/WG.1/2010/14); however, the effects indicators for exceedance have not been related so far to nitrogen concentrations in mosses per se. Recent studies have shown that vegetation responses to nitrogen deposition might depend more on the nitrogen form (ammonia or nitrate) than dose. Vegetation tends to be more sensitive to ammonia (see ECE/EB.AIR/WG.5/2007/3) than to nitrate exposure.

IV. Ozone

9. Data on the impacts of ozone on French dwarf bean (*Phaseolus vulgaris*) in 2011 were submitted from nine sites across Europe and one in the United States of America, indicating the widespread occurrence of leaf ozone damage on the ozone-sensitive variety. The data from 2008–2011 were combined in a database. However, there was no clear dose-response relationship with calculated ozone concentration-based parameters. A flux model has been developed and more work will be conducted on developing flux-effect relationships in the coming year.

10. A comprehensive report has been prepared on the effects of ozone on carbon sequestration in the living biomass of trees. Contributions from the ICP Vegetation Programme Coordination Centre, together with those from participants and from studies conducted in collaboration with the Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) were included. The report contained the first flux-based assessment for Europe, and included predictions of effects for the current (2000) and future (2040) years.

Table 2.
Estimated reduction of carbon storage in the living biomass of trees due to ozone in 2000 and 2040 (per millions of tons of carbon)

Input data	*Year*	*DO_3SE parameterization*	*POD_Y or AOT40*	*NE*	*ACE*	*CCE*	*ME*	***Total***
EMEP	2000	Standard	POD_1	256 (8.5)	40.3 (14.3)	735 (14.1)	218 (11.9)	**1 249 (12.0)**
	2000	Cl. specific	$POD_{1/1.6}$	553 (14.5)	44.3 (15.0)	877 (14.8)	215 (10.7)	**1 689 (13.7)**
	2000	SMD_{off}	POD_1	268 (8.8)	43.1 (15.1)	1 034 (19.7)	437 (23.4)	**1 782 (17.3)**
	2000	Standard	AOT40	29.7 (1.3)	10.5 (2.8)	499 (10.3)	253 (14.2)	**792 (8.2)**
RCA3	2000	Standard	POD_1	317 (10.4)	60.6 (21.2)	1 247 (21.4)	305 (14.7)	**1 929 (16.2)**
	2000	Standard	AOT40	41.8 (2.1)	13.2 (5.0)	483 (10.4)	254 (14.1)	**791 (8.4)**
	2040	Standard	POD_1	271 (9.3)	52.9 (19.8)	821 (15.7)	184 (10.2)	**1 330 (12.6)**
	2040	Standard	AOT40	-0.9 (-0.3)	4.4 (2.3)	68.5 (2.1)	57.1 (4.1)	**129 (2.1)**

Note: Values in brackets show the percentage of estimated reduction.

Abbreviations: ACE = Atlantic Central Europe; AOT40 = accumulated ozone exposure over a threshold of 40 parts per billion; CCE = Continental Central Europe; DO_3SE = Deposition of Ozone for Stomatal Exchange model;[3] Cl. Specific = climate specific; ME = Mediterranean Europe; NE = Northern Europe; POD_Y = Phototoxic ozone dose ; RCA3 = Rossby Centre regional atmospheric climate model[4] version 3; SMDoff = soil moisture deficit module switched off.

11. When applying a standard parameterization for deciduous and coniferous trees, current ambient ground-level ozone was estimated to reduce carbon sequestration in the living biomass of trees by 12.0% to 16.2% (depending on ozone, meteorological and climate input data) in the European Union (EU-27) plus Norway and Switzerland in 2000 (table 2). The flux-based approach indicated the highest ozone impact on forests in Central Europe, where moderate ozone concentrations coincide with a climate conducive to high stomatal ozone fluxes and with high forest carbon stocks. A considerable reduction was

[3] See http://www.sei-international.org/do3se.
[4] See http://www.smhi.se/en/Research/Research-departments/climate-research-rossby-centre2-552/rossby-centre-regional-atmospheric-model-rca4-1.16562.

also calculated for parts of Northern Europe, especially when applying climate region-specific parameterizations. The concentration-based approach (AOT40) predicted substantially lower reductions in carbon storage (circa 8% in the year 2000) than the flux-based approach, apart from in the Mediterranean.

12. Although a decline in stomatal ozone flux was predicted in 2040, carbon sequestration in the living biomass of trees will still be reduced by 12.6% (compared with 16.2% in 2000). In 2040, the reduction in carbon sequestration was predicted to be considerably higher for the flux-based than the concentration-based (2.1%) approach. Further details can be found in the Working Group on Effects 2012 impact assessment report.

V. Heavy metals

13. Twenty-six countries are expected to submit data on heavy metal concentrations in mosses for the European moss survey 2010/11. The final report of the 2010/11 survey will be published in 2013.

14. A review of the scientific literature showed that little is known about the relationship between heavy metal concentrations in mosses and the impacts of heavy metals on terrestrial ecosystems. Toxicity of heavy metals is often limited to areas close to pollution sources, with impacts often declining exponentially with distance from the pollution source. For example, in agreement with the observed gradient of heavy metal concentrations in mosses near a heavy metal pollution source, an increase was observed in the abundance of soil mesofauna with distance from the pollution source. However, in the European survey, mosses are not sampled close to pollution sources and hence concentrations are often too low to detect any impact on terrestrial ecosystems in the sampling areas.

VI. Persistent organic pollutants

15. Six countries participating in the European moss survey 2010/11 will submit data on the concentration of POPs (polycyclic aromatic hydrocarbons (PAHs) in particular) in mosses. The results will be reported in 2013.

16. In addition, a review paper was submitted to a scientific journal on the application of terrestrial mosses as biomonitors of atmospheric POPs pollution. Examples in the literature show that mosses are suitable organisms to monitor spatial patterns and temporal trends of atmospheric concentrations or deposition of POPs. These examples include PAHs, polychlorobiphenyls, dioxins and furans and polybrominated diphenyl ethers. The majority of studies report on PAHs concentrations in mosses and relatively few studies have been conducted on other POPs. So far, many studies have focused on spatial patterns around pollution sources or the concentration in mosses in remote areas such as the polar regions, as an indication of long-range transport of POPs. Very few studies have determined temporal trends or have directly related the concentrations in mosses with measured atmospheric concentrations and/or deposition fluxes.

VII. Participation in Task Force meetings since 1987

17. The participation of countries and experts in ICP Vegetation Task Force meetings has increased since the establishment of ICP Vegetation in 1987 (see figure below). In 2012, the Task Force meeting was held in Brescia, Italy, and hosted by the *Università*

Cattolica del Sacro Cuore. The meeting was attended by 73 experts from 21 countries, including 19 Parties to the Convention, as well as Egypt and South Africa.

Participation in ICP Vegetation Task Force meetings since 1987