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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 rivers and lakes

Report of the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes

Summary

The present report presents a summary of the discussion and other results from the twenty-eighth meeting of the Task Force under the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes (Verbania Pallanza, Italy, 8–12 October 2012). The report is 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 3.3).

I. Introduction

1. The twenty-eighth meeting of the Task Force of the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes (ICP Waters) was held in Verbania Pallanza, Italy, from 8 to 12 October 2012. It was attended by 38 experts from 15 Parties to the Convention on Long-range Transboundary Air Pollution. At present, 29 countries have participated in one or more of the activities of ICP Waters.

2. The Task Force considered progress reports from the Programme Centre and the National Focal Centres on the results on trends in water chemistry, biological response, heavy metals and dynamic modelling, and ecosystem services. The presentations are published in a recent ICP Waters report.[1, 2]

II. Ongoing activities

A. ICP Waters Task Force meeting 2012

3. *Biodiversity:* Preliminary results from the forthcoming report, Biodiversity — effects of air pollution and climate change, were presented. The Task Force was impressed by the new data analysis and ongoing work regarding biodiversity, which would culminate in the publication of this ICP Waters report in late 2013. Data presented at the Task Force meeting by several countries showed clear recovery of key species and communities of species in lakes and streams as a response to decreasing acidity in the water. By these measures biodiversity is improving. The Task Force urged continued monitoring of biodiversity, by various metrics, in acid-impacted waters recovering from chronic acid deposition.

4. *Ecosystem services:* The Task Force was content with the focus on ecosystem services and urged all national focal points to contribute national examples to the ICP Waters report on ecosystem services that was being prepared. A summary of the report is given in section B below.

5. *Cooperation between ICP Waters and the European Long-Term Ecosystem Research Network:* The Task Force applauded the important work done by European Long-Term Ecosystem Research Network (LTER Europe)[3] to support and sustain monitoring networks. Monitoring is the basis of the work done by ICP Waters, and the data that are collected are highly suitable for analysis of effects of climate change and air pollution. Increased cooperation is expected to be of mutual interest. For ICP Waters, it is particularly important to increase visibility and secure funding at the national level. The Task Force meeting urged all National Focal Centres to contact their national representative in LTER Europe to consider possibilities to include their sites in the LTER network.

6. *Nitrogen:* The Task Force noted several contributions from individual countries that had demonstrated a recent decrease in trends of aquatic nitrogen concentrations. Causal explanations included changes in nitrogen deposition and climate change. Continued

[1] Brit Lisa Skjelkvåle and others, eds., *Proceedings of the 28th Task Force meeting of the ICP Waters Programme in Verbania Pallanza, Italy, October 8–10, 2012*, ICP Waters report 112/2013, available from http://www.icp-waters.no/TFmeetings/TFmeeting2012/tabid/143/Default.aspx.

[2] All documentation for the Task Force meeting is available on the ICP Waters website from http://www.icp-waters.no/Publications/Reports/tabid/120/Default.aspx#d2.

[3] See www.lter-europe.net.

monitoring of water chemistry is essential to understanding the fate of nitrogen in ecosystems.

7. *Sulphur:* The Task Force was impressed by country presentations showing the full story of the chemical and biological effects of reduced sulphur deposition since the 1970s, underlining the success of emission reduction measures.

8. *Dynamic modelling/critical loads:* The Task Force was happy to see that empirical indicators of acidification status (presence/absence of fish) agreed very well with modelled acidification status of acid-sensitive lakes. The value of monitoring data was once again proven.

9. *Parties in Eastern Europe, the Caucasus and Central Asia:* The Task Force urged the ICP Waters Programme Centre to continue its efforts to include Parties in Eastern Europe, the Caucasus and Central Asia in Programme Centre activities.

10. *Chemical intercomparison:* Results from the twenty-sixth chemical intercomparison were reported. Sixty-eight laboratories from 26 countries participated. The quality of results was similar to that in former years. In total, 74 per cent of all results were acceptable. The chemical intercomparison is a valuable tool for quality assurance of laboratory analyses.

11. *Biological intercalibration:* Results from the fifteenth biological intercalibration of invertebrates were reported. Three laboratories from three countries participated. Ten laboratories participate on a regular basis in the intercalibration. The goal was to evaluate the quality and harmonize the taxonomic work.

12. *Participation in other groups under the Working Group on Effects:* Representatives of the ICP Waters Programme Centre actively participated in the meetings of the task forces of other International Cooperative Programmes, i.e., the ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems and the ICP on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends, as well as those of the Joint Expert Group on Dynamic Modelling.

13. *New ICP Waters reports:* Representatives of the ICP Waters Programme Centre informed the Task Force about three latest ICP Waters reports.[4,5]

B. A short summary of the report: Effects of long-range transported air pollution (LRTAP) on freshwater ecosystem services[6]

14. *What are ecosystem services?* The links between nature and the economy are often described using the concept of ecosystem services, or flows of value to human societies as a result of the state and quantity of natural capital. Ecosystem services fall into four broad categories: provisioning services, regulating services, supporting services and cultural services (see figure below). Provisioning services are the products obtained from ecosystems, such as food, fibre and wood/fuel. Regulating services refer to the regulation of, e.g., climate, water quantity and water quality. Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences. Supporting services are those

[4] Arne Fjellheim, Arne Johannessen and Torunn Svanevik Landås, *Biological intercalibration: Invertebrates 1612*. ICP Waters report 113/2012. Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

[5] Ivar Dahl, *Intercomparison 1226: pH, Cond, HCO3, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn*. ICP Waters report 111/2012. Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

[6] S. Holen, R. F. Wright and I. Seifert, *Effects of long range transported air pollution (LRTAP) on freshwater ecosystem services*. ICP Waters report 115/2013 (forthcoming).

that are necessary for the production of all other ecosystem services. The concept of ecosystem services has arisen in response to an increased need for making visible human dependency on nature and ecosystems, in order to ensure sustainable management and avoid irreversible damage to the ecosystems that ultimately will damage human welfare. Ecosystem services can capture a wider set of costs and benefits than those traditionally valued in economic analysis.

15. *Ecosystem services and surface water acidification:* Estimation of economic impacts and the costs and benefits of controlling acid rain has been an issue in Europe since the 1970s. However, uncertainties in the relationship between deposition and effects were so large that the role of cost-benefit analysis has been limited.[7] Ecosystem services can capture a wider set of costs and benefits, not traditionally valued in economic analysis.[8] Economic evaluation of damage to freshwater ecosystems by long-range transported air pollution is not straightforward because many of the ecosystem services are not traded in markets. There are many limitations to the economic evaluation of damage to ecosystems. Increased scientific knowledge improves capacity to value ecosystem damage or recovery, but some fundamental difficulties remain. Economic evaluation is limited to instances where the impacts of ecosystem damage on human welfare can be recognized and measured scientifically. Some aspects of acidification and recovery may also be so complex and/or uncertain that valuation scenarios may be too simplistic or even misleading.

16. *Provisioning services affected by surface water acidification:* Sport fishing is impaired in regions with acidified waters. Commercial fishing is also affected. Acid water is disadvantageous to the aquaculture industry because smolt production requires abundant freshwater of suitable quality for reproduction of trout and salmon. Water acidification also increases corrosivity, and thus increases corrosion of turbines for hydropower production and adversely affects other industrial uses of water.

17. *Regulating services affected by surface water acidification:* Lakes and rivers are important parts of the biogeochemical cycles of several major elements such as carbon, nitrogen and sulphur. Nitrogen is removed from the water by such processes as denitrification, uptake by algae and other plants, and is in part retained in the sediment. Removal of nitrogen thus means that less nitrogen flows to the sea, where it is often a pollutant and growth-limiting nutrient. Sulphur is also removed from water in lakes and rivers, mostly by reduction at the sediment-water interface and storage in the sediments. Removal of nitrogen and sulphur is related to the water flushing time. Acid deposition increases the flux of sulphate and nitrate from terrestrial catchments; a fraction of both is lost in lakes and rivers.

18. Lakes and rivers also modify the dissolved organic carbon concentrations. Organic carbon flowing from soils and wetlands in the terrestrial catchment is broken down by sunlight and microbial activity in lakes and rivers. Acid deposition is thought to depress the concentrations of organic carbon in run-off from terrestrial catchments. Lakes sequester carbon in sediments, and thus act as a sink for atmospheric carbon dioxide.

19. Nuisance growth of the aquatic macrophyte *Juncus bulbosus* has been observed in an increasing number of lakes and rivers in Europe. Among the consequences of such nuisance growth are reduced biodiversity, reduced suitability of the ecosystems for fish spawning, clogging of hydropower inlet screens and reduced suitability of the ecosystems for recreational uses such as fishing, boating and bathing. For rivers an enhanced supply of nitrogen appears to be a trigger for enhanced growth. Acid deposition may thereby promote growth of *Juncus bulbosus*.

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[7] Frederic C. Menz and Hans M. Seip, “Acid rain in Europe and the United States: an update”, *Environmental Science and Policy*, vol. 7 (2004), pp. 253–265.

[8] TEEB, *The Economics of Ecosystems and Biodiversity: Economic and Ecological Foundations* (London, Earthscan Publications Limited, 2010).

20. *Cultural services affected by surface water acidification:* Surface water acidification has major effects on the use of the ecosystems for recreation. Tourism declines in acid-impacted regions. Cultural losses have included the abandonment of traditional gathering of fish from mountain lakes by the local farmers, as a supplement to their food resources and income. In Norway, the disappearance of salmon in major rivers beginning in the 1920s meant the end of century-old traditions of salmon fishing and all the secondary supporting activities. The English lords no longer came to fish in rivers in southernmost Norway.

21. *Supporting services affected by surface water acidification:* For supporting services, impacts on biodiversity are probably the most significant effect of acidification. Acidification affects all trophic levels and all organism groups in freshwaters. The numbers of species decreases and, in the case of extirpation of fish, whole trophic levels can be lost. Acidified freshwaters no longer provide a suitable habitat for the full biodiversity characteristic of non-impacted waters.

22. *Valuation of sulphur and nitrogen emission reductions for ecosystem services of surface waters:* Ongoing work in both Europe and Canada indicates significant improvements in the ability to value in monetary terms the numerous potential benefits and costs of acid deposition abatement. Improvements in modelling and valuation increase understanding of the socioeconomic impacts of acid deposition policies. This can support more effective and efficient management strategies. A Canadian report presents a generic approach to environmental valuation for acid rain.[9] This approach follows four steps: pollution is emitted; pollution changes ambient air quality; ambient air quality has physical effects on humans and the environment; and physical effects are assigned monetary value based on their links to human beings.

23. Although environmental economic research has come a long way, there are still large gaps in understanding regarding the nature and value of acid deposition impacts. Despite the fact that some economic-evaluation modelling capacity currently exists, economic-evaluation models for acid deposition do not adequately account for environmental benefits resulting from abatement. Hence, future research efforts should focus on quantifying the benefits and costs associated with acid deposition effects on forest growth and productivity, recreational fishing, wildlife consumption and biodiversity.

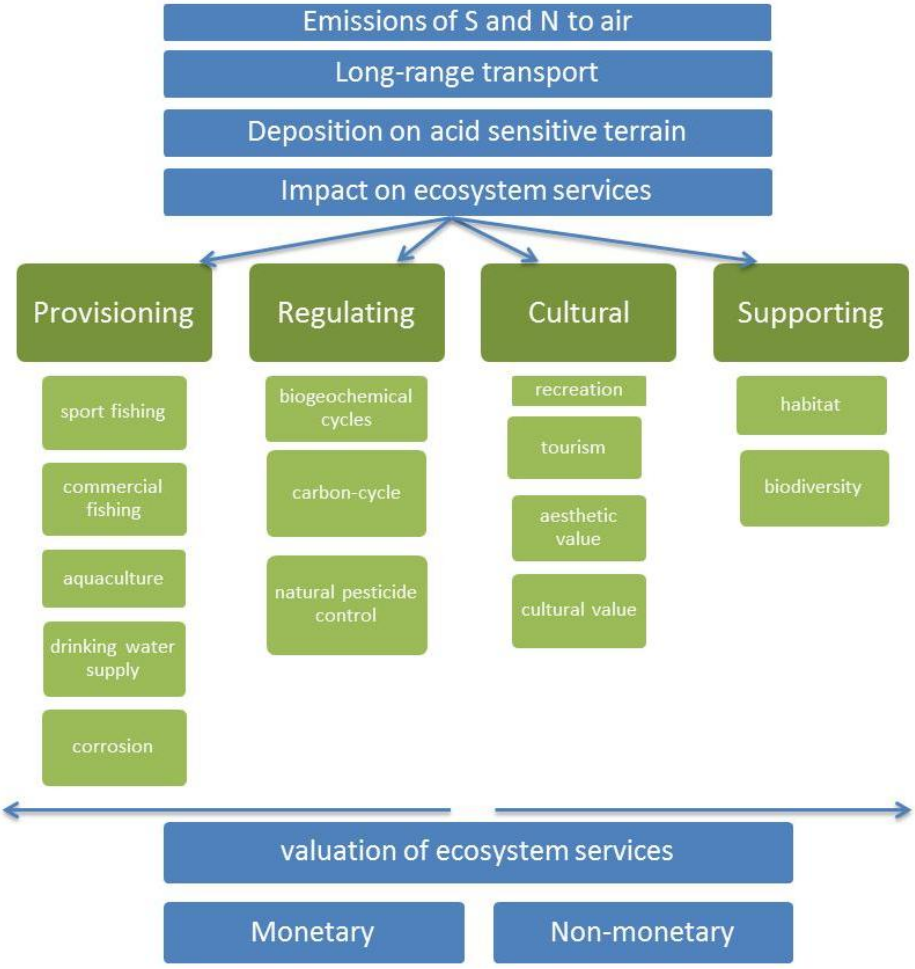
24. The implementation of measures in Europe and North America to reduce the emissions of air pollutants and thereby reduce acid deposition shows that society as a whole places a higher value on the terrestrial and aquatic ecosystems than the cost of implementing these measures. It is the total value of the ecosystem services provided, including aesthetic and ethical aspects that are not readily quantifiable in terms of economic value, as well as the more-easily quantifiable services such as loss of commercial fisheries, that have been judged to be worth the costs of emission reductions. This has not always been the case, however. An editorial in 1977 in the well-respected scientific journal *Nature* called acid rain a "million dollar problem with a billion dollar solution",[10] referring to the loss of salmon on the one hand and the cost of installing scrubbers for sulphur removal at power plants on the other. In Europe, the signing of the Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent in 1986 marked a turning point. Parties agreed that reducing emissions was worth the cost in terms of protection of the environment (i.e., protecting ecosystem services). Similarly, in the United States of America the signing of the Clean Air Act Amendments in 1990 entailed a commitment to reducing acid deposition, and thus the first step in protecting ecosystem

[9] Y. Bourassa, M. Donohue and F. W. Balesh, "Socio-economic impacts of acid deposition", in H. Morrison, ed., *2004 Canadian Acid Deposition Science Assessment* (Ottawa, Environment Canada, 2005).

[10] Anon., "Million-dollar problem — billion-dollar solution?", *Nature*, vol. 268, No. 5616 (July 1977), p. 89.

services. Also in Canada similar legislation was instigated to reduce acid deposition and impacts on ecosystems. Nevertheless, it appears that there has never been a thorough analysis of the total costs and benefits of reducing acid deposition in terms of ecosystem services.

Schematic links between emissions of air pollutants and impacts on freshwater ecosystem services



Note: Emissions of sulphur and nitrogen compounds to the atmosphere, followed by long-range transport and deposition of acid to sensitive terrain, causes acidification of freshwaters and damage to aquatic organisms. The many services provided to society by these ecosystems are thus affected. The loss of ecosystem services can be evaluated in terms of money: damage to fish means reduced income from commercial or sport fisheries, or in non-monetary terms, such as the diminishment of aesthetic value: a lake that has lost its fish is less attractive than a lake that has intact fish populations. The concept of ecosystem services is simply a means by which all these different types of environmental effects and their societal impacts can be evaluated together in a systematic manner.