PART II – Chapter 26

Forest monitoring in Europe and its importance to clean air policies and sustainable forest management

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Abstract: Forest monitoring in Europe provides information relevant to clean air policies, political processes related to sustainable forest management (SFM), and regional forest policy-making. This holds true in particular for the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe. ICP Forests reveals effects of air pollution on forests, conducts risk assessments, and assesses the effectiveness of air pollution abatement measures. Its results contribute to the scientific basis for clean air policies under CLRTAP. CLRTAP is a particular success story. Since 1980, emissions of SO_2 have been reduced by 80% to 90%. Since 1990, emissions of NOx and VOCs were reduced by about 50%. One of the reasons for the successful implementation of CLRTAP is the close connection of monitoring, science, and policy. A driving factor has been public awareness of the threats of air pollution to human health, ecosystems, and materials. ICP Forests also develops models describing relationships between air pollution, carbon fluxes, climate change, and biodiversity and substantiates the positive effects of clean air policy on SFM. It provides information on several SFM indicators to the report *State of Europe's Forests* that, together with the outlook studies on the forest sector, contributes valuable input to forest policy-making.

Keywords: Forest monitoring, Europe, air pollution, sustainable forest management, forest politics

26.1 Introduction

Several international processes of environmental and forest policies are relevant to sustainable forest management (SFM) with respect to forest health, forest growth, forest biodiversity, climate change, carbon fluxes, and air pollution. Air pollution is known to affect the structure and functioning of forest ecosystems in many parts of the world. In Europe air pollution was among the first environmental challenges to SFM to be recognised as requiring international scientific and political action due to its transboundary impact. Symptoms of forest decline reported from many parts of Europe from the late 1970s onward were largely attributed to sulphur (S) and nitrogen (N) compounds transported through the atmosphere over long distances (Schütt 1979, Manion 1981, Ulrich 1981). The forest decline became one of the main drivers for negotiations for Europe-wide air pollution control within the Convention on Long-range Transboundary Air Pollution (CLRTAP). Established in 1979 under the United Nations Economic Commission for Europe (UNECE) as a response to the threats of acidification to aquatic and terrestrial ecosystems, CLRTAP agreed on the terms for air pollution control throughout Europe based on scientific information and evidence. It has adopted a series of legally binding protocols on the reduction of emissions of S, N, ozone (O_3), heavy metals (HM), volatile organic compounds (VOCs), and persistent organic pollutants (POPs). During the past three decades CLRTAP and related air-pollution-control policies of the European Commission (EC), have succeeded in improving air quality and reducing pollutant deposition (EMEP 2004).

In 1985, in order to facilitate the collection of policy-relevant forest information, CLRTAP established the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) (Lorenz 1996). In 1986 the European Union (EU) adopted Council Regulation (EEC) No. 3528/86 on the Protection of the Community's Forests Against Atmospheric Pollution. This triggered a close cooperation between the EU and ICP Forests for about two decades. Long-term monitoring by ICP Forests revealed that damage symptoms not only developed less dramatically than originally feared but also could be – across all Europe – explained mainly by tree age, insects, fungi, weather conditions, and other natural factors (e.g. Lorenz 2004). Also, the increasing forest growth in many parts of Europe did not support the thesis of large-scale forest dieback across Europe due to air pollution (Spiecker et al. 1996). Research on forest damage as well as results from the long-term intensive monitoring, however, provided evidence that some hypotheses on the effects of air pollution held true in many forest ecosystems in Europe (e.g. De Vries et al. 1995, Augustin et al. 2005, Elling et al. 2007). Results from ICP Forests showed that critical loads of air-pollutant deposition were exceeded at the majority of the forest monitoring sites and that implementation of legally binding protocols under CLRTAP would lead to a recovery of forest soils from acidification (Lorenz et al. 2008). The attention of politicians and the general public to the effect of air pollution on forests has decreased as the first signs of recovery of forests soils and improvements of the condition of trees became evident. This lack of attention to air pollution and forest damage is risky since both are closely related to carbon fluxes, climate change, biodiversity, and SFM (Lorenz et al. 2010).

The forest decline observed in Europe from the late 1970s also raised concerns in other forums about forest ecosystems not being able to fulfill their ecological, economic, and social functions. These concerns stimulated the establishment of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 1990, now Forest Europe (FE). FE facilitates high-level cooperation among the 47 signatories in Europe, including the EU. Under the leadership of the responsible ministers, FE works to strengthen SFM in order to maintain the multiple benefits that forests provide to society.

The aim of the present chapter is an analysis of the relevance of

- forest information for-clean air policy and SFM processes
- clean-air policy to SFM
- SFM monitoring and reporting to regional forest policy-making

Section 26.2 describes the political and scientific accomplishments of CLRTAP and highlights observed and predicted benefits of clean-air measures to forest ecosystems. Section 26.3 provides an overview of the international SFM processes and their implications for regional forest policy-making. Section 26.4 draws conclusions and provides recommendations on the further implementation of monitoring, clean-air policy, and SFM in Europe.

26.2 The Convention on Long-range Transboundary Air Pollution

26.2.1 Background and aims of CLRTAP

Transboundary air pollution was recognised as a problem deserving international attention about 1970. Acidification of lakes and streams and the extinction of fish in Scandinavian countries attracted international interest, and the problem was addressed within the Organization for Economic Co-operation and Development (OECD). The organisation also conducted the first survey of the new phenomenon, leading to the conclusion that atmospheric pollutants were transported across borders to such an extent that coordinated action of several countries was needed (OECD 1977). This led to the establishment of an international treaty – CLRTAP, signed in 1979 under UNECE (UNECE 1979). Initially, some countries envisaged firm commitments as part of the convention but negotiations resulted in a framework convention where commitments had to be added as protocols.

Provisions on scientific research, monitoring, and other scientific and technical support to CLRTAP were already an integral part of the convention text. Atmospheric monitoring had started under the European Monitoring and Evaluation Programme (EMEP) umbrella a couple of years earlier and cooperative monitoring of effects was also mentioned in the original text of CLRTAP. One year later, in 1980, the Working Group on Effects (WGE) was established under CLRTAP in order to address monitoring and assessment of air pollution effects on "human health and the environment, including agriculture, forestry, materials, aquatic and other natural ecosystems, and visibility, with a view to establishing a scientific basis for dose/effect relationships designed to protect the environment."

Table II 26.1 Protocols under Convention on Long-range Transboundary Air Pollution.

Protocol	Signed	Entered into force	Revisions
Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)	1984	1988	
Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	1985	1987	
Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes	1988	1991	
Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	1991	1997	
Protocol on Further Reduction of Sulphur Emissions	1994	1998	
Protocol on Heavy Metals	1998	2003	2012
Protocol on Persistent Organic Pollutants (POPs)	1998	2003	2009
Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.	1999	2005	2012

26.2.2 The protocols under CLRTAP

Adoption of first protocols

Under CLRTAP, eight protocols have been signed and adopted (Table II 26.1). All but the first protocol, which was an agreement on the financial support from EMEP, address the reduction of emissions of atmospheric pollutants. It took considerable time to agree on the need for costly action to reduce air pollution exposure and effects. Acidification of lakes and streams, which mainly was considered to be a Scandinavian problem, was not considered reason enough to justify action in the rest of Europe. However, forest damages on the European continent, in particular those observed in Germany, changed the opinion of policy-makers. A change in position of the West German government opened the way for constructive negotiations on common reductions. *Waldsterben* (the German word for forest dieback) became well-known all over Europe at this time as a synonym for complex forest damages due to air pollution.

Discussions on reductions were initiated within CLRTAP and resulted in the first sulphur protocol in 1985. The agreement was to reduce 1980 sulphur emissions by 30% by 1993. Though the protocol was signed by a large number of countries, a few, such as Poland and the United Kingdom, did not sign. The United Kingdom in particular strongly argued at this time against the control of sulphur emissions. The protocol was also seen as a first step towards further emission reductions.

The 1985 sulphur protocol was followed by similar protocols: for nitrogen oxides (NO_x) in 1988 and volatile organic compounds (VOCs) in 1991. The NO_x protocol was essentially an agreement not to increase emissions, while the VOCs protocol stipulated a 30% reduction in emissions by 1999.

Protocols and the critical loads concept

When the sulphur protocol was signed in 1985, there was a general understanding that proposals for further reductions should be based on scientific evidence. One step in this direction was the development and inclusion of critical loads and levels as a basis for effects-based emission control. Critical loads were defined as "a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (Nilsson and Grennfelt 1988). The concept was applied primarily to forest soils and surface waters and Parties to the Convention were asked to map the sensitivities of their ecosystems, i.e. the critical loads. From these maps and corresponding deposition maps it was then possible to derive maps of the exceedances on critical loads. The methods, criteria, and indicators used are given in the ICP modelling and mapping manual (ICP Modelling and Mapping 2010).

The critical loads concept was accepted as a basis for further protocols in 1988 and, together with cost-effectiveness of abatement measures, it paved the way for the second sulphur protocol, signed in 1994. The protocol reflected a completely new way of thinking in international environmental control; parties signed up for emission reductions based on cost efficiency and on the critical loads concept. Thus, the protocol resulted in reduction requirements – emission ceilings – that varied among countries.

The signing of the second sulphur protocol was intended to be followed by a new protocol for NO_x. While acidification was the only effect to be addressed by the sulphur protocols, the use of the critical loads concept for the control of NO_x became much more complicated. Emissions of NO_x contributed to many effects such as acidification, eutrophication, and formation of tropospheric O_3. Moreover other compounds contributed to these effects, in particular sulphur for acidification, ammonia for eutrophication, and VOCs for O_3 formation. Instead of a new protocol for NO_x, however, CLRTAP further developed the structure for the second sulphur protocol to include several compounds and several effects. This extended structure was the basis for implementation of the Gothenburg Protocol signed in 1999. This new protocol took into account acidification of surface waters and soils, eutrophication of terrestrial ecosystems, and vegetation effects from tropospheric O_3. In addition to NO_x the Gothenburg Protocol required control of sulphur dioxide (SO_2), ammonia, and VOCs. The target year for this protocol was set to be 2010.

Within CLRTAP, the scientific support to policy is organised through the Task Force on Integrated Assessment Modelling (TFIAM). Through this body, dose-effects data (e.g. critical loads exceedances) and source-receptor relations are linked with emission control options in order to form optimal solutions for emission control.

Even if the achievements of CLRTAP were substantial, there were still needs for further control of air pollution in Europe. Critical loads were still exceeded in many areas, especially with respect to nitrogen deposition; if ecosystems damaged from acid depositions were to be recovered within a reasonable time, further emissions reductions were necessary. The protocols needed therefore to be renegotiated to attend to additional requests on control. The Gothenburg Protocol was therefore renegotiated, and in May 2012 a revision of the protocol was signed. This time, however, the main driving force shifted from ecosystems to health effects – it became evident that several hundreds of thousands people die every year in Europe from air pollution effects. The protocol included updated requests on emission reduction on the main compounds of the protocol with 2020 as the target year. As a consequence of the increased interest in health effects, particles ($PM_{2.5}$) were included for the first time in an international agreement. Though ecosystem effects are still important, due to significant progress in emission reductions for SO_2, the main interest has become eutrophication effects due to nitrogen deposition. Another main component of the revision is that it can be signed by countries that did not sign the original protocol (e.g. Russia and Belarus). Even if the new emission ceilings for most countries are significantly lower than those in the original protocol signed in 1999, committed levels for 2020 are in line with what is already achieved with present legislation. This means that countries are not willing to agree on more stringent commitments than those already decided through national and EU legislation.

Implementation of protocols by countries

Over the 30 years the CLRTAP has been in force, emission reductions have been considerable. Emissions of SO_2 from land-based sources in Europe are today 80%–90% lower than in the 1980s, and those of NO_x are about half of what they were at their peak about 1990, as are emissions of VOCs. Limited progress was recorded only for ammonia (Table II 26.2).

Large emission reductions are achieved through several measures. Emission standards at the EU and national levels have probably been the most important factor for emission reductions of S and NO_x so far. However, the political and subsequent economic changes in Europe after 1989 were also important factors leading to considerable reductions in sulphur emissions. The first significant European standards were agreed upon under the Council of the European Communities (CEC) at the end of the 1980s and were directed towards large combustion plants and motor vehicles. These standards in many cases required installations of flue gas purification systems (e.g. desulphurisation equipment in coal-fired plants, and catalytic converters on gasoline cars). Later these standards were improved and introduced into many other areas.

In addition, emission reductions have been achieved through changes in energy and industrial production means and processes, such as conversion from coal to natural gas and use of nuclear power. Energy conservation and efficiency have also contributed to emission reductions. Process-related emissions from industry have also been reduced substantially – the pulp and paper industry is a point in case. Until the 1970s, many plants for production of chemical pulp were based on non-recoverable chemicals. The conversion to recoverable chemicals and introduction of energy efficiency measures reduced emissions in many areas to only fractions of previously recorded emissions. After the year 2000, legislation on emission reductions expanded into new areas such as emissions from off-road vehicles and

Table II 26.2 Emission reductions of SO_2, NO_x and ammonia within EU27 between 1990 and 2010. Data from EEA 2012. Emissions of nitrogen oxides expressed as NO_2.

	1990 1000 tonnes	2010 1000 tonnes	% change
Sulphur dioxide	24 857	4575	–82
Nitrogen oxides	17 143	9162	–47
Ammonia	5018	3799	–24

the marine sector.

Emission reductions are to a large extent also observed in the downward trends in atmospheric concentrations and deposition. Atmospheric deposition of sulphur has been reduced by more than 70% since 1990 over large areas in Europe, and the deposition of oxidised nitrogen (from NO_x emissions) declined by about 30% over the same period.

26.2.3 The value of a science-based approach

Scientific research, monitoring, and modelling, as pointed out earlier in this chapter, are a requisite part of CLRTAP. This is manifested by the existence and role played by its two scientific bodies, EMEP and WGE. The link between these two bodies and the policy body, Working Group on Strategy and Review (WGSR), is of great importance. One example of these interactions is the development of "blame matrices" through which the transboundary transport of pollutants between countries were quantified. Transboundary transport of atmospheric pollutants was both a scientific and a policy issue in the early phase of international cooperation. It was important not only to demonstrate that air pollution was transported across boundaries but also to quantify the exchange of pollutants between countries. Quantitative estimates on transport were used in the international negotiations to show the transboundary nature of pollutants as well as the benefits to be gained by common actions. Another such example is the critical-loads concept. The concept was easily accepted by policy-makers as a way to quantify the long-term needs for control, but it was also of interest to the scientific community since it pointed to the importance of differentiating natural processes from those that are human induced. Within the CLRTAP framework, much scientific work was carried out to search for and quantify critical thresholds for environmental effects (Posch et al. 1999).

Science has evolved to encompass new considerations, for example, air pollution effects on biodiversity and the need to take into account recovery of damaged ecosystems. In all new scientific work, monitoring of the effects has been of utmost importance and the establishment of monitoring programs under WGE in the mid-1980s was therefore one of the most important decisions of the convention. These so-called International Co-operative Programmes (ICPs) cover various media such as forests, water, and materials and include a centre for coordinating the inventories of critical loads. Forests and forest issues are covered not only by ICP Forests but also partly by ICP Integrated Monitoring, which is directed towards integrated analyses of ecosystems processes and effects; by ICP Vegetation, which mainly covers ozone effects to vegetation; and by ICP Modelling and Mapping, through which data from mapping critical loads are collected and compiled for policy purposes.

The monitored time series, now covering more than 25 years, have been used for the development and validation of new models and in particular for the verification that reported emission reductions result in expected ecosystem improvements.

26.2.4 The importance of public awareness

Public awareness has been crucial to the success of air pollution control in Europe. The obvious signs of damage, in particular fish extinction in Scandinavian lakes and rivers about 1970 and the forest damages on the European continent about 1980 have been important drivers. Both the fish extinction and forest damages triggered alarming headlines and political debates that brought the issue to the attention of the highest international political levels. Acidification was mainly seen during the 1970s as a phenomenon limited to some lake areas in Northern Europe. After the warnings from continental scientists on the forest situation, the concern extended to the rest of Europe, making international negotiations on control easier. At about the same time, North America faced a similar development, as both the acidification of lakes and forest damages were problems that received a great deal of attention both from the public and at the highest political level.

At the end of the 1980s, public interest decreased and other environmental problems such as the depletion of the stratospheric O_3 layer became a priority. After 2000, public interest has focused more on air pollution effects on human health than the need to control air pollution for its effects on nature.

26.2.5 The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

Approach of ICP Forests

ICP Forests has implemented a standardised forest monitoring system in the pan-European region that addresses two different scales by means of two different levels of monitoring intensity. Level I addresses large-scale monitoring of the spatial and temporal variation of forest health and vitality. It also includes the assessment of foliage chemistry, soil condition, and species diversity. As large-scale information alone is difficult to interpret with respect to natural and anthropogenic changes in environmental conditions, Level II addresses monitoring on the forest-ecosystem scale to determine cause-effect relationships and to quantify processes. In this way thresholds, i.e. critical limits, can be found, above (or below) which forest ecosystems are expected to react to air pollution and environmental stress. This information permits risk assessments and scenario analyses of future development of forests in Europe. Cause-effect relationships identified at the ecosystem scale may in some cases be applied to data assessed at the large scale. This scaling up allows comprehensive large-scale scenario analyses. With its more than 6800 large-scale and more than 760 ecosystem-scale plots in 39 countries of Europe, and with Canada and the United States of America contributing national reports, ICP Forests constitutes one of the largest forest monitoring programmes in the world.

Towards the monitoring of SFM indicators

ICP Forests has benefitted greatly from large-scale forest-monitoring data assessed by EC under Regulation (EC) No 2152/2003 (Forest Focus). Under that regulation, the EU Member States had assessed soil and biodiversity data on the Level I plots using ICP Forests methods. Moreover, assessments of cause-effects relationships and the building of models became possible by a revision of the monitoring system that was financially supported by EC under Regulation (EC) 1655/2000 and Regulation (EC) 1682/2004 (LIFE+). According to its Green Paper on Forest Protection and Information in the EU (SEC 2010, 163 final), EC has recognised the need for harmonised, reliable, and comprehensive information on forests. The paper acknowledges that such information is needed to ensure that forest policy-making brings greatest benefits in socio-economic and ecological terms. It also refers to the reporting obligations of EU towards the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CDB).

Because of its multidisciplinary approach, the monitoring system of ICP Forests provides information beyond air pollution, also addressing the relationships between forest health and vitality, air pollution, carbon fluxes, climate change, and biodiversity. Transnational results relevant to SFM are also used in reporting by FE (Forest Europe et al. 2011). FE defines SFM as "stewardship and use of forest lands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality, and their potential to fulfil now and in future, relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems." This definition considers the long-term ecological, economic, and social functions as well as the biodiversity, productivity, regeneration capacity, and vitality of forests. Compliance of forest management with that definition of SFM is validated against a set of six pan-European criteria endorsed by FE. Fulfilment of these criteria is evaluated through a set of 35 quantitative and 17 qualitative indicators (Forest Europe et al.2011). ICP Forest is the international data provider for SFM Indicators 2.1 (Deposition of air pollutants), 2.2 (Soil condition), and 2.3 (Defoliation).

Data assessed by countries under ICP Forests are often useful to countries for meeting national reporting obligations towards international conventions and processes. This is the case, for instance, for data on carbon pools in forests (above-ground and below-ground biomass, deadwood, litter, and soil organic matter) provided to UNFCCC under its inventory of greenhouse-gas emissions and removals resulting from human-induced "land use, land-use change, and forestry" (LULUCF). Information on forest species diversity (tree species and ground vegetation species) is reported to CBD. The large-scale annual harmonised assessments of damage types (e.g. biotic damage such as pests and diseases) as well as damages of unknown origin can be seen as an early

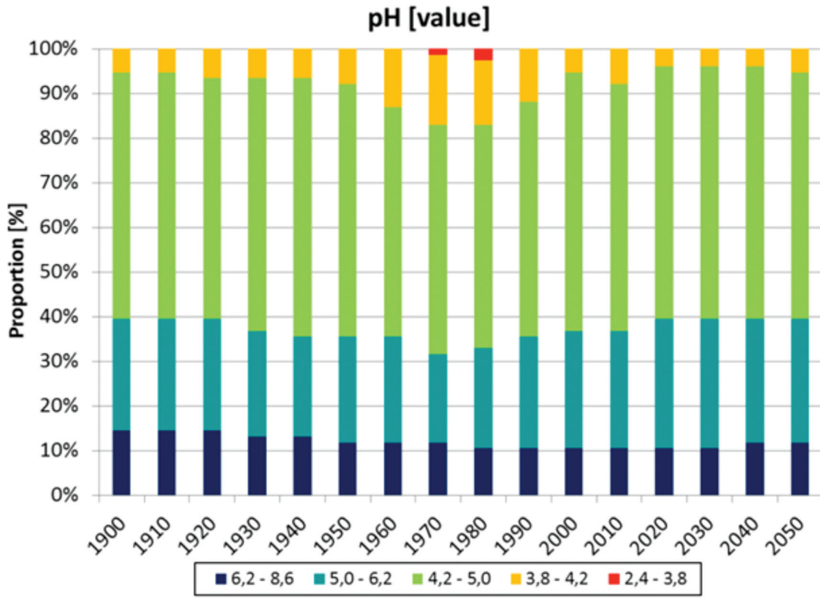

Figure II 26.1 Trend of pH value in soil solution on 77 Level II plots in terms of buffering classes (Nagel et al. 2011).

warning system. Also relevant to the understanding of threats to SFM are model calculations based on ICP Forests data. The data permits the description of nutrient, carbon, and water cycling in forest ecosystems and contributes to assessing risks from, for example, nutrient imbalance and exceedances of critical deposition loads as well as climate change and drought. Analyses of these data contribute to a better understanding of carbon fluxes as well as the development of forest health and species diversity under different scenarios of forest management, climate change, and atmospheric deposition. Results of these analyses enable ICP Forests to verify the effectiveness of clean air policies and of some aspect of forest management.

Policy-relevant monitoring results

The results collected by ICP Forests provide evidence of the negative effects of air pollution on forest ecosystems. For instance, in 2004, through fall of acidity exceeded the critical loads (see 26.2.2) on one-fourth of 186 Level II plots and of N on two-thirds of the plots (Lorenz et al. 2008). The critical limit of N for nutrient imbalances was exceeded in the soil solution in 50% of the measurements (organic soil layer of Level II plots) on all 173 plots assessed (Iost et al. 2012). Augustin et al. (2005) found high S contents in needles and leaves on German Level I plots, weakly correlated with defoliation. The plant biodiversity model BERN (Schlutow and Huebener 2004) was applied to 20 Level II sites for estimating probabilities for the growth of different plant communities depending on present geo-ecological site conditions. The adaptability of existing vegetation to future site conditions was calculated assuming a deposition scenario with full implementation of current national emission legislation in all countries of the EU. Even under this scenario, there are eight plots (of 20) on which the present main tree species would not be adapted to the site conditions under the deposition situation to be expected (Schlutow et al. 2011).

There is also, however, evidence of the positive effects of clean air policies on forests. For instance, the reduction of air pollution emissions (see 26.2.2) is reflected by decreasing through fall deposition under the forest canopy in several studies (e.g. Lorenz et al. 2010). For 106 Level II plots in 17 countries, critical loads for acidification and eutrophication as well as their exceedances were calculated, using the simple mass balance approach (ICP Modelling and Mapping 2010). By means of the VSD+ model (Bonten et al. 2011), the future development of soil parameters was calculated for different pollution scenarios on 77 Level II plots. Results show widespread soil acidification in the year 1980, with nearly 60% of the plots affected by critical load exceedances. A continuing positive trend is expected until 2020, leading to full protection at least under the most ambitious deposition-reduction scenario. Critical loads for nutrient N were exceeded also on 60% of the plots in 1980 and will continue to exceed by 2020 on 10–30% of the plots, depending on the deposition scenario. While the C/N ratios will decrease, soil-solution pH can recover to pre-industrial values on all 77 plots (Figure II 26.1) (Nagel et al. 2011). There are also signs of recovery of trees. There is a correlation between the decrease in defoliation of *Pinus sylvestris* in Europe since 1994 and the decrease in S deposition. This holds true particularly in regions of previously high S deposition and defoliation in parts of Poland, the Czech Republic, the Slovak Republic, and part of the Baltic States (Lorenz 2004).

26.3 Regional processes for SFM

26.3.1 International processes and their networks

Forest policy and management in Europe are under the direct or indirect influence of a significant number of processes and organisations. Within the EU, forestry matters are addressed, for instance, within the council Working Party on Forestry and the Standing Forestry Committee of the European Commission. However, many Directorates General (DGs) have a stake on forest issues: DG Energy with biomass, DG Environment for issues related to forest biodiversity and its conservation, and DG Agriculture and Rural Development and DG Enterprise for the productive side of forests, in particular regarding wood industries. All of them touch upon, address, and certainly contribute to SFM in the region. However, those processes and organisations pursue their own agendas based on different understandings of SFM. At the pan-European level, a series of other organisations and processes also exert influence.

First, UN bodies such as the Food and Agriculture Organization (FAO), European Forestry Commission (EFC), and the UNECE Committee on Forests and the Forest Industry (COFFI) have a long history of deliberating on how to assess and improve SFM in the region. According to its mandate, the EFC is to "advise on the formulation of forest policy and to review and coordinate its implementation at the regional level; to exchange information and, generally through special subsidiary bodies, advise on suitable practices and action with regard to technical and economic problems, and to make appropriate recommendations in relation to them foregoing." Together with COFFI, whose mandate is, among others, to "provide member countries with the information and services which they need for policy- and decision-making as regards their forest and forest industry sector, formulate recommendations addressed to member governments and interested organisations," the EFC provides a solid platform for policy advice at the pan-European level.

Over the years other processes have contributed to SFM worldwide and regionally under the aegis of UNEP (United Nations Environment Programme). Biodiversity conventions, for instance, such as CBD and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), have specifically addressed forest biodiversity or species whose habitats are found in forests. Their legally binding character and outreach has contributed to a wide understanding of SFM practices and their positive effects on the conservation of biodiversity.

In the case of COFFI and EFC, the proximity of policy advice to information gathering and sharing has allowed policy dialogues very much based on scientific evidence and data. A recent example pertains to wood energy. Detailed data and information collected through the Joint Wood Energy Enquiry, *Forest Products Annual Market Review*, and outlook studies for the European and North American Regions have fed into a policy dialogue on the suitability of using wood as a source of energy. Such a debate would have been merely theoretical if data had not been able to provide a reliable platform on which to base policy recommendations. This debate also included data for and information from CLRTAP.

Key documents such as the *State of Europe's Forests*, outlook studies, and various reviews allow the pan-European processes to benefit from the most up-to-date information and base their recommendations on them. The link between data and recommendations in these studies is direct.

Other non-UN pan-European processes have an important role to play in defining policies and supporting SFM in the region. FE is a case in point. In the past 20 years this process has demonstrated the willingness of European governments to engage in cooperation on SFM and provided the definition of principles and criteria for SFM that most countries have embraced, although on a voluntary basis. The process has also evolved into the negotiation of a legally binding agreement, which is expected and meant to further strengthen the role of SFM in the pan-European region.

The role of the European Forest Institute (EFI) is also significant. Information compiled, assessments, and research performed by the institute are a primary source of knowledge on forests in the region and likewise feed into policy processes and decisions. The link between the research role of EFI and its policy capacity has been enhanced with the creation of ThinkForest, a policy think tank stimulating several debates and exchanges of opinion in the region.

26.3.2 SFM monitoring and reporting in regional forest policy-making

The majority of forest-related international economic or policy agreements include an element of reporting; however, the role that information plays varies among processes. In general, data collected for the purpose of international statistics is not directly linked to forest-related policy commitments. The increasing amount and complexity of information gathered have required their interpretation, thus statistical datasets are often accompanied by thematic reports providing an analysis and interpretation of collected data (e.g. *UNECE/FAO Forest Products Annual Market Review* or FAO's *Global Forest Resources Assessment*). Most of the policy processes and conventions use reporting for monitoring the status and trends of variables related to their provisions (ICP Forests, FE, United Nations Forum on Forests (UNFF), and CBD). For instance, s specific information system for direct reporting on compliance at the national level with the undertaken commitments was developed by the Kyoto Protocol of UNFCCC.

In Europe regular activities on international forest cooperation were undertaken by FAO, in collaboration with UNECE, soon after the Second World War. Activities included the collection of forest information, which was based on data generated in individual countries. The first international statistics and assessments of forests in Europe focused on basic forest-related variables (e.g. forest area, growing stock) predominantly linked with economic activities (e.g. exploitable forests, removals, forest products). With time, the scope of information collected was enlarged to include information on other functions and aspects, which resulted in the comprehensive sets of data covering practically the whole scope of forest management that exists today (e.g. Criteria and Indicators for SFM).

Countries' information systems were primarily designed to address national issues, while the provision of information for international databases and reports was seen as an additional function. This resulted in high variability of national forest information systems that is reflected in the different scopes, frequencies, and methodologies of collected data. The first international statistics were a mere compilation of raw data collected according to national standards; in consequence, the level of comparability of data in international systems was low. Attempts to improve information comparability were undertaken with the increased interest and demand for forest-related information, partly resulting from the development of policy agreements (CLRTAP, criteria and indicators processes, Rio processes) in the last two decades of the 20th century.

The initial method applied for the improvement of the comprehensiveness of international information was the harmonisation of data, which transforms information reported according to the various national standards into a form responding to internationally agreed-upon definitions. The advanced method of harmonisation uses ground data collected through national forest inventories (NFI). An alternative approach is the standardisation of data collection, where countries collect data on the ground according to the same internationally agreed-upon methodology in all participating countries.

The majority of international statistical systems improve the integration of information through the harmonisation of national data (e.g., FAO, UNECE/FAO, EU Eurostat, EC Joint Research Centre, and OECD. FE defined the scope of required information (through the criteria and indicators for SFM) but does not define the method according to which information should be collected. As a result, the related reporting (Forest Europe/UNECE/FAO *State of Europe's Forests*) includes a combination of information coming from harmonised and standardised systems. Standardisation of the data collection is the main approach, which was applied by CLRTAP for the purposes of ICP Forests. The majority of the relevant reporting systems in the EU rely on the harmonised national data. However some information, such as on forest fires, is collected through a standardised system thanks to the European Forest Fire Information System (EFFIS).

The collection of information generated at the national level, harmonised to various extents, is the main reporting approach applied for the purpose of global conventions and processes such as UNFCCC, CBD, and UNFF.

26.4 Conclusions

CLRTAP is a particularly successful experience, especially when compared to other international processes. Clean-air policy in Europe was greatly promoted by concerns that forests could no longer fulfil their ecological, economic, and social functions due to the impact of air pollution. Considerable emission reductions were reached under CLRTAP. Since 1980 emissions of SO_2 from land-based sources have been reduced by 80%–90%. Emissions of NO_x and VOCs were reduced by approximately half since 1990. The success of CLRTAP stems from several factors. A driving force for the implementation of CLRTAP policy was public awareness of the threats that air pollution poses to human health and to all kinds of ecosystems, including forests. Moreover, there is probably no other environmental problem for which policy, monitoring, and analysis have been so closely connected to science as that of air pollution.

The overall impression is that the close involvement of science in the policy process for CLRTAP has contributed substantially to its success.

Scientific information provided by ICP Forests has on one hand revealed effects of air pollution on forests, thereby promoting clean-air policy. On the other hand, it has contributed positively to clean-air policy for SFM, as shown for several FE indicators. For instance, deposition of air pollutants (Indicator 2.1) on forests has been reduced for many years. This has induced a recovery of forest soil condition (Indicator 2.2) from acidification. Scenario analyses reveal that if protocols adopted by CLRTAP are implemented, the recovery of forest soils will continue and exceedances of critical loads will be reduced. This in turn is assumed to be of benefit for forest vegetation. Defoliation (Indictor 2.3) was shown to have decreased, especially in parts of Central Europe and Eastern Europe, where air pollution had been notably reduced during the political and economic transition in these countries.

However, none of the symptoms of forest decline are due solely to air pollution. For instance, defoliation attributed to existing air-pollution loads may be partly caused by such factors as tree age and drought, while seemingly natural damage by insects and fungi may be a result of predisposition caused by air pollution. For this reason it remains impossible to estimate both the exact extent to which air pollution is responsible for forest decline and the extent to which clean-air policy prevents forest decline or causes forest recovery. However, the positive effects of clean-air policy revealed by forest monitoring and the related benefits to the ecological, economic, and social functions of forests and hence of benefit to SFM cannot be denied.

The monitoring system of ICP Forests is not only useful for assessing effects of air pollution and the effectiveness of clean-air policy. It also assesses relationships between forest health and vitality, air pollution, carbon fluxes, climate change, and biodiversity. It may provide harmonised information for further FE indicators such as carbon stock (Indicator 1.4), forest damage (Indicator 2.4), deadwood (Indicator 4.5), and threatened forest species (Indicator 4.8).

The methodologies for the collection and processing of information for international processes have been evolving with the increased reporting capacity and governmental interest in the forest-related issues. Despite efforts aimed at the coordination of these developments, individual processes/organisations often decide to construct their own information systems. Due to different modalities endorsed by the individual processes, the final data reported by these bodies is often not comparable. This results in a variety of systems and approaches to collection of forest information, confusion in data interpretation, and duplication of efforts.

In addition to an increased reporting burden for countries, the situation leads to diverse results and assessments, which do not always reflect real differences, and intricacies are not easy to explain to the general public. Thus citizens and policy-makers may receive confusing, if not contradictory, messages despite tremendous investment in communication and pedagogics.

The concept of SFM with its set of criteria and indicators, which covers the whole scope of aspects related to forest management, should prevent biased and partial assessment, given its consistent and holistic nature. The *State of Europe's Forests* publication (Forest Europe et al. 2011), the most comprehensive and up-to-date review in the pan-European region, is based on this approach. It provides an objective picture of European forests, underlining progress and shortfalls, and highlights threats and challenges that forests and the forest sector face. Together with the outlook studies on the forest sector (UNECE and FAO, 2011), it provides a valuable input to forest policy-making.

However, it must be acknowledged that the findings of the *State of Europe's Forests* report do not seem to directly influence regional forest policy, let alone national forest policy-making and forest management on the ground. Policy processes in the region have not yet addressed or have dealt poorly with some of the crucial issues identified in the report: robust and harmonised monitoring systems throughout the region, the increased wood mobilisation needed to meet the greater demand, uncontrolled pests and diseases, and rural depopulation leading to an aging and shrinking workforce, among others. If the forest sector wants to develop and make the best contribution to a green economy, these issues need to be put on the table and dealt with through a cross-sectorial strategy.

International activities on forest information remain essential to regional and national policy-making. Nevertheless, they should not be selectively used as a tool to validate a certain point of view on forests or justify projects or processes. They should be based on scientific methods and backed by the best available data. In any case, intergovernmental bodies should make sure that the main conclusion of the reports that they commission or sponsor are discussed and, when appropriate, included in their agendas.

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