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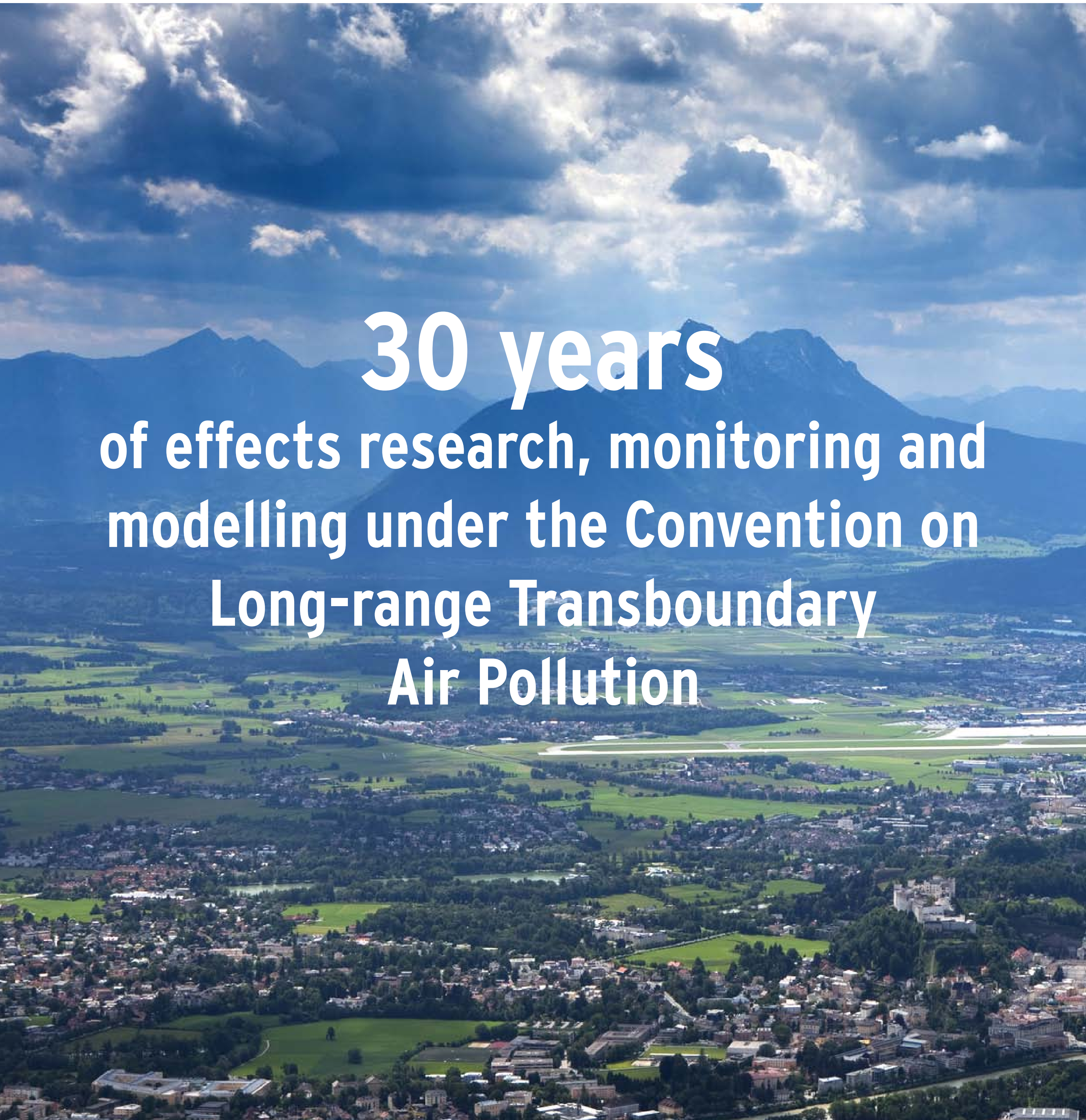
Working Group on Effects
of the
UNECE Convention on Long-range Transboundary Air Pollution

LRTAP
Long-range Transboundary Air Pollution

United Nations Economic Commission for Europe
Convention on Long-range
Transboundary Air Pollution (CLRTAP)

Working Group on Effects



30 years
of effects research, monitoring and modelling under the Convention on Long-range Transboundary Air Pollution

Clean air is essential for human health and well-being, for a healthy environment and biodiversity and for maintaining our cultural heritage. However, human activities such as combustion of fuel, other industrial and household processes and intensive agriculture result in pollution of the atmosphere. To monitor the impacts of air pollution on human health, the environment and materials the Working Group on Effects (WGE) was established in 1981. The WGE also makes predictions on impacts for the future based on various emission abatement strategies and taking climate change scenarios into account. After all, many air pollutants also contribute to the warming of our climate.

Effects research is important...

- Effects were the reason why the LRTAP Convention was established.
- The success of clean air policies needs to be measured in terms of effects.
- The existing close links between science and policy are considered as core strength of the LRTAP Convention and will continue to be crucial.
- Integrated effects assessment requires cooperative monitoring and research, including modelling and mapping.
- Close cooperation between WGE, EMEP and other Convention bodies provides an integrated approach to support air pollution abatement policies.
- There are still unsolved air pollution problems and new challenges are evolving.
- The air pollution effects programmes provide a strong basis for addressing interactions with effects of climate change.

1981 – start of a unique network of scientific Programmes

Established in 1980 as one of the working bodies of the Convention on Long-range Transboundary Air Pollution, the Working Group on Effects of Sulphur Compounds, later the Working Group on Effects (WGE), started its activities with the first meeting 1981 in Geneva.

Over the last 30 years...
The WGE has contributed to the demonstrable improvements the Convention has achieved, e.g. in reducing acidification of ecosystems, reducing the highest peak levels of ozone and the albeit considerably smaller reduction of emissions of nitrogen compounds.

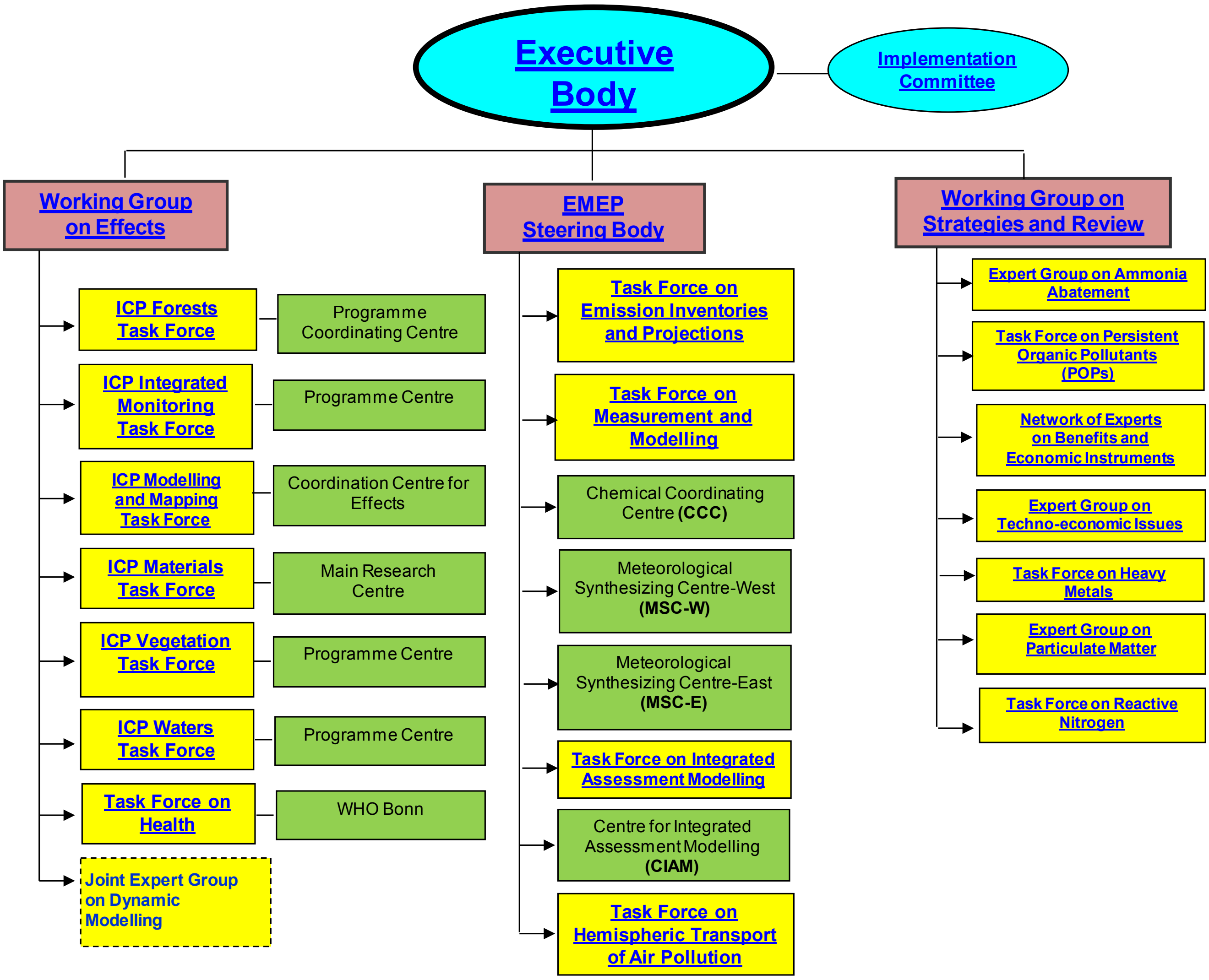


Figure 1: Working Group on Effects and intergovernmental bodies under the LRTAP Convention. http://www.unece.org/env/lrtap/WorkingGroups/wge/welcome.html
Lead Countries and institutions:
ICP Forests: Germany, Programme Co-ordinating Centre at vTI Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute for World Forestry, Hamburg. (http://www.icp-forests.org/)
ICP Integrated Monitoring: Sweden, Programme Centre at the Finnish Environment Institute (SYKE), Helsinki, Finland. (http://www.environment.fi/default.asp?contentid=361570&lan=EN)
ICP Modelling and Mapping: France, Coordination Centre for Effects (CCE) at the National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands. (www.icpmapping.org; www.rivm.nl/cce)
ICP Materials: Co-chaired by Sweden and Italy, Main Research Centre at the Corrosion and Metals Research Institute (KIMAB), Stockholm. (http://www.corr-institute.se/ICP-Materials/web/page.aspx)
ICP Vegetation: United Kingdom, Programme Centre at the Centre for Ecology and Hydrology, Bangor. (http://icpvegetation.ceh.ac.uk)
ICP Waters: Norway, Programme Centre at the Norwegian Institute for Water Research (NIVA), Oslo. (http://www.icp-waters.no/)
Task Force Health: European Centre for Environment and Health (ECEH), WHO Regional Office for Europe, Bonn, Germany. (http://www.unece.org/env/lrtap/WorkingGroups/wge/who.htm)

Today...

Six International Cooperative Programmes (ICPs) and a Task Force on Health Effects of Air Pollution (Task Force Health) form the WGE (Figure 1). Their work covers a variety of receptors (forests, surface waters, vegetation, materials and people) and addresses many interlinking environmental problems and causative pollutants: nitrogen enrichment ('eutrophication'), acidification, ozone, particulate matter, health effects, corrosion, contamination by heavy metals and persistent organic pollutants. A Joint Expert Group on Dynamic Modelling supports exchange of research between dynamic modelling efforts of the ICPs.

Current activities and future challenges

The tasks of the Programmes of the Working Group on Effects:

- Perform long-term monitoring in widespread networks across the UNECE region and case studies at plots and catchments with intensive measurements;
- Provide information on the degree and geographic extent of impacts on human health and the environment;
- Demonstrate inter-relationships between emissions and effects using policy relevant indicators;
- Conduct scientific research on dose-response functions to establish acceptable thresholds ('critical loads and levels');
- Apply models to evaluate the success of air pollution abatement policies.

Recently, a common effort of the Programmes has been the analysis of effects of different emission reduction scenarios for the revision of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol). The final results of this analysis will be reported by the end of 2011. In this brochure we mainly present selected other recent results of the ICPs and the Task Force Health.

The newly adopted Long-term Strategy of the Convention has led the WGE to extend its efforts on assessing interactions between the effects of air pollution, changes of climate and responses by ecosystems, materials and human health. Data sets and scientific experience of the Programmes provide a good basis for this task. Investigation and documentation of recovery of ecosystems and improvement of air quality for human health in response to decreasing emissions gain increasing importance in WGE's work. The Programmes also will gather basic information on effects of new substances of interest to the Convention such as black carbon.

Ambiguous effects of nitrogen deposition

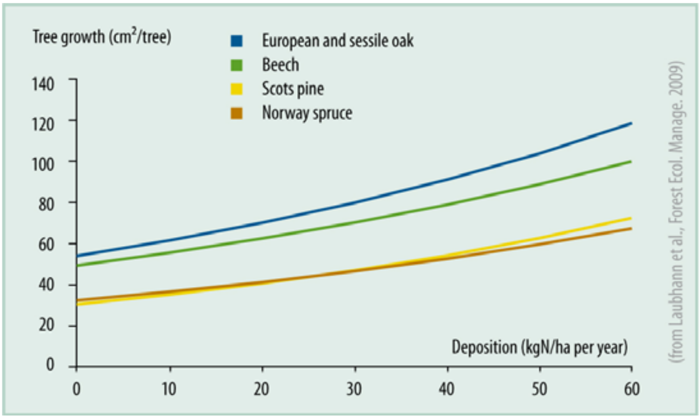
Reactive nitrogen accelerates growth but also causes environmental damage

Nitrogen deposition stimulates forest growth and thus carbon storage, but on the other hand causes nutrient imbalances leading to a destabilisation of forest stands. Balanced nutrient supply is at risk across wide areas of Europe through excess nitrogen deposition.

Trees absorb carbon dioxide from the atmosphere and store it in the wood as carbon. Net increment of wood provided, forests can help to mitigate climate change by acting as carbon sinks. Nitrogen deposition increased tree growth in the 1990s (Figure 2). The effect was smallest on soils that were already well supplied with nitrogen. Thus nitrogen saturation of the ecosystems might reduce the additional growth in future.

The C/N-index is a useful indicator for soil nutrient imbalances induced by excess nitrogen input. If this index is less than 1, the organic matter and nutrient cycling is most likely disturbed and forest health and vitality may be at risk. Such regions are mostly located in Central-Western Europe and parts of Central-Eastern Europe and the Baltic States (Figure 3). Furthermore, when C/N ratio in the forest floor is small and N deposition is high (> 20 kg N ha-1 yr-1), nitrates leach from the soil into ground- and surface waters. Excessive nitrogen leads to eutrophication and biodiversity losses.

Figure 2: Tree growth in relation to nitrogen deposition (based on nearly 400 ICP Forests intensive monitoring plots, 1994 – 1999). An annual nitrogen deposition of 1 kg/ha corresponded to an average increased tree growth of approximately 1% leading to an average carbon fixation in tree stems of about 20kg/ha per year.



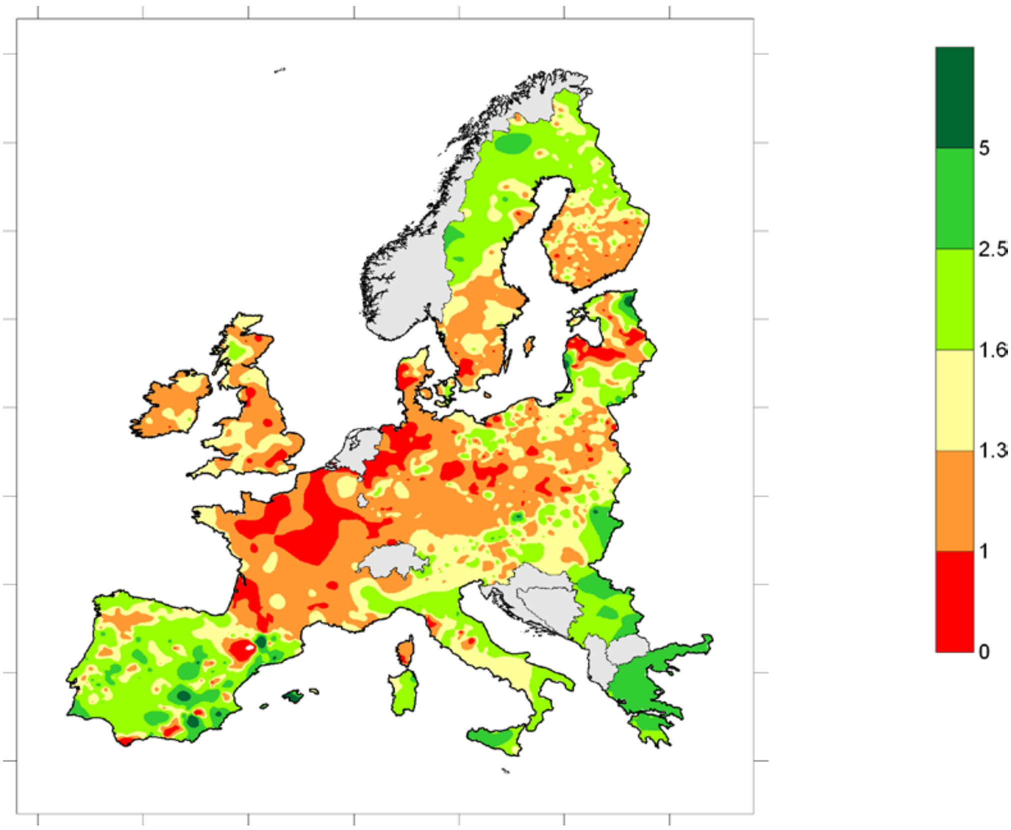


Figure 3: Kriged map of European areas with forest soil C/N-index based on the second soil survey (more than 4 000 ICP Forests monitoring plots, 2004 and 2008, co-financed by the EU). Excess nitrogen deposition leads to nutrient imbalances and destabilisation. Affected area, where C:N index is less than 1, is indicated in red (De Vos and Cools 2011).

Surface water chemistry is gradually improving

Lakes and rivers in Europe and North America show strong signs of chemical recovery in response to reduced acid deposition

Surface water quality in acid-sensitive areas has improved strongly in Europe and North America since the 1980s. The consistent pattern of chemical recovery (decreasing sulphate, and increasing pH and alkalinity) across a large number of sites is the strongest evidence that emission control programmes are having their intended effect.

Monitoring data from the ICP Waters programme document that the reductions in acid deposition are mirrored in improved water quality in most regions. In many areas, water quality is now sufficient for the return of acid-sensitive species of fish, invertebrates and mussels.

About 70% of the 200 investigated sites show significant declines in non-marine sulphate during 1990-1999 and 1999-2008. The rates of decline tend to be smaller in the latter period. Most sites show no significant trends in nitrate for either period. There are multiple controls of nitrate leaching from catchments. Sulphate is still the far most important acidifying anion in acidified surface waters.

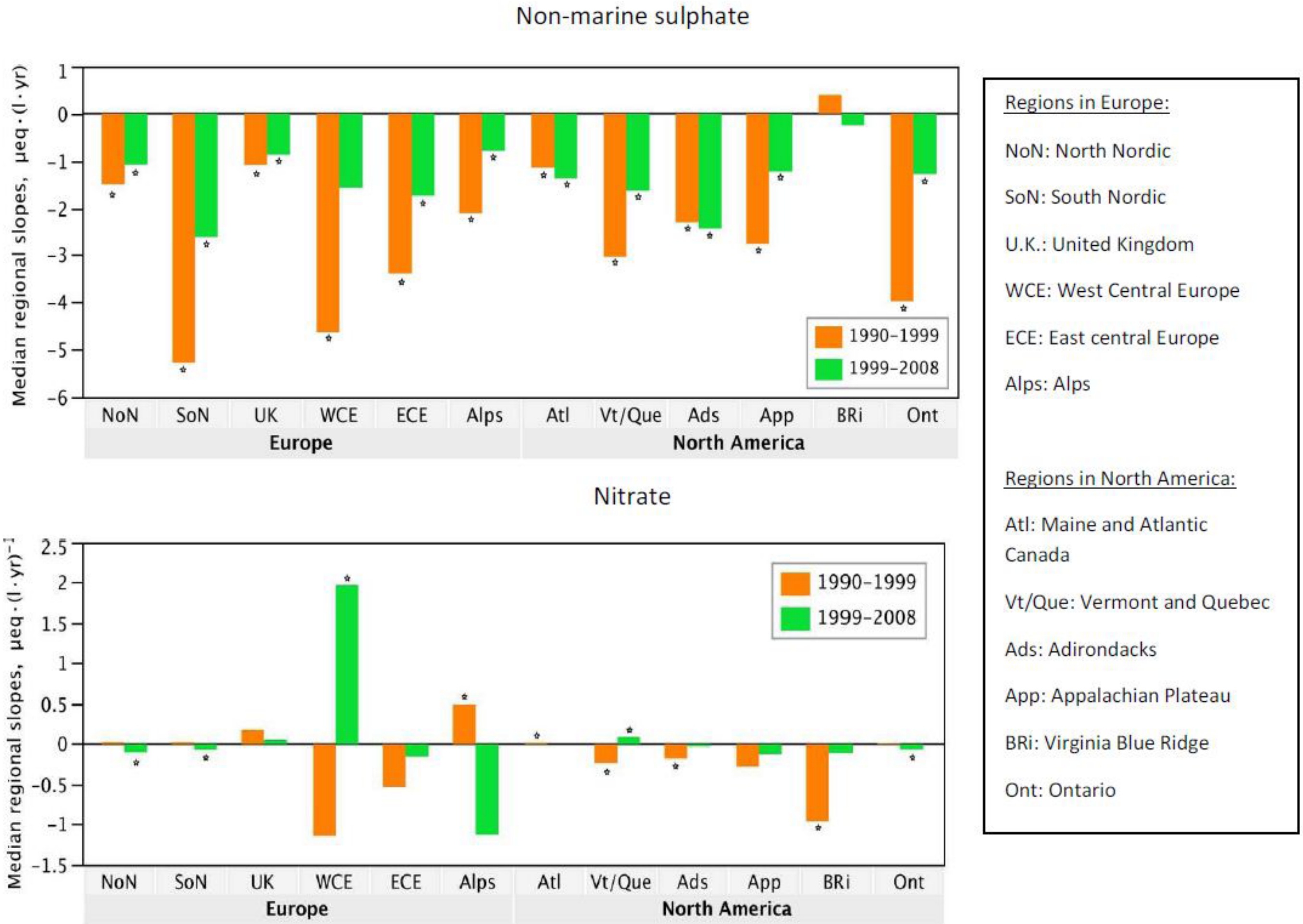


Figure 4: Yearly changes in the concentrations of sulphate and nitrate in different regions in Europe and North America. A long bar indicates large yearly changes, while a short bar indicates small changes. The bars over the midline indicate increasing concentrations while the bars under that line indicate decreasing concentrations. The changes are calculated for the timespan 1990-1999 (red) and 1999-2008 (green). An asterisk indicates if the change is statistically significant.

Observations confirm modelling results

High nitrogen deposition leads to nitrate leaching in sensitive ecosystems

The critical loads and levels approach is a key instrument for developing emission reduction policies under both UNECE CLRTAP and the EU. Testing, validation and further developments of the key concepts in the critical loads mapping approach is therefore important. The long-term detailed ICP Integrated Monitoring dataset permits an evaluation of the link between critical thresholds of the ecosystems and empirical impact indicators.

Regarding nitrogen enrichment ('eutrophication') of terrestrial ecosystems, there is evidence on the link between exceedance of critical loads of nutrient nitrogen and nitrogen leaching (Figure 5), whether the critical load was calculated with a mass balance model or an empirical critical load was used. At the most acidified or acid-sensitive ICP Integrated Monitoring sites, the critical load of acidification for aquatic ecosystems was exceeded to a higher degree, than at other, less sensitive sites (Figure 6). These results support the use of the critical loads approach in the integrated assessment modelling.

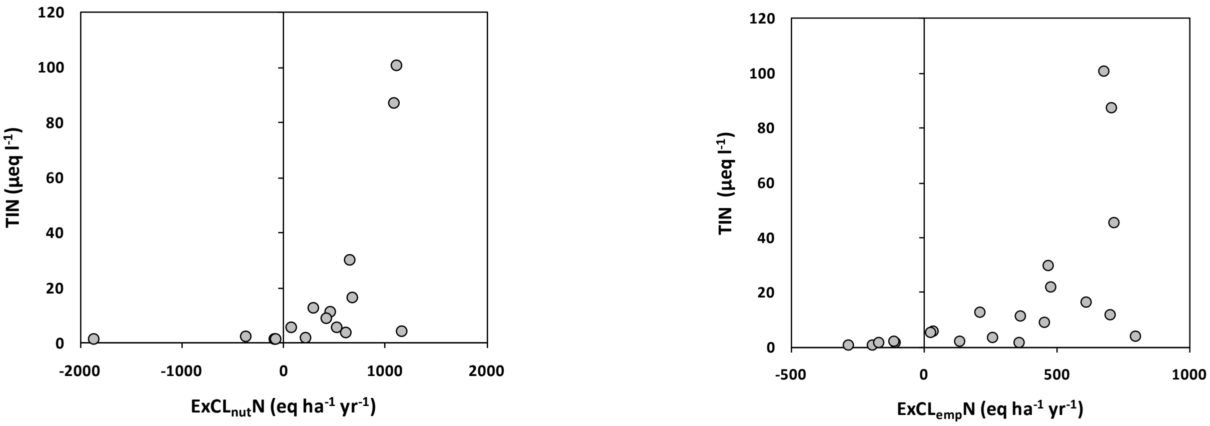


Figure 5: Exceedance of critical loads vs. annual mean concentrations of inorganic nitrogen (TIN = NO3+NH4) in runoff based on national data for the year 2000 (NAT2000 scenario) at 15 – 21 ICP Integrated Monitoring sites. a) Exceedance of critical loads of mass balance nutrient nitrogen for terrestrial ecosystems (ExCLnutN), b) Exceedance of empiricaål values of critical load for nutrient nitrogen (ExCLempN). Negative values indicate non-exceedance of the critical loads.

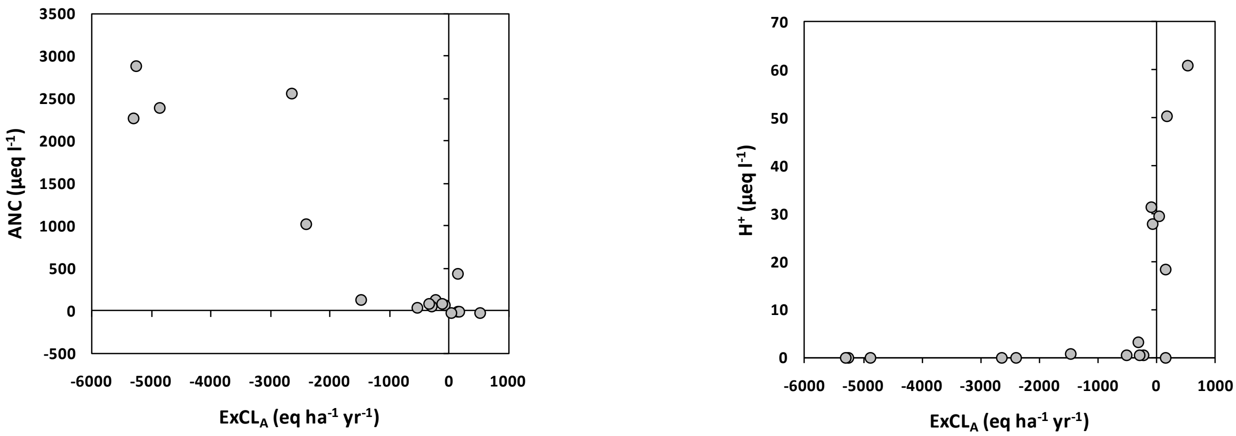


Figure 6: Exceedance of critical load of acidification (ExCLA, NAT2000 scenario) for aquatic ecosystems vs. annual mean concentrations of a) Acid Neutralising Capacity (ANC) and b) hydrogen-ion (H+) in runoff for 18 ICP Integrated Monitoring sites. Negative values indicate non-exceedance of the critical loads.

Budgets calculations prove accumulation of heavy metals

Deposition of CLRTAP priority heavy metals (Pb, Cd and Hg) leads to high retention and accumulation in soils, especially in the forest organic layer in ecosystems and catchments. Indications of negative effects on the biological systems of soils have been found. Metals cause direct threats on the terrestrial environment and, if discharged, also on the aquatic environment. A specific hazard chain rises by mercury methylation, uptake in fish and fish consumption by humans.

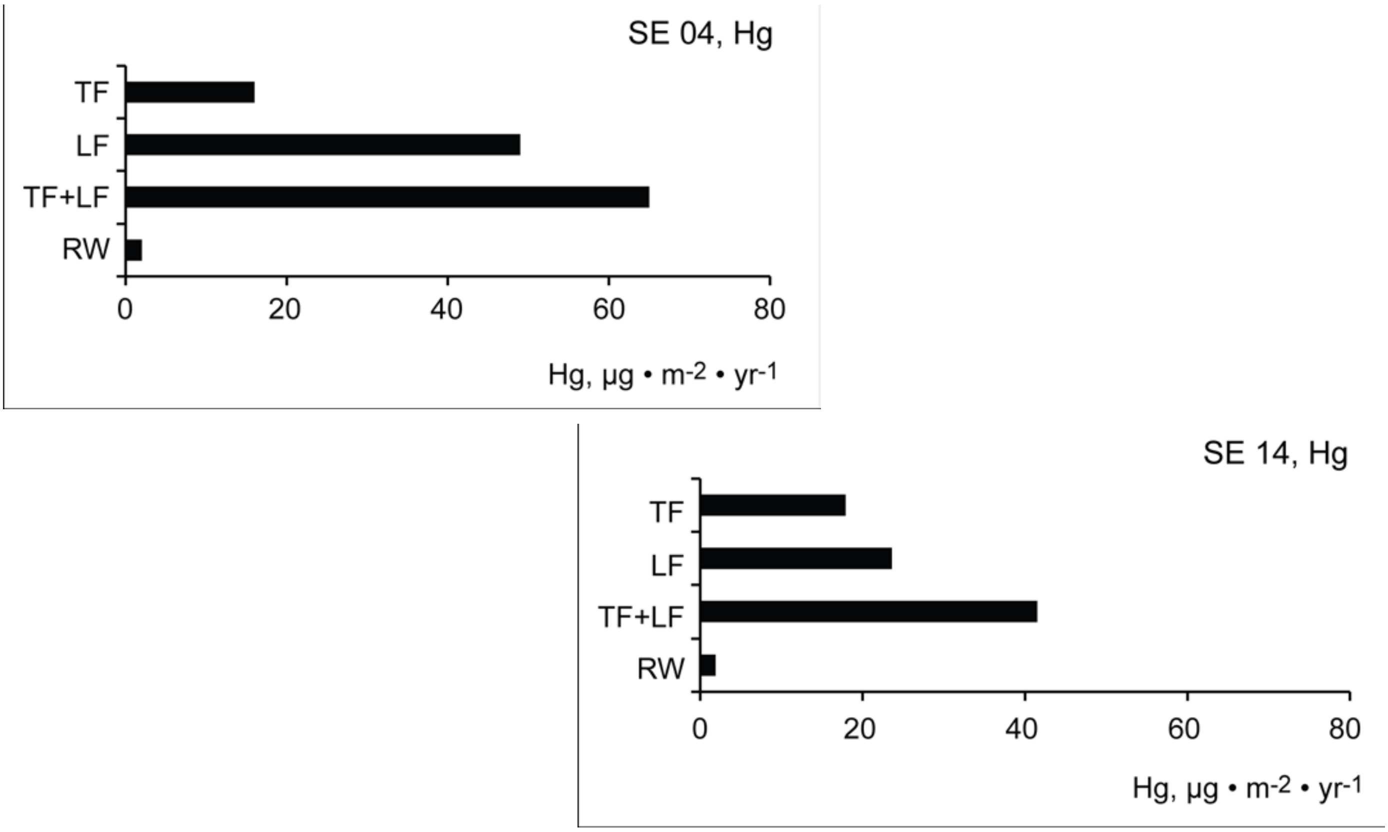


Figure 7. Mercury (Hg) input and output for two Swedish catchments (SE 04: Gårdsjön, SE 14: Aneboda) in the period 2000-2009. The input by throughfall (TF) and litterfall (LF) giving total input TF+LF clearly exceeds the output by runoff (RW).

Ozone-induced crop losses and declining heavy metal deposition

Crops and natural vegetation are affected by tropospheric ozone

Ground-level ozone causes widespread damage to many species of crops (Figure 8) and other vegetation in Europe. Hence, ozone has a negative impact on food security and ecosystem services such as carbon storage in vegetation. Percentage yield losses and economic losses due to ozone effects on wheat and tomato were estimated to be 13.7% and 9.4%, and 3.20 and 1.02 billion Euro respectively in EU27+Norway+Switzerland in 2000, based on modelling ozone uptake (Figure 9).

Figure 8: Ozone-induced visible injury on lettuce in Greece (Source: D. Velissariou)

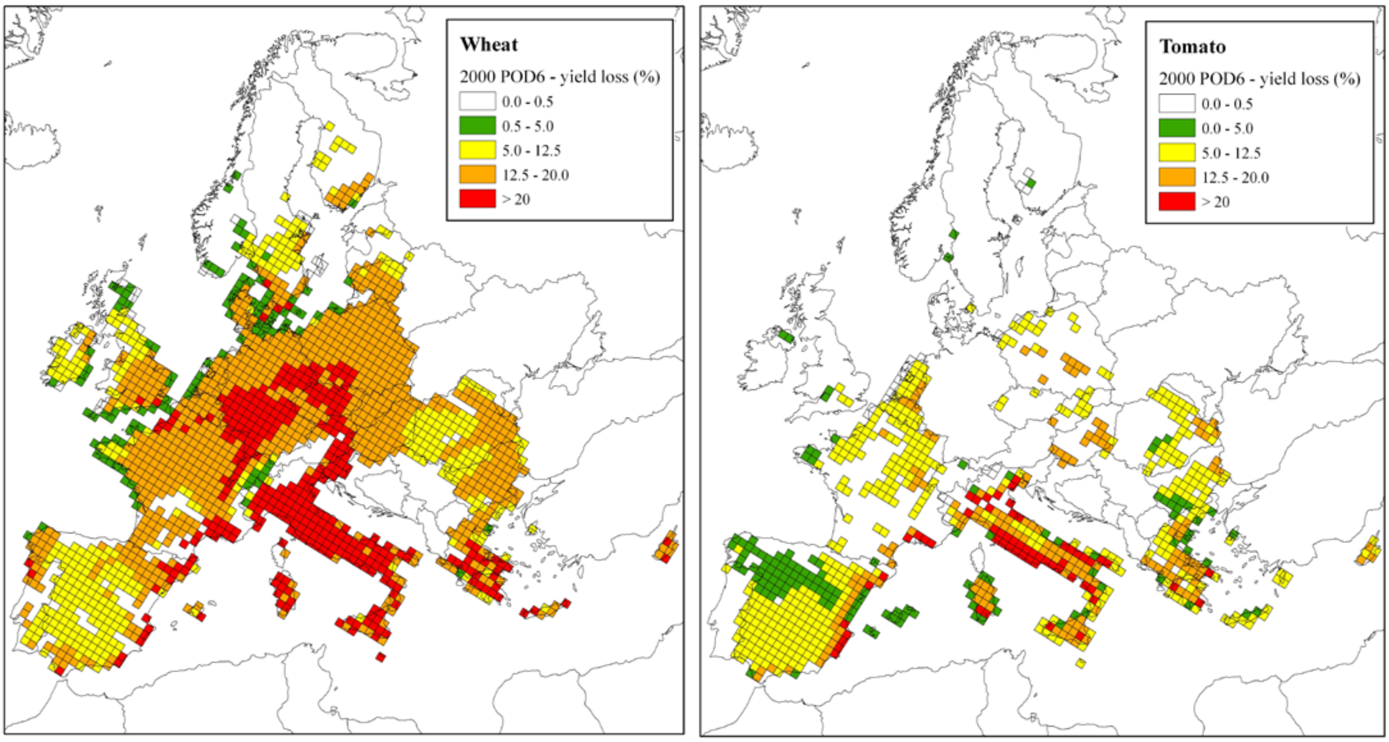
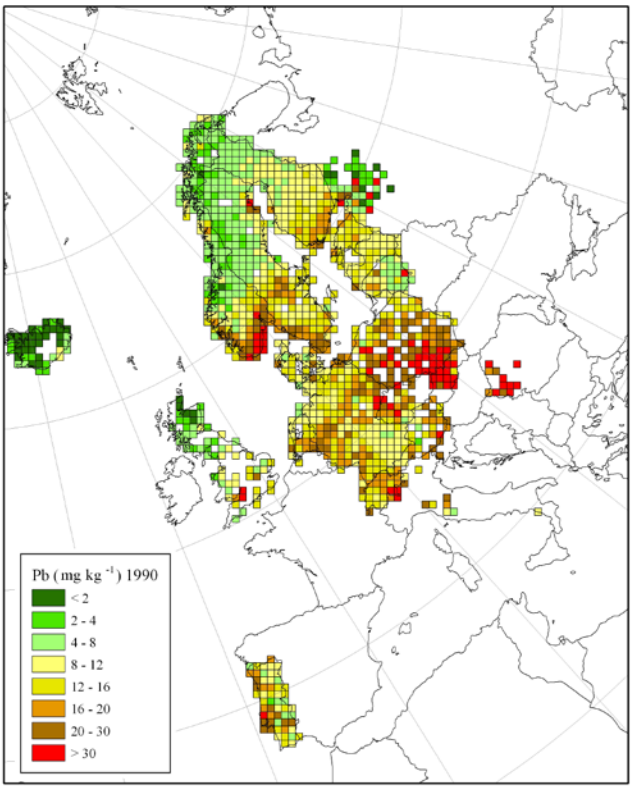
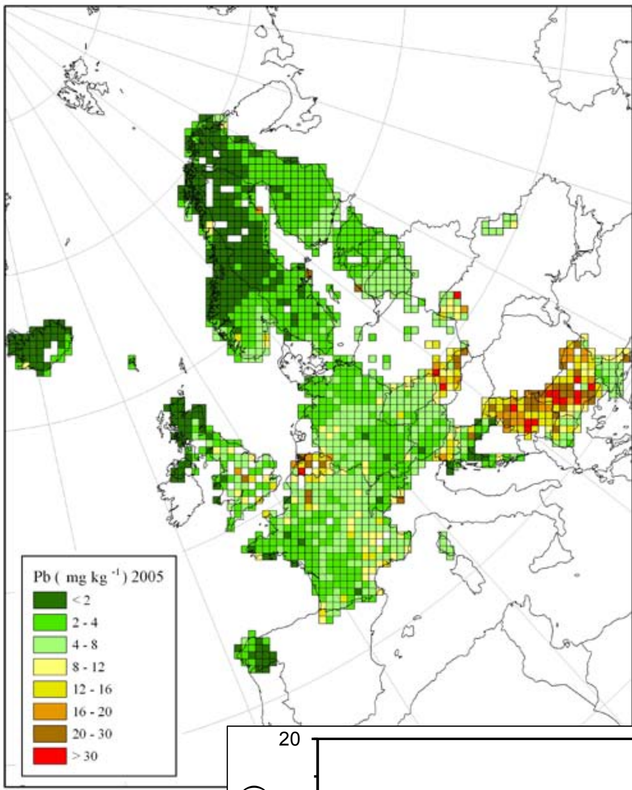


Figure 9: Yield losses of wheat (left) and tomato (right) due to ozone pollution in 2000, based on modelling ozone uptake (Source: ICP Vegetation and EMEP/MSC-West)

Mosses indicate reduced heavy metals deposition

The implementation of the Convention's Protocol on Heavy Metals has resulted in a considerable decline in the deposition of heavy metals to vegetation. Phasing-out leaded petrol has resulted in an average decline of lead concentrations in mosses across Europe of 72% between 1990 and 2005.





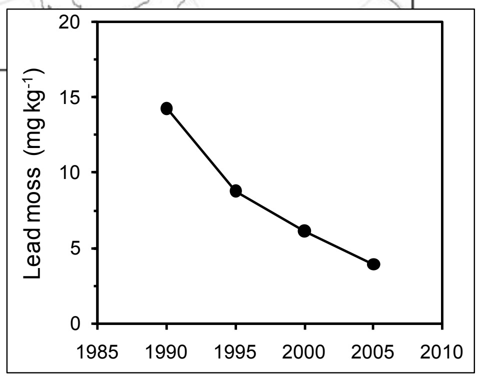


Figure 10: Decline in lead concentrations in mosses between 1990 and 2005

Modelling and Mapping of effects, risks and trends – useful instruments to inform policy

Eutrophication continues to be a widespread problem in Europe

ICP Modelling and Mapping intensively collaborates with other ICPs and EMEP by including effect-based indicators in policy relevant models and assessments that are applied by the Task Force on Integrated Assessment Modelling.

Under the baseline scenario, the risk of eutrophication (Figure 11 a) in 2020 will affect about 40 % (50 % in 2000) of the natural area in Europe (60 % in the EU 27). The computed area at risk of acidification is shown to decrease from about 10 % in 2000 to 4 % in 2020 (Figure 11 b).

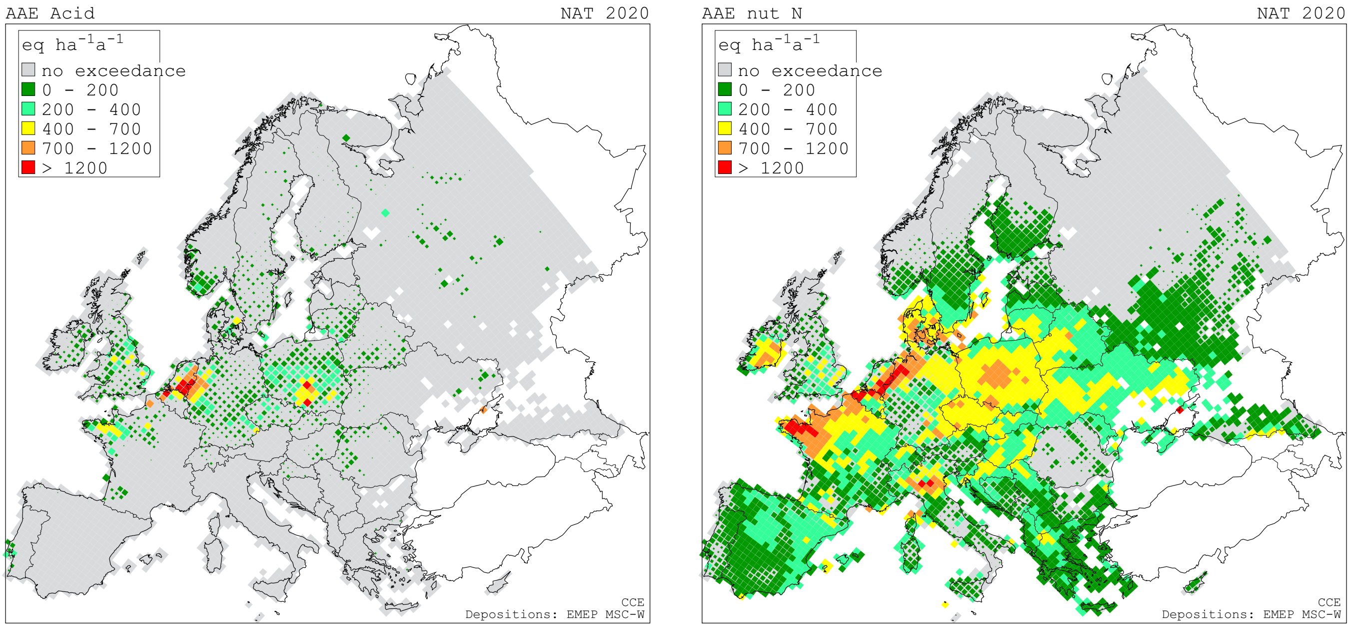


Figure 11: Map of critical loads exceedance for a) acidification and b) eutrophication in 2020 under baseline scenario (CCE status report 2010). Red and grey shading indicate the areas at highest (exceedance > 1200 eq ha-1a-1) and no risk respectively.

Excessive nitrogen deposition is computed to lead to a significant change of plant species diversity in at least 4% of Europe's natural area, especially covering a broad area in central Europe (Figure 12).

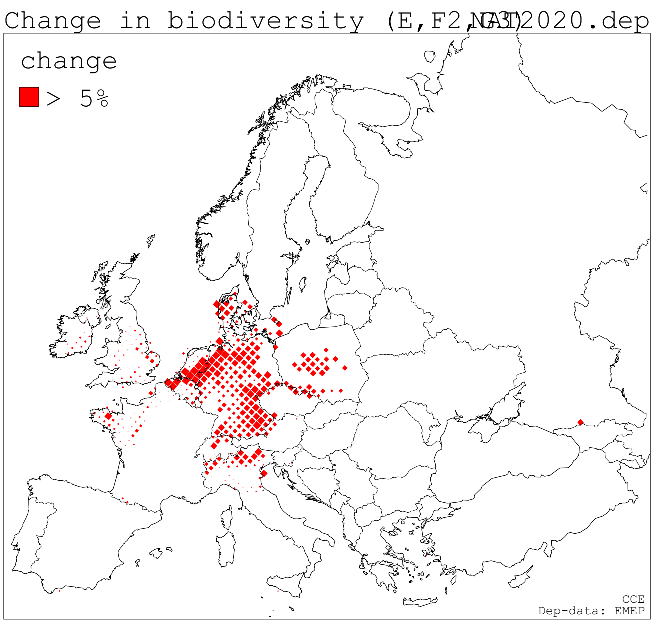


Figure 12: Areas where the change in species is expected to be greater than 5% due to nitrogen deposition by 2020. Considered ecosystems are semi-natural grasslands, arctic and (sub)alpine scrub habitats and understorey vegetation of coniferous boreal woodlands (CCE Status report 2010)

Assessment of critical loads of heavy metals suggested that exceedances were more widespread and of greater magnitude for mercury than for lead whereas cadmium exceedances were restricted to small areas of the EMEP domain (Figure 13). Critical concentrations of mercury in rainwater turn out to be exceeded in nearly all grids for which data was provided by National Focal Centres.

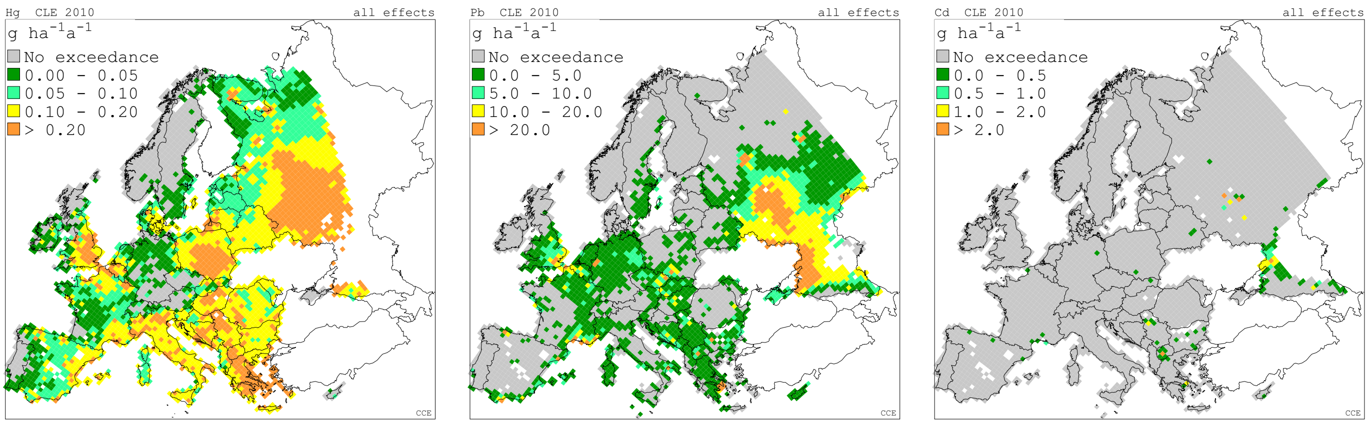


Figure 13: Exceedance of critical loads for mercury (a), lead (b) and cadmium (c) for 2010 based on the current legislation scenario (CCE Status report 2010).

Current policies not sufficient to protect human health

Thousands of life years lost in Europe due to air pollution

It has been estimated that fine particulate matter reduced life expectancy by ca. 8.6 months in Europe in 2000, with the effects ranging from 3 to 14 months between countries. Reduction of primary particulate matter as well as precursor gases due to the full implementation of current legislation is estimated to reduce these impacts by ca 40% by 2020.

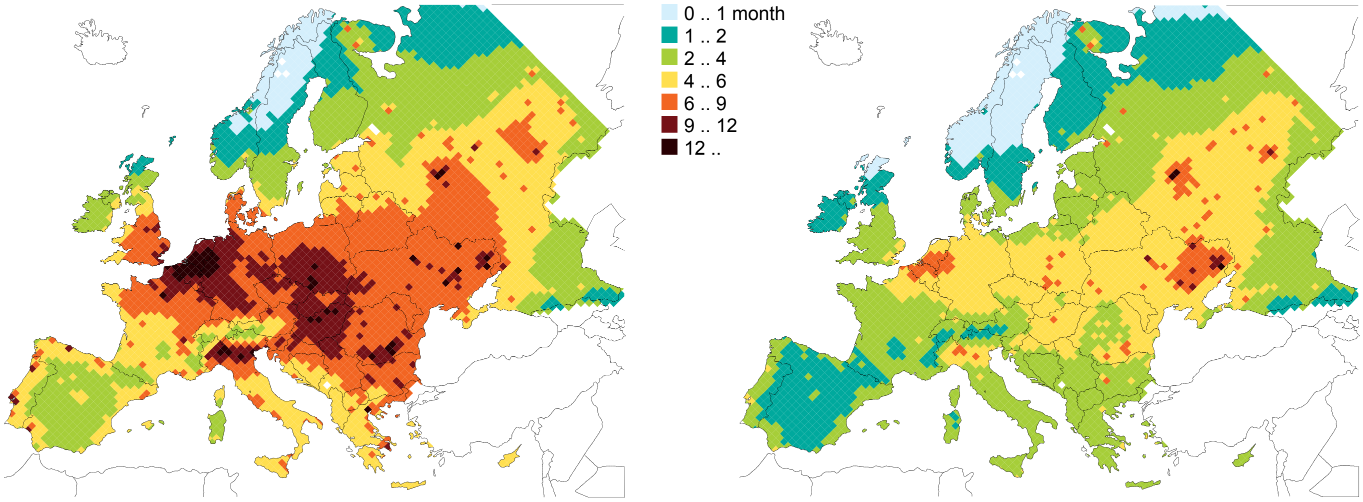


Figure 14: Loss in statistical life expectancy that can be attributed to the identified anthropogenic contributions to PM2.5 (in months) for emissions in 2000 (left) and emissions of the baseline scenario for 2020 of the Clean Air for Europe Programme (right), source IIASA.

Ozone in high concentration affects health, leading to ca. 21 000 premature deaths annually in 25 EU countries. Current policies are not expected to reduce population exposure and health effects attributed to ozone significantly, though ca. 1/3 of the effects could be prevented by implementation of the maximum technically feasible reduction of ozone precursor emissions. Further policies and actions will be needed to reduce the remaining health impacts of particulate matter and ozone in Europe.

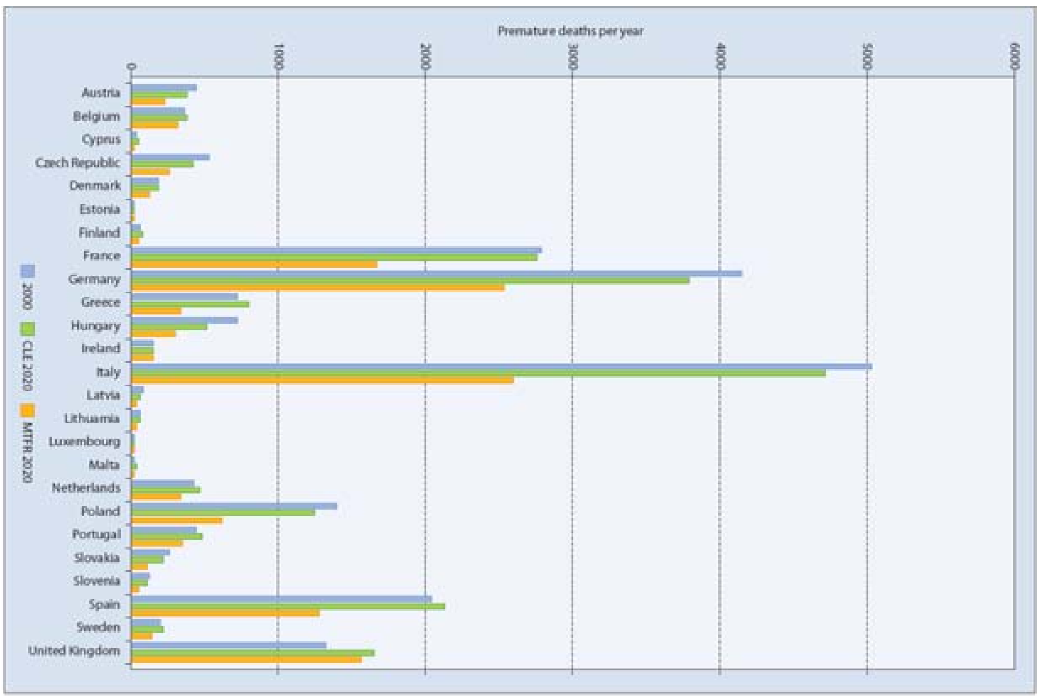


Figure 15: Estimates of cases of premature death per year attributable to ozone for the Clean Air for Europe Programme baseline scenario (2000) and predictions based on current legislation and maximum technically feasible reduction scenarios with climate change effects included.

Saving costs by reducing air pollution effects on materials

While corrosion is reduced, soiling raises in importance
Implementing the second Sulphur Protocol within UNECE resulted in corrosion cost savings of 6.6 billion € per year in Europe. During 1987-1997 corrosion decreased by 50% but since the turn of the century corrosion levels are constant. In 2008-2009 corrosion values above 2020 targets were still recorded in 12% of the sites testing effects on carbon steel, in 21% for zinc and 48% for limestone , the indicator materials for protecting infrastructure and cultural heritage. While corrosion decreases (Figure 16), soiling of buildings due to black carbon and other particles are becoming more important. ICP Materials has calculated PM10 target levels, 20 μg m-3 for 2020 and 10 μg m-3 for 2050 based on a tolerable loss of reflectance and reasonable maintenance intervals.

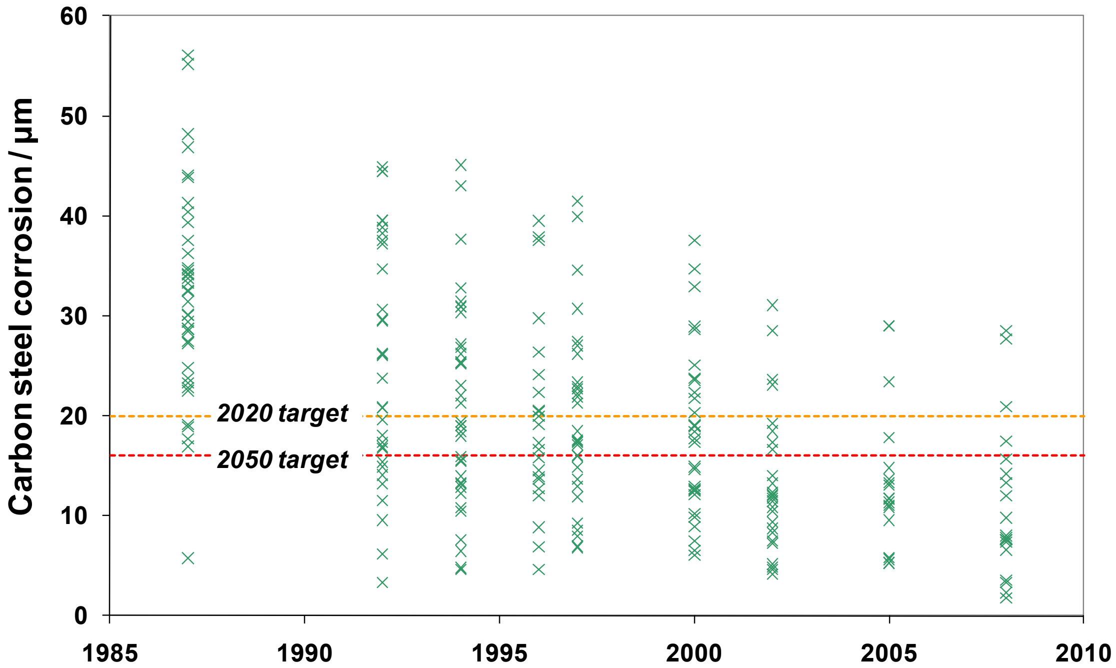


Figure 16: Carbon steel corrosion in the period 1987-2008 measured at ICP Materials test sites. Dashed lines indicate targets for protecting infrastructure and cultural heritage for 2020 and 2050.

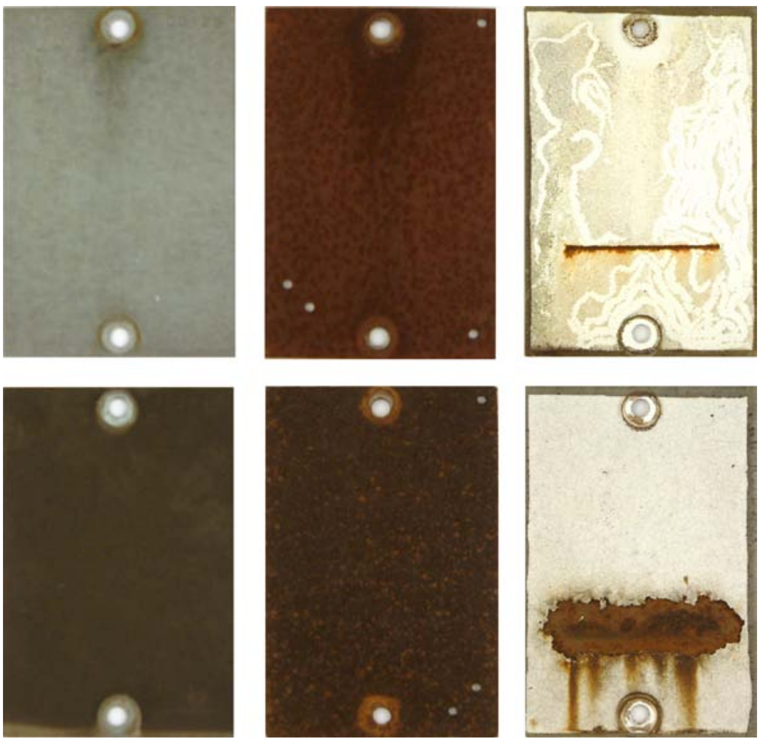


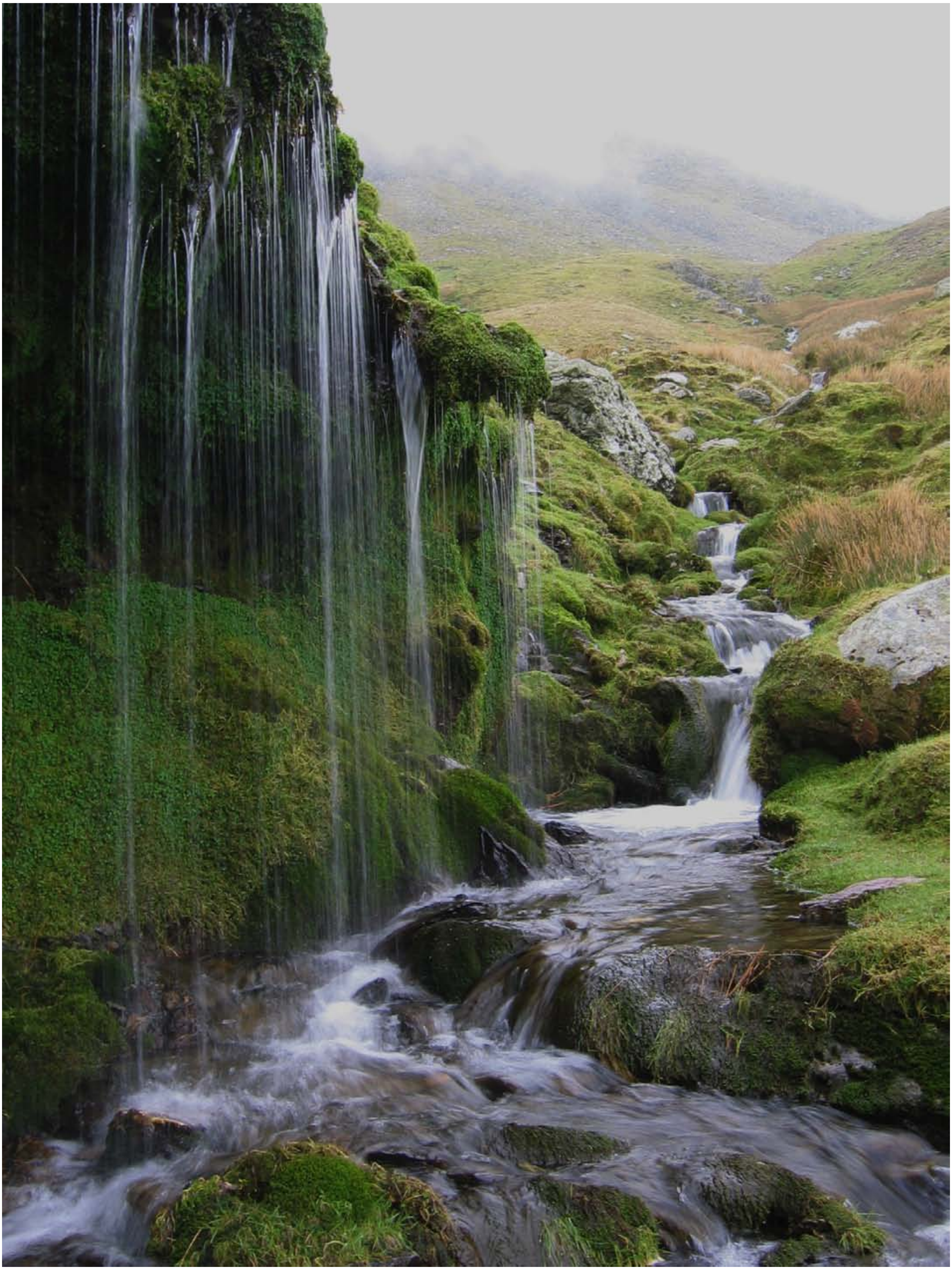
Figure 17: Exposed corrosion samples. The painted steel samples were deliberately scratched before exposure in order to simulate, for example, a stone chip hitting the vehicle lacquer.

Moving forward

For 30 years the science conducted by Working Group on Effects has underpinned policies in the fight against air pollution. The Convention on Long-range Transboundary Air Pollution is currently negotiating stricter air pollution targets for 2020 and has developed aspirational targets for 2050. The Working Group on Effects recognizes the importance of an integrated approach to combat air pollution and climate change, and therefore also assesses the impacts of air pollution in a changing climate.

Active participation of the Parties (including the European Commission) to the Convention in the effects-based activities has been vital for the delivery of high quality data from national monitoring programmes and research and will remain vital for future success. In return, many Parties as well as the European Commission, will continue to benefit from the use of methodologies, databases and results produced by the Working Group on Effects. The Working Group on Effects is aiming to engage more Eastern European and Central Asian countries in its future activities and supports capacity building in these countries.

Realizing the global impact of air pollution, the Working Group on Effects plans to further its global cooperation by providing methodological guidance on the impacts of air pollution to other regions such as Asia, Latin America and Africa.



Imprint

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